



MCUXpresso SDK Documentation

Release 25.09.00-pvw2



NXP
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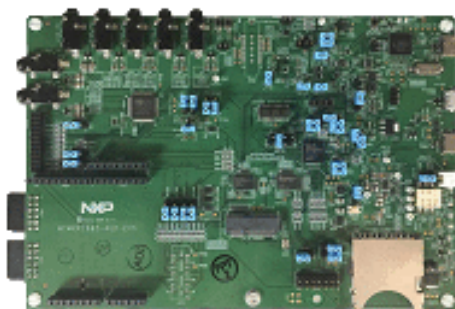
This documentation contains information specific to the mimxrt685audevk board.

Chapter 1

MIMXRT685-AUD-EVK

1.1 Overview

This i.MX RT600 EVK (MIMXRT685-AUD-EVK) features NXP's advanced implementation of the Arm Cortex-M33 core, combined with the highly optimized Cadence Tensilica HiFi 4 DSP processor core. The MIMXRT685-AUD-EVK supports development for the MIMXRT685 product and its features make it ideal for ML/AI, voice and audio applications. The i.MX RT600 AUD-EVK can help jumpstart your next design with the included schematics and layout files.



MCU device and part on board is shown below:

- Device: MIMXRT685S
- PartNumber: MIMXRT685SFVKB

1.2 Getting Started with MCUXpresso SDK Package

1.2.1 Getting Started with Package

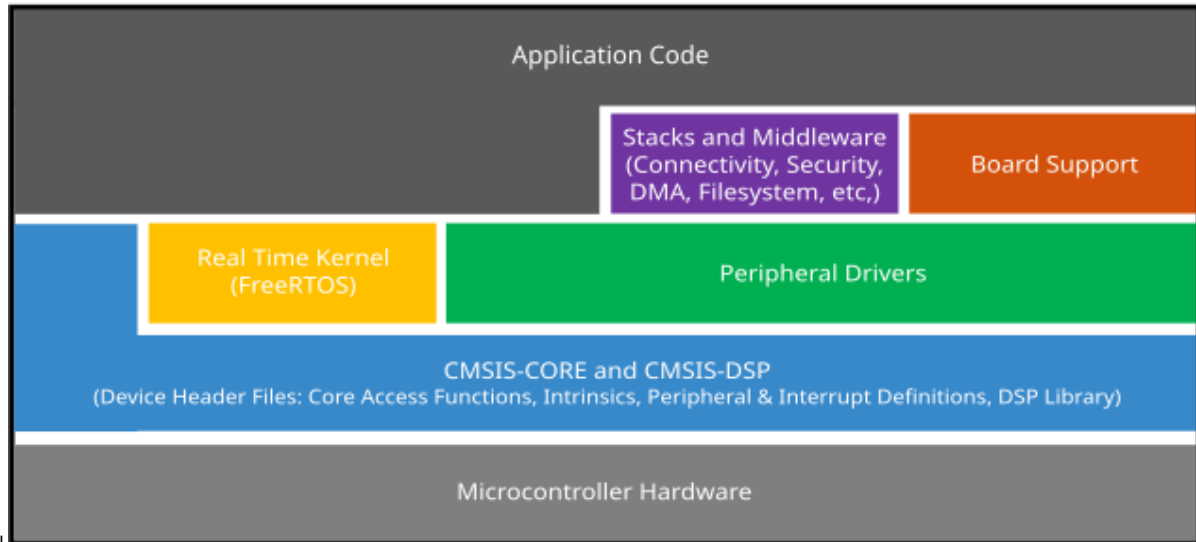
Overview

The NXP MCUXpresso software and tools offer comprehensive development solutions designed to optimize, ease, and help accelerate embedded system development of applications based on general purpose, crossover, and Bluetooth-enabled MCUs from NXP. The MCUXpresso SDK includes a flexible set of peripheral drivers designed to speed up and simplify development of embedded applications. Along with the peripheral drivers, the MCUXpresso SDK provides an extensive and rich set of example applications covering everything from basic peripheral use case examples to full demo applications. The MCUXpresso SDK contains optional RTOS integrations

such as FreeRTOS and Azure RTOS, a USB host and device stack, and various other middleware to support rapid development.

For supported toolchain versions, see *MCUXpresso SDK Release Notes for EVK-MIMXRT685* (document MCUXSDKMIMXRT6XXRN).

For more details about MCUXpresso SDK, see [MCUXpresso Software Development Kit \(SDK\)](#).



MCUXpresso SDK board support package folders

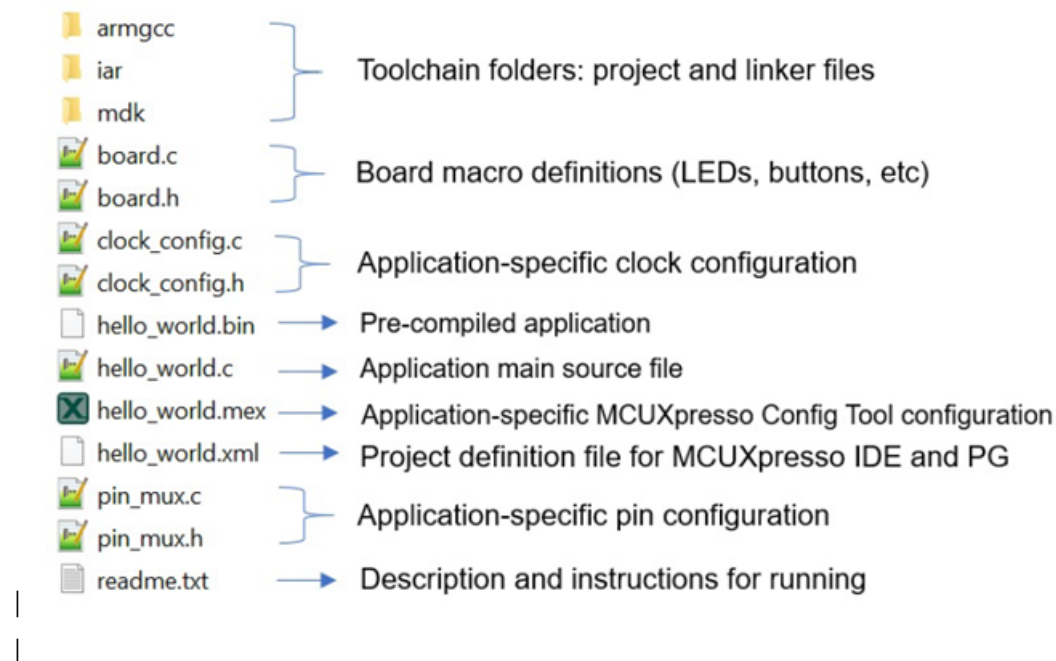
MCUXpresso SDK board support package provides example applications for NXP development and evaluation boards for Arm Cortex-M cores including Freedom, Tower System, i.mxrt EVK boards, and LPCXpresso boards. Board support packages are found inside the top-level boards folder and each supported board has its own folder (an MCUXpresso SDK package can support multiple boards). Within each `<board_name>` folder, there are various subfolders to classify the type of examples it contains. These include (but are not limited to):

- `demo_apps`: Full-featured applications that highlight key functionality and use cases of the target MCU. These applications typically use multiple MCU peripherals and may leverage stacks and middleware.
- `driver_examples`: Simple applications that show how to use the MCUXpresso SDK's peripheral drivers for a single use case. These applications typically only use a single peripheral but there are cases where multiple peripherals are used (for example, SPI conversion using DMA).
- `rtos_examples`: Basic FreeRTOS OS examples that show the use of various RTOS objects (semaphores, queues, and so on) and interfaces with the MCUXpresso SDK's RTOS drivers

Example application structure This section describes how the various types of example applications interact with the other components in the MCUXpresso SDK. To get a comprehensive understanding of all MCUXpresso SDK components and folder structure, see *MCUXpresso SDK API Reference Manual*.

Each `<board_name>` folder in the boards directory contains a comprehensive set of examples that are relevant to that specific piece of hardware. Although we use the `hello_world` example (part of the `demo_apps` folder), the same general rules apply to any type of example in the `<board_name>` folder.

In the `hello_world` application folder you see the following contents:



All files in the application folder are specific to that example, so it is easy to copy and paste an existing example to start developing a custom application based on a project provided in the MCUXpresso SDK.

Parent topic: [MCUXpresso SDK board support package folders](#)

Locating example application source files When opening an example application in any of the supported IDEs, various source files are referenced. The MCUXpresso SDK devices folder is the central component to all example applications. It means that the examples reference the same source files and, if one of these files is modified, it could potentially impact the behavior of other examples.

The main areas of the MCUXpresso SDK tree used in all example applications are:

- `devices/<device_name>`: The device's CMSIS header file, MCUXpresso SDK feature file, and a few other files
- `devices/<device_name>/drivers`: All of the peripheral drivers for your specific MCU
- `devices/<device_name>/<tool_name>`: Toolchain-specific startup code, including vector table definitions
- `devices/<device_name>/utilities`: Items such as the debug console that are used by many of the example applications

For examples containing an RTOS, there are references to the appropriate source code. RTOSes are in the `rtos` folder. The core files of each of these are shared, so modifying one could have potential impacts on other projects that depend on that file.

Parent topic: [MCUXpresso SDK board support package folders](#)

Run a demo using MCUXpresso IDE

Note: Ensure that the MCUXpresso IDE toolchain is included when generating the MCUXpresso SDK package.

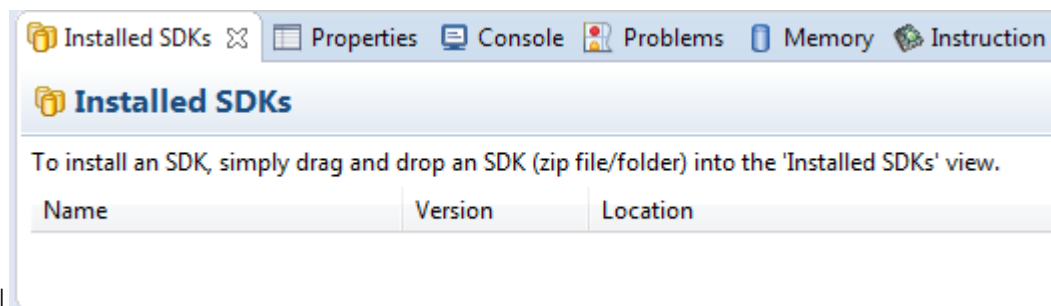
This section describes the steps required to configure MCUXpresso IDE to build, run, and debug example applications. The `hello_world` demo application targeted for the MIMXRT685-EVK hardware platform is used as an example, though these steps can be applied to any example application in the MCUXpresso SDK.

Select the workspace location Every time MCUXpresso IDE launches, it prompts the user to select a workspace location. MCUXpresso IDE is built on top of Eclipse which uses workspace to store information about its current configuration, and in some use cases, source files for the projects are in the workspace. The location of the workspace can be anywhere, but it is recommended that the workspace be located outside the MCUXpresso SDK tree.

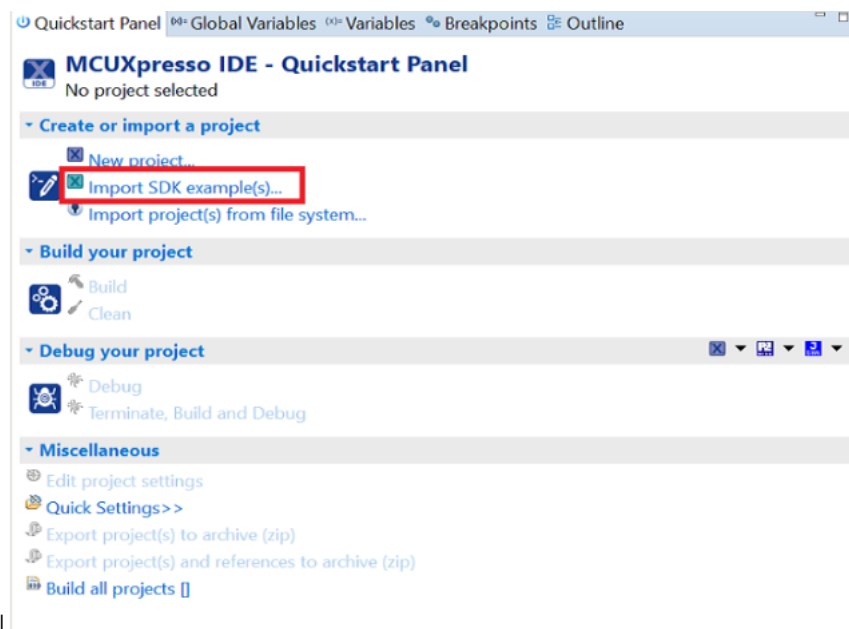
Parent topic: [Run a demo using MCUXpresso IDE](#)

Build an example application To build an example application, follow these steps.

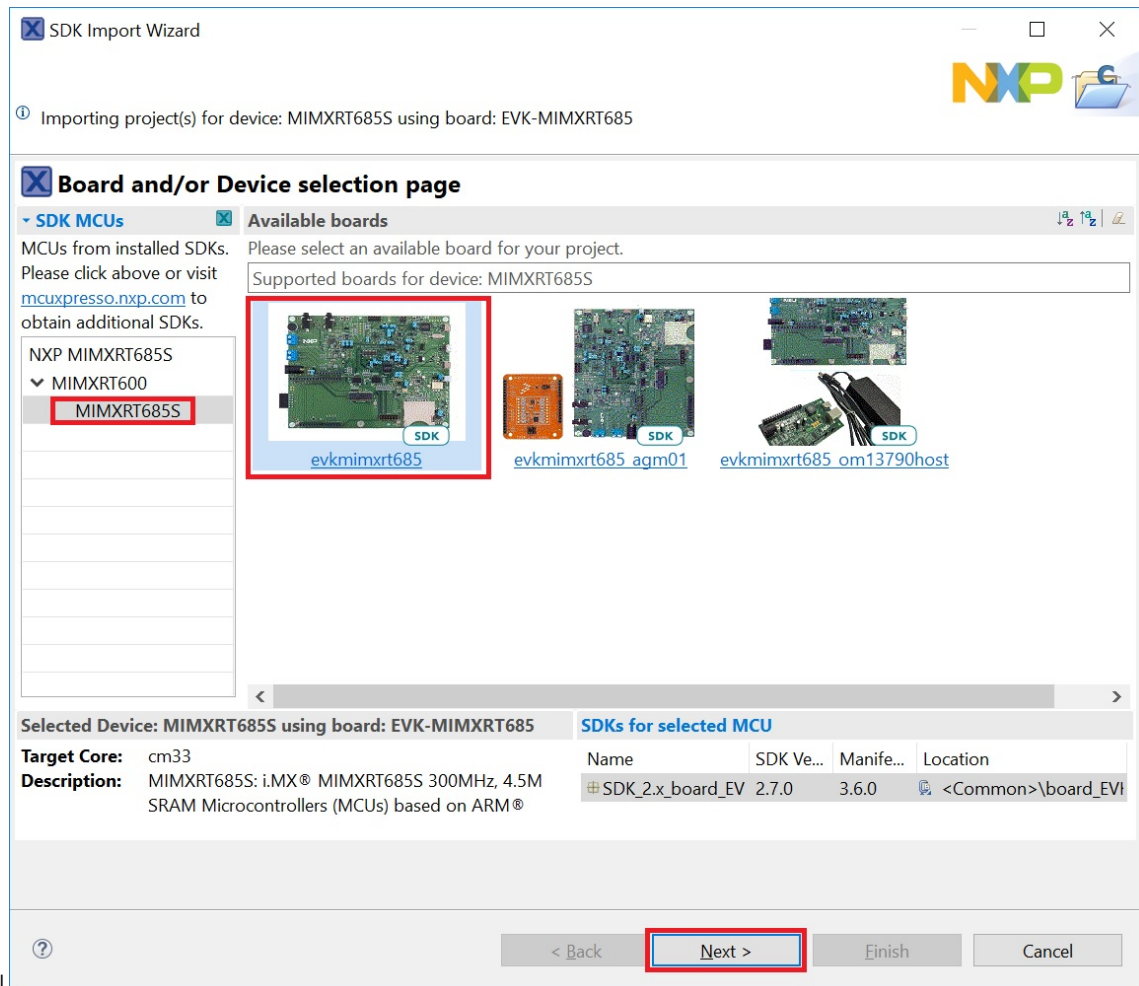
1. Drag and drop the SDK zip file into the **Installed SDKs** view to install an SDK. In the window that appears, click **OK** and wait until the import has finished.



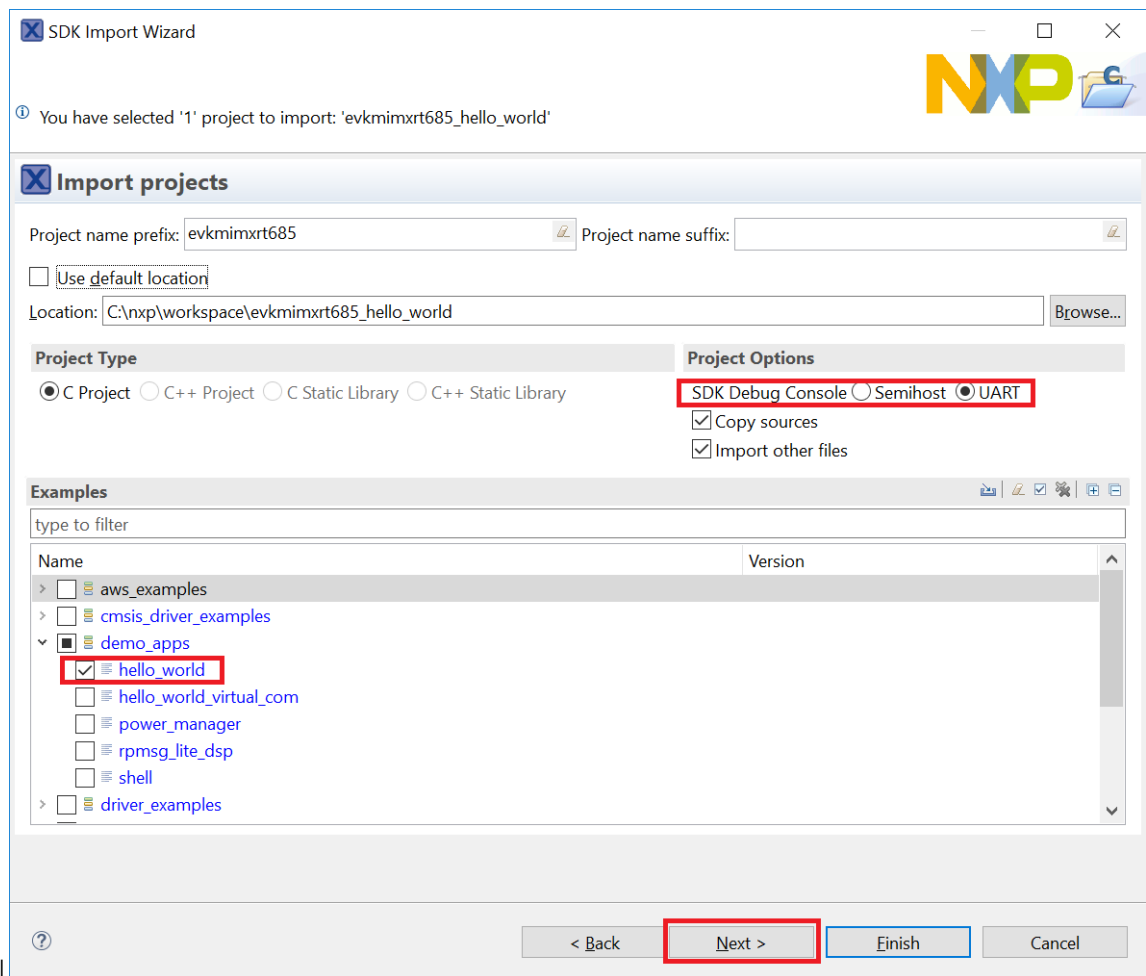
2. On the **Quickstart Panel**, click **Import SDK example(s)...**



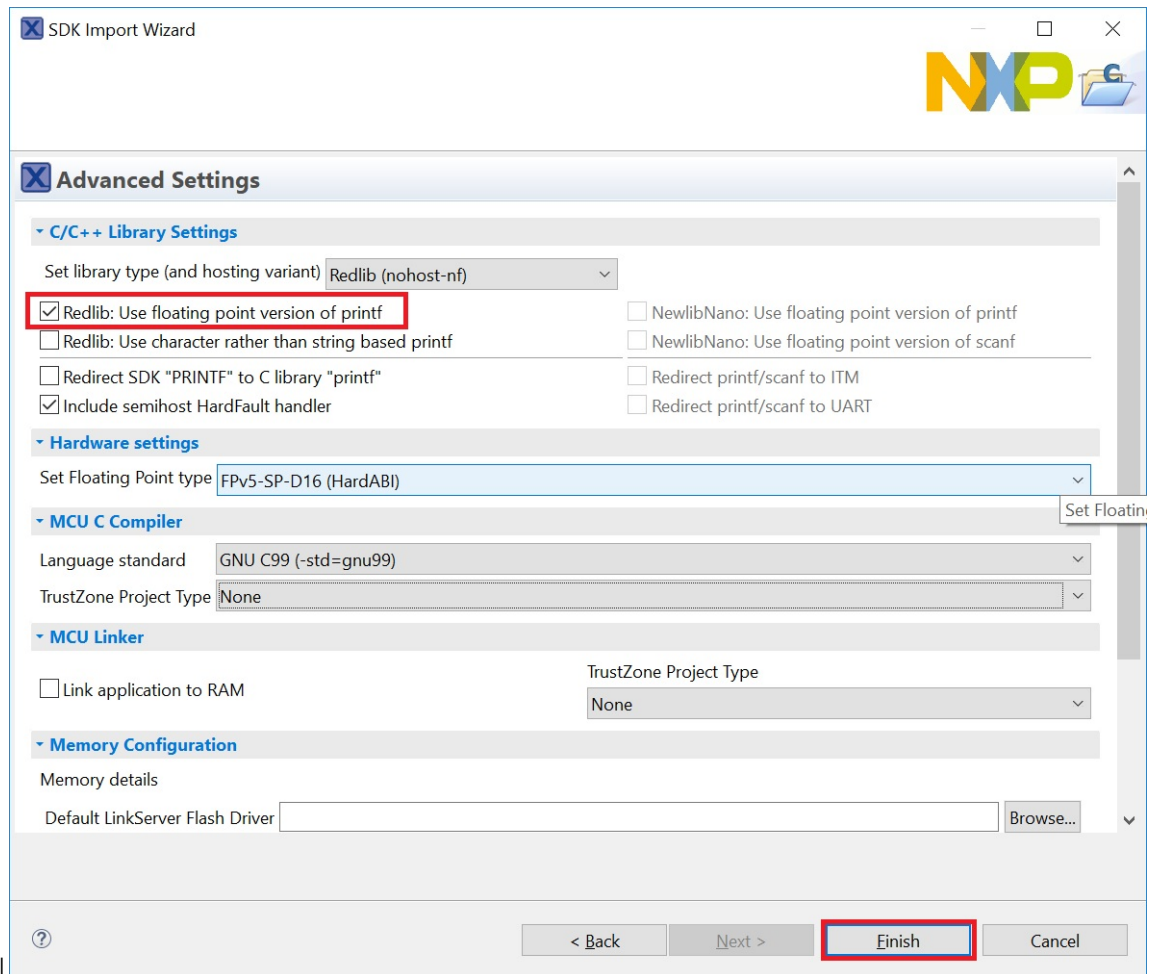
3. In the window that appears, expand the **MIMXRT600** folder and select **MIMXRT685S**. Then, select **evkmimxrt685** and click **Next**.



4. Expand the `demo_apps` folder and select `hello_world`. Then, click **Next**.



5. Ensure **Redlib: Use floating-point version of printf** is selected if the example prints floating-point numbers on the terminal. Otherwise, it is not necessary to select this option. Then, click **Finish**.



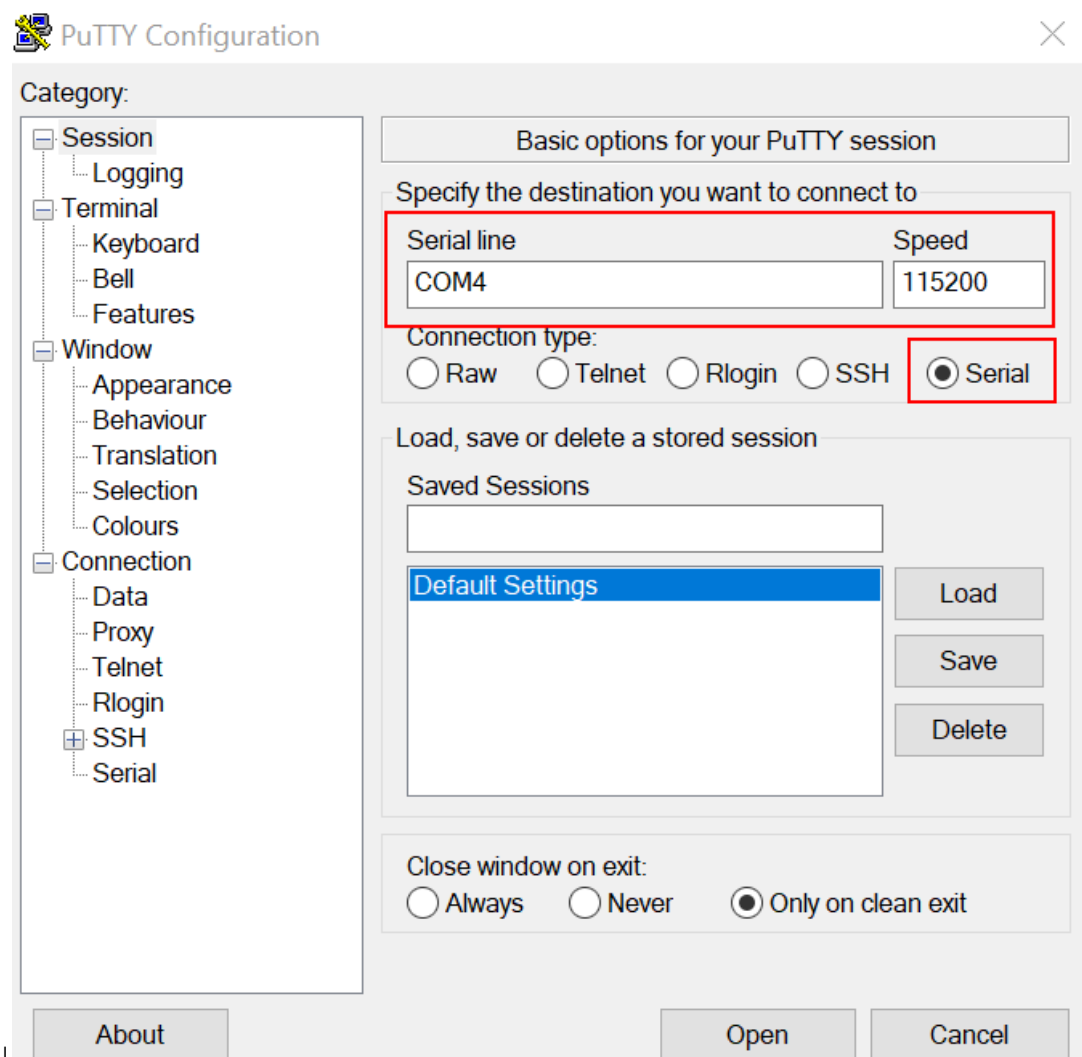
Parent topic: [Run a demo using MCUXpresso IDE](#)

Run an example application For more information on debug probe support in the MCUXpresso IDE, see community.nxp.com.

To download and run the application, perform the following steps:

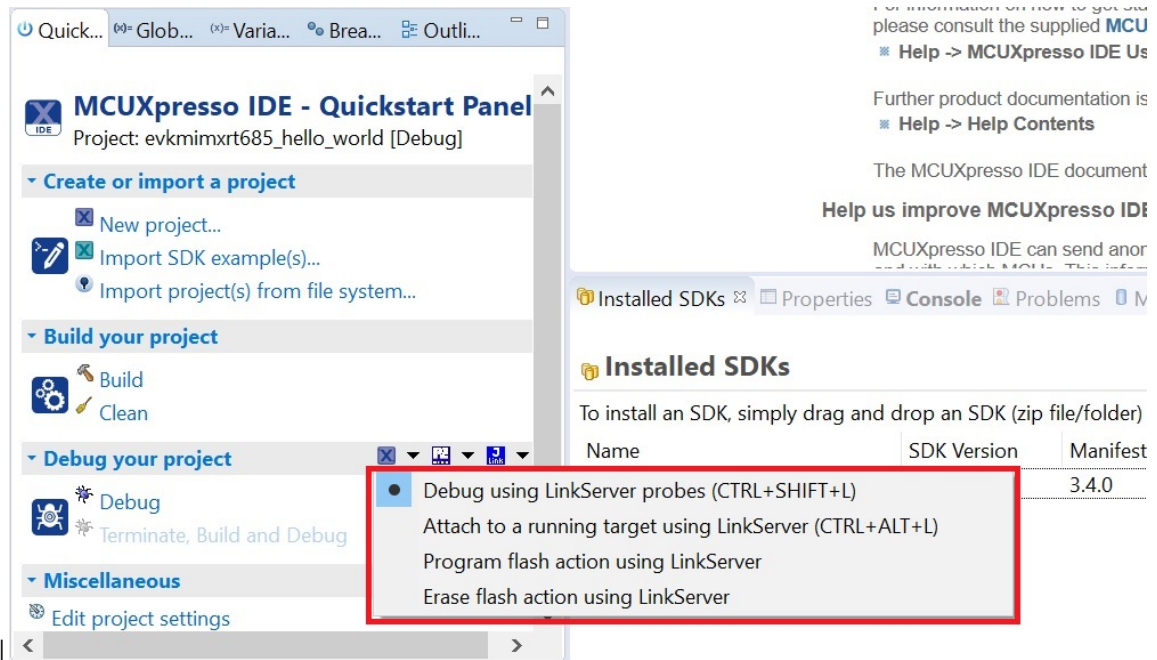
1. See the table in [Default debug interfaces](#) to determine the debug interface that comes loaded on your specific hardware platform.
 - For boards with CMSIS-DAP/mbd/DAPLink interfaces, visit developer.mbed.org/handbook/Windows-serial-configuration and follow the instructions to install the Windows operating system serial driver. If running on Linux OS, this step is not required.
 - For boards with a P&E Micro interface, see [PE micro](#) to download and install the P&E Micro Hardware Interface Drivers package.
2. Connect the development platform to your PC via a USB cable.
3. Open the terminal application on the PC, such as PuTTY or TeraTerm, and connect to the debug serial port number (to determine the COM port number, see [How to determine COM port](#)). Configure the terminal with these settings:
 1. 115200 or 9600 baud rate, depending on your board (reference BOARD_DEBUG_UART_BAUDRATE variable in board.h file)
 2. No parity

3. 8 data bits

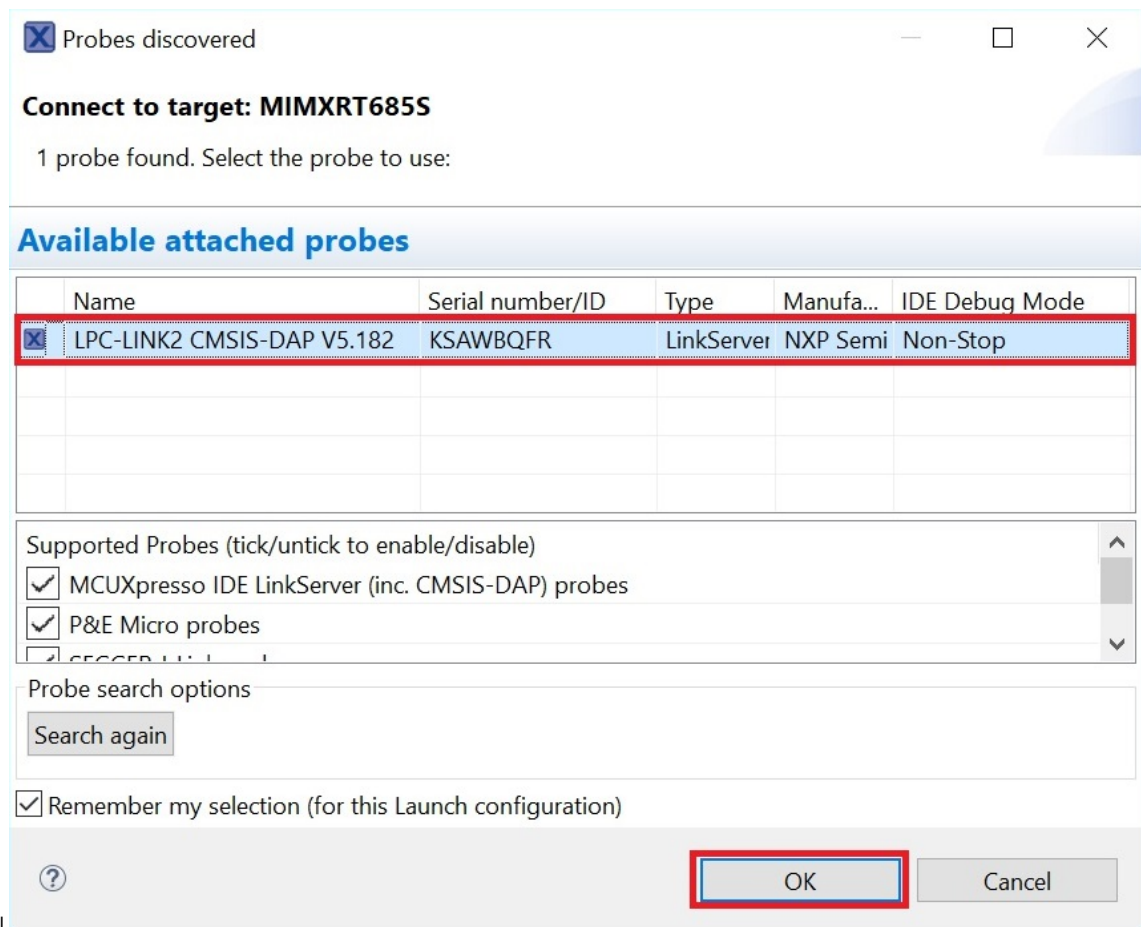


4. 1 stop bit

4. On the **Quickstart Panel**, click **Debug** evkmimxrt685_hello_world [Debug] to launch the debug session.

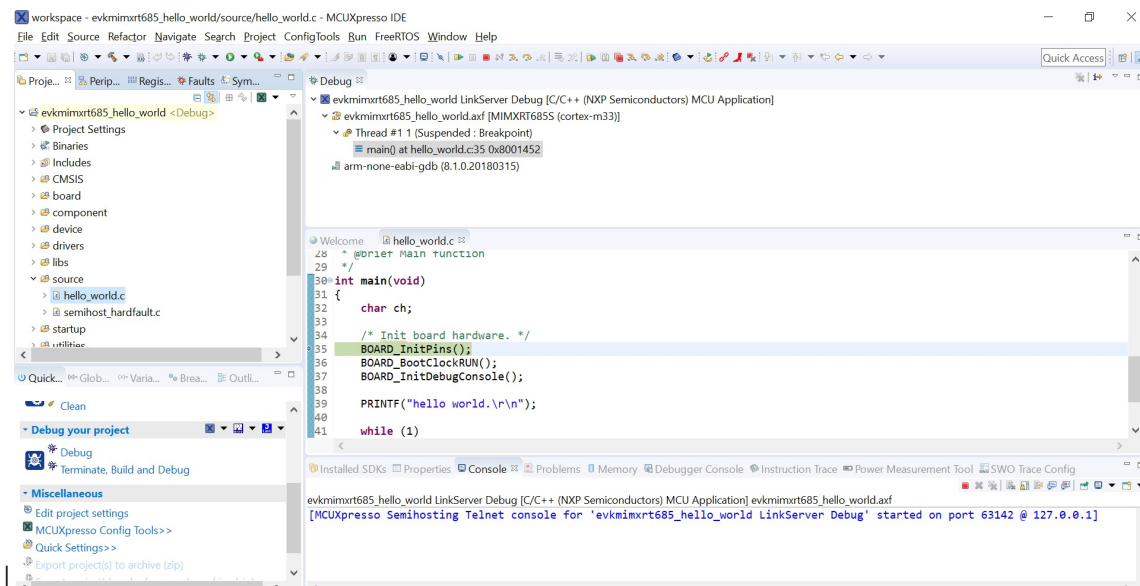


- The first time you debug a project, the **Debug Emulator Selection** dialog is displayed, showing all supported probes that are attached to your computer. Select the probe through which you want to debug and click **OK**. (For any future debug sessions, the stored probe selection is automatically used, unless the probe cannot be found.)



****Note:**** If the debug probe is CMSIS-DAP and the debugging application is running in flash, make sure
 → that the board is set to FlexSPI flash boot mode \(\ISP2: ISP1: ISP0 = ON, OFF, ON\). Otherwise, you
 → should not set to FlexSPI boot mode when debugging the application. If the debug probe is J-Link,
 → ****Reset before running**** must be disabled. Double click the `<example> J-Link Debug.launch` file, and
 → deselect this option under ****JLink Debugger -\>Additional Options**** menu.

6. The application is downloaded to the target and automatically runs to main().



7. Start the application by clicking **Resume**.



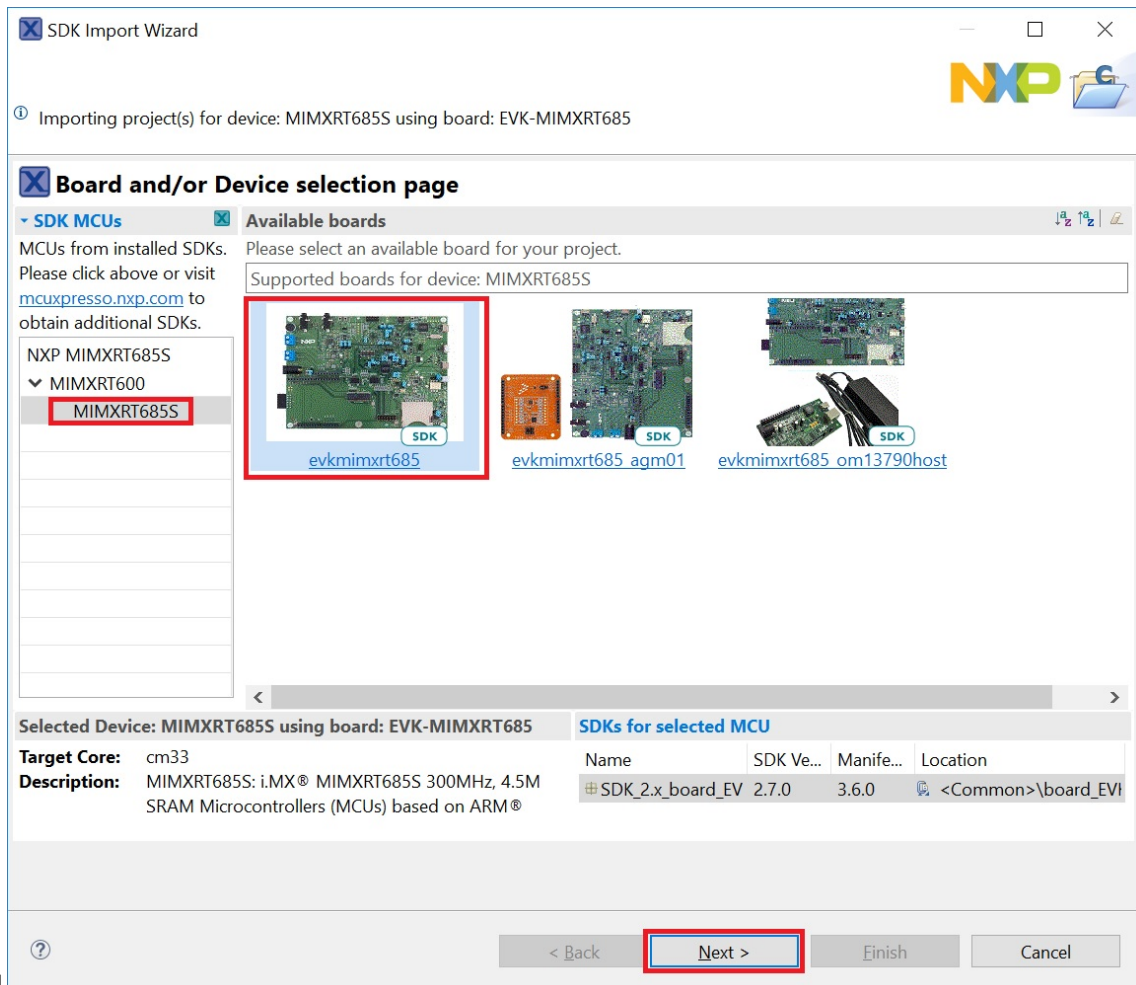
The hello_world application is now running and a banner is displayed on the terminal. If not, check your terminal settings and connections.



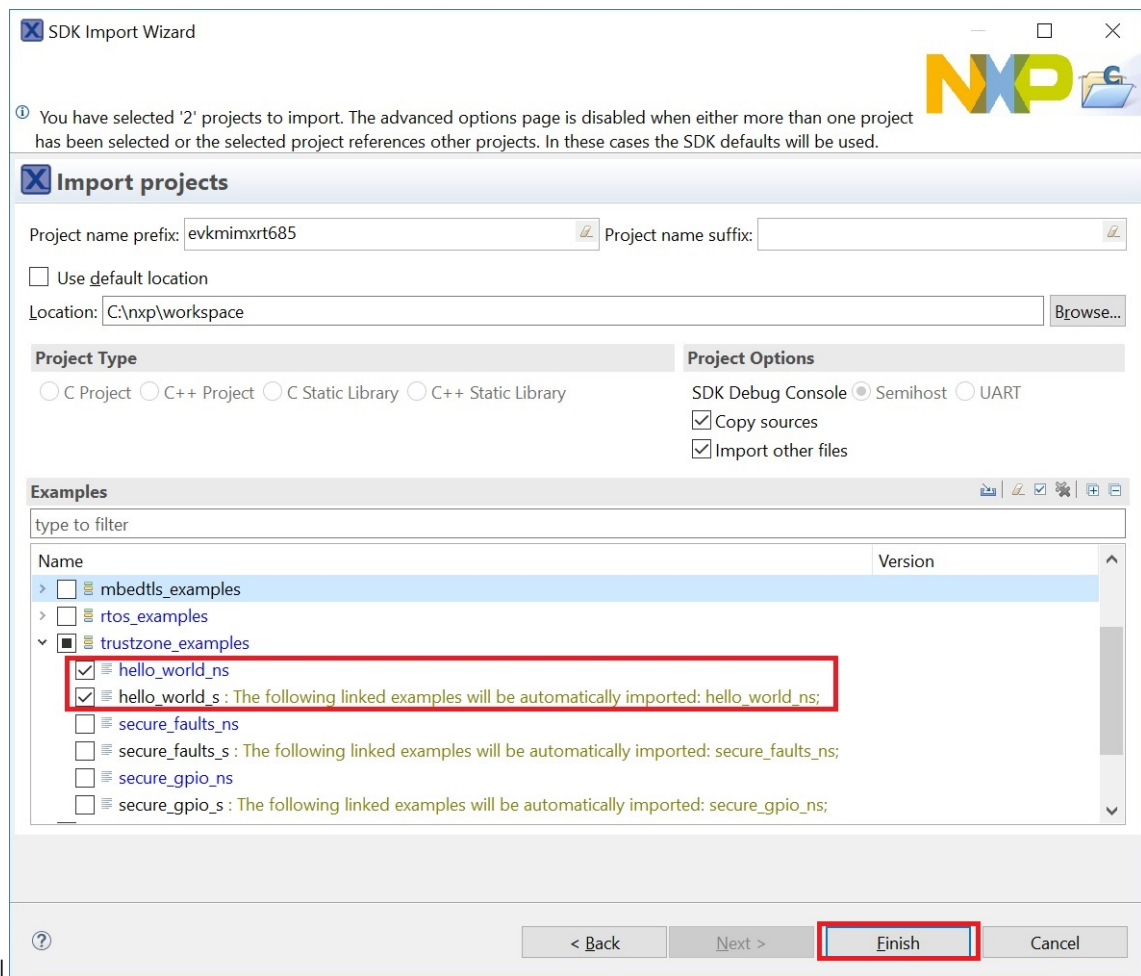
Parent topic: [Run a demo using MCUXpresso IDE](#)

Build a TrustZone example application This section describes the steps required to configure MCUXpresso IDE to build, run, and debug TrustZone example applications. The TrustZone version of the hello_world example application targeted for the MIMXRT685-EVK hardware platform is used as an example, though these steps can be applied to any TrustZone example application in the MCUXpresso SDK.

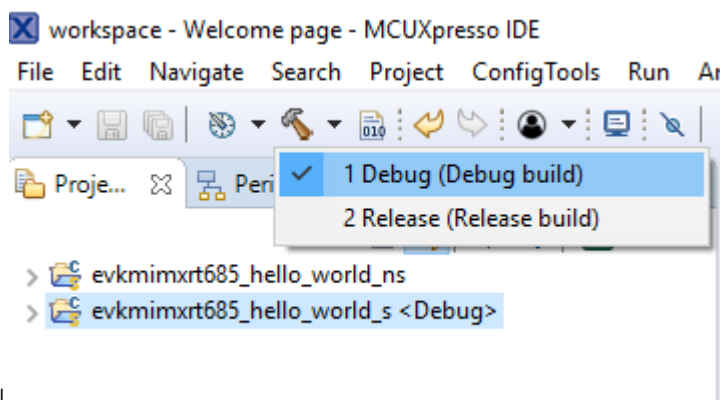
1. TrustZone examples are imported into the workspace in a similar way as single core applications. When the SDK zip package for MIMXRT685-EVK is installed and available in the **Installed SDKs** view, click **Import SDK example(s)...** on the Quickstart Panel. In the window that appears, expand the **MIMXRT600** folder and select **MIMXRT685S**. Then, select **evkmimxrt685** and click **Next**.



2. Expand the trustzone_examples/ folder and select hello_world_s. Because TrustZone examples are linked together, the non-secure project is automatically imported with the secure project, and there is no need to select it explicitly. Then, click **Finish**.



- Now, two projects should be imported into the workspace. To start building the TrustZone application, highlight the `evkmimxrt685\_hello\_world\_s` project (TrustZone master project) in the Project Explorer. Then, choose the appropriate build target, **Debug, or Release**, by clicking the downward facing arrow next to the hammer icon, as shown in Figure 3. For this example, select the **Debug** target.



The project starts building after the build target is selected. It is requested to build the application for the `secure` project first, because the non-secure project must know the secure project since CMSE library when running the linker. It is not possible to finish the non-secure project linker when the secure project since CMSE library is not ready.

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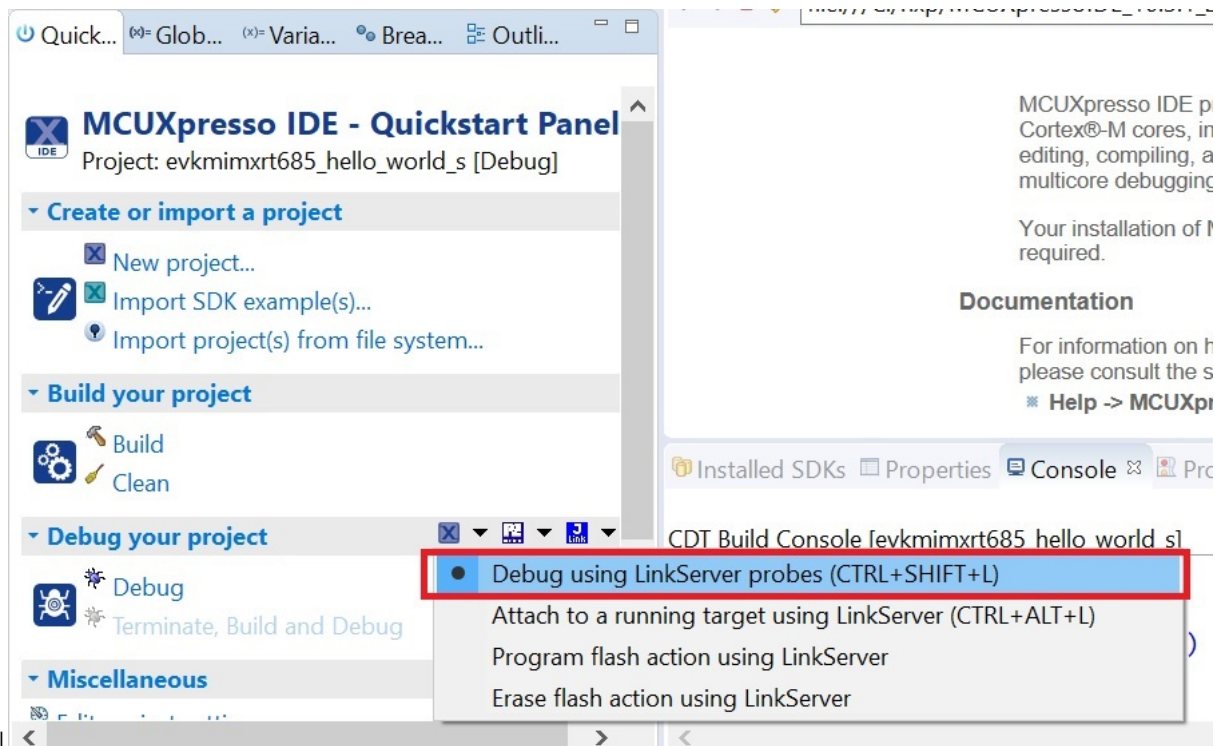
Note: When the **Release** build is requested, it is necessary to change the build configuration of both the secure and non-secure application projects first. To do this, select both projects in the Project Explorer view by clicking to select the first project, then using shift-click or control-click to select the second project. Right click in the Project Explorer view to display the context-sensitive menu and select **Build Configurations** \> **Set Active** \> **Release**. This is also possible by using the menu item of **Project** \> **Build Configuration** \> **Set Active** \> **Release**. After switching to the **Release** build configuration. Build the application for the secure project first.

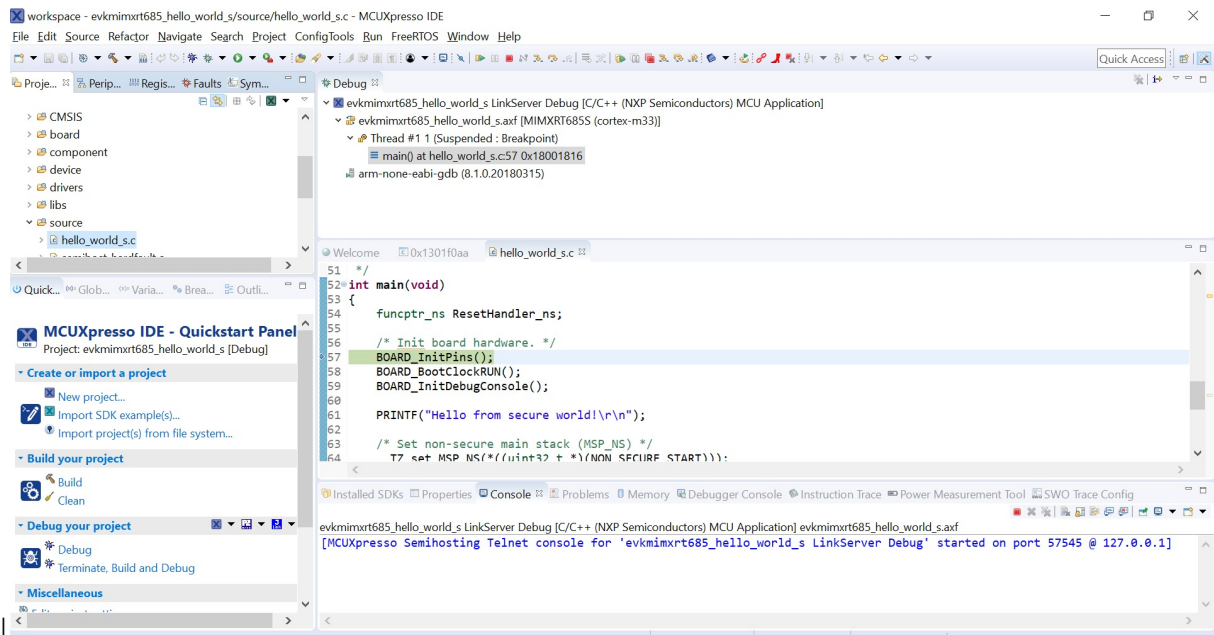
Switching TrustZone projects into the Release build configuration")

Parent topic: [Run a demo using MCUXpresso IDE](#)

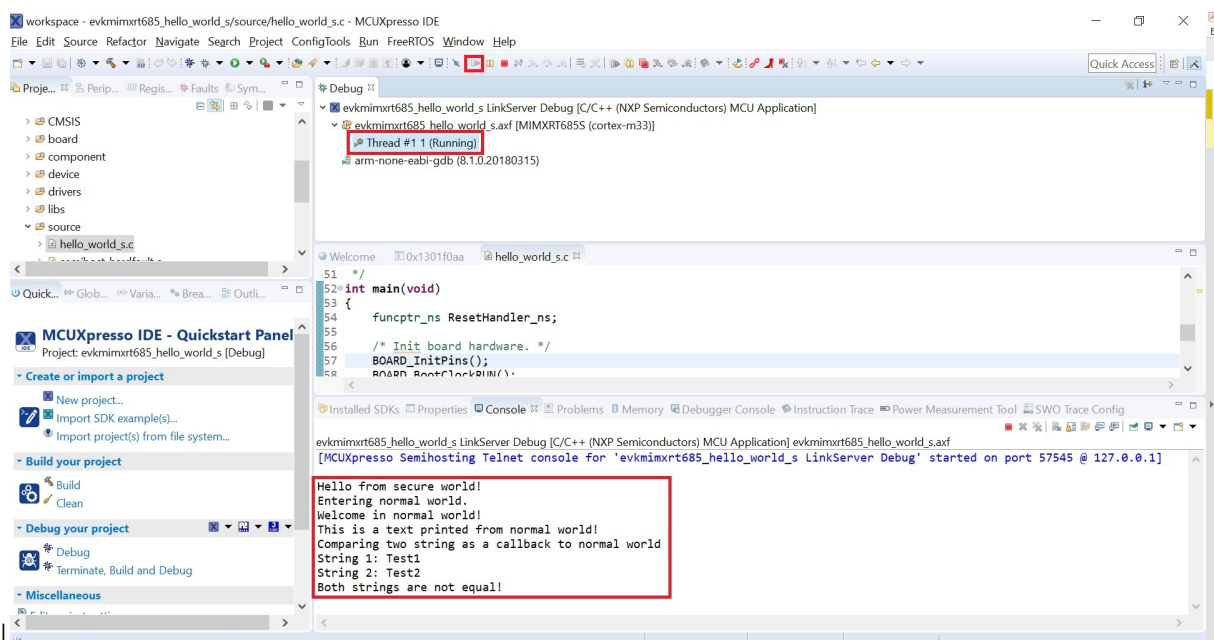
Run a TrustZone example application To download and run the application, perform all steps as described in Section 3.3, “Run an example application”. These steps are common for single core, and TrustZone applications, ensuring evkmimxrt685_hello_world_s is selected for debugging.

In the Quickstart Panel, click **Debug evkmimxrt685_hello_world_s [Debug]** to launch the second debug session.





Now, the TrustZone sessions should be opened. Click **Resume**. The hello_world TrustZone application then starts running, and the secure application starts the non-secure application during runtime.



Parent topic: [Run a demo using MCUXpresso IDE](#)

Run a demo application using IAR

This section describes the steps required to build, run, and debug example applications provided in the MCUXpresso SDK.

Note: IAR Embedded Workbench for Arm version 8.40.2 is used in the following example, and the IAR toolchain should correspond to the latest supported version, as described in the *MCUXpresso SDK Release Notes* (document ID: MCUXSDKRN).

Build an example application Do the following steps to build the `hello_world` example application.

1. Open the desired demo application workspace. Most example application workspace files can be located using the following path:

```
<install_dir>/boards/<board_name>/<example_type>/<application_name>/iar
```

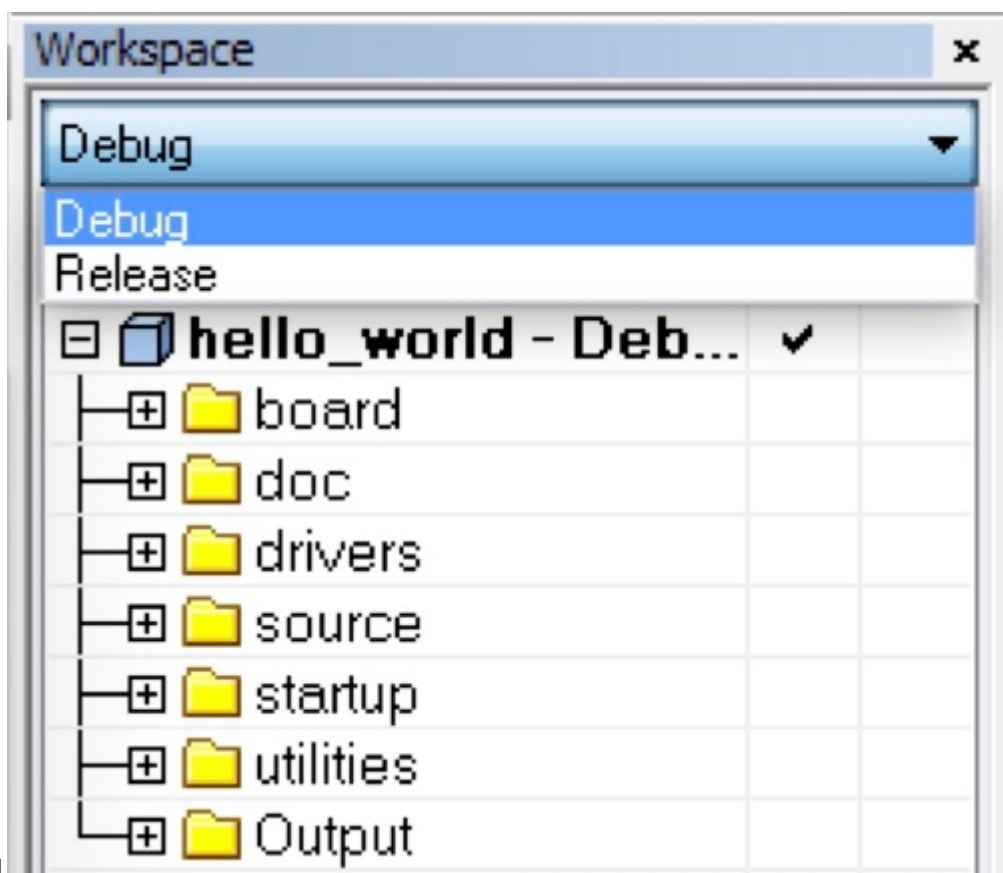
Using the MIMXRT685-EVK hardware platform as an example, the `hello_world` workspace is located in:

```
<install_dir>/boards/k32w061dk6/demo_apps/hello_world/iar/hello_world.eww
```

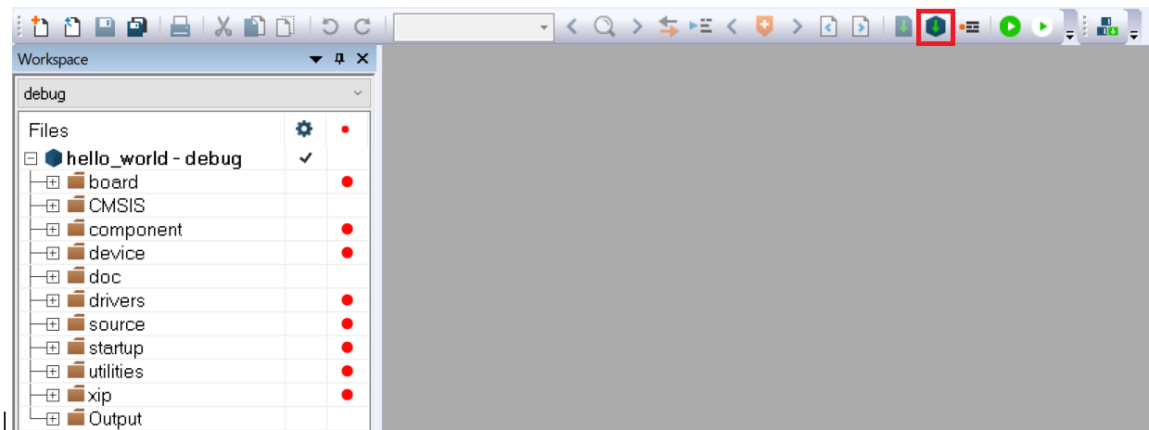
Other example applications may have additional folders in their path.

2. Select the desired build target from the drop-down menu.

For this example, select **hello_world – debug**.



3. To build the demo application, click **Make**, highlighted in red in Figure 2.

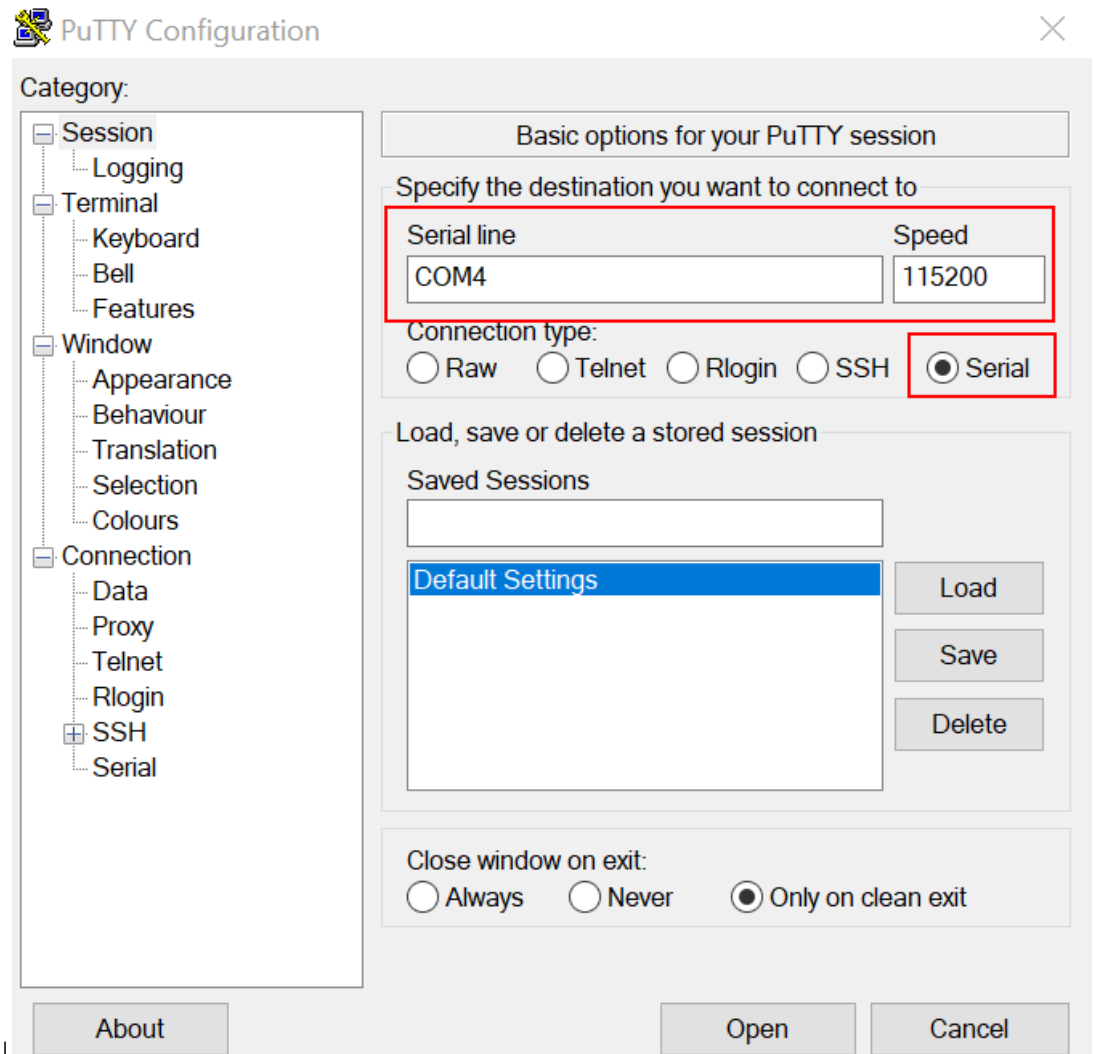


4. The build completes without errors.

Parent topic: [Run a demo application using IAR](#)

Run an example application To download and run the application, perform these steps:

1. See the table in [Default debug interfaces](#) to determine the debug interface that comes loaded on your specific hardware platform.
2. Connect the development platform to your PC via USB cable.
3. Open the terminal application on the PC, such as PuTTY or TeraTerm, and connect to the debug COM port (to determine the COM port number, see [How to determine COM port](#)). Configure the terminal with these settings:
 1. 115200 or 9600 baud rate, depending on your board (reference BOARD_DEBUG_UART_BAUDRATE variable in the board.h file)
 2. No parity
 3. 8 data bits

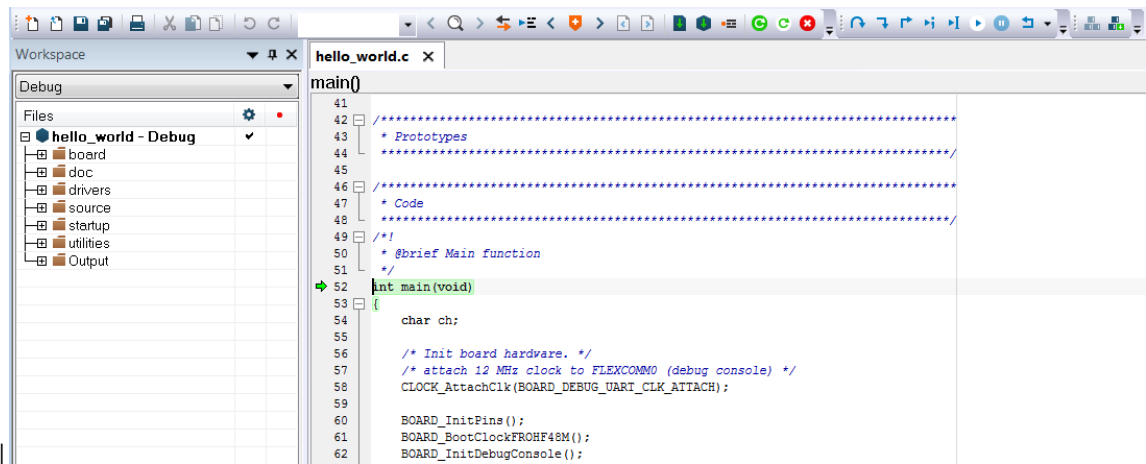


4. 1 stop bit

4. In IAR, click the **Download and Debug** button to download the application to the target.



5. The application is then downloaded to the target and automatically runs to the `main()` function.



6. Run the code by clicking the **Go** button.



7. The hello_world application is now running and a banner is displayed on the terminal. If it does not appear, check your terminal settings and connections.



Parent topic: [Run a demo application using IAR](#)

Build a TrustZone example application This section describes the particular steps that must be done in order to build and run a TrustZone application. The demo applications workspace files are located in this folder:

```
<install_dir>/boards/<board_name>/trustzone_examples/<application_name>/[<core_type>]/iar/  
↪<application_name>_ns/iar
```

```
<install_dir>/boards/<board_name>/trustzone_examples/<application_name>/[<core_type>]/iar/  
↪<application_name>_s/iar
```

Begin with a simple TrustZone version of the Hello World application. The TrustZone Hello World IAR workspaces are located in this folder:

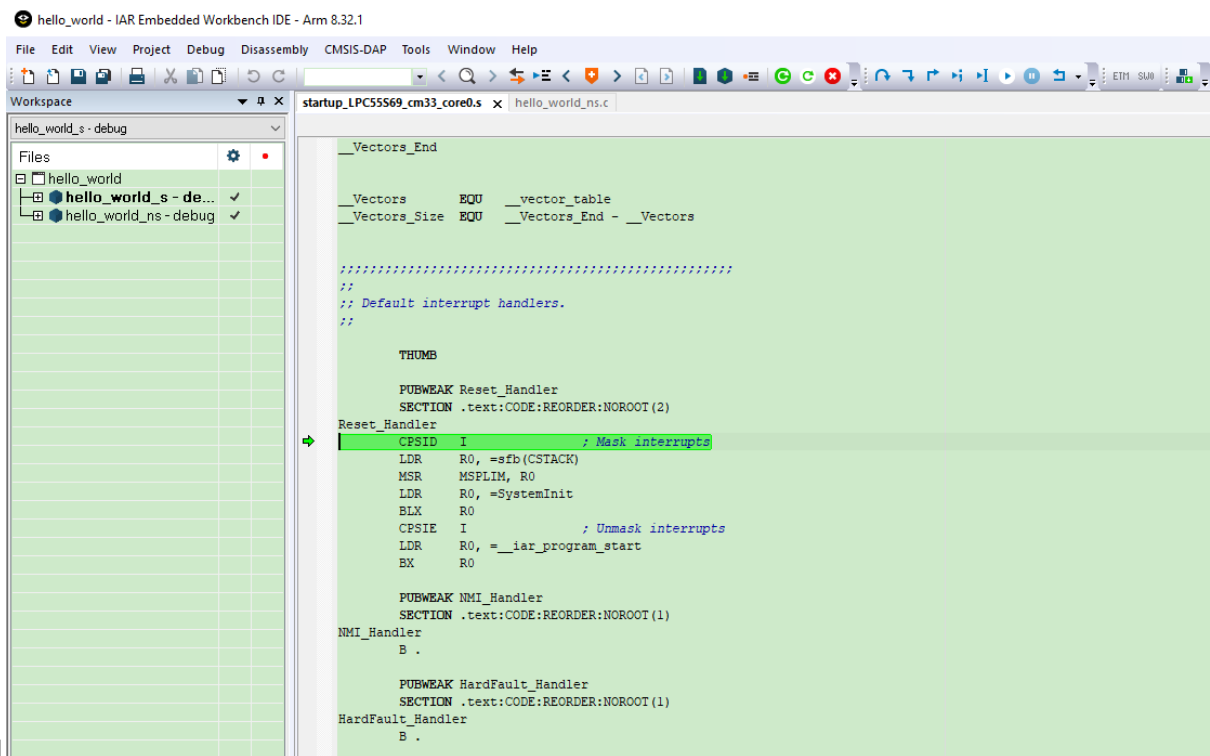
```
<install_dir>/boards/evkmimxrt685/trustzone_examples/hello_world/hello_world_s/iar/hello_world_s.  
→.eww
```

```
<install_dir>/boards/evkmimxrt685/trustzone_examples/hello_world/hello_world_s/iar/hello_world.eww
```

This project `hello_world.eww` contains both secure and non-secure projects in one workspace and it allows the user to easily transition from one project to another. Build both applications separately by clicking **Make**. It is requested to build the application for the secure project first, because the non-secure project must know the secure project, since the CMSE library is running the linker. It is not possible to finish the non-secure project linker with the secure project since CMSE library is not ready.

Parent topic: [Run a demo application using IAR](#)

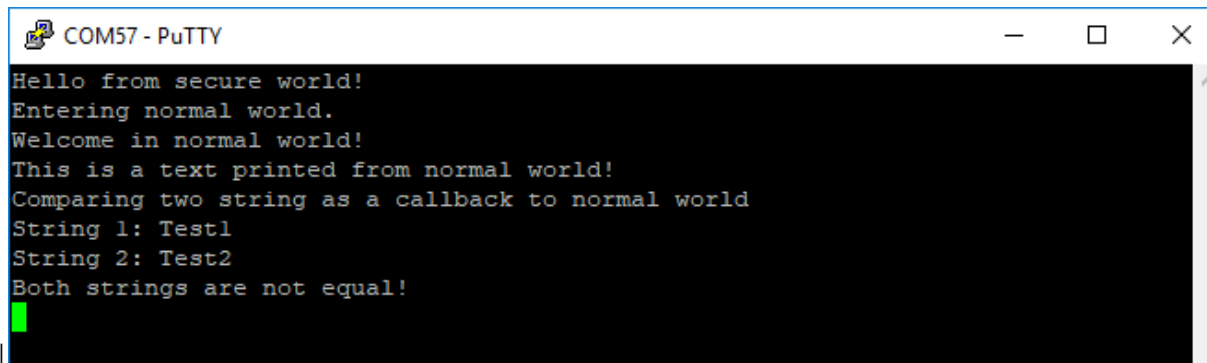
Run a TrustZone example application The secure project is configured to download both secure and non-secure output files, so debugging can be fully managed from the secure project. To download and run the TrustZone application, switch to the secure application project and perform steps 1 – 4 as described in *Section 4.2, Run an example application*. These steps are common for both single core, and TrustZone applications in IAR. After clicking **Download and Debug**, both the secure and non-secure images are loaded into the device memory, and the secure application is executed. It stops at the `Reset_Handler` function.



Run the code by clicking **Go** to start the application.



The TrustZone `hello_world` application is now running and a banner is displayed on the terminal. If this is not true, check your terminal settings and connections.

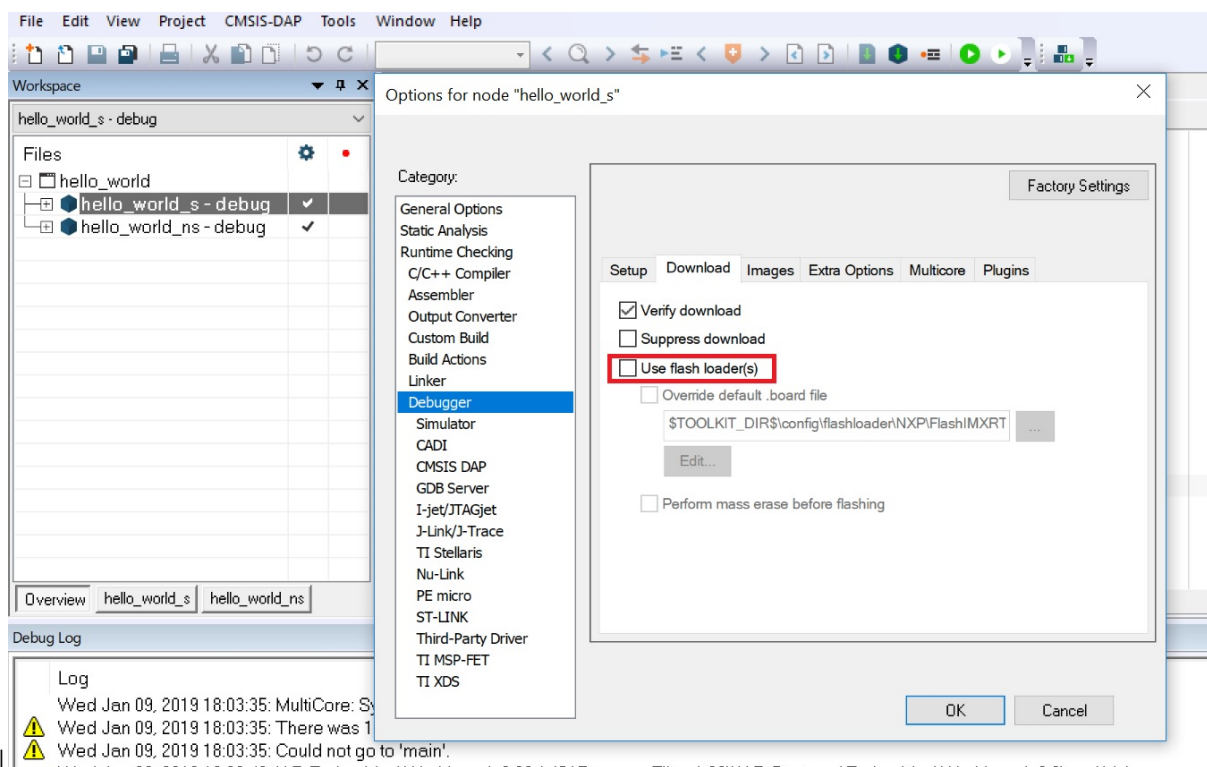


```

COM57 - PuTTY
Hello from secure world!
Entering normal world.
Welcome in normal world!
This is a text printed from normal world!
Comparing two string as a callback to normal world
String 1: Test1
String 2: Test2
Both strings are not equal!

```

Note: If the application is running in RAM (debug/release build target), in **Options**>Debugger > Download** tab, disable **Use flash loader(s)**. This can avoid the `_ns` download issue on i.MXRT600.



Parent topic: [Run a demo application using IAR](#)

IAR RAM debugging notes In the SDK examples, there are many build configurations. For example, debug, release, flash_debug, and flash_release. The debug/release configuration demonstrates the application running in RAM, while flash_debug/flash_release runs in the flash (XIP).

XIP debugging is clean with the “**boot from flash**” setting on the board because the debugging has the same sequence as a normal boot.

The debugging steps are as follows:

1. The debugger downloads the image to the flash.
2. The debugger resets the device and boots from ROM.
3. The debugger halts the device and waits for the command from the user.

However, with RAM debugging with the *boot from flash* setting on the board, the situation is complicated.

1. The debugger downloads the image to the RAM.
2. The debugger resets the device and boots it from ROM.

Note: The image downloaded for debugging and the image running from the flash are different. The images are different because the image in flash might be written by the previous debugging.

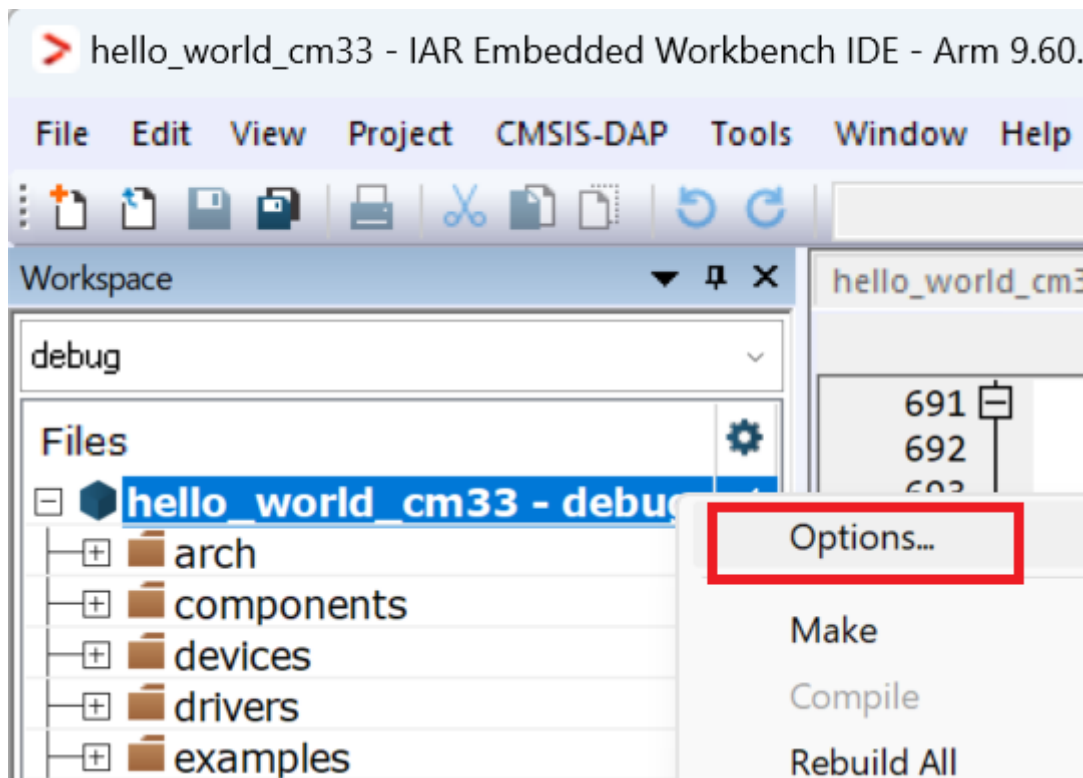
3. The debugger halts the device and sets the PC register value to the entry address of the downloaded image.

The problem here is that step 2 might overwrite the RAM written in step 1. The other issue is that the hardware status is undetermined when PC is set to the start of the RAM application.

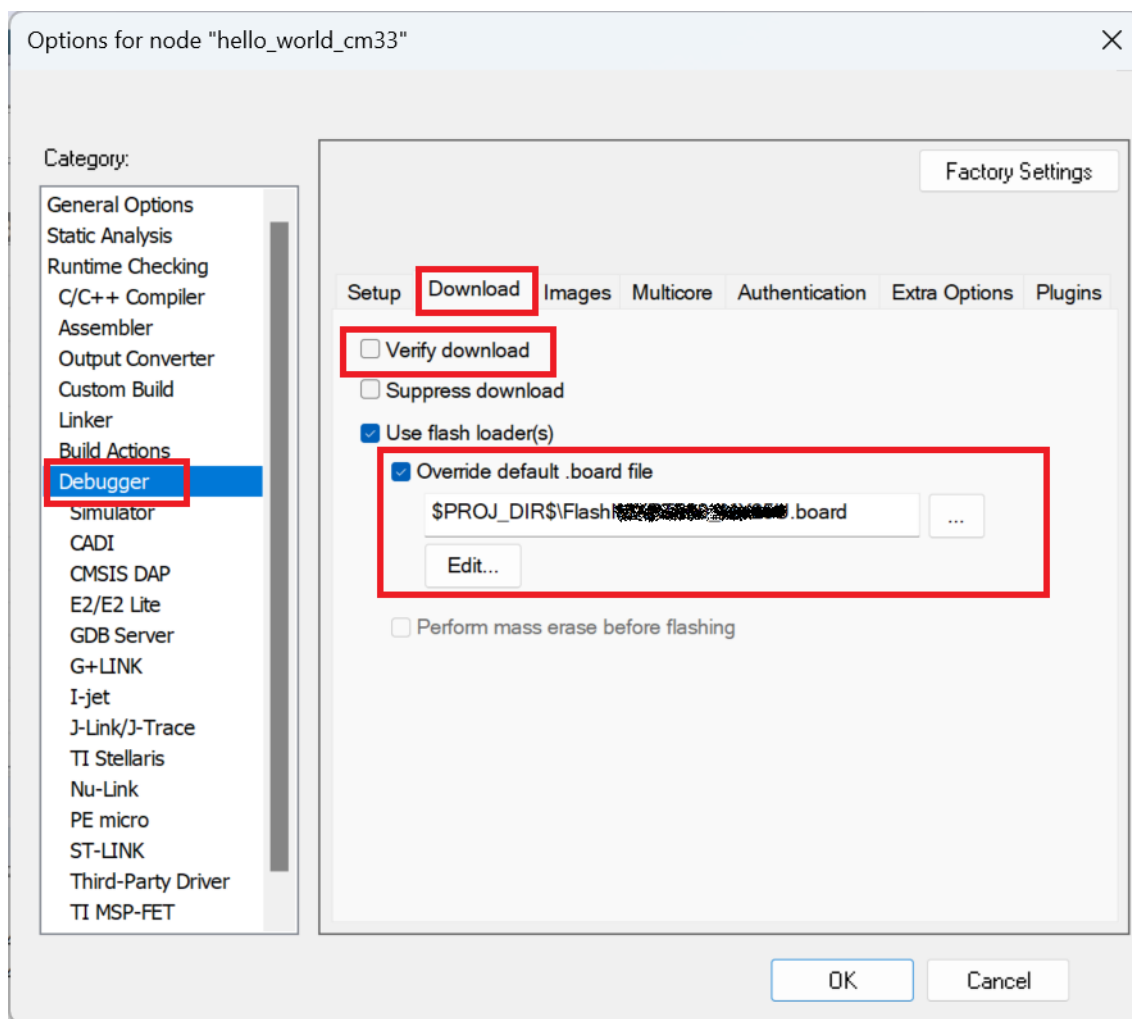
To avoid the RAM debugging issue, MCUX IDE/armgcc/MDK provides a plain load feature. To get a clean debugging status, the RAM image is downloaded to the flash.

IAR needs a special setting to achieve the plain load feature as follows:

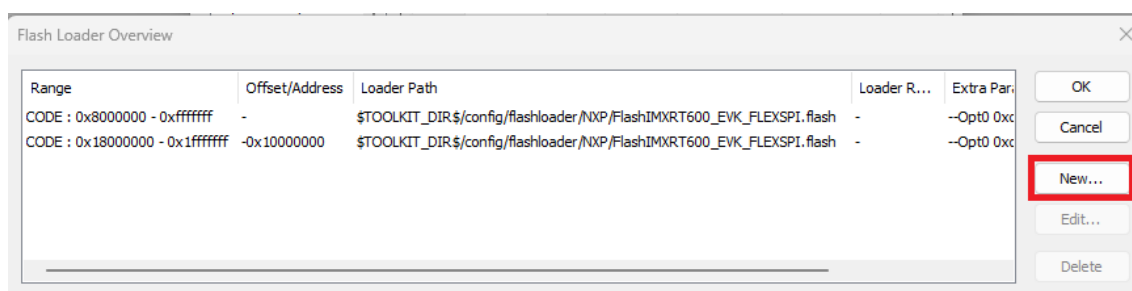
1. Right-click the project and select **Options**.



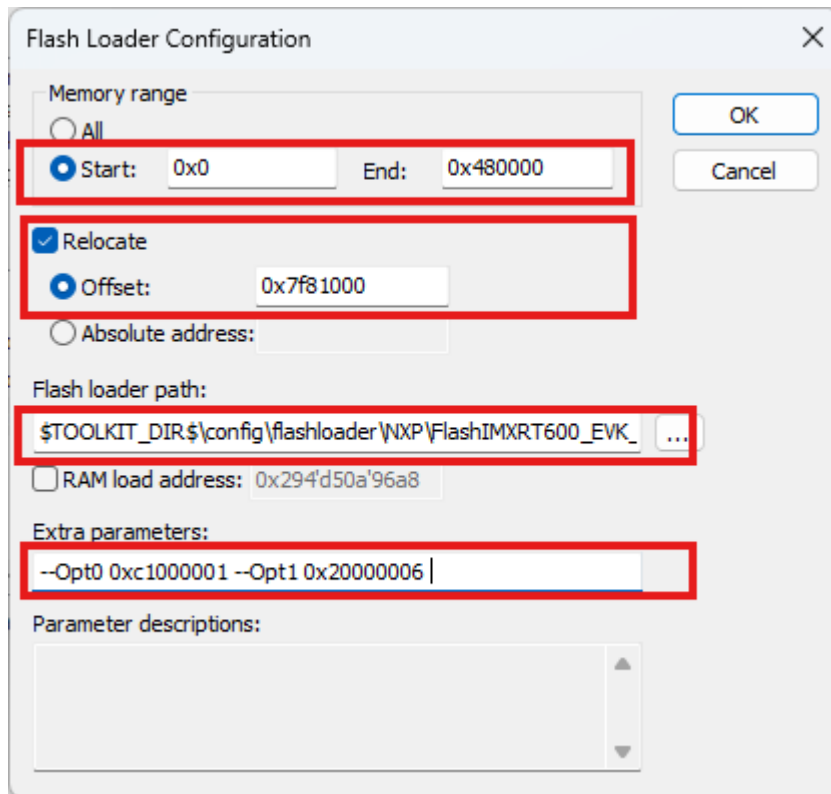
2. Select **Debugger > Download** in the **Options for node <project_name>** dialog box.
3. Clear the **Verify download** checkbox because the download address is different from the real address.
4. Select the **Override default.board file** option.
5. Copy the default *.board file to the IAR workspace folder.
6. Change the *.board file path.
7. Click the **Edit** button.



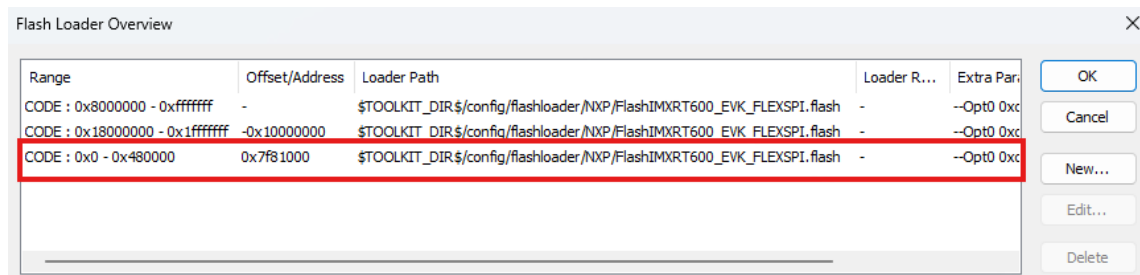
8. Create a range for RAM.



9. Set the memory range, relocate offset, and flashloader path.



The new RAM range appears in the flashloader overview.



- Follow the instructions in [Run an example application](#) and now it is safe to debug the RAM application. As a result, the downloaded RAM application can also boot on reset.

Parent topic: [Run a demo application using IAR](#)

Run a demo using Arm GCC

This section describes the steps to configure the command-line Arm GCC tools to build, run, and debug demo applications and necessary driver libraries provided in the MCUXpresso SDK. The `hello_world` demo application is targeted for the MIMXRT685-EVK hardware platform which is used as an example.

Note: ARMGCC version 8-2019-q3 is used as an example in this document. The latest GCC version for this package is as described in the *MCUXpresso SDK Release Notes Supporting MIMXRT685-EVK* (document MCUXSDKMIMXRT6XXRN).

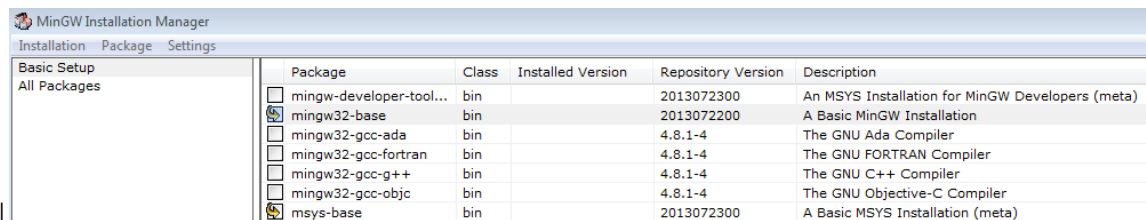
Set up toolchain This section contains the steps to install the necessary components required to build and run an MCUXpresso SDK demo application with the Arm GCC toolchain, as supported by the MCUXpresso SDK. There are many ways to use Arm GCC tools, but this example focuses on a Windows operating system environment.

Install GCC Arm Embedded tool chain Download and run the installer from GNU Arm Embedded Toolchain. This is the actual toolset (in other words, compiler, linker, and so on). The GCC toolchain should correspond to the latest supported version, as described in *MCUXpresso SDK Release Notes*.

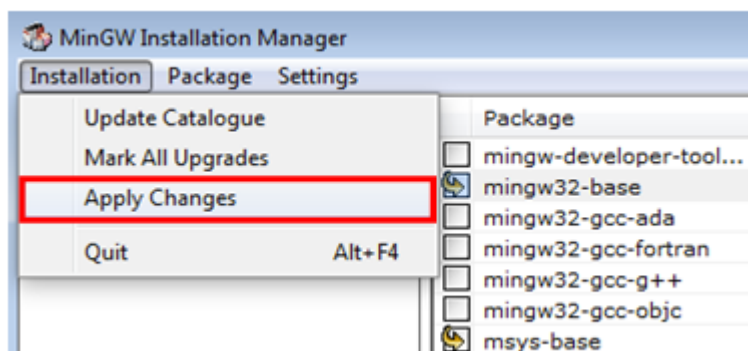
Parent topic:Set up toolchain

Install MinGW (only required on Windows OS) The Minimalist GNU for Windows (MinGW) development tools provide a set of tools that are not dependent on third-party C-Runtime DLLs (such as Cygwin). The build environment used by the MCUXpresso SDK does not use the MinGW build tools, but does leverage the base install of both MinGW and MSYS. MSYS provides a basic shell with a Unix-like interface and tools.

1. Download the latest MinGW mingw-get-setup installer from [MinGW](#).
 2. Run the installer. The recommended installation path is C:\MinGW, however, you may install to any location.
- Note:** The installation path cannot contain any spaces.
3. Ensure that the **mingw32-base** and **msys-base** are selected under **Basic Setup**.



4. In the **Installation** menu, click **Apply Changes** and follow the remaining instructions to complete the installation.

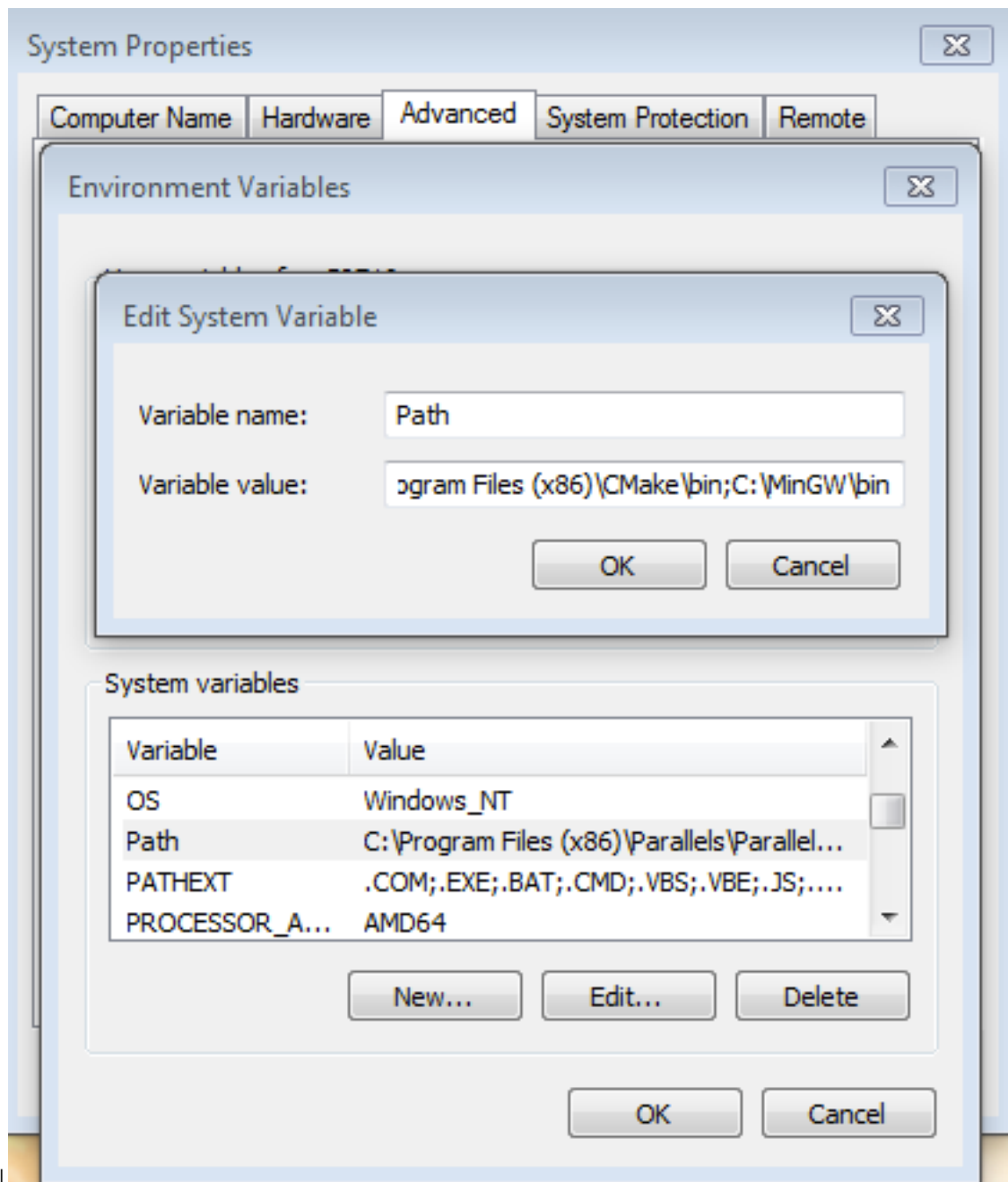


5. Add the appropriate item to the Windows operating system path environment variable. It can be found under **Control Panel->System and Security->System->Advanced System Settings** in the **Environment Variables...** section. The path is:

```
<mingw_install_dir>\bin
```

Assuming the default installation path, C:\MinGW, an example is shown below. If the path is not set correctly, the toolchain will not work.

Note: If you have C:\MinGW\msys\x.x\bin in your PATH variable (as required by Kinetis SDK 1.0.0), remove it to ensure that the new GCC build system works correctly.



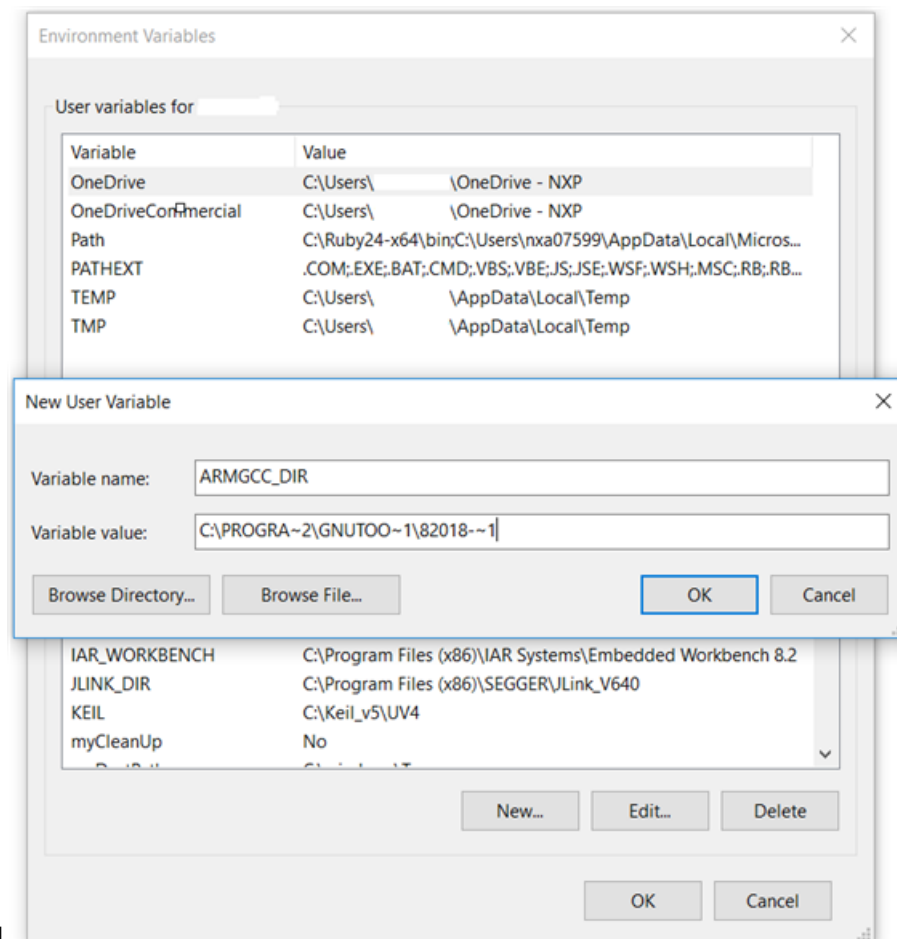
Parent topic:Set up toolchain

Add a new system environment variable for ARMGCC_DIR Create a new *system* environment variable and name it as `ARMGCC_DIR`. The value of this variable should point to the Arm GCC Embedded tool chain installation path. For this example, the path is:

See the installation folder of the GNU Arm GCC Embedded tools for the exact pathname of your installation.

Short path should be used for path setting, you could convert the path to short path by running command for %I in (.) do echo %~sI in above path.

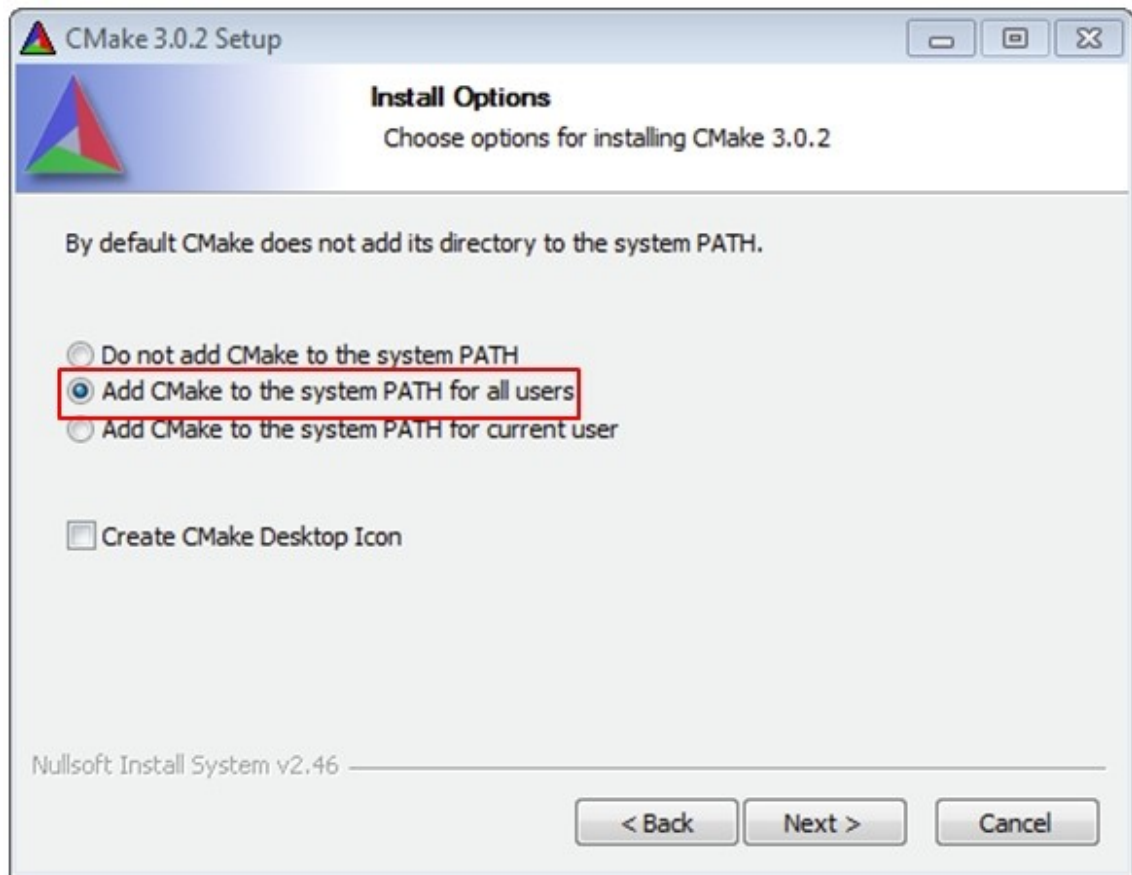
```
C:\Program Files (x86)\GNU Tools Arm Embedded\8 2018-q4-major>for %I in (.) do echo %~sI
C:\Program Files (x86)\GNU Tools Arm Embedded\8 2018-q4-major>echo C:\PROGRA~2\GNUTOO~1\82018~1
C:\PROGRA~2\GNUTOO~1\82018~1
```



Parent topic: Set up toolchain

Install CMake

1. Download CMake 3.0.x from www.cmake.org/cmake/resources/software.html.
2. Install CMake, ensuring that the option **Add CMake to system PATH** is selected when installing. The user chooses to select whether it is installed into the PATH for all users or just the current user. In this example, it is installed for all users.



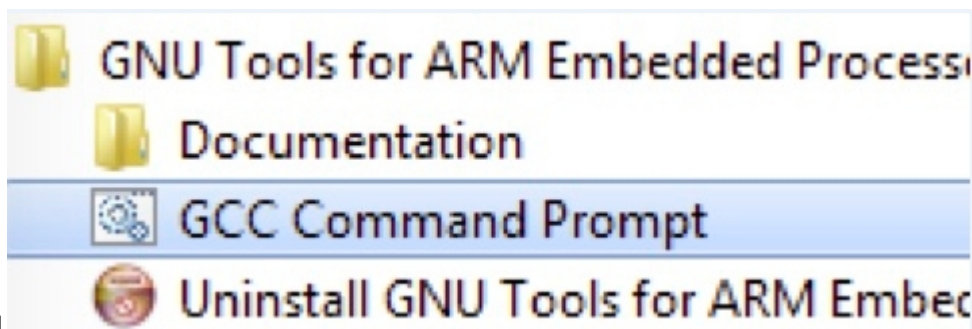
3. Follow the remaining instructions of the installer.
4. You may need to reboot your system for the PATH changes to take effect.
5. Make sure `sh.exe` is not in the Environment Variable PATH. This is a limitation of mingw32-make.

Parent topic:Set up toolchain

Parent topic:[Run a demo using Arm GCC](#)

Build an example application To build an example application, follow these steps.

1. Open a GCC Arm Embedded tool chain command window. To launch the window, from the Windows operating system **Start** menu, go to **Programs > GNU Tools Arm Embedded <version>** and select **GCC Command Prompt**.



2. Change the directory to the example application project directory which has a path similar to the following:

```
<install_dir>/boards/<board_name>/<example_type>/<application_name>/armgcc
```

For this example, the exact path is:

```
<install_dir>/examples/evkmimxrt685/demo_apps/hello_world/armgcc
```

Note: To change directories, use the `cd` command.

3. Type **build_debug.bat** on the command line or double click on **build_debug.bat** file in Windows Explorer to build it. The output is as shown in Figure 2.

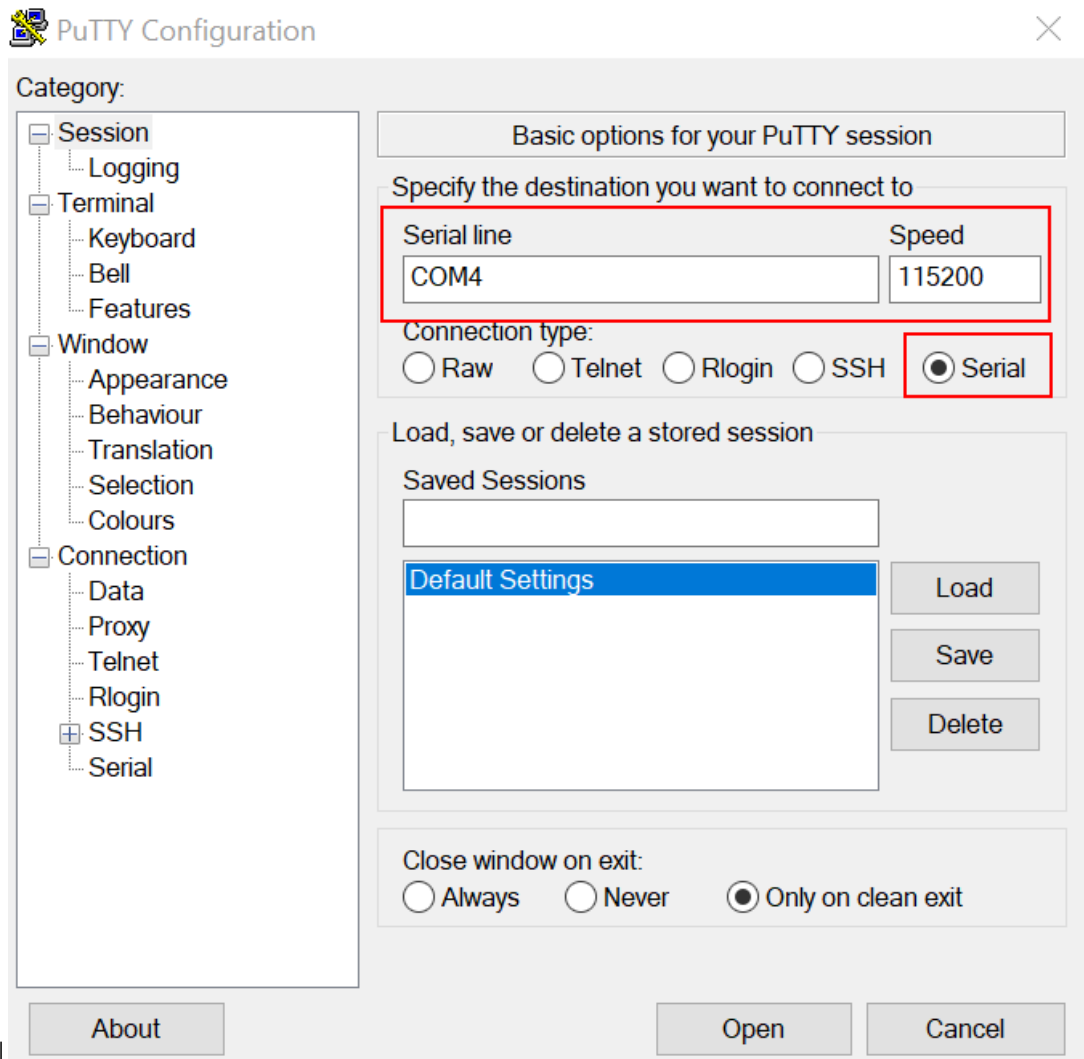
Parent topic: [Run a demo using Arm GCC](#)

Run an example application This section describes steps to run a demo application using J-Link GDB Server application. To update the on-board LPC-Link2 debugger to Jlink firmware, see [Updating debugger firmware](#).

Note: J-Link GDB Server application is not supported for TFM examples. Use CMSIS DAP instead of J-Link for flashing and debugging TFM examples.

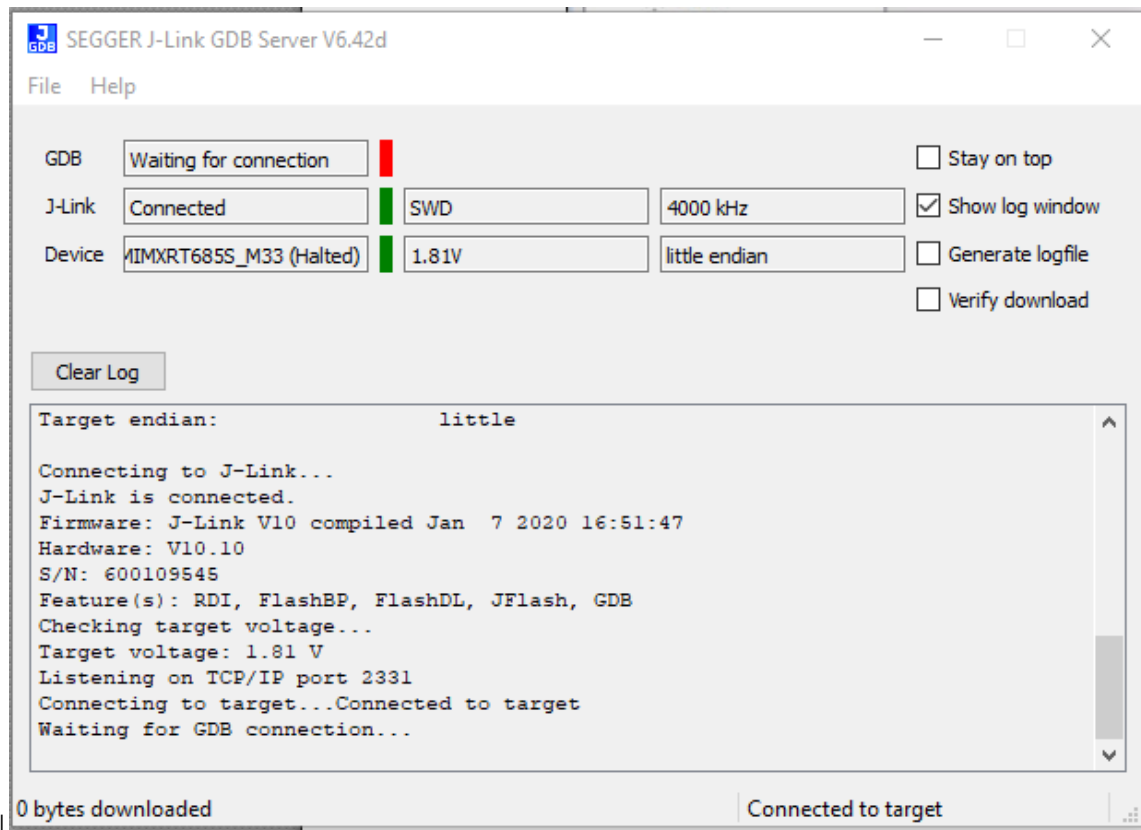
After the J-Link interface is configured and connected, follow these steps to download and run the demo applications:

1. Connect the development platform to your PC via USB cable between the LPC-Link2 USB connector and the PC USB connector. If using a standalone J-Link debug pod, connect it to the SWD/JTAG connector of the board.
2. Open the terminal application on the PC, such as PuTTY or TeraTerm, and connect to the debug serial port number (to determine the COM port number, see [How to determine COM port](#)). Configure the terminal with these settings:
 1. 115200 or 9600 baud rate, depending on your board (reference BOARD_DEBUG_UART_BAUDRATE variable in board.h file)
 2. No parity
 3. 8 data bits
 4. 1 stop bit

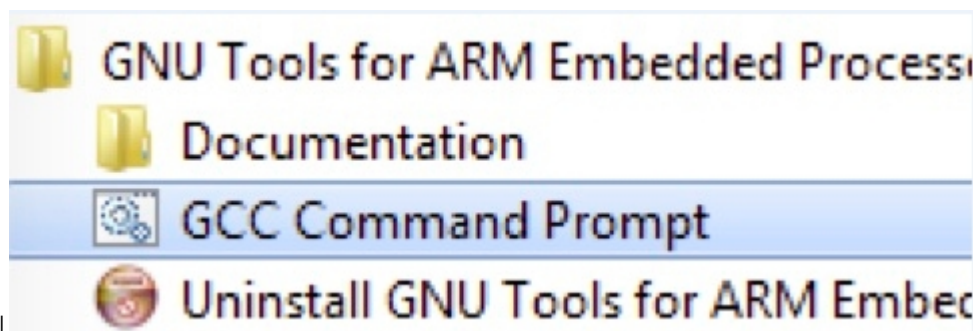


****Note:**** Make sure that the board is set to FlexSPI flash boot mode \ (ISP2: ISP1: ISP0 = ON, OFF, ON\)
 ↪ before use GDB debug.

3. Open the J-Link GDB Server application.
4. Open the J-Link GDB Server application. Go to the SEGGER install folder. For example, `C:\Program Files(x86)\SEGGER\JLink_Vxxx`. Open the command windows. Use the `JLinkGDBServer.exe -device MIMXRT685S_M33 -if SWD -scriptfile: <install_dir>/boards/<board_name>/<example_type>/<application_name>/evkmimxrt685.JLinkScript` command.
5. After it is connected, the screen should look like this figure:



6. If not already running, open a GCC Arm Embedded tool chain command window. To launch the window, from the Windows operating system Start menu, go to **Programs -> GNU Tools Arm Embedded <version>** and select **GCC Command Prompt**.



7. Change to the directory that contains the example application output. The output can be found in using one of these paths, depending on the build target selected:

```
<install_dir>/boards/<board_name>/<example_type>/<application_name>/armgcc/debug
```

```
<install_dir>/boards/<board_name>/<example_type>/<application_name>/armgcc/release
```

For this example, the path is:

```
<install_dir>/boards/evkmimxrt685/demo_apps/hello_world/armgcc/debug
```

8. Run the `arm-none-eabi-gdb.exe <application_name>.elf` command. For this example, it is `arm-none-eabi-gdb.exe hello_world.elf`.

```

C:\nxp\SDK 2.5.0 EVK-MIMXRT685\boards\evkmimxrt685\demo_apps\hello_world\armgcc\debug>arm-none-eabi-gdb hello_world.elf
GNU gdb (GNU Tools for Arm Embedded Processors 7-2018-q2-update) 8.1.0.20180315-git
Copyright (C) 2018 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law. Type "show copying"
and "show warranty" for details.
This GDB was configured as "--host=i686-w64-mingw32 --target=arm-none-eabi".
Type "show configuration" for configuration details.
For bug reporting instructions, please see:
<http://www.gnu.org/software/gdb/bugs/>.
Find the GDB manual and other documentation resources online at:
<http://www.gnu.org/software/gdb/documentation/>.
For help, type "help".
Type "apropos word" to search for commands related to "word"...
Reading symbols from hello_world.elf...done.
(gdb) _

```

9. Run these commands:

1. target remote localhost:2331
2. monitor halt
3. load
4. monitor reset

10. The application is now downloaded and halted at the watchpoint. Execute the monitor go command to start the demo application.

The hello_world application is now running and a banner is displayed on the terminal. If this does not appear, check your terminal settings and connections.

```

COM4 - PuTTY
hello world.

```

Parent topic: [Run a demo using Arm GCC](#)

Build a TrustZone example application This section describes the steps to build and run a TrustZone application. The demo application build scripts are located in this folder:

```
<install_dir>/boards/<board_name>/trustzone_examples/<application_name>/[<core_type>]/
↪<application_name>_ns/armgcc
```

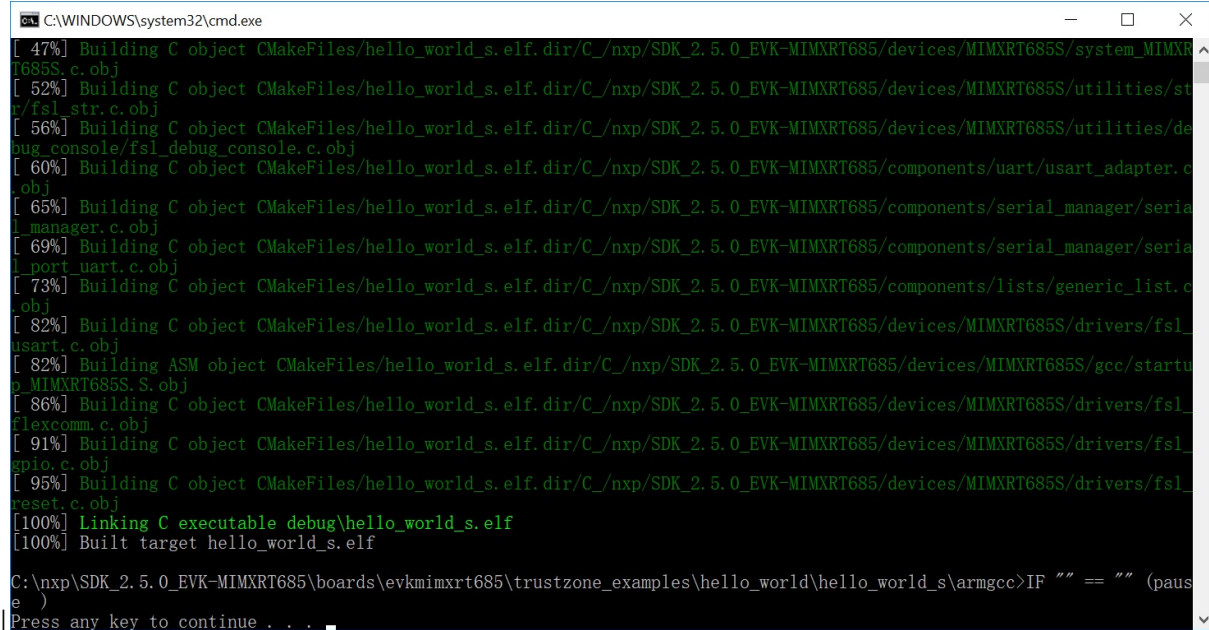
```
<install_dir>/boards/<board_name>/trustzone_examples/<application_name>/[<core_type>]/
↪<application_name>_s/armgcc
```

Begin with a simple TrustZone version of the Hello World application. The TrustZone Hello World GCC build scripts are located in this folder:

```
<install_dir>/boards/evkmimxrt685/trustzone_examples/hello_world/hello_world_ns/armgcc/build_debug.  
↪ bat
```

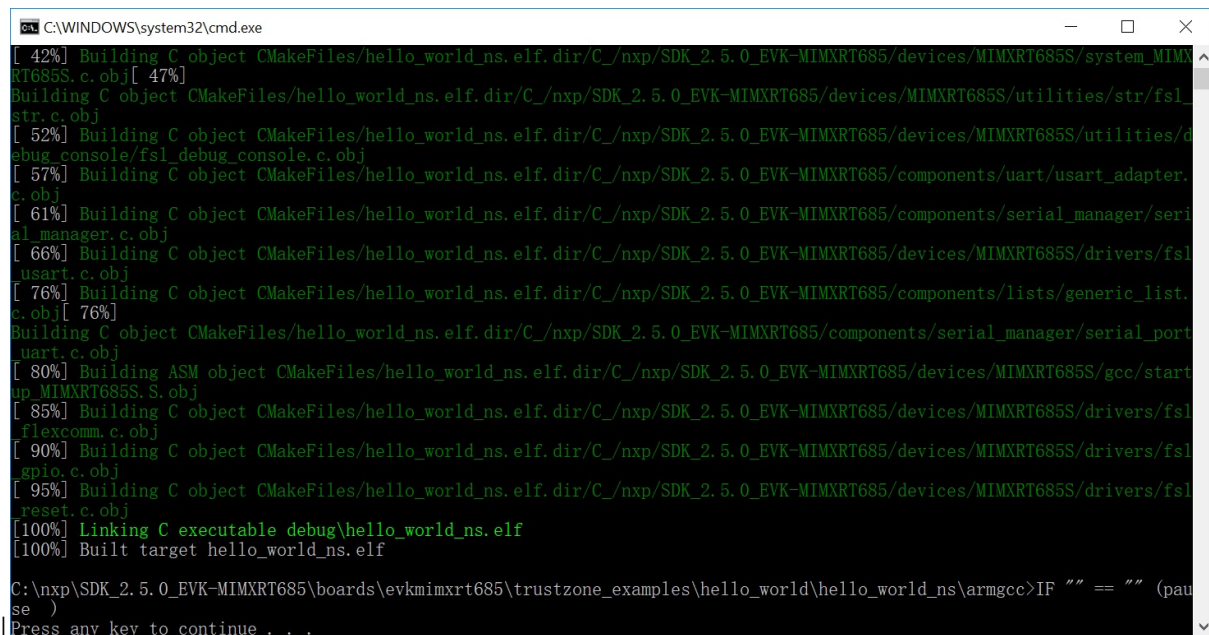
```
<install_dir>/boards/evkmimxrt685/trustzone_examples/hello_world/hello_world_s/armgcc/build_debug.  
↪ bat
```

Build both applications separately, following steps for single core examples as described in *Section 6.2, “Build an example application”*. It is requested to build the application for the secure project first, because the non-secure project must know the secure project, since CMSE library is running the linker. It is not possible to finish the non-secure project linker with the secure project because the CMSE library is not ready.



```
C:\WINDOWS\system32\cmd.exe
[ 47%] Building C object CMakeFiles/hello_world_s.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/devices/MIMXRT685S/system_MIMXRT685S.c.obj
[ 52%] Building C object CMakeFiles/hello_world_s.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/devices/MIMXRT685S/utilities/string/fsl_str.c.obj
[ 56%] Building C object CMakeFiles/hello_world_s.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/devices/MIMXRT685S/utilities/debug_console/fsl_debug_console.c.obj
[ 60%] Building C object CMakeFiles/hello_world_s.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/components/uart/usart_adapter.c.obj
[ 65%] Building C object CMakeFiles/hello_world_s.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/components/serial_manager/serial_manager.c.obj
[ 69%] Building C object CMakeFiles/hello_world_s.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/components/serial_manager/serial_port_uart.c.obj
[ 73%] Building C object CMakeFiles/hello_world_s.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/components/lists/generic_list.c.obj
[ 82%] Building C object CMakeFiles/hello_world_s.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/devices/MIMXRT685S/drivers/fsl_usart.c.obj
[ 82%] Building ASM object CMakeFiles/hello_world_s.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/devices/MIMXRT685S/gcc/startup_MIMXRT685S.S.obj
[ 86%] Building C object CMakeFiles/hello_world_s.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/devices/MIMXRT685S/drivers/fsl_flexcomm.c.obj
[ 91%] Building C object CMakeFiles/hello_world_s.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/devices/MIMXRT685S/drivers/fsl_gpio.c.obj
[ 95%] Building C object CMakeFiles/hello_world_s.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/devices/MIMXRT685S/drivers/fsl_reset.c.obj
[100%] Linking C executable debug\hello_world_s.elf
[100%] Built target hello_world_s.elf

C:\nxp\SDK_2.5.0_EVK-MIMXRT685\boards\evkmimxrt685\trustzone_examples\hello_world\hello_world_s\armgcc>IF "" == "" (pause)
Press any key to continue . . .
```



```
C:\WINDOWS\system32\cmd.exe
[ 42%] Building C object CMakeFiles/hello_world_ns.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/devices/MIMXRT685S/system_MIMXRT685S.c.obj[ 47%]
Building C object CMakeFiles/hello_world_ns.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/devices/MIMXRT685S/utilities/string/fsl_str.c.obj
[ 52%] Building C object CMakeFiles/hello_world_ns.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/devices/MIMXRT685S/utilities/debug_console/fsl_debug_console.c.obj
[ 57%] Building C object CMakeFiles/hello_world_ns.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/components/uart/usart_adapter.c.obj
[ 61%] Building C object CMakeFiles/hello_world_ns.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/components/serial_manager/serial_manager.c.obj
[ 66%] Building C object CMakeFiles/hello_world_ns.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/devices/MIMXRT685S/drivers/fsl_usart.c.obj
[ 76%] Building C object CMakeFiles/hello_world_ns.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/components/lists/generic_list.c.obj[ 76%]
Building C object CMakeFiles/hello_world_ns.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/components/serial_manager/serial_port_uart.c.obj
[ 80%] Building ASM object CMakeFiles/hello_world_ns.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/devices/MIMXRT685S/gcc/startup_MIMXRT685S.S.obj
[ 85%] Building C object CMakeFiles/hello_world_ns.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/devices/MIMXRT685S/drivers/fsl_flexcomm.c.obj
[ 90%] Building C object CMakeFiles/hello_world_ns.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/devices/MIMXRT685S/drivers/fsl_gpio.c.obj
[ 95%] Building C object CMakeFiles/hello_world_ns.elf.dir/C:/nxp/SDK_2.5.0_EVK-MIMXRT685/devices/MIMXRT685S/drivers/fsl_reset.c.obj
[100%] Linking C executable debug\hello_world_ns.elf
[100%] Built target hello_world_ns.elf

C:\nxp\SDK_2.5.0_EVK-MIMXRT685\boards\evkmimxrt685\trustzone_examples\hello_world\hello_world_ns\armgcc>IF "" == "" (pause)
Press any key to continue . . .
```

Parent topic:[Run a demo using Arm GCC](#)

Run a TrustZone example application When running a TrustZone application, the same prerequisites for J-Link/J-Link OpenSDA firmware, and the serial console as for the single core application, apply, as described in *Section 6.3, “Run an example application”*.

To download and run the TrustZone application, perform steps 1 to 10, as described in *Section 5.3, “Run an example application”*. These steps are common for both single core and TrustZone applications in Arm GCC.

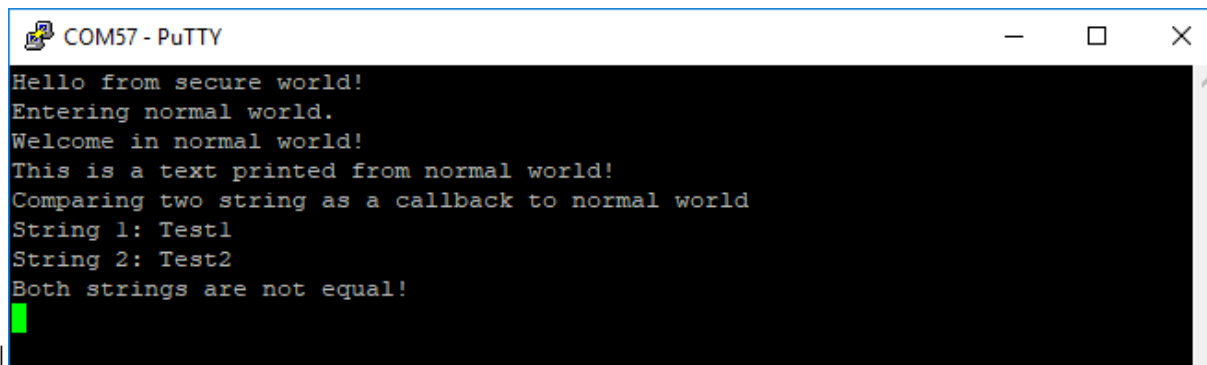
Then, run these commands:

1. arm-none-eabi-gdb.exe
2. target remote localhost:2331
3. monitor halt
4. monitor exec SetFlashDLNoRMWThreshold = 0x20000
5. load <install_dir>/boards/evkmimxrt685/trustzone_examples/hello_world/hello_world_ns/armgcc/debug/hello_world_ns.elf
6. load <install_dir>/boards/evkmimxrt685/trustzone_examples/hello_world/hello_world_s/armgcc/debug/hello_world_s.elf
7. monitor reset

The application is now downloaded and halted at the watchpoint. Execute the monitor go command to start the demo application.

```
$ arm-none-eabi-gdb.exe
GNU gdb (GNU Tools for Arm Embedded Processors 8-2019-q3-update) 8.3.0.20190703-git
Copyright (C) 2019 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.
Type "show copying" and "show warranty" for details.
This GDB was configured as "--host=i686-w64-mingw32 --target=arm-none-eabi".
Type "show configuration" for configuration details.
For bug reporting instructions, please see:
<http://www.gnu.org/software/gdb/bugs/>.
Find the GDB manual and other documentation resources online at:
<http://www.gnu.org/software/gdb/documentation/>.

For help, type "help".
Type "apropos word" to search for commands related to "word".
(gdb) target remote localhost:2331
Remote debugging using localhost:2331
warning: No executable has been specified and target does not support
determining executable automatically. Try using the "file" command.
0x0001c04a in ?? ()
(gdb) monitor halt
(gdb) load hello_world_ns/armgcc/debug/hello_world_ns.elf
Loading section .interrupts, size 0x130 lma 0x8041000
Loading section .text, size 0x1be8 lma 0x8041130
Loading section .ARM, size 0x8 lma 0x8042d18
Loading section .init_array, size 0x4 lma 0x8042d20
Loading section .fini_array, size 0x4 lma 0x8042d24
Loading section .data, size 0x60 lma 0x8042d28
Start address 0xc01e4, load size 7560
Transfer rate: 3691 KB/sec, 1260 bytes/write.
(gdb) load hello_world_s/armgcc/debug/hello_world_s.elf
Loading section .flash_config, size 0x1000 lma 0x18000000
Loading section .interrupts, size 0x130 lma 0x18001000
Loading section .text, size 0x5258 lma 0x18001130
Loading section .ARM, size 0x8 lma 0x18006388
Loading section .init_array, size 0x4 lma 0x18006390
Loading section .fini_array, size 0x4 lma 0x18006394
Loading section .data, size 0x70 lma 0x18006398
Loading section .gnu.sgstubs, size 0x20 lma 0x18040e00
Start address 0x100801e4, load size 25640
Transfer rate: 4173 KB/sec, 2848 bytes/write.
(gdb) monitor reset
Resetting target
(gdb) monitor go
(gdb) |
```

```
COM57 - PuTTY
Hello from secure world!
Entering normal world.
Welcome in normal world!
This is a text printed from normal world!
Comparing two string as a callback to normal world
String 1: Test1
String 2: Test2
Both strings are not equal!
```

Parent topic: [Run a demo using Arm GCC](#)

Run a demo using Keil MDK/μVision

This section describes the steps required to build, run, and debug example applications provided in the MCUXpresso SDK.

Install CMSIS device pack After the MDK tools are installed, Cortex Microcontroller Software Interface Standard (CMSIS) device packs must be installed to fully support the device from a debug perspective. These packs include things such as memory map information, register definitions, and flash programming algorithms. Follow these steps to install the MIMXRT685S CMSIS pack.

1. Download the MIMXRT685S pack.
2. After downloading the DFP, double click to install it.

Parent topic: [Run a demo using Keil MDK/μVision](#)

Build an example application

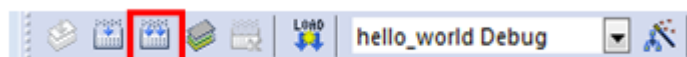
1. Open the desired example application workspace in:

```
<install_dir>/boards/<board_name>/*<example\_type>*/<application_name>/mdk
```

The workspace file is named as <demo_name>.uvmpw. For this specific example, the actual path is:

```
<install_dir>/boards/evkmimxrt685s/demo_apps/hello_world/mdk/hello_world.uvmpw
```

2. To build the demo project, select **Rebuild**, highlighted in red.

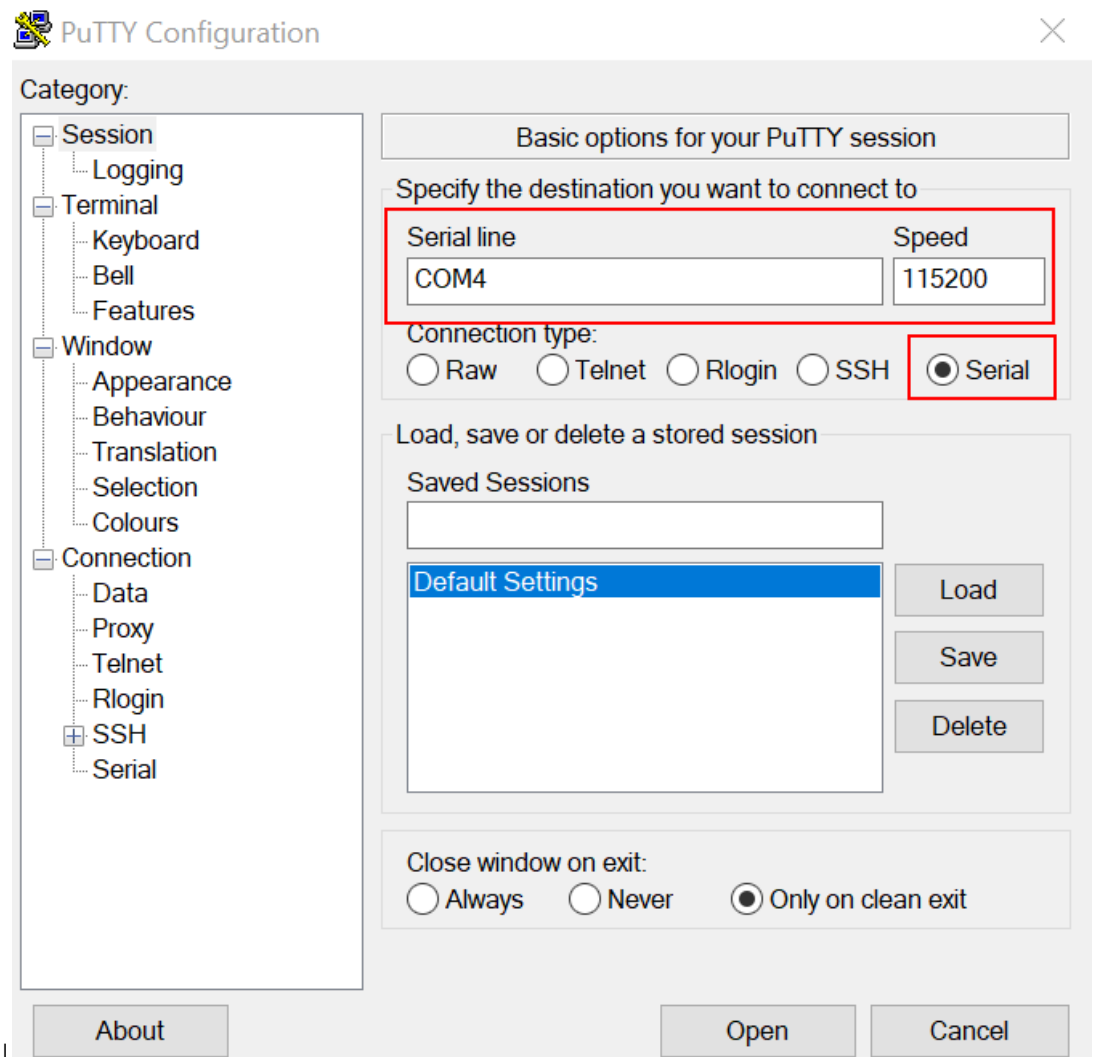


3. The build completes without errors.

Parent topic: [Run a demo using Keil MDK/μVision](#)

Run an example application To download and run the application, perform these steps:

1. Reference the table in [Default debug interfaces](#) to determine the debug interface that comes loaded on your specific hardware platform.
2. Connect the development platform to your PC via USB cable.
3. Open the terminal application on the PC, such as PuTTY or TeraTerm, and connect to the debug serial port number (to determine the COM port number, see [How to determine COM port](#)). Configure the terminal with these settings:
 1. 115200 or 9600 baud rate, depending on your board (reference BOARD_DEBUG_UART_BAUDRATE variable in the board.h file)
 2. No parity
 3. 8 data bits

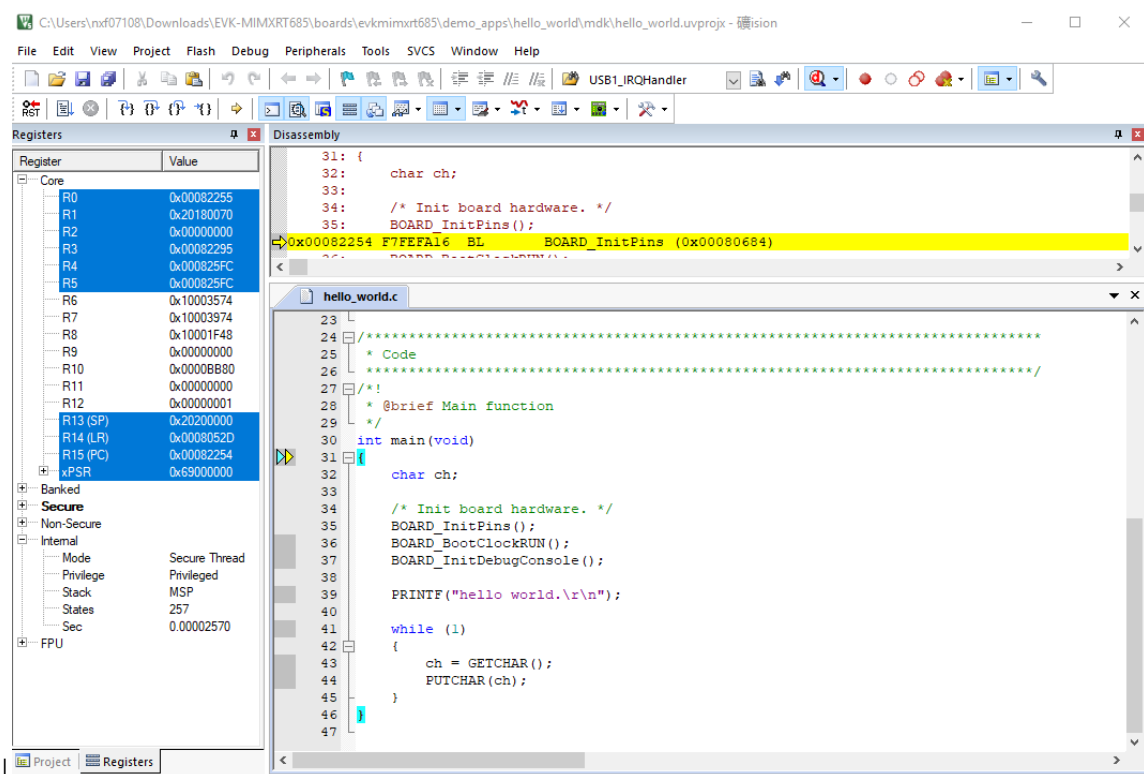


4. 1 stop bit

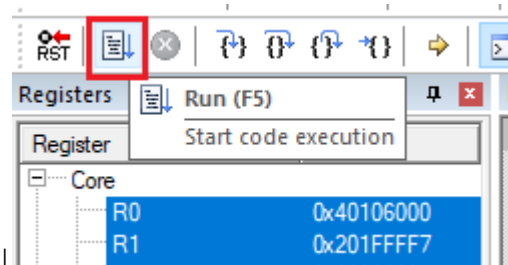
4. To debug the application, click **load** (or press the F8 key). Then, click the **Start/Stop Debug Session** button, highlighted in red in Figure 2. If using **J-Link** as the debugger, click **Project option > Debug > Settings > Debug > Port**, and select **SW**.

Note: When debugging with jlink, it expects one jlinkscript file named JLinkSettings.JLinkScript in the folder where the uVision project files are located. For details, see SEGGER Wiki. For the contents in this JLinkSettings.JLinkScript, use contents in evk-mimxrt1020_sdram_init.jlinkscript.

Note: Make sure that the board is set to FlexSPI flash boot mode (ISP2: ISP1: ISP0 = ON, OFF, ON) before using Keil debug.



5. Run the code by clicking **Run** to start the application, as shown in Figure 3.



The `hello\_world` application is now running and a banner is displayed on the terminal, as shown in [Figure 4](run_an_example_application_001.md#S127DD02). If this is not true, check your terminal settings and connections.

```

```

Parent topic: [Run a demo using Keil MDK/μVision](#)

Build a TrustZone example application This section describes the particular steps that must be done in order to build and run a TrustZone application. The demo applications workspace files are located in this folder:

```
<install_dir>/boards/<board_name>/trustzone_examples/<application_name>/<application_name>_ns/  
→ mdk
```



```
<install_dir>/boards/<board_name>/trustzone_examples/<application_name>/<application_name>_s/  
↪mdk
```

Begin with a simple TrustZone version of the Hello World application. The TrustZone Hello World Keil MSDK/μVision workspaces are located in this folder:

```
<install_dir>/boards/evkmimxrt595/trustzone_examples/hello_world/hello_world_ns/mdk/hello_world_ns.  
↪uvmpw
```

```
<install_dir>/boards/evkmimxrt595/trustzone_examples/hello_world/hello_world_s/mdk/hello_world_s.  
↪uvmpw
```

```
<install_dir>/boards/evkmimxrt595/trustzone_examples/hello_world/hello_world_s/mdk/hello_world.  
↪uvmpw
```

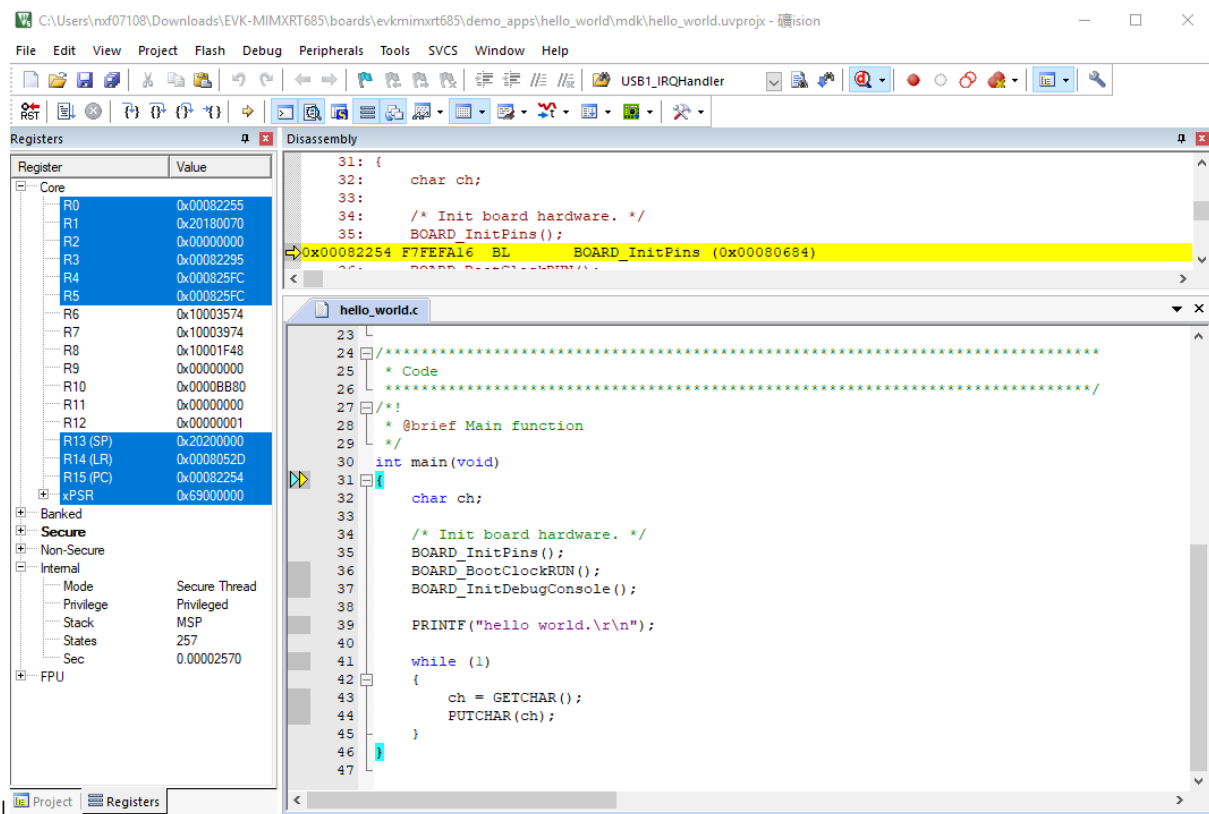
This project `hello_world.uvmpw` contains both secure and non-secure projects in one workspace and it allows the user to easily transition from one project to another.

Build both applications separately by clicking **Rebuild**. It is requested to build the application for the secure project first, because the non-secure project must know the secure project since CMSE library is running the linker. It is not possible to finish the non-secure project linker with the secure project because CMSE library is not ready.

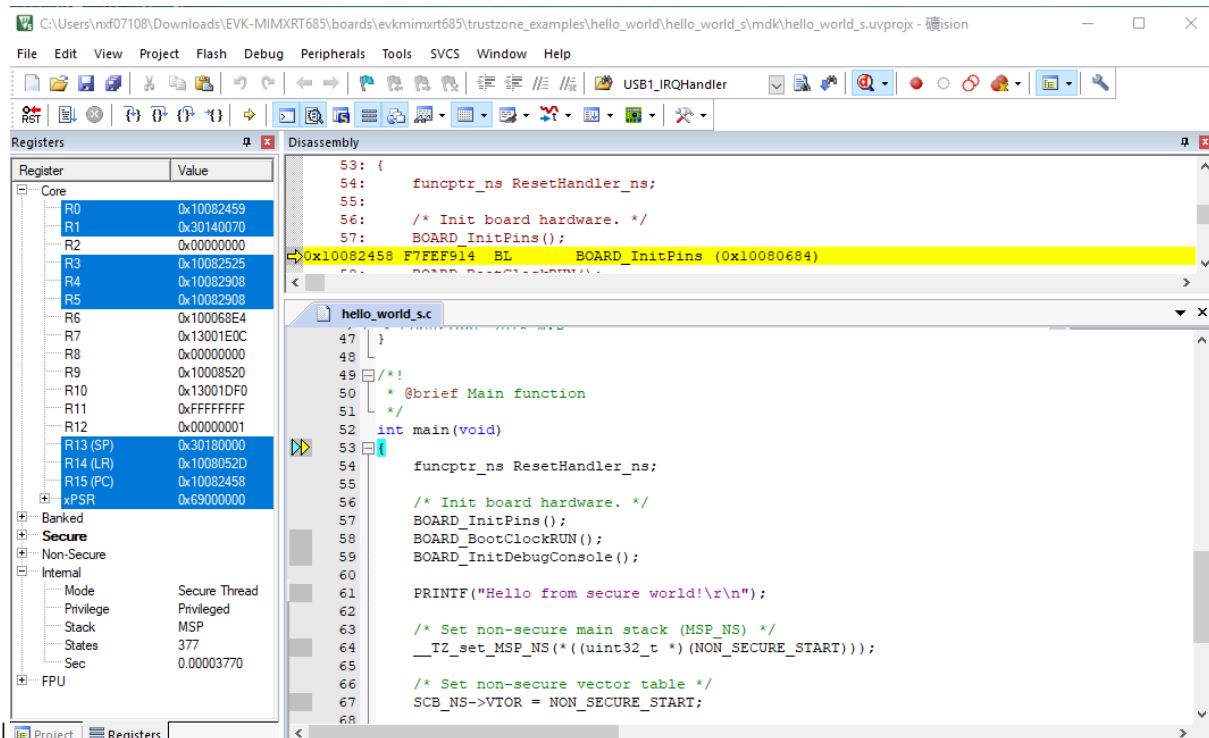
Parent topic: [Run a demo using Keil MDK/μVision](#)

Run a TrustZone example application The secure project is configured to download both secure and non-secure output files so debugging can be fully managed from the secure project.

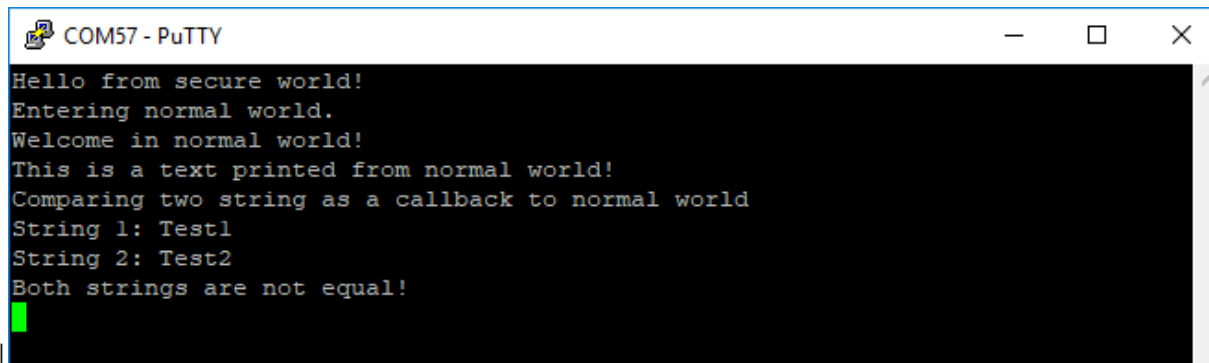
To download and run the TrustZone application, switch to the secure application project and perform steps as described in [Run a TrustZone example application](#). These steps are common for single core, dual-core, and TrustZone applications in μVision. After clicking **Download and Debug**, both the secure and non-secure images are loaded into the device flash memory, and the secure application is executed. It stops at the `main()` function.



Run the code by clicking **Run** to start the application.



The hello_world application is now running and a banner is displayed on the terminal. If not, check your terminal settings and connections.



```
COM57 - PuTTY
Hello from secure world!
Entering normal world.
Welcome in normal world!
This is a text printed from normal world!
Comparing two string as a callback to normal world
String 1: Test1
String 2: Test2
Both strings are not equal!
```

Parent topic: [Run a demo using Keil MDK/μVision](#)

Run a demo using the prebuilt binary

This section describes the steps to write a prebuilt binary in the SDK package to the external Flash and boot from the external Flash. The `hello_world` demo application is used as an example.

Note: The prebuilt binaries are provided for quick evaluation of the SDK and the board. Only parts of the examples are provided with prebuilt binary such as examples under `boards/<board_name>/demo_apps` and `boards/<board_name>/usb_examples`.

Identify the load address of the binary Several toolchains are supported by the MCUXpresso SDK, usually the prebuilt binaries are built from `armgcc flash_release` targets using Arm GCC. If there is no `flash_release` target, then `release` target is used.

Take `hello_world` demo application as an example, the `hello_world.bin` is located in:

```
<install_dir>/boards/<board_name>/<demo_apps>/hello_world/
```

And it was built from:

```
<install_dir>/boards/<board_name>/<demo_apps>/hello_world/armgcc/build_flash_release.sh
```

The load address can be identified by the linker file in the same folder. Such as `<device_name>_flash.ld`.

```
MEMORY
{
  m_flash_config      (RX) : ORIGIN = 0x08000400, LENGTH = 0x00000200
  m_interrupts         (RX) : ORIGIN = 0x08001000, LENGTH = 0x00000130
  m_text               (RX) : ORIGIN = 0x08001130, LENGTH = 0x001FEED0
  m_data               (RW) : ORIGIN = 0x20080000, LENGTH = 0x00180000
  m_usb_sram           (RW) : ORIGIN = 0x40140000, LENGTH = 0x00004000
```

So, the load address for `hello_world.bin` is `0x08000400`.

Parent topic: [Run a demo using the prebuilt binary](#)

Write the binary to external flash Take J-Link Commander as an example to write the `hello_world.bin` to external flash.

Run the J-Link Commander, run the following command to connect to the core.

```
J-Link>connect
J-Link>?
```

Select the correct device from the pop-up window **Target device settings**.

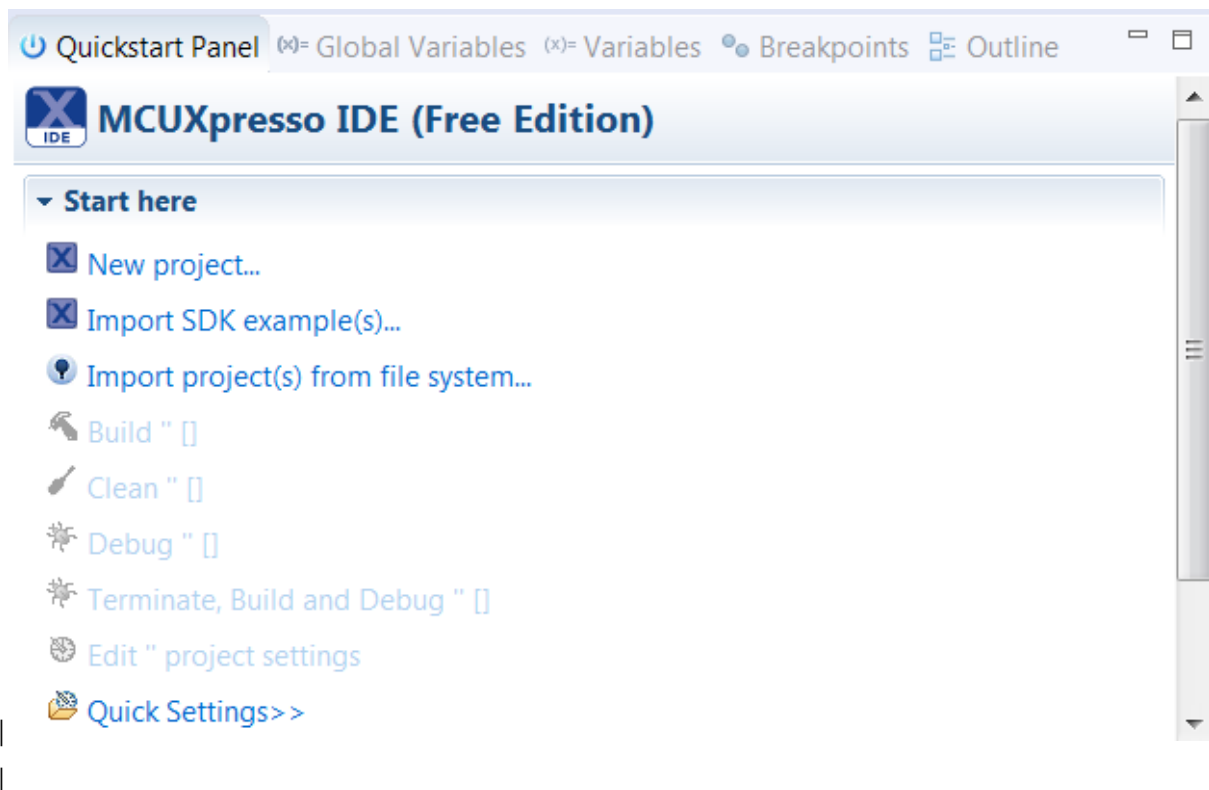
Specify targets interface as SWD and the target interface speed as per the guide in the command window. The **Cortex-M33 identified** appears when it is connected successfully.

Parent topic:[Run a demo using the prebuilt binary](#)

MCUXpresso IDE New Project Wizard

MCUXpresso IDE features a new project wizard. The wizard provides functionality for the user to create new projects from the installed SDKs (and from pre-installed part support). It offers user the flexibility to select and change multiple builds. The wizard also includes a library and provides source code options. The source code is organized as software components, categorized as drivers, utilities, and middleware.

To use the wizard, start the MCUXpresso IDE. This is located in the **QuickStart Panel** at the bottom left of the MCUXpresso IDE window. Select **New project**, as shown in *Figure 1*.



For more details and usage of new project wizard, see the *MCUXpresso_IDE_User_Guide.pdf* in the MCUXpresso IDE installation folder.

How to determine COM port

This section describes the steps necessary to determine the debug COM port number of your NXP hardware development platform.

1. **Linux:** The serial port can be determined by running the following command after the USB Serial is connected to the host:

```
$ dmesg | grep "ttyUSB"
[503175.307873] usb 3-12: cp210x converter now attached to ttyUSB0
[503175.309372] usb 3-12: cp210x converter now attached to ttyUSB1
```

There are two ports, one is Cortex-A core debug console and the other is for Cortex M4.

2. **Windows:** To determine the COM port open Device Manager in the Windows operating system. Click the **Start** menu and type **Device Manager** in the search bar.
3. In the Device Manager, expand the **Ports (COM & LPT)** section to view the available ports. The COM port names will be different for all the NXP boards.

How to define IRQ handler in CPP files

With MCUXpresso SDK, users could define their own IRQ handler in application level to override the default IRQ handler. For example, to override the default PIT_IRQHandler define in startup_DEVICE.s, application code like app.c can be implement like:

```
c
void PIT_IRQHandler(void)
{
    // Your code
}
```

When application file is CPP file, like app.cpp, then `extern "C"` should be used to ensure the function prototype alignment.

```
cpp
extern "C" {
    void PIT_IRQHandler(void);
}
void PIT_IRQHandler(void)
{
    // Your code
}
```

Default debug interfaces

The MCUXpresso SDK supports various hardware platforms that come loaded with various factory programmed debug interface configurations. *Table 1* lists the hardware platforms supported by the MCUXpresso SDK, their default debug interface, and any version information that helps differentiate a specific interface configuration.

Note: The *OpenSDA details* column in *Table 1* is not applicable to LPC.

Hardware platform	Default interface	OpenSDA details
EVK-MC56F83000	P&E Micro OSJTAG	N/A
EVK-MIMXRT595	CMSIS-DAP	N/A
EVK-MIMXRT685	CMSIS-DAP	N/A
FRDM-K22F	CMSIS-DAP/mbd/DAPLink	OpenSDA v2.1
FRDM-K28F	DAPLink	OpenSDA v2.1
FRDM-K32L2A4S	CMSIS-DAP	OpenSDA v2.1
FRDM-K32L2B	CMSIS-DAP	OpenSDA v2.1
FRDM-K32W042	CMSIS-DAP	N/A
FRDM-K64F	CMSIS-DAP/mbd/DAPLink	OpenSDA v2.0
FRDM-K66F	J-Link OpenSDA	OpenSDA v2.1

continues on next page

Table 1 – continued from previous page

Hardware platform	Default interface	OpenSDA details
FRDM-K82F	CMSIS-DAP	OpenSDA v2.1
FRDM-KE15Z	DAPLink	OpenSDA v2.1
FRDM-KE16Z	CMSIS-DAP/mbd/DAPLink	OpenSDA v2.2
FRDM-KL02Z	P&E Micro OpenSDA	OpenSDA v1.0
FRDM-KL03Z	P&E Micro OpenSDA	OpenSDA v1.0
FRDM-KL25Z	P&E Micro OpenSDA	OpenSDA v1.0
FRDM-KL26Z	P&E Micro OpenSDA	OpenSDA v1.0
FRDM-KL27Z	P&E Micro OpenSDA	OpenSDA v1.0
FRDM-KL28Z	P&E Micro OpenSDA	OpenSDA v2.1
FRDM-KL43Z	P&E Micro OpenSDA	OpenSDA v1.0
FRDM-KL46Z	P&E Micro OpenSDA	OpenSDA v1.0
FRDM-KL81Z	CMSIS-DAP	OpenSDA v2.0
FRDM-KL82Z	CMSIS-DAP	OpenSDA v2.0
FRDM-KV10Z	CMSIS-DAP	OpenSDA v2.1
FRDM-KV11Z	P&E Micro OpenSDA	OpenSDA v1.0
FRDM-KV31F	P&E Micro OpenSDA	OpenSDA v1.0
FRDM-KW24	CMSIS-DAP/mbd/DAPLink	OpenSDA v2.1
FRDM-KW36	DAPLink	OpenSDA v2.2
FRDM-KW41Z	CMSIS-DAP/DAPLink	OpenSDA v2.1 or greater
Hexiwear	CMSIS-DAP/mbd/DAPLink	OpenSDA v2.0
HVP-KE18F	DAPLink	OpenSDA v2.2
HVP-KV46F150M	P&E Micro OpenSDA	OpenSDA v1
HVP-KV11Z75M	CMSIS-DAP	OpenSDA v2.1
HVP-KV58F	CMSIS-DAP	OpenSDA v2.1
HVP-KV31F120M	P&E Micro OpenSDA	OpenSDA v1
JN5189DK6	CMSIS-DAP	N/A
LPC54018 IoT Module	N/A	N/A
LPCXpresso54018	CMSIS-DAP	N/A
LPCXpresso54102	CMSIS-DAP	N/A
LPCXpresso54114	CMSIS-DAP	N/A
LPCXpresso51U68	CMSIS-DAP	N/A
LPCXpresso54608	CMSIS-DAP	N/A
LPCXpresso54618	CMSIS-DAP	N/A
LPCXpresso54628	CMSIS-DAP	N/A
LPCXpresso54S018M	CMSIS-DAP	N/A
LPCXpresso55s16	CMSIS-DAP	N/A
LPCXpresso55s28	CMSIS-DAP	N/A
LPCXpresso55s69	CMSIS-DAP	N/A
MAPS-KS22	J-Link OpenSDA	OpenSDA v2.0
MIMXRT1170-EVK	CMSIS-DAP	N/A
TWR-K21D50M	P&E Micro OSJTAG	N/AOpenSDA v2.0
TWR-K21F120M	P&E Micro OSJTAG	N/A
TWR-K22F120M	P&E Micro OpenSDA	OpenSDA v1.0
TWR-K24F120M	CMSIS-DAP/mbd	OpenSDA v2.1
TWR-K60D100M	P&E Micro OSJTAG	N/A
TWR-K64D120M	P&E Micro OpenSDA	OpenSDA v1.0
TWR-K64F120M	P&E Micro OpenSDA	OpenSDA v1.0
TWR-K65D180M	P&E Micro OpenSDA	OpenSDA v1.0
TWR-K65D180M	P&E Micro OpenSDA	OpenSDA v1.0
TWR-KV10Z32	P&E Micro OpenSDA	OpenSDA v1.0
TWR-K80F150M	CMSIS-DAP	OpenSDA v2.1
TWR-K81F150M	CMSIS-DAP	OpenSDA v2.1
TWR-KE18F	DAPLink	OpenSDA v2.1
TWR-KL28Z72M	P&E Micro OpenSDA	OpenSDA v2.1
TWR-KL43Z48M	P&E Micro OpenSDA	OpenSDA v1.0

continues on next page

Table 1 – continued from previous page

Hardware platform	Default interface	OpenSDA details
TWR-KL81Z72M	CMSIS-DAP	OpenSDA v2.0
TWR-KL82Z72M	CMSIS-DAP	OpenSDA v2.0
TWR-KM34Z75M	P&E Micro OpenSDA	OpenSDA v1.0
TWR-KM35Z75M	DAPLink	OpenSDA v2.2
TWR-KV10Z32	P&E Micro OpenSDA	OpenSDA v1.0
TWR-KV11Z75M	P&E Micro OpenSDA	OpenSDA v1.0
TWR-KV31F120M	P&E Micro OpenSDA	OpenSDA v1.0
TWR-KV46F150M	P&E Micro OpenSDA	OpenSDA v1.0
TWR-KV58F220M	CMSIS-DAP	OpenSDA v2.1
TWR-KW24D512	P&E Micro OpenSDA	OpenSDA v1.0
USB-KW24D512	N/A External probe	N/A
USB-KW41Z	CMSIS-DAP\DAPlink	OpenSDA v2.1 or greater

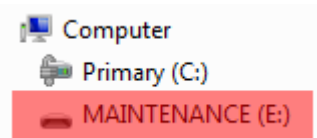
Updating debugger firmware

Updating OpenSDA firmware Any NXP hardware platform that comes with an OpenSDA-compatible debug interface has the ability to update the OpenSDA firmware. For reference, OpenSDA firmware files can be found at the links below:

- J-Link: Download appropriate image from www.segger.com/opensda.html. Choose the appropriate J-Link binary based on the table in [Default debug interfaces](#). Any OpenSDA v1.0 interface should use the standard OpenSDA download (in other words, the one with no version). For OpenSDA 2.0 or 2.1, select the corresponding binary.
- P&E Micro: Downloading P&E Micro OpenSDA firmware images requires registration with P&E Micro (www.pemicro.com).

Perform the following steps to update the OpenSDA firmware on your board for Windows and Linux OS users:

1. Unplug the board's USB cable.
2. Press the **Reset** button on the board. While still holding the button, plug the USB cable back into the board.
3. When the board re-enumerates, it shows up as a disk drive called **MAINTENANCE**.



4. Drag and drop the new firmware image onto the MAINTENANCE drive.

Note: If for any reason the firmware update fails, the board can always reenter maintenance mode by holding down **Reset** button and power cycling.

These steps show how to update the OpenSDA firmware on your board for Mac OS users.

1. Unplug the board's USB cable.
2. Press the **Reset** button of the board. While still holding the button, plug the USB cable back into the board.
3. For boards with OpenSDA v2.0 or v2.1, it shows up as a disk drive called **BOOTLOADER** in **Finder**. Boards with OpenSDA v1.0 may or may not show up depending on the bootloader version. If you see the drive in **Finder**, proceed to the next step. If you do not see the drive in **Finder**, use a PC with Windows OS 7 or an earlier version to either update the OpenSDA

firmware, or update the OpenSDA bootloader to version 1.11 or later. The bootloader update instructions and image can be obtained from P&E Microcomputer website.

4. For OpenSDA v2.1 and OpenSDA v1.0 (with bootloader 1.11 or later) users, drag the new firmware image onto the BOOTLOADER drive in **Finder**.
5. For OpenSDA v2.0 users, type these commands in a Terminal window:

```
> sudo mount -u -w -o sync /Volumes/BOOTLOADER  
> cp -X <path to update file> /Volumes/BOOTLOADER
```

Note: If for any reason the firmware update fails, the board can always reenter bootloader mode by holding down the **Reset** button and power cycling.

Parent topic: [Updating debugger firmware](#)

Updating LPCXpresso board firmware The LPCXpresso hardware platform comes with a CMSIS-DAP-compatible debug interface (known as LPC-Link2). This firmware in this debug interface may be updated using the host computer utility called LPCScript. This typically used when switching between the default debugger protocol (CMSIS-DAP) to SEGGER J-Link, or for updating this firmware with new releases of these. This section contains the steps to reprogram the debug probe firmware.

Note: If MCUXpresso IDE is used and the jumper making DFULink is installed on the board (JP5 on some boards, but consult the board user manual or schematic for specific jumper number), LPC-Link2 debug probe boots to DFU mode, and MCUXpresso IDE automatically downloads the CMSIS-DAP firmware to the probe before flash memory programming (after clicking **Debug**). Using DFU mode ensures that most up-to-date/compatible firmware is used with MCUXpresso IDE.

NXPN provides the LPCScript utility, which is the recommended tool for programming the latest versions of CMSIS-DAP and J-Link firmware onto LPC-Link2 or LPCXpresso boards. The utility can be downloaded from www.nxp.com/lpcutilities.

These steps show how to update the debugger firmware on your board for Windows operating system. For Linux OS, follow the instructions described in LPCScript user guide (www.nxp.com/lpcutilities, select **LPCScript**, and then the documentation tab).

1. Install the LPCScript utility.
2. Unplug the board's USB cable.
3. Make the DFU link (install the jumper labeled DFULink).
4. Connect the probe to the host via USB (use Link USB connector).
5. Open a command shell and call the appropriate script located in the LPCScript installation directory (<LPCScript install dir>).
 1. To program CMSIS-DAP debug firmware: <LPCScript install dir>/scripts/program_CMSIS
 2. To program J-Link debug firmware: <LPCScript install dir>/scripts/program_JLINK
6. Remove DFU link (remove the jumper installed in Step 3).
7. Repower the board by removing the USB cable and plugging it in again.

Parent topic: [Updating debugger firmware](#)

1.3 Getting Started with MCUXpresso SDK GitHub

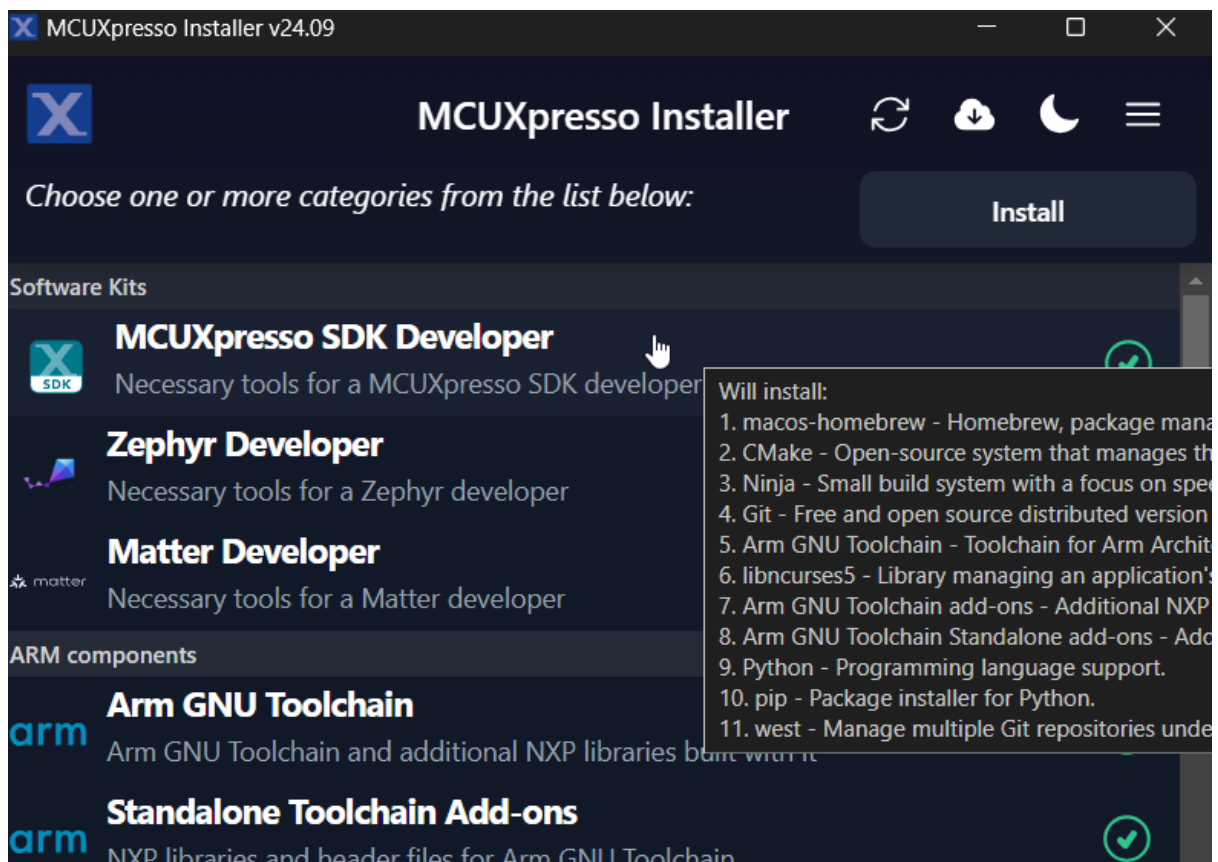
1.3.1 Getting Started with MCUXpresso SDK Repository

Installation

NOTE

If the installation instruction asks/selects whether to have the tool installation path added to the PATH variable, agree/select the choice. This option ensures that the tool can be used in any terminal in any path. [Verify the installation](#) after each tool installation.

Install Prerequisites with MCUXpresso Installer The MCUXpresso Installer offers a quick and easy way to install the basic tools needed. The MCUXpresso Installer can be obtained from <https://github.com/nxp-mcuxpresso/vscode-for-mcux/wiki/Dependency-Installation>. The MCUXpresso Installer is an automated installation process, simply select MCUXpresso SDK Developer from the menu and click install. If you prefer to install the basic tools manually, refer to the next section.



Alternative: Manual Installation

Basic tools

Git Git is a free and open source distributed version control system. Git is designed to handle everything from small to large projects with speed and efficiency. To install Git, visit the official [Git website](#). Download the appropriate version (you may use the latest one) for your operating system (Windows, macOS, Linux). Then run the installer and follow the installation instructions.

User `git --version` to check the version if you have a version installed.

Then configure your username and email using the commands:

```
git config --global user.name "Your Name"
git config --global user.email "youremail@example.com"
```

Python Install python 3.10 or latest. Follow the [Python Download](#) guide.

Use `python --version` to check the version if you have a version installed.

West Please use the west version equal or greater than 1.2.0

```
# Note: you can add option '--default-timeout=1000' if you meet connection issue. Or you may set a different
↪source using option '-i'.
# for example, in China you could try: pip install -U west -i https://pypi.tuna.tsinghua.edu.cn/simple
pip install -U west
```

Build And Configuration System

CMake It is strongly recommended to use CMake version equal or later than 3.30.0. You can get latest CMake distributions from [the official CMake download page](#).

For Windows, you can directly use the .msi installer like `cmake-3.31.4-windows-x86_64.msi` to install.

For Linux, CMake can be installed using the system package manager or by getting binaries from [the official CMake download page](#).

After installation, you can use `cmake --version` to check the version.

Ninja Please use the ninja version equal or later than 1.12.1.

By default, Windows comes with the Ninja program. If the default Ninja version is too old, you can directly download the [ninja binary](#) and register the ninja executor location path into your system path variable to work.

For Linux, you can use your [system package manager](#) or you can directly download the [ninja binary](#) to work.

After installation, you can use `ninja --version` to check the version.

Kconfig MCUXpresso SDK uses Kconfig python implementation. We customize it based on our needs and integrate it into our build and configuration system. The Kconfiglib sources are placed under `mcuxsdk/scripts/kconfig` folder.

Please make sure [python](#) environment is setup ready then you can use the Kconfig.

Ruby Our build system supports IDE project generation for iar, mdk, codewarrior and xtensa to provide OOB from build to debug. This feature is implemented with ruby. You can follow the guide [ruby environment setup](#) to setup the ruby environment. Since we provide a built-in portable ruby, it is just a simple one cmd installation.

If you only work with CLI, you can skip this step.

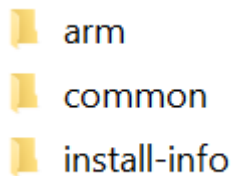
Toolchain MCUXpresso SDK supports all mainstream toolchains for embedded development. You can install your used or interested toolchains following the guides.

Toolchain	Download and Installation Guide	Note
Armgcc	Arm GNU Toolchain Install Guide	ARMGCC is default toolchain
IAR	IAR Installation and Licensing quick reference guide	
MDK	MDK Installation	
Armclang	Installing Arm Compiler for Embedded	
Zephyr	Zephyr SDK	
Codewarrior	NXP CodeWarrior	
Xtensa	Tensilica Tools	
NXP S32Compiler RISC-V Zen-V	NXP Website	

After you have installed the toolchains, register them in the system environment variables. This will allow the west build to recognize them:

Toolchain	Environment Variable	Example	Cmd Line Argument
Armgcc	AR-MGCC_DIR	C:\armgcc for windows/usr for Linux. Typically arm-none-eabi-* is installed under /usr/bin	– toolchain armgcc
IAR	IAR_DIR	C:\iar\ewarm-9.60.3 for Windows/opt/iarsystems/bxarm-9.60.3 for Linux	– toolchain iar
MDK	MDK_DIR	C:\Keil_v5 for Windows.MDK IDE is not officially supported with Linux.	– toolchain mdk
Armclang	ARM-CLANG_DIR	C:\ArmCompilerforEmbedded6.22 for Windows/opt/ArmCompilerforEmbedded6.21 for Linux	– toolchain mdk
Zephyr	ZEPHYR_DIR	c:\NXP\zephyr-sdk-<version> for windows/opt/zephyr-sdk-<version> for Linux	– toolchain zephyr
CodeWarrior	CW_DIR	C:\Freescall\CW MCU v11.2 for windowsCodeWarrior is not supported with Linux	– toolchain code-warrior
Xtensa	XCC_DIR	C:\xtensa\XtDevTools\install\tools\RI-2023.11-win32\XtensaTools for windows/opt/xtensa/XtDevTools/install/tools/RI-2023.11-Linux/XtensaTools for Linux	– toolchain xtensa
NXP S32Compiler RISC-V Zen-V	RISCV-LVM_DIR	C:\riscv-llvm-win32_b298_b298_2024.08.12 for Windows/opt/riscv-llvm-Linux-x64_b298_b298_2024.08.12 for Linux	– toolchain riscv-llvm

- The <toolchain>_DIR is the root installation folder, not the binary location folder. For IAR, it is directory containing following installation folders:



- MDK IDE using armclang toolchain only officially supports Windows. In Linux, please directly use armclang toolchain by setting ARMCLANG_DIR. In Windows, since most Keil users will install MDK IDE instead of standalone armclang toolchain, the MDK_DIR has higher priority than ARMCLANG_DIR.
- For Xtensa toolchain, please set the XTENSA_CORE environment variable. Here's an example list:

Device Core	XTENSA_CORE
RT500 fusion1	nxp_rt500_RI23_11_newlib
RT600 hifi4	nxp_rt600_RI23_11_newlib
RT700 hifi1	rt700_hifi1_RI23_11_nlib
RT700 hifi4	t700_hifi4_RI23_11_nlib
i.MX8ULP fusion1	fusion_nxp02_dsp_prod

- In Windows, the short path is used in environment variables. If any toolchain is using the long path, you can open a command window from the toolchain folder and use below command to get the short path: for %i in (.) do echo %~fsi

Tool installation check Once installed, open a terminal or command prompt and type the associated command to verify the installation.

If you see the version number, you have successfully installed the tool. Else, check whether the tool's installation path is added into the PATH variable. You can add the installation path to the PATH with the commands below:

- Windows: Open command prompt or powershell, run below command to show the user PATH variable.

```
reg query HKEY_CURRENT_USER\Environment /v PATH
```

The tool installation path should be C:\Users\xxx\AppData\Local\Programs\Git\cmd. If the path is not seen in the output from above, append the path value to the PATH variable with the command below:

```
reg add HKEY_CURRENT_USER\Environment /v PATH /d "%PATH%;C:\Users\xxx\AppData\
↪Local\Programs\Git\cmd"
```

Then close the command prompt or powershell and verify the tool command again.

- Linux:
 1. Open the \$HOME/.bashrc file using a text editor, such as vim.
 2. Go to the end of the file.
 3. Add the line which appends the tool installation path to the PATH variable and export PATH at the end of the file. For example, export PATH="/Directory1:\$PATH".
 4. Save and exit.

5. Execute the script with `source .bashrc` or reboot the system to make the changes live. To verify the changes, run `echo $PATH`.
- macOS:
 1. Open the `$HOME/.bash_profile` file using a text editor, such as `nano`.
 2. Go to the end of the file.
 3. Add the line which appends the tool installation path to the `PATH` variable and export `PATH` at the end of the file. For example, export `PATH="/Directory1:$PATH"`.
 4. Save and exit.
 5. Execute the script with `source .bash_profile` or reboot the system to make the changes live. To verify the changes, run `echo $PATH`.

Get MCUXpresso SDK Repo

Establish SDK Workspace To get the MCUXpresso SDK repository, use the `west` tool to clone the manifest repository and checkout all the west projects.

```
# Initialize west with the manifest repository
west init -m https://github.com/nxp-mcuxpresso/mcuxsdk-manifests/ mcuxpresso-sdk

# Update the west projects
cd mcuxpresso-sdk
west update

# Allow the usage of west extensions provided by MCUXpresso SDK
west config commands.allow__extensions true
```

Install Python Dependency(If do tool installation manually) To create a Python virtual environment in the west workspace core repo directory `mcuxsdk`, follow these steps:

1. Navigate to the core directory:

```
cd mcuxsdk
```

2. [Optional] Create and activate the virtual environment: If you don't want to use the python virtual environment, skip this step. **We strongly suggest you use `venv` to avoid conflicts with other projects using python.**

```
python -m venv .venv

# For Linux/MacOS
source .venv/bin/activate

# For Windows
.\.venv\Scripts\activate
# If you are using powershell and see the issue that the activate script cannot be run.
# You may fix the issue by opening the powershell as administrator and run below command:
powershell Set-ExecutionPolicy RemoteSigned
# then run above activate command again.
```

Once activated, your shell will be prefixed with `(.venv)`. The virtual environment can be deactivated at any time by running `deactivate` command.

Remember to activate the virtual environment every time you start working in this directory. If you are using some modern shell like `zsh`, there are some powerful plugins to help you auto switch `venv` among workspaces. For example, [zsh-autoswitch-virtualenv](#).

3. Install the required Python packages:

```
# Note: you can add option '--default-timeout=1000' if you meet connection issue. Or you may set a ↵
↵different source using option '-i'.
# for example, in China you could try: pip3 install -r mcuxsdk/scripts/requirements.txt -i https://pypi.
↵tuna.tsinghua.edu.cn/simple
pip install -r scripts/requirements.txt
```

Explore Contents

This section helps you build basic understanding of current fundamental project content and guides you how to build and run the provided example project in whole SDK delivery.

Folder View The whole MCUXpresso SDK project, after you have done the west init and west update operations follow the guideline at [Getting Started Guide](#), have below folder structure:

Folder	Description
mani-fests	Manifest repo, contains the manifest file to initialize and update the west workspace.
mcuxsdk	The MCUXpresso SDK source code, examples, middleware integration and script files.

All the projects record in the [Manifest repo](#) are checked out to the folder mcuxsdk/, the layout of mcuxsdk folder is shown as below:

Folder	Description
arch	Arch related files such as ARM CMSIS core files, RISC-V files and the build files related to the architecture.
cmake	The cmake modules, files which organize the build system.
com-po-nents	Software components.
de-vices	Device support package which categorized by device series. For each device, header file, feature file, startup file and linker files are provided, also device specific drivers are included.
docs	Documentation source and build configuration for this sphinx built online documentation.
drivers	Peripheral drivers.
ex-am-ples	Various demos and examples, support files on different supported boards. For each board support, there are board configuration files.
mid-dle-ware	Middleware components integrated into SDK.
rtos	Rtos components integrated into SDK.
scripts	Script files for the west extension command and build system support.
svd	Svd files for devices, this is optional because of large size. Customers run west manifest config group.filter +optional and west update mcux-soc-svd to get this folder.

Examples Project The examples project is part of the whole SDK delivery, and locates in the folder mcuxsdk/examples of west workspace.

Examples files are placed in folder of <example_category>, these examples include (but are not limited to)

- **demo_apps:** Basic demo set to start using SDK, including `hello_world` and `led_blinky`.
- **driver_examples:** Simple applications that show how to use the peripheral drivers for a single use case. These applications typically only use a single peripheral but there are cases where multiple peripherals are used (for example, SPI transfer using DMA).

Board porting layers are placed in folder of `_boards/<board_name>` which aims at providing the board specific parts for examples code mentioned above.

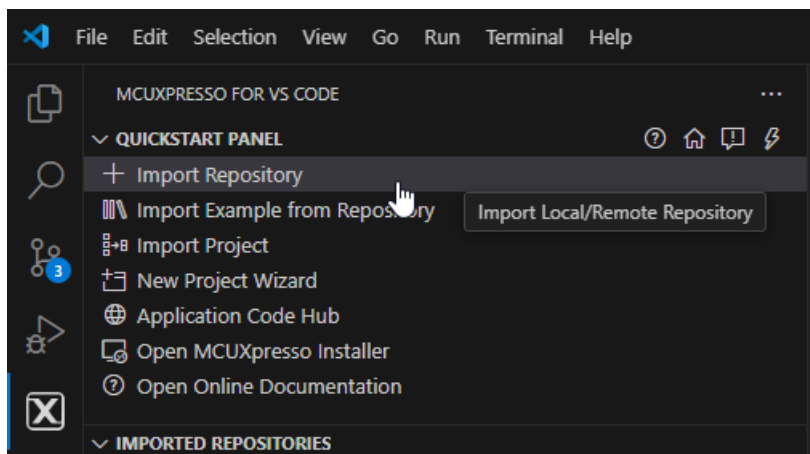
Run a demo using MCUXpresso for VS Code

This section explains how to configure MCUXpresso for VS Code to build, run, and debug example applications. This guide uses the `hello_world` demo application as an example. However, these steps can be applied to any example application in the MCUXpresso SDK.

Build an example application This section assumes that the user has already obtained the SDK as outlined in [Get MCUXpresso SDK Repo](#).

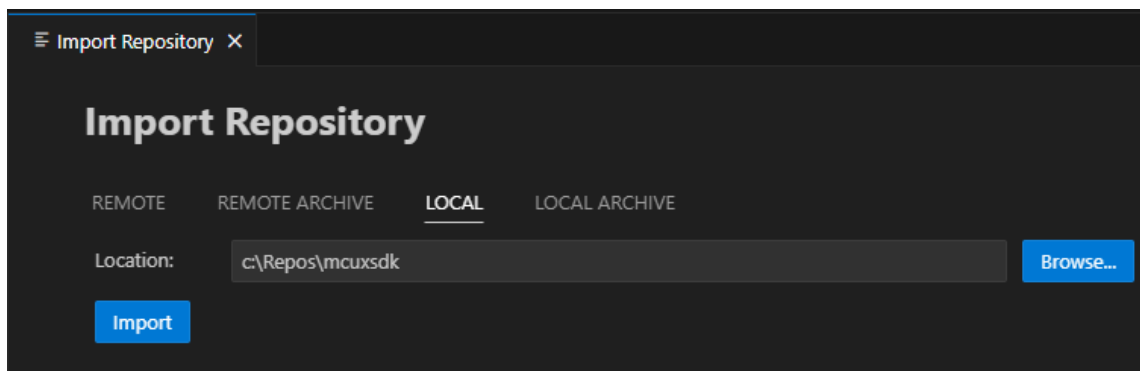
To build an example application:

1. Import the SDK into your workspace. Click **Import Repository** from the **QUICKSTART PANEL**.

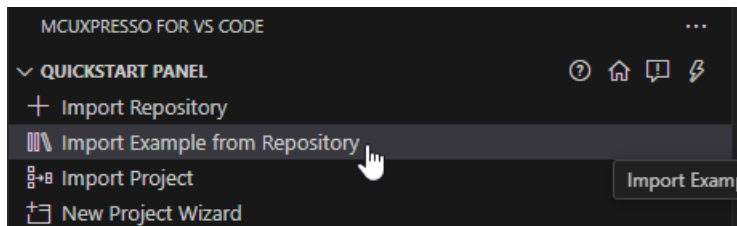


Note: You can import the SDK in several ways. Refer to [MCUXpresso for VS Code Wiki](#) for details.

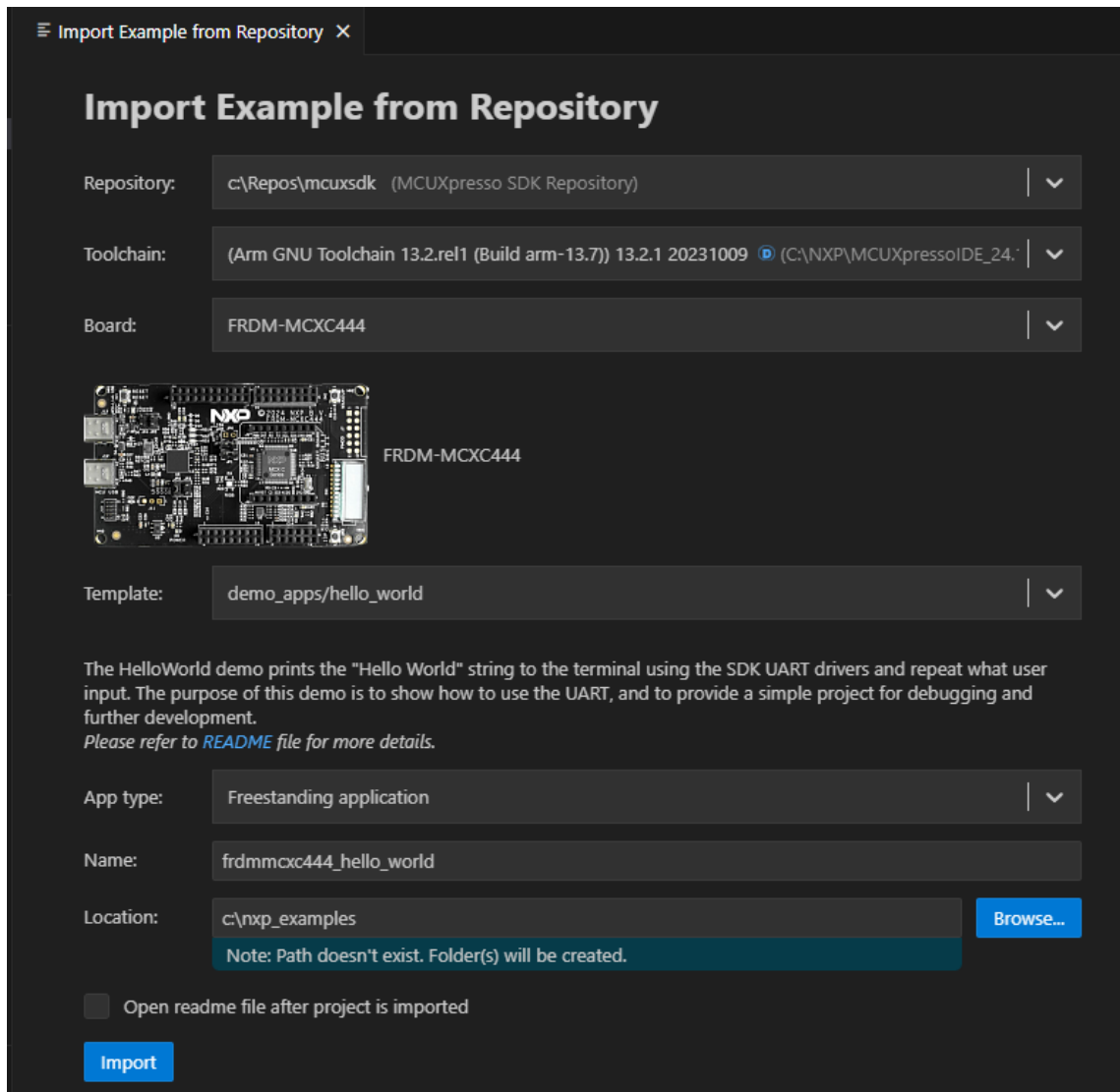
Select **Local** if you've already obtained the SDK as seen in [Get MCUXpresso SDK Repo](#). Select your location and click **Import**.



2. Click **Import Example from Repository** from the **QUICKSTART PANEL**.

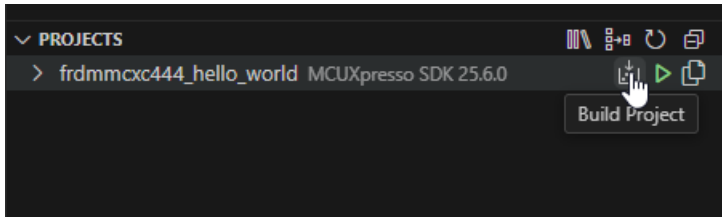


In the dropdown menu, select the MCUXpresso SDK, the Arm GNU Toolchain, your board, template, and application type. Click **Import**.

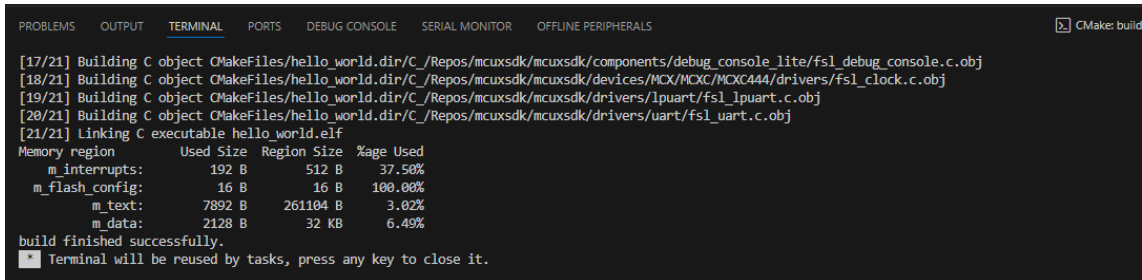


Note: The MCUXpresso SDK projects can be imported as **Repository applications** or **Freestanding applications**. The difference between the two is the import location. Projects imported as Repository examples will be located inside the MCUXpresso SDK, whereas Freestanding examples can be imported to a user-defined location. Select between these by designating your selection in the **App type** dropdown menu.

3. VS Code will prompt you to confirm if the imported files are trusted. Click **Yes**.
4. Navigate to the **PROJECTS** view. Find your project and click the **Build Project** icon.

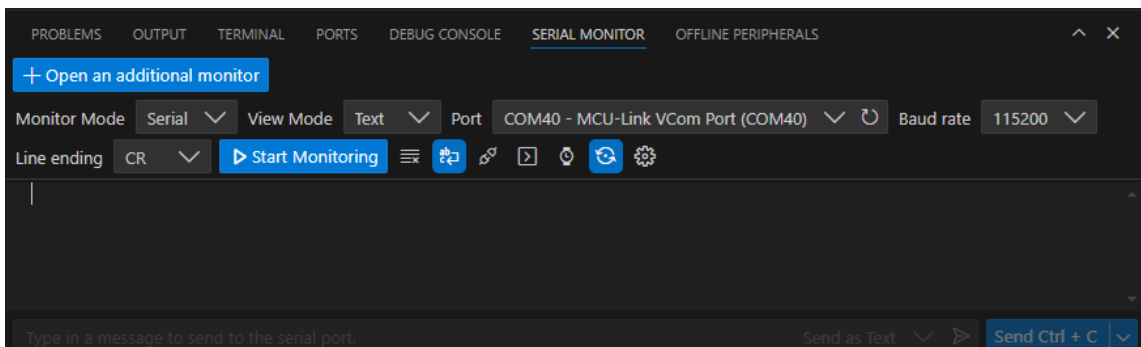


The integrated terminal will open at the bottom and will display the build output.

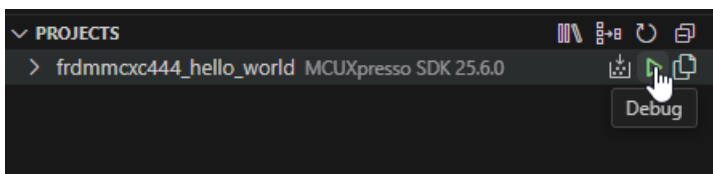


Run an example application **Note:** for full details on MCUXpresso for VS Code debug probe support, see [MCUXpresso for VS Code Wiki](#).

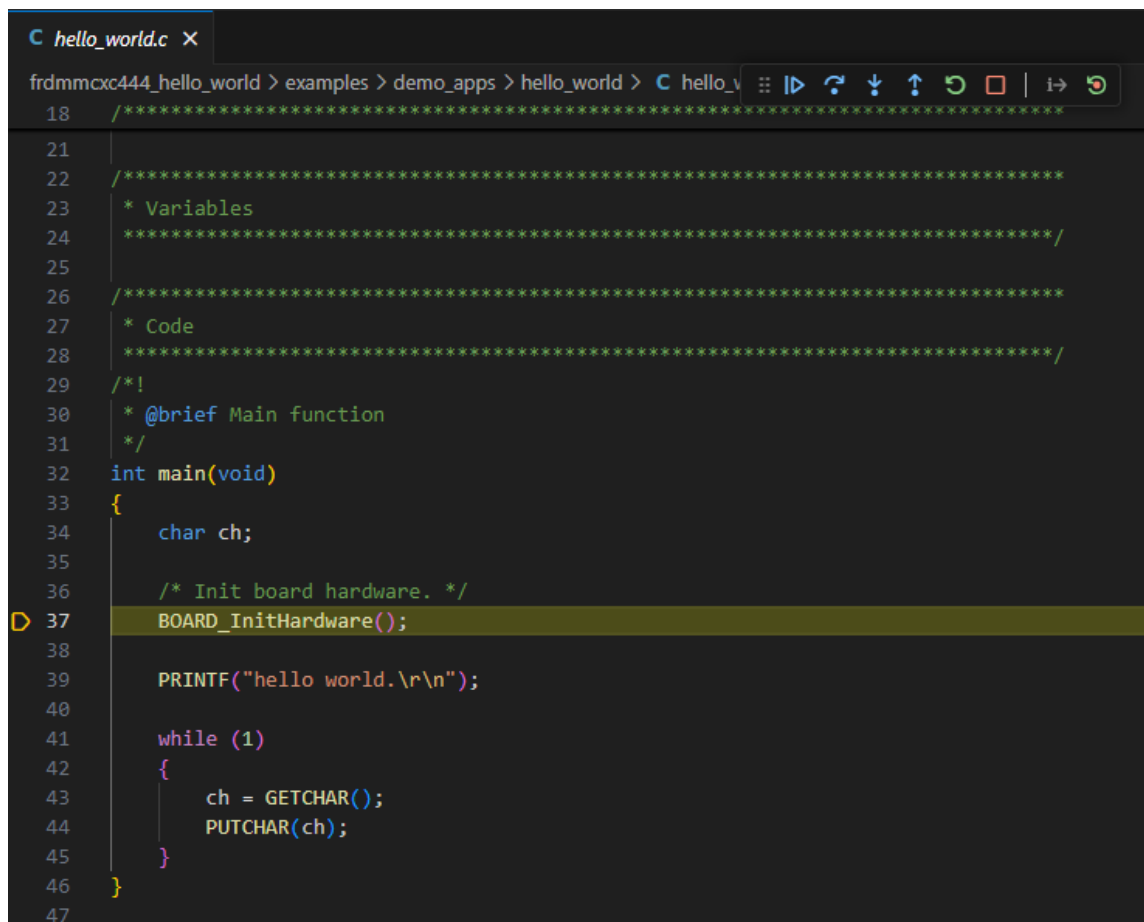
1. Open the **Serial Monitor** from the VS Code's integrated terminal. Select the VCom Port for your device and set the baud rate to 115200.



2. Navigate to the **PROJECTS** view and click the play button to initiate a debug session.



The debug session will begin. The debug controls are initially at the top.

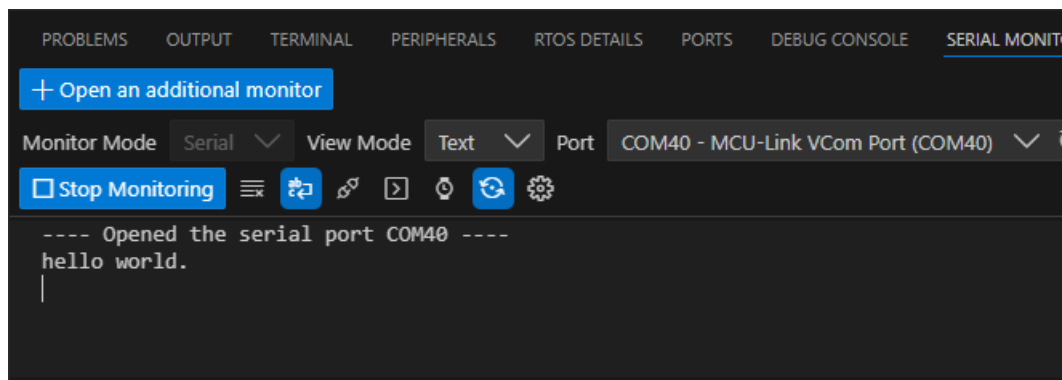


```

18  /*****
21
22  /*****
23  * Variables
24  *****/
25
26  /*****
27  * Code
28  *****/
29  /*!
30  * @brief Main function
31  */
32  int main(void)
33  {
34      char ch;
35
36      /* Init board hardware. */
37      BOARD_InitHardware();
38
39      PRINTF("hello world.\r\n");
40
41      while (1)
42      {
43          ch = GETCHAR();
44          PUTCHAR(ch);
45      }
46  }
47

```

3. Click **Continue** on the debug controls to resume execution of the code. Observe the output on the **Serial Monitor**.



```

PROBLEMS  OUTPUT  TERMINAL  PERIPHERALS  RTOS DETAILS  PORTS  DEBUG CONSOLE  SERIAL MONITOR
+ Open an additional monitor
Monitor Mode: Serial View Mode: Text Port: COM40 - MCU-Link VCom Port (COM40)
[Stop Monitoring] [Icons]
---- Opened the serial port COM40 ----
hello world.
|

```

Running a demo using ARMGCC CLI/IAR/MDK

Supported Boards Use the west extension `west list_project` to understand the board support scope for a specified example. All supported build command will be listed in output:

```
west list_project -p examples/demo_apps/hello_world [-t armgcc]
```

```
INFO: [ 1][west build -p always examples/demo_apps/hello_world --toolchain armgcc --config release -b_
↪evk9mimx8ulp -Dcore_id=cm33]
```

```
INFO: [ 2][west build -p always examples/demo_apps/hello_world --toolchain armgcc --config release -b_
↪evkbimxrt1050]
```

```
INFO: [ 3][west build -p always examples/demo_apps/hello_world --toolchain armgcc --config release -b_
```

(continues on next page)

(continued from previous page)

```

↪ evkbnmimxrt1060]
INFO: [ 4][west build -p always examples/demo_apps/hello_world --toolchain armgcc --config release -b_
↪ evkbnmimxrt1170 -Dcore_id=cm4]
INFO: [ 5][west build -p always examples/demo_apps/hello_world --toolchain armgcc --config release -b_
↪ evkbnmimxrt1170 -Dcore_id=cm7]
INFO: [ 6][west build -p always examples/demo_apps/hello_world --toolchain armgcc --config release -b_
↪ evkbnmimxrt1060]
INFO: [ 7][west build -p always examples/demo_apps/hello_world --toolchain armgcc --config release -b_
↪ evkbnmimxrt7ulp]
...

```

The supported toolchains and build targets for an example are decided by the example-self example.yml and board example.yml, please refer Example Toolchains and Targets for more details.

Build the project Use west build -h to see help information for west build command. Compared to zephyr's west build, MCUXpresso SDK's west build command provides following additional options for mcux examples:

- --toolchain: specify the toolchain for this build, default armgcc.
- --config: value for CMAKE_BUILD_TYPE. If not provided, build system will get all the example supported build targets and use the first debug target as the default one. Please refer Example Toolchains and Targets for more details about example supported build targets.

Here are some typical usages for generating a SDK example:

```

# Generate example with default settings, default used device is the mainset MK22F51212
west build -b frdmk22f examples/demo_apps/hello_world

# Just print cmake commands, do not execute it
west build -b frdmk22f examples/demo_apps/hello_world --dry-run

# Generate example with other toolchain like iar, default armgcc
west build -b frdmk22f examples/demo_apps/hello_world --toolchain iar

# Generate example with other config type
west build -b frdmk22f examples/demo_apps/hello_world --config release

# Generate example with other devices with --device
west build -b frdmk22f examples/demo_apps/hello_world --device MK22F12810 --config release

```

For multicore devices, you shall specify the corresponding core id by passing the command line argument -Dcore_id. For example

```

west build -b evkbnmimxrt1170 examples/demo_apps/hello_world --toolchain iar -Dcore_id=cm7 --config_
↪ flexspi_nor_debug

```

For shield, please use the --shield to specify the shield to run, like

```

west build -b mimxrt700evk --shield a8974 examples/issdk_examples/sensors/fxls8974cf/fxls8974cf_poll -
↪ Dcore_id=cm33_core0

```

Sysbuild(System build) To support multicore project building, we ported Sysbuild from Zephyr. It supports combine multiple projects for compilation. You can build all projects by adding --sysbuild for main application. For example:

```

west build -b evkbnmimxrt1170 --sysbuild ./examples/multicore_examples/hello_world/primary -Dcore_
↪ id=cm7 --config flexspi_nor_debug --toolchain=armgcc -p always

```

For more details, please refer to System build.

Config a Project Example in MCUXpresso SDK is configured and tested with pre-defined configuration. You can follow steps blow to change the configuration.

1. Run cmake configuration

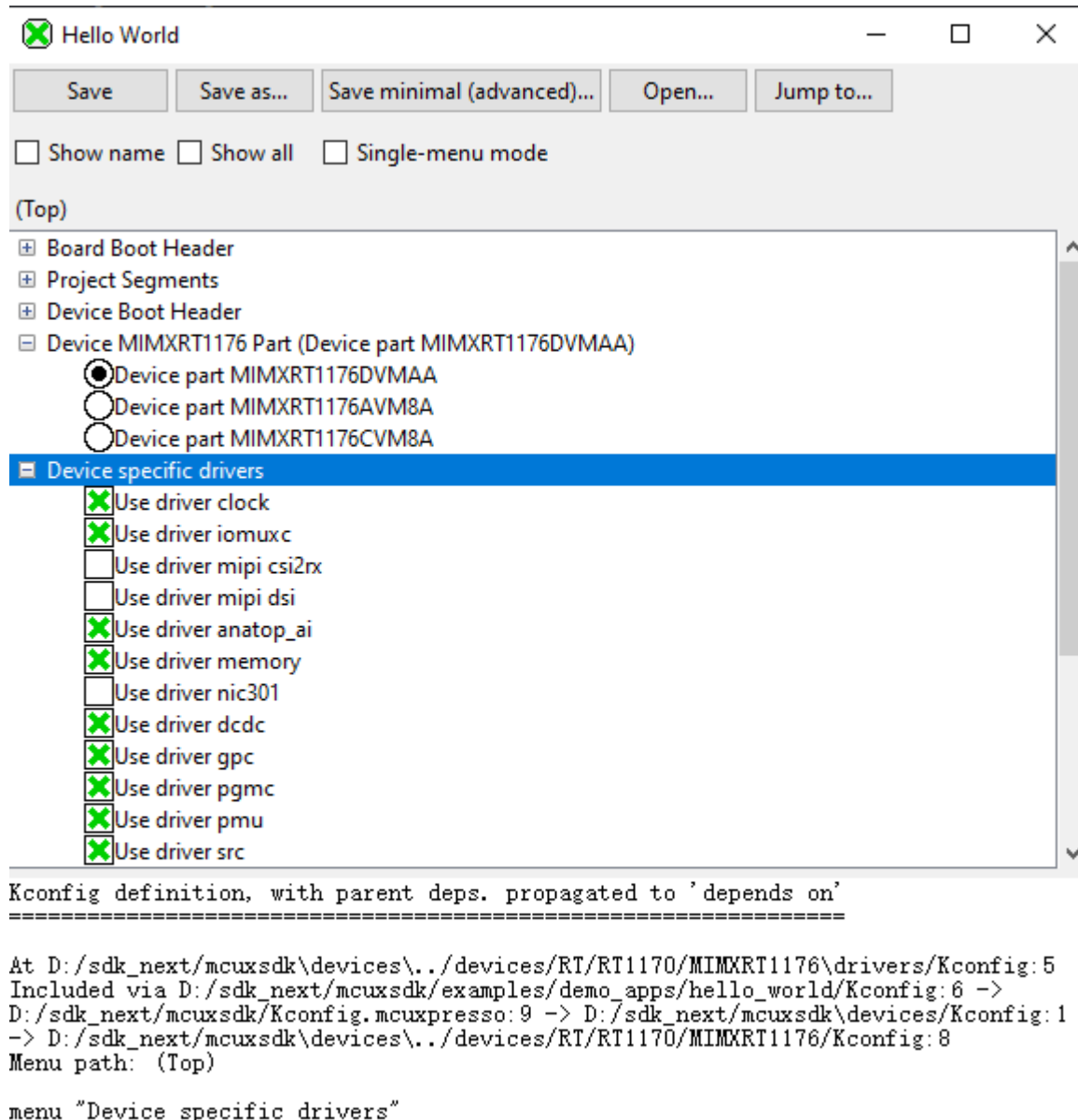
```
west build -b evkbmimxrt1170 examples/demo_apps/hello_world -Dcore_id=cm7 --cmake-only -p
```

Please note the project will be built without --cmake-only parameter.

2. Run guiconfig target

```
west build -t guiconfig
```

Then you will get the Kconfig GUI launched, like



You can reconfigure the project by selecting/deselecting Kconfig options.

After saving and closing the Kconfig GUI, you can directly run `west build` to build with the new configuration.

Flash *Note:* Please refer Flash and Debug The Example to enable west flash/debug support.

Flash the hello_world example:

```
west flash -r linkserver
```

Debug Start a gdb interface by following command:

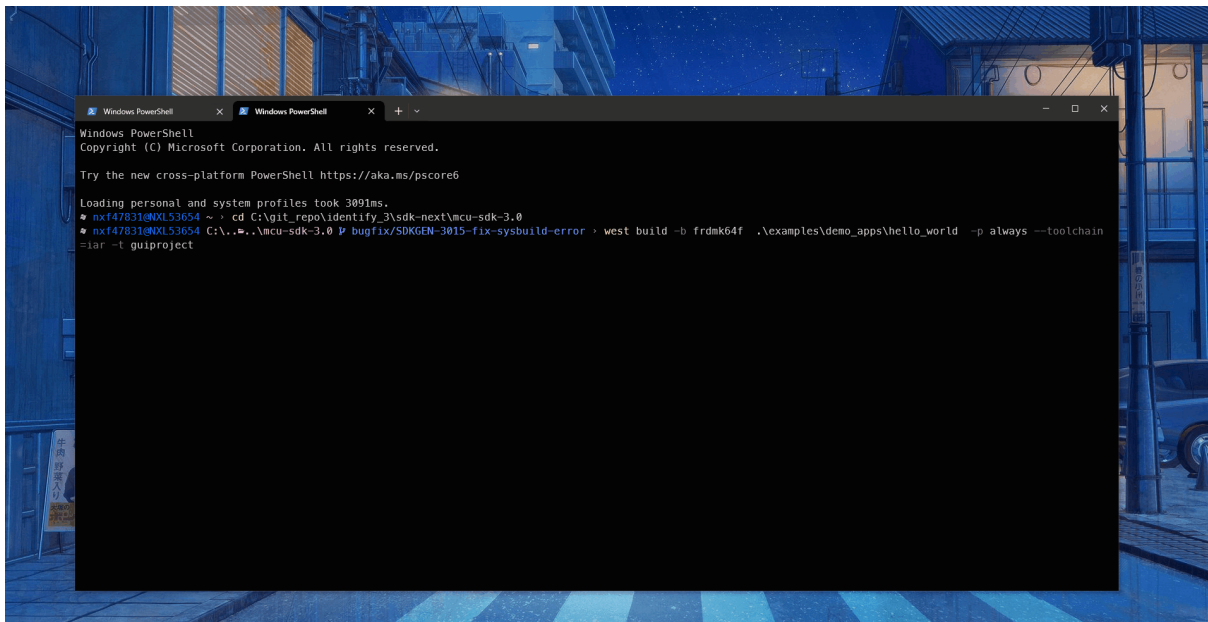
```
west debug -r linkserver
```

Work with IDE Project The above build functionalities are all with CLI. If you want to use the toolchain IDE to work to enjoy the better user experience especially for debugging or you are already used to develop with IDEs like IAR, MDK, Xtensa and CodeWarrior in the embedded world, you can play with our IDE project generation functionality.

This is the cmd to generate the evkbmimxrt1170 hello_world IAR IDE project files.

```
west build -b evkbmimxrt1170 examples/demo_apps/hello_world --toolchain iar -Dcore_id=cm7 --config_↵
↵flexspi_nor_debug -p always -t guiproject
```

By default, the IDE project files are generated in mcuxsdk/build/<toolchain> folder, you can open the project file with the IDE tool to work:



Note, please follow the [Installation](#) to setup the environment especially make sure that [ruby](#) has been installed.

1.4 Getting Started with MCUXpresso SDK Xplorer

1.4.1 Getting Started with MCUXpresso SDK Xplorer

Overview

Cadence Tensilica Xplorer is a complete development environment that helps users create application code for high-performance Tensilica processors. Xplorer is the interface to powerful

software development tools such as the XCC compiler, assembler, linker, debugger, code profiler, and full set of GUI tools.

Xplorer, including both GUI and command-line environment, is the only available development IDE for the DSP core of MIMXRT600.

Install Xplorer Toolchains

This section provides information on Xtensa Software Tools Platform Support and steps to:

- Install the Xtensa Xplorer IDE and Tools
- Install License Key
- Install RT600 DSP Build Configuration
- Install Xtensa On Chip Debugger Daemon
- Program LPC-Link2 with SEGGER J-Link
- Install Xtensa Software Tools without IDE

Xtensa Software Tools Platform Support The Xtensa Software Tools are officially supported on the following platforms:

Windows: Win 10 64-bit, Win 8 64-bit, Win 7 64-bit.

Linux: RHEL 6 64-bit (with 'Desktop' package installed).

There may be compatibility issues with other versions of Linux or Windows, especially when using the IDE.

Note: The security-enhanced Linux (SELinux) is not a supported platform because the OS can prevent different shared libraries (including Xtensa Tools) from loading.

For more information on platform support and installation guidelines, see the Xtensa Development Tools Installation Guide.

Parent topic: [Install Xplorer Toolchains](#)

Install the Xtensa Xplorer IDE and Tools To install the Xtends Xplorer IDE and tools, perform the following steps:

1. Go to the URL <https://tensilicatools.com/download/rt600-download-page/> and log in. If you are accessing the site for the first time, make sure to register.
2. Make sure to use your corporate email address to register.



3. Once registered you should receive an email confirmation with an activation link from 'Tensilica Tools' no-reply@tensilicatools.com. Make sure to check the spam folder if this email does not show up in the inbox.
4. To complete the registration, click the activation link.
5. Once registered, log in to see the material available for download:



1. Download and install the **Xplorer IDE V10.1.11** for your operating system (Windows or Linux).
2. Download the **DSP Configuration** for your operating system – installed later through the IDE, see Install RT600 DSP Build Configuration. **Note:** NXP recommends version **10.1.11** of the Xtensa Xplorer IDE and tools for use with the RT600 DSP.

Parent topic: [Install Xplorer Toolchains](#)

Install License Key Xtensa development tools use FLEXlm for license management. FLEXlm licensing is required for tools such as the Xtensa Xplorer IDE, Xtensa C and C++ compiler, and Instruction Set Simulator (ISS).

Currently RT600 supports node-locked license for Xtensa tools. A node-locked license permits tools to run on a specific computer, tied to the MAC address of the primary network interface permanently attached to the machine.

Identify PC MAC Address To generate the correct license file, you should first identify the appropriate MAC for the computer you plan to run Xtensa tools on. Remove ‘-’ or ‘:’ symbols in the MAC address.

Windows:

```
C:\Users>ipconfig /all

Wireless LAN adapter Wireless Network Connection:

    Connection-specific DNS Suffix  . : us-sjo01.nxp.com
    Description . . . . . : Intel(R) Dual Band Wireless-AC 8265
    Physical Address. . . . . : 14-4F-8A-63-8C-33
    DHCP Enabled. . . . . : Yes
```

Linux:

```
[user@rhel ~]$ ifconfig
eth0      Link encap:Ethernet  HWaddr 12:34:56:78:90:AB
```

Note: For Linux: MAC address must be associated with eth0 interface. If not, FLEXlm cannot perform the license checkout, compilation, or simulation of code is not possible. If the host has the MAC address associated with another interface, for example em1, the following approach may be used.

```
# Add udev rule for naming interface
$ sudo vim /etc/udev/rules.d/70-persistent-net.rules
# udev rule (replace 'XX' with the MAC address of your PC):
SUBSYSTEM=="net", ACTION=="add", ATTR{address}=="XX:XX:XX:XX:XX:XX", NAME="eth0"
# Change "em1" to "eth0" in your interfaces file.
$ sudo vim /etc/network/interfaces
# Restart udev or reboot machine
$ sudo reboot
```

Alternatively, you can use the approach recommended by your IT team to rename the interface to eth0.

Parent topic: Install License Key

Download License Key To download the license key:

1. Reload or return to the Tensilica URL: <https://tensilicatools.com/download/rt600-download-page/>.
2. Click the button and get the license key for RT600 SDK.



CLICK TO GET A LICENSE KEY FOR RT600 SDK

3. Provide the address.

Get a License Key for RT600 SDK

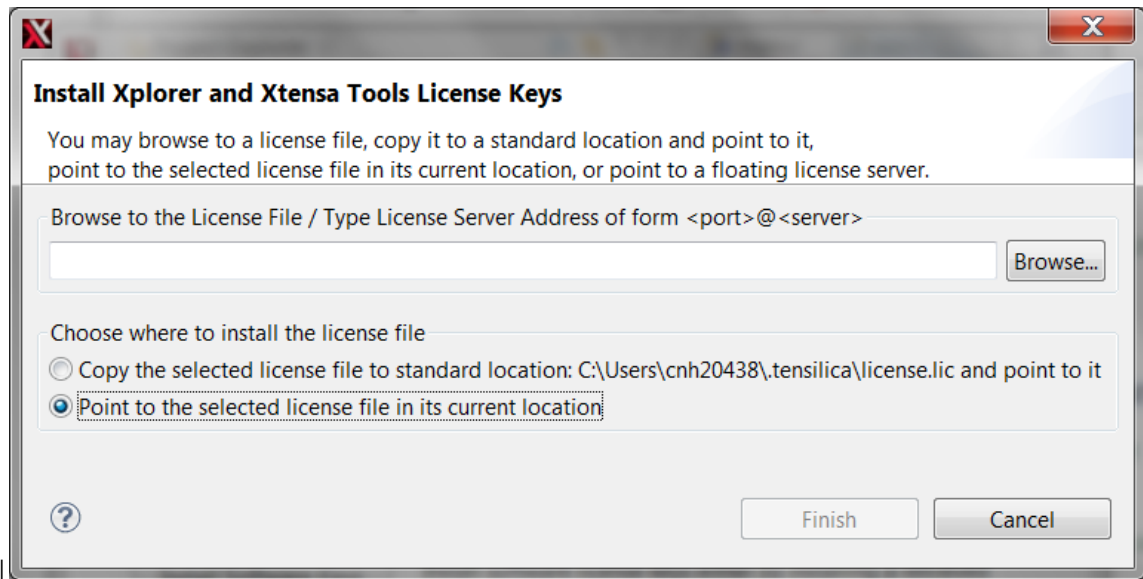
Please Enter a MAC Address

Your machine may have multiple MAC addresses. Please use one that is permanently installed. The license checker will confirm that the MAC address is present, even if that particular network interface isn't in use. For example, you can enter the MAC address for your LAN interface, and that will work even if you are using the WiFi interface for your development.

Accept

Cancel

4. Once the license file has been generated and downloaded, open your recently installed Xplorer V10.1.11.
5. Select menu **Help > Xplorer License Keys > Install Software Keys**.
6. Select the license key file.



7. Click the **Finish** button.

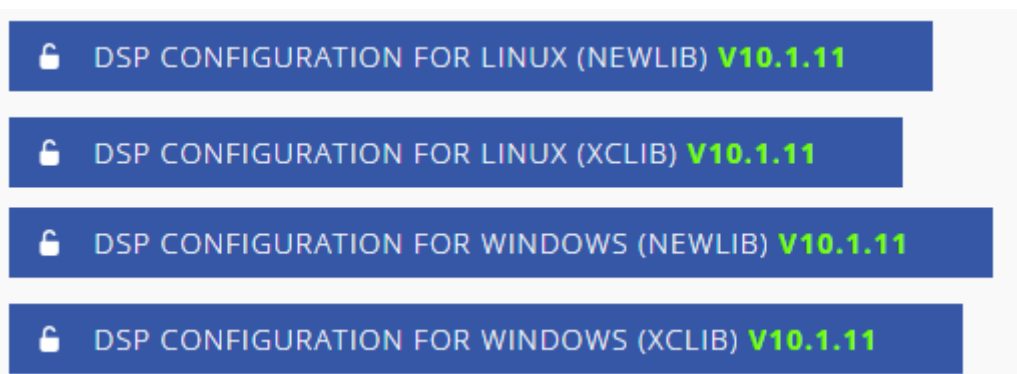
Note: The generated license file only supports debug/run on the RT600 device target. It does not support software simulation/Xplorer ISS. If you have special requirements to run the software simulations, contact Cadence directly.

Parent topic:Install License Key

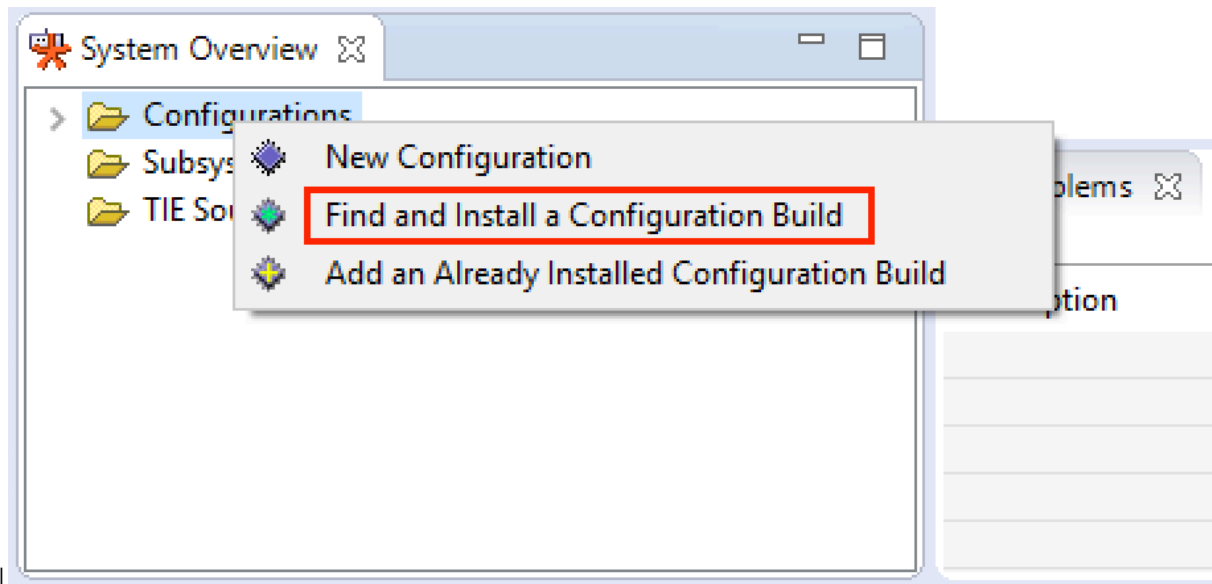
Parent topic:[Install Xplorer Toolchains](#)

Install RT600 DSP Build Configuration ‘*Build Configuration*’ is a term that describes all parameters and necessary build includes for the Tensilica processor implementation for development. It is mandatory to install a specific build configuration before starting development on RT600.

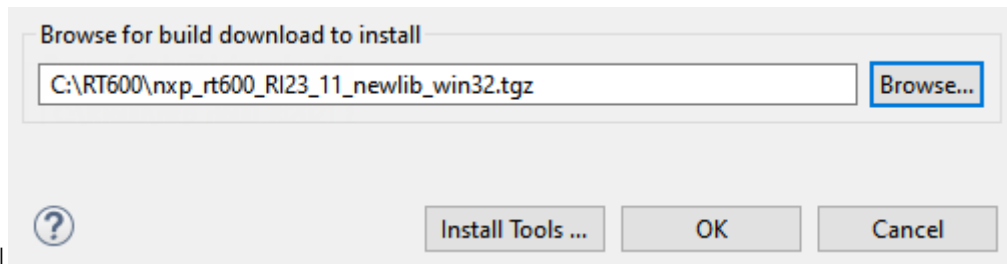
The build configuration is provided by NXP as a binary file and is imported into the Xplorer IDE. The binary file for the OS is available at the Tensilica URL: <https://tensilicatools.com/download/rt600-download-page/>.



The build configuration is installed into the IDE using the **System Overview** panel available in the lower left corner, by default. If the **System Overview** panel is not visible, toggle using the **Window > Show View > System Overview** menu item.



Click **OK** for build download to install.



Parent topic: [Install Xplorer Toolchains](#)

Install Xtensa On Chip Debugger Daemon The Xtensa On Chip Debugger Daemon (xt-ocd), is a gdb-based debugging tool but is not installed by default with the Xplorer IDE. For installation, a self-extracting executable installer is included with the IDE, which can be found at the following location:

Windows:

C:\usr\xtensa\XtDevTools\downloads\RI-2023.11\tools\xt-ocd-14.11-windows64-installer.exe

Linux:

~/xtensa/XtDevTools/downloads/RI-2023.11/tools/xt-ocd-14.11-linux64-installer

Currently, xt-ocd supports J-Link and Arm RVI/DSTREAM probes over Serial Wire Debug (SWD) for RT600. xt-ocd installs support for J-Link probes but does not install the required J-Link drivers which must be installed separately. Make sure that the latest version of J-Link software is installed.

Note: For Linux: When installing xt-ocd on Linux, ensure that the symlink is manually added to the installed J-Link driver: `ln -s <jlink-install-dir>libjlinkarm.so.6 <xocd-install-dir>/modules/libjlinkarm.so.6.`

xt-ocd is configured with an XML input file 'topology.xml' that modifies to fit the debugger hardware. Using J-link as an example, use the content below to replace the original template.

Note: It is mandatory to replace the 'usbser' section with the 9-digits number J-Link serial number on the back of the J-Link hardware in use.

```

<configuration>
  <controller id='Controller0' module='jlink' usbser='600100000' type='swd' speed='1000000' locking='1' />
  <driver id='XtensaDriver0' dap='1' xdm-id='12' module='xtensa' step-intr='mask,stepover,setps' />
  <chain controller='Controller0'>
    <tap id='TAP0' irwidth='4' />
  </chain>
  <system module='jtag'>
    <component id='Component0' tap='TAP0' config='trax' />
  </system>
  <device id='Xtensa0' component='Component0' driver='XtensaDriver0' ap-sel='3' />
  <application id='GDBStub' module='gdbstub' port='20000' sys-reset='0'>
    <target device='Xtensa0' />
  </application>
</configuration>

```

Below is another topology.xml example if Arm RealView ICE (RVI) and DSTREAM debug probes is used.

```

<configuration>
  <controller id='Controller0' module='rvi' />
  <driver id='XtensaDriver0' debug='' inst-verify='mem' module='xtensa' step-intr='mask,stepover,setps' />
  <driver id='TraxDriver0' module='trax' />
  <chain controller='Controller0'>
    <tap id='TAP0' irwidth='4' />
  </chain>
  <system module='jtag'>
    <component id='Component0' tap='TAP0' config='trax' />
  </system>
  <device id='Xtensa0' component='Component0' driver='XtensaDriver0' xdm-id='12' />
  <device id='Trax0' component='Component0' driver='TraxDriver0' xdm-id='12' />
  <application id='GDBStub' module='gdbstub' port='20000'>
    <target device='Xtensa0' />
  </application>
  <application id='TraxApp' module='traxapp' port='11444'>
    <target device='Trax0' />
  </application>
</configuration>

```

Congratulations! All Xplorer toolchains are installed.

For more details on Xtensa software tools, build configurations, or xt-ocd daemon, see the full set of documents in Xplorer menu **Help > PDF Documentation**.

Parent topic: [Install Xplorer Toolchains](#)

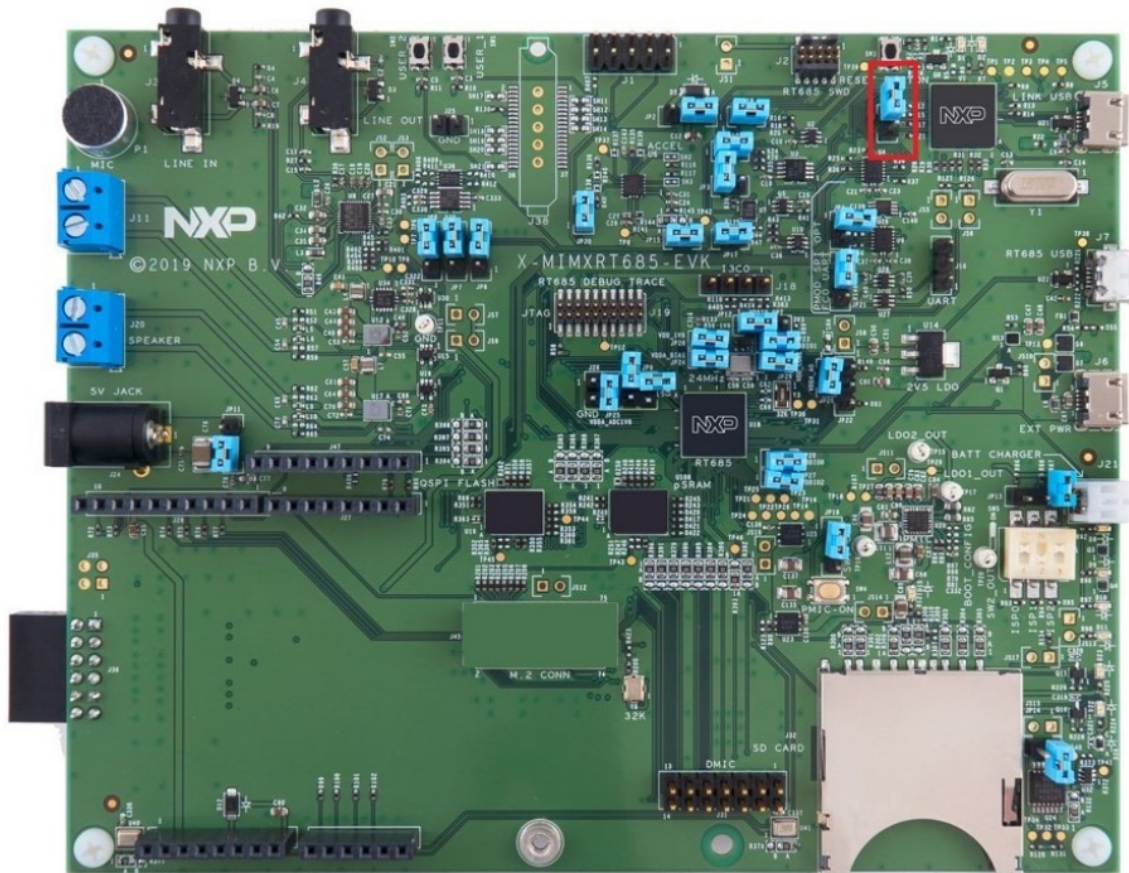
Program LPC-Link2 with SEGGER J-Link In addition to standalone probes, the onboard LPC-Link2 debug probe is used to debug HiFi4 DSP over SWD ports. The RT600 EVK has an LPC4300 MCU (top right corner on EVK) and by default has been pre-programmed as CMSIS-DAP probe. CMSIS-DAP is not compatible with HiFi4. Therefore, a few extra steps are required to flash it with J-Link firmware and support both Arm CM33 core and HiFi4 DSP core.

The steps are:

1. Install LPCScript, a command-line tool for programming onboard LPC-Link2 debug probe with the latest CMSIS-DAP and J-Link firmware. LPCScript is available for download from: <https://www.nxp.com/design/microcontrollers-developer-resources/lpc-microcontroller-utilities/lpcscript-v2.1.0:LPCSCRIPT>.
2. After the download is complete, run the installer.

Note: During the installation, the DFU, and VCOM drivers are automatically installed for all platforms.

3. To update the LPC-Link2 debug circuit firmware, unplug the USB cable on J5 and then connect to the DFULink jumper. In the MIMXRT685-EVK, JP1 is the LPCXpresso DFU jumper as shown in Figure 1.
4. Connect JP1 using the jumper.



5. Reconnect the board to the host computer over the debug link USB connector J5.
6. Launch LPCScript by double-clicking the *Boot LPCScript* file in the LPCScript install location: C:\ProgramData\Microsoft\Windows\Start Menu\Programs\LPCScript.

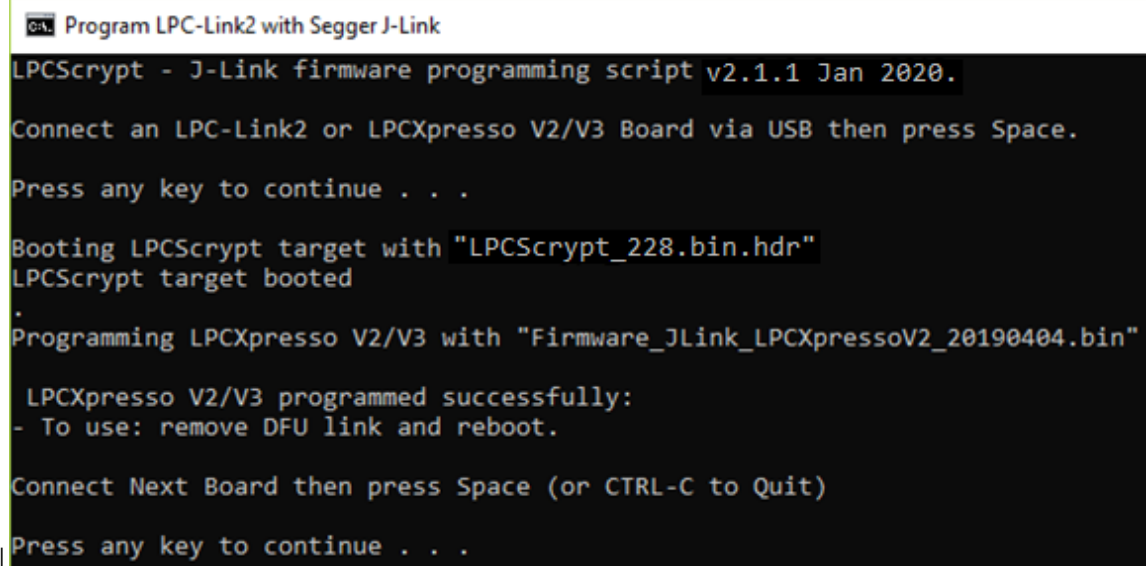
Name	Date modified	Type	Size
Boot LPCScript	9/10/2018 10:14 AM	Shortcut	2 KB
LPCScript on the Web	9/10/2018 10:14 AM	Internet Shortcut	1 KB
Open LPCScript simple CLI	9/10/2018 10:14 AM	Shortcut	1 KB
Program LPC-Link2 with CMSIS-DAP	9/10/2018 10:14 AM	Shortcut	1 KB
Program LPC-Link2 with Segger J-Link	9/10/2018 10:14 AM	Shortcut	1 KB
Uninstall LPCScript	9/10/2018 10:14 AM	Shortcut	1 KB

7. In that command shell, run the program_JLINK script to install the JLink debug firmware.

```
<LPCScript Intall Dir>scripts\program_JLINK
```

****Note:**** File paths in this document use the Windows directory separator, on Linux or Mac OSX. The file paths must be replaced with '/' For Windows users, shortcuts to the scripts are available from the LPCScript entry on the Start menu.

8. Verify once you select the firmware (in this case J-Link), LPCScript. The console appears as shown in Figure 4.



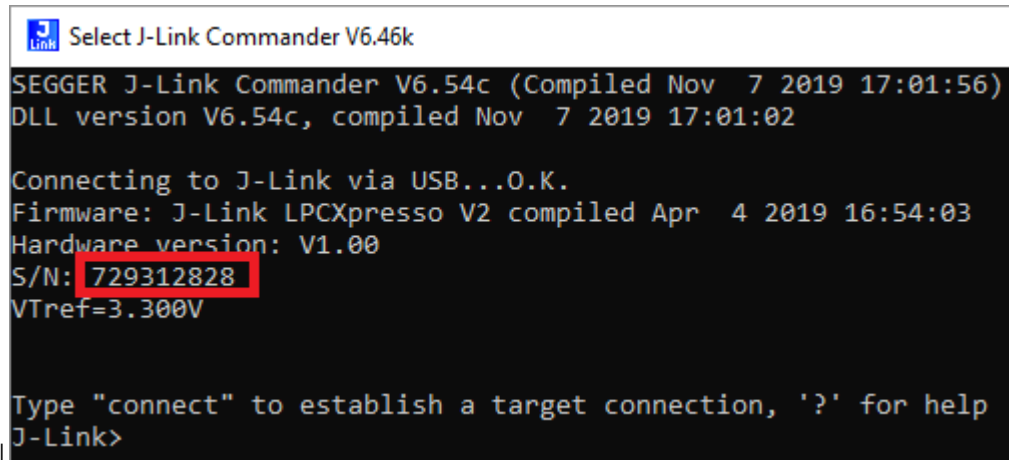
```

Program LPC-Link2 with Segger J-Link
LPCScript - J-Link firmware programming script v2.1.1 Jan 2020.
Connect an LPC-Link2 or LPCXpresso V2/V3 Board via USB then press Space.
Press any key to continue . . .
Booting LPCScript target with "LPCScript_228.bin.hdr"
LPCScript target booted
Programming LPCXpresso V2/V3 with "Firmware_JLink_LPCXpressoV2_20190404.bin"
LPCXpresso V2/V3 programmed successfully:
- To use: remove DFU link and reboot.
Connect Next Board then press Space (or CTRL-C to Quit)
Press any key to continue . . .

```

9. Open/ Disconnect JP1 and power cycle the board. The onboard LPC-Link2 is ready to be used as SEGGER J-Link probe.

Every EVK/ LPC-Link2 has a different J-Link S/N. Therefore, make sure to write down the S/N for xt-ocd and topology.xml as indicated in Install Xtensa On Chip Debugger Daemon.

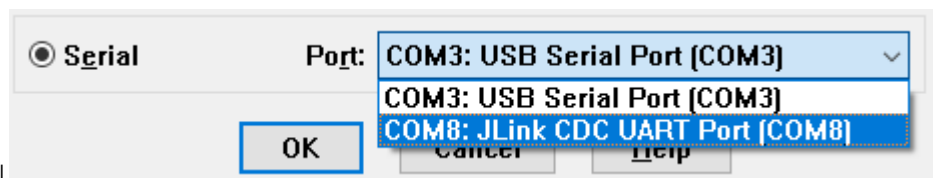


```

Select J-Link Commander V6.46k
SEGGER J-Link Commander V6.54c (Compiled Nov  7 2019 17:01:56)
DLL version V6.54c, compiled Nov  7 2019 17:01:02
Connecting to J-Link via USB...O.K.
Firmware: J-Link LPCXpresso V2 compiled Apr  4 2019 16:54:03
Hardware version: V1.00
S/N: 729312828
VTref=3.300V
Type "connect" to establish a target connection, '?' for help
J-Link>

```

10. Another benefit is that LPC-Link2 debug probe creates a virtual serial port over USB, so the extra UART2USB cable for debugging is not required.



The download link provides the document, demo videos and details on LPC-Link2. If you have any questions, or have difficulties to program the probe, see [\[https://www.nxp.com/design/microcontrollers-developer-\]](https://www.nxp.com/design/microcontrollers-developer-)

(continues on next page)

(continued from previous page)

```
↪resources/lpc-microcontroller-utilities/lpcscrypt-v2.1.0:LPCSCRYPT](https://www.nxp.com/design/  
↪microcontrollers-developer-resources/lpc-microcontroller-utilities/lpcscrypt-v2.1.0:LPCSCRYPT).
```

Parent topic:[Install Xplorer Toolchains](#)

Install Xtensa Software Tools without IDE The Xtensa Software Tools can also be installed without the use of the IDE. The installation without the IDE is useful in a command-line only Linux environment, or for better compatibility with an unsupported Linux environment.

The command-line tools package is available as a redistributable zip file that is extracted with an Xplorer IDE install. To gain access to the tools package, the IDE must be installed once in the organization. The tools package is available at: `~/xtensa/XtDevTools/downloads/RI-2023.11/tools/XtensaTools_RI_2023_11_linux.tgz..`

With the tools package and the DSP Build Configuration package available from the [Tensilica Tools download site](#), the toolchain can be set up as follows:

```
# Create Xtensa install root  
mkdir -p ~/xtensa/tools  
mkdir -p ~/xtensa/builds  
# Set up the configuration-independent Xtensa Tool:  
tar zxvf XtensaTools_RI_2023_11_linux.tgz -C ~/xtensa/tools  
# Set up the configuration-specific core files:  
tar zxvf nxp_rt600_RI23_11_newlib_linux_redist.tgz -C ~/xtensa/builds  
# Install the Xtensa development toolchain:  
cd ~/xtensa  
./builds/RI-2023.11-linux/nxp_rt600_RI23_11_newlib/install \  
--xtensa-tools./tools/RI-2023.11-linux/XtensaTools \  
--registry ./tools/RI-2023.11-linux/XtensaTools/configg
```

Parent topic:[Install Xplorer Toolchains](#)

Install MCUXpresso SDK

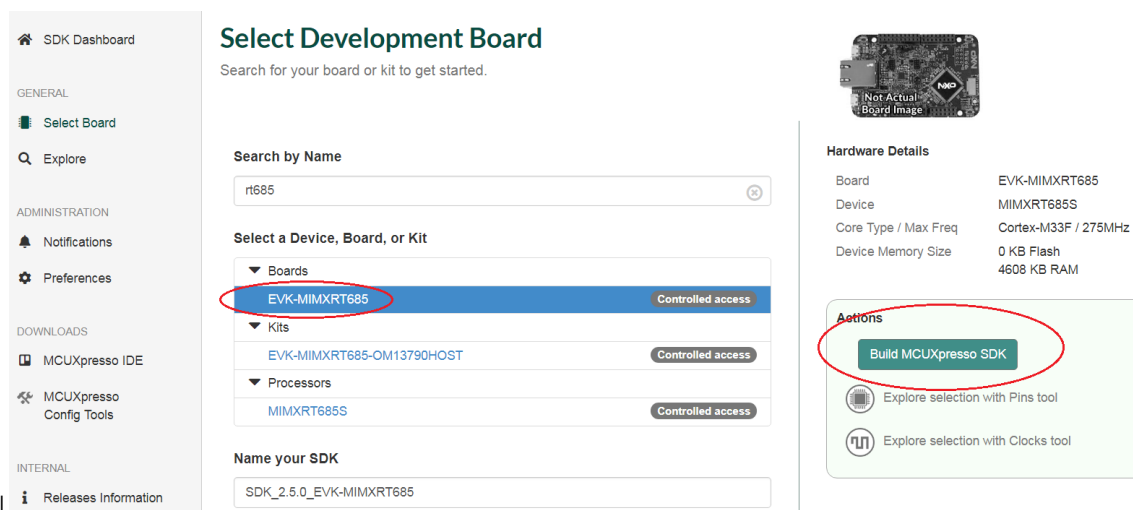
This section list the steps to:

- Download MCUXpresso SDK for RT600
- Enable MCUXpresso SDK DSP
- Initialize DSP Core
- Link DSP Profiles

Download MCUXpresso SDK for RT600 DSP enablement for RT600, including drivers, middleware libraries, and demo applications are included with the latest RT600 SDK available for download from <https://mcuxpresso.nxp.com>. If you are accessing the site for the first time, make sure to register.

Once logged in, perform the following steps to use the SDK builder.

1. Click the link **Select Board /Processor** on the left panel.
2. In the **Search by Name** field, enter the name of the board. For example, *RT685*.
3. From the search results, select *EVK-MIMXRT685*.
4. Click the **Build MCUXpresso SDK** button on the right panel.



5. In the Build SDK for EVK-MIMXRT685 page, select the required environment settings.
6. Click the **Download SDK** button at the bottom of the page.
7. Save the archive in a local directory.

Parent topic: [Install MCUXpresso SDK](#)

Enable MCUXpresso SDK DSP The following DSP-specific enablements are available inside the MCUXpresso SDK release package for RT600.

-

<SDK_ROOT>/devices/MIMXRT685S/

Unified device and peripheral driver source code that can be compiled for both Arm and DSP cores.

****Note:**** Only a limited subset of peripheral drivers and components is supported on the DSP.

~ ~ ~
<SDK_ROOT>/boards/evkmimxrt685/dsp_examples/

DSP example applications

-

<SDK_ROOT>/middleware/multicore/rpmsg_lite/

Unified RPMsg-Lite multicore communication library, with porting layers for Arm and DSP cores

~ ~ ~
<SDK_ROOT>/middleware/dsp/audio_framework/

Xtensa Audio Framework \XAF\ for DSP core

-

<SDK_ROOT>/middleware/dsp/audio_framework/libxa_af_hostless/

Source code and documentation for the core XAF framework

```
-   \
<SDK_ROOT>/middleware/dsp/audio_framework/testxa_af_hostless/
```

- Utilities and tests for developing applications with the XAF framework

```
<SDK_ROOT>/middleware/dsp/audio_framework/testxa_af_hostless/test/plugins
```

- XAF components and codec binaries

-

```
<SDK_ROOT>/middleware/dsp/naturedsp/hifi4/
```

NatureDSP Math Library for HiFi4 DSP

****Parent topic:****[Install MCUXpresso SDK](../topics/install_mcuxpresso_sdk.md)

Initialize DSP Core To minimize the power consumption, the DSP core is not powered when RT600 boots up. To initialize, run, or debug DSP applications, you must execute some code on the Arm core.

The DSP management interface library provided in the SDK is available at the location: `<SDK_ROOT>/devices/MIMXRT685S/drivers/fsl_dsp.c`.

```
/* Initialize DSP core. */
void DSP_Init(void);
/* Deinit DSP core. */
void DSP_Deinit(void);
/* Copy DSP image to destination address. */
void DSP_CopyImage(dsp_copy_image_t *dspCopyImage);
/* Start DSP core. */
void DSP_Start(void);
/* Stop DSP core. */
void DSP_Stop(void);
```

The SDK includes a helper function used by the DSP example applications at: `<SDK_ROOT>/boards/evkmimxrt685/dsp_examples/dsp_support.c`.

```
/* Prepare DSP core for code execution:
- Setup PMIC for DSP
- Initialize DSP clock and core
- (Optional) Copy DSP binary image into RAM
- Start DSP core
*/
void BOARD_DSP_Init(void);
```

After executing this function during your Arm application startup, the DSP is initialized and ready to run. From here, code is loaded and debugged on the DSP with Xplorer IDE and tools.

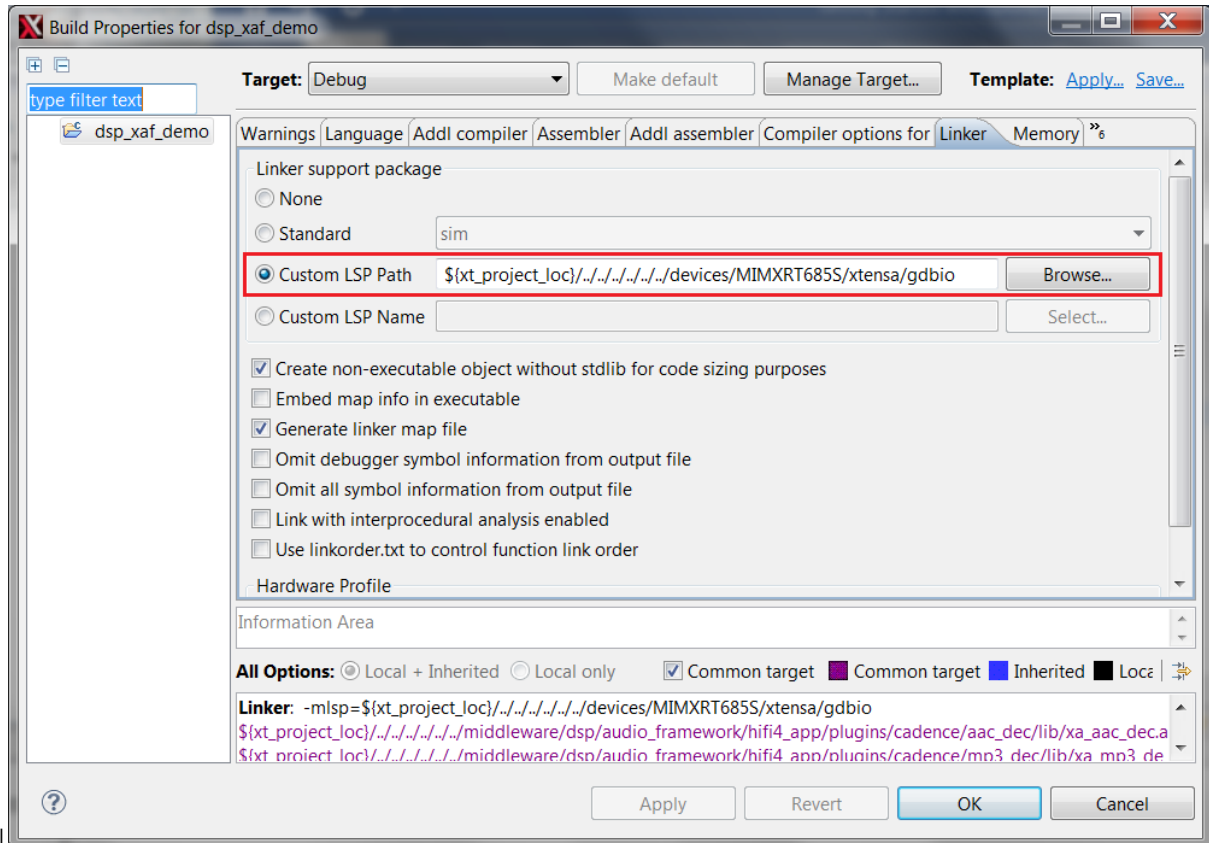
Parent topic:[Install MCUXpresso SDK](#)

Link DSP Profiles The Xtensa Software Tools use the linker support packages (LSPs) to link a HiFi4 DSP application for the RT600. An LSP includes both a system memory map and a collection

of libraries to include into the final binary. The LSPs are provided in the MCUXpresso SDK and are available at: <SDK_ROOT>/devices/MIMXRT685S/xtensa/.

DSP sample applications are configured to link against one of these custom LSPs. By default, *Debug* targets are linked against the gdbio LSP intended for use with an attached debugger and captures I/O requests (printf) through gdb. The *Release* target links against the min-rt LSP, which includes minimal runtime support.

To change the LSP used by a project target in the Xplorer IDE, use the **Linker** tab in the project **Build Properties** dialog box.



The MCUXpresso SDK ships with other standard LSPs for RT600. For more information on LSPs and creating a custom memory map using Xtensa software tools, see the Cadence Linker Support Packages (LSPs) Reference Manual.

Parent topic: [Install MCUXpresso SDK](#)

Run and Debug DSP Demo using Xplorer IDE

This section lists the steps to:

- Prepare Arm Core for 'Hello World'
- Start Xtensa Debugger Daemon
- Prepare DSP Core for 'Hello World'
- Run and Debug DSP Audio Framework
- Launch DSP Application from Arm Core

Prepare Arm Core for ‘Hello World’ Each of the DSP demos included in the MCUXpresso SDK consists of two separate applications that run on the Arm core and DSP core. The Arm core application initializes the DSP core in the manner described in Initialize DSP Core and executes other application-specific functionality.

To debug the ‘Hello World’ DSP application, you must first set up and execute the Arm application using an environment of your choice.

- Build and execute the ‘Hello World’ Arm demo located in: `<SDK_ROOT>/boards/evkmimxrt685/dsp_examples/hello_world_uart/cm33/`.

Preparing an Arm core development environment is outside the scope of this document. For information on how to use the SDK for Arm core development, see the *Getting Started with MCUXpresso SDK for MIMXRT600.pdf* document at `<SDK_ROOT>/docs/`.

Note: IAR Embedded Workbench may require a patch to enable compatibility with RT600. For details on the patch, contact NXP directly.

Note: If you are using MCUXpresso, it is highly recommended to upgrade to latest version of the SDK and match the latest EVK board.

Parent topic: [Run and Debug DSP Demo using Xplorer IDE](#)

Start Xtensa Debugger Daemon To debug DSP applications on RT600, ensure that the xt-ocd daemon is running. This application runs a gdb server that the Xtensa core debugger connects to.

Go to the command-line window and change directory (cd) to xt-ocd daemon installation path. The default path on Windows is `C:\Program Files (x86)\Tensilica\Xtensa OCD Daemon 14.08`.

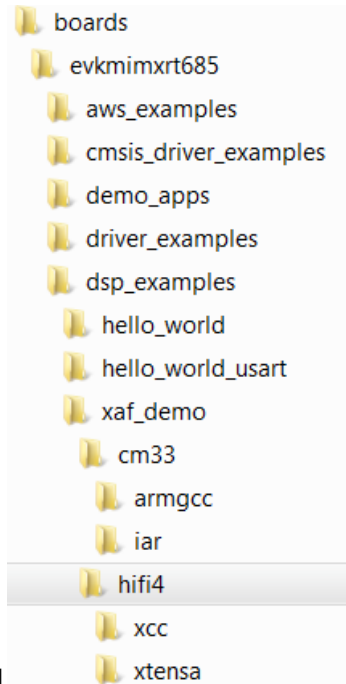
Execute the daemon with the custom topology.

```
**xt-ocd.exe -c topology.xml**
XOCD <VERSION_INFO>
(c) 1999-2021 Cadence Design Systems Inc. All rights reserved.
[Debug Log 2021-06-17 08:12:29]
Loading module "gdbstub" <VERSION_INFO>
Loading module "jlink" <VERSION_INFO>
Using JLINK lib <VERSION_INFO>
Jlink USB Serial Number: XXXXXXXXXX
Connected to Jlink Device:
  Name:'J-Link LPCXpresso V2 compiled Apr  4 2019 16:54:03'
  S/N:XXXXXXXX
  Firmware: J-Link LPCXpresso V2 compiled Apr  4 2019 16:54:03
  Requested/Set TCK: 2000kHz/65534kHz
Jlink: Select SWD
SWD-DP with ID 0x6BA02477
Loading module "jtag" <VERSION_INFO>
Loading module "xtensa" <VERSION_INFO>
Starting thread 'GDBStub'
Opened GDB socket at port 20000
Initialize XDM driver
Warning: Warning: DAP Reset request failed! Ignoring...
```

Note: Some warning messages are expected and can be ignored. If you receive an error initializing the XDM driver, initialize and start the DSP core before debugging. For details on initializing and debugging, see Initialize DSP Core and Link DSP Profiles. For details on xt-ocd runtime options and configuration, see Chapter 7 of the Xtensa Debug Guide, available in **Help > PDF Documentation**.

Parent topic: [Run and Debug DSP Demo using Xplorer IDE](#)

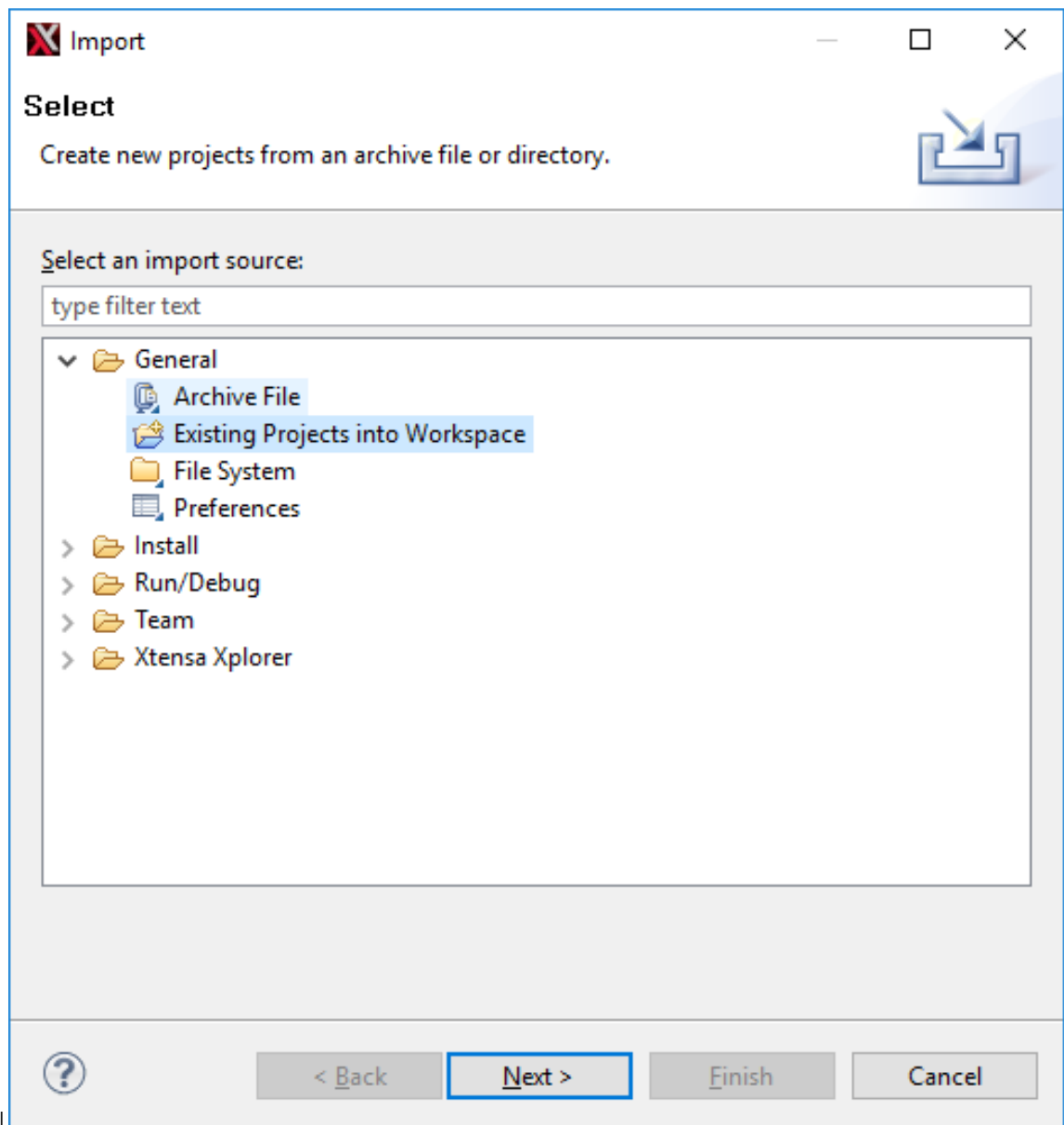
Prepare DSP Core for ‘Hello World’ The RT600 SDK provides a collection of DSP example applications located in `boards/evkmimxrt685/dsp_examples/`. Each DSP example has two source directories, one for the Arm Cortex-M33 core (‘cm33’) and one for the DSP HiFi4 core (‘dsp’).



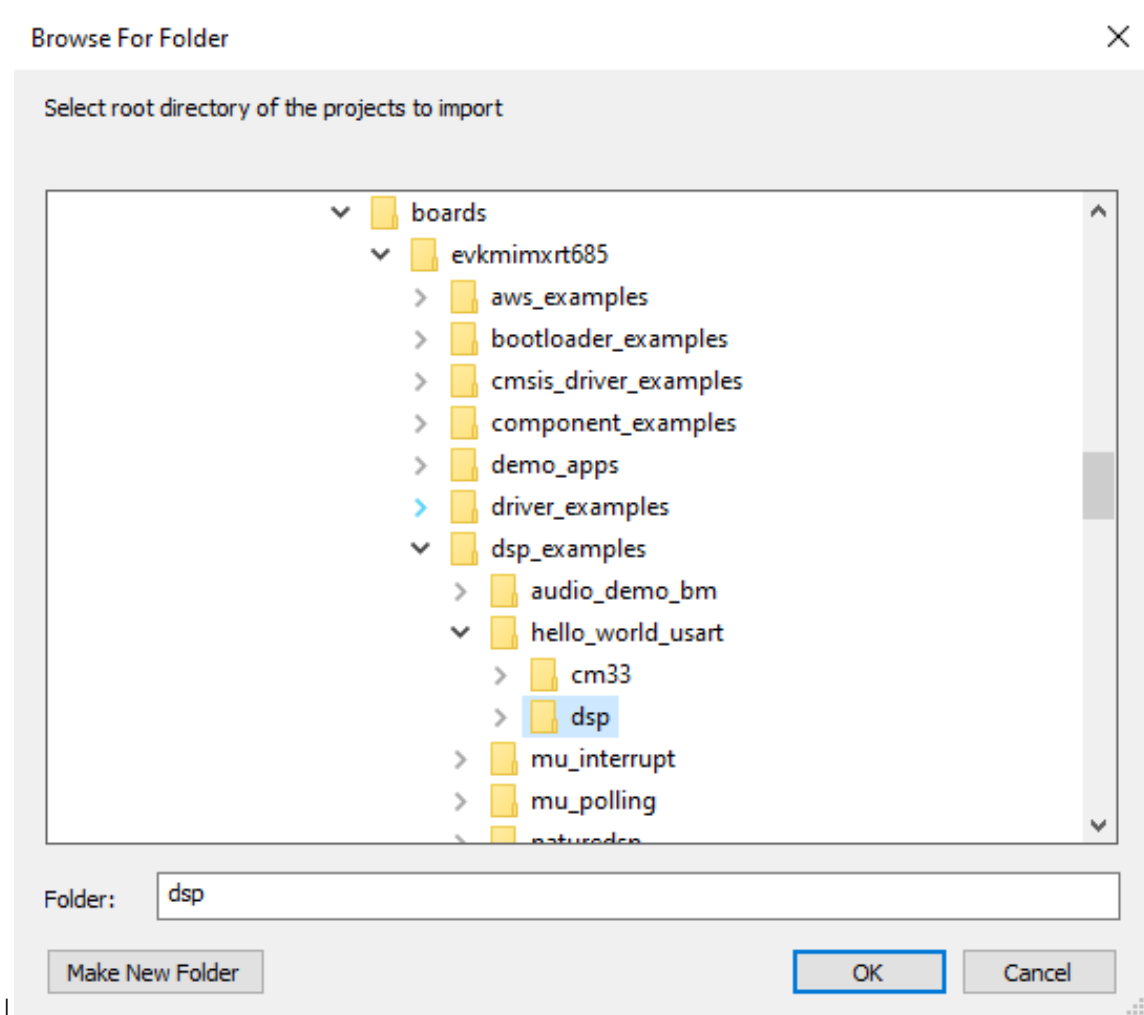
The projects for different supported toolchains are build in the above directories. For the DSP example above, the ‘xcc’ project builds on the command line and the ‘xtensa’ directory is an Xplorer IDE project.

To run the ‘Hello World’ demo, import the SDK sources into the Xplorer IDE.

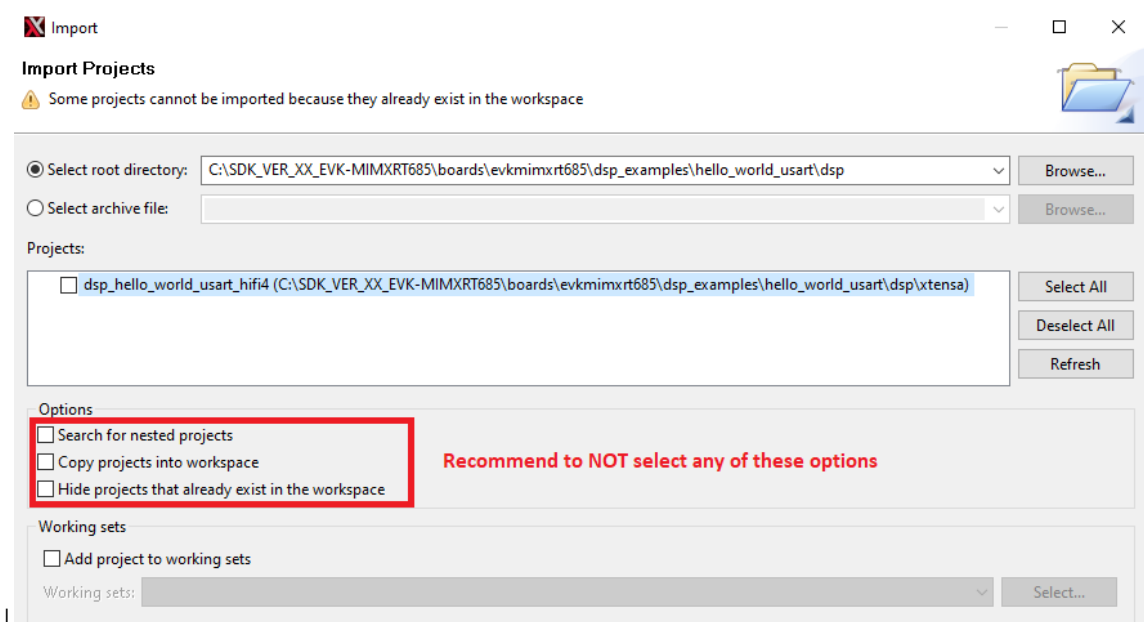
1. Select **File > Import > General > Existing Projects into Workspace**.



2. Select the SDK directory `<SDK_ROOT>\boards\evkmimxrt685\dsp_examples\hello_world_usart\dsp\xtensa` as root directory.

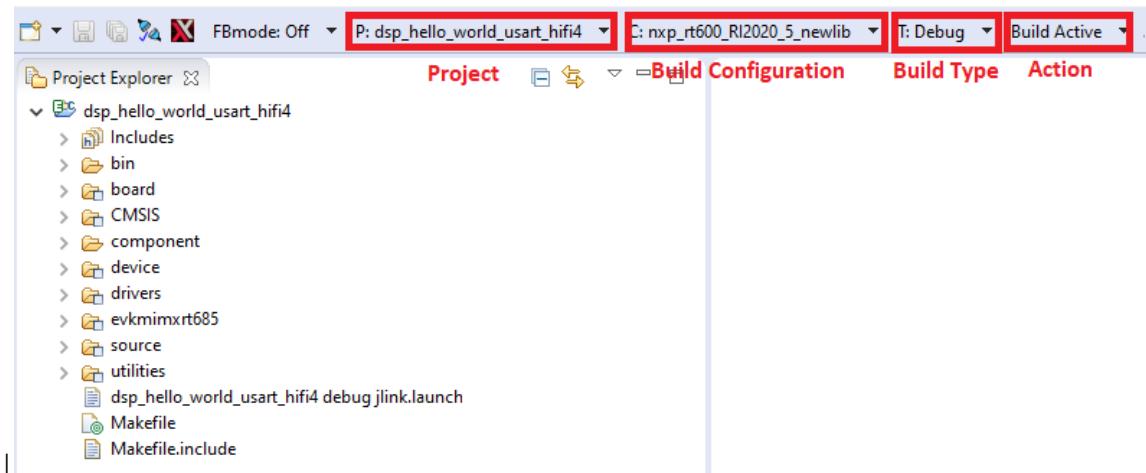


3. Leave all the other check boxes blank.

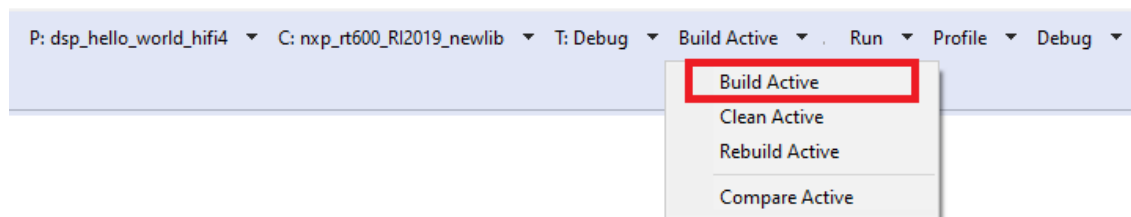


Once imported, the 'dsp_hello_world_usart_hifi4' appears in the Project Explorer.

4. To make a build selection for the project and hardware target configuration, use the drop-down buttons on the menu bar.

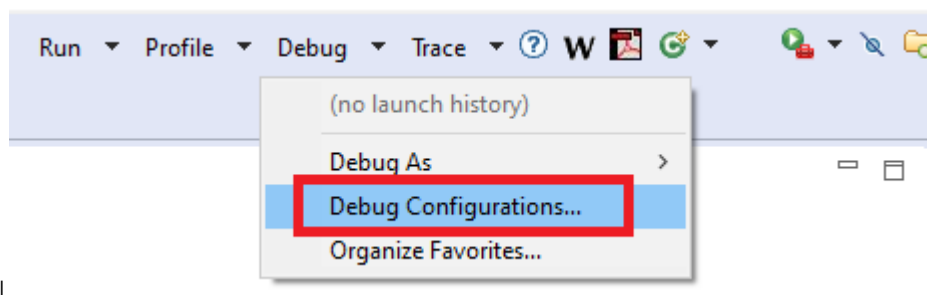


5. To build the project for debug, profile, or trace, use the action buttons on the right side of the menu bar.



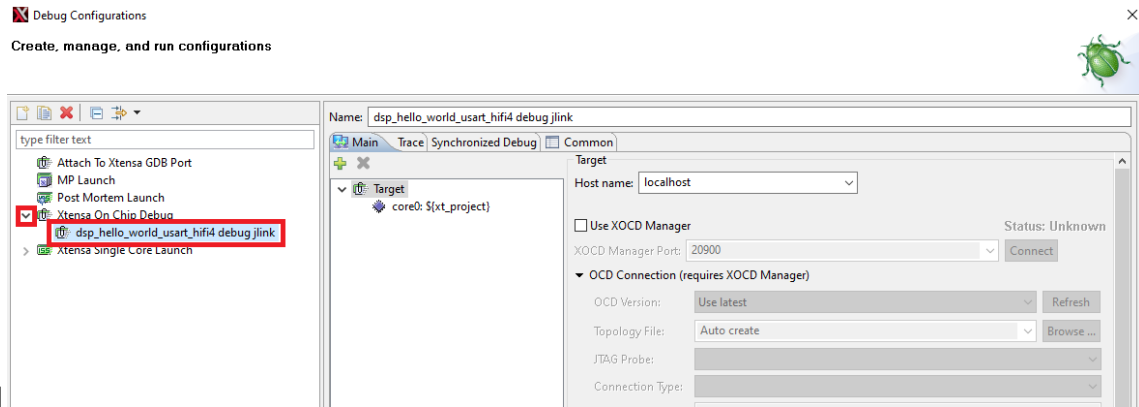
A default debug configuration is provided by the SDK project, which utilizes the on-chip debugger.

6. To choose the configuration, select the **Debug Configurations** menu item.

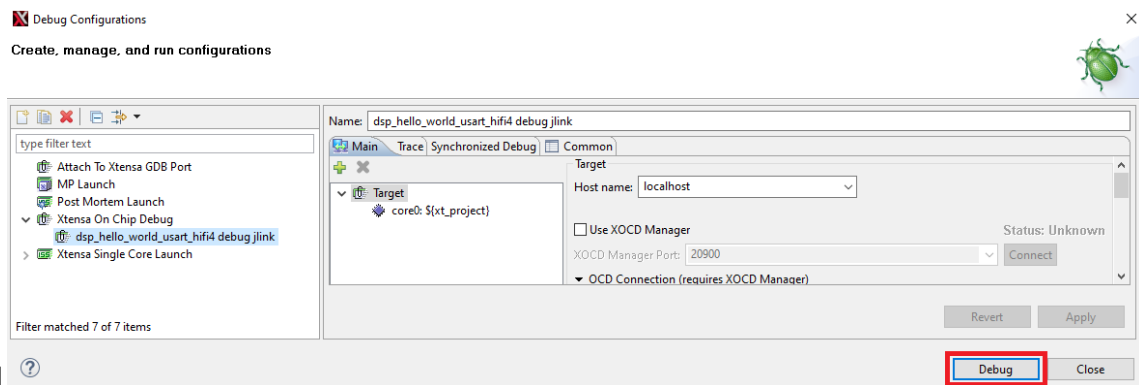


The ****Debug Configurations**** dialog box appears.

7. Expand the **Xtensa On Chip Debug** tree option and select 'dsp_hello_world_hifi4_debug_jlink'.

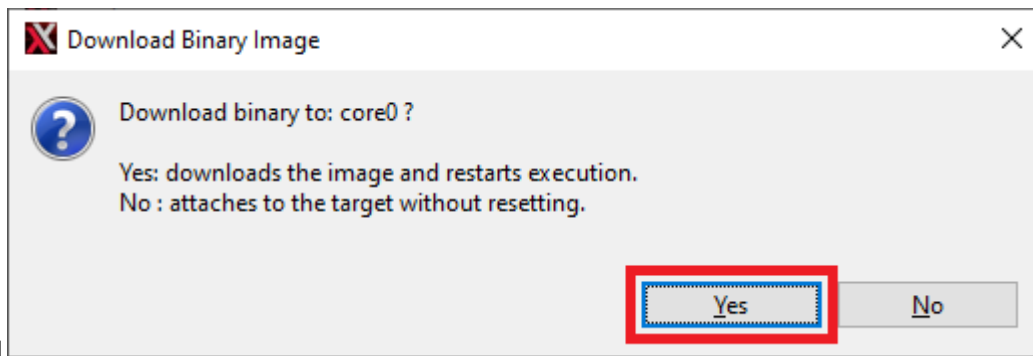


8. Click the **Debug** button. The actual debug on the chip initiates.



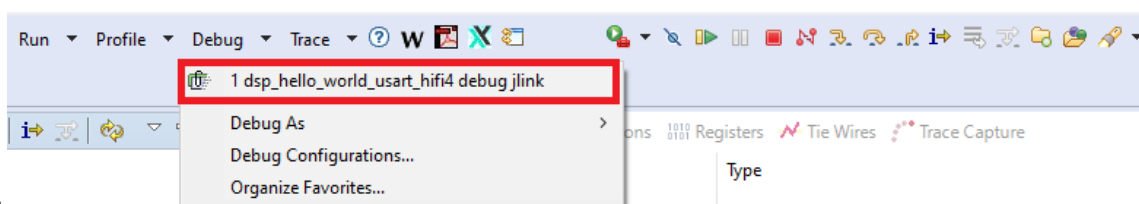
The Xplorer IDE prompts whether binaries should download to the hardware.

9. Select **Yes**.



10. The Xplorer IDE transitions to the **Debug** perspective after the binary download.

Note: After initial configuration, it is possible to select the same debug configuration as in Figure 8.



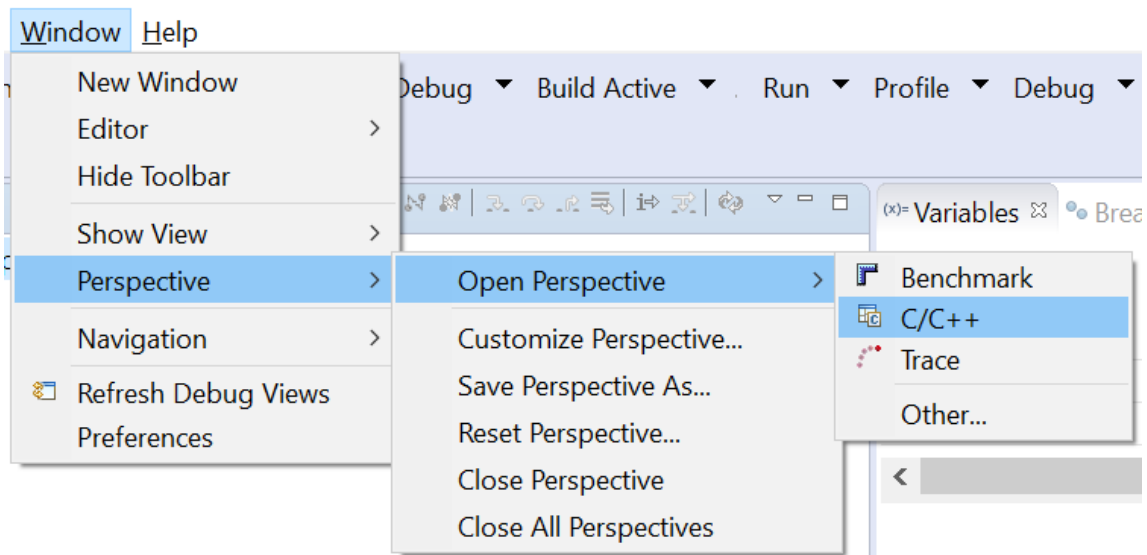
The **Debug** perspective appears as in [Figure 9](prepare_dsp_core_for_hello_world.md#GVDVWQC).

The program stops at the start of `main()` function. To run the program, click the **Resume** or **Stepping through** icon button as shown in [Figure 10](prepare_dsp_core_for_hello_world.md#LKWEUGG).

- After resuming / stepping through the `printf` statement, the following output appears in the **Console** view of the IDE.

```
Hello World running on core nxp_rt600_RI2020_5_newlib
```

To return to the default IDE layout after the debugging completes, select the previous code perspective.



Parent topic: [Run and Debug DSP Demo using Xplorer IDE](#)

Run and Debug DSP Audio Framework The DSP audio framework demo consists of separate applications that run on the Arm core and DSP core. The Arm application runs a command shell and relays the input requests to the DSP application using RPMsg-Lite.

EVK Board Setup for Audio Demo The DSP audio demo is tested against EVK-MIMXRT685 Rev E and requires UART for serial console.

For the codec to output audio properly, attach one jumper on the board as follows:

JP7-1 <==> JP8-2

Note: DSP operates DMA and audio peripherals same as CM33 side. Jumper settings, I2S configs, or pin mux settings are all same with CM33 side. For information on steps to operate I2S, DMIC and DMA, see the SDK CM33 side driver examples. `SDK\boards\evkmimxrt685\driver_examples\i2s;`

Note: Jumper settings are different on different version of EVKs or validation boards. The above mentioned setting is for SDK 2.8.0 and Rev E EVK or later only. For old version of boards or SDKs, double check the SDK driver examples for correct settings for the pin mux and jumper settings.

The demo uses the UART for console input and output. Connect the EVK board to a PC via the USB debug interface (J5) and open up a serial interface on your PC using a terminal tool such as PuTTY on Windows or screen on Linux.

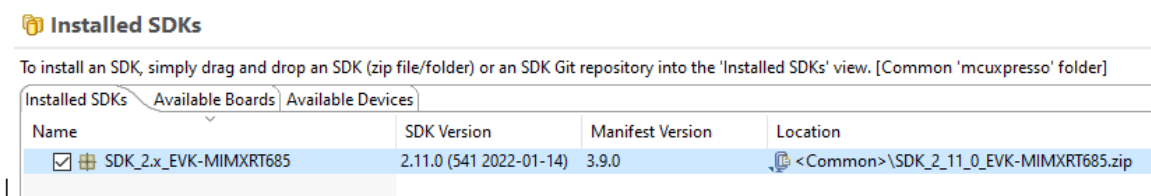
Parent topic:Run and Debug DSP Audio Framework

Debug Audio Demo To debug this DSP application, set up and execute the Arm application in a desired environment. For more information on Arm development environment options, see ‘Getting Started with MCUXpresso SDK for EVK-MIMXRT685.pdf.

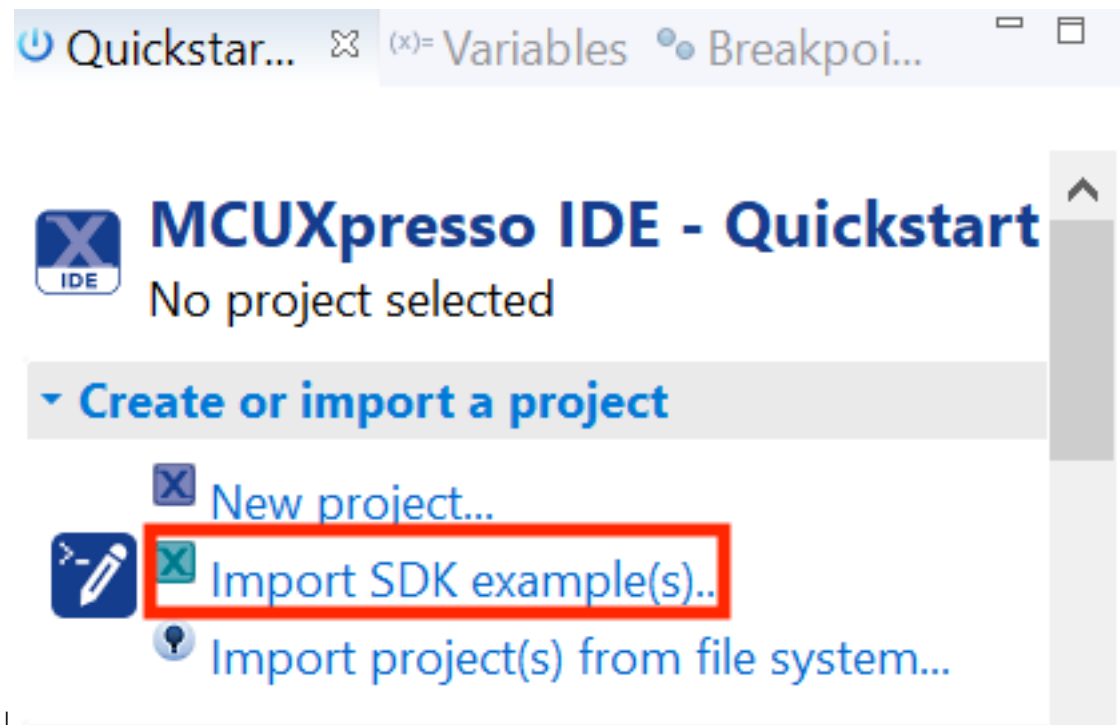
The following example uses the NXP MCUXpresso IDE for the Arm environment.

To debug the audio demo, perform the following steps.

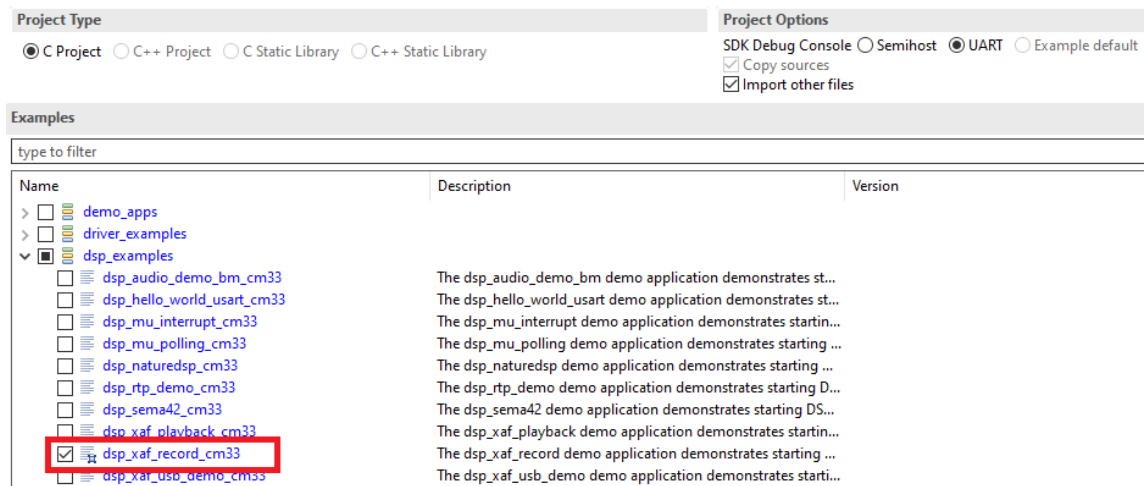
1. Install the MCUXpresso SDK for RT600 into the MCUXpresso IDE using the Installed SDK panel as shown in



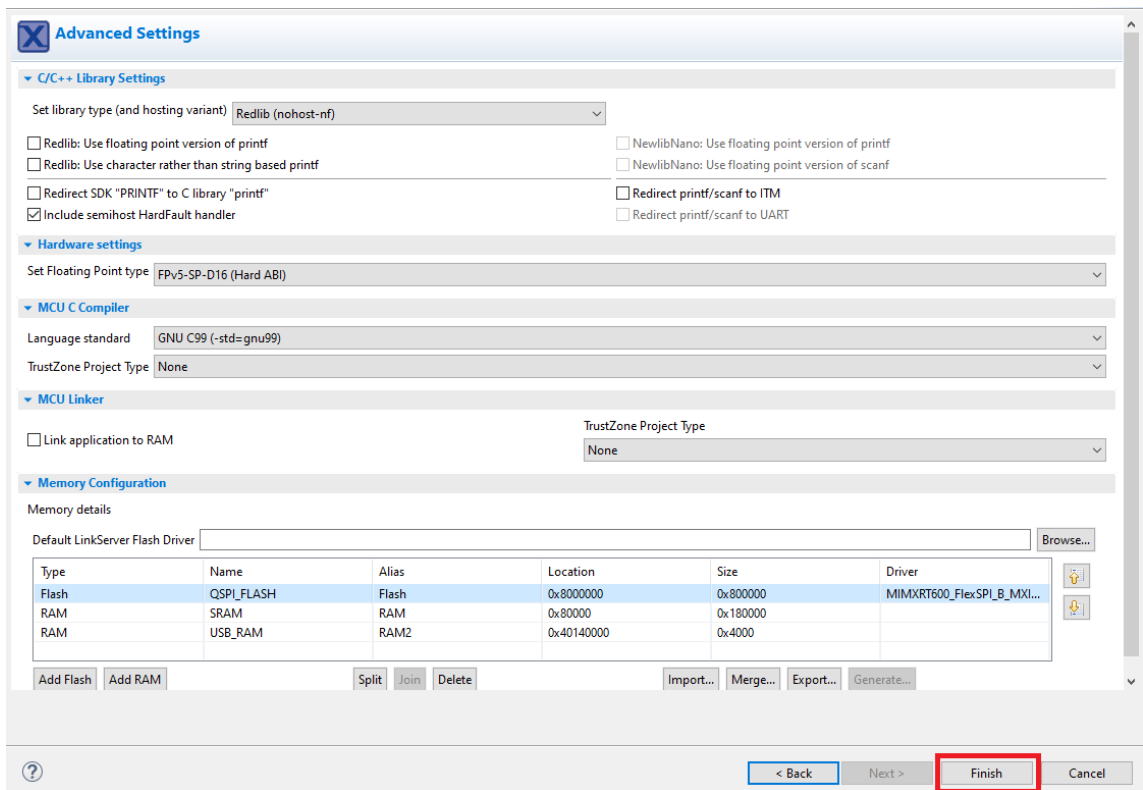
2. To import an example from the installed SDK., use the **Import SDK examples** link in the **Quickstart** panel on the lower left of the screen.



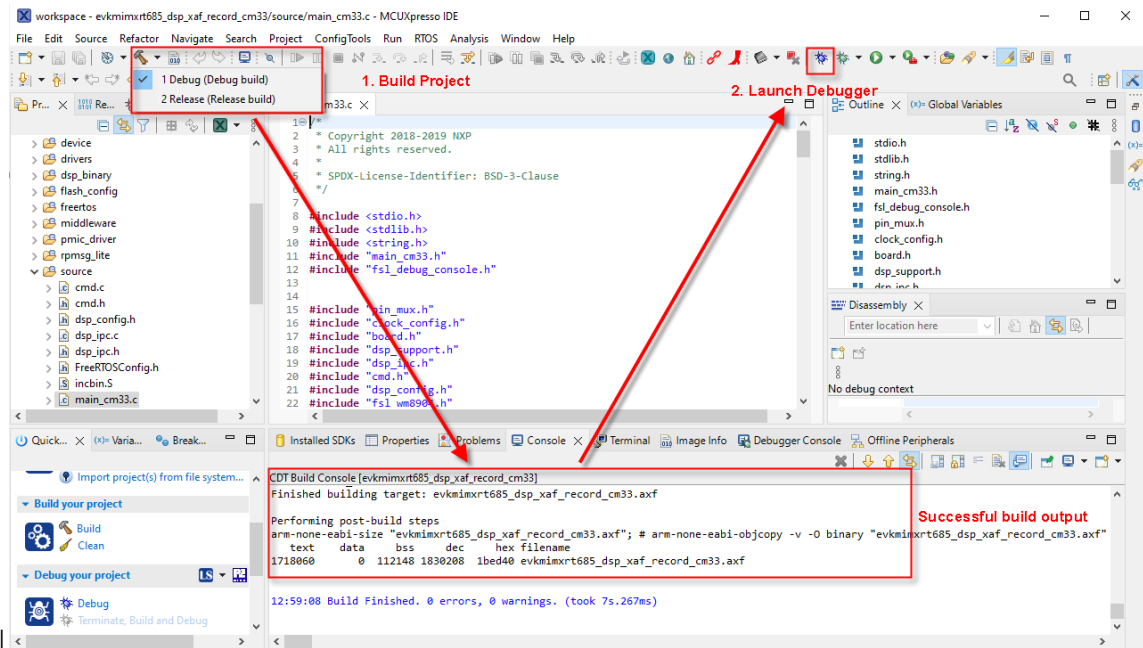
3. Select the ‘dsp_xaf_record_cm33’ example for Cortex-M33 core.



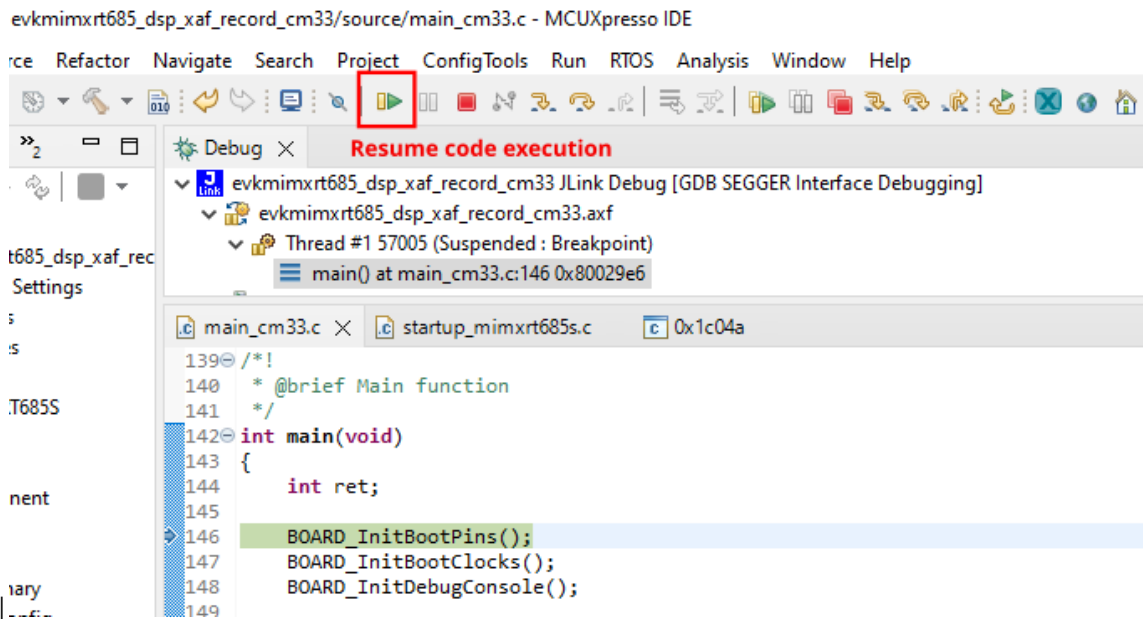
4. Click the **Finish** button.



5. Build the project and launch the debugger on success.



6. Use the debug toolbar to resume the code execution.



7. Observe serial terminal output with shell prompt.

```
*****
DSP audio framework demo start
*****
Configure WM8904 codec
DSP image copied to DSP TCM
[APP_DSP_IPC_Task] start
[APP_Shell_Task] start
Copyright 2022 NXP
>>
```

8. Using the Xplorer IDE, load and execute xaf_record using the steps described in Prepare DSP Core for 'Hello World'.

- After the DSP application runs, use the serial shell to invoke the 'record_dmic [language]' command. For information on the supported languages, check VIT ReleaseNotes.txt. Using the serial shell creates an audio pipeline that captures microphone audio, perform voice recognition (VIT), and playback via the codec speaker line out (J4 on the EVK).

```
>> help
"help": List all the registered commands
"exit": Exit program
"version": Query DSP for component versions
"record_dmic": Record DMIC audio , perform voice recognition (VIT) and playback on codec
USAGE: record_dmic [language]
```

For voice recognition say supported the wake-word and in 3 s say the frame supported command. If selected model contains strings, then the wake-word and the list of commands appears in the console.

Note: this command does not return to the shell

- The serial terminal shows the IPC communications to set up an audio device..

```
>> record_dmic en
Command not recognized. Enter 'help' to view a list of available commands.
>> record_dmic en
[CM33 CMD] Setting VIT language to en
[DSP Main] Number of channels 2, sampling rate 16000, PCM width 16
[CM33 CMD] [APP_DSP_IPC_Task] response from DSP, cmd: 19, error: 0
[DSP Record] Audio Device Ready
[CM33 CMD] DSP DMIC Recording started
[DSP VoiceSeeker] VoiceSeekerLight_GetRequiredHeapMemoryBytes: 51120 bytes
[CM33 CMD] To see VIT functionality say wakeword and command
[DSP VoiceSeeker] VoiceSeekerLight_Create: voiceseekeer_status = 0
[DSP VoiceSeeker] VoiceSeekerLight_GetLibVersion: v0.6.0
```

The VIT wake-word and supported commands appear in the serial console.

The serial console prints the detected wake-word and commands.

For more information on configuration and using the Audio Framework demo, see the file `\boards\evkmimxrt685\dsp\_examples\xaf\_record\cm33\readme.txt`.

For more details about VIT which supports English and Mandarin models, see `\middleware\vit\HIFI4\Doc\VIT\_Integration\_Guide.pdf`.

Parent topic: Run and Debug DSP Audio Framework

Parent topic: [Run and Debug DSP Demo using Xplorer IDE](#)

Launch DSP Application from Arm Core In the previous example, the Arm application and DSP application are independently loaded and debugged. This section list the steps to produce one Arm application binary that includes and starts the DSP application without the use of a debugger or a loader.

The Arm core application for each DSP demo uses a global preprocessor macro to control loading of the DSP binary application:

DSP_IMAGE_COPY_TO_RAM

When this macro is set to '1'/TRUE (default value), it instructs the DSP demo application to do the following:

- Link the DSP application binary images into the Arm binary
- Copy the DSP application images into RAM on program boot
- Initialize the DSP to run from the RAM image

Note: When modifying the Arm project, make sure to supply the global preprocessor macro to both the C compiler and assembler.

To build the DSP application image for the Arm application, select the **Release** target option in the Xplorer IDE. For more information on building with min-rt LSP, see section Link DSP Profiles.



Three DSP binaries are generated and are loaded into different TCM or SRAM address segments:

- <SDK_ROOT>/boards/evkmimxrt685/dsp_examples/xaf_record/dsp/binary/**dsp_data_release.bin**
- <SDK_ROOT>/boards/evkmimxrt685/dsp_examples/xaf_record/dsp/binary/**dsp_text_release.bin**
- <SDK_ROOT>/boards/evkmimxrt685/dsp_examples/xaf_record/dsp/binary/**dsp_ncache_release.bin**

Note: Depending on the environment, there might be a need to copy the binary images into the Arm application workspace.

Parent topic: [Run and Debug DSP Demo using Xplorer IDE](#)

Run and Debug from Command-Line Environment / LINUX

RT600 SDK has been configured to be as flexible to support multiple toolchains, including the Arm GCC and XCC command-line environments. The principles and essentials are still the same as with the IDE. The command-line environment settings are nearly identical between WIN32 and LINUX, with few different path settings.

Build and Debug Arm Application The Arm application requires the GNU Arm Embedded Toolchain and CMake version 3.x for command-line compile and linking. For more information on installation and configuration of required build tools for command-line development, see the *Getting Started with MCUXpresso SDK for EVK_MIMXRT685.pdf* in the <SDK_ROOT>/docs/ directory.

To build and debug:

1. Launch a command prompt / terminal and change directory to the xaf_record application.

```
user@linux:~/SDK/boards/evkmimxrt685/dsp_examples/xaf_record/cm33/armgcc$ ls -l
build_all.bat
build_all.sh
build_debug.bat
build_debug.sh
build_flash_debug.bat
build_flash_debug.sh
build_flash_release.bat
build_flash_release.sh
build_release.bat
build_release.sh
clean.bat
clean.sh
CMakeLists.txt
```

2. Use .bat files to build the configuration on Windows, and .sh files on Linux/UNIX.

```
user@linux:~/SDK/boards/evkmimxrt685/dsp_examples/xaf_record/cm33/armgcc$ ./build_debug.sh
...
[100%] Linking C executable debug/dsp_xaf_record_cm33.elf
[100%] Built target dsp_xaf_record_cm33.elf
```

3. Launch the GDB server.

```
user@linux:/opt/JLink$ ./JLinkGDBServerCLExe -device MIMXRT685S_M33 -if SWD
SEGGER J-Link GDB Server V6.46j Command Line Version
...
Listening on TCP/IP port 2331
Connecting to target...Connected to target
Waiting for GDB connection...
```

4. Connect with GDB to the device and load Arm application.

```
user@jlinux:~/SDK/boards/evkmimxrt685/dsp_examples/xaf_record/cm33/armgcc$ arm-none-eabi-
→gdb debug/dsp_xaf_record_cm33.elf
...
Reading symbols from debug/dsp_xaf_record_cm33.elf...
(gdb) target remote localhost:2331
Remote debugging using localhost:2331
0x1301ec7a in ?? ()
(gdb) mon reset
Resetting target
(gdb) load
Loading section .flash_config, size 0x200 lma 0x7f400
Loading section .interrupts, size 0x130 lma 0x80000
Loading section .text, size 0xe330 lma 0x80130
Loading section CodeQuickAccess, size 0x52c lma 0x8e460
Loading section .ARM, size 0x8 lma 0x8e98c
Loading section .init_array, size 0x4 lma 0x8e994
Loading section .fini_array, size 0x4 lma 0x8e998
Loading section .data, size 0x104 lma 0x8e99c
Start address 0x801e4, load size 60576
Transfer rate: 272 KB/sec, 5506 bytes/write.
(gdb) b main
Breakpoint 1 at 0x808f2: file /SDK/boards/src/dsp_examples/xaf_record/cm33/main_cm33.c, line 161.
(gdb) c
Continuing.
Breakpoint 1, main ()
    at /SDK/boards/src/dsp_examples/xaf_record/cm33/main_cm33.c:161
161     BOARD_InitHardware();
```

Parent topic:[Run and Debug from Command-Line Environment / LINUX](#)

Build and Debug DSP Application The Xtensa command-line toolchain is installed as part of the Xplorer IDE. The tools can be optionally installed on a new Windows or Linux system without the IDE using the redistributable compressed file found at: <XTENSA_ROOT>/XtDevTools/downloads/RI-2023.11/tools/. For more information, see [Install Xtensa On Chip Debugger Daemon](#).

In order to use the command-line tools, some environment variables must be set up for use with the cmake build scripts:

```
# Add tools binaries to PATH. Assume ~/xtensa/ is install root - please adjust accordingly.
export PATH=$PATH:~/xtensa/XtDevTools/install/tools/RI-2023.11-linux/XtensaTools/bin
# (Optional) Use environment variable to control license file
# NOTE: ~/.flexlmrc will override this selection. Please delete that file before proceeding.
export LM_LICENSE_FILE=~/.RT600.lic
# Setup env vars needed for compile and linking
export XCC_DIR=~/.xtensa/XtDevTools/install/tools/RI-2023.11-linux/XtensaTools
export XTENSA_SYSTEM=~/.xtensa/XtDevTools/install/builds/RI-2023.11-linux/
npx_rt600_RI23_11_newlib/configexport XTENSA_CORE=npx_rt600_RI23_11_newlibb
```

Note: On Windows, you can use the ‘setx’ command instead of the ‘export’ command to set the environment variables.

1. Use the batch/shell script to build out the DSP application from the command line, in the ‘xcc’ directory:

```
user@linux:~/SDK/boards/evkmimxrt685/dsp_examples/xaf_record/dsp/xcc$ ./build_debug.sh
...
[100%] Built target dsp_xaf_record_hifi4.elf
```

Note: Some warnings during the linking process (floating-point ABI) may appear. However, the warnings may be ignored.

2. Launch xt-ocd debugging server (replace topology.xml with your custom version – see section 1.5 of this document):

```
user@linux:/opt/Tensilica/xocd-14.11$ ./xt-ocd.exe -c topology.xml
```

Note: If the Arm core fails to initialize the DSP, the xt-ocd daemon may fail to start. Therefore, the Arm core must initialize the DSP first.

3. Connect with Xtensa GDB to the device and execute the DSP application:

```
user@linux:/SDK/boards/evkmimxrt685/dsp_examples/xaf_record/dsp/xcc$ xt-gdb
debug/dsp_xaf_record_hifi4.elf
GNU gdb (GDB) 7.11.1 <Xtensa Tools VERSION NUMBER>
...
Reading symbols from debug/dsp_xaf_record_hifi4.elf...done.
(xt-gdb)
(xt-gdb) target remote localhost:20000
Remote debugging using localhost:20000
__DoubleExceptionVector ()
    at /home/xpgcust/tree/RI-2023.11/ib/tools/swtools-x86_64-linux/xtensa-elf/src/xos/src/xos_
↳ vectors.S:216
216 /home/xpgcust/tree/RI-2023.11/ib/tools/swtools-x86_64-linux/xtensa-elf/src/xos/src/xos_
↳ vectors.S: No such file or directory.
(xt-gdb) reset
__ResetVector ()
    at /home/xpgcust/tree/RI-2023.11/ib/tools/swtools-x86_64-linux/xtensa-elf/src/xtos/xea2/reset-
↳ vector-xea2.S:71
71 /home/xpgcust/tree/RI-2023.11/ib/tools/swtools-x86_64-linux/xtensa-elf/src/xtos/xea2/reset-
↳ vector-xea2.S: No such file or directory.
(xt-gdb) load
Loading section .rtos.rodata, size 0x80 lma 0x200000
Loading section .rodata, size 0x17d50 lma 0x200080
```

(continues on next page)

(continued from previous page)

```

Loading section .text, size 0x633f0 lma 0x217dd0
Loading section .rtos.percpu.data, size 0x4 lma 0x27b1c0
Loading section .data, size 0x110c lma 0x27b1d0
Loading section NonCacheable, size 0x2960 lma 0x20040000
Loading section .Level3InterruptVector.literal, size 0x4 lma 0x24000000
Loading section .DebugExceptionVector.literal, size 0x4 lma 0x24000004
Loading section .NMIXExceptionVector.literal, size 0x4 lma 0x24000008
Loading section .ResetVector.text, size 0x13c lma 0x24020000
Loading section .WindowVectors.text, size 0x16c lma 0x24020400
Loading section .Level2InterruptVector.text, size 0x1c lma 0x2402057c
Loading section .Level3InterruptVector.text, size 0xc lma 0x2402059c
Loading section .DebugExceptionVector.text, size 0xc lma 0x240205bc
Loading section .NMIXExceptionVector.text, size 0xc lma 0x240205dc
Loading section .KernelExceptionVector.text, size 0xc lma 0x240205fc
Loading section .UserExceptionVector.text, size 0x18 lma 0x2402061c
Loading section .DoubleExceptionVector.text, size 0x8 lma 0x2402063c
Start address 0x24020000, load size 520016
Transfer rate: 8 KB/sec, 10612 bytes/write.
(xt-gdb) b main
Breakpoint 1 at 0x21ab5b: file /SDK/boards/src/dsp_examples/xaf_record/hifi4/xaf_main_hifi4.c,
↳ line 366.
(xt-gdb) c
Continuing.
Breakpoint 1, main ()
    at /SDK/boards/src/dsp_examples/xaf_record/hifi4/xaf_main_hifi4.c:366
366  xos_start_main("main", 7, 0);
(xt-gdb) c
Continuing.

```

Note: You can use the gdb command ‘set substitute-path’ to map the missing symbols from the toolchain libraries. For example:

```

set substitute-path /home/xpgcust/tree/RI-2023.11/ib/tools/swtools-x86_64-linux ~/xtensa/tools/RI-
↳ 2023.11-linux/XtensaTools

```

For more information on xt-gdb, see the Cadence GNU Debugger User’s Guide and the Cadence Xtensa Debug Guide. The documents are available at:

- [~/xtensa/XtDevTools/downloads/RI-2023.11/docs/gnu_gdb_ug.pdf](#)
- [~/xtensa/XtDevTools/downloads/RI-2023.11/docs/xtensa_debug_guide.pdf](#)

Parent topic: [Run and Debug from Command-Line Environment / LINUX](#)

HiFi4 System Programming

This section provides more examples, tips, and some best practices about HiFi4 programming on RT600 EVKs. It focuses more on RT6xx and SDK. For general HiFi programming, see the Xtensa IDE documents. You can find them in the directory **Xtensa Xplorer IDE menu Help > PDF Documentation**.

The following are some frequently used references:

- Xtensa Instruction Set Architecture (ISA) Reference Manual: Architecture/ high-level overview.
- HiFi 4 DSP User’s Guide: Most useful reference manual for DSP programmer. It has all details about HiFi4 instructions and intrinsics, as well as some algorithm optimization techniques.
- Xtensa XOS Reference Manual: XOS is the default and native embedded kernel for Xtensa HiFi cores. SDK examples use XOS as well.

- Xtensa System Software Reference Manual: XTOS, also known as the basic runtime and handlers, has been depreciated and moved toward XOS. However, the Xtensa Processor Hardware Abstraction Layer/ HAL is still very useful in many perspectives. SDK examples use HAL functions.
- Xtensa Linker Support Packages (LSPs) Reference Manual and GNU Linker User's Guide: Both documents are useful for understanding the HiFi program linker and the memory map.

Specifically for RT6xx, the user manual and the data sheet are the most important references. All product specifications are found in the user guide and data sheet documents.

HiFi4 Boot Loader and Memory Map This section provides an overview of:

- HiFi4 Boot Loader
- Linker and Memory Map
- Cache and Data Exchange Memory Partitions
- Boot or Run from Flash

HiFi4 Boot Loader For better power efficiency, by default the HiFi4 DSP is powered off when RT6xx powers up. To boot up, Cortex M33 acts as master core to configure DSP local memories, clocks, load DSP images, and so on. SDK has wrapped up this part as HiFi4 Boot Loader or the DSP driver. The essentials are located in: <SDK path>\devices\MIMXRT685S\drivers\fsl_dsp.h & fsl_dsp.c.

For each DSP example, it also provides two more implementation files for detailed configurations: <SDK path>\boards\evkmimxrt685\dsp_examples\<any dsp example>\cm33\dsp_support.h & dsp_support.c

Below is the DSP boot procedure with more elaborations.

To run DSP at full power, for example, 600 MHz, SoC Vddcore is set to 1.1 V. If full power is not required, for example, to run DSP at the half speed at 300 MHz, then Vddcore only requires 0.8 V. RT6xx EVK integrates NXP PCA9420 PMIC for power management and by default Vddcore is set to 1.0 V.

Therefore, PMIC is initialized for better power management. For details on Vddcore and DSP frequency operating conditions, see any dsp_example\cm33\pmic_support.c BOARD_SetPmicVoltageForFreq(), or see the data sheet, section 13.1, General Operating Conditions.

```
/* Initialize PMIC PCA9420 */
BOARD_InitPmic();
/* Configure PMIC Vddcore value according to main/dsp clock. */
BOARD_SetPmicVoltageForFreq(CLOCK_GetMainClkFreq(), CLK_600MHZ);
```

It is possible to clock DSP from various clock sources. The DSP PLL for full power and can also run at FFRO low-frequency clocks to save the power.

```
/* Enable DSP PLL clock 594MHz. */
CLOCK_InitSysPfd(kCLOCK_Pfd1, 16);
/* Let DSP run on DSP PLL clock with divider 1 (594Mhz). */
CLOCK_AttachClk(kDSP_PLL_to_DSP_MAIN_CLK);
CLOCK_SetClkDiv(kCLOCK_DivDspCpuClk, 1);
```

As Cortex M33 and SRAM are clocked at lower speed/ max frequency at 300 MHz, set the DSP AHB bus clock divider as 2.

```
CLOCK_SetClkDiv(kCLOCK_DivDspRamClk, 2);
```


If DSP clock is running at 300 MHz or lower, it is more efficient to use divider as 1. For divider as 1, note that an extra register `SYSCTL0_PACKERENABLE` is set. For more details, see the user manual section 4.5.2.18 DSP Main Ram Clock Divider and section 4.5.5.3 Packer Enable.

```
/* This is a quick register setting example for secure mode */
/* SYSCTL0->PACKERENABLE = 0x4 */
```

Power up TCM/ DSP local memories and cache, supply clock, and reset peripherals.

```
/* Initializing DSP core */
DSP_Init();
```

For SDK DSP examples, split the DSP images into three parts.

One is for vectors and critical sections sitting on TCM/ DSP local memories. The second one is for normal code and data sections sitting on SRAM, and the final is for non-cached DSP initialized data in SRAM.

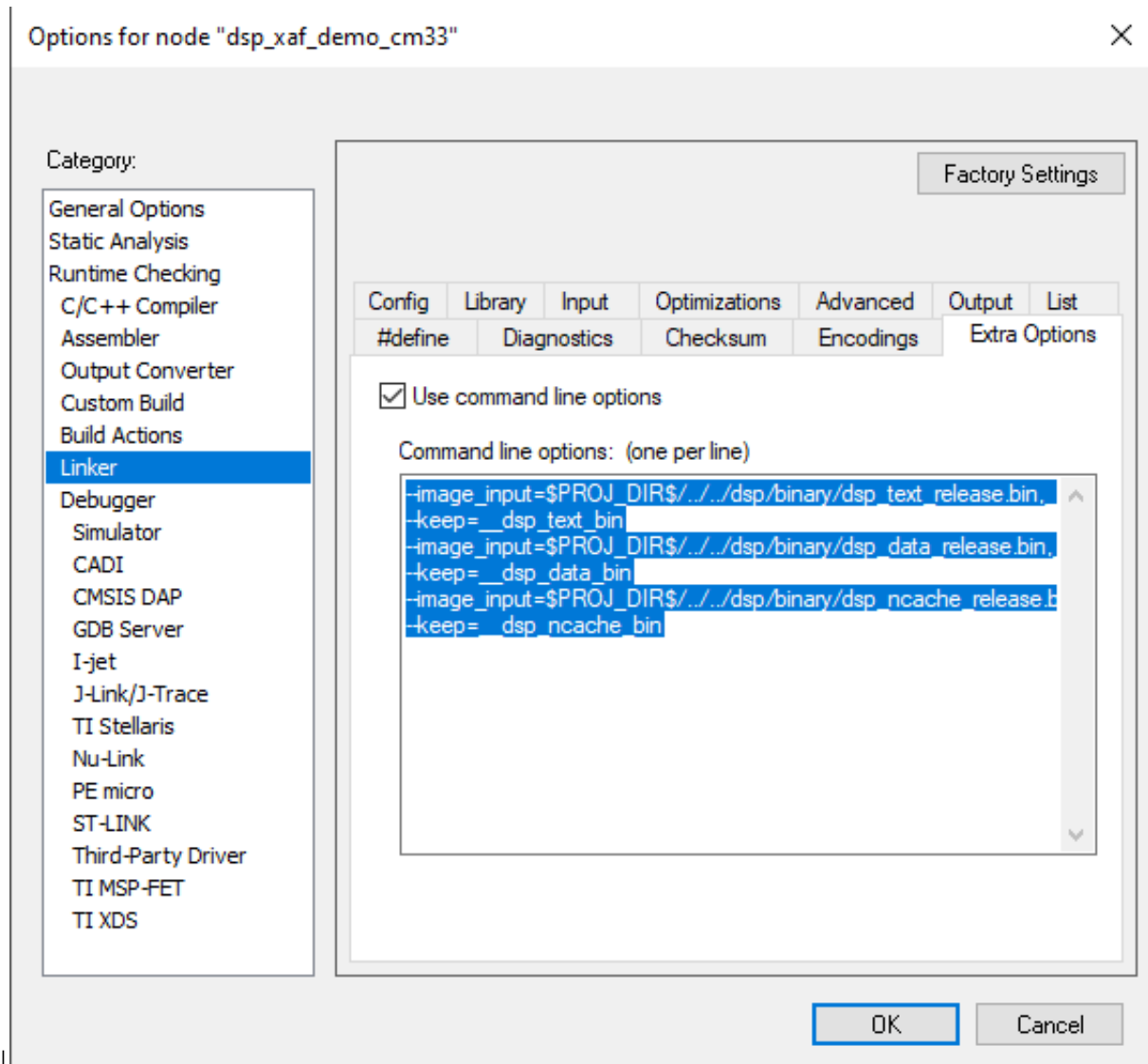
Here, Cortex M33 load those binaries to its destination. When the DSP program is debugged, it is possible to load DSP binaries from the Xtensa Xplorer IDE, as described in Prepare DSP Core for 'Hello World'. To load binaries, remove the `DSP_IMAGE_COPY_TO_RAM` compilation flag or set it to 0. By default, the compilation flag is set to 1 and always load the DSP images.

```
#if DSP_IMAGE_COPY_TO_RAM
/* Copy application from RAM to DSP_TCM */
DSP_CopyImage(&tcm_image);
/* Copy application from RAM to DSP_RAM */
DSP_CopyImage(&sram_image);
/* Copy application from RAM to DSP_Uncached RAM */
DSP_CopyImage(&ncache_image);
#endif
```

The DSP stall register `SYSCTL0_DSPSTALL` controls the HiFi4 operation. Start the DSP and run it.

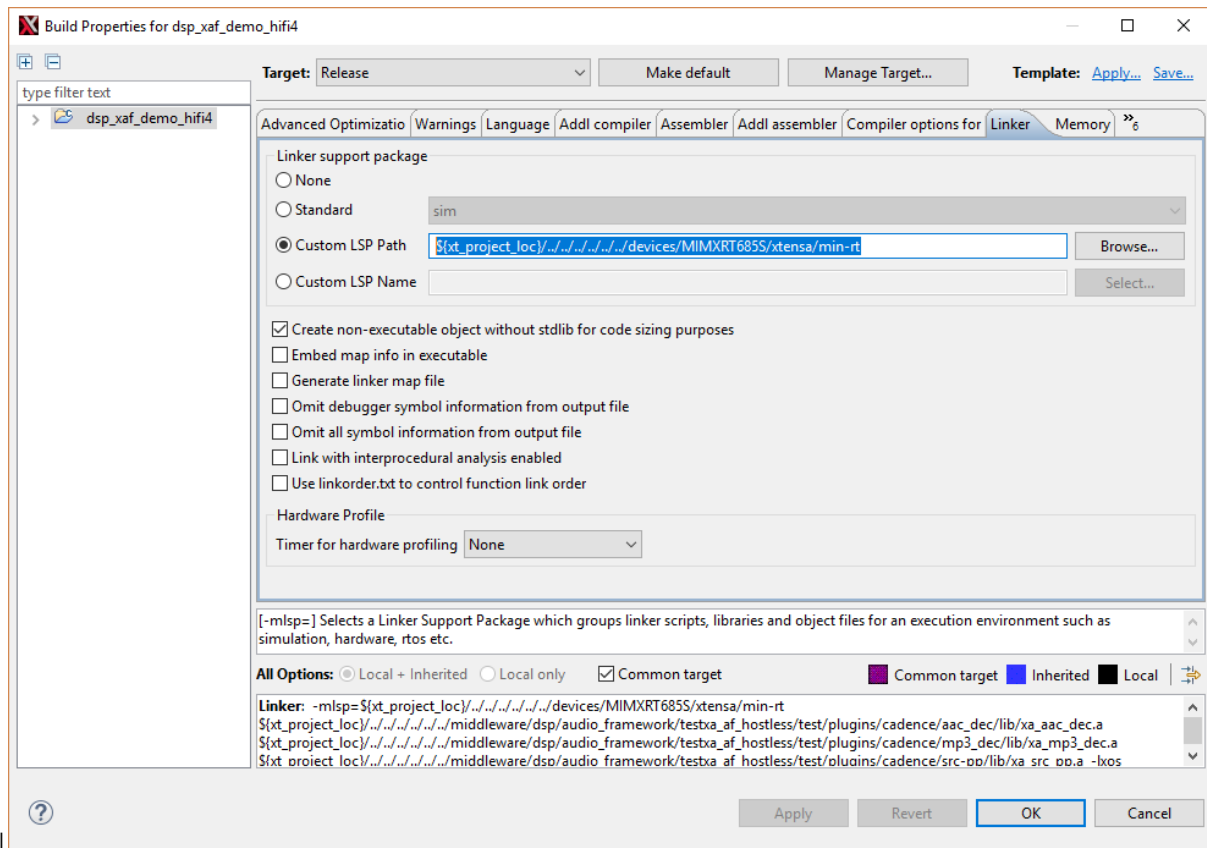
```
/* Run DSP core */
DSP_Start();
```

The post build scripts create the DSP images. For details, see `Makefile.include` in any DSP example. To reduce the image size and make image copy more efficient, they are split into SRAM part; TCM part, and uncached SRAM part. DSP images are set and linked into Cortex M33 side. For IAR, the linker is set in **Project Options > Linker > Extra Options**. For ArmGCC or Linux environment, set in any DSP example\cm33\incbin_gcc.S.



Parent topic:HiFi4 Boot Loader and Memory Map

Linker and Memory Map When importing the SDK DSP examples, by default the mode is set as Release. The default mode means that the images must be built in Release mode with 'min-rt' Linker Support Package/ LSP. To double-check, open **SDK DSP examples > Build Properties > Linker**.



SDK provides three different LSPs.

- **‘min-rt’ for Release mode** - ‘min-rt’ eliminates all unnecessary debug info and reduces image size.
- **‘gdbio’ for Debug mode** - gdbio’ support standard ‘printf’/log output back to Xtensa Explorer debug console, as well as other debug utilities, perfect for debug purpose but not appropriate for official deployment nor loading directly from Cortex M33 side.
- **‘sim’ for simulations** - ‘sim’ only works for software simulation and does not fit on device debugging.

The memory map is identical for different LSPs. It sits with linker scripts in SDK path\devices\MIMXRT685S\xtensa\‘LSP name’\ldscripts\elf32xtensa.x. It specifies how HiFi4 DSP organizes image sections on the memory. For example:

- 0x0020 0000 ~ 0x0048 0000, size 2.5 M bytes, for code and data.
- Stack and Heap are at the top of the segment and count top down from 0x0048 0000 to lower.
- 0x2400 0000 ~ 0x2400 FFFF, size 64 K bytes, for Data TCM. By default, it is empty.
- 0x2402 0000 ~ 0x2402 FFFF, size 64 K bytes, for instruction TCM. By default it only contains essential vectors and left around 62 K for applications.
- 0x2004 0000 ~ 0x2007 FFFF, size 256 K bytes. This is non-cached area for Cortex M33 and HiFi4 DSP data exchange.

Note that both Cortex M33 and HiFi4 DSP have access to all SRAM partitions. It means that a unified memory map is necessary at system level and both cores must not affect each other’s memory map. For SDK examples, see that HiFi4 memory map starts from 0x0020 0000 and Cortex M33 side sits under this address. Using IAR environment, as an example, its memory map sits in SDK path\boards\evkmimxrt685\dsp_examples\ any example\cm33\iar\MIMXRT685Sxxxx_ram.icf.

- 0x0008 0000 ~ 0x0017 FFFF, for interrupt vectors and code.
- 0x0018 0000 ~ 0x001F FFFF, for data.

The memory map is flexible and can be adjusted as per the requirement of the application. Note that modifying the core's memory map might affect another. Changes to both the cores must be made accordingly. For example, when allocating more SRAM partitions to DSP, you must reduce the memory taken at Cortex M33 side. Otherwise, Cortex M33 might not work properly. Also, when loading DSP image directly from Cortex M33 side, the image still sits in Cortex M33 data section before booting up. Therefore, it raises the bar for application data section requirements. You may consider running the application from FLASH.

Parent topic:HiFi4 Boot Loader and Memory Map

Cache and Data Exchange Memory Partitions You may have noticed that HiFi4 DSP has a small non-cached area that starts from 0x20040000. The non-cached are used for data exchange between two cores. As both M33 and HiFi DSP have shared access to all SRAM partitions, shared memory access is the most effective way to exchange data between two cores. The given physical addresses are read/ written by both cores at same address, no memory mapping or address converting is required. For example, if a piece of data array is passed from Cortex M33 to HiFi4 DSP, only the start pointer and the size of the array is passed, and conversely. It is convenient for system programming and simplifies the inter-core communications.

Consider cache here. Cortex M33 has no cache, the entire SRAM is considered as its local memory. Therefore, any memory write is flushed immediately. HiFi4 has 32 K instruction cache and 64 K data cache, and both cache are enabled by default. Therefore, the memory write is not flushed immediately. To make a tradeoff between performance and IPC convenience, set the non-cached area for data exchange memory partitions.

The above memory map has specified the non-cached region, and in DSP code, and HAL functions are called to disable the cache. For details, see the audio framework example in SDK path\boards\evkmimxrt685\dsp_examples\xaf_demo\dsp\xaf_main_dsp.c. For more details about HAL cache function, see the Xtensa System Software Reference Manual, section 3.11 Cache

```
/* Disable DSP cache for RPSMsg-Lite shared memory. */
xthal_set_region_attribute((void *)RPSMSG_LITE_SHMEM_BASE, RPSMSG_LITE_SHMEM_SIZE,
↳XCHAL_CA_BYPASS, 0);
/* Disable DSP cache for noncacheable sections. */
xthal_set_region_attribute((uint32_t *)&NonCacheable_start,
                          (uint32_t *)&NonCacheable_end - (uint32_t *)&NonCacheable_start, XCHAL_CA_
↳BYPASS, 0);
```

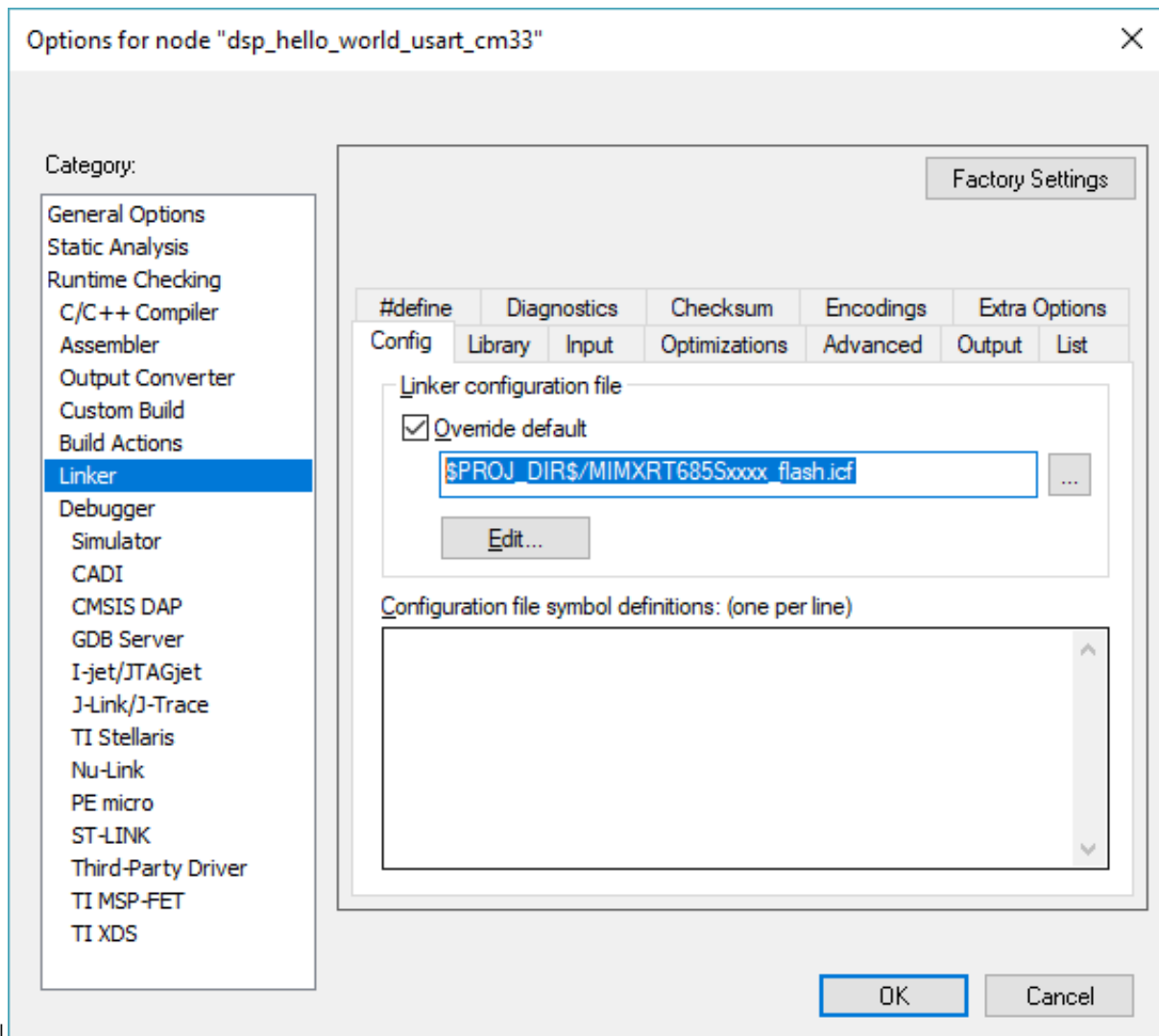
Note that the XHAL call sets cache attribute of the whole region/ 512 M bytes even if the set size is passed. This is also one reason why non-cached attribute is set on the overlapping SRAM address and starts from 0x2000 0000. This also distinguished the physical SRAM addresses starting from 0x0000 0000, which is cacheable area for HiFi4.

Data exchange memory partitions are flexible and can be configured as per application's requirement. However, to mitigate the possible AHB arbitration between the two cores, use of the first eight 32 K and following four 64 K memory partitions is recommended. DSP Data TCM is also used as data exchange area for those data have high demand on timing performance. You must avoid accessing same partition at same time for frequent data exchange between two cores. You can keep one core in Sleep or Wait for Interrupt while another core operating, or set up a ping pong data exchange/ DMA such that when one core fills one partition, another core fetches another partition, and conversely.

For more details about the RT6xx memory map, see the user manual, section 2 Memory Map, and section 2.1.11 HiFi4 memory map.

Parent topic:HiFi4 Boot Loader and Memory Map

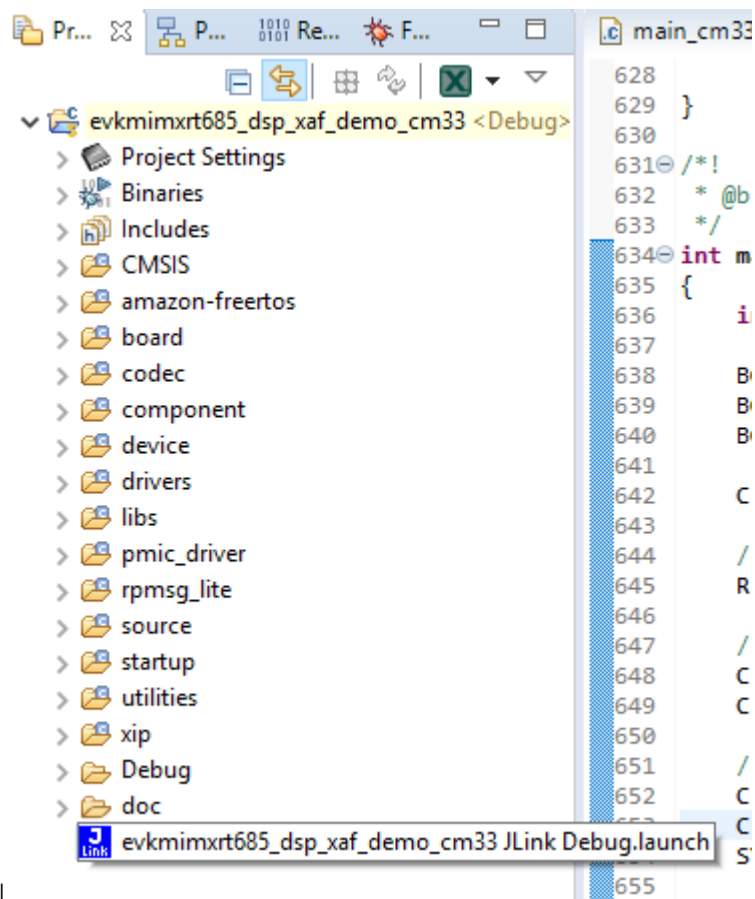
Boot or Run from Flash Boot from Flash is straight forward when using IAR environment. SDK provides either two or four different build configurations based on the project: debug (from SRAM)/ release (from SRAM)/ flash_debug/ flash_release. Flash configurations use different memory map in project linker options. For details, see Figure 1.



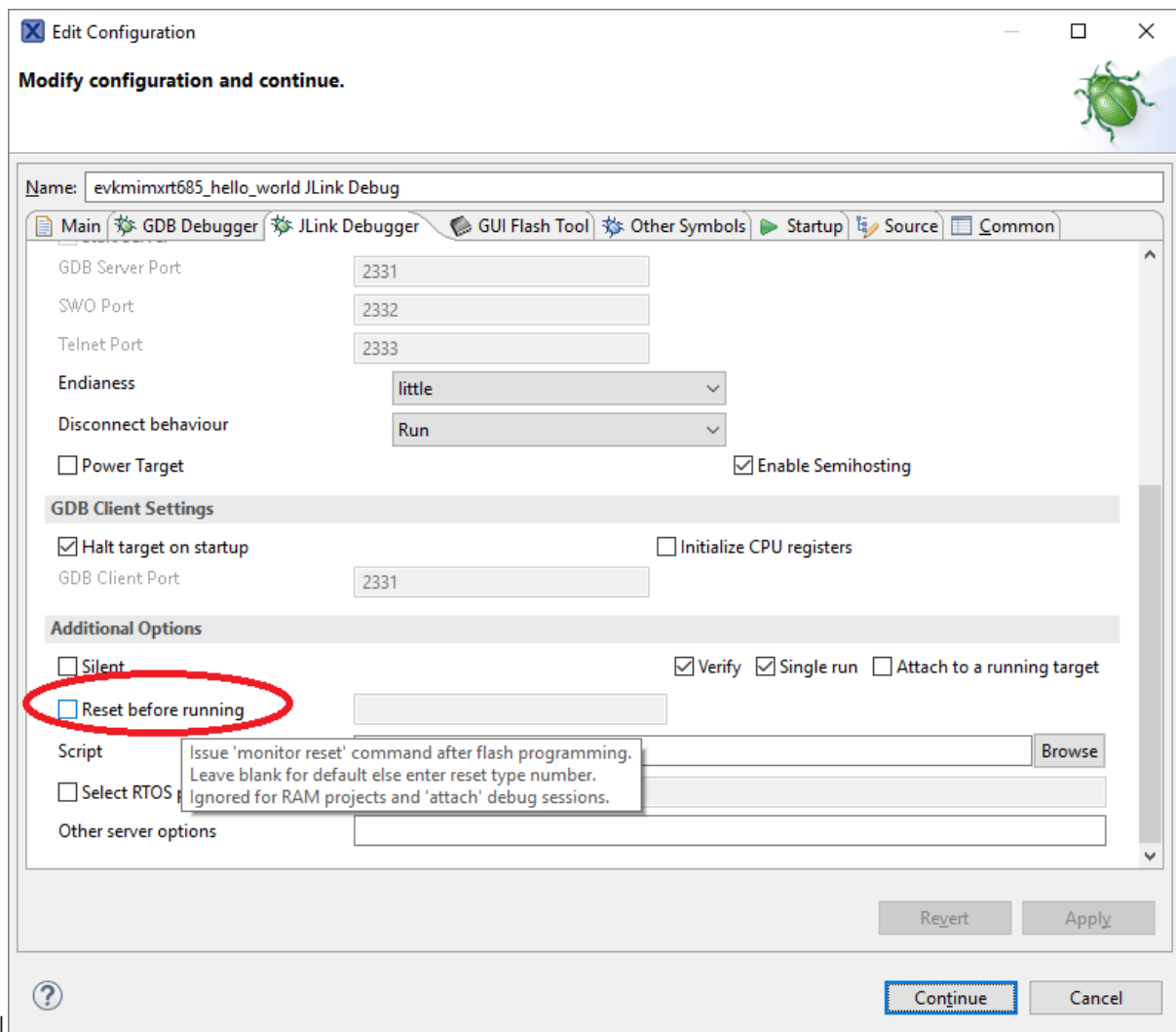
To enable booting from flash, change the ISP mode/ SW5 switches on the EVK.

If using MCUXpresso/ armgcc build environment, note that by default build environment is set to boot from flash. Using MCUXpresso as an example:

1. Make sure to use the latest version of MCUXpresso.
2. Import the SDK examples.
3. Once completed, double click the last file/ J-Link Debug.



4. Launch to modify J-Link debugger setting.
5. Make sure to deselect **Reset before running**. This helps the flash-based program get into main function.



- Make sure to:
 - Modify `DSP_IMAGE_COPY_TO_RAM` and Define to 1 in **Project settings > C/C++ General > Paths and Symbols > Symbols**.
 - Have the right compilation flag as C/C++. Compilation flags do not work on *.S files.
 - Have `#define DSP_IMAGE_COPY_TO_RAM 1` as the first line of source/incbin.S to include the DSP binaries.
 - Use the correct DSP binaries at correct path (must be release binaries).
 - Provide the right image path to incbin.S.
- To run/boot from flash, make sure that the board is set to FlexSPI flash boot mode (ISP2: ISP1: ISP0 = ON, OFF, ON).

Parent topic: HiFi4 Boot Loader and Memory Map

Parent topic: [HiFi4 System Programming](#)

Peripheral Drivers and Interrupts This section provides information on the basics of peripheral drivers, interrupts, DMA, and how peripheral drivers work on HiFi4 DSP.

Basics As both cores use shared SRAM and all digital peripherals, SDK drivers work the same on HiFi4 DSP. User Manual section 1.3 Block Diagram shows the system architect on this perspective. For applications, it is the same to use SDK drivers on HiFi4 DSP with Cortex M33 core. SDK has a DSP hello world UART example showing how easy to use UART on DSP side, same as Cortex M33 programming:

```
#include <xtensa/config/core.h>
#include "fsl_debug_console.h"
/* Init board hardware. */
BOARD_InitDebugConsole();
PRINTF("Hello World running on DSP core '%s', %s_%s\r\n", XCHAL_CORE_ID);
```

Compare with Hello world programming on Cortex M33 side. There are two major differences:

- Pin initialization is not necessary for DSP. It is doable but it is highly recommended managing all pins from Cortex M33 side to make pins all-in-one place. It is also to avoid possible conflicts when you set pins on two different cores;
- Clock setting is not necessary for DSP. It is also doable but same it is highly recommended managing all clock sources all-in-one place;

Parent topic:Peripheral Drivers and Interrupts

DMA RT6xx has two DMA controllers. Each has the same DMA request and trigger input possibilities. The two intended scenarios for their use are:

- One DMA controller (DMA0) is used by the CM33, the other (DMA1) is used by the HiFi4. This case can apply to systems where there is no need to differentiate security between the CPUs or between different tasks.
- One DMA controller (DMA0) is secured and has access to secure spaces and peripherals. The other (DMA1) is not secured and does not have access to secure spaces and peripherals. In this scenario, only the secure code running on the CM33 has access to the secure DMA controller. The other code and the HiFi4 share the non-secure DMA controller (if needed).

HiFi4 DSP always uses DMA1 controller. Again, it is the same to call DMA drivers at HiFi4 DSP side. The DMA destination buffer and DMA descriptor have to be in non-cached area to ensure that each transaction flushes to memory immediately. The below example code showing how to create a DMIC DMA channel:

```
AT_NONCACHEABLE_SECTION_ALIGN(
    static uint8_t s_buffer[BUFFER_SIZE * BUFFER_NUM], 4
);
AT_NONCACHEABLE_SECTION_ALIGN(
    dma_descriptor_t s_dmaDescriptorPingpong[2], 16
);
#define DEMO_DMA (DMA1)
#define DEMO_DMIC_RX_CHANNEL DMAREQ_DMIC0
DMA_Init(DEMO_DMA);
DMA_EnableChannel(DEMO_DMA, DEMO_DMIC_RX_CHANNEL);
DMA_SetChannelPriority(DEMO_DMA, DEMO_DMIC_RX_CHANNEL, kDMA_ChannelPriority2);
DMA_CreateHandle(&s_dmicRxDmaHandle, DEMO_DMA, DEMO_DMIC_RX_CHANNEL);
```

Macro AT_NONCACHEABLE_SECTION_ALIGN is defined in SDK driver layer and refer to non-cached area specified by memory map.

For more details about DMA, see the User Manual Chapter 11 RT6xx DMA Controller and SDK DMA examples in <SDK path>\boards\evkmimxrt685\driver_examples\dma.

For audio peripherals/ DMIC/ I2S DMA, see <SDK path>\boards\evkmimxrt685\driver_examples\dmic and <SDK path>\boards\evkmimxrt685\driver_examples\i2s.

Parent topic:Peripheral Drivers and Interrupts

Interrupts HiFi4 DSP has total 32 interrupts and 4 interrupt levels. Besides the first five interrupts, the rest interrupt 5 ~ 31 are multiplexed to allow more control over priorities and more general flexibility. To see the full list, see the User Manual section 8.6.3 DSP Interrupt Input Multiplexers.

It only requires few lines of code to enable an interrupt by calling XOS function calls, and peripheral controls are identical as Cortex M33 side. For example, the below code shows how to enable a UTick timer at DSP side:

First, include XOS system header files and libraries to enable necessary XOS functions.

To include libraries, go to Build **Properties** > **Libraries** > **Add libraries** > **Select 'xos' & 'xtutil'** and **OK** to accept.

```
#include <xtensa/config/core.h>
#include <xtensa/xos.h>
```

Set up the UTick callback and delay functions. This part is identical with Cortex M33 side. For Cortex M33 side implementation, see SDK path\\boards\\evkmimxrt685\\driver_examples\\utick

```
#define UTICK_TIME_1S      (1000000UL)
#define EXAMPLE_UTICK      UTICK0
static volatile bool utickExpired;
static void UTickCallback(void)
{
    utickExpired = true;
}
static void UTickDelay(uint32_t usec)
{
    /* Set the UTICK timer to wake up the device from reduced power mode */
    UTICK_SetTick(EXAMPLE_UTICK, kUTICK_Onetime, usec - 1, UTickCallback);
    while (!utickExpired)
    {
    }
    utickExpired = false;
}
```

Initialize the XOS and start UTick timer. The XOS function calls are the differences with Cortex M33 side:

```
/* Initialize XOS thread and start scheduler. Priority 7*/
xos_start_main("main", 7, 0);
/* Init board hardware. */
CLOCK_AttachClk(kLPOSC_to_UTICK_CLK);
CLOCK_EnableClock(kCLOCK_InputMux);
UTICK_Init(EXAMPLE_UTICK);
INPUTMUX_AttachSignal(INPUTMUX, 10U, kINPUTMUX_Utick0ToDspInterrupt);
/* To register interrupt callback */
xos_register_interrupt_handler(15, (XosIntFunc *)UTICK0_DriverIRQHandler, NULL);
/* To enable the interrupt */
xos_interrupt_enable(15);
while (1)
{
    UTickDelay(UTICK_TIME_1S);
    PRINTF("DSP UTICK TIMER every 1s\r\n");
}
```

Pay attention to the instant numbers. Pick interrupt 15, which maps to DSP_INT0_SEL10 as a L1 interrupts, lowest priority level. For more details about RT6xx HiFi4 DSP interrupt configuration, see User Manual section 51.7 Interrupt. Therefore, for Inputmux, attach UTick interrupt to 10. 15-5=10 as first five interrupts are reserved, not user configurable. To get it to highest priority level, for example L3, configure interrupt as follows.

```
INPUTMUX_AttachSignal(INPUTMUX, 24U,
kINPUTMUX_Utick0ToDspInterrupt);
xos_register_interrupt_handler(29, (XosIntFunc
*)UTICK0_DriverIRQHandler, NULL);
xos_interrupt_enable(29);
```

kINPUTMUX_Utick0ToDspInterrupt specifies DSP interrupt multiplexing value. It has been defined in SDK and matching User Manual section 8.6.3 DSP Interrupt Input Multiplexers.

For more details about XOS interrupt handling, see the Xtensa XOS Reference Manual Chapter 18 Interrupt and Exception Handling, and Chapter 26 Interrupt Handler Restrictions.

Parent topic:Peripheral Drivers and Interrupts

Complete Example To present better how peripheral drivers work on HiFi4 DSP, below list a bare-metal DSP example program that transfers data from DMIC to codec on RT6xx EVKs. The full workspace located in <SDK path>\boards\evkmimxrt685\dsp_examples\audio_demo_bm. This example is derived from Cortex M33 driver <SDK path>\boards\evkmimxrt685\driver_examples\dmic\dmic_i2s_dma with below slightly modifications to adapt to HiFi4 DSP.

- Move DMA buffer and descriptors into non-cached memory partitions;
- Using DMA1 for DSP;
- Calling XOS functions to enable interrupts.
- This example does not contain any pin mux initializing or clock configurations. See the above Cortex M33 example dmic_i2s_dma to set up Cortex M33 side. Once Cortex M33 side ready, this example is compiled and run same as any other SDK DSP examples.

Connect headphone/earphone on audio out of the board, speak on DMIC, or play song nearby the DMIC, you can hear sound on the left channel of headphone/earphone.

```
/* Start XOS */
xos_start_main("main", 7, 0);
/* Disable DSP cache for noncacheable sections. DMA MUST run on none-cacheable/ cache bypass area*/
xthal_set_region_attribute((uint32_t *)&NonCacheable_start,
                          (uint32_t *)&NonCacheable_end - (uint32_t *)&NonCacheable_start, XCHAL_CA_
↳BYPASS, 0);
xthal_set_region_attribute((uint32_t *)&NonCacheable_init_start,
                          (uint32_t *)&NonCacheable_init_end - (uint32_t *)&NonCacheable_init_start, XCHAL_
↳CA_BYPASS,
                          0);
PRINTF("Configure DMA\r\n");
/* DSP_INT0_SEL18 = DMA1 */
INPUTMUX_AttachSignal(INPUTMUX, 18U, kINPUTMUX_Dmac1ToDspInterrupt);
/* Map DMA IRQ handler to INPUTMUX selection DSP_INT0_SEL18
 * EXTINT19 = DSP INT 23 */
xos_register_interrupt_handler(XCHAL_EXTINT19_NUM, (XosIntFunc *)DMA_IRQHandle, DMA1);
xos_interrupt_enable(XCHAL_EXTINT19_NUM);
/* The rest DMA & DMIC operations are identical with CM33 side */
```

Parent topic:Peripheral Drivers and Interrupts

Parent topic:[HiFi4 System Programming](#)

Messaging Unit, Semaphore, and IPC Message Unit/ MU and Semaphore/ SEMA42 are essential for DSP programming. The inter-core communications a.k.a IPC on RT600 is based on MU and SEMA42. SDK provides three simple examples about standalone MU and SEMA 42. SDK path \boards\evkmimxrt685\dsp_examples\mu_interrupt, mu_polling, and sema42. These bare-metal examples show how IPC work between two cores. Furthermore, the audio framework

demo/ SDK path \boards\evkmimxrt685\dsp_examples\xaf_demo is complete. It uses rpmsg_lite as IPC protocol, which based on MU to transfer messages between the two cores.

First Cortex M33 side initializes rpmsg master, main_cm33.c in app_task()

```
g_my_rpmsg = rpmsg_lite_master_init((void *)RPMSG_LITE_SHMEM_BASE, RPMSG_LITE_
↳SHMEM_SIZE, RPMSG_LITE_LINK_ID, RL_NO_FLAGS);
g_my_queue = rpmsg_queue_create(g_my_rpmsg);
g_my_ept = rpmsg_lite_create_ept(g_my_rpmsg, LOCAL_EPT_ADDR, rpmsg_queue_rx_cb, g_my_
↳queue);
```

Rpmsg initialize MU interrupts for MUA/ master in rpmsg_platform.c platform_init_interrupt()

```
/* Register ISR to environment layer */
env_register_isr(vector_id, isr_data);
env_lock_mutex(platform_lock);
RL_ASSERT(0 <= isr_counter);
if (isr_counter == 0)
{
    MU_EnableInterrupts(APP_MU, (1UL << 27U) >> RPMSG_MU_CHANNEL);
```

For DSP side, it also initializes rpmsg client and tries to hook with the master, in xaf_main_dsp.c:DSP_Main()

```
/* Initialize standard SDK demo application pins */
my_rpmsg = rpmsg_lite_remote_init((void *)RPMSG_LITE_SHMEM_BASE, RPMSG_LITE_LINK_ID,
↳RL_NO_FLAGS, &rpmsg_ctxt);
while (!rpmsg_lite_is_link_up(my_rpmsg))
{
```

It has rpmsg porting as well, initialize MU interrupts for MUB/ client in rpmsg_platform.c platform_init_interrupt() and enable it in platform_interrupt_enable()

```
xos_register_interrupt_handler(6, MU_B_IRQHandler, ((void *)0));
xos_interrupt_enable(6);
```

Once they hooked up both sides are ready for message exchange. SDK defines various SRTM message structures to pass the commands/ messages. In SDK example, it shows how to pass an MP3 decoding message, a AAC decoding message, a DMIC recording message and so on. Using MP3 decoding message as an example, It fills SRTM structure with input buffer address pointer, input buffer size, output buffer address pointer, output buffer size and so on. And then calling rpmsg to send it to DSP and waiting for the response.

```
rpmsg_lite_send(g_my_rpmsg, g_my_ept, g_remote_addr, (char *)msg, sizeof(THE_MESSAGE), RL_
↳BLOCK);
rpmsg_queue_recv(g_my_rpmsg, g_my_queue, (unsigned long *)&g_remote_addr, (char *)msg,
↳sizeof(THE_MESSAGE), len,
    RL_BLOCK);
```

DSP side listens to rpmsg event.

```
my_ept = rpmsg_lite_create_ept(my_rpmsg, DSP_EPT_ADDR, my_ept_read_cb, (**void**) &rpmsg_
↳user_data, &my_ept_context);
```

Once received, it handles message and proceeds the command. For MP3 decoding case, it decodes the MP3 data in the input buffer, and flushes the output buffer. It also fills out the SRTM message structure with actual read data size and actual write data size, and eventually sends the response message back to Cortex M33 side.

```
/*Send response message*
/rpmsg_lite_send(my_rpmsg, my_ept, remote_addr, (**char**) &msg, **sizeof*(THE_MESSAGE),
↳RL_DONT_BLOCK);
```

For this example, DSP is considered as a coprocessor and rpmsg has been used for a light-weight IPC for both cores. All modules are open-sourced and could be easily adapted to whatever application needs.

Parent topic:[HiFi4 System Programming](#)

NatureDSP Library To facilitate application development on RT6xx HiFi4 DSP, NXP licensed NatureDSP signal processing library and embedded as is in source code format. It is found at <SDK path>\middleware\dsp\naturedsp_hifi4.

This is an extensive library, containing the most commonly used signal processing functions: FFT, FIR, vector, matrix, and common mathematics. API and programing guide in .\doc\NatureDSP_Signal_Library_Reference_HiFi4.pdf, and performance data in .\doc\NatureDSP_Signal_Library_Performance_HiFi4.pdf

As this is a huge library, it is impossible to build an all-in-one example on the RT6xx hardware. Fortunately, this library is in source code format and each function/ filter are wrapped in standalone source file. They could be integrated to any application as needed.

Parent topic:[HiFi4 System Programming](#)

System Optimization Performance and power efficiency are key for embedded systems. The following sections list some tips and best practices for system optimization from this perspective.

Profiling The Xtensa Xplorer IDE tool can run software simulation and profile the application directly. Both simulation and profiling are cycle accurate. This is convenient for algorithm or heavy application developers.

Figure 1 shows profiling result of the helloworld program on simulation console.

Events	Number	Number per 100 instrs	
Committed instructions	3492 (100.00)		
Instruction fetches	4066 (116.44)		
From IRAM	2545 (72.88)		
ICache fetches	1521 (43.56)		
ICache misses	43 (1.23)	2.83% of ICache fetches	
Loop buffer hits	338 (9.68)	8.31% of Instruction fetches	
Taken branches	702 (20.10)		
Exceptions	35 (1.00)		
WindowUnderflow	17 (0.49)		
WindowOverflow	18 (0.52)		
Loads	481 (13.77)		
From IRAM	16 (0.46)		
DCache loads	465 (13.32)		
DCache load misses	9 (0.26)	1.94% of DCache loads	
Stores	308 (8.82)		
DCache stores	308 (8.82)		
DCache store misses	10 (0.29)	3.25% of DCache stores	
DCache castouts	15 (0.43)		
PIF transfers (16 bytes each)	1552 (44.44)		
IFetch reads	496 (14.20)		
Data reads	304 (8.71)		
Data writes	240 (6.87)		
ICache prefetches	416 (11.91)		
DCache prefetches	96 (2.75)		
ICache prefetch hits	12 (0.34)	27.91% of ICache allocates	
Cycles: total = 9078			
	CPI	Summed CPI	Summed % Cycle
Committed instructions	3492 (1.0000	1.0000	38.47
Taken branches	2121 (0.6074	1.6074	23.36
Pipeline interlocks	357 (0.1022	1.7096	3.93
ICache misses	519 (0.1486	1.8582	5.72

Figure 1 shows the profiling chart, partially.

Function Name	Function (%)	Function (F)	Children (C)	Total (F+C)	Called	Size (bytes)
<TOTAL>	100.00	9,078	N/A	N/A	N/A	N/A
ResetHandler	45.96	4,173	0	4,173	<spontaneous>	246
xthal_dcache_all_writeback	9.77	887	0	887	1	25
_vprintf_r	4.40	400	1,776	2,176	1	8,306
_malloc_r	3.39	308	101	409	1	1,318
_WindowUnderflow8	2.61	237	0	237	16	29
_WindowOverflow8	2.48	226	0	226	16	29
_fclose_r	2.40	218	501	719	3	162
_sinit	2.03	185	170	355	1	267
_start	1.78	162	4,688	4,850	1	150
_sfvwrite_r	1.56	142	385	527	1	951
memset	1.56	142	0	142	3	143
_clibrary_init	1.50	137	165	302	1	35
_fflush_r	1.48	135	310	445	4	41
_sflush_r	1.46	133	127	260	4	377

The generated license file only supports debug/run on the RT6xx device target. It does not support software simulation/Xplorer ISS. If there are special requirements to run the software simulations, contact Cadence directly.

It is also common to measure exact cycle counts for specific processing/ timing measurements. The following is an example code to show how to do the cycle counts.

```
/* Cycle counts inline function */
static unsigned long inline get_ccount(void)
{
    unsigned long r;
    __asm__ volatile ("rsr.ccount %0" : "=r" (r));
    return r;
}
tic = get_ccount();
processing_function();
toc = get_ccount();
printf("Processing takes %d cycles \r\n", toc - tic);
```

Parent topic:System Optimization

Using Local Memories RT6xx HiFi4 DSP has 64 K data TCM and 64 K instruction TCM. The TCM is filled with less than 2 K of kernel vectors and the rest is available for application needs. They are the fastest RAM available with no access latency, and can improve critical data/ instruction performance considerably. Consider using TCM as much as possible.

To program code/ data to TCM area:

1. Define macros for sections in TCM. Reuse existing .drm0 and .iram0 sections. Both sections are default TCM sections for every Xplorer project/ memory map. The following are the sections in fsl_common.h.

```
#define DRAM0_DATA __attribute__((section(".dram0.data")))
#define DRAM0_BSS __attribute__((section(".dram0.bss")))
#define IRAM0_TEXT __attribute__((section(".iram0.text")))
#define ALIGNED(alignbytes) __attribute__((aligned(alignbytes)))
```

2. Use macros to declare code and data to be placed in TCM. The data and bss/ uninitialized data are different sections. The following is an example for an FFT function call.

```
DRAM0_DATA const static int32_t fft_in_ref[FFT_LENGTH] = {
DRAM0_DATA const static int32_t fft_out_ref[FFT_LENGTH] = {
DRAM0_BSS static int32_t fft_out[FFT_LENGTH];
IRAM0_TEXT int TEST_FFT()
{
    ...
    fft_cplx32x32(fft_out, fft_in, FFT_HANDLE, 3);
    ...
}
```

3. The TCM addresses start from 0x2400 0000, which is too far away to main(). Therefore, the project enables long calls to ensure that main() is able to call sub functions. To enable, select **Build Properties > Optimization > Enable long calls** and select the **Yes** checkbox. Alternatively, add -mlongcalls to the compiler flags.

Parent topic:System Optimization

Power Efficiency RT6xx HiFi4 DSP has been equipped as a powerful processing core that can run at 600 MHz, but it may not be necessary at all time. It is always recommended to optimize the power efficiency at system level.

Voltage level and core frequency have huge impact on the power efficiency. Using FFT processing as example, continuous FFT may take ~130 mW at Vddcore 1.1 V / 452 MHz, and ~4 mW at Vddcore 0.7 V / 29 MHz, at room temperature. Profile or do cycle counts for software workload. If it only requires 300 MHz at peak, then the run at full power is not required. Instead, it can run with Vddcore 0.8 V 300 MHz. For more information on the Vddcore and DSP frequency operating conditions, see any *dsp example|cm33|pmic_support.c BOARD_SetPmicVoltageForFreq()*, or see the data sheet, section 13.1 General Operating Conditions.

Some other tips for better power efficiency:

- Turn off DSP/ set DSPSTALL, if needed.
- If possible, make DSP clock adapts to its workload.
- Call XT_WAITI when DSP is in while loop waiting for interrupt. Similar to Arm side __WFI(), it suspends some processor operations to reduce the power consumption.

```
#include <xtensa/tie/xt_interrupt.h >
extern void XT_WAITI(immediate s);
```

The immediate value passed is the interrupt level or lower to be IGNORED. For example, if you call XT_WAITI(2) both L1 and L2 interrupts are ignored and only L3 interrupts can wake up DSP.

Current can further reduce when clocks are turned off to unused memory partitions. For more information, see User Manual 4.5.5.13 DSP SRAM access disable, Register SYSCTL0_DSP_SRAM_ACCESS_DISABLE.

- PLLs consume power. Consider FFRO for low-power use cases.

Parent topic:System Optimization

Parent topic:[HiFi4 System Programming](#)

Note about the source code in the document

Example code shown in this document has the following copyright and BSD-3-Clause license:

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1.5 Release Notes

1.5.1 MCUXpresso SDK Release Notes

Overview

The MCUXpresso SDK is a comprehensive software enablement package designed to simplify and accelerate application development with Arm Cortex-M-based devices from NXP, including its general purpose, crossover and Bluetooth-enabled MCUs. MCUXpresso SW and Tools for DSC further extends the SDK support to current 32-bit Digital Signal Controllers. The MCUXpresso SDK includes production-grade software with integrated RTOS (optional), integrated enabling software technologies (stacks and middleware), reference software, and more.

In addition to working seamlessly with the MCUXpresso IDE, the MCUXpresso SDK also supports and provides example projects for various toolchains. The Development tools chapter in the associated Release Notes provides details about toolchain support for your board. Support for the MCUXpresso Config Tools allows easy cloning of existing SDK examples and demos, allowing users to leverage the existing software examples provided by the SDK for their own projects.

Underscoring our commitment to high quality, the MCUXpresso SDK is MISRA compliant and checked with Coverity static analysis tools. For details on MCUXpresso SDK, see [MCUXpresso-SDK: Software Development Kit for MCUXpresso](#).

MCUXpresso SDK

As part of the MCUXpresso software and tools, MCUXpresso SDK is the evolution of Kinetis SDK, includes support for LPC, DSC, PN76, and i.MX System-on-Chip (SoC). The same drivers, APIs, and middleware are still available with support for Kinetis, LPC, DSC, and i.MX silicon. The MCUXpresso SDK adds support for the MCUXpresso IDE, an Eclipse-based toolchain that works with all MCUXpresso SDKs. Easily import your SDK into the new toolchain to access to all of the available components, examples, and demos for your target silicon. In addition to the MCUXpresso IDE, support for the MCUXpresso Config Tools allows easy cloning of existing SDK examples and demos, allowing users to leverage the existing software examples provided by the SDK for their own projects.

In order to maintain compatibility with legacy Freescale code, the filenames and source code in MCUXpresso SDK containing the legacy Freescale prefix FSL has been left as is. The FSL prefix has been redefined as the NXP Foundation Software Library.

Development tools

The MCUXpresso SDK was tested with following development tools. Same versions or above are recommended.

- MCUXpresso IDE, Rev. 25.06.xx
- IAR Embedded Workbench for Arm, version is 9.60.4
- Keil MDK, version is 5.41
- MCUXpresso for VS Code v25.06
- GCC Arm Embedded Toolchain 14.2.x
- Xtensa Xplorer, version is 10.1.11
- Xtensa C Compiler, version is RI-2023.11

Supported development systems

This release supports board and devices listed in following table. The board and devices in bold were tested in this release.

Devel- opment boards	MCU devices		
MIMXRT685-AUD-EVK	MIMXRT633SFAWBR, MIMXRT685SFAWBR, MIMXRT685SVFVKB	MIMXRT633SFFOB, MIMXRT685SFFOB,	MIMXRT633SFVKB, MIMXRT685SFVKB ,

MCUXpresso SDK release package

The MCUXpresso SDK release package content is aligned with the silicon subfamily it supports. This includes the boards, CMSIS, devices, middleware, and RTOS support.

Device support The device folder contains the whole software enablement available for the specific System-on-Chip (SoC) subfamily. This folder includes clock-specific implementation, device register header files, device register feature header files, and the system configuration source files. Included with the standard SoC support are folders containing peripheral drivers, toolchain support, and a standard debug console. The device-specific header files provide a direct access to the microcontroller peripheral registers. The device header file provides an overall SoC memory mapped register definition. The folder also includes the feature header file for each peripheral on the microcontroller. The toolchain folder contains the startup code and linker files for each supported toolchain. The startup code efficiently transfers the code execution to the main() function.

Board support The boards folder provides the board-specific demo applications, driver examples, and middleware examples.

Demo application and other examples The demo applications demonstrate the usage of the peripheral drivers to achieve a system level solution. Each demo application contains a readme file that describes the operation of the demo and required setup steps. The driver examples demonstrate the capabilities of the peripheral drivers. Each example implements a common use case to help demonstrate the driver functionality.

RTOS

FreeRTOS Real-time operating system for microcontrollers from Amazon

Middleware

Wireless EdgeFast Bluetooth PAL For more information, see the MCUXpresso SDK EdgeFast Bluetooth Protocol Abstraction Layer User's Guide.

Ethermind BT/BLE Stack nxp_bt_ble_stack

coreHTTP coreHTTP

PSA Test Suite Arm Platform Security Architecture Test Suite

mbedTLS mbedtls SSL/TLS library v3.x

wpa_supplicant-rtos NXP Wi-Fi WPA Supplicant

NXP Wi-Fi The MCUXpresso SDK provides driver for NXP Wi-Fi external modules. The Wi-Fi driver is integrated with LWIP TCPIP stack and demonstrated with several network applications (iperf and AWS IoT).

For more information, see Getting Started with NXP based Wireless Modules and i.MX RT Platform Running on RTOS (document: UM11441).

Voice Seeker (no AEC) VoiceSeeker is a multi-microphone voice control audio front-end signal processing solution. VoiceSeeker is not featuring acoustic echo cancellation (AEC).

Voice intelligent technology library Voice Intelligent Technology (VIT) Library provides wake word and voice command engine for voice control

USB Type-C PD Stack See the *MCUXpresso SDK USB Type-C PD Stack User's Guide* (document MCUXSDKUSBPDU) for more information

USB Host, Device, OTG Stack See the *MCUXpresso SDK USB Stack User's Guide* (document MCUXSDKUSBSUG) for more information.

TinyCBOR Concise Binary Object Representation (CBOR) Library

TF-M Trusted Firmware - M Library

SDMMC stack The SDMMC software is integrated with MCUXpresso SDK to support SD/MMC/SDIO standard specification. This also includes a host adapter layer for bare-metal/RTOS applications.

PKCS#11 The PKCS#11 standard specifies an application programming interface (API), called "Cryptoki," for devices that hold cryptographic information and perform cryptographic functions. Cryptoki follows a simple object based approach, addressing the goals of technology independence (any kind of device) and resource sharing (multiple applications accessing multiple devices), presenting to applications a common, logical view of the device called a "cryptographic token".

Multicore Multicore Software Development Kit

MCU Boot Open source MCU Bootloader.

mbedTLS mbedtls SSL/TLS library v2.x

lwIP The lwIP TCP/IP stack is pre-integrated with MCUXpresso SDK and runs on top of the MCUXpresso SDK Ethernet driver with Ethernet-capable devices/boards.

For details, see the *lwIP TCPIP Stack and MCUXpresso SDK Integration User's Guide* (document MCUXSDKLWIPUG).

lwIP is a small independent implementation of the TCP/IP protocol suite.

eIQ The package contains several example applications using the eIQ TensorFlow Lite for Microcontrollers library.

eIQ machine learning SDK containing:

- Arm CMSIS-NN library (neural network kernels optimized for Cortex-M cores)
- Inference engines:
 - TensorFlow Lite Micro
 - DeepView RT
- Example code for TensorFlow Lite Micro, Glow, and DeepView RT

LVGL LVGL Open Source Graphics Library

llhttp HTTP parser llhttp

LittleFS LittleFS filesystem stack

FreeMASTER FreeMASTER communication driver for 32-bit platforms.

File systemFatfs The FatFs file system is integrated with the MCUXpresso SDK and can be used to access either the SD card or the USB memory stick when the SD card driver or the USB Mass Storage Device class implementation is used.

emWin The MCUXpresso SDK is pre-integrated with the SEGGER emWin GUI middleware. The AppWizard provides developers and designers with a flexible tool to create stunning user interface applications, without writing any code.

DSP Neural Networks DSP Neural Networks Framework based on Xtensa Neural Networks Library from Cadence Design Systems for Xtensa HiFi Audio Engines.

NatureDSP for Hifi4 Digital Signal Processing for Xtensa Hifi4 DSP Audio Engines.

DSP Audio Streamer DSP Audio Streamer Framework based on Xtensa Audio Framework from Cadence Design Systems for Xtensa DSP Audio Engines.

DSP Codecs Codecs for Cadence DSPs

cJSON Ultralightweight JSON parser in ANSI C

AWS IoT Amazon Web Service (AWS) IoT Core SDK.

NXP PSA CRYPTO DRIVER PSA crypto driver for crypto library integration via driver wrappers

CMSIS DSP Library The MCUXpresso SDK is shipped with the standard CMSIS development pack, including the prebuilt libraries.

Release contents

Provides an overview of the MCUXpresso SDK release package contents and locations.

Deliverable	Location
Boards	INSTALL_DIR/boards
Demo Applications	INSTALL_DIR/boards/<board_name>/demo_apps
Driver Examples	INSTALL_DIR/boards/<board_name>/driver_examples
eIQ examples	INSTALL_DIR/boards/<board_name>/eiq_examples
Board Project Template for MCUXpresso IDE NPW	INSTALL_DIR/boards/<board_name>/project_template
Driver, SoC header files, extension header files and feature header files, utilities	INSTALL_DIR/devices/<device_name>
CMSIS drivers	INSTALL_DIR/devices/<device_name>/cmsis_drivers
Peripheral drivers	INSTALL_DIR/devices/<device_name>/drivers
Toolchain linker files and startup code	INSTALL_DIR/devices/<device_name>/<toolchain_name>
Utilities such as debug console	INSTALL_DIR/devices/<device_name>/utilities
Device Project Template for MCUXpresso IDE NPW	INSTALL_DIR/devices/<device_name>/project_template
CMSIS Arm Cortex-M header files, DSP library source	INSTALL_DIR/CMSIS
Components and board device drivers	INSTALL_DIR/components
RTOS	INSTALL_DIR/rtos
Release Notes, Getting Started Document and other documents	INSTALL_DIR/docs
Tools such as shared cmake files	INSTALL_DIR/tools
Middleware	INSTALL_DIR/middleware

Known issues

This section lists the known issues, limitations, and/or workarounds.

New Project Wizard compile failure

The following components request the user to manually select other components that they depend upon in order to compile.

These components depend on several other components and the New Project Wizard (NPW) is not able to decide which one is needed by the user.

Note: xxx means core variants, such as, cm0plus, cm33, cm4, cm33_nodsp.

****Components:****issdk_mag3110, issdk_host, systick, gpio_kinetis, gpio_lpc, issdk_mpl3115, sensor_fusion_agm01, sensor_fusion_agm01_lpc, issdk_mma845x, issdk_mma8491q, issdk_mma865x, issdk_mma9553, and CMSIS_RTOS2.CMSIS_RTOS2, and components which include cache driver, such as enet_qos.

Also for low-level adapter components, currently the different types of the same adapter cannot be selected at the same time.

For example, if there are two types of timer adapters, gpt_adapter and pit_adapter, only one can be selected as timer adapter

in one project at a time. Duplicate implementation of the function results in an error.

Note: Most of middleware components have complex dependencies and are not fully supported in new project wizard. Adding a middleware component may result in compile failure.

Low speed devices not supported

The host examples cannot support low-speed devices.

IAR cannot debug RAM application with J-Link

Currently, IAR will call J-Link reset after the application is downloaded to SRAM, but such operation will cause SRAM data lost.

Here is a workaround to avoid real reset, with the cost of no any reset during the debugging, and hardware status uncleared.

1. Build and debug IAR project once and see the settings folder created.
2. Create the _JLinkScript file in the settings folder with the following contents.

```
void ResetTarget(void) {  
    JLINK_TARGET_Halt();  
}
```

3. Debug the project again and now it can work.

DSP_rtp_demo failure

The dsp_rtp_demo streaming fails after several minutes with timeout from the DSP side. The issue is probably caused by the incompatibility of the codec and the new XAF version.

CMSIS PACK new project compile failure

The generated configuration cannot be applied globally. The components, serial_manager_usb_cdc_virtual and serial_manager_usb_cdc_virtual_xxx (xxx means core variants like cm0plus, cm33, cm4, and cm33_nodsp) are unsupported for new project wizard of CMSIS pack and will lead to compile failure if selected while creating new project(s).

lwip_httpsrv_ota_wifi example fails to accept the new image on EVKMIMXRT685

After uploading the new image over https, and rebooting the board the new image starts. However, reboot starts it is not possible to accept the update and make it permanent. This issue is specific to combination of EVKMIMXRT685 board and AW-NM191NF-uSD Wi-Fi module. Other configurations are not affected.

LE encryption failure causes connection to fail

There can be a corner case when LE link encryption can fail. This occurs when device under test (DUT); RT Bluetooth controller here, while waiting for the response to LL_SLAVE_FEATURES_REQ, instead receives the LL_ENC_REQ response from a remote device.

This causes deadlock scenario where DUT and remote devices are stuck waiting for response from peer.

Connection disconnects with 7.5 ms connection interval

When wireless example works as a peripheral, the central role with 7.5 ms connection interval connects to the wireless example. However, when using the 6th/7th/8th central to connect the wireless example, all the previous connections with the previous centrals are disconnected.

When wireless example works as central and the connection interval is 7.5 ms, the 4th peripheral is not scanned.

a2dp sink demo: Noise may occur when phone plays music with other operations

Noise may occur when phone plays music with other operations.

For example:

- Switches the WIFI network of the phone when playing music
- Switches music when playing the online music

Volume is very loud from codec in the a2dp sink and hfp demos

After connecting to the phone and playing music or calling, the codec volume is very loud.

Wireless EdgeFast_Bluetooth stack is not supported by any kits

Wireless EdgeFast_Bluetooth stack can be downloaded by MIMXRT1040-EVK-AGM01, MIMXRT1040-EVKOM13790HOST, and MIMXRT1040-EVK-OM13588 in <https://mcuxpresso.nxp.com/en/welcome>. However, it is not supported in these kits.

lwip_httpsrv_ota_wifi example fails to accept the new image on EVKMIMXRT685

After uploading the new image over https, and rebooting the board the new image starts. However, reboot starts it is not possible to accept the update and make it permanent. This issue is specific to combination of EVKMIMXRT685 board and AW-NM191NF-uSD Wi-Fi module. Other configurations are not affected.

Examples hello_world_ns, secure_faults_ns, and secure_faults_trdc_ns have incorrect library path in GUI projects

When the affected examples are generated as GUI projects, the library linking the secure and non-secure worlds has an incorrect path set. This causes linking errors during project compilation.

Examples: hello_world_ns, hello_world_s, secure_faults_ns, secure_faults_s, secure_faults_trdc_ns, secure_faults_trdc_s

Affected toolchains: mdk, iar

Workaround: In the IDE project settings for the non-secure (_ns) project, find the linked library (named hello_world_s_CMSE_lib.o, or similar, depending on the example project) and replace

the path to the library with <build_directory>/<secure_world_project_folder>/<IDE>/, replacing the subdirectory names with the build directory, the secure world project name, and IDE name.

1.6 ChangeLog

1.6.1 MCUXpresso SDK Changelog

Board Support Files

board

[25.06.00]

- Initial version

clock_config

[25.06.00]

- Initial version

pin_mux

[25.06.00]

- Initial version
-

1.7 Driver API Reference Manual

This section provides a link to the Driver API RM, detailing available drivers and their usage to help you integrate hardware efficiently.

[MIMXRT685S](#)

1.8 Middleware Documentation

Find links to detailed middleware documentation for key components. While not all onboard middleware is covered, this serves as a useful reference for configuration and development.

1.8.1 Multicore

[Multicore SDK](#)

1.8.2 MCU Boot

`mcuboot_opensource`

1.8.3 eIQ

`eiq`

1.8.4 FreeMASTER

freemaster

1.8.5 AWS IoT

AWS IoT

1.8.6 NXP Wi-Fi

Wi-Fi, Bluetooth, 802.15.4

1.8.7 FreeRTOS

FreeRTOS

1.8.8 Wireless EdgeFast Bluetooth PAL

`edgefast_bluetooth`

1.8.9 lwIP

lwIP

1.8.10 File systemFatfs

FatFs

1.8.11 DSP Audio Streamer

Xtensa Audio Framework (XAF)

Chapter 2

MIMXRT685S

2.1 ACMP: Analog Comparator Driver

`void ACMP_Init(CMP_Type *base, const acmp_config_t *config)`

Initializes the ACMP.

The default configuration can be got by calling `ACMP_GetDefaultConfig()`.

Parameters

- `base` – ACMP peripheral base address.
- `config` – Pointer to ACMP configuration structure.

`void ACMP_Deinit(CMP_Type *base)`

Deinitializes the ACMP.

Parameters

- `base` – ACMP peripheral base address.

`void ACMP_GetDefaultConfig(acmp_config_t *config)`

Gets the default configuration for ACMP.

This function initializes the user configuration structure to default value. The default value are:

Example:

```
config->enableHighSpeed = false;
config->enableInvertOutput = false;
config->useUnfilteredOutput = false;
config->enablePinOut = false;
config->enableHysteresisBothDirections = false;
config->hysteresisMode = kACMP_hysteresisMode0;
```

Parameters

- `config` – Pointer to ACMP configuration structure.

`void ACMP_Enable(CMP_Type *base, bool enable)`

Enables or disables the ACMP.

Parameters

- `base` – ACMP peripheral base address.
- `enable` – True to enable the ACMP.

void ACMP_EnableLinkToDAC(CMP_Type *base, bool enable)

Enables the link from CMP to DAC enable.

When this bit is set, the DAC enable/disable is controlled by the bit CMP_C0[EN] instead of CMP_C1[DACEN].

Parameters

- base – ACMP peripheral base address.
- enable – Enable the feature or not.

void ACMP_SetChannelConfig(CMP_Type *base, const *acmp_channel_config_t* *config)

Sets the channel configuration.

Note that the plus/minus mux's setting is only valid when the positive/negative port's input isn't from DAC but from channel mux.

Example:

```
acmp_channel_config_t configStruct = {0};
configStruct.positivePortInput = kACMP_PortInputFromDAC;
configStruct.negativePortInput = kACMP_PortInputFromMux;
configStruct.minusMuxInput = 1U;
ACMP_SetChannelConfig(CMP0, &configStruct);
```

Parameters

- base – ACMP peripheral base address.
- config – Pointer to channel configuration structure.

void ACMP_EnableDMA(CMP_Type *base, bool enable)

Enables or disables DMA.

Parameters

- base – ACMP peripheral base address.
- enable – True to enable DMA.

void ACMP_EnableWindowMode(CMP_Type *base, bool enable)

Enables or disables window mode.

Parameters

- base – ACMP peripheral base address.
- enable – True to enable window mode.

void ACMP_SetFilterConfig(CMP_Type *base, const *acmp_filter_config_t* *config)

Configures the filter.

The filter can be enabled when the filter count is bigger than 1, the filter period is greater than 0 and the sample clock is from divided bus clock or the filter is bigger than 1 and the sample clock is from external clock. Detailed usage can be got from the reference manual.

Example:

```
acmp_filter_config_t configStruct = {0};
configStruct.filterCount = 5U;
configStruct.filterPeriod = 200U;
configStruct.enableSample = false;
ACMP_SetFilterConfig(CMP0, &configStruct);
```

Parameters

- base – ACMP peripheral base address.

- config – Pointer to filter configuration structure.

void ACMP_SetDACConfig(CMP_Type *base, const *acmp_dac_config_t* *config)

Configures the internal DAC.

Example:

```
acmp_dac_config_t configStruct = {0};
configStruct.referenceVoltageSource = kACMP_VrefSourceVin1;
configStruct.DACValue = 20U;
configStruct.enableOutput = false;
configStruct.workMode = kACMP_DACWorkLowSpeedMode;
ACMP_SetDACConfig(CMP0, &configStruct);
```

Parameters

- base – ACMP peripheral base address.
- config – Pointer to DAC configuration structure. “NULL” is for disabling the feature.

void ACMP_SetRoundRobinConfig(CMP_Type *base, const *acmp_round_robin_config_t* *config)

Configures the round robin mode.

Example:

```
acmp_round_robin_config_t configStruct = {0};
configStruct.fixedPort = kACMP_FixedPlusPort;
configStruct.fixedChannelNumber = 3U;
configStruct.checkerChannelMask = 0xF7U;
configStruct.sampleClockCount = 0U;
configStruct.delayModulus = 0U;
ACMP_SetRoundRobinConfig(CMP0, &configStruct);
```

Parameters

- base – ACMP peripheral base address.
- config – Pointer to round robin mode configuration structure. “NULL” is for disabling the feature.

void ACMP_SetRoundRobinPreState(CMP_Type *base, uint32_t mask)

Defines the pre-set state of channels in round robin mode.

Note: The pre-state has different circuit with get-round-robin-result in the SOC even though they are same bits. So get-round-robin-result can't return the same value as the value are set by pre-state.

Parameters

- base – ACMP peripheral base address.
- mask – Mask of round robin channel index. Available range is channel0:0x01 to channel7:0x80.

static inline uint32_t ACMP_GetRoundRobinStatusFlags(CMP_Type *base)

Gets the channel input changed flags in round robin mode.

Parameters

- base – ACMP peripheral base address.

Returns

Mask of channel input changed asserted flags. Available range is channel0:0x01 to channel7:0x80.

`void ACMP_ClearRoundRobinStatusFlags(CMP_Type *base, uint32_t mask)`

Clears the channel input changed flags in round robin mode.

Parameters

- `base` – ACMP peripheral base address.
- `mask` – Mask of channel index. Available range is channel0:0x01 to channel7:0x80.

`static inline uint32_t ACMP_GetRoundRobinResult(CMP_Type *base)`

Gets the round robin result.

Note that the set-pre-state has different circuit with get-round-robin-result in the SOC even though they are same bits. So `ACMP_GetRoundRobinResult()` can't return the same value as the value are set by `ACMP_SetRoundRobinPreState`.

Parameters

- `base` – ACMP peripheral base address.

Returns

Mask of round robin channel result. Available range is channel0:0x01 to channel7:0x80.

`void ACMP_EnableInterrupts(CMP_Type *base, uint32_t mask)`

Enables interrupts.

Parameters

- `base` – ACMP peripheral base address.
- `mask` – Interrupts mask. See “_acmp_interrupt_enable”.

`void ACMP_DisableInterrupts(CMP_Type *base, uint32_t mask)`

Disables interrupts.

Parameters

- `base` – ACMP peripheral base address.
- `mask` – Interrupts mask. See “_acmp_interrupt_enable”.

`uint32_t ACMP_GetStatusFlags(CMP_Type *base)`

Gets status flags.

Parameters

- `base` – ACMP peripheral base address.

Returns

Status flags asserted mask. See “_acmp_status_flags”.

`void ACMP_ClearStatusFlags(CMP_Type *base, uint32_t mask)`

Clears status flags.

Parameters

- `base` – ACMP peripheral base address.
- `mask` – Status flags mask. See “_acmp_status_flags”.

`void ACMP_SetDiscreteModeConfig(CMP_Type *base, const acmp_discrete_mode_config_t *config)`

Configure the discrete mode.

Configure the discrete mode when supporting 3V domain with 1.8V core.

Parameters

- base – ACMP peripheral base address.
- config – Pointer to configuration structure. See “acmp_discrete_mode_config_t”.

void ACMP_GetDefaultDiscreteModeConfig(*acmp_discrete_mode_config_t* *config)

Get the default configuration for discrete mode setting.

Parameters

- config – Pointer to configuration structure to be restored with the setting values.

FSL_ACMP_DRIVER_VERSION

ACMP driver version 2.3.0.

enum _acmp_interrupt_enable

Interrupt enable/disable mask.

Values:

enumerator kACMP_OutputRisingInterruptEnable

Enable the interrupt when comparator outputs rising.

enumerator kACMP_OutputFallingInterruptEnable

Enable the interrupt when comparator outputs falling.

enumerator kACMP_RoundRobinInterruptEnable

Enable the Round-Robin interrupt.

enum _acmp_status_flags

Status flag mask.

Values:

enumerator kACMP_OutputRisingEventFlag

Rising-edge on compare output has occurred.

enumerator kACMP_OutputFallingEventFlag

Falling-edge on compare output has occurred.

enumerator kACMP_OutputAssertEventFlag

Return the current value of the analog comparator output.

enum _acmp_offset_mode

Comparator hard block offset control.

If OFFSET level is 1, then there is no hysteresis in the case of positive port input crossing negative port input in the positive direction (or negative port input crossing positive port input in the negative direction). Hysteresis still exists for positive port input crossing negative port input in the falling direction. If OFFSET level is 0, then the hysteresis selected by *acmp_hysteresis_mode_t* is valid for both directions.

Values:

enumerator kACMP_OffsetLevel0

The comparator hard block output has level 0 offset internally.

enumerator kACMP_OffsetLevel1

The comparator hard block output has level 1 offset internally.

enum _acmp_hysteresis_mode

Comparator hard block hysteresis control.

See chip data sheet to get the actual hysteresis value with each level.

Values:

enumerator kACMP_HysteresisLevel0

Offset is level 0 and Hysteresis is level 0.

enumerator kACMP_HysteresisLevel1

Offset is level 0 and Hysteresis is level 1.

enumerator kACMP_HysteresisLevel2

Offset is level 0 and Hysteresis is level 2.

enumerator kACMP_HysteresisLevel3

Offset is level 0 and Hysteresis is level 3.

enum _acmp_reference_voltage_source

CMP Voltage Reference source.

Values:

enumerator kACMP_VrefSourceVin1

Vin1 is selected as resistor ladder network supply reference Vin.

enumerator kACMP_VrefSourceVin2

Vin2 is selected as resistor ladder network supply reference Vin.

enum _acmp_port_input

Port input source.

Values:

enumerator kACMP_PortInputFromDAC

Port input from the 8-bit DAC output.

enumerator kACMP_PortInputFromMux

Port input from the analog 8-1 mux.

enum _acmp_fixed_port

Fixed mux port.

Values:

enumerator kACMP_FixedPlusPort

Only the inputs to the Minus port are swept in each round.

enumerator kACMP_FixedMinusPort

Only the inputs to the Plus port are swept in each round.

enum _acmp_dac_work_mode

Internal DAC's work mode.

Values:

enumerator kACMP_DACWorkLowSpeedMode

DAC is selected to work in low speed and low power mode.

enumerator kACMP_DACWorkHighSpeedMode

DAC is selected to work in high speed high power mode.

typedef enum _acmp_offset_mode acmp_offset_mode_t

Comparator hard block offset control.

If OFFSET level is 1, then there is no hysteresis in the case of positive port input crossing negative port input in the positive direction (or negative port input crossing positive port input in the negative direction). Hysteresis still exists for positive port input crossing negative port input in the falling direction. If OFFSET level is 0, then the hysteresis selected by acmp_hysteresis_mode_t is valid for both directions.

typedef enum *_acmp_hysteresis_mode* acmp_hysteresis_mode_t

Comparator hard block hysteresis control.

See chip data sheet to get the actual hysteresis value with each level.

typedef enum *_acmp_reference_voltage_source* acmp_reference_voltage_source_t

CMP Voltage Reference source.

typedef enum *_acmp_port_input* acmp_port_input_t

Port input source.

typedef enum *_acmp_fixed_port* acmp_fixed_port_t

Fixed mux port.

typedef enum *_acmp_dac_work_mode* acmp_dac_work_mode_t

Internal DAC's work mode.

typedef struct *_acmp_config* acmp_config_t

Configuration for ACMP.

typedef struct *_acmp_channel_config* acmp_channel_config_t

Configuration for channel.

The comparator's port can be input from channel mux or DAC. If port input is from channel mux, detailed channel number for the mux should be configured.

typedef struct *_acmp_filter_config* acmp_filter_config_t

Configuration for filter.

typedef struct *_acmp_dac_config* acmp_dac_config_t

Configuration for DAC.

typedef struct *_acmp_round_robin_config* acmp_round_robin_config_t

Configuration for round robin mode.

typedef struct *_acmp_discrete_mode_config* acmp_discrete_mode_config_t

Configuration for discrete mode.

CMP_C0_CFx_MASK

The mask of status flags cleared by writing 1.

CMP_C1_CHNn_MASK

CMP_C2_CHnF_MASK

struct *_acmp_config*

#include <fsl_acmp.h> Configuration for ACMP.

Public Members

acmp_offset_mode_t offsetMode

Offset mode.

acmp_hysteresis_mode_t hysteresisMode

Hysteresis mode.

bool enableHighSpeed

Enable High Speed (HS) comparison mode.

bool enableInvertOutput

Enable inverted comparator output.

bool useUnfilteredOutput

Set compare output(COUT) to equal COUTA(true) or COUT(false).

bool enablePinOut

The comparator output is available on the associated pin.

struct __acmp_channel_config

#include <fsl_acmp.h> Configuration for channel.

The comparator's port can be input from channel mux or DAC. If port input is from channel mux, detailed channel number for the mux should be configured.

Public Members

acmp_port_input_t positivePortInput

Input source of the comparator's positive port.

uint32_t plusMuxInput

Plus mux input channel(0~7).

acmp_port_input_t negativePortInput

Input source of the comparator's negative port.

uint32_t minusMuxInput

Minus mux input channel(0~7).

struct __acmp_filter_config

#include <fsl_acmp.h> Configuration for filter.

Public Members

bool enableSample

Using external SAMPLE as sampling clock input, or using divided bus clock.

uint32_t filterCount

Filter Sample Count. Available range is 1-7, 0 would cause the filter disabled.

uint32_t filterPeriod

Filter Sample Period. The divider to bus clock. Available range is 0-255.

struct __acmp_dac_config

#include <fsl_acmp.h> Configuration for DAC.

Public Members

acmp_reference_voltage_source_t referenceVoltageSource

Supply voltage reference source.

uint32_t DACValue

Value for DAC Output Voltage. Available range is 0-255.

bool enableOutput

Enable the DAC output.

struct __acmp_round_robin_config

#include <fsl_acmp.h> Configuration for round robin mode.

Public Members

acmp_fixed_port_t fixedPort

Fixed mux port.

uint32_t fixedChannelNumber

Indicates which channel is fixed in the fixed mux port.

uint32_t checkerChannelMask

Mask of checker channel index. Available range is channel0:0x01 to channel7:0x80 for round-robin checker.

uint32_t sampleClockCount

Specifies how many round-robin clock cycles(0~3) later the sample takes place.

uint32_t delayModulus

Comparator and DAC initialization delay modulus.

struct _acmp_discrete_mode_config

#include <fsl_acmp.h> Configuration for discrete mode.

Public Members

bool enablePositiveChannelDiscreteMode

Positive Channel Continuous Mode Enable. By default, the continuous mode is used.

bool enableNegativeChannelDiscreteMode

Negative Channel Continuous Mode Enable. By default, the continuous mode is used.

2.2 CACHE: CACHE Memory Controller

uint32_t CACHE64_GetInstance(CACHE64_POLSEL_Type *base)

Returns an instance number given peripheral base address.

Parameters

- base – The peripheral base address.

Returns

CACHE64_POLSEL instance number starting from 0.

uint32_t CACHE64_GetInstanceByAddr(*uint32_t* address)

brief Returns an instance number given physical memory address.

param address The physical memory address.

Returns

CACHE64_CTRL instance number starting from 0.

status_t CACHE64_Init(CACHE64_POLSEL_Type *base, const *cache64_config_t* *config)

Initializes an CACHE64 instance with the user configuration structure.

This function configures the CACHE64 module with user-defined settings. Call the CACHE64_GetDefaultConfig() function to configure the configuration structure and get the default configuration.

Parameters

- base – CACHE64_POLSEL peripheral base address.
- config – Pointer to a user-defined configuration structure.

Return values

kStatus_Success – CACHE64 initialize succeed

void CACHE64_GetDefaultConfig(*cache64_config_t* *config)

Gets the default configuration structure.

This function initializes the CACHE64 configuration structure to a default value. The default values are first region covers whole cacheable area, and policy set to write back.

Parameters

- config – Pointer to a configuration structure.

void CACHE64_EnableCache(CACHE64_CTRL_Type *base)

Enables the cache.

Parameters

- base – CACHE64_CTRL peripheral base address.

void CACHE64_DisableCache(CACHE64_CTRL_Type *base)

Disables the cache.

Parameters

- base – CACHE64_CTRL peripheral base address.

void CACHE64_InvalidateCache(CACHE64_CTRL_Type *base)

Invalidates the cache.

Parameters

- base – CACHE64_CTRL peripheral base address.

void CACHE64_InvalidateCacheByRange(uint32_t address, uint32_t size_byte)

Invalidates cache by range.

Note: Address and size should be aligned to “CACHE64_LINESIZE_BYTE”. The startAddr here will be forced to align to CACHE64_LINESIZE_BYTE if startAddr is not aligned. For the size_byte, application should make sure the alignment or make sure the right operation order if the size_byte is not aligned.

Parameters

- address – The physical address of cache.
- size_byte – size of the memory to be invalidated, should be larger than 0.

void CACHE64_CleanCache(CACHE64_CTRL_Type *base)

Cleans the cache.

Parameters

- base – CACHE64_CTRL peripheral base address.

void CACHE64_CleanCacheByRange(uint32_t address, uint32_t size_byte)

Cleans cache by range.

Note: Address and size should be aligned to “CACHE64_LINESIZE_BYTE”. The startAddr here will be forced to align to CACHE64_LINESIZE_BYTE if startAddr is not aligned. For the size_byte, application should make sure the alignment or make sure the right operation order if the size_byte is not aligned.

Parameters

- address – The physical address of cache.
- size_byte – size of the memory to be cleaned, should be larger than 0.

void CACHE64_CleanInvalidateCache(CACHE64_CTRL_Type *base)

Cleans and invalidates the cache.

Parameters

- base – CACHE64_CTRL peripheral base address.

void CACHE64_CleanInvalidateCacheByRange(uint32_t address, uint32_t size_byte)

Cleans and invalidate cache by range.

Note: Address and size should be aligned to “CACHE64_LINESIZE_BYTE”. The startAddr here will be forced to align to CACHE64_LINESIZE_BYTE if startAddr is not aligned. For the size_byte, application should make sure the alignment or make sure the right operation order if the size_byte is not aligned.

Parameters

- address – The physical address of cache.
- size_byte – size of the memory to be Cleaned and Invalidated, should be larger than 0.

void CACHE64_EnableWriteBuffer(CACHE64_CTRL_Type *base, bool enable)

Enables/disables the write buffer.

Parameters

- base – CACHE64_CTRL peripheral base address.
- enable – The enable or disable flag. true - enable the write buffer. false - disable the write buffer.

static inline void ICACHE_InvalidateByRange(uint32_t address, uint32_t size_byte)

Invalidates instruction cache by range.

Note: Address and size should be aligned to CACHE64_LINESIZE_BYTE due to the cache operation unit FSL_FEATURE_CACHE64_CTRL_LINESIZE_BYTE. The startAddr here will be forced to align to the cache line size if startAddr is not aligned. For the size_byte, application should make sure the alignment or make sure the right operation order if the size_byte is not aligned.

Parameters

- address – The physical address.
- size_byte – size of the memory to be invalidated, should be larger than 0.

static inline void DCACHE_InvalidateByRange(uint32_t address, uint32_t size_byte)

Invalidates data cache by range.

Note: Address and size should be aligned to CACHE64_LINESIZE_BYTE due to the cache operation unit FSL_FEATURE_CACHE64_CTRL_LINESIZE_BYTE. The startAddr here will be forced to align to the cache line size if startAddr is not aligned. For the size_byte, application should make sure the alignment or make sure the right operation order if the size_byte is not aligned.

Parameters

- address – The physical address.
- size_byte – size of the memory to be invalidated, should be larger than 0.

```
static inline void DCACHE_CleanByRange(uint32_t address, uint32_t size_byte)
```

Clean data cache by range.

Note: Address and size should be aligned to CACHE64_LINESIZE_BYTE due to the cache operation unit FSL_FEATURE_CACHE64_CTRL_LINESIZE_BYTE. The startAddr here will be forced to align to the cache line size if startAddr is not aligned. For the size_byte, application should make sure the alignment or make sure the right operation order if the size_byte is not aligned.

Parameters

- address – The physical address.
- size_byte – size of the memory to be cleaned, should be larger than 0.

```
static inline void DCACHE_CleanInvalidateByRange(uint32_t address, uint32_t size_byte)
```

Cleans and Invalidates data cache by range.

Note: Address and size should be aligned to CACHE64_LINESIZE_BYTE due to the cache operation unit FSL_FEATURE_CACHE64_CTRL_LINESIZE_BYTE. The startAddr here will be forced to align to the cache line size if startAddr is not aligned. For the size_byte, application should make sure the alignment or make sure the right operation order if the size_byte is not aligned.

Parameters

- address – The physical address.
- size_byte – size of the memory to be Cleaned and Invalidated, should be larger than 0.

```
FSL_CACHE_DRIVER_VERSION
```

cache driver version.

```
enum _cache64_policy
```

Level 2 cache controller way size.

Values:

```
enumerator kCACHE64_PolicyNonCacheable
```

Non-cacheable

```
enumerator kCACHE64_PolicyWriteThrough
```

Write through

```
enumerator kCACHE64_PolicyWriteBack
```

Write back

```
typedef enum _cache64_policy cache64_policy_t
```

Level 2 cache controller way size.

```
typedef struct _cache64_config cache64_config_t
```

CACHE64 configuration structure.

CACHE64_LINESIZE_BYTE

cache line size.

CACHE64_REGION_NUM

cache region number.

CACHE64_REGION_ALIGNMENT

cache region alignment.

struct __cache64_config

#include <fsl_cache.h> CACHE64 configuration structure.

Public Members

uint32_t boundaryAddr[(3U) - 1]

< The cache controller can divide whole memory into 3 regions. Boundary address is the FlexSPI internal address (start from 0) instead of system address (start from FlexSPI AMBA base) to split adjacent regions and must be 1KB aligned. The boundary address itself locates in upper region. Cacheable policy for each region.

2.3 CASPER: The Cryptographic Accelerator and Signal Processing Engine with RAM sharing

2.4 casper_driver

FSL_CASPER_DRIVER_VERSION

CASPER driver version. Version 2.2.4.

Current version: 2.2.4

Change log:

- Version 2.0.0
 - Initial version
- Version 2.0.1
 - Bug fix KPSDK-24531 double_scalar_multiplication() result may be all zeroes for some specific input
- Version 2.0.2
 - Bug fix KPSDK-25015 CASPER_MEMCPY hard-fault on LPC55xx when both source and destination buffers are outside of CASPER_RAM
- Version 2.0.3
 - Bug fix KPSDK-28107 RSUB, FILL and ZERO operations not implemented in enum _casper_operation.
- Version 2.0.4
 - For GCC compiler, enforce O1 optimize level, specifically to remove strict-aliasing option. This driver is very specific and requires -fno-strict-aliasing.
- Version 2.0.5
 - Fix sign-compare warning.
- Version 2.0.6

- Fix IAR Pa082 warning.
- Version 2.0.7
 - Fix MISRA-C 2012 issue.
- Version 2.0.8
 - Add feature macro for CASPER_RAM_OFFSET.
- Version 2.0.9
 - Remove unused function Jac_oncurve().
 - Fix ECC384 build.
- Version 2.0.10
 - Fix MISRA-C 2012 issue.
- Version 2.1.0
 - Add ECC NIST P-521 elliptic curve.
- Version 2.2.0
 - Rework driver to support multiple curves at once.
- Version 2.2.1
 - Fix MISRA-C 2012 issue.
- Version 2.2.2
 - Enable hardware interleaving to RAMX0 and RAMX1 for CASPER by feature macro FSL_FEATURE_CASPER_RAM_HW_INTERLEAVE
- Version 2.2.3
 - Added macro into CASPER_Init and CASPER_Deinit to support devices without clock and reset control.
- Version 2.2.4
 - Fix MISRA-C 2012 issue.

enum _casper_operation
CASPER operation.

Values:

enumerator kCASPER_OpMul6464NoSum

enumerator kCASPER_OpMul6464Sum

Walking 1 or more of J loop, doing $r=a*b$ using $64x64=128$

enumerator kCASPER_OpMul6464FullSum

Walking 1 or more of J loop, doing $c,r=r+a*b$ using $64x64=128$, but assume inner j loop

enumerator kCASPER_OpMul6464Reduce

Walking 1 or more of J loop, doing $c,r=r+a*b$ using $64x64=128$, but sum all of w.

enumerator kCASPER_OpAdd64

Walking 1 or more of J loop, doing $c,r[-1]=r+a*b$ using $64x64=128$, but skip 1st write

enumerator kCASPER_OpSub64

Walking add with off_AB, and in/out off_RES doing $c,r=r+a+c$ using $64+64=65$

enumerator kCASPER_OpDouble64

Walking subtract with off_AB, and in/out off_RES doing $r=r-a$ using $64-64=64$, with last borrow implicit if any

enumerator kCASPER_OpXor64

Walking add to self with off_RES doing $c, r = r + r + c$ using $64 + 64 = 65$

enumerator kCASPER_OpRSub64

Walking XOR with off_AB, and in/out off_RES doing $r = r \wedge a$ using $64 \wedge 64 = 64$

enumerator kCASPER_OpShiftLeft32

Walking subtract with off_AB, and in/out off_RES using $r = a - r$

enumerator kCASPER_OpShiftRight32

Walking shift left doing $r1, r = (b * D) | r1$, where D is 2^{amt} and is loaded by app (off_CD not used)

enumerator kCASPER_OpCopy

Walking shift right doing $r, r1 = (b * D) | r1$, where D is $2^{(32 - \text{amt})}$ and is loaded by app (off_CD not used) and off_RES starts at MSW

enumerator kCASPER_OpRemask

Copy from ABoff to resoff, 64b at a time

enumerator kCASPER_OpFill

Copy and mask from ABoff to resoff, 64b at a time

enumerator kCASPER_OpZero

Fill RESOFF using 64 bits at a time with value in A and B

enumerator kCASPER_OpCompare

Fill RESOFF using 64 bits at a time of 0s

enumerator kCASPER_OpCompareFast

Compare two arrays, running all the way to the end

enum _casper_algo_t

Algorithm used for CASPER operation.

Values:

enumerator kCASPER_ECC_P256

ECC_P256

enumerator kCASPER_ECC_P384

ECC_P384

enumerator kCASPER_ECC_P521

ECC_P521

Values:

enumerator kCASPER_RamOffset_Result

enumerator kCASPER_RamOffset_Base

enumerator kCASPER_RamOffset_TempBase

enumerator kCASPER_RamOffset_Modulus

enumerator kCASPER_RamOffset_M64

typedef enum _casper_operation casper_operation_t

CASPER operation.

typedef enum _casper_algo_t casper_algo_t

Algorithm used for CASPER operation.

`void CASPER_Init(CASPER_Type *base)`

Enables clock and disables reset for CASPER peripheral.

Enable clock and disable reset for CASPER.

Parameters

- `base` – CASPER base address

`void CASPER_Deinit(CASPER_Type *base)`

Disables clock for CASPER peripheral.

Disable clock and enable reset.

Parameters

- `base` – CASPER base address

`CASPER_CP`

`CASPER_CP_CTRL0`

`CASPER_CP_CTRL1`

`CASPER_CP_LOADER`

`CASPER_CP_STATUS`

`CASPER_CP_INTENSET`

`CASPER_CP_INTENCLR`

`CASPER_CP_INTSTAT`

`CASPER_CP_AREG`

`CASPER_CP_BREG`

`CASPER_CP_CREG`

`CASPER_CP_DREG`

`CASPER_CP_RES0`

`CASPER_CP_RES1`

`CASPER_CP_RES2`

`CASPER_CP_RES3`

`CASPER_CP_MASK`

`CASPER_CP_REMASK`

`CASPER_CP_LOCK`

`CASPER_CP_ID`

`CASPER_Wr32b(value, off)`

`CASPER_Wr64b(value, off)`

`CASPER_Rd32b(off)`

`N_wordlen_max`

2.5 casper_driver_pkha

```
void CASPER_ModExp(CASPER_Type *base, const uint8_t *signature, const uint8_t *pubN,
                  size_t wordLen, uint32_t pubE, uint8_t *plaintext)
```

Performs modular exponentiation - $(A^E) \bmod N$.

This function performs modular exponentiation.

Parameters

- base – CASPER base address
- signature – first addend (in little endian format)
- pubN – modulus (in little endian format)
- wordLen – Size of pubN in bytes
- pubE – exponent
- plaintext – **[out]** Output array to store result of operation (in little endian format)

```
void CASPER_ecc_init(casper_algo_t curve)
```

Initialize prime modulus mod in Casper memory .

Set the prime modulus mod in Casper memory and set N_wordlen according to selected algorithm.

Parameters

- curve – elliptic curve algorithm

```
void CASPER_ECC_SECP256R1_Mul(CASPER_Type *base, uint32_t resX[8], uint32_t resY[8],
                              uint32_t X[8], uint32_t Y[8], uint32_t scalar[8])
```

Performs ECC secp256r1 point single scalar multiplication.

This function performs ECC secp256r1 point single scalar multiplication $[resX; resY] = scalar * [X; Y]$ Coordinates are affine in normal form, little endian. Scalars are little endian. All arrays are little endian byte arrays, uint32_t type is used only to enforce the 32-bit alignment (0-mod-4 address).

Parameters

- base – CASPER base address
- resX – **[out]** Output X affine coordinate in normal form, little endian.
- resY – **[out]** Output Y affine coordinate in normal form, little endian.
- X – Input X affine coordinate in normal form, little endian.
- Y – Input Y affine coordinate in normal form, little endian.
- scalar – Input scalar integer, in normal form, little endian.

```
void CASPER_ECC_SECP256R1_MulAdd(CASPER_Type *base, uint32_t resX[8], uint32_t
                                resY[8], uint32_t X1[8], uint32_t Y1[8], uint32_t
                                scalar1[8], uint32_t X2[8], uint32_t Y2[8], uint32_t
                                scalar2[8])
```

Performs ECC secp256r1 point double scalar multiplication.

This function performs ECC secp256r1 point double scalar multiplication $[resX; resY] = scalar1 * [X1; Y1] + scalar2 * [X2; Y2]$ Coordinates are affine in normal form, little endian. Scalars are little endian. All arrays are little endian byte arrays, uint32_t type is used only to enforce the 32-bit alignment (0-mod-4 address).

Parameters

- base – CASPER base address
- resX – **[out]** Output X affine coordinate.
- resY – **[out]** Output Y affine coordinate.
- X1 – Input X1 affine coordinate.
- Y1 – Input Y1 affine coordinate.
- scalar1 – Input scalar1 integer.
- X2 – Input X2 affine coordinate.
- Y2 – Input Y2 affine coordinate.
- scalar2 – Input scalar2 integer.

```
void CASPER_ECC_SECP384R1_Mul(CASPER_Type *base, uint32_t resX[12], uint32_t resY[12],  
                               uint32_t X[12], uint32_t Y[12], uint32_t scalar[12])
```

Performs ECC secp384r1 point single scalar multiplication.

This function performs ECC secp384r1 point single scalar multiplication $[resX; resY] = scalar * [X; Y]$ Coordinates are affine in normal form, little endian. Scalars are little endian. All arrays are little endian byte arrays, uint32_t type is used only to enforce the 32-bit alignment (0-mod-4 address).

Parameters

- base – CASPER base address
- resX – **[out]** Output X affine coordinate in normal form, little endian.
- resY – **[out]** Output Y affine coordinate in normal form, little endian.
- X – Input X affine coordinate in normal form, little endian.
- Y – Input Y affine coordinate in normal form, little endian.
- scalar – Input scalar integer, in normal form, little endian.

```
void CASPER_ECC_SECP384R1_MulAdd(CASPER_Type *base, uint32_t resX[12], uint32_t  
                                resY[12], uint32_t X1[12], uint32_t Y1[12], uint32_t  
                                scalar1[12], uint32_t X2[12], uint32_t Y2[12], uint32_t  
                                scalar2[12])
```

Performs ECC secp384r1 point double scalar multiplication.

This function performs ECC secp384r1 point double scalar multiplication $[resX; resY] = scalar1 * [X1; Y1] + scalar2 * [X2; Y2]$ Coordinates are affine in normal form, little endian. Scalars are little endian. All arrays are little endian byte arrays, uint32_t type is used only to enforce the 32-bit alignment (0-mod-4 address).

Parameters

- base – CASPER base address
- resX – **[out]** Output X affine coordinate.
- resY – **[out]** Output Y affine coordinate.
- X1 – Input X1 affine coordinate.
- Y1 – Input Y1 affine coordinate.
- scalar1 – Input scalar1 integer.
- X2 – Input X2 affine coordinate.
- Y2 – Input Y2 affine coordinate.
- scalar2 – Input scalar2 integer.


```
void CASPER_ECC_SECP521R1_Mul(CASPER_Type *base, uint32_t resX[18], uint32_t resY[18],
                              uint32_t X[18], uint32_t Y[18], uint32_t scalar[18])
```

Performs ECC secp521r1 point single scalar multiplication.

This function performs ECC secp521r1 point single scalar multiplication $[resX; resY] = scalar * [X; Y]$ Coordinates are affine in normal form, little endian. Scalars are little endian. All arrays are little endian byte arrays, uint32_t type is used only to enforce the 32-bit alignment (0-mod-4 address).

Parameters

- base – CASPER base address
- resX – **[out]** Output X affine coordinate in normal form, little endian.
- resY – **[out]** Output Y affine coordinate in normal form, little endian.
- X – Input X affine coordinate in normal form, little endian.
- Y – Input Y affine coordinate in normal form, little endian.
- scalar – Input scalar integer, in normal form, little endian.

```
void CASPER_ECC_SECP521R1_MulAdd(CASPER_Type *base, uint32_t resX[18], uint32_t
                                resY[18], uint32_t X1[18], uint32_t Y1[18], uint32_t
                                scalar1[18], uint32_t X2[18], uint32_t Y2[18], uint32_t
                                scalar2[18])
```

Performs ECC secp521r1 point double scalar multiplication.

This function performs ECC secp521r1 point double scalar multiplication $[resX; resY] = scalar1 * [X1; Y1] + scalar2 * [X2; Y2]$ Coordinates are affine in normal form, little endian. Scalars are little endian. All arrays are little endian byte arrays, uint32_t type is used only to enforce the 32-bit alignment (0-mod-4 address).

Parameters

- base – CASPER base address
- resX – **[out]** Output X affine coordinate.
- resY – **[out]** Output Y affine coordinate.
- X1 – Input X1 affine coordinate.
- Y1 – Input Y1 affine coordinate.
- scalar1 – Input scalar1 integer.
- X2 – Input X2 affine coordinate.
- Y2 – Input Y2 affine coordinate.
- scalar2 – Input scalar2 integer.

```
void CASPER_ECC_equal(int *res, uint32_t *op1, uint32_t *op2)
```

```
void CASPER_ECC_equal_to_zero(int *res, uint32_t *op1)
```

2.6 Clock Driver

```
enum __clock_ip_name
```

Clock gate name used for CLOCK_EnableClock/CLOCK_DisableClock.

Values:

enumerator kCLOCK_IpInvalid
Invalid Ip Name.

enumerator kCLOCK_RomCtrlr
Clock gate name: RomCtrlr

enumerator kCLOCK_PowerQuad
Clock gate name: PowerQuad

enumerator kCLOCK_Casper
Clock gate name: Casper

enumerator kCLOCK_HashCrypt
Clock gate name: HashCrypt

enumerator kCLOCK_Puf
Clock gate name: Puf

enumerator kCLOCK_Rng
Clock gate name: Rng

enumerator kCLOCK_Flexspi
Clock gate name: Flexspi

enumerator kCLOCK_OtpCtrl
Clock gate name: OtpCtrl

enumerator kCLOCK_UsbhsPhy
Clock gate name: UsbhsPhy

enumerator kCLOCK_UsbhsDevice
Clock gate name: UsbhsDevice

enumerator kCLOCK_UsbhsHost
Clock gate name: UsbhsHost

enumerator kCLOCK_UsbhsSram
Clock gate name: UsbhsSram

enumerator kCLOCK_Sct
Clock gate name: Sct

enumerator kCLOCK_Sdio0
Clock gate name: Sdio0

enumerator kCLOCK_Sdio1
Clock gate name: Sdio1

enumerator kCLOCK_Acmp0
Clock gate name: Acmp0

enumerator kCLOCK_Adc0
Clock gate name: Adc0

enumerator kCLOCK_ShsGpio0
Clock gate name: ShsGpio0

enumerator kCLOCK_Utick0
Clock gate name: Utick0

enumerator kCLOCK_Wwdt0
Clock gate name: Wwdt0

enumerator kCLOCK_Flexcomm0
Clock gate name: Flexcomm0

enumerator kCLOCK_Flexcomm1
Clock gate name: Flexcomm1

enumerator kCLOCK_Flexcomm2
Clock gate name: Flexcomm2

enumerator kCLOCK_Flexcomm3
Clock gate name: Flexcomm3

enumerator kCLOCK_Flexcomm4
Clock gate name: Flexcomm4

enumerator kCLOCK_Flexcomm5
Clock gate name: Flexcomm5

enumerator kCLOCK_Flexcomm6
Clock gate name: Flexcomm6

enumerator kCLOCK_Flexcomm7
Clock gate name: Flexcomm7

enumerator kCLOCK_Flexcomm14
Clock gate name: Flexcomm14

enumerator kCLOCK_Flexcomm15
Clock gate name: Flexcomm15

enumerator kCLOCK_Usart0
Clock gate name: Usart0

enumerator kCLOCK_Usart1
Clock gate name: Usart1

enumerator kCLOCK_Usart2
Clock gate name: Usart2

enumerator kCLOCK_Usart3
Clock gate name: Usart3

enumerator kCLOCK_Usart4
Clock gate name: Usart4

enumerator kCLOCK_Usart5
Clock gate name: Usart5

enumerator kCLOCK_Usart6
Clock gate name: Usart6

enumerator kCLOCK_Usart7
Clock gate name: Usart7

enumerator kCLOCK_I2s0
Clock gate name: I2s0

enumerator kCLOCK_I2s1
Clock gate name: I2s1

enumerator kCLOCK_I2s2
Clock gate name: I2s2

enumerator kCLOCK_I2s3
Clock gate name: I2s3

enumerator kCLOCK_I2s4
Clock gate name: I2s4

enumerator kCLOCK_I2s5
Clock gate name: I2s5

enumerator kCLOCK_I2s6
Clock gate name: I2s6

enumerator kCLOCK_I2s7
Clock gate name: I2s7

enumerator kCLOCK_I2c0
Clock gate name: I2c0

enumerator kCLOCK_I2c1
Clock gate name: I2c1

enumerator kCLOCK_I2c2
Clock gate name: I2c2

enumerator kCLOCK_I2c3
Clock gate name: I2c3

enumerator kCLOCK_I2c4
Clock gate name: I2c4

enumerator kCLOCK_I2c5
Clock gate name: I2c5

enumerator kCLOCK_I2c6
Clock gate name: I2c6

enumerator kCLOCK_I2c7
Clock gate name: I2c7

enumerator kCLOCK_I2c15
Clock gate name: I2c15

enumerator kCLOCK_Spi0
Clock gate name: Spi0

enumerator kCLOCK_Spi1
Clock gate name: Spi1

enumerator kCLOCK_Spi2
Clock gate name: Spi2

enumerator kCLOCK_Spi3
Clock gate name: Spi3

enumerator kCLOCK_Spi4
Clock gate name: Spi4

enumerator kCLOCK_Spi5
Clock gate name: Spi5

enumerator kCLOCK_Spi6
Clock gate name: Spi6

enumerator kCLOCK_Spi7
Clock gate name: Spi7

enumerator kCLOCK_Spi14
Clock gate name: Spi14

enumerator kCLOCK_Dmic0
Clock gate name: Dmic0

enumerator kCLOCK_OsEventTimer
Clock gate name: OsEventTimer

enumerator kCLOCK_HsGpio0
Clock gate name: HsGpio0

enumerator kCLOCK_HsGpio1
Clock gate name: HsGpio1

enumerator kCLOCK_HsGpio2
Clock gate name: HsGpio2

enumerator kCLOCK_HsGpio3
Clock gate name: HsGpio3

enumerator kCLOCK_HsGpio4
Clock gate name: HsGpio4

enumerator kCLOCK_HsGpio5
Clock gate name: HsGpio5

enumerator kCLOCK_HsGpio6
Clock gate name: HsGpio6

enumerator kCLOCK_HsGpio7
Clock gate name: HsGpio7

enumerator kCLOCK_Crc
Clock gate name: Crc

enumerator kCLOCK_Dmac0
Clock gate name: Dmac0

enumerator kCLOCK_Dmac1
Clock gate name: Dmac1

enumerator kCLOCK_Mu
Clock gate name: Mu

enumerator kCLOCK_Sema
Clock gate name: Sema

enumerator kCLOCK_Freqme
Clock gate name: Freqme

enumerator kCLOCK_Ct32b0
Clock gate name: Ct32b0

enumerator kCLOCK_Ct32b1
Clock gate name: Ct32b1

enumerator kCLOCK_Ct32b2
Clock gate name: Ct32b2

enumerator kCLOCK_Ct32b3
Clock gate name: Ct32b3

enumerator kCLOCK_Ct32b4
Clock gate name: Ct32b4

enumerator kCLOCK_Rtc
Clock gate name: Rtc

enumerator kCLOCK_Mrt0
Clock gate name: Mrt0

enumerator kCLOCK_Wwdt1
Clock gate name: Wwdt1

enumerator kCLOCK_I3c0
Clock gate name: I3c0

enumerator kCLOCK_Pint
Clock gate name: Pint

enumerator kCLOCK_InputMux
Clock gate name: Input Mux.

enum _clock_name

Clock name used to get clock frequency.

Values:

enumerator kCLOCK_CoreSysClk
Core clock (aka HCLK)

enumerator kCLOCK_BusClk
Bus clock (AHB/APB clock, aka HCLK)

enumerator kCLOCK_MclkClk
MCLK, to MCLK pin

enumerator kCLOCK_ClockOutClk
CLOCKOUT

enumerator kCLOCK_AdcClk
ADC

enumerator kCLOCK_FlexspiClk
FLEXSPI

enumerator kCLOCK_SctClk
SCT

enumerator kCLOCK_Wdt0Clk
Watchdog0

enumerator kCLOCK_Wdt1Clk
Watchdog1

enumerator kCLOCK_SystickClk
Systick

enumerator kCLOCK_Sdio0Clk
SDIO0

enumerator kCLOCK_Sdio1Clk
SDIO1

enumerator kCLOCK_I3cClk
I3C

enumerator kCLOCK_UsbClk
USB

enumerator kCLOCK_DmicClk
Digital Mic clock

enumerator kCLOCK_DspCpuClk
DSP clock

enumerator kCLOCK_AcmpClk
Acmp clock

enumerator kCLOCK_Flexcomm0Clk
Flexcomm0Clock

enumerator kCLOCK_Flexcomm1Clk
Flexcomm1Clock

enumerator kCLOCK_Flexcomm2Clk
Flexcomm2Clock

enumerator kCLOCK_Flexcomm3Clk
Flexcomm3Clock

enumerator kCLOCK_Flexcomm4Clk
Flexcomm4Clock

enumerator kCLOCK_Flexcomm5Clk
Flexcomm5Clock

enumerator kCLOCK_Flexcomm6Clk
Flexcomm6Clock

enumerator kCLOCK_Flexcomm7Clk
Flexcomm7Clock

enumerator kCLOCK_Flexcomm14Clk
Flexcomm14Clock

enumerator kCLOCK_Flexcomm15Clk
Flexcomm15Clock

enum _clock_pfd
PLL PFD clock name.

Values:

enumerator kCLOCK_Pfd0
PLL PFD0

enumerator kCLOCK_Pfd1
PLL PFD1

enumerator kCLOCK_Pfd2
PLL PFD2

enumerator kCLOCK_Pfd3

PLL PFD3

enum _clock_attach_id

The enumerator of clock attach Id.

Values:

enumerator kSFRO_to_SYS_PLL

Attach SFRO to SYS_PLL.

enumerator kXTALIN_CLK_to_SYS_PLL

Attach XTALIN_CLK to SYS_PLL.

enumerator kFFRO_DIV2_to_SYS_PLL

Attach FFRO_DIV2 to SYS_PLL.

enumerator kNONE_to_SYS_PLL

Attach NONE to SYS_PLL.

enumerator kSFRO_to_AUDIO_PLL

Attach SFRO to AUDIO_PLL.

enumerator kXTALIN_CLK_to_AUDIO_PLL

Attach XTALIN_CLK to AUDIO_PLL.

enumerator kFFRO_DIV2_to_AUDIO_PLL

Attach FFRO_DIV2 to AUDIO_PLL.

enumerator kNONE_to_AUDIO_PLL

Attach NONE to AUDIO_PLL.

enumerator kFFRO_DIV4_to_MAIN_CLK

Attach FFRO_DIV4 to MAIN_CLK.

enumerator kXTALIN_CLK_to_MAIN_CLK

Attach XTALIN_CLK to MAIN_CLK.

enumerator kLPOSC_to_MAIN_CLK

Attach LPOSC to MAIN_CLK.

enumerator kFFRO_to_MAIN_CLK

Attach FFRO to MAIN_CLK.

enumerator kSFRO_to_MAIN_CLK

Attach SFRO to MAIN_CLK.

enumerator kMAIN_PLL_to_MAIN_CLK

Attach MAIN_PLL to MAIN_CLK.

enumerator kOSC32K_to_MAIN_CLK

Attach OSC32K to MAIN_CLK.

enumerator kFFRO_to_DSP_MAIN_CLK

Attach FFRO to DSP_MAIN_CLK.

enumerator kXTALIN_CLK_to_DSP_MAIN_CLK

Attach XTALIN_CLK to DSP_MAIN_CLK.

enumerator kLPOSC_to_DSP_MAIN_CLK

Attach LPOSC to DSP_MAIN_CLK.

enumerator kSFRO_to_DSP_MAIN_CLK
Attach SFRO to DSP_MAIN_CLK.

enumerator kMAIN_PLL_to_DSP_MAIN_CLK
Attach MAIN_PLL to DSP_MAIN_CLK.

enumerator kDSP_PLL_to_DSP_MAIN_CLK
Attach DSP_PLL to DSP_MAIN_CLK.

enumerator kOSC32K_to_DSP_MAIN_CLK
Attach OSC32K to DSP_MAIN_CLK.

enumerator kSFRO_to_ADC_CLK
Attach SFRO to ADC_CLK.

enumerator kXTALIN_CLK_to_ADC_CLK
Attach XTALIN_CLK to ADC_CLK.

enumerator kLPOSC_to_ADC_CLK
Attach LPOSC to ADC_CLK.

enumerator kFFRO_to_ADC_CLK
Attach FFRO to ADC_CLK.

enumerator kMAIN_PLL_to_ADC_CLK
Attach MAIN_PLL to ADC_CLK.

enumerator kAUX0_PLL_to_ADC_CLK
Attach AUX0_PLL to ADC_CLK.

enumerator kAUX1_PLL_to_ADC_CLK
Attach AUX1_PLL to ADC_CLK.

enumerator kSFRO_to_CLKOUT
Attach SFRO to CLKOUT.

enumerator kXTALIN_CLK_to_CLKOUT
Attach XTALIN_CLK to CLKOUT.

enumerator kLPOSC_to_CLKOUT
Attach LPOSC to CLKOUT.

enumerator kFFRO_to_CLKOUT
Attach FFRO to CLKOUT.

enumerator kMAIN_CLK_to_CLKOUT
Attach MAIN_CLK to CLKOUT.

enumerator kDSP_MAIN_to_CLKOUT
Attach DSP_MAIN to CLKOUT.

enumerator kMAIN_PLL_to_CLKOUT
Attach MAIN_PLL to CLKOUT.

enumerator kAUX0_PLL_to_CLKOUT
Attach AUX0_PLL to CLKOUT.

enumerator kDSP_PLL_to_CLKOUT
Attach DSP_PLL to CLKOUT.

enumerator kAUX1_PLL_to_CLKOUT
Attach AUX1_PLL to CLKOUT.

enumerator kAUDIO_PLL_to_CLKOUT
Attach AUDIO_PLL to CLKOUT.

enumerator kOSC32K_to_CLKOUT
Attach OSC32K to CLKOUT.

enumerator kNONE_to_CLKOUT
Attach NONE to CLKOUT.

enumerator kMAIN_CLK_to_I3C_CLK
Attach MAIN_CLK to I3C_CLK.

enumerator kFFRO_to_I3C_CLK
Attach FFRO to I3C_CLK.

enumerator kNONE_to_I3C_CLK
Attach NONE to I3C_CLK.

enumerator kI3C_CLK_to_I3C_TC_CLK
Attach I3C_CLK to I3C_TC_CLK.

enumerator kLPOSC_to_I3C_TC_CLK
Attach LPOSC to I3C_TC_CLK.

enumerator kNONE_to_I3C_TC_CLK
Attach NONE to I3C_TC_CLK.

enumerator kLPOSC_to_OSTIMER_CLK
Attach LPOSC to OSTIMER_CLK.

enumerator kOSC32K_to_OSTIMER_CLK
Attach OSC32K to OSTIMER_CLK.

enumerator kHCLK_to_OSTIMER_CLK
Attach HCLK to OSTIMER_CLK.

enumerator kNONE_to_OSTIMER_CLK
Attach NONE to OSTIMER_CLK.

enumerator kMAIN_CLK_to_FLEXSPI_CLK
Attach MAIN_CLK to FLEXSPI_CLK.

enumerator kMAIN_PLL_to_FLEXSPI_CLK
Attach MAIN_PLL to FLEXSPI_CLK.

enumerator kAUX0_PLL_to_FLEXSPI_CLK
Attach AUX0_PLL to FLEXSPI_CLK.

enumerator kFFRO_to_FLEXSPI_CLK
Attach FFRO to FLEXSPI_CLK.

enumerator kAUX1_PLL_to_FLEXSPI_CLK
Attach AUX1_PLL to FLEXSPI_CLK.

enumerator kNONE_to_FLEXSPI_CLK
Attach NONE to FLEXSPI_CLK.

enumerator kMAIN_CLK_to_SCT_CLK
Attach MAIN_CLK to SCT_CLK.

enumerator kMAIN_PLL_to_SCT_CLK
Attach MAIN_PLL to SCT_CLK.

enumerator kAUX0_PLL_to_SCT_CLK
Attach AUX0_PLL to SCT_CLK.

enumerator kFFRO_to_SCT_CLK
Attach FFRO to SCT_CLK.

enumerator kAUX1_PLL_to_SCT_CLK
Attach AUX1_PLL to SCT_CLK.

enumerator kAUDIO_PLL_to_SCT_CLK
Attach AUDIO_PLL to SCT_CLK.

enumerator kNONE_to_SCT_CLK
Attach NONE to SCT_CLK.

enumerator kLPOSC_to_UTICK_CLK
Attach LPOSC to UTICK_CLK.

enumerator kNONE_to_UTICK_CLK
Attach NONE to UTICK_CLK.

enumerator kLPOSC_to_WDT0_CLK
Attach LPOSC to WDT0_CLK.

enumerator kNONE_to_WDT0_CLK
Attach NONE to WDT0_CLK.

enumerator kLPOSC_to_WDT1_CLK
Attach LPOSC to WDT1_CLK.

enumerator kNONE_to_WDT1_CLK
Attach NONE to WDT1_CLK.

enumerator kOSC32K_to_32KHZWAKE_CLK
Attach OSC32K to 32KHZWAKE_CLK.

enumerator kLPOSC_DIV32_to_32KHZWAKE_CLK
Attach LPOSC_DIV32 to 32KHZWAKE_CLK.

enumerator kNONE_to_32KHZWAKE_CLK
Attach NONE to 32KHZWAKE_CLK.

enumerator kMAIN_CLK_DIV_to_SYSTICK_CLK
Attach MAIN_CLK_DIV to SYSTICK_CLK.

enumerator kLPOSC_to_SYSTICK_CLK
Attach LPOSC to SYSTICK_CLK.

enumerator kOSC32K_to_SYSTICK_CLK
Attach OSC32K to SYSTICK_CLK.

enumerator kSFRO_to_SYSTICK_CLK
Attach SFRO to SYSTICK_CLK.

enumerator kNONE_to_SYSTICK_CLK
Attach NONE to SYSTICK_CLK.

enumerator kMAIN_CLK_to_SDIO0_CLK
Attach MAIN_CLK to SDIO0_CLK.

enumerator kMAIN_PLL_to_SDIO0_CLK
Attach MAIN_PLL to SDIO0_CLK.

enumerator kAUX0_PLL_to_SDIO0_CLK

Attach AUX0_PLL to SDIO0_CLK.

enumerator kFFRO_to_SDIO0_CLK

Attach FFRO to SDIO0_CLK.

enumerator kAUX1_PLL_to_SDIO0_CLK

Attach AUX1_PLL to SDIO0_CLK.

enumerator kNONE_to_SDIO0_CLK

Attach NONE to SDIO0_CLK.

enumerator kMAIN_CLK_to_SDIO1_CLK

Attach MAIN_CLK to SDIO1_CLK.

enumerator kMAIN_PLL_to_SDIO1_CLK

Attach MAIN_PLL to SDIO1_CLK.

enumerator kAUX0_PLL_to_SDIO1_CLK

Attach AUX0_PLL to SDIO1_CLK.

enumerator kFFRO_to_SDIO1_CLK

Attach FFRO to SDIO1_CLK.

enumerator kAUX1_PLL_to_SDIO1_CLK

Attach AUX1_PLL to SDIO1_CLK.

enumerator kNONE_to_SDIO1_CLK

Attach NONE to SDIO1_CLK.

enumerator kFFRO_to_ESPI_CLK

Attach FFRO to ESPI_CLK.

enumerator kNONE_to_ESPI_CLK

Attach NONE to ESPI_CLK.

enumerator kXTALIN_CLK_to_USB_CLK

Attach XTALIN_CLK to USB_CLK.

enumerator kMAIN_CLK_to_USB_CLK

Attach MAIN_CLK to USB_CLK.

enumerator kNONE_to_USB_CLK

Attach NONE to USB_CLK.

enumerator kFFRO_to_MCLK_CLK

Attach FFRO to MCLK_CLK.

enumerator kAUDIO_PLL_to_MCLK_CLK

Attach AUDIO_PLL to MCLK_CLK.

enumerator kNONE_to_MCLK_CLK

Attach NONE to MCLK_CLK.

enumerator kSFRO_to_DMIC_CLK

Attach SFRO to DMIC_CLK.

enumerator kFFRO_to_DMIC_CLK

Attach FFRO to DMIC_CLK.

enumerator kAUDIO_PLL_to_DMIC_CLK

Attach AUDIO_PLL to DMIC_CLK.

enumerator kMASTER_CLK_to_DMIC_CLK
Attach MASTER_CLK to DMIC_CLK.

enumerator kLPOSC_to_DMIC_CLK
Attach LPOSC to DMIC_CLK.

enumerator k32K_WAKE_CLK_to_DMIC_CLK
Attach 32K_WAKE_CLK to DMIC_CLK.

enumerator kNONE_to_DMIC_CLK
Attach NONE to DMIC_CLK.

enumerator kMAIN_CLK_to_ACMP_CLK
Attach MAIN_CLK to ACMP_CLK.

enumerator kSFRO_to_ACMP_CLK
Attach SFRO to ACMP_CLK.

enumerator kFFRO_to_ACMP_CLK
Attach FFRO to ACMP_CLK.

enumerator kAUX0_PLL_to_ACMP_CLK
Attach AUX0_PLL to ACMP_CLK.

enumerator kAUX1_PLL_to_ACMP_CLK
Attach AUX1_PLL to ACMP_CLK.

enumerator kNONE_to_ACMP_CLK
Attach NONE to ACMP_CLK.

enumerator kSFRO_to_FLEXCOMM0
Attach SFRO to FLEXCOMM0.

enumerator kFFRO_to_FLEXCOMM0
Attach FFRO to FLEXCOMM0.

enumerator kAUDIO_PLL_to_FLEXCOMM0
Attach AUDIO_PLL to FLEXCOMM0.

enumerator kMASTER_CLK_to_FLEXCOMM0
Attach MASTER_CLK to FLEXCOMM0.

enumerator kFRG_to_FLEXCOMM0
Attach FRG to FLEXCOMM0.

enumerator kNONE_to_FLEXCOMM0
Attach NONE to FLEXCOMM0.

enumerator kSFRO_to_FLEXCOMM1
Attach SFRO to FLEXCOMM1.

enumerator kFFRO_to_FLEXCOMM1
Attach FFRO to FLEXCOMM1.

enumerator kAUDIO_PLL_to_FLEXCOMM1
Attach AUDIO_PLL to FLEXCOMM1.

enumerator kMASTER_CLK_to_FLEXCOMM1
Attach MASTER_CLK to FLEXCOMM1.

enumerator kFRG_to_FLEXCOMM1
Attach FRG to FLEXCOMM1.

enumerator kNONE_to_FLEXCOMM1
Attach NONE to FLEXCOMM1.

enumerator kSFRO_to_FLEXCOMM2
Attach SFRO to FLEXCOMM2.

enumerator kFFRO_to_FLEXCOMM2
Attach FFRO to FLEXCOMM2.

enumerator kAUDIO_PLL_to_FLEXCOMM2
Attach AUDIO_PLL to FLEXCOMM2.

enumerator kMASTER_CLK_to_FLEXCOMM2
Attach MASTER_CLK to FLEXCOMM2.

enumerator kFRG_to_FLEXCOMM2
Attach FRG to FLEXCOMM2.

enumerator kNONE_to_FLEXCOMM2
Attach NONE to FLEXCOMM2.

enumerator kSFRO_to_FLEXCOMM3
Attach SFRO to FLEXCOMM3.

enumerator kFFRO_to_FLEXCOMM3
Attach FFRO to FLEXCOMM3.

enumerator kAUDIO_PLL_to_FLEXCOMM3
Attach AUDIO_PLL to FLEXCOMM3.

enumerator kMASTER_CLK_to_FLEXCOMM3
Attach MASTER_CLK to FLEXCOMM3.

enumerator kFRG_to_FLEXCOMM3
Attach FRG to FLEXCOMM3.

enumerator kNONE_to_FLEXCOMM3
Attach NONE to FLEXCOMM3.

enumerator kSFRO_to_FLEXCOMM4
Attach SFRO to FLEXCOMM4.

enumerator kFFRO_to_FLEXCOMM4
Attach FFRO to FLEXCOMM4.

enumerator kAUDIO_PLL_to_FLEXCOMM4
Attach AUDIO_PLL to FLEXCOMM4.

enumerator kMASTER_CLK_to_FLEXCOMM4
Attach MASTER_CLK to FLEXCOMM4.

enumerator kFRG_to_FLEXCOMM4
Attach FRG to FLEXCOMM4.

enumerator kNONE_to_FLEXCOMM4
Attach NONE to FLEXCOMM4.

enumerator kSFRO_to_FLEXCOMM5
Attach SFRO to FLEXCOMM5.

enumerator kFFRO_to_FLEXCOMM5
Attach FFRO to FLEXCOMM5.

enumerator kAUDIO_PLL_to_FLEXCOMM5

Attach AUDIO_PLL to FLEXCOMM5.

enumerator kMASTER_CLK_to_FLEXCOMM5

Attach MASTER_CLK to FLEXCOMM5.

enumerator kFRG_to_FLEXCOMM5

Attach FRG to FLEXCOMM5.

enumerator kNONE_to_FLEXCOMM5

Attach NONE to FLEXCOMM5.

enumerator kSFRO_to_FLEXCOMM6

Attach SFRO to FLEXCOMM6.

enumerator kFFRO_to_FLEXCOMM6

Attach FFRO to FLEXCOMM6.

enumerator kAUDIO_PLL_to_FLEXCOMM6

Attach AUDIO_PLL to FLEXCOMM6.

enumerator kMASTER_CLK_to_FLEXCOMM6

Attach MASTER_CLK to FLEXCOMM6.

enumerator kFRG_to_FLEXCOMM6

Attach FRG to FLEXCOMM6.

enumerator kNONE_to_FLEXCOMM6

Attach NONE to FLEXCOMM6.

enumerator kSFRO_to_FLEXCOMM7

Attach SFRO to FLEXCOMM7.

enumerator kFFRO_to_FLEXCOMM7

Attach FFRO to FLEXCOMM7.

enumerator kAUDIO_PLL_to_FLEXCOMM7

Attach AUDIO_PLL to FLEXCOMM7.

enumerator kMASTER_CLK_to_FLEXCOMM7

Attach MASTER_CLK to FLEXCOMM7.

enumerator kFRG_to_FLEXCOMM7

Attach FRG to FLEXCOMM7.

enumerator kNONE_to_FLEXCOMM7

Attach NONE to FLEXCOMM7.

enumerator kSFRO_to_FLEXCOMM14

Attach SFRO to FLEXCOMM14.

enumerator kFFRO_to_FLEXCOMM14

Attach FFRO to FLEXCOMM14.

enumerator kAUDIO_PLL_to_FLEXCOMM14

Attach AUDIO_PLL to FLEXCOMM14.

enumerator kMASTER_CLK_to_FLEXCOMM14

Attach MASTER_CLK to FLEXCOMM14.

enumerator kFRG_to_FLEXCOMM14

Attach FRG to FLEXCOMM14.

enumerator kNONE_to_FLEXCOMM14
Attach NONE to FLEXCOMM14.

enumerator kSFRO_to_FLEXCOMM15
Attach SFRO to FLEXCOMM15.

enumerator kFFRO_to_FLEXCOMM15
Attach FFRO to FLEXCOMM15.

enumerator kAUDIO_PLL_to_FLEXCOMM15
Attach AUDIO_PLL to FLEXCOMM15.

enumerator kMASTER_CLK_to_FLEXCOMM15
Attach MASTER_CLK to FLEXCOMM15.

enumerator kFRG_to_FLEXCOMM15
Attach FRG to FLEXCOMM15.

enumerator kNONE_to_FLEXCOMM15
Attach NONE to FLEXCOMM15.

enumerator kMAIN_CLK_to_CTIMER0
Attach MAIN_CLK to CTIMER0.

enumerator kSFRO_to_CTIMER0
Attach SFRO to CTIMER0.

enumerator kFFRO_to_CTIMER0
Attach FFRO to CTIMER0.

enumerator kAUDIO_PLL_to_CTIMER0
Attach AUDIO_PLL to CTIMER0.

enumerator kMASTER_CLK_to_CTIMER0
Attach MASTER_CLK to CTIMER0.

enumerator kLPOSC_to_CTIMER0
Attach LPOSC to CTIMER0.

enumerator kNONE_to_CTIMER0
Attach NONE to CTIMER0.

enumerator kMAIN_CLK_to_CTIMER1
Attach MAIN_CLK to CTIMER1.

enumerator kSFRO_to_CTIMER1
Attach SFRO to CTIMER1.

enumerator kFFRO_to_CTIMER1
Attach FFRO to CTIMER1.

enumerator kAUDIO_PLL_to_CTIMER1
Attach AUDIO_PLL to CTIMER1.

enumerator kMASTER_CLK_to_CTIMER1
Attach MASTER_CLK to CTIMER1.

enumerator kLPOSC_to_CTIMER1
Attach LPOSC to CTIMER1.

enumerator kNONE_to_CTIMER1
Attach NONE to CTIMER1.

enumerator kMAIN_CLK_to_CTIMER2
Attach MAIN_CLK to CTIMER2.

enumerator kSFRO_to_CTIMER2
Attach SFRO to CTIMER2.

enumerator kFFRO_to_CTIMER2
Attach FFRO to CTIMER2.

enumerator kAUDIO_PLL_to_CTIMER2
Attach AUDIO_PLL to CTIMER2.

enumerator kMASTER_CLK_to_CTIMER2
Attach MASTER_CLK to CTIMER2.

enumerator kLPOSC_to_CTIMER2
Attach LPOSC to CTIMER2.

enumerator kNONE_to_CTIMER2
Attach NONE to CTIMER2.

enumerator kMAIN_CLK_to_CTIMER3
Attach MAIN_CLK to CTIMER3.

enumerator kSFRO_to_CTIMER3
Attach SFRO to CTIMER3.

enumerator kFFRO_to_CTIMER3
Attach FFRO to CTIMER3.

enumerator kAUDIO_PLL_to_CTIMER3
Attach AUDIO_PLL to CTIMER3.

enumerator kMASTER_CLK_to_CTIMER3
Attach MASTER_CLK to CTIMER3.

enumerator kLPOSC_to_CTIMER3
Attach LPOSC to CTIMER3.

enumerator kNONE_to_CTIMER3
Attach NONE to CTIMER3.

enumerator kMAIN_CLK_to_CTIMER4
Attach MAIN_CLK to CTIMER4.

enumerator kSFRO_to_CTIMER4
Attach SFRO to CTIMER4.

enumerator kFFRO_to_CTIMER4
Attach FFRO to CTIMER4.

enumerator kAUDIO_PLL_to_CTIMER4
Attach AUDIO_PLL to CTIMER4.

enumerator kMASTER_CLK_to_CTIMER4
Attach MASTER_CLK to CTIMER4.

enumerator kLPOSC_to_CTIMER4
Attach LPOSC to CTIMER4.

enumerator kNONE_to_CTIMER4
Attach NONE to CTIMER4.

enum _clock_div_name

Clock dividers.

Values:

enumerator kCLOCK_DivSysCpuAhbClk

Sys Cpu Ahb Clk Divider.

enumerator kCLOCK_DivMainPllClk

Main Pll Clk Divider.

enumerator kCLOCK_DivDspPllClk

Dsp Pll Clk Divider.

enumerator kCLOCK_DivAux0PllClk

Aux0 Pll Clk Divider.

enumerator kCLOCK_DivAux1PllClk

Aux1 Pll Clk Divider.

enumerator kCLOCK_DivPfc0Clk

Pfc0 Clk Divider.

enumerator kCLOCK_DivPfc1Clk

Pfc1 Clk Divider.

enumerator kCLOCK_DivAdcClk

Adc Clk Divider.

enumerator kCLOCK_DivFlexspiClk

Flexspi Clk Divider.

enumerator kCLOCK_DivSctClk

Sct Clk Divider.

enumerator kCLOCK_DivSdio0Clk

Sdio0 Clk Divider.

enumerator kCLOCK_DivSdio1Clk

Sdio1 Clk Divider.

enumerator kCLOCK_DivSystickClk

Systick Clk Divider.

enumerator kCLOCK_DivUsbHsFclk

Usb Hs Fclk Divider.

enumerator kCLOCK_DivAudioPllClk

Audio Pll Clk Divider.

enumerator kCLOCK_DivAcmpClk

Acmp Clk Divider.

enumerator kCLOCK_DivClockOut

Clock Out Divider.

enumerator kCLOCK_DivDmicClk

Dmic Clk Divider.

enumerator kCLOCK_DivDspCpuClk

Dsp Cpu Clk Divider.

enumerator kCLOCK_DivDspRamClk

Dsp Ram Clk Divider.

enumerator kCLOCK_DivMclkClk

Mclk Clk Divider.

enumerator kCLOCK_DivPllFrgClk

Pll Frg Clk Divider.

enumerator kCLOCK_DivI3cClk

I3c Clk Divider.

enumerator kCLOCK_DivI3cTcClk

I3c Tc Clk Divider.

enumerator kCLOCK_DivI3cSlowClk

I3c Slow Clk Divider.

enum _clock_ffro_freq

FFRO frequency configuration.

Values:

enumerator kCLOCK_Ffro48M

48MHz FFRO clock.

enumerator kCLOCK_Ffro60M

60MHz FFRO clock.

enum _sys_pll_src

SysPLL Reference Input Clock Source.

Values:

enumerator kCLOCK_SysPllSFroClk

16MHz FRO clock

enumerator kCLOCK_SysPllXtalIn

OSC clock

enumerator kCLOCK_SysPllFFroDiv2

FRO48/60 div2 clock

enumerator kCLOCK_SysPllNone

Gated to reduce power

enum _sys_pll_mult

SysPLL Multiplication Factor.

Values:

enumerator kCLOCK_SysPllMult16

Divide by 16

enumerator kCLOCK_SysPllMult17

Divide by 17

enumerator kCLOCK_SysPllMult18

Divide by 18

enumerator kCLOCK_SysPllMult19

Divide by 19

enumerator kCLOCK_SysPllMult20
Divide by 20

enumerator kCLOCK_SysPllMult21
Divide by 21

enumerator kCLOCK_SysPllMult22
Divide by 22

enum _audio_pll_src
AudioPll Reference Input Clock Source.
Values:

enumerator kCLOCK_AudioPllSFroClk
16MHz FRO clock

enumerator kCLOCK_AudioPllXtalIn
OSC clock

enumerator kCLOCK_AudioPllFFroDiv2
FRO48/60 div2 clock

enumerator kCLOCK_AudioPllNone
Gated to reduce power

enum _audio_pll_mult
AudioPll Multiplication Factor.
Values:

enumerator kCLOCK_AudioPllMult16
Divide by 16

enumerator kCLOCK_AudioPllMult17
Divide by 17

enumerator kCLOCK_AudioPllMult18
Divide by 18

enumerator kCLOCK_AudioPllMult19
Divide by 19

enumerator kCLOCK_AudioPllMult20
Divide by 20

enumerator kCLOCK_AudioPllMult21
Divide by 21

enumerator kCLOCK_AudioPllMult22
Divide by 22

typedef enum _clock_ip_name clock_ip_name_t
Clock gate name used for CLOCK_EnableClock/CLOCK_DisableClock.

typedef enum _clock_name clock_name_t
Clock name used to get clock frequency.

typedef enum _clock_pfd clock_pfd_t
PLL PFD clock name.

typedef enum _clock_attach_id clock_attach_id_t
The enumerator of clock attach Id.

```
typedef enum _clock_div_name clock_div_name_t
```

Clock dividers.

```
typedef enum _clock_ffro_freq clock_ffro_freq_t
```

FFRO frequency configuration.

```
typedef enum _sys_pll_src sys_pll_src_t
```

SysPLL Reference Input Clock Source.

```
typedef enum _sys_pll_mult sys_pll_mult_t
```

SysPLL Multiplication Factor.

```
typedef struct _clock_sys_pll_config clock_sys_pll_config_t
```

PLL configuration for SYSPLL.

```
typedef enum _audio_pll_src audio_pll_src_t
```

AudioPll Reference Input Clock Source.

```
typedef enum _audio_pll_mult audio_pll_mult_t
```

AudioPll Multiplication Factor.

```
typedef struct _clock_audio_pll_config clock_audio_pll_config_t
```

PLL configuration for SYSPLL.

```
typedef struct _clock_frg_clk_config clock_frg_clk_config_t
```

PLL configuration for FRG.

```
volatile uint32_t g_xtalFreq
```

External XTAL (SYSOSC) clock frequency.

The XTAL (SYSOSC) clock frequency in Hz, when the clock is setup, use the function `CLOCK_SetXtalFreq` to set the value in to clock driver. For example, if XTAL is 16MHz,

```
CLOCK_SetXtalFreq(16000000);
```

```
volatile uint32_t g_clkinFreq
```

External CLK_IN pin clock frequency (clkin) clock frequency.

The CLK_IN pin (clkin) clock frequency in Hz, when the clock is setup, use the function `CLOCK_SetClkinFreq` to set the value in to clock driver. For example, if CLK_IN is 16MHz,

```
CLOCK_SetClkinFreq(16000000);
```

```
volatile uint32_t g_mclkFreq
```

External XTAL (SYSOSC) clock frequency.

The MCLK in (mclk_in) PIN clock frequency in Hz, when the clock is setup, use the function `CLOCK_SetMclkInFreq` to set the value in to clock driver. For example, if mclk_In is 16MHz,

```
CLOCK_SetMclkInFreq(16000000);
```

```
static inline void CLOCK_EnableClock(clock_ip_name_t clk)
```

```
static inline void CLOCK_DisableClock(clock_ip_name_t clk)
```

```
void CLOCK_AttachClk(clock_attach_id_t connection)
```

Configure the clock selection muxes.

Parameters

- connection – : Clock to be configured.

Returns

Nothing

`void CLOCK_SetClkDiv(clock_div_name_t div_name, uint32_t divider)`

Setup peripheral clock dividers.

Parameters

- `div_name` – : Clock divider name
- `divider` – : Value to be divided. Divided clock frequency = Undivided clock frequency / divider.

Returns

Nothing

`uint32_t CLOCK_GetFreq(clock_name_t clockName)`

Return Frequency of selected clock.

Returns

Frequency of selected clock

`uint32_t CLOCK_GetFRGClkFreq(uint32_t id)`

Return Input frequency for the Fractional baud rate generator.

Returns

Input Frequency for FRG

`void CLOCK_SetFRGClkFreq(const clock_frg_clk_config_t *config)`

Set output of the Fractional baud rate generator.

Parameters

- `config` – : Configuration to set to FRGn clock.

`static inline uint32_t CLOCK_GetSFroFreq(void)`

Return Frequency of FRO 16MHz.

Returns

Frequency of FRO 16MHz

`uint32_t CLOCK_GetSysPllFreq(void)`

Return Frequency of SYSPLL.

Returns

Frequency of SYSPLL

`uint32_t CLOCK_GetSysPfdFreq(clock_pfd_t pfd)`

Get current output frequency of specific System PLL PFD.

Parameters

- `pfd` – : pfd name to get frequency.

Returns

Frequency of SYSPLL PFD.

`uint32_t CLOCK_GetAudioPllFreq(void)`

Return Frequency of AUDIO PLL.

Returns

Frequency of AUDIO PLL

`uint32_t CLOCK_GetAudioPfdFreq(clock_pfd_t pfd)`

Get current output frequency of specific Audio PLL PFD.

Parameters

- `pfd` – : pfd name to get frequency.

Returns

Frequency of AUDIO PLL PFD.

uint32_t CLOCK_GetFFroFreq(void)

Return Frequency of High-Freq output of FRO.

Returns

Frequency of High-Freq output of FRO

uint32_t CLOCK_GetMainClkFreq(void)

Return Frequency of main clk.

Returns

Frequency of main clk

uint32_t CLOCK_GetDspMainClkFreq(void)

Return Frequency of DSP main clk.

Returns

Frequency of DSP main clk

uint32_t CLOCK_GetAcmpClkFreq(void)

Return Frequency of ACMP clk.

Returns

Frequency of ACMP clk

uint32_t CLOCK_GetDmicClkFreq(void)

Return Frequency of DMIC clk.

Returns

Frequency of DMIC clk

uint32_t CLOCK_GetUsbClkFreq(void)

Return Frequency of USB clk.

Returns

Frequency of USB clk

uint32_t CLOCK_GetSdioClkFreq(uint32_t id)

Return Frequency of SDIO clk.

Parameters

- id – : SDIO index to get frequency.

Returns

Frequency of SDIO clk

uint32_t CLOCK_GetI3cClkFreq(void)

Return Frequency of I3C clk.

Returns

Frequency of I3C clk

uint32_t CLOCK_GetSystickClkFreq(void)

Return Frequency of systick clk.

Returns

Frequency of systick clk

uint32_t CLOCK_GetWdtClkFreq(uint32_t id)

Return Frequency of WDT clk.

Parameters

- id – : WDT index to get frequency.

Returns

Frequency of WDT clk

uint32_t CLOCK_GetMclkClkFreq(void)

Return Frequency of mclk.

Returns

Frequency of mclk clk

uint32_t CLOCK_GetSctClkFreq(void)

Return Frequency of sct.

Returns

Frequency of sct clk

void CLOCK_EnableSysOscClk(bool enable, bool enableLowPower, uint32_t delay_us)

Enable/Disable sys osc clock from external crystal clock.

Parameters

- enable – : true to enable system osc clock, false to bypass system osc.
- enableLowPower – : true to enable low power mode, false to enable high gain mode.
- delay_us – : Delay time after OSC power up.

static inline uint32_t CLOCK_GetXtalInClkFreq(void)

Return Frequency of sys osc Clock.

Returns

Frequency of sys osc Clock. Or CLK_IN pin frequency.

static inline uint32_t CLOCK_GetMclkInClkFreq(void)

Return Frequency of MCLK Input Clock.

Returns

Frequency of MCLK input Clock.

static inline uint32_t CLOCK_GetLpOscFreq(void)

Return Frequency of Lower power osc.

Returns

Frequency of LPOSC

static inline uint32_t CLOCK_GetOsc32KFreq(void)

Return Frequency of 32kHz osc.

Returns

Frequency of 32kHz osc

static inline void CLOCK_EnableOsc32K(bool enable)

Enables and disables 32kHz osc.

Parameters

- enable – : true to enable 32k osc clock, false to disable clock

static inline uint32_t CLOCK_GetWakeClk32KFreq(void)

Return Frequency of 32khz wake clk.

Returns

Frequency of 32kHz wake clk

static inline void CLOCK_SetXtalFreq(uint32_t freq)

Set the XTALIN (system OSC) frequency based on board setting.

Parameters

- freq – : The XTAL input clock frequency in Hz.

static inline void CLOCK_SetClkinFreq(uint32_t freq)

Set the CLKIN (CLKIN pin) frequency based on board setting.

Parameters

- freq – : The CLK_IN pin input clock frequency in Hz.

static inline void CLOCK_SetMclkFreq(uint32_t freq)

Set the MCLK in (mclk_in) clock frequency based on board setting.

Parameters

- freq – : The MCLK input clock frequency in Hz.

uint32_t CLOCK_GetFlexCommClkFreq(uint32_t id)

Return Frequency of Flexcomm functional Clock.

Parameters

- id – : flexcomm index to get frequency.

Returns

Frequency of Flexcomm functional Clock

uint32_t CLOCK_GetCtimerClkFreq(uint32_t id)

Return Frequency of Ctimer Clock.

Parameters

- id – : ctimer index to get frequency.

Returns

Frequency of Ctimer Clock

uint32_t CLOCK_GetClockOutClkFreq(void)

Return Frequency of ClockOut.

Returns

Frequency of ClockOut

uint32_t CLOCK_GetAdcClkFreq(void)

Return Frequency of Adc Clock.

Returns

Frequency of Adc Clock.

uint32_t CLOCK_GetFlexspiClkFreq(void)

Return Frequency of Flexspi Clock.

Returns

Frequency of Flexspi.

void CLOCK_EnableFfroClk(*clock_ffro_freq_t* ffroFreq)

brief Enable FFRO 48M/60M clock. param ffroFreq : target fro frequency. return Nothing

void CLOCK_EnableSfroClk(void)

brief Enable SFRO clock. param Nothing return Nothing

void CLOCK_InitSysPll(const *clock_sys_pll_config_t* *config)

Initialize the System PLL.

Parameters

- config – : Configuration to set to PLL.

static inline void CLOCK_DeinitSysPll(void)

brief Deinit the System PLL. param none.

status_t CLOCK_InitSysPfd(*clock_pfd_t* pfd, uint8_t divider)

Initialize the System PLL PFD.

Note: It is recommended that PFD settings are kept between 12-35.

Parameters

- pfd – : Which PFD clock to enable.
- divider – : The PFD divider value.

Returns

kStatus_Success if successfully, kStatus_Timeout if timeout happen.

static inline void CLOCK_DeinitSysPfd(*clock_pfd_t* pfd)

brief Disable the audio PLL PFD. param pfd : Which PFD clock to disable.

void CLOCK_InitAudioPll(const *clock_audio_pll_config_t* *config)

Initialize the audio PLL.

Parameters

- config – : Configuration to set to PLL.

static inline void CLOCK_DeinitAudioPll(void)

brief Deinit the Audio PLL. param none.

status_t CLOCK_InitAudioPfd(*clock_pfd_t* pfd, uint8_t divider)

Initialize the audio PLL PFD.

Note: It is recommended that PFD settings are kept between 12-35.

Parameters

- pfd – : Which PFD clock to enable.
- divider – : The PFD divider value.

Returns

kStatus_Success if successfully, kStatus_Timeout if timeout happen.

static inline void CLOCK_DeinitAudioPfd(uint32_t pfd)

brief Disable the audio PLL PFD. param pfd : Which PFD clock to disable.

void CLOCK_EnableUsbhsDeviceClock(void)

Enable USB HS device PLL clock.

This function enables USB HS device PLL clock.

void CLOCK_EnableUsbhsHostClock(void)

Enable USB HS host PLL clock.

This function enables USB HS host PLL clock.

bool CLOCK_EnableUsbHs0PhyPllClock(*clock_attach_id_t* src, uint32_t freq)

brief Enable USB hs0PhyPll clock.

param src USB HS clock source. param freq The frequency specified by src. retval true The clock is set successfully. retval false The clock source is invalid to get proper USB HS clock.

FSL_CLOCK_DRIVER_VERSION

CLOCK driver version 2.7.4.

SDK_DEVICE_MAXIMUM_CPU_CLOCK_FREQUENCY

CLOCK_GetCTimerClkFreq

CMP_CLOCKS

Clock ip name array for ACMP.

FLEXCOMM_CLOCKS

Clock ip name array for FLEXCOMM.

USART_CLOCKS

Clock ip name array for LPUART.

I2C_CLOCKS

Clock ip name array for I2C.

I3C_CLOCKS

Clock ip name array for I3C.

SPI_CLOCKS

Clock ip name array for SPI.

FLEXI2S_CLOCKS

Clock ip name array for FLEXI2S.

UTICK_CLOCKS

Clock ip name array for UTICK.

DMIC_CLOCKS

Clock ip name array for DMIC.

CTIMER_CLOCKS

Clock ip name array for CT32B.

GPIO_CLOCKS

Clock ip name array for GPIO.

LPADC_CLOCKS

Clock ip name array for ADC.

MRT_CLOCKS

Clock ip name array for MRT.

SCT_CLOCKS

Clock ip name array for SCT.

RTC_CLOCKS

Clock ip name array for RTC.

WWDT_CLOCKS

Clock ip name array for WWDT.

CRC_CLOCKS

Clock ip name array for CRC.

USB_CLOCKS

Clock ip name array for USB.

DMA_CLOCKS

Clock ip name array for DMA.

PINT_CLOCKS

Clock ip name array for PINT.

FLEXSPI_CLOCKS

 Clock ip name array for FLEXSPI.

CACHE64_CLOCKS

 Clock ip name array for Cache64.

MU_CLOCKS

 Clock ip name array for MUA.

SEMA42_CLOCKS

 Clock ip name array for SEMA.

TRNG_CLOCKS

 Clock ip name array for RNG.

PUF_CLOCKS

 Clock ip name array for PUF.

HASHCRYPT_CLOCKS

 Clock ip name array for HashCrypt.

CASPER_CLOCKS

 Clock ip name array for Casper.

USDHC_CLOCKS

 Clock ip name array for uSDHC.

OSTIMER_CLOCKS

 Clock ip name array for OSTimer.

POWERQUAD_CLOCKS

 Clock ip name array for Powerquad.

CLK_GATE_REG_OFFSET_SHIFT

 Clock gate name used for CLOCK_EnableClock/CLOCK_DisableClock.

CLK_GATE_REG_OFFSET_MASK

CLK_GATE_BIT_SHIFT_SHIFT

CLK_GATE_BIT_SHIFT_MASK

CLK_GATE_DEFINE(reg_offset, bit_shift)

CLK_GATE_ABSTRACT_REG_OFFSET(x)

CLK_GATE_ABSTRACT_BITS_SHIFT(x)

CLK_CTL0_PSCCTL0

CLK_CTL0_PSCCTL1

CLK_CTL0_PSCCTL2

CLK_CTL1_PSCCTL0

CLK_CTL1_PSCCTL1

CLK_CTL1_PSCCTL2

SYSPLL0CLKSEL_OFFSET

Clock Mux Switches The encoding is as follows each connection identified is 32bits wide starting from LSB upwards.

[12 bits for reg offset, 0 means end of descriptor, 4 bits for choice] [bit 31 define CLKCTL0 or CLKCTL1]*

MAINCLKSELA_OFFSET

MAINCLKSELB_OFFSET

FLEXSPIFCLKSEL_OFFSET

SCTFCLKSEL_OFFSET

USBHSFCLKSEL_OFFSET

SDIO0FCLKSEL_OFFSET

SDIO1FCLKSEL_OFFSET

ESPICLKSEL_OFFSET

ADC0FCLKSEL0_OFFSET

ADC0FCLKSEL1_OFFSET

UTICKFCLKSEL_OFFSET

WDT0FCLKSEL_OFFSET

WAKECLK32KHZSEL_OFFSET

SYSTICKFCLKSEL_OFFSET

AUDIOPLL0CLKSEL_OFFSET

DSPCPUCLKSELA_OFFSET

DSPCPUCLKSELB_OFFSET

OSEVENTFCLKSEL_OFFSET

FC0FCLKSEL_OFFSET

FC1FCLKSEL_OFFSET

FC2FCLKSEL_OFFSET

FC3FCLKSEL_OFFSET

FC4FCLKSEL_OFFSET

FC5FCLKSEL_OFFSET

FC6FCLKSEL_OFFSET

FC7FCLKSEL_OFFSET

FC14FCLKSEL_OFFSET

FC15FCLKSEL_OFFSET

DMIC0FCLKSEL_OFFSET

CT32BIT0FCLKSEL_OFFSET
CT32BIT1FCLKSEL_OFFSET
CT32BIT2FCLKSEL_OFFSET
CT32BIT3FCLKSEL_OFFSET
CT32BIT4FCLKSEL_OFFSET
AUDIOMCLKSEL_OFFSET
CLKOUTSEL0_OFFSET
CLKOUTSEL1_OFFSET
I3C0FCLKSEL_OFFSET
I3C0FCLKSTCSEL_OFFSET
WDT1FCLKSEL_OFFSET
ACMP0FCLKSEL_OFFSET
MAINPLLCLKDIV_OFFSET
DSPPLLCLKDIV_OFFSET
AUX0PLLCLKDIV_OFFSET
AUX1PLLCLKDIV_OFFSET
SYSCPUAHBCLKDIV_OFFSET
PFC0CLKDIV_OFFSET
PFC1CLKDIV_OFFSET
FLEXSPIFCLKDIV_OFFSET
SCTFCLKDIV_OFFSET
USBHSFCLKDIV_OFFSET
SDIO0FCLKDIV_OFFSET
SDIO1FCLKDIV_OFFSET
ADC0FCLKDIV_OFFSET
WAKECLK32KHZDIV_OFFSET
SYSTICKFCLKDIV_OFFSET
AUDIOPLLCLKDIV_OFFSET
DSPCPUCLKDIV_OFFSET
DSPMAINRAMCLKDIV_OFFSET
FRGPLLCLKDIV_OFFSET
DMIC0FCLKDIV_OFFSET
AUDIOMCLKDIV_OFFSET

CLKOUTDIV_OFFSET
I3C0CLKSTCDIV_OFFSET
I3C0CLKSDIV_OFFSET
I3C0CLKDIV_OFFSET
ACMP0CLKDIV_OFFSET
CLKCTL0_TUPLE_MUXA(reg, choice)
CLKCTL0_TUPLE_MUXB(reg, choice)
CLKCTL1_TUPLE_MUXA(reg, choice)
CLKCTL1_TUPLE_MUXB(reg, choice)
CLKCTL_TUPLE_REG(base, tuple)
CLKCTL_TUPLE_SEL(tuple)

Values:

enumerator kCLOCK_FrgMainClk
Main System clock

enumerator kCLOCK_FrgPllDiv
Main pll clock divider

enumerator kCLOCK_FrgSFro
16MHz FRO

enumerator kCLOCK_FrgFFro
FRO48/60

sys_pll_src_t sys_pll_src
Reference Input Clock Source

uint32_t numerator
30 bit numerator of fractional loop divider.

uint32_t denominator
30 bit numerator of fractional loop divider.

sys_pll_mult_t sys_pll_mult
Multiplication Factor

audio_pll_src_t audio_pll_src
Reference Input Clock Source

uint32_t numerator
30 bit numerator of fractional loop divider.

uint32_t denominator
30 bit numerator of fractional loop divider.

audio_pll_mult_t audio_pll_mult
Multiplication Factor

uint8_t num
FRG clock

```
enum _clock_frg_clk_config sfg_clock_src

uint8_t divider
    Denominator of the fractional divider.

uint8_t mult
    Numerator of the fractional divider.

struct _clock_sys_pll_config
    #include <fsl_clock.h> PLL configuration for SYSPLL.

struct _clock_audio_pll_config
    #include <fsl_clock.h> PLL configuration for SYSPLL.

struct _clock_frg_clk_config
    #include <fsl_clock.h> PLL configuration for FRG.
```

2.7 CRC: Cyclic Redundancy Check Driver

```
FSL_CRC_DRIVER_VERSION
    CRC driver version. Version 2.1.1.
    Current version: 2.1.1
    Change log:
        • Version 2.0.0
            – initial version
        • Version 2.0.1
            – add explicit type cast when writing to WR_DATA
        • Version 2.0.2
            – Fix MISRA issue
        • Version 2.1.0
            – Add CRC_WriteSeed function
        • Version 2.1.1
            – Fix MISRA issue

enum _crc_polynomial
    CRC polynomials to use.
    Values:
    enumerator kCRC_Polynomial_CRC_CCITT
         $x^{16}+x^{12}+x^5+1$ 
    enumerator kCRC_Polynomial_CRC_16
         $x^{16}+x^{15}+x^2+1$ 
    enumerator kCRC_Polynomial_CRC_32
         $x^{32}+x^{26}+x^{23}+x^{22}+x^{16}+x^{12}+x^{11}+x^{10}+x^8+x^7+x^5+x^4+x^2+x+1$ 

typedef enum _crc_polynomial crc_polynomial_t
    CRC polynomials to use.
```



```
typedef struct _crc_config crc_config_t
```

CRC protocol configuration.

This structure holds the configuration for the CRC protocol.

```
void CRC_Init(CRC_Type *base, const crc_config_t *config)
```

Enables and configures the CRC peripheral module.

This functions enables the CRC peripheral clock in the LPC SYSCON block. It also configures the CRC engine and starts checksum computation by writing the seed.

Parameters

- base – CRC peripheral address.
- config – CRC module configuration structure.

```
static inline void CRC_Deinit(CRC_Type *base)
```

Disables the CRC peripheral module.

This functions disables the CRC peripheral clock in the LPC SYSCON block.

Parameters

- base – CRC peripheral address.

```
void CRC_Reset(CRC_Type *base)
```

resets CRC peripheral module.

Parameters

- base – CRC peripheral address.

```
void CRC_WriteSeed(CRC_Type *base, uint32_t seed)
```

Write seed to CRC peripheral module.

Parameters

- base – CRC peripheral address.
- seed – CRC Seed value.

```
void CRC_GetDefaultConfig(crc_config_t *config)
```

Loads default values to CRC protocol configuration structure.

Loads default values to CRC protocol configuration structure. The default values are:

```
config->polynomial = kCRC_Polynomial_CRC_CCITT;
config->reverseIn = false;
config->complementIn = false;
config->reverseOut = false;
config->complementOut = false;
config->seed = 0xFFFFU;
```

Parameters

- config – CRC protocol configuration structure

```
void CRC_GetConfig(CRC_Type *base, crc_config_t *config)
```

Loads actual values configured in CRC peripheral to CRC protocol configuration structure.

The values, including seed, can be used to resume CRC calculation later.

Parameters

- base – CRC peripheral address.
- config – CRC protocol configuration structure

```
void CRC_WriteData(CRC_Type *base, const uint8_t *data, size_t dataSize)
```

Writes data to the CRC module.

Writes input data buffer bytes to CRC data register.

Parameters

- `base` – CRC peripheral address.
- `data` – Input data stream, MSByte in `data[0]`.
- `dataSize` – Size of the input data buffer in bytes.

```
static inline uint32_t CRC_Get32bitResult(CRC_Type *base)
```

Reads 32-bit checksum from the CRC module.

Reads CRC data register.

Parameters

- `base` – CRC peripheral address.

Returns

final 32-bit checksum, after configured bit reverse and complement operations.

```
static inline uint16_t CRC_Get16bitResult(CRC_Type *base)
```

Reads 16-bit checksum from the CRC module.

Reads CRC data register.

Parameters

- `base` – CRC peripheral address.

Returns

final 16-bit checksum, after configured bit reverse and complement operations.

```
CRC_DRIVER_USE_CRC16_CCITT_FALSE_AS_DEFAULT
```

Default configuration structure filled by `CRC_GetDefaultConfig()`. Uses CRC-16/CCITT-FALSE as default.

```
struct __crc_config
```

#include <fsl_crc.h> CRC protocol configuration.

This structure holds the configuration for the CRC protocol.

Public Members

crc_polynomial_t polynomial

CRC polynomial.

bool reverseIn

Reverse bits on input.

bool complementIn

Perform 1's complement on input.

bool reverseOut

Reverse bits on output.

bool complementOut

Perform 1's complement on output.

uint32_t seed

Starting checksum value.

2.8 CTIMER: Standard counter/timers

`void CTIMER_Init(CTIMER_Type *base, const ctimer_config_t *config)`

Ungates the clock and configures the peripheral for basic operation.

Note: This API should be called at the beginning of the application before using the driver.

Parameters

- `base` – Ctimer peripheral base address
- `config` – Pointer to the user configuration structure.

`void CTIMER_Deinit(CTIMER_Type *base)`

Gates the timer clock.

Parameters

- `base` – Ctimer peripheral base address

`void CTIMER_GetDefaultConfig(ctimer_config_t *config)`

Fills in the timers configuration structure with the default settings.

The default values are:

```
config->mode = kCTIMER_TimerMode;
config->input = kCTIMER_Capture_0;
config->prescale = 0;
```

Parameters

- `config` – Pointer to the user configuration structure.

`status_t CTIMER_SetupPwmPeriod(CTIMER_Type *base, const ctimer_match_t pwmPeriodChannel, ctimer_match_t matchChannel, uint32_t pwmPeriod, uint32_t pulsePeriod, bool enableInt)`

Configures the PWM signal parameters.

Enables PWM mode on the match channel passed in and will then setup the match value and other match parameters to generate a PWM signal. This function can manually assign the specified channel to set the PWM cycle.

Note: When setting PWM output from multiple output pins, all should use the same PWM period

Parameters

- `base` – Ctimer peripheral base address
- `pwmPeriodChannel` – Specify the channel to control the PWM period
- `matchChannel` – Match pin to be used to output the PWM signal
- `pwmPeriod` – PWM period match value
- `pulsePeriod` – Pulse width match value
- `enableInt` – Enable interrupt when the timer value reaches the match value of the PWM pulse, if it is 0 then no interrupt will be generated.

Returns

kStatus_Success on success kStatus_Fail If matchChannel is equal to pwmPeriodChannel; this channel is reserved to set the PWM cycle If PWM pulse width register value is larger than 0xFFFFFFFF.

```
status_t CTIMER_SetupPwm(CTIMER_Type *base, const ctimer_match_t pwmPeriodChannel,
                        ctimer_match_t matchChannel, uint8_t dutyCyclePercent, uint32_t
                        pwmFreq_Hz, uint32_t srcClock_Hz, bool enableInt)
```

Configures the PWM signal parameters.

Enables PWM mode on the match channel passed in and will then setup the match value and other match parameters to generate a PWM signal. This function can manually assign the specified channel to set the PWM cycle.

Note: When setting PWM output from multiple output pins, all should use the same PWM frequency. Please use CTIMER_SetupPwmPeriod to set up the PWM with high resolution.

Parameters

- base – Ctimer peripheral base address
- pwmPeriodChannel – Specify the channel to control the PWM period
- matchChannel – Match pin to be used to output the PWM signal
- dutyCyclePercent – PWM pulse width; the value should be between 0 to 100
- pwmFreq_Hz – PWM signal frequency in Hz
- srcClock_Hz – Timer counter clock in Hz
- enableInt – Enable interrupt when the timer value reaches the match value of the PWM pulse, if it is 0 then no interrupt will be generated.

```
static inline void CTIMER_UpdatePwmPulsePeriod(CTIMER_Type *base, ctimer_match_t
                                              matchChannel, uint32_t pulsePeriod)
```

Updates the pulse period of an active PWM signal.

Parameters

- base – Ctimer peripheral base address
- matchChannel – Match pin to be used to output the PWM signal
- pulsePeriod – New PWM pulse width match value

```
status_t CTIMER_UpdatePwmDutycycle(CTIMER_Type *base, const ctimer_match_t
                                   pwmPeriodChannel, ctimer_match_t matchChannel,
                                   uint8_t dutyCyclePercent)
```

Updates the duty cycle of an active PWM signal.

Note: Please use CTIMER_SetupPwmPeriod to update the PWM with high resolution. This function can manually assign the specified channel to set the PWM cycle.

Parameters

- base – Ctimer peripheral base address
- pwmPeriodChannel – Specify the channel to control the PWM period
- matchChannel – Match pin to be used to output the PWM signal
- dutyCyclePercent – New PWM pulse width; the value should be between 0 to 100

Returns

kStatus_Success on success kStatus_Fail If PWM pulse width register value is larger than 0xFFFFFFFF.

```
static inline void CTIMER_EnableInterrupts(CTIMER_Type *base, uint32_t mask)
```

Enables the selected Timer interrupts.

Parameters

- base – Ctimer peripheral base address
- mask – The interrupts to enable. This is a logical OR of members of the enumeration ctimer_interrupt_enable_t

```
static inline void CTIMER_DisableInterrupts(CTIMER_Type *base, uint32_t mask)
```

Disables the selected Timer interrupts.

Parameters

- base – Ctimer peripheral base address
- mask – The interrupts to enable. This is a logical OR of members of the enumeration ctimer_interrupt_enable_t

```
static inline uint32_t CTIMER_GetEnabledInterrupts(CTIMER_Type *base)
```

Gets the enabled Timer interrupts.

Parameters

- base – Ctimer peripheral base address

Returns

The enabled interrupts. This is the logical OR of members of the enumeration ctimer_interrupt_enable_t

```
static inline uint32_t CTIMER_GetStatusFlags(CTIMER_Type *base)
```

Gets the Timer status flags.

Parameters

- base – Ctimer peripheral base address

Returns

The status flags. This is the logical OR of members of the enumeration ctimer_status_flags_t

```
static inline void CTIMER_ClearStatusFlags(CTIMER_Type *base, uint32_t mask)
```

Clears the Timer status flags.

Parameters

- base – Ctimer peripheral base address
- mask – The status flags to clear. This is a logical OR of members of the enumeration ctimer_status_flags_t

```
static inline void CTIMER_StartTimer(CTIMER_Type *base)
```

Starts the Timer counter.

Parameters

- base – Ctimer peripheral base address

```
static inline void CTIMER_StopTimer(CTIMER_Type *base)
```

Stops the Timer counter.

Parameters

- base – Ctimer peripheral base address

FSL_CTIMER_DRIVER_VERSION

Version 2.3.3

enum _ctimer_capture_channel

List of Timer capture channels.

Values:

enumerator kCTIMER_Capture_0
Timer capture channel 0

enumerator kCTIMER_Capture_1
Timer capture channel 1

enumerator kCTIMER_Capture_3
Timer capture channel 3

enum _ctimer_capture_edge

List of capture edge options.

Values:

enumerator kCTIMER_Capture_RiseEdge
Capture on rising edge

enumerator kCTIMER_Capture_FallEdge
Capture on falling edge

enumerator kCTIMER_Capture_BothEdge
Capture on rising and falling edge

enum _ctimer_match

List of Timer match registers.

Values:

enumerator kCTIMER_Match_0
Timer match register 0

enumerator kCTIMER_Match_1
Timer match register 1

enumerator kCTIMER_Match_2
Timer match register 2

enumerator kCTIMER_Match_3
Timer match register 3

enum _ctimer_external_match

List of external match.

Values:

enumerator kCTIMER_External_Match_0
External match 0

enumerator kCTIMER_External_Match_1
External match 1

enumerator kCTIMER_External_Match_2
External match 2

enumerator kCTIMER_External_Match_3
External match 3

enum _ctimer_match_output_control

List of output control options.

Values:

enumerator kCTIMER_Output_NoAction

No action is taken

enumerator kCTIMER_Output_Clear

Clear the EM bit/output to 0

enumerator kCTIMER_Output_Set

Set the EM bit/output to 1

enumerator kCTIMER_Output_Toggle

Toggle the EM bit/output

enum _ctimer_timer_mode

List of Timer modes.

Values:

enumerator kCTIMER_TimerMode

enumerator kCTIMER_IncreaseOnRiseEdge

enumerator kCTIMER_IncreaseOnFallEdge

enumerator kCTIMER_IncreaseOnBothEdge

enum _ctimer_interrupt_enable

List of Timer interrupts.

Values:

enumerator kCTIMER_Match0InterruptEnable

Match 0 interrupt

enumerator kCTIMER_Match1InterruptEnable

Match 1 interrupt

enumerator kCTIMER_Match2InterruptEnable

Match 2 interrupt

enumerator kCTIMER_Match3InterruptEnable

Match 3 interrupt

enum _ctimer_status_flags

List of Timer flags.

Values:

enumerator kCTIMER_Match0Flag

Match 0 interrupt flag

enumerator kCTIMER_Match1Flag

Match 1 interrupt flag

enumerator kCTIMER_Match2Flag

Match 2 interrupt flag

enumerator kCTIMER_Match3Flag

Match 3 interrupt flag

enum *ctimer_callback_type_t*

Callback type when registering for a callback. When registering a callback an array of function pointers is passed the size could be 1 or 8, the callback type will tell that.

Values:

enumerator *kCTIMER_SingleCallback*

Single Callback type where there is only one callback for the timer. based on the status flags different channels needs to be handled differently

enumerator *kCTIMER_MultipleCallback*

Multiple Callback type where there can be 8 valid callbacks, one per channel. for both match/capture

typedef enum *_ctimer_capture_channel* *ctimer_capture_channel_t*

List of Timer capture channels.

typedef enum *_ctimer_capture_edge* *ctimer_capture_edge_t*

List of capture edge options.

typedef enum *_ctimer_match* *ctimer_match_t*

List of Timer match registers.

typedef enum *_ctimer_external_match* *ctimer_external_match_t*

List of external match.

typedef enum *_ctimer_match_output_control* *ctimer_match_output_control_t*

List of output control options.

typedef enum *_ctimer_timer_mode* *ctimer_timer_mode_t*

List of Timer modes.

typedef enum *_ctimer_interrupt_enable* *ctimer_interrupt_enable_t*

List of Timer interrupts.

typedef enum *_ctimer_status_flags* *ctimer_status_flags_t*

List of Timer flags.

typedef void (**ctimer_callback_t*)(uint32_t flags)

typedef struct *_ctimer_match_config* *ctimer_match_config_t*

Match configuration.

This structure holds the configuration settings for each match register.

typedef struct *_ctimer_config* *ctimer_config_t*

Timer configuration structure.

This structure holds the configuration settings for the Timer peripheral. To initialize this structure to reasonable defaults, call the `CTIMER_GetDefaultConfig()` function and pass a pointer to the configuration structure instance.

The configuration structure can be made constant so as to reside in flash.

void `CTIMER_SetupMatch(CTIMER_Type *base, ctimer_match_t matchChannel, const ctimer_match_config_t *config)`

Setup the match register.

User configuration is used to setup the match value and action to be taken when a match occurs.

Parameters

- `base` – Ctimer peripheral base address
- `matchChannel` – Match register to configure

- `config` – Pointer to the match configuration structure

`uint32_t CTIMER_GetOutputMatchStatus(CTIMER_Type *base, uint32_t matchChannel)`

Get the status of output match.

This function gets the status of output MAT, whether or not this output is connected to a pin. This status is driven to the MAT pins if the match function is selected via IOCON. 0 = LOW. 1 = HIGH.

Parameters

- `base` – Ctimer peripheral base address
- `matchChannel` – External match channel, user can obtain the status of multiple match channels at the same time by using the logic of “|” enumeration `ctimer_external_match_t`

Returns

The mask of external match channel status flags. Users need to use the `_ctimer_external_match` type to decode the return variables.

`void CTIMER_SetupCapture(CTIMER_Type *base, ctimer_capture_channel_t capture, ctimer_capture_edge_t edge, bool enableInt)`

Setup the capture.

Parameters

- `base` – Ctimer peripheral base address
- `capture` – Capture channel to configure
- `edge` – Edge on the channel that will trigger a capture
- `enableInt` – Flag to enable channel interrupts, if enabled then the registered call back is called upon capture

`static inline uint32_t CTIMER_GetTimerCountValue(CTIMER_Type *base)`

Get the timer count value from TC register.

Parameters

- `base` – Ctimer peripheral base address.

Returns

return the timer count value.

`void CTIMER_RegisterCallBack(CTIMER_Type *base, ctimer_callback_t *cb_func, ctimer_callback_type_t cb_type)`

Register callback.

This function configures CTimer Callback in following modes:

- **Single Callback:** `cb_func` should be pointer to callback function pointer
For example: `ctimer_callback_t ctimer_callback = pwm_match_callback;`
`CTIMER_RegisterCallBack(CTIMER, &ctimer_callback, kCTIMER_SingleCallback);`
- **Multiple Callback:** `cb_func` should be pointer to array of callback function pointers Each element corresponds to Interrupt Flag in IR register.
For example: `ctimer_callback_t ctimer_callback_table[] = { ctimer_match0_callback, NULL, NULL, ctimer_match3_callback, NULL, NULL, NULL, NULL};`
`CTIMER_RegisterCallBack(CTIMER, &ctimer_callback_table[0], kCTIMER_MultipleCallback);`

Parameters

- `base` – Ctimer peripheral base address
- `cb_func` – Pointer to callback function pointer

- `cb_type` – callback function type, singular or multiple

static inline void CTIMER_Reset(CTIMER_Type *base)

Reset the counter.

The timer counter and prescale counter are reset on the next positive edge of the APB clock.

Parameters

- `base` – Ctimer peripheral base address

static inline void CTIMER_SetPrescale(CTIMER_Type *base, uint32_t prescale)

Setup the timer prescale value.

Specifies the maximum value for the Prescale Counter.

Parameters

- `base` – Ctimer peripheral base address
- `prescale` – Prescale value

static inline uint32_t CTIMER_GetCaptureValue(CTIMER_Type *base, *ctimer_capture_channel_t* capture)

Get capture channel value.

Get the counter/timer value on the corresponding capture channel.

Parameters

- `base` – Ctimer peripheral base address
- `capture` – Select capture channel

Returns

The timer count capture value.

static inline void CTIMER_EnableResetMatchChannel(CTIMER_Type *base, *ctimer_match_t* match, bool enable)

Enable reset match channel.

Set the specified match channel reset operation.

Parameters

- `base` – Ctimer peripheral base address
- `match` – match channel used
- `enable` – Enable match channel reset operation.

static inline void CTIMER_EnableStopMatchChannel(CTIMER_Type *base, *ctimer_match_t* match, bool enable)

Enable stop match channel.

Set the specified match channel stop operation.

Parameters

- `base` – Ctimer peripheral base address.
- `match` – match channel used.
- `enable` – Enable match channel stop operation.

static inline void CTIMER_EnableMatchChannelReload(CTIMER_Type *base, *ctimer_match_t* match, bool enable)

Enable reload channel falling edge.

Enable the specified match channel reload match shadow value.

Parameters

- base – Ctimer peripheral base address.
- match – match channel used.
- enable – Enable .

```
static inline void CTIMER__EnableRisingEdgeCapture(CTIMER_Type *base,
                                                    ctimer_capture_channel_t capture, bool
                                                    enable)
```

Enable capture channel rising edge.

Sets the specified capture channel for rising edge capture.

Parameters

- base – Ctimer peripheral base address.
- capture – capture channel used.
- enable – Enable rising edge capture.

```
static inline void CTIMER__EnableFallingEdgeCapture(CTIMER_Type *base,
                                                    ctimer_capture_channel_t capture, bool
                                                    enable)
```

Enable capture channel falling edge.

Sets the specified capture channel for falling edge capture.

Parameters

- base – Ctimer peripheral base address.
- capture – capture channel used.
- enable – Enable falling edge capture.

```
static inline void CTIMER__SetShadowValue(CTIMER_Type *base, ctimer_match_t match,
                                           uint32_t matchvalue)
```

Set the specified match shadow channel.

Parameters

- base – Ctimer peripheral base address.
- match – match channel used.
- matchvalue – Reload the value of the corresponding match register.

```
struct __ctimer_match_config
#include <fsl_ctimer.h> Match configuration.
```

This structure holds the configuration settings for each match register.

Public Members

```
uint32_t matchValue
```

This is stored in the match register

```
bool enableCounterReset
```

true: Match will reset the counter false: Match will not reser the counter

```
bool enableCounterStop
```

true: Match will stop the counter false: Match will not stop the counter

ctimer_match_output_control_t outControl

Action to be taken on a match on the EM bit/output

bool outPinInitState

Initial value of the EM bit/output

bool enableInterrupt

true: Generate interrupt upon match false: Do not generate interrupt on match

struct *_ctimer_config*

#include <fsl_ctimer.h> Timer configuration structure.

This structure holds the configuration settings for the Timer peripheral. To initialize this structure to reasonable defaults, call the `CTIMER_GetDefaultConfig()` function and pass a pointer to the configuration structure instance.

The configuration structure can be made constant so as to reside in flash.

Public Members

ctimer_timer_mode_t mode

Timer mode

ctimer_capture_channel_t input

Input channel to increment the timer, used only in timer modes that rely on this input signal to increment TC

uint32_t prescale

Prescale value

2.9 DMA: Direct Memory Access Controller Driver

void DMA_Init(DMA_Type *base)

Initializes DMA peripheral.

This function enable the DMA clock, set descriptor table and enable DMA peripheral.

Parameters

- base – DMA peripheral base address.

void DMA_Deinit(DMA_Type *base)

Deinitializes DMA peripheral.

This function gates the DMA clock.

Parameters

- base – DMA peripheral base address.

void DMA_InstallDescriptorMemory(DMA_Type *base, void *addr)

Install DMA descriptor memory.

This function used to register DMA descriptor memory for linked transfer, a typical case is ping pong transfer which will request more than one DMA descriptor memory space, although current DMA driver has a default DMA descriptor buffer, but it support one DMA descriptor for one channel only.

Parameters

- base – DMA base address.
- addr – DMA descriptor address

static inline bool DMA_ChannelIsActive(DMA_Type *base, uint32_t channel)

Return whether DMA channel is processing transfer.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

Returns

True for active state, false otherwise.

static inline bool DMA_ChannelIsBusy(DMA_Type *base, uint32_t channel)

Return whether DMA channel is busy.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

Returns

True for busy state, false otherwise.

static inline void DMA_EnableChannelInterrupts(DMA_Type *base, uint32_t channel)

Enables the interrupt source for the DMA transfer.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

static inline void DMA_DisableChannelInterrupts(DMA_Type *base, uint32_t channel)

Disables the interrupt source for the DMA transfer.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

static inline void DMA_EnableChannel(DMA_Type *base, uint32_t channel)

Enable DMA channel.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

static inline void DMA_DisableChannel(DMA_Type *base, uint32_t channel)

Disable DMA channel.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

static inline void DMA_EnableChannelPeriphRq(DMA_Type *base, uint32_t channel)

Set PERIPHREQEN of channel configuration register.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

```
static inline void DMA_DisableChannelPeriphRq(DMA_Type *base, uint32_t channel)
```

Get PERIPHREQEN value of channel configuration register.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

Returns

True for enabled PeriphRq, false for disabled.

```
void DMA_ConfigureChannelTrigger(DMA_Type *base, uint32_t channel, dma_channel_trigger_t  
                                *trigger)
```

Set trigger settings of DMA channel.

Deprecated:

Do not use this function. It has been superceded by DMA_SetChannelConfig.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.
- trigger – trigger configuration.

```
void DMA_SetChannelConfig(DMA_Type *base, uint32_t channel, dma_channel_trigger_t  
                          *trigger, bool isPeriph)
```

set channel config.

This function provide a interface to configure channel configuration registers.

Parameters

- base – DMA base address.
- channel – DMA channel number.
- trigger – channel configurations structure.
- isPeriph – true is periph request, false is not.

```
static inline uint32_t DMA_SetChannelXferConfig(bool reload, bool clrTrig, bool intA, bool intB,  
                                                uint8_t width, uint8_t srcInc, uint8_t dstInc,  
                                                uint32_t bytes)
```

DMA channel xfer transfer configurations.

Parameters

- reload – true is reload link descriptor after current exhaust, false is not
- clrTrig – true is clear trigger status, wait software trigger, false is not
- intA – enable interruptA
- intB – enable interruptB
- width – transfer width
- srcInc – source address interleave size
- dstInc – destination address interleave size
- bytes – transfer bytes

Returns

The value of xfer config

uint32_t DMA_GetRemainingBytes(DMA_Type *base, uint32_t channel)

Gets the remaining bytes of the current DMA descriptor transfer.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

Returns

The number of bytes which have not been transferred yet.

static inline void DMA_SetChannelPriority(DMA_Type *base, uint32_t channel, dma_priority_t priority)

Set priority of channel configuration register.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.
- priority – Channel priority value.

static inline dma_priority_t DMA_GetChannelPriority(DMA_Type *base, uint32_t channel)

Get priority of channel configuration register.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

Returns

Channel priority value.

static inline void DMA_SetChannelConfigValid(DMA_Type *base, uint32_t channel)

Set channel configuration valid.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

static inline void DMA_DoChannelSoftwareTrigger(DMA_Type *base, uint32_t channel)

Do software trigger for the channel.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

static inline void DMA_LoadChannelTransferConfig(DMA_Type *base, uint32_t channel, uint32_t xfer)

Load channel transfer configurations.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.
- xfer – transfer configurations.

void DMA_CreateDescriptor(dma_descriptor_t *desc, dma_xfercfg_t *xfercfg, void *srcAddr, void *dstAddr, void *nextDesc)

Create application specific DMA descriptor to be used in a chain in transfer.

Deprecated:

Do not use this function. It has been superceded by DMA_SetupDescriptor.

Parameters

- desc – DMA descriptor address.
- xfercfg – Transfer configuration for DMA descriptor.
- srcAddr – Address of last item to transmit
- dstAddr – Address of last item to receive.
- nextDesc – Address of next descriptor in chain.

```
void DMA_SetupDescriptor(dma_descriptor_t *desc, uint32_t xfercfg, void *srcStartAddr, void  
                        *dstStartAddr, void *nextDesc)
```

setup dma descriptor

Note: This function do not support configure wrap descriptor.

Parameters

- desc – DMA descriptor address.
- xfercfg – Transfer configuration for DMA descriptor.
- srcStartAddr – Start address of source address.
- dstStartAddr – Start address of destination address.
- nextDesc – Address of next descriptor in chain.

```
void DMA_SetupChannelDescriptor(dma_descriptor_t *desc, uint32_t xfercfg, void *srcStartAddr,  
                               void *dstStartAddr, void *nextDesc, dma_burst_wrap_t  
                               wrapType, uint32_t burstSize)
```

setup dma channel descriptor

Note: This function support configure wrap descriptor.

Parameters

- desc – DMA descriptor address.
- xfercfg – Transfer configuration for DMA descriptor.
- srcStartAddr – Start address of source address.
- dstStartAddr – Start address of destination address.
- nextDesc – Address of next descriptor in chain.
- wrapType – burst wrap type.
- burstSize – burst size, reference `_dma_burst_size`.

```
void DMA_LoadChannelDescriptor(DMA_Type *base, uint32_t channel, dma_descriptor_t  
                             *descriptor)
```

load channel transfer decriptor.

This function can be used to load desscriptor to driver internal channel descriptor that is used to start DMA transfer, the head descriptor table is defined in DMA driver, it is useful for the case:

- a. for the polling transfer, application can allocate a local descriptor memory table to prepare a descriptor firstly and then call this api to load the configured descriptor to driver descriptor table.


```

DMA_Init(DMA0);
DMA_EnableChannel(DMA0, DEMO_DMA_CHANNEL);
DMA_SetupDescriptor(desc, xferCfg, s_srcBuffer, &s_destBuffer[0], NULL);
DMA_LoadChannelDescriptor(DMA0, DEMO_DMA_CHANNEL, (dma_descriptor_t *)desc);
DMA_DoChannelSoftwareTrigger(DMA0, DEMO_DMA_CHANNEL);
while(DMA_ChannelIsBusy(DMA0, DEMO_DMA_CHANNEL))
{}

```

Parameters

- base – DMA base address.
- channel – DMA channel.
- descriptor – configured DMA descriptor.

void DMA_AbortTransfer(*dma_handle_t* *handle)

Abort running transfer by handle.

This function aborts DMA transfer specified by handle.

Parameters

- handle – DMA handle pointer.

void DMA_CreateHandle(*dma_handle_t* *handle, DMA_Type *base, uint32_t channel)

Creates the DMA handle.

This function is called if using transaction API for DMA. This function initializes the internal state of DMA handle.

Parameters

- handle – DMA handle pointer. The DMA handle stores callback function and parameters.
- base – DMA peripheral base address.
- channel – DMA channel number.

void DMA_SetCallback(*dma_handle_t* *handle, *dma_callback* callback, void *userData)

Installs a callback function for the DMA transfer.

This callback is called in DMA IRQ handler. Use the callback to do something after the current major loop transfer completes.

Parameters

- handle – DMA handle pointer.
- callback – DMA callback function pointer.
- userData – Parameter for callback function.

void DMA_PrepareTransfer(*dma_transfer_config_t* *config, void *srcAddr, void *dstAddr, uint32_t byteWidth, uint32_t transferBytes, *dma_transfer_type_t* type, void *nextDesc)

Prepares the DMA transfer structure.

Deprecated:

Do not use this function. It has been superseded by DMA_PrepareChannelTransfer. This function prepares the transfer configuration structure according to the user input.

Note: The data address and the data width must be consistent. For example, if the SRC is 4 bytes, so the source address must be 4 bytes aligned, or it shall result in source address error(SAE).

Parameters

- config – The user configuration structure of type `dma_transfer_t`.
- srcAddr – DMA transfer source address.
- dstAddr – DMA transfer destination address.
- byteWidth – DMA transfer destination address width(bytes).
- transferBytes – DMA transfer bytes to be transferred.
- type – DMA transfer type.
- nextDesc – Chain custom descriptor to transfer.

```
void DMA_PrepareChannelTransfer(dma_channel_config_t *config, void *srcStartAddr, void  
                               *dstStartAddr, uint32_t xferCfg, dma_transfer_type_t type,  
                               dma_channel_trigger_t *trigger, void *nextDesc)
```

Prepare channel transfer configurations.

This function used to prepare channel transfer configurations.

Parameters

- config – Pointer to DMA channel transfer configuration structure.
- srcStartAddr – source start address.
- dstStartAddr – destination start address.
- xferCfg – xfer configuration, user can reference `DMA_CHANNEL_XFER` about to how to get xferCfg value.
- type – transfer type.
- trigger – DMA channel trigger configurations.
- nextDesc – address of next descriptor.

```
status_t DMA_SubmitTransfer(dma_handle_t *handle, dma_transfer_config_t *config)
```

Submits the DMA transfer request.

Deprecated:

Do not use this function. It has been superceded by `DMA_SubmitChannelTransfer`.

This function submits the DMA transfer request according to the transfer configuration structure. If the user submits the transfer request repeatedly, this function packs an unprocessed request as a TCD and enables scatter/gather feature to process it in the next time.

Parameters

- handle – DMA handle pointer.
- config – Pointer to DMA transfer configuration structure.

Return values

- `kStatus_DMA_Success` – It means submit transfer request succeed.
- `kStatus_DMA_QueueFull` – It means TCD queue is full. Submit transfer request is not allowed.

- kStatus_DMA_Busy – It means the given channel is busy, need to submit request later.

```
void DMA_SubmitChannelTransferParameter(dma_handle_t *handle, uint32_t xferCfg, void
                                     *srcStartAddr, void *dstStartAddr, void *nextDesc)
```

Submit channel transfer paramter directly.

This function used to configure channel head descriptor that is used to start DMA transfer, the head descriptor table is defined in DMA driver, it is useful for the case:

- for the single transfer, application doesn't need to allocate descriptor table, the head descriptor can be used for it.

```
DMA_SetChannelConfig(base, channel, trigger, isPeriph);
DMA_CreateHandle(handle, base, channel)
DMA_SubmitChannelTransferParameter(handle, DMA_CHANNEL_XFER(reload, clrTrig,
↪ intA, intB, width, srcInc, dstInc,
bytes), srcStartAddr, dstStartAddr, NULL);
DMA_StartTransfer(handle)
```

- for the linked transfer, application should responsible for link descriptor, for example, if 4 transfer is required, then application should prepare three descriptor table with macro , the head descriptor in driver can be used for the first transfer descriptor.

```
define link descriptor table in application with macro
DMA_ALLOCATE_LINK_DESCRIPTOR(nextDesc[3]);

DMA_SetupDescriptor(nextDesc0, DMA_CHANNEL_XFER(reload, clrTrig, intA, intB, width,
↪ srcInc, dstInc, bytes),
srcStartAddr, dstStartAddr, nextDesc1);
DMA_SetupDescriptor(nextDesc1, DMA_CHANNEL_XFER(reload, clrTrig, intA, intB, width,
↪ srcInc, dstInc, bytes),
srcStartAddr, dstStartAddr, nextDesc2);
DMA_SetupDescriptor(nextDesc2, DMA_CHANNEL_XFER(reload, clrTrig, intA, intB, width,
↪ srcInc, dstInc, bytes),
srcStartAddr, dstStartAddr, NULL);
DMA_SetChannelConfig(base, channel, trigger, isPeriph);
DMA_CreateHandle(handle, base, channel)
DMA_SubmitChannelTransferParameter(handle, DMA_CHANNEL_XFER(reload, clrTrig,
↪ intA, intB, width, srcInc, dstInc,
bytes), srcStartAddr, dstStartAddr, nextDesc0);
DMA_StartTransfer(handle);
```

Parameters

- handle – Pointer to DMA handle.
- xferCfg – xfer configuration, user can reference DMA_CHANNEL_XFER about to how to get xferCfg value.
- srcStartAddr – source start address.
- dstStartAddr – destination start address.
- nextDesc – address of next descriptor.

```
void DMA_SubmitChannelDescriptor(dma_handle_t *handle, dma_descriptor_t *descriptor)
```

Submit channel descriptor.

This function used to configure channel head descriptor that is used to start DMA transfer, the head descriptor table is defined in DMA driver, this function is typical for the ping pong case:

- a. for the ping pong case, application should responsible for the descriptor, for example, application should prepare two descriptor table with macro.

```

define link descriptor table in application with macro
DMA_ALLOCATE_LINK_DESCRIPTOR(nextDesc[2]);

DMA_SetupDescriptor(nextDesc0, DMA_CHANNEL_XFER(reload, clrTrig, intA, intB, width,
↪ srcInc, dstInc, bytes),
srcStartAddr, dstStartAddr, nextDesc1);
DMA_SetupDescriptor(nextDesc1, DMA_CHANNEL_XFER(reload, clrTrig, intA, intB, width,
↪ srcInc, dstInc, bytes),
srcStartAddr, dstStartAddr, nextDesc0);
DMA_SetChannelConfig(base, channel, trigger, isPeriph);
DMA_CreateHandle(handle, base, channel)
DMA_SubmitChannelDescriptor(handle, nextDesc0);
DMA_StartTransfer(handle);

```

Parameters

- handle – Pointer to DMA handle.
- descriptor – descriptor to submit.

status_t DMA_SubmitChannelTransfer(*dma_handle_t* *handle, *dma_channel_config_t* *config)

Submits the DMA channel transfer request.

This function submits the DMA transfer request according to the transfer configuration structure. If the user submits the transfer request repeatedly, this function packs an unprocessed request as a TCD and enables scatter/gather feature to process it in the next time. It is used for the case:

- a. for the single transfer, application doesn't need to allocate descriptor table, the head descriptor can be used for it.

```

DMA_CreateHandle(handle, base, channel)
DMA_PrepareChannelTransfer(config,srcStartAddr,dstStartAddr,xferCfg,type,trigger,NULL);
DMA_SubmitChannelTransfer(handle, config)
DMA_StartTransfer(handle)

```

- b. for the linked transfer, application should responsible for link descriptor, for example, if 4 transfer is required, then application should prepare three descriptor table with macro , the head descriptor in driver can be used for the first transfer descriptor.

```

define link descriptor table in application with macro
DMA_ALLOCATE_LINK_DESCRIPTOR(nextDesc);
DMA_SetupDescriptor(nextDesc0, DMA_CHANNEL_XFER(reload, clrTrig, intA, intB, width,
↪ srcInc, dstInc, bytes),
srcStartAddr, dstStartAddr, nextDesc1);
DMA_SetupDescriptor(nextDesc1, DMA_CHANNEL_XFER(reload, clrTrig, intA, intB, width,
↪ srcInc, dstInc, bytes),
srcStartAddr, dstStartAddr, nextDesc2);
DMA_SetupDescriptor(nextDesc2, DMA_CHANNEL_XFER(reload, clrTrig, intA, intB, width,
↪ srcInc, dstInc, bytes),
srcStartAddr, dstStartAddr, NULL);
DMA_CreateHandle(handle, base, channel)
DMA_PrepareChannelTransfer(config,srcStartAddr,dstStartAddr,xferCfg,type,trigger,
↪ nextDesc0);
DMA_SubmitChannelTransfer(handle, config)
DMA_StartTransfer(handle)

```

- c. for the ping pong case, application should responsible for link descriptor, for example, application should prepare two descriptor table with macro , the head descriptor in driver can be used for the first transfer descriptor.

```

define link descriptor table in application with macro
DMA_ALLOCATE_LINK_DESCRIPTOR(nextDesc);

DMA_SetupDescriptor(nextDesc0, DMA_CHANNEL_XFER(reload, clrTrig, intA, intB, width,
↪ srcInc, dstInc, bytes),
srcStartAddr, dstStartAddr, nextDesc1);
DMA_SetupDescriptor(nextDesc1, DMA_CHANNEL_XFER(reload, clrTrig, intA, intB, width,
↪ srcInc, dstInc, bytes),
srcStartAddr, dstStartAddr, nextDesc0);
DMA_CreateHandle(handle, base, channel)
DMA_PrepareChannelTransfer(config,srcStartAddr,dstStartAddr,xferCfg,type,trigger,
↪nextDesc0);
DMA_SubmitChannelTransfer(handle, config)
DMA_StartTransfer(handle)

```

Parameters

- handle – DMA handle pointer.
- config – Pointer to DMA transfer configuration structure.

Return values

- kStatus_DMA_Success – It means submit transfer request succeed.
- kStatus_DMA_QueueFull – It means TCD queue is full. Submit transfer request is not allowed.
- kStatus_DMA_Busy – It means the given channel is busy, need to submit request later.

void DMA_StartTransfer(*dma_handle_t* *handle)

DMA start transfer.

This function enables the channel request. User can call this function after submitting the transfer request. It will trigger transfer start with software trigger only when hardware trigger is not used.

Parameters

- handle – DMA handle pointer.

void DMA_IRQHandle(DMA_Type *base)

DMA IRQ handler for descriptor transfer complete.

This function clears the channel major interrupt flag and call the callback function if it is not NULL.

Parameters

- base – DMA base address.

FSL_DMA_DRIVER_VERSION

DMA driver version.

Version 2.5.3.

_dma_transfer_status DMA transfer status

Values:

enumerator kStatus_DMA_Busy

Channel is busy and can't handle the transfer request.

_dma_addr_interleave_size dma address interleave size

Values:

enumerator kDMA__AddressInterleave0xWidth
dma source/destination address no interleave

enumerator kDMA__AddressInterleave1xWidth
dma source/destination address interleave 1xwidth

enumerator kDMA__AddressInterleave2xWidth
dma source/destination address interleave 2xwidth

enumerator kDMA__AddressInterleave4xWidth
dma source/destination address interleave 3xwidth

_dma_transfer_width dma transfer width

Values:

enumerator kDMA__Transfer8BitWidth
dma channel transfer bit width is 8 bit

enumerator kDMA__Transfer16BitWidth
dma channel transfer bit width is 16 bit

enumerator kDMA__Transfer32BitWidth
dma channel transfer bit width is 32 bit

enum _dma_priority

DMA channel priority.

Values:

enumerator kDMA__ChannelPriority0
Highest channel priority - priority 0

enumerator kDMA__ChannelPriority1
Channel priority 1

enumerator kDMA__ChannelPriority2
Channel priority 2

enumerator kDMA__ChannelPriority3
Channel priority 3

enumerator kDMA__ChannelPriority4
Channel priority 4

enumerator kDMA__ChannelPriority5
Channel priority 5

enumerator kDMA__ChannelPriority6
Channel priority 6

enumerator kDMA__ChannelPriority7
Lowest channel priority - priority 7

enum _dma_int

DMA interrupt flags.

Values:

enumerator kDMA_IntA

DMA interrupt flag A

enumerator kDMA_IntB

DMA interrupt flag B

enumerator kDMA_IntError

DMA interrupt flag error

enum _dma_trigger_type

DMA trigger type.

Values:

enumerator kDMA_NoTrigger

Trigger is disabled

enumerator kDMA_LowLevelTrigger

Low level active trigger

enumerator kDMA_HighLevelTrigger

High level active trigger

enumerator kDMA_FallingEdgeTrigger

Falling edge active trigger

enumerator kDMA_RisingEdgeTrigger

Rising edge active trigger

_dma_burst_size DMA burst size

Values:

enumerator kDMA_BurstSize1

burst size 1 transfer

enumerator kDMA_BurstSize2

burst size 2 transfer

enumerator kDMA_BurstSize4

burst size 4 transfer

enumerator kDMA_BurstSize8

burst size 8 transfer

enumerator kDMA_BurstSize16

burst size 16 transfer

enumerator kDMA_BurstSize32

burst size 32 transfer

enumerator kDMA_BurstSize64

burst size 64 transfer

enumerator kDMA_BurstSize128

burst size 128 transfer

enumerator kDMA_BurstSize256

burst size 256 transfer

enumerator kDMA_BurstSize512

burst size 512 transfer

enumerator kDMA__BurstSize1024

Burst size 1024 transfer

enum __dma__trigger__burst

DMA trigger burst.

Values:

enumerator kDMA__SingleTransfer

Single transfer

enumerator kDMA__LevelBurstTransfer

Burst transfer driven by level trigger

enumerator kDMA__EdgeBurstTransfer1

Perform 1 transfer by edge trigger

enumerator kDMA__EdgeBurstTransfer2

Perform 2 transfers by edge trigger

enumerator kDMA__EdgeBurstTransfer4

Perform 4 transfers by edge trigger

enumerator kDMA__EdgeBurstTransfer8

Perform 8 transfers by edge trigger

enumerator kDMA__EdgeBurstTransfer16

Perform 16 transfers by edge trigger

enumerator kDMA__EdgeBurstTransfer32

Perform 32 transfers by edge trigger

enumerator kDMA__EdgeBurstTransfer64

Perform 64 transfers by edge trigger

enumerator kDMA__EdgeBurstTransfer128

Perform 128 transfers by edge trigger

enumerator kDMA__EdgeBurstTransfer256

Perform 256 transfers by edge trigger

enumerator kDMA__EdgeBurstTransfer512

Perform 512 transfers by edge trigger

enumerator kDMA__EdgeBurstTransfer1024

Perform 1024 transfers by edge trigger

enum __dma__burst__wrap

DMA burst wrapping.

Values:

enumerator kDMA__NoWrap

Wrapping is disabled

enumerator kDMA__SrcWrap

Wrapping is enabled for source

enumerator kDMA__DstWrap

Wrapping is enabled for destination

enumerator kDMA__SrcAndDstWrap

Wrapping is enabled for source and destination

enum *_dma_transfer_type*

DMA transfer type.

Values:

enumerator *kDMA_MemoryToMemory*

Transfer from memory to memory (increment source and destination)

enumerator *kDMA_PeripheralToMemory*

Transfer from peripheral to memory (increment only destination)

enumerator *kDMA_MemoryToPeripheral*

Transfer from memory to peripheral (increment only source)

enumerator *kDMA_StaticToStatic*

Peripheral to static memory (do not increment source or destination)

typedef struct *_dma_descriptor* *dma_descriptor_t*

DMA descriptor structure.

typedef struct *_dma_xfercfg* *dma_xfercfg_t*

DMA transfer configuration.

typedef enum *_dma_priority* *dma_priority_t*

DMA channel priority.

typedef enum *_dma_int* *dma_irq_t*

DMA interrupt flags.

typedef enum *_dma_trigger_type* *dma_trigger_type_t*

DMA trigger type.

typedef enum *_dma_trigger_burst* *dma_trigger_burst_t*

DMA trigger burst.

typedef enum *_dma_burst_wrap* *dma_burst_wrap_t*

DMA burst wrapping.

typedef enum *_dma_transfer_type* *dma_transfer_type_t*

DMA transfer type.

typedef struct *_dma_channel_trigger* *dma_channel_trigger_t*

DMA channel trigger.

typedef struct *_dma_channel_config* *dma_channel_config_t*

DMA channel trigger.

typedef struct *_dma_transfer_config* *dma_transfer_config_t*

DMA transfer configuration.

typedef void (**dma_callback*)(struct *_dma_handle* **handle*, void **userData*, bool *transferDone*,
uint32_t *intmode*)

Define Callback function for DMA.

typedef struct *_dma_handle* *dma_handle_t*

DMA transfer handle structure.

DMA_MAX_TRANSFER_COUNT

DMA max transfer size.

FSL_FEATURE_DMA_LINK_DESCRIPTOR_ALIGN_SIZE

DMA channel numbers.

DMA head link descriptor table align size

DMA_ALLOCATE_HEAD_DESCRIPTOR(name, number)

DMA head descriptor table allocate macro To simplify user interface, this macro will help allocate descriptor memory, user just need to provide the name and the number for the allocate descriptor.

Parameters

- name – Allocate decriptor name.
- number – Number of descriptor to be allocated.

DMA_ALLOCATE_HEAD_DESCRIPTOR_AT_NONCACHEABLE(name, number)

DMA head descriptor table allocate macro at noncacheable section To simplify user interface, this macro will help allocate descriptor memory at noncacheable section, user just need to provide the name and the number for the allocate descriptor.

Parameters

- name – Allocate decriptor name.
- number – Number of descriptor to be allocated.

DMA_ALLOCATE_LINK_DESCRIPTOR(name, number)

DMA link descriptor table allocate macro To simplify user interface, this macro will help allocate descriptor memory, user just need to provide the name and the number for the allocate descriptor.

Parameters

- name – Allocate decriptor name.
- number – Number of descriptor to be allocated.

DMA_ALLOCATE_LINK_DESCRIPTOR_AT_NONCACHEABLE(name, number)

DMA link descriptor table allocate macro at noncacheable section To simplify user interface, this macro will help allocate descriptor memory at noncacheable section, user just need to provide the name and the number for the allocate descriptor.

Parameters

- name – Allocate decriptor name.
- number – Number of descriptor to be allocated.

DMA_ALLOCATE_DATA_TRANSFER_BUFFER(name, width)

DMA transfer buffer address need to align with the transfer width.

DMA_CHANNEL_GROUP(channel)

DMA_CHANNEL_INDEX(base, channel)

DMA_COMMON_REG_GET(base, channel, reg)

DMA linked descriptor address algin size.

DMA_COMMON_CONST_REG_GET(base, channel, reg)

DMA_COMMON_REG_SET(base, channel, reg, value)

DMA_DESCRIPTOR_END_ADDRESS(start, inc, bytes, width)

DMA descriptor end address calculate.

Parameters

- start – start address
- inc – address interleave size
- bytes – transfer bytes

- width – transfer width

DMA_CHANNEL_XFER(reload, clrTrig, intA, intB, width, srcInc, dstInc, bytes)

struct __dma_descriptor

#include <fsl_dma.h> DMA descriptor structure.

Public Members

volatile uint32_t xfercfg

Transfer configuration

void *srcEndAddr

Last source address of DMA transfer

void *dstEndAddr

Last destination address of DMA transfer

void *linkToNextDesc

Address of next DMA descriptor in chain

struct __dma_xfercfg

#include <fsl_dma.h> DMA transfer configuration.

Public Members

bool valid

Descriptor is ready to transfer

bool reload

Reload channel configuration register after current descriptor is exhausted

bool swtrig

Perform software trigger. Transfer if fired when 'valid' is set

bool clrtrig

Clear trigger

bool intA

Raises IRQ when transfer is done and set IRQA status register flag

bool intB

Raises IRQ when transfer is done and set IRQB status register flag

uint8_t byteWidth

Byte width of data to transfer

uint8_t srcInc

Increment source address by 'srcInc' x 'byteWidth'

uint8_t dstInc

Increment destination address by 'dstInc' x 'byteWidth'

uint16_t transferCount

Number of transfers

struct __dma_channel_trigger

#include <fsl_dma.h> DMA channel trigger.

Public Members

dma_trigger_type_t type

Select hardware trigger as edge triggered or level triggered.

dma_trigger_burst_t burst

Select whether hardware triggers cause a single or burst transfer.

dma_burst_wrap_t wrap

Select wrap type, source wrap or dest wrap, or both.

struct *_dma_channel_config*

#include <fsl_dma.h> DMA channel trigger.

Public Members

void *srcStartAddr

Source data address

void *dstStartAddr

Destination data address

void *nextDesc

Chain custom descriptor

uint32_t xferCfg

channel transfer configurations

dma_channel_trigger_t *trigger

DMA trigger type

bool isPeriph

select the request type

struct *_dma_transfer_config*

#include <fsl_dma.h> DMA transfer configuration.

Public Members

uint8_t *srcAddr

Source data address

uint8_t *dstAddr

Destination data address

uint8_t *nextDesc

Chain custom descriptor

dma_xfercfg_t xfercfg

Transfer options

bool isPeriph

DMA transfer is driven by peripheral

struct *_dma_handle*

#include <fsl_dma.h> DMA transfer handle structure.

Public Members

dma_callback callback

Callback function. Invoked when transfer of descriptor with interrupt flag finishes

void *userData

Callback function parameter

DMA_Type *base

DMA peripheral base address

uint8_t channel

DMA channel number

2.10 DMIC: Digital Microphone

2.11 DMIC DMA Driver

status_t DMIC_TransferCreateHandleDMA(DMIC_Type *base, *dmic_dma_handle_t* *handle, *dmic_dma_transfer_callback_t* callback, void *userData, *dma_handle_t* *rxDmaHandle)

Initializes the DMIC handle which is used in transactional functions.

Parameters

- base – DMIC peripheral base address.
- handle – Pointer to *dmic_dma_handle_t* structure.
- callback – Callback function.
- userData – User data.
- rxDmaHandle – User-requested DMA handle for RX DMA transfer.

status_t DMIC_TransferReceiveDMA(DMIC_Type *base, *dmic_dma_handle_t* *handle, *dmic_transfer_t* *xfer, uint32_t channel)

Receives data using DMA.

This function receives data using DMA. This is a non-blocking function, which returns right away. When all data is received, the receive callback function is called.

Parameters

- base – USART peripheral base address.
- handle – Pointer to *usart_dma_handle_t* structure.
- xfer – DMIC DMA transfer structure. See *dmic_transfer_t*.
- channel – DMIC start channel number.

Return values

kStatus_Success –

void DMIC_TransferAbortReceiveDMA(DMIC_Type *base, *dmic_dma_handle_t* *handle)

Aborts the received data using DMA.

This function aborts the received data using DMA.

Parameters

- base – DMIC peripheral base address
- handle – Pointer to *dmic_dma_handle_t* structure

```
status_t DMIC_TransferGetReceiveCountDMA(DMIC_Type *base, dmic_dma_handle_t *handle,
                                         uint32_t *count)
```

Get the number of bytes that have been received.

This function gets the number of bytes that have been received.

Parameters

- base – DMIC peripheral base address.
- handle – DMIC handle pointer.
- count – Receive bytes count.

Return values

- kStatus_NoTransferInProgress – No receive in progress.
- kStatus_InvalidArgument – Parameter is invalid.
- kStatus_Success – Get successfully through the parameter count;

```
void DMIC_InstallDMADescriptorMemory(dmic_dma_handle_t *handle, void *linkAddr, size_t
                                     linkNum)
```

Install DMA descriptor memory.

This function used to register DMA descriptor memory for linked transfer, a typical case is ping pong transfer which will request more than one DMA descriptor memory space, it should be called after DMIC_TransferCreateHandleDMA. User should be take care about the address of DMA descriptor pool which required align with 16BYTE at least.

Parameters

- handle – Pointer to DMA channel transfer handle.
- linkAddr – DMA link descriptor address.
- linkNum – DMA link descriptor number.

```
FSL_DMIC_DMA_DRIVER_VERSION
```

DMIC DMA driver version 2.4.1.

```
typedef struct _dmic_transfer dmic_transfer_t
```

DMIC transfer structure.

```
typedef struct _dmic_dma_handle dmic_dma_handle_t
```

```
typedef void (*dmic_dma_transfer_callback_t)(DMIC_Type *base, dmic_dma_handle_t *handle,
status_t status, void *userData)
```

DMIC transfer callback function.

```
struct _dmic_transfer
```

```
#include <fsl_dmic_dma.h> DMIC transfer structure.
```

Public Members

```
void *data
```

The buffer of data to be transfer.

```
uint8_t dataWidth
```

DMIC support 16bit/32bit

```
size_t dataSize
```

The byte count to be transfer.

```
uint8_t dataAddrInterleaveSize
    destination address interleave size

struct _dmic_transfer *linkTransfer
    use to support link transfer

struct _dmic_dma_handle
    #include <fsl_dmic_dma.h> DMIC DMA handle.
```

Public Members

```
DMIC_Type *base
    DMIC peripheral base address.

dma_handle_t *rxDmaHandle
    The DMA RX channel used.

dmic_dma_transfer_callback_t callback
    Callback function.

void *userData
    DMIC callback function parameter.

size_t transferSize
    Size of the data to receive.

volatile uint8_t state
    Internal state of DMIC DMA transfer

uint32_t channel
    DMIC channel used.

bool isChannelValid
    DMIC channel initialization flag

dma_descriptor_t *desLink
    descriptor pool pointer

size_t linkNum
    number of descriptor in descriptors pool
```

2.12 DMIC Driver

```
uint32_t DMIC_GetInstance(DMIC_Type *base)
    Get the DMIC instance from peripheral base address.
```

Parameters

- base – DMIC peripheral base address.

Returns

DMIC instance.

```
void DMIC_Init(DMIC_Type *base)
    Turns DMIC Clock on.
```

Parameters

- base – : DMIC base

Returns

Nothing

void DMIC_DeInit(DMIC_Type *base)

Turns DMIC Clock off.

Parameters

- base – : DMIC base

Returns

Nothing

void DMIC_SetOperationMode(DMIC_Type *base, operation_mode_t mode)

Set DMIC operating mode.

Deprecated:

Do not use this function. It has been superceded by DMIC_EnableChannelInterrupt, DMIC_EnableChannelDma.

Parameters

- base – : The base address of DMIC interface
- mode – : DMIC mode

Returns

Nothing

void DMIC_Use2fs(DMIC_Type *base, bool use2fs)

Configure Clock scaling.

Parameters

- base – : The base address of DMIC interface
- use2fs – : clock scaling

Returns

Nothing

void DMIC_CfgChannelDc(DMIC_Type *base, dmic_channel_t channel, dc_removal_t dc_cut_level, uint32_t post_dc_gain_reduce, bool saturate16bit)

Configure DMIC channel.

Parameters

- base – : The base address of DMIC interface
- channel – : DMIC channel
- dc_cut_level – : dc_removal_t, Cut off Frequency
- post_dc_gain_reduce – : Fine gain adjustment in the form of a number of bits to downshift.
- saturate16bit – : If selects 16-bit saturation.

static inline void DMIC_EnableChannelSignExtend(DMIC_Type *base, dmic_channel_t channel, bool enable)

Enbale channel sign extend which allows processing of 24bit audio data on 32bit machines.

Parameters

- base – : The base address of DMIC interface
- channel – : DMIC channel

- enable – : true is enable sign extend, false is disable sign extend

```
void DMIC_ConfigChannel(DMIC_Type *base, dmic_channel_t channel, stereo_side_t side,  
                        dmic_channel_config_t *channel_config)
```

Configure DMIC channel.

Parameters

- base – : The base address of DMIC interface
- channel – : DMIC channel
- side – : *stereo_side_t*, choice of left or right
- channel_config – : Channel configuration

Returns

Nothing

```
void DMIC_EnableChannel(DMIC_Type *base, uint32_t channelmask)
```

Enable a particular channel.

Parameters

- base – : The base address of DMIC interface
- channelmask – reference *_dmic_channel_mask*

Returns

Nothing

```
void DMIC_FifoChannel(DMIC_Type *base, uint32_t channel, uint32_t trig_level, uint32_t  
                     enable, uint32_t resetn)
```

Configure fifo settings for DMIC channel.

Parameters

- base – : The base address of DMIC interface
- channel – : DMIC channel
- trig_level – : FIFO trigger level
- enable – : FIFO level
- resetn – : FIFO reset

Returns

Nothing

```
static inline void DMIC_EnableChannelInterrupt(DMIC_Type *base, dmic_channel_t channel,  
                                                bool enable)
```

Enable a particular channel interrupt request.

Parameters

- base – : The base address of DMIC interface
- channel – : Channel selection
- enable – : true is enable, false is disable

```
static inline void DMIC_EnableChannelDma(DMIC_Type *base, dmic_channel_t channel, bool  
                                         enable)
```

Enable a particular channel dma request.

Parameters

- base – : The base address of DMIC interface
- channel – : Channel selection

- enable – : true is enable, false is disable

```
static inline void DMIC__EnableChannelFifo(DMIC_Type *base, dmic_channel_t channel, bool enable)
```

Enable a particular channel fifo.

Parameters

- base – : The base address of DMIC interface
- channel – : Channel selection
- enable – : true is enable, false is disable

```
static inline void DMIC__DoFifoReset(DMIC_Type *base, dmic_channel_t channel)
```

Channel fifo reset.

Parameters

- base – : The base address of DMIC interface
- channel – : Channel selection

```
static inline uint32_t DMIC__FifoGetStatus(DMIC_Type *base, uint32_t channel)
```

Get FIFO status.

Parameters

- base – : The base address of DMIC interface
- channel – : DMIC channel

Returns

FIFO status

```
static inline void DMIC__FifoClearStatus(DMIC_Type *base, uint32_t channel, uint32_t mask)
```

Clear FIFO status.

Parameters

- base – : The base address of DMIC interface
- channel – : DMIC channel
- mask – : Bits to be cleared

Returns

FIFO status

```
static inline uint32_t DMIC__FifoGetData(DMIC_Type *base, uint32_t channel)
```

Get FIFO data.

Parameters

- base – : The base address of DMIC interface
- channel – : DMIC channel

Returns

FIFO data

```
static inline uint32_t DMIC__FifoGetAddress(DMIC_Type *base, uint32_t channel)
```

Get FIFO address.

Parameters

- base – : The base address of DMIC interface
- channel – : DMIC channel

Returns

FIFO data

`void DMIC__ResetChannelDecimator(DMIC_Type *base, uint32_t channelMask, bool reset)`
DMIC channel Decimator reset.

Parameters

- `base` – : The base address of DMIC interface
- `channelMask` – : DMIC channel mask, reference `_dmic_channel_mask`
- `reset` – : `true` is reset decimator, `false` is release decimator.

`static inline void DMIC__EnableChannelGlobalSync(DMIC_Type *base, uint32_t channelMask, uint32_t syncCounter)`

Enable DMIC channel global sync function.

Parameters

- `base` – : The base address of DMIC interface
- `channelMask` – : DMIC channel mask, reference `_dmic_channel_mask`
- `syncCounter` – : sync counter will trigger a pulse whenever count reaches `CCOUNTVAL`. If `CCOUNTVAL` is set to 0, there will be a pulse on every cycle

`static inline void DMIC__DisableChannelGlobalSync(DMIC_Type *base, uint32_t channelMask)`
Disbale DMIC channel global sync function.

Parameters

- `base` – : The base address of DMIC interface
- `channelMask` – : DMIC channel mask, reference `_dmic_channel_mask`

`void DMIC__EnableIntCallback(DMIC_Type *base, dmic_callback_t cb)`
Enable callback.

This function enables the interrupt for the selected DMIC peripheral. The callback function is not enabled until this function is called.

Parameters

- `base` – Base address of the DMIC peripheral.
- `cb` – callback Pointer to store callback function.

Return values

None. –

`void DMIC__DisableIntCallback(DMIC_Type *base, dmic_callback_t cb)`
Disable callback.

This function disables the interrupt for the selected DMIC peripheral.

Parameters

- `base` – Base address of the DMIC peripheral.
- `cb` – callback Pointer to store callback function..

Return values

None. –

`static inline void DMIC__SetGainNoiseEstHwvad(DMIC_Type *base, uint32_t value)`
Sets the gain value for the noise estimator.

Parameters

- `base` – DMIC base pointer
- `value` – gain value for the noise estimator.

Return values

None. –

static inline void DMIC__SetGainSignalEstHwvad(DMIC_Type *base, uint32_t value)

Sets the gain value for the signal estimator.

Parameters

- base – DMIC base pointer
- value – gain value for the signal estimator.

Return values

None. –

static inline void DMIC__SetFilterCtrlHwvad(DMIC_Type *base, uint32_t value)

Sets the hwvad filter cutoff frequency parameter.

Parameters

- base – DMIC base pointer
- value – cut off frequency value.

Return values

None. –

static inline void DMIC__SetInputGainHwvad(DMIC_Type *base, uint32_t value)

Sets the input gain of hwvad.

Parameters

- base – DMIC base pointer
- value – input gain value for hwvad.

Return values

None. –

static inline void DMIC__CtrlClrIntrHwvad(DMIC_Type *base, bool st10)

Clears hwvad internal interrupt flag.

Parameters

- base – DMIC base pointer
- st10 – bit value.

Return values

None. –

static inline void DMIC__FilterResetHwvad(DMIC_Type *base, bool rstt)

Resets hwvad filters.

Parameters

- base – DMIC base pointer
- rstt – Reset bit value.

Return values

None. –

static inline uint16_t DMIC__GetNoiseEnvlpEst(DMIC_Type *base)

Gets the value from output of the filter z7.

Parameters

- base – DMIC base pointer

Return values

output – of filter z7.

void DMIC_HwvadEnableIntCallback(DMIC_Type *base, *dmic_hwvad_callback_t* vadcb)

Enable hwvad callback.

This function enables the hwvad interrupt for the selected DMIC peripheral. The callback function is not enabled until this function is called.

Parameters

- base – Base address of the DMIC peripheral.
- vadcb – callback Pointer to store callback function.

Return values

None. –

void DMIC_HwvadDisableIntCallback(DMIC_Type *base, *dmic_hwvad_callback_t* vadcb)

Disable callback.

This function disables the hwvad interrupt for the selected DMIC peripheral.

Parameters

- base – Base address of the DMIC peripheral.
- vadcb – callback Pointer to store callback function..

Return values

None. –

FSL_DMIC_DRIVER_VERSION

DMIC driver version 2.3.3.

_dmic_status DMIC transfer status.

Values:

enumerator kStatus_DMIC_Busy

DMIC is busy

enumerator kStatus_DMIC_Idle

DMIC is idle

enumerator kStatus_DMIC_OverRunError

DMIC over run Error

enumerator kStatus_DMIC_UnderRunError

DMIC under run Error

enum __operation__mode

DMIC different operation modes.

Values:

enumerator kDMIC_OperationModeInterrupt

Interrupt mode

enumerator kDMIC_OperationModeDma

DMA mode

enum __stereo__side

DMIC left/right values.

Values:

enumerator kDMIC_Left

Left Stereo channel

enumerator kDMIC_Right

Right Stereo channel

enum pdm_div_t

DMIC Clock pre-divider values.

Values:

enumerator kDMIC_PdmDiv1

DMIC pre-divider set in divide by 1

enumerator kDMIC_PdmDiv2

DMIC pre-divider set in divide by 2

enumerator kDMIC_PdmDiv3

DMIC pre-divider set in divide by 3

enumerator kDMIC_PdmDiv4

DMIC pre-divider set in divide by 4

enumerator kDMIC_PdmDiv6

DMIC pre-divider set in divide by 6

enumerator kDMIC_PdmDiv8

DMIC pre-divider set in divide by 8

enumerator kDMIC_PdmDiv12

DMIC pre-divider set in divide by 12

enumerator kDMIC_PdmDiv16

DMIC pre-divider set in divide by 16

enumerator kDMIC_PdmDiv24

DMIC pre-divider set in divide by 24

enumerator kDMIC_PdmDiv32

DMIC pre-divider set in divide by 32

enumerator kDMIC_PdmDiv48

DMIC pre-divider set in divide by 48

enumerator kDMIC_PdmDiv64

DMIC pre-divider set in divide by 64

enumerator kDMIC_PdmDiv96

DMIC pre-divider set in divide by 96

enumerator kDMIC_PdmDiv128

DMIC pre-divider set in divide by 128

enum __compensation

Pre-emphasis Filter coefficient value for 2FS and 4FS modes.

Values:

enumerator kDMIC_CompValueZero

Compensation 0

enumerator kDMIC_CompValueNegativePoint16

Compensation -0.16

enumerator kDMIC_CompValueNegativePoint15

Compensation -0.15

enumerator kDMIC_CompValueNegativePoint13

Compensation -0.13

enum __dc_removal

DMIC DC filter control values.

Values:

enumerator kDMIC_DcNoRemove

Flat response no filter

enumerator kDMIC_DcCut155

Cut off Frequency is 155 Hz

enumerator kDMIC_DcCut78

Cut off Frequency is 78 Hz

enumerator kDMIC_DcCut39

Cut off Frequency is 39 Hz

enum __dmic_channel

DMIC Channel number.

Values:

enumerator kDMIC_Channel0

DMIC channel 0

enumerator kDMIC_Channel1

DMIC channel 1

enumerator kDMIC_ChannelMAX

Maximum number of DMIC channels

__dmic_channel_mask DMIC Channel mask.

Values:

enumerator kDMIC_EnableChannel0

DMIC channel 0 mask

enumerator kDMIC_EnableChannel1

DMIC channel 1 mask

enum __dmic_phy_sample_rate

DMIC and decimator sample rates.

Values:

enumerator kDMIC_PhyFullSpeed

Decimator gets one sample per each chosen clock edge of PDM interface

enumerator kDMIC_PhyHalfSpeed

PDM clock to Microphone is halved, decimator receives each sample twice

typedef enum *operation_mode* operation_mode_t

DMIC different operation modes.

typedef enum *stereo_side* stereo_side_t

DMIC left/right values.

typedef enum *_compensation* compensation_t

Pre-emphasis Filter coefficient value for 2FS and 4FS modes.

typedef enum *_dc_removal* dc_removal_t

DMIC DC filter control values.

typedef enum *_dmic_channel* dmic_channel_t

DMIC Channel number.

typedef enum *_dmic_phy_sample_rate* dmic_phy_sample_rate_t

DMIC and decimator sample rates.

typedef struct *_dmic_channel_config* dmic_channel_config_t

DMIC Channel configuration structure.

typedef void (*dmic_callback_t)(void)

DMIC Callback function.

typedef void (*dmic_hwvad_callback_t)(void)

HWVAD Callback function.

struct *_dmic_channel_config*

#include <fsl_dmic.h> DMIC Channel configuration structure.

Public Members

pdm_div_t divhfk

DMIC Clock pre-divider values

uint32_t osr

oversampling rate(CIC decimation rate) for PCM

uint32_t gainshift

4FS PCM data gain control

compensation_t preac2coef

Pre-emphasis Filter coefficient value for 2FS

compensation_t preac4coef

Pre-emphasis Filter coefficient value for 4FS

dc_removal_t dc_cut_level

DMIC DC filter control values.

uint32_t post_dc_gain_reduce

Fine gain adjustment in the form of a number of bits to downshift

dmic_phy_sample_rate_t sample_rate

DMIC and decimator sample rates

bool saturate16bit

Selects 16-bit saturation. 0 means results roll over if out range and do not saturate. 1 means if the result overflows, it saturates at 0xFFFF for positive overflow and 0x8000 for negative overflow.

bool enableSignExtend

sign extend feature which allows processing of 24bit audio data on 32bit machine

2.13 DSP Driver

`typedef struct _dsp_copy_image dsp_copy_image_t`

Structure for DSP copy image to destination address.

Defines start and destination address for copying image with given size.

`void DSP_Init(void)`

Initializing DSP core.

Power up DSP TCM Enable DSP clock Reset DSP peripheral

`void DSP_Deinit(void)`

Deinit DSP core.

Power down DSP TCM Disable DSP clock Set DSP peripheral reset

`void DSP_CopyImage(dsp_copy_image_t *dspCopyImage)`

Copy DSP image to destination address.

Copy DSP image from source address to destination address with given size.

Parameters

- `dspCopyImage` – Structure contains information for DSP copy image to destination address.

`static inline void DSP_Start(void)`

Start DSP core.

`static inline void DSP_Stop(void)`

Stop DSP core.

`FSL_DSP_DRIVER_VERSION`

reset driver version 2.1.1.

`uint32_t *srcAddr`

`uint32_t *destAddr`

`uint32_t size`

`struct _dsp_copy_image`

`#include <fsl_dsp.h>` Structure for DSP copy image to destination address.

Defines start and destination address for copying image with given size.

2.14 FLEXCOMM: FLEXCOMM Driver

2.15 FLEXCOMM Driver

`FSL_FLEXCOMM_DRIVER_VERSION`

FlexCOMM driver version 2.0.2.

`enum FLEXCOMM_PERIPH_T`

FLEXCOMM peripheral modes.

Values:

enumerator `FLEXCOMM_PERIPH_NONE`

No peripheral

enumerator FLEXCOMM_PERIPH_USART

USART peripheral

enumerator FLEXCOMM_PERIPH_SPI

SPI Peripheral

enumerator FLEXCOMM_PERIPH_I2C

I2C Peripheral

enumerator FLEXCOMM_PERIPH_I2S_TX

I2S TX Peripheral

enumerator FLEXCOMM_PERIPH_I2S_RX

I2S RX Peripheral

typedef void (*flexcomm_irq_handler_t)(void *base, void *handle)

Typedef for interrupt handler.

IRQn_Type const kFlexcommIrqs[]

Array with IRQ number for each FLEXCOMM module.

uint32_t FLEXCOMM_GetInstance(void *base)

Returns instance number for FLEXCOMM module with given base address.

status_t FLEXCOMM_Init(void *base, FLEXCOMM_PERIPH_T periph)

Initializes FLEXCOMM and selects peripheral mode according to the second parameter.

void FLEXCOMM_SetIRQHandler(void *base, flexcomm_irq_handler_t handler, void *flexcommHandle)

Sets IRQ handler for given FLEXCOMM module. It is used by drivers register IRQ handler according to FLEXCOMM mode.

2.16 FLEXSPI: Flexible Serial Peripheral Interface Driver

uint32_t FLEXSPI_GetInstance(FLEXSPI_Type *base)

Get the instance number for FLEXSPI.

Parameters

- base – FLEXSPI base pointer.

status_t FLEXSPI_CheckAndClearError(FLEXSPI_Type *base, uint32_t status)

Check and clear IP command execution errors.

Parameters

- base – FLEXSPI base pointer.
- status – interrupt status.

void FLEXSPI_Init(FLEXSPI_Type *base, const flexspi_config_t *config)

Initializes the FLEXSPI module and internal state.

This function enables the clock for FLEXSPI and also configures the FLEXSPI with the input configure parameters. Users should call this function before any FLEXSPI operations.

Parameters

- base – FLEXSPI peripheral base address.
- config – FLEXSPI configure structure.

void FLEXSPI_GetDefaultConfig(*flexspi_config_t* *config)

Gets default settings for FLEXSPI.

Parameters

- config – FLEXSPI configuration structure.

void FLEXSPI_Deinit(FLEXSPI_Type *base)

Deinitializes the FLEXSPI module.

Clears the FLEXSPI state and FLEXSPI module registers.

Parameters

- base – FLEXSPI peripheral base address.

void FLEXSPI_UpdateDllValue(FLEXSPI_Type *base, *flexspi_device_config_t* *config,
flexspi_port_t port)

Update FLEXSPI DLL value depending on currently flexspi root clock.

Parameters

- base – FLEXSPI peripheral base address.
- config – Flash configuration parameters.
- port – FLEXSPI Operation port.

void FLEXSPI_SetFlashConfig(FLEXSPI_Type *base, *flexspi_device_config_t* *config,
flexspi_port_t port)

Configures the connected device parameter.

This function configures the connected device relevant parameters, such as the size, command, and so on. The flash configuration value cannot have a default value. The user needs to configure it according to the connected device.

Parameters

- base – FLEXSPI peripheral base address.
- config – Flash configuration parameters.
- port – FLEXSPI Operation port.

void FLEXSPI_SoftwareReset(FLEXSPI_Type *base)

Software reset for the FLEXSPI logic.

This function sets the software reset flags for both AHB and buffer domain and resets both AHB buffer and also IP FIFOs.

Parameters

- base – FLEXSPI peripheral base address.

static inline void FLEXSPI_Enable(FLEXSPI_Type *base, bool enable)

Enables or disables the FLEXSPI module.

Parameters

- base – FLEXSPI peripheral base address.
- enable – True means enable FLEXSPI, false means disable.

void FLEXSPI_UpdateAhbBuffersSettings(FLEXSPI_Type *base, *flexspi_ahbBuffers_ctrl_t*
**ptrAhbBufferCtrl*)

Update all AHB buffers' settings, including buffer size, master ID.

Parameters

- base – FLEXSPI peripheral base address.

- ptrAhbBufferCtrl – Pointer to structure flexspi_ahbBuffers_ctrl_t which store all AHB buffers' settings.

static inline void FLEXSPI_EnableInterrupts(FLEXSPI_Type *base, uint32_t mask)

Enables the FLEXSPI interrupts.

Parameters

- base – FLEXSPI peripheral base address.
- mask – FLEXSPI interrupt source.

static inline void FLEXSPI_DisableInterrupts(FLEXSPI_Type *base, uint32_t mask)

Disable the FLEXSPI interrupts.

Parameters

- base – FLEXSPI peripheral base address.
- mask – FLEXSPI interrupt source.

static inline void FLEXSPI_EnableTxDMA(FLEXSPI_Type *base, bool enable)

Enables or disables FLEXSPI IP Tx FIFO DMA requests.

Parameters

- base – FLEXSPI peripheral base address.
- enable – Enable flag for transmit DMA request. Pass true for enable, false for disable.

static inline void FLEXSPI_EnableRxDMA(FLEXSPI_Type *base, bool enable)

Enables or disables FLEXSPI IP Rx FIFO DMA requests.

Parameters

- base – FLEXSPI peripheral base address.
- enable – Enable flag for receive DMA request. Pass true for enable, false for disable.

static inline uint32_t FLEXSPI_GetTxFifoAddress(FLEXSPI_Type *base)

Gets FLEXSPI IP tx fifo address for DMA transfer.

Parameters

- base – FLEXSPI peripheral base address.

Return values

The – tx fifo address.

static inline uint32_t FLEXSPI_GetRxFifoAddress(FLEXSPI_Type *base)

Gets FLEXSPI IP rx fifo address for DMA transfer.

Parameters

- base – FLEXSPI peripheral base address.

Return values

The – rx fifo address.

static inline void FLEXSPI_ResetFifos(FLEXSPI_Type *base, bool txFifo, bool rxFifo)

Clears the FLEXSPI IP FIFO logic.

Parameters

- base – FLEXSPI peripheral base address.
- txFifo – Pass true to reset TX FIFO.
- rxFifo – Pass true to reset RX FIFO.

```
static inline void FLEXSPI_GetFifoCounts(FLEXSPI_Type *base, size_t *txCount, size_t *rxCount)
```

Gets the valid data entries in the FLEXSPI FIFOs.

Parameters

- base – FLEXSPI peripheral base address.
- txCount – **[out]** Pointer through which the current number of bytes in the transmit FIFO is returned. Pass NULL if this value is not required.
- rxCount – **[out]** Pointer through which the current number of bytes in the receive FIFO is returned. Pass NULL if this value is not required.

```
static inline uint32_t FLEXSPI_GetInterruptStatusFlags(FLEXSPI_Type *base)
```

Get the FLEXSPI interrupt status flags.

Parameters

- base – FLEXSPI peripheral base address.

Return values

interrupt – status flag, use status flag to AND flexspi_flags_t could get the related status.

```
static inline void FLEXSPI_ClearInterruptStatusFlags(FLEXSPI_Type *base, uint32_t mask)
```

Get the FLEXSPI interrupt status flags.

Parameters

- base – FLEXSPI peripheral base address.
- mask – FLEXSPI interrupt source.

```
static inline void FLEXSPI_GetDataLearningPhase(FLEXSPI_Type *base, uint8_t *portAPhase, uint8_t *portBPhase)
```

Gets the sampling clock phase selection after Data Learning.

Parameters

- base – FLEXSPI peripheral base address.
- portAPhase – Pointer to a uint8_t type variable to receive the selected clock phase on PORTA.
- portBPhase – Pointer to a uint8_t type variable to receive the selected clock phase on PORTB.

```
static inline flexspi_arb_command_source_t FLEXSPI_GetArbitratorCommandSource(FLEXSPI_Type *base)
```

Gets the trigger source of current command sequence granted by arbitrator.

Parameters

- base – FLEXSPI peripheral base address.

Return values

trigger – source of current command sequence.

```
static inline flexspi_ip_error_code_t FLEXSPI_GetIPCommandErrorCode(FLEXSPI_Type *base, uint8_t *index)
```

Gets the error code when IP command error detected.

Parameters

- base – FLEXSPI peripheral base address.
- index – Pointer to a uint8_t type variable to receive the sequence index when error detected.

Return values

error – code when IP command error detected.

```
static inline flexspi_ahb_error_code_t FLEXSPI_GetAHBCommandErrorCode(FLEXSPI_Type  
                                                                    *base, uint8_t  
                                                                    *index)
```

Gets the error code when AHB command error detected.

Parameters

- base – FLEXSPI peripheral base address.
- index – Pointer to a uint8_t type variable to receive the sequence index when error detected.

Return values

error – code when AHB command error detected.

```
static inline bool FLEXSPI_GetBusIdleStatus(FLEXSPI_Type *base)
```

Returns whether the bus is idle.

Parameters

- base – FLEXSPI peripheral base address.

Return values

- true – Bus is idle.
- false – Bus is busy.

```
void FLEXSPI_UpdateRxSampleClock(FLEXSPI_Type *base, flexspi_read_sample_clock_t  
                                clockSource)
```

Update read sample clock source.

Parameters

- base – FLEXSPI peripheral base address.
- clockSource – clockSource of type flexspi_read_sample_clock_t

```
void FLEXSPI_UpdateLUT(FLEXSPI_Type *base, uint32_t index, const uint32_t *cmd, uint32_t  
                      count)
```

Updates the LUT table.

Parameters

- base – FLEXSPI peripheral base address.
- index – From which index start to update. It could be any index of the LUT table, which also allows user to update command content inside a command. Each command consists of up to 8 instructions and occupy 4*32-bit memory.
- cmd – Command sequence array.
- count – Number of sequences.

```
static inline void FLEXSPI_WriteData(FLEXSPI_Type *base, uint32_t data, uint8_t fifoIndex)
```

Writes data into FIFO.

Parameters

- base – FLEXSPI peripheral base address
- data – The data bytes to send
- fifoIndex – Destination fifo index.

`static inline uint32_t FLEXSPI_ReadData(FLEXSPI_Type *base, uint8_t fifoIndex)`

Receives data from data FIFO.

Parameters

- `base` – FLEXSPI peripheral base address
- `fifoIndex` – Source fifo index.

Returns

The data in the FIFO.

`status_t FLEXSPI_WriteBlocking(FLEXSPI_Type *base, uint8_t *buffer, size_t size)`

Sends a buffer of data bytes using blocking method.

Note: This function blocks via polling until all bytes have been sent.

Parameters

- `base` – FLEXSPI peripheral base address
- `buffer` – The data bytes to send
- `size` – The number of data bytes to send

Return values

- `kStatus_Success` – write success without error
- `kStatus_FLEXSPI_SequenceExecutionTimeout` – sequence execution timeout
- `kStatus_FLEXSPI_IpCommandSequenceError` – IP command sequence error detected
- `kStatus_FLEXSPI_IpCommandGrantTimeout` – IP command grant timeout detected

`status_t FLEXSPI_ReadBlocking(FLEXSPI_Type *base, uint8_t *buffer, size_t size)`

Receives a buffer of data bytes using a blocking method.

Note: This function blocks via polling until all bytes have been sent.

Parameters

- `base` – FLEXSPI peripheral base address
- `buffer` – The data bytes to send
- `size` – The number of data bytes to receive

Return values

- `kStatus_Success` – read success without error
- `kStatus_FLEXSPI_SequenceExecutionTimeout` – sequence execution timeout
- `kStatus_FLEXSPI_IpCommandSequenceError` – IP command sequencen error detected
- `kStatus_FLEXSPI_IpCommandGrantTimeout` – IP command grant timeout detected

status_t FLEXSPI_TransferBlocking(FLEXSPI_Type *base, *flexspi_transfer_t* *xfer)

Execute command to transfer a buffer data bytes using a blocking method.

Parameters

- base – FLEXSPI peripheral base address
- xfer – pointer to the transfer structure.

Return values

- kStatus_Success – command transfer success without error
- kStatus_FLEXSPI_SequenceExecutionTimeout – sequence execution timeout
- kStatus_FLEXSPI_IpCommandSequenceError – IP command sequence error detected
- kStatus_FLEXSPI_IpCommandGrantTimeout – IP command grant timeout detected

void FLEXSPI_TransferCreateHandle(FLEXSPI_Type *base, *flexspi_handle_t* *handle, *flexspi_transfer_callback_t* callback, void *userData)

Initializes the FLEXSPI handle which is used in transactional functions.

Parameters

- base – FLEXSPI peripheral base address.
- handle – pointer to *flexspi_handle_t* structure to store the transfer state.
- callback – pointer to user callback function.
- userData – user parameter passed to the callback function.

status_t FLEXSPI_TransferNonBlocking(FLEXSPI_Type *base, *flexspi_handle_t* *handle, *flexspi_transfer_t* *xfer)

Performs a interrupt non-blocking transfer on the FLEXSPI bus.

Note: Calling the API returns immediately after transfer initiates. The user needs to call FLEXSPI_GetTransferCount to poll the transfer status to check whether the transfer is finished. If the return status is not kStatus_FLEXSPI_Busy, the transfer is finished. For FLEXSPI_Read, the dataSize should be multiple of rx watermark level, or FLEXSPI could not read data properly.

Parameters

- base – FLEXSPI peripheral base address.
- handle – pointer to *flexspi_handle_t* structure which stores the transfer state.
- xfer – pointer to *flexspi_transfer_t* structure.

Return values

- kStatus_Success – Successfully start the data transmission.
- kStatus_FLEXSPI_Busy – Previous transmission still not finished.

status_t FLEXSPI_TransferGetCount(FLEXSPI_Type *base, *flexspi_handle_t* *handle, size_t *count)

Gets the master transfer status during a interrupt non-blocking transfer.

Parameters

- `base` – FLEXSPI peripheral base address.
- `handle` – pointer to `flexspi_handle_t` structure which stores the transfer state.
- `count` – Number of bytes transferred so far by the non-blocking transaction.

Return values

- `kStatus_InvalidArgument` – `count` is Invalid.
- `kStatus_Success` – Successfully return the count.

`void FLEXSPI_TransferAbort(FLEXSPI_Type *base, flexspi_handle_t *handle)`

Aborts an interrupt non-blocking transfer early.

Note: This API can be called at any time when an interrupt non-blocking transfer initiates to abort the transfer early.

Parameters

- `base` – FLEXSPI peripheral base address.
- `handle` – pointer to `flexspi_handle_t` structure which stores the transfer state

`void FLEXSPI_TransferHandleIRQ(FLEXSPI_Type *base, flexspi_handle_t *handle)`

Master interrupt handler.

Parameters

- `base` – FLEXSPI peripheral base address.
- `handle` – pointer to `flexspi_handle_t` structure.

`FSL_FLEXSPI_DRIVER_VERSION`

FLEXSPI driver version.

Status structure of FLEXSPI.

Values:

enumerator `kStatus_FLEXSPI_Busy`

FLEXSPI is busy

enumerator `kStatus_FLEXSPI_SequenceExecutionTimeout`

Sequence execution timeout error occurred during FLEXSPI transfer.

enumerator `kStatus_FLEXSPI_IpCommandSequenceError`

IP command Sequence execution timeout error occurred during FLEXSPI transfer.

enumerator `kStatus_FLEXSPI_IpCommandGrantTimeout`

IP command grant timeout error occurred during FLEXSPI transfer.

CMD definition of FLEXSPI, use to form LUT instruction, `_flexspi_command`.

Values:

enumerator `kFLEXSPI_Command_STOP`

Stop execution, deassert CS.

enumerator `kFLEXSPI_Command_SDR`

Transmit Command code to Flash, using SDR mode.

enumerator kFLEXSPI_Command_RADDR_SDR
Transmit Row Address to Flash, using SDR mode.

enumerator kFLEXSPI_Command_CADDR_SDR
Transmit Column Address to Flash, using SDR mode.

enumerator kFLEXSPI_Command_MODE1_SDR
Transmit 1-bit Mode bits to Flash, using SDR mode.

enumerator kFLEXSPI_Command_MODE2_SDR
Transmit 2-bit Mode bits to Flash, using SDR mode.

enumerator kFLEXSPI_Command_MODE4_SDR
Transmit 4-bit Mode bits to Flash, using SDR mode.

enumerator kFLEXSPI_Command_MODE8_SDR
Transmit 8-bit Mode bits to Flash, using SDR mode.

enumerator kFLEXSPI_Command_WRITE_SDR
Transmit Programming Data to Flash, using SDR mode.

enumerator kFLEXSPI_Command_READ_SDR
Receive Read Data from Flash, using SDR mode.

enumerator kFLEXSPI_Command_LEARN_SDR
Receive Read Data or Preamble bit from Flash, SDR mode.

enumerator kFLEXSPI_Command_DATSZ_SDR
Transmit Read/Program Data size (byte) to Flash, SDR mode.

enumerator kFLEXSPI_Command_DUMMY_SDR
Leave data lines undriven by FlexSPI controller.

enumerator kFLEXSPI_Command_DUMMY_RWDS_SDR
Leave data lines undriven by FlexSPI controller, dummy cycles decided by RWDS.

enumerator kFLEXSPI_Command_DDR
Transmit Command code to Flash, using DDR mode.

enumerator kFLEXSPI_Command_RADDR_DDR
Transmit Row Address to Flash, using DDR mode.

enumerator kFLEXSPI_Command_CADDR_DDR
Transmit Column Address to Flash, using DDR mode.

enumerator kFLEXSPI_Command_MODE1_DDR
Transmit 1-bit Mode bits to Flash, using DDR mode.

enumerator kFLEXSPI_Command_MODE2_DDR
Transmit 2-bit Mode bits to Flash, using DDR mode.

enumerator kFLEXSPI_Command_MODE4_DDR
Transmit 4-bit Mode bits to Flash, using DDR mode.

enumerator kFLEXSPI_Command_MODE8_DDR
Transmit 8-bit Mode bits to Flash, using DDR mode.

enumerator kFLEXSPI_Command_WRITE_DDR
Transmit Programming Data to Flash, using DDR mode.

enumerator kFLEXSPI_Command_READ_DDR
Receive Read Data from Flash, using DDR mode.

enumerator kFLEXSPI_Command_LEARN_DDR

Receive Read Data or Preamble bit from Flash, DDR mode.

enumerator kFLEXSPI_Command_DATSZ_DDR

Transmit Read/Program Data size (byte) to Flash, DDR mode.

enumerator kFLEXSPI_Command_DUMMY_DDR

Leave data lines undriven by FlexSPI controller.

enumerator kFLEXSPI_Command_DUMMY_RWDS_DDR

Leave data lines undriven by FlexSPI controller, dummy cycles decided by RWDS.

enumerator kFLEXSPI_Command_JUMP_ON_CS

Stop execution, deassert CS and save operand[7:0] as the instruction start pointer for next sequence

enum _flexspi_pad

pad definition of FLEXSPI, use to form LUT instruction.

Values:

enumerator kFLEXSPI_1PAD

Transmit command/address and transmit/receive data only through DATA0/DATA1.

enumerator kFLEXSPI_2PAD

Transmit command/address and transmit/receive data only through DATA[1:0].

enumerator kFLEXSPI_4PAD

Transmit command/address and transmit/receive data only through DATA[3:0].

enumerator kFLEXSPI_8PAD

Transmit command/address and transmit/receive data only through DATA[7:0].

enum _flexspi_flags

FLEXSPI interrupt status flags.

Values:

enumerator kFLEXSPI_SequenceExecutionTimeoutFlag

Sequence execution timeout.

enumerator kFLEXSPI_AhbBusTimeoutFlag

AHB Bus timeout.

enumerator kFLEXSPI_SckStoppedBecauseTxEmptyFlag

SCK is stopped during command sequence because Async TX FIFO empty.

enumerator kFLEXSPI_SckStoppedBecauseRxFullFlag

SCK is stopped during command sequence because Async RX FIFO full.

enumerator kFLEXSPI_DataLearningFailedFlag

Data learning failed.

enumerator kFLEXSPI_IpTxFifoWatermarkEmptyFlag

IP TX FIFO WaterMark empty.

enumerator kFLEXSPI_IpRxFifoWatermarkAvailableFlag

IP RX FIFO WaterMark available.

enumerator kFLEXSPI_AhbCommandSequenceErrorFlag

AHB triggered Command Sequences Error.

enumerator kFLEXSPI_IpCommandSequenceErrorFlag

IP triggered Command Sequences Error.

enumerator kFLEXSPI_AhbCommandGrantTimeoutFlag
AHB triggered Command Sequences Grant Timeout.

enumerator kFLEXSPI_IpCommandGrantTimeoutFlag
IP triggered Command Sequences Grant Timeout.

enumerator kFLEXSPI_IpCommandExecutionDoneFlag
IP triggered Command Sequences Execution finished.

enumerator kFLEXSPI_AllInterruptFlags
All flags.

enum _flexspi_read_sample_clock
FLEXSPI sample clock source selection for Flash Reading.

Values:

enumerator kFLEXSPI_ReadSampleClkLoopbackInternally
Dummy Read strobe generated by FlexSPI Controller and loopback internally.

enumerator kFLEXSPI_ReadSampleClkLoopbackFromDqsPad
Dummy Read strobe generated by FlexSPI Controller and loopback from DQS pad.

enumerator kFLEXSPI_ReadSampleClkLoopbackFromSckPad
SCK output clock and loopback from SCK pad.

enumerator kFLEXSPI_ReadSampleClkExternalInputFromDqsPad
Flash provided Read strobe and input from DQS pad.

enum _flexspi_cs_interval_cycle_unit
FLEXSPI interval unit for flash device select.

Values:

enumerator kFLEXSPI_CsIntervalUnit1SckCycle
Chip selection interval: CSINTERVAL * 1 serial clock cycle.

enumerator kFLEXSPI_CsIntervalUnit256SckCycle
Chip selection interval: CSINTERVAL * 256 serial clock cycle.

enum _flexspi_ahb_write_wait_unit
FLEXSPI AHB wait interval unit for writing.

Values:

enumerator kFLEXSPI_AhbWriteWaitUnit2AhbCycle
AWRWAIT unit is 2 ahb clock cycle.

enumerator kFLEXSPI_AhbWriteWaitUnit8AhbCycle
AWRWAIT unit is 8 ahb clock cycle.

enumerator kFLEXSPI_AhbWriteWaitUnit32AhbCycle
AWRWAIT unit is 32 ahb clock cycle.

enumerator kFLEXSPI_AhbWriteWaitUnit128AhbCycle
AWRWAIT unit is 128 ahb clock cycle.

enumerator kFLEXSPI_AhbWriteWaitUnit512AhbCycle
AWRWAIT unit is 512 ahb clock cycle.

enumerator kFLEXSPI_AhbWriteWaitUnit2048AhbCycle
AWRWAIT unit is 2048 ahb clock cycle.

enumerator kFLEXSPI_AhbWriteWaitUnit8192AhbCycle

AWRWAIT unit is 8192 ahb clock cycle.

enumerator kFLEXSPI_AhbWriteWaitUnit32768AhbCycle

AWRWAIT unit is 32768 ahb clock cycle.

enum _flexspi_ip_error_code

Error Code when IP command Error detected.

Values:

enumerator kFLEXSPI_IpCmdErrorNoError

No error.

enumerator kFLEXSPI_IpCmdErrorJumpOnCsInIpCmd

IP command with JMP_ON_CS instruction used.

enumerator kFLEXSPI_IpCmdErrorUnknownOpCode

Unknown instruction opcode in the sequence.

enumerator kFLEXSPI_IpCmdErrorSdrDummyInDdrSequence

Instruction DUMMY_SDR/DUMMY_RWDS_SDR used in DDR sequence.

enumerator kFLEXSPI_IpCmdErrorDdrDummyInSdrSequence

Instruction DUMMY_DDR/DUMMY_RWDS_DDR used in SDR sequence.

enumerator kFLEXSPI_IpCmdErrorInvalidAddress

Flash access start address exceed the whole flash address range (A1/A2/B1/B2).

enumerator kFLEXSPI_IpCmdErrorSequenceExecutionTimeout

Sequence execution timeout.

enumerator kFLEXSPI_IpCmdErrorFlashBoundaryAcrosss

Flash boundary crossed.

enum _flexspi_ahb_error_code

Error Code when AHB command Error detected.

Values:

enumerator kFLEXSPI_AhbCmdErrorNoError

No error.

enumerator kFLEXSPI_AhbCmdErrorJumpOnCsInWriteCmd

AHB Write command with JMP_ON_CS instruction used in the sequence.

enumerator kFLEXSPI_AhbCmdErrorUnknownOpCode

Unknown instruction opcode in the sequence.

enumerator kFLEXSPI_AhbCmdErrorSdrDummyInDdrSequence

Instruction DUMMY_SDR/DUMMY_RWDS_SDR used in DDR sequence.

enumerator kFLEXSPI_AhbCmdErrorDdrDummyInSdrSequence

Instruction DUMMY_DDR/DUMMY_RWDS_DDR used in SDR sequence.

enumerator kFLEXSPI_AhbCmdSequenceExecutionTimeout

Sequence execution timeout.

enum _flexspi_port

FLEXSPI operation port select.

Values:

enumerator kFLEXSPI_PortA1

Access flash on A1 port.

enumerator kFLEXSPI_PortA2

Access flash on A2 port.

enumerator kFLEXSPI_PortB1

Access flash on B1 port.

enumerator kFLEXSPI_PortB2

Access flash on B2 port.

enumerator kFLEXSPI_PortCount

enum _flexspi_arb_command_source

Trigger source of current command sequence granted by arbitrator.

Values:

enumerator kFLEXSPI_AhbReadCommand

enumerator kFLEXSPI_AhbWriteCommand

enumerator kFLEXSPI_IpCommand

enumerator kFLEXSPI_SuspendedCommand

enum _flexspi_command_type

Command type.

Values:

enumerator kFLEXSPI_Command

FlexSPI operation: Only command, both TX and Rx buffer are ignored.

enumerator kFLEXSPI_Config

FlexSPI operation: Configure device mode, the TX fifo size is fixed in LUT.

enumerator kFLEXSPI_Read

enumerator kFLEXSPI_Write

typedef enum _flexspi_pad flexspi_pad_t

pad definition of FLEXSPI, use to form LUT instruction.

typedef enum _flexspi_flags flexspi_flags_t

FLEXSPI interrupt status flags.

typedef enum _flexspi_read_sample_clock flexspi_read_sample_clock_t

FLEXSPI sample clock source selection for Flash Reading.

typedef enum _flexspi_cs_interval_cycle_unit flexspi_cs_interval_cycle_unit_t

FLEXSPI interval unit for flash device select.

typedef enum _flexspi_ahb_write_wait_unit flexspi_ahb_write_wait_unit_t

FLEXSPI AHB wait interval unit for writing.

typedef enum _flexspi_ip_error_code flexspi_ip_error_code_t

Error Code when IP command Error detected.

typedef enum _flexspi_ahb_error_code flexspi_ahb_error_code_t

Error Code when AHB command Error detected.

```
typedef enum _flexspi_port flexspi_port_t
    FLEXSPI operation port select.

typedef enum _flexspi_arb_command_source flexspi_arb_command_source_t
    Trigger source of current command sequence granted by arbitrator.

typedef enum _flexspi_command_type flexspi_command_type_t
    Command type.

typedef struct _flexspi_ahbBuffer_config flexspi_ahbBuffer_config_t

typedef struct _flexspi_ahbBuffers_ctrl flexspi_ahbBuffers_ctrl_t
    Structure to control all AHB buffers.

typedef struct _flexspi_config flexspi_config_t
    FLEXSPI configuration structure.

typedef struct _flexspi_device_config flexspi_device_config_t
    External device configuration items.

typedef struct _flexspi_transfer flexspi_transfer_t
    Transfer structure for FLEXSPI.

typedef struct _flexspi_handle flexspi_handle_t

typedef void (*flexspi_transfer_callback_t)(FLEXSPI_Type *base, flexspi_handle_t *handle,
status_t status, void *userData)
    FLEXSPI transfer callback function.

typedef struct _flexspi_addr_map_config flexspi_addr_map_config_t
    Address mapping configuration structure.

FSL_FEATURE_FLEXSPI_AHB_BUFFER_COUNT

FLEXSPI_LUT_SEQ(cmd0, pad0, op0, cmd1, pad1, op1)
    Formula to form FLEXSPI instructions in LUT table.

struct _flexspi_ahbBuffer_config
    #include <fsl_flexspi.h>
```

Public Members

```
uint8_t priority
    This priority for AHB Master Read which this AHB RX Buffer is assigned.

uint8_t masterIndex
    AHB Master ID the AHB RX Buffer is assigned.

uint16_t bufferSize
    AHB buffer size in byte.

bool enablePrefetch
    AHB Read Prefetch Enable for current AHB RX Buffer corresponding Master, allows
    prefetch disable/enable separately for each master.

struct _flexspi_ahbBuffers_ctrl
    #include <fsl_flexspi.h> Structure to control all AHB buffers.
```

Public Members

flexspi_ahbBuffer_config_t buffer[FSL_FEATURE_FLEXSPI_AHB_BUFFER_COUNTn(0)]

Configurations of all AHB buffers.

struct *_flexspi_config*

#include <fsl_flexspi.h> FLEXSPI configuration structure.

Public Members

flexspi_read_sample_clock_t rxSampleClock

Sample Clock source selection for Flash Reading.

bool enableSckFreeRunning

Enable/disable SCK output free-running.

bool enableDoze

Enable/disable doze mode support.

bool enableHalfSpeedAccess

Enable/disable divide by 2 of the clock for half speed commands.

bool enableSckBDiffOpt

Enable/disable SCKB pad use as SCKA differential clock output, when enable, Port B flash access is not available.

bool enableSameConfigForAll

Enable/disable same configuration for all connected devices when enabled, same configuration in FLASHA1CRx is applied to all.

uint16_t seqTimeoutCycle

Timeout wait cycle for command sequence execution, timeout after ahbGrantTimeoutCycle*1024 serial root clock cycles.

uint8_t ipGrantTimeoutCycle

Timeout wait cycle for IP command grant, timeout after ipGrantTimeoutCycle*1024 AHB clock cycles.

uint8_t txWatermark

FLEXSPI IP transmit watermark value.

uint8_t rxWatermark

FLEXSPI receive watermark value.

struct *_flexspi_device_config*

#include <fsl_flexspi.h> External device configuration items.

Public Members

uint32_t flexspiRootClk

FLEXSPI serial root clock.

bool isSck2Enabled

FLEXSPI use SCK2.

uint32_t flashSize

Flash size in KByte.

bool addressShift

Address shift.

flexspi_cs_interval_cycle_unit_t CSIntervalUnit

CS interval unit, 1 or 256 cycle.

uint16_t CSInterval

CS line assert interval, multiply CS interval unit to get the CS line assert interval cycles.

uint8_t CSHoldTime

CS line hold time.

uint8_t CSSetupTime

CS line setup time.

uint8_t dataValidTime

Data valid time for external device.

uint8_t columnSpace

Column space size.

bool enableWordAddress

If enable word address.

uint8_t AWRSeqIndex

Sequence ID for AHB write command.

uint8_t AWRSeqNumber

Sequence number for AHB write command.

uint8_t ARDSeqIndex

Sequence ID for AHB read command.

uint8_t ARDSeqNumber

Sequence number for AHB read command.

flexspi_ahb_write_wait_unit_t AHBWriteWaitUnit

AHB write wait unit.

uint16_t AHBWriteWaitInterval

AHB write wait interval, multiply AHB write interval unit to get the AHB write wait cycles.

bool enableWriteMask

Enable/Disable FLEXSPI drive DQS pin as write mask when writing to external device.

struct *_flexspi_transfer*

#include <fsl_flexspi.h> Transfer structure for FLEXSPI.

Public Members

uint32_t deviceAddress

Operation device address.

flexspi_port_t port

Operation port.

flexspi_command_type_t cmdType

Execution command type.

uint8_t seqIndex

Sequence ID for command.

uint8_t SeqNumber
Sequence number for command.

uint32_t *data
Data buffer.

size_t dataSize
Data size in bytes.

struct __flexspi_handle
#include <fsl_flexspi.h> Transfer handle structure for FLEXSPI.

Public Members

uint32_t state
Internal state for FLEXSPI transfer

uint8_t *data
Data buffer.

size_t dataSize
Remaining Data size in bytes.

size_t transferTotalSize
Total Data size in bytes.

flexspi_transfer_callback_t completionCallback
Callback for users while transfer finish or error occurred

void *userData
FLEXSPI callback function parameter.

struct __flexspi_addr_map_config
#include <fsl_flexspi.h> Address mapping configuration structure.

Public Members

uint32_t addrStart
Remapping start address.

uint32_t addrEnd
Remapping end address.

uint32_t addrOffset
Address offset.

bool remapEnable
Enable address remapping.

struct ahbConfig

Public Members

uint8_t ahbGrantTimeoutCycle
Timeout wait cycle for AHB command grant, timeout after ahbGrantTimeoutCyle*1024 AHB clock cycles.

uint16_t ahbBusTimeoutCycle

Timeout wait cycle for AHB read/write access, timeout after ahbBusTimeoutCycle*1024 AHB clock cycles.

uint8_t resumeWaitCycle

Wait cycle for idle state before suspended command sequence resume, timeout after ahbBusTimeoutCycle AHB clock cycles.

flexspi_ahbBuffer_config_t buffer[FSL_FEATURE_FLEXSPI_AHB_BUFFER_COUNTn(0)]

AHB buffer size.

bool enableClearAHBBufferOpt

Enable/disable automatically clean AHB RX Buffer and TX Buffer when FLEXSPI returns STOP mode ACK.

bool enableReadAddressOpt

Enable/disable remove AHB read burst start address alignment limitation. when enable, there is no AHB read burst start address alignment limitation.

bool enableAHBPrefetch

Enable/disable AHB read prefetch feature, when enabled, FLEXSPI will fetch more data than current AHB burst.

bool enableAHBBufferable

Enable/disable AHB bufferable write access support, when enabled, FLEXSPI return before waiting for command execution finished.

bool enableAHBCachable

Enable AHB bus cachable read access support.

2.17 FLEXSPI DMA Driver

```
void FLEXSPI_TransferCreateHandleDMA(FLEXSPI_Type *base, flexspi_dma_handle_t *handle,
                                     flexspi_dma_callback_t callback, void *userData,
                                     dma_handle_t *txDmaHandle, dma_handle_t
                                     *rxDmaHandle)
```

Initializes the FLEXSPI handle for transfer which is used in transactional functions and set the callback.

Parameters

- base – FLEXSPI peripheral base address
- handle – Pointer to flexspi_dma_handle_t structure
- callback – FLEXSPI callback, NULL means no callback.
- userData – User callback function data.
- txDmaHandle – User requested DMA handle for TX DMA transfer.
- rxDmaHandle – User requested DMA handle for RX DMA transfer.

```
void FLEXSPI_TransferUpdateSizeDMA(FLEXSPI_Type *base, flexspi_dma_handle_t *handle,
                                   flexspi_dma_transfer_nsize_t nsize)
```

Update FLEXSPI DMA transfer source data transfer size(SSIZE) and destination data transfer size(DSIZE).

See also:

flexspi_dma_transfer_nsize_t.

Parameters

- base – FLEXSPI peripheral base address
- handle – Pointer to flexspi_dma_handle_t structure
- nsize – FLEXSPI DMA transfer data transfer size(SSIZE/DSIZE), by default the size is kFLEXPSI_DMAnSize1Bytes(one byte).

status_t FLEXSPI_TransferDMA(FLEXSPI_Type *base, flexspi_dma_handle_t *handle, flexspi_transfer_t *xfer)

Transfers FLEXSPI data using an dma non-blocking method.

This function writes/receives data to/from the FLEXSPI transmit/receive FIFO. This function is non-blocking.

Parameters

- base – FLEXSPI peripheral base address.
- handle – Pointer to flexspi_dma_handle_t structure
- xfer – FLEXSPI transfer structure.

Return values

- kStatus_FLEXSPI_Busy – FLEXSPI is busy transfer.
- kStatus_InvalidArgument – The watermark configuration is invalid, the watermark should be power of 2 to do successfully DMA transfer.
- kStatus_Success – FLEXSPI successfully start dma transfer.

void FLEXSPI_TransferAbortDMA(FLEXSPI_Type *base, flexspi_dma_handle_t *handle)

Aborts the transfer data using dma.

This function aborts the transfer data using dma.

Parameters

- base – FLEXSPI peripheral base address.
- handle – Pointer to flexspi_dma_handle_t structure

status_t FLEXSPI_TransferGetTransferCountDMA(FLEXSPI_Type *base, flexspi_dma_handle_t *handle, size_t *count)

Gets the transferred counts of transfer.

Parameters

- base – FLEXSPI peripheral base address.
- handle – Pointer to flexspi_dma_handle_t structure.
- count – Bytes transfer.

Return values

- kStatus_Success – Succeed get the transfer count.
- kStatus_NoTransferInProgress – There is not a non-blocking transaction currently in progress.

FSL_FLEXSPI_DMA_DRIVER_VERSION

FLEXSPI DMA driver version 2.2.1.

enum flexspi_dma_ntransfer_size

dma transfer configuration

Values:

```

enumerator kFLEXPSI_DMAnSize1Bytes
    Source/Destination data transfer size is 1 byte every time
enumerator kFLEXPSI_DMAnSize2Bytes
    Source/Destination data transfer size is 2 bytes every time
enumerator kFLEXPSI_DMAnSize4Bytes
    Source/Destination data transfer size is 4 bytes every time
typedef struct flexspi_dma_handle flexspi_dma_handle_t
typedef void (*flexspi_dma_callback_t)(FLEXSPI_Type *base, flexspi_dma_handle_t *handle,
status_t status, void *userData)
    FLEXSPI dma transfer callback function for finish and error.
typedef enum flexspi_dma_ntransfer_size flexspi_dma_transfer_nsize_t
    dma transfer configuration
struct flexspi_dma_handle
    #include <fsl_flexspi_dma.h> FLEXSPI DMA transfer handle, users should not touch the con-
    tent of the handle.

```

Public Members

```

dma_handle_t *txDmaHandle
    dma handler for FLEXSPI Tx.
dma_handle_t *rxDmaHandle
    dma handler for FLEXSPI Rx.
size_t transferSize
    Bytes need to transfer.
flexspi_dma_transfer_nsize_t nsize
    dma SSIZE/DSIZE in each transfer.
uint8_t nbytes
    dma minor byte transfer count initially configured.
uint8_t count
    The transfer data count in a DMA request.
uint32_t state
    Internal state for FLEXSPI dma transfer.
flexspi_dma_callback_t completionCallback
    A callback function called after the dma transfer is finished.
void *userData
    User callback parameter

```

2.18 FMEAS: Frequency Measure Driver

```

static inline void FMEAS_StartMeasure(FMEAS_SYSCON_Type *base)
    Starts a frequency measurement cycle.

```

Parameters

- base – : SYSCON peripheral base address.

static inline bool FMEAS_IsMeasureComplete(*FMEAS_SYSCON_Type* *base)

Indicates when a frequency measurement cycle is complete.

Parameters

- base – : SYSCON peripheral base address.

Returns

true if a measurement cycle is active, otherwise false.

uint32_t FMEAS_GetFrequency(*FMEAS_SYSCON_Type* *base, uint32_t refClockRate)

Returns the computed value for a frequency measurement cycle.

Parameters

- base – : SYSCON peripheral base address.
- refClockRate – : Reference clock rate used during the frequency measurement cycle.

Returns

Frequency in Hz.

FSL_FMEAS_DRIVER_VERSION

Defines LPC Frequency Measure driver version 2.1.1.

typedef FREQME_Type FMEAS_SYSCON_Type

FMEAS_SYSCON_FREQMECTRL_CAPVAL_MASK

FMEAS_SYSCON_FREQMECTRL_CAPVAL_SHIFT

FMEAS_SYSCON_FREQMECTRL_CAPVAL

FMEAS_SYSCON_FREQMECTRL_PROG_MASK

FMEAS_SYSCON_FREQMECTRL_PROG_SHIFT

FMEAS_SYSCON_FREQMECTRL_PROG

2.19 Hashcrypt: The Cryptographic Accelerator

2.20 Hashcrypt Background HASH

void HASHCRYPT_SHA_SetCallback(*HASHCRYPT_Type* *base, *hashcrypt_hash_ctx_t* *ctx, *hashcrypt_callback_t* callback, void *userData)

Initializes the HASHCRYPT handle for background hashing.

This function initializes the hash context for background hashing (Non-blocking) APIs. This is less typical interface to hash function, but can be used for parallel processing, when main CPU has something else to do. Example is digital signature RSASSA-PKCS1-V1_5-VERIFY((n,e),M,S) algorithm, where background hashing of M can be started, then CPU can compute $S^e \bmod n$ (in parallel with background hashing) and once the digest becomes available, CPU can proceed to comparison of EM with EM'.

Parameters

- base – HASHCRYPT peripheral base address.
- ctx – **[out]** Hash context.
- callback – Callback function.

- `userData` – User data (to be passed as an argument to callback function, once callback is invoked from isr).

`status_t` HASHCRYPT_SHA_UpdateNonBlocking(HASHCRYPT_Type *base, *hashcrypt_hash_ctx_t* *ctx, const uint8_t *input, size_t inputSize)

Create running hash on given data.

Configures the HASHCRYPT to compute new running hash as AHB master and returns immediately. HASHCRYPT AHB Master mode supports only aligned input address and can be called only once per continuous block of data. Every call to this function must be preceded with HASHCRYPT_SHA_Init() and finished with HASHCRYPT_SHA_Finish(). Once callback function is invoked by HASHCRYPT isr, it should set a flag for the main application to finalize the hashing (padding) and to read out the final digest by calling HASHCRYPT_SHA_Finish().

Parameters

- `base` – HASHCRYPT peripheral base address
- `ctx` – Specifies callback. Last incomplete 512-bit block of the input is copied into clear buffer for padding.
- `input` – 32-bit word aligned pointer to Input data.
- `inputSize` – Size of input data in bytes (must be word aligned)

Returns

Status of the hash update operation.

2.21 Hashcrypt common functions

FSL_HASHCRYPT_DRIVER_VERSION

HASHCRYPT driver version. Version 2.2.16.

Current version: 2.2.16

Change log:

- Version 2.0.0
 - Initial version
- Version 2.0.1
 - Support loading AES key from unaligned address
- Version 2.0.2
 - Support loading AES key from unaligned address for different compiler and core variants
- Version 2.0.3
 - Remove SHA512 and AES ICB algorithm definitions
- Version 2.0.4
 - Add SHA context switch support
- Version 2.1.0
 - Update the register name and macro to align with new header.
- Version 2.1.1
 - Fix MISRA C-2012.
- Version 2.1.2

- Support loading AES input data from unaligned address.
- Version 2.1.3
 - Fix MISRA C-2012.
- Version 2.1.4
 - Fix context switch cannot work when switching from AES.
- Version 2.1.5
 - Add data synchronization barrier inside `hashcrypt_sha_ldm_stm_16_words()` to prevent possible optimization issue.
- Version 2.2.0
 - Add AES-OFB and AES-CFB mixed IP/SW modes.
- Version 2.2.1
 - Add data synchronization barrier inside `hashcrypt_sha_ldm_stm_16_words()` prevent compiler from reordering memory write when `-O2` or higher is used.
- Version 2.2.2
 - Add data synchronization barrier inside `hashcrypt_sha_ldm_stm_16_words()` to fix optimization issue
- Version 2.2.3
 - Added check for size in `hashcrypt_aes_one_block` to prevent overflowing COUNT field in MEMCTRL register, if its bigger than COUNT field do a multiple runs.
- Version 2.2.4
 - In all `HASHCRYPT_AES_xx` functions have been added setting CTRL_MODE bitfield to 0 after processing data, which decreases power consumption.
- Version 2.2.5
 - Add data synchronization barrier and instruction synchronization barrier inside `hashcrypt_sha_process_message_data()` to fix optimization issue
- Version 2.2.6
 - Add data synchronization barrier inside `HASHCRYPT_SHA_Update()` and `hashcrypt_get_data()` function to fix optimization issue on MDK and ARMGCC release targets
- Version 2.2.7
 - Add data synchronization barrier inside `HASHCRYPT_SHA_Update()` to fix optimization issue on MCUX IDE release target
- Version 2.2.8
 - Unify hashcrypt hashing behavior between aligned and unaligned input data
- Version 2.2.9
 - Add handling of set ERROR bit in the STATUS register
- Version 2.2.10
 - Fix missing error statement in `hashcrypt_save_running_hash()`
- Version 2.2.11
 - Fix incorrect SHA-256 calculation for long messages with reload
- Version 2.2.12

- Fix hardfault issue on the Keil compiler due to unaligned memcpy() input on some optimization levels
- Version 2.2.13
 - Added function hashcrypt_seed_prng() which loading random number into PRNG_SEED register before AES operation for SCA protection
- Version 2.2.14
 - Modify function hashcrypt_get_data() to prevent issue with unaligned access
- Version 2.2.15
 - Add wait on DIGEST BIT inside hashcrypt_sha_one_block() to fix issues with some optimization flags
- Version 2.2.16
 - Add DSB instruction inside hashcrypt_sha_ldm_stm_16_words() to fix issues with some optimization flags

enum __hashcrypt_algo_t

Algorithm used for Hashcrypt operation.

Values:

enumerator kHASHCRYPT_Sha1

SHA_1

enumerator kHASHCRYPT_Sha256

SHA_256

enumerator kHASHCRYPT_Aes

AES

typedef enum __hashcrypt_algo_t hashcrypt_algo_t

Algorithm used for Hashcrypt operation.

void HASHCRYPT_Init(HASHCRYPT_Type *base)

Enables clock and disables reset for HASHCRYPT peripheral.

Enable clock and disable reset for HASHCRYPT.

Parameters

- base – HASHCRYPT base address

void HASHCRYPT_Deinit(HASHCRYPT_Type *base)

Disables clock for HASHCRYPT peripheral.

Disable clock and enable reset.

Parameters

- base – HASHCRYPT base address

HASHCRYPT_MODE_SHA1

Algorithm definitions correspond with the values for Mode field in Control register !

HASHCRYPT_MODE_SHA256

HASHCRYPT_MODE_AES

2.22 Hashcrypt AES

enum `_hashcrypt_aes_mode_t`

AES mode.

Values:

enumerator `kHASHCRYPT_AesEcb`

AES ECB mode

enumerator `kHASHCRYPT_AesCbc`

AES CBC mode

enumerator `kHASHCRYPT_AesCtr`

AES CTR mode

enum `_hashcrypt_aes_keysize_t`

Size of AES key.

Values:

enumerator `kHASHCRYPT_Aes128`

AES 128 bit key

enumerator `kHASHCRYPT_Aes192`

AES 192 bit key

enumerator `kHASHCRYPT_Aes256`

AES 256 bit key

enumerator `kHASHCRYPT_InvalidKey`

AES invalid key

enum `_hashcrypt_key`

HASHCRYPT key source selection.

Values:

enumerator `kHASHCRYPT_UserKey`

HASHCRYPT user key

enumerator `kHASHCRYPT_SecretKey`

HASHCRYPT secret key (dedicated hw bus from PUF)

typedef enum `_hashcrypt_aes_mode_t` `hashcrypt_aes_mode_t`

AES mode.

typedef enum `_hashcrypt_aes_keysize_t` `hashcrypt_aes_keysize_t`

Size of AES key.

typedef enum `_hashcrypt_key` `hashcrypt_key_t`

HASHCRYPT key source selection.

typedef struct `_hashcrypt_handle` `hashcrypt_handle_t`

struct `_hashcrypt_handle` `__attribute__((aligned))`

`status_t` `HASHCRYPT_AES_SetKey`(`HASHCRYPT_Type` *base, `hashcrypt_handle_t` *handle,
const `uint8_t` *key, `size_t` keySize)

Set AES key to `hashcrypt_handle_t` struct and optionally to HASHCRYPT.

Sets the AES key for encryption/decryption with the `hashcrypt_handle_t` structure. The `hashcrypt_handle_t` input argument specifies key source.

Parameters

- base – HASHCRYPT peripheral base address.
- handle – Handle used for the request.
- key – 0-mod-4 aligned pointer to AES key.
- keySize – AES key size in bytes. Shall equal 16, 24 or 32.

Returns

status from set key operation

```
status_t HASHCRYPT_AES_EncryptEcb(HASHCRYPT_Type *base, hashcrypt_handle_t *handle,  
                                const uint8_t *plaintext, uint8_t *ciphertext, size_t  
                                size)
```

Encrypts AES on one or multiple 128-bit block(s).

Encrypts AES. The source plaintext and destination ciphertext can overlap in system memory.

Parameters

- base – HASHCRYPT peripheral base address
- handle – Handle used for this request.
- plaintext – Input plain text to encrypt
- ciphertext – **[out]** Output cipher text
- size – Size of input and output data in bytes. Must be multiple of 16 bytes.

Returns

Status from encrypt operation

```
status_t HASHCRYPT_AES_DecryptEcb(HASHCRYPT_Type *base, hashcrypt_handle_t *handle,  
                                const uint8_t *ciphertext, uint8_t *plaintext, size_t  
                                size)
```

Decrypts AES on one or multiple 128-bit block(s).

Decrypts AES. The source ciphertext and destination plaintext can overlap in system memory.

Parameters

- base – HASHCRYPT peripheral base address
- handle – Handle used for this request.
- ciphertext – Input plain text to encrypt
- plaintext – **[out]** Output cipher text
- size – Size of input and output data in bytes. Must be multiple of 16 bytes.

Returns

Status from decrypt operation

```
status_t HASHCRYPT_AES_EncryptCbc(HASHCRYPT_Type *base, hashcrypt_handle_t *handle,  
                                const uint8_t *plaintext, uint8_t *ciphertext, size_t  
                                size, const uint8_t iv[16])
```

Encrypts AES using CBC block mode.

Parameters

- base – HASHCRYPT peripheral base address
- handle – Handle used for this request.
- plaintext – Input plain text to encrypt

- ciphertext – **[out]** Output cipher text
- size – Size of input and output data in bytes. Must be multiple of 16 bytes.
- iv – Input initial vector to combine with the first input block.

Returns

Status from encrypt operation

```
status_t HASHCRYPT_AES_DecryptCbc(HASHCRYPT_Type *base, hashcrypt_handle_t *handle,  
                                  const uint8_t *ciphertext, uint8_t *plaintext, size_t  
                                  size, const uint8_t iv[16])
```

Decrypts AES using CBC block mode.

Parameters

- base – HASHCRYPT peripheral base address
- handle – Handle used for this request.
- ciphertext – Input cipher text to decrypt
- plaintext – **[out]** Output plain text
- size – Size of input and output data in bytes. Must be multiple of 16 bytes.
- iv – Input initial vector to combine with the first input block.

Returns

Status from decrypt operation

```
status_t HASHCRYPT_AES_CryptCtr(HASHCRYPT_Type *base, hashcrypt_handle_t *handle,  
                                const uint8_t *input, uint8_t *output, size_t size, uint8_t  
                                counter[16U], uint8_t counterlast[16U], size_t *szLeft)
```

Encrypts or decrypts AES using CTR block mode.

Encrypts or decrypts AES using CTR block mode. AES CTR mode uses only forward AES cipher and same algorithm for encryption and decryption. The only difference between encryption and decryption is that, for encryption, the input argument is plain text and the output argument is cipher text. For decryption, the input argument is cipher text and the output argument is plain text.

Parameters

- base – HASHCRYPT peripheral base address
- handle – Handle used for this request.
- input – Input data for CTR block mode
- output – **[out]** Output data for CTR block mode
- size – Size of input and output data in bytes
- counter – **[inout]** Input counter (updates on return)
- counterlast – **[out]** Output cipher of last counter, for chained CTR calls (statefull encryption). NULL can be passed if chained calls are not used.
- szLeft – **[out]** Output number of bytes in left unused in counterlast block. NULL can be passed if chained calls are not used.

Returns

Status from encrypt operation

```
status_t HASHCRYPT_AES_CryptOfb(HASHCRYPT_Type *base, hashcrypt_handle_t *handle,  
                                const uint8_t *input, uint8_t *output, size_t size, const  
                                uint8_t iv[16U])
```

Encrypts or decrypts AES using OFB block mode.

Encrypts or decrypts AES using OFB block mode. AES OFB mode uses only forward AES cipher and same algorithm for encryption and decryption. The only difference between encryption and decryption is that, for encryption, the input argument is plain text and the output argument is cipher text. For decryption, the input argument is cipher text and the output argument is plain text.

Parameters

- base – HASHCRYPT peripheral base address
- handle – Handle used for this request.
- input – Input data for OFB block mode
- output – **[out]** Output data for OFB block mode
- size – Size of input and output data in bytes
- iv – Input initial vector to combine with the first input block.

Returns

Status from encrypt operation

```
status_t HASHCRYPT_AES_EncryptCfb(HASHCRYPT_Type *base, hashcrypt_handle_t *handle,  
                                   const uint8_t *plaintext, uint8_t *ciphertext, size_t size,  
                                   const uint8_t iv[16])
```

Encrypts AES using CFB block mode.

Parameters

- base – HASHCRYPT peripheral base address
- handle – Handle used for this request.
- plaintext – Input plain text to encrypt
- ciphertext – **[out]** Output cipher text
- size – Size of input and output data in bytes. Must be multiple of 16 bytes.
- iv – Input initial vector to combine with the first input block.

Returns

Status from encrypt operation

```
status_t HASHCRYPT_AES_DecryptCfb(HASHCRYPT_Type *base, hashcrypt_handle_t *handle,  
                                   const uint8_t *ciphertext, uint8_t *plaintext, size_t size,  
                                   const uint8_t iv[16])
```

Decrypts AES using CFB block mode.

Parameters

- base – HASHCRYPT peripheral base address
- handle – Handle used for this request.
- ciphertext – Input cipher text to decrypt
- plaintext – **[out]** Output plaintext text
- size – Size of input and output data in bytes. Must be multiple of 16 bytes.
- iv – Input initial vector to combine with the first input block.

Returns

Status from encrypt operation

`HASHCRYPT_AES_BLOCK_SIZE`

AES block size in bytes

`AES_ENCRYPT`

`AES_DECRYPT`

`struct __hashcrypt_handle`

#include <fsl_hashcrypt.h> Specify HASHCRYPT's key resource.

Public Members

`uint32_t keyWord[8]`

Copy of user key (set by `HASHCRYPT_AES_SetKey()`).

hashcrypt_key_t keyType

For operations with key (such as AES encryption/decryption), specify key type.

2.23 Hashcrypt HASH

`typedef struct __hashcrypt_hash_ctx_t hashcrypt_hash_ctx_t`

Storage type used to save hash context.

`typedef void (*hashcrypt_callback_t)(HASHCRYPT_Type *base, hashcrypt_hash_ctx_t *ctx, status_t status, void *userData)`

HASHCRYPT background hash callback function.

`status_t HASHCRYPT_SHA(HASHCRYPT_Type *base, hashcrypt_algo_t algo, const uint8_t *input, size_t inputSize, uint8_t *output, size_t *outputSize)`

Create HASH on given data.

Perform the full SHA in one function call. The function is blocking.

Parameters

- `base` – HASHCRYPT peripheral base address
- `algo` – Underlying algorithm to use for hash computation.
- `input` – Input data
- `inputSize` – Size of input data in bytes
- `output` – **[out]** Output hash data
- `outputSize` – **[out]** Output parameter storing the size of the output hash in bytes

Returns

Status of the one call hash operation.

`status_t HASHCRYPT_SHA_Init(HASHCRYPT_Type *base, hashcrypt_hash_ctx_t *ctx, hashcrypt_algo_t algo)`

Initialize HASH context.

This function initializes the HASH.

Parameters

- `base` – HASHCRYPT peripheral base address
- `ctx` – **[out]** Output hash context

- algo – Underlying algorithm to use for hash computation.

Returns

Status of initialization

```
status_t HASHCRYPT_SHA_Update(HASHCRYPT_Type *base, hashcrypt_hash_ctx_t *ctx, const
                             uint8_t *input, size_t inputSize)
```

Add data to current HASH.

Add data to current HASH. This can be called repeatedly with an arbitrary amount of data to be hashed. The functions blocks. If it returns kStatus_Success, the running hash has been updated (HASHCRYPT has processed the input data), so the memory at `input` pointer can be released back to system. The HASHCRYPT context buffer is updated with the running hash and with all necessary information to support possible context switch.

Parameters

- base – HASHCRYPT peripheral base address
- ctx – **[inout]** HASH context
- input – Input data
- inputSize – Size of input data in bytes

Returns

Status of the hash update operation

```
status_t HASHCRYPT_SHA_Finish(HASHCRYPT_Type *base, hashcrypt_hash_ctx_t *ctx, uint8_t
                             *output, size_t *outputSize)
```

Finalize hashing.

Outputs the final hash (computed by HASHCRYPT_HASH_Update()) and erases the context.

Parameters

- base – HASHCRYPT peripheral base address
- ctx – **[inout]** Input hash context
- output – **[out]** Output hash data
- outputSize – **[inout]** Optional parameter (can be passed as NULL). On function entry, it specifies the size of `output[]` buffer. On function return, it stores the number of updated output bytes.

Returns

Status of the hash finish operation

HASHCRYPT_HASH_CTX_SIZE

HASHCRYPT HASH Context size.

```
struct _hashcrypt_hash_ctx_t
```

#include <fsl_hashcrypt.h> Storage type used to save hash context.

Public Members

uint32_t x[30]

storage

2.24 I2C: Inter-Integrated Circuit Driver

2.25 I2C DMA Driver

```
void I2C_MasterTransferCreateHandleDMA(I2C_Type *base, i2c_master_dma_handle_t *handle,  
                                       i2c_master_dma_transfer_callback_t callback, void  
                                       *userData, dma_handle_t *dmaHandle)
```

Init the I2C handle which is used in transactional functions.

Parameters

- base – I2C peripheral base address
- handle – pointer to i2c_master_dma_handle_t structure
- callback – pointer to user callback function
- userData – user param passed to the callback function
- dmaHandle – DMA handle pointer

```
status_t I2C_MasterTransferDMA(I2C_Type *base, i2c_master_dma_handle_t *handle,  
                               i2c_master_transfer_t *xfer)
```

Performs a master dma non-blocking transfer on the I2C bus.

Parameters

- base – I2C peripheral base address
- handle – pointer to i2c_master_dma_handle_t structure
- xfer – pointer to transfer structure of i2c_master_transfer_t

Return values

- kStatus_Success – Sucessully complete the data transmission.
- kStatus_I2C_Busy – Previous transmission still not finished.
- kStatus_I2C_Timeout – Transfer error, wait signal timeout.
- kStatus_I2C_ArbitrationLost – Transfer error, arbitration lost.
- kStataus_I2C_Nak – Transfer error, receive Nak during transfer.

```
status_t I2C_MasterTransferGetCountDMA(I2C_Type *base, i2c_master_dma_handle_t *handle,  
                                       size_t *count)
```

Get master transfer status during a dma non-blocking transfer.

Parameters

- base – I2C peripheral base address
- handle – pointer to i2c_master_dma_handle_t structure
- count – Number of bytes transferred so far by the non-blocking transaction.

```
void I2C_MasterTransferAbortDMA(I2C_Type *base, i2c_master_dma_handle_t *handle)
```

Abort a master dma non-blocking transfer in a early time.

Parameters

- base – I2C peripheral base address
- handle – pointer to i2c_master_dma_handle_t structure

```
FSL_I2C_DMA_DRIVER_VERSION
```

I2C DMA driver version.

```
typedef struct _i2c_master_dma_handle i2c_master_dma_handle_t  
I2C master dma handle typedef.
```



```
typedef void (*i2c_master_dma_transfer_callback_t)(I2C_Type *base, i2c_master_dma_handle_t *handle, status_t status, void *userData)
```

I2C master dma transfer callback typedef.

```
typedef void (*flexcomm_i2c_dma_master_irq_handler_t)(I2C_Type *base, i2c_master_dma_handle_t *handle)
```

Typedef for master dma handler.

```
I2C_MAX_DMA_TRANSFER_COUNT
```

Maximum length of single DMA transfer (determined by capability of the DMA engine)

```
struct i2c_master_dma_handle
```

#include <fsl_i2c_dma.h> I2C master dma transfer structure.

Public Members

uint8_t state

Transfer state machine current state.

uint32_t transferCount

Indicates progress of the transfer

uint32_t remainingBytesDMA

Remaining byte count to be transferred using DMA.

uint8_t *buf

Buffer pointer for current state.

bool checkAddrNack

Whether to check the nack signal is detected during addressing.

dma_handle_t *dmaHandle

The DMA handler used.

i2c_master_transfer_t transfer

Copy of the current transfer info.

i2c_master_dma_transfer_callback_t completionCallback

Callback function called after dma transfer finished.

void *userData

Callback parameter passed to callback function.

2.26 I2C Driver

```
FSL_I2C_DRIVER_VERSION
```

I2C driver version.

I2C status return codes.

Values:

enumerator kStatus_I2C_Busy

The master is already performing a transfer.

enumerator kStatus_I2C_Idle

The slave driver is idle.

enumerator kStatus_I2C_Nak

The slave device sent a NAK in response to a byte.

enumerator kStatus_I2C_InvalidParameter

Unable to proceed due to invalid parameter.

enumerator kStatus_I2C_BitError

Transferred bit was not seen on the bus.

enumerator kStatus_I2C_ArbitrationLost

Arbitration lost error.

enumerator kStatus_I2C_NoTransferInProgress

Attempt to abort a transfer when one is not in progress.

enumerator kStatus_I2C_DmaRequestFail

DMA request failed.

enumerator kStatus_I2C_StartStopError

Start and stop error.

enumerator kStatus_I2C_UnexpectedState

Unexpected state.

enumerator kStatus_I2C_Timeout

Timeout when waiting for I2C master/slave pending status to set to continue transfer.

enumerator kStatus_I2C_Addr_Nak

NAK received for Address

enumerator kStatus_I2C_EventTimeout

Timeout waiting for bus event.

enumerator kStatus_I2C_SclLowTimeout

Timeout SCL signal remains low.

enum _i2c_status_flags

I2C status flags.

Note: These enums are meant to be OR'd together to form a bit mask.

Values:

enumerator kI2C_MasterPendingFlag

The I2C module is waiting for software interaction. bit 0

enumerator kI2C_MasterArbitrationLostFlag

The arbitration of the bus was lost. There was collision on the bus. bit 4

enumerator kI2C_MasterStartStopErrorFlag

There was an error during start or stop phase of the transaction. bit 6

enumerator kI2C_MasterIdleFlag

The I2C master idle status. bit 5

enumerator kI2C_MasterRxReadyFlag

The I2C master rx ready status. bit 1

enumerator kI2C_MasterTxReadyFlag

The I2C master tx ready status. bit 2

enumerator `ki2C_MasterAddrNackFlag`

The I2C master address nack status. bit 7

enumerator `ki2C_MasterDataNackFlag`

The I2C master data nack status. bit 3

enumerator `ki2C_SlavePendingFlag`

The I2C module is waiting for software interaction. bit 8

enumerator `ki2C_SlaveNotStretching`

Indicates whether the slave is currently stretching clock (0 = yes, 1 = no). bit 11

enumerator `ki2C_SlaveSelected`

Indicates whether the slave is selected by an address match. bit 14

enumerator `ki2C_SaveDeselected`

Indicates that slave was previously deselected (deselect event took place, w1c). bit 15

enumerator `ki2C_SlaveAddressedFlag`

One of the I2C slave's 4 addresses is matched. bit 22

enumerator `ki2C_SlaveReceiveFlag`

Slave receive data available. bit 9

enumerator `ki2C_SlaveTransmitFlag`

Slave data can be transmitted. bit 10

enumerator `ki2C_SlaveAddress0MatchFlag`

Slave address0 match. bit 20

enumerator `ki2C_SlaveAddress1MatchFlag`

Slave address1 match. bit 12

enumerator `ki2C_SlaveAddress2MatchFlag`

Slave address2 match. bit 13

enumerator `ki2C_SlaveAddress3MatchFlag`

Slave address3 match. bit 21

enumerator `ki2C_MonitorReadyFlag`

The I2C monitor ready interrupt. bit 16

enumerator `ki2C_MonitorOverflowFlag`

The monitor data overrun interrupt. bit 17

enumerator `ki2C_MonitorActiveFlag`

The monitor is active. bit 18

enumerator `ki2C_MonitorIdleFlag`

The monitor idle interrupt. bit 19

enumerator `ki2C_EventTimeoutFlag`

The bus event timeout interrupt. bit 24

enumerator `ki2C_SclTimeoutFlag`

The SCL timeout interrupt. bit 25

enumerator `ki2C_MasterAllClearFlags`

enumerator `ki2C_SlaveAllClearFlags`

enumerator `ki2C_CommonAllClearFlags`

enum _i2c_interrupt_enable
I2C interrupt enable.

Note: These enums are meant to be OR'd together to form a bit mask.

Values:

enumerator kI2C_MasterPendingInterruptEnable

The I2C master communication pending interrupt.

enumerator kI2C_MasterArbitrationLostInterruptEnable

The I2C master arbitration lost interrupt.

enumerator kI2C_MasterStartStopErrorInterruptEnable

The I2C master start/stop timing error interrupt.

enumerator kI2C_SlavePendingInterruptEnable

The I2C slave communication pending interrupt.

enumerator kI2C_SlaveNotStretchingInterruptEnable

The I2C slave not stretching interrupt, deep-sleep mode can be entered only when this interrupt occurs.

enumerator kI2C_SlaveDeselectedInterruptEnable

The I2C slave deselection interrupt.

enumerator kI2C_MonitorReadyInterruptEnable

The I2C monitor ready interrupt.

enumerator kI2C_MonitorOverflowInterruptEnable

The monitor data overrun interrupt.

enumerator kI2C_MonitorIdleInterruptEnable

The monitor idle interrupt.

enumerator kI2C_EventTimeoutInterruptEnable

The bus event timeout interrupt.

enumerator kI2C_SclTimeoutInterruptEnable

The SCL timeout interrupt.

enumerator kI2C_MasterAllInterruptEnable

enumerator kI2C_SlaveAllInterruptEnable

enumerator kI2C_CommonAllInterruptEnable

I2C_RETRY_TIMES

Retry times for waiting flag.

I2C_MASTER_TRANSMIT_IGNORE_LAST_NACK

Whether to ignore the nack signal of the last byte during master transmit.

I2C_STAT_MSTCODE_IDLE

Master Idle State Code

I2C_STAT_MSTCODE_RXREADY

Master Receive Ready State Code

I2C_STAT_MSTCODE_TXREADY

Master Transmit Ready State Code

I2C_STAT_MSTCODE_NACKADR

Master NACK by slave on address State Code

I2C_STAT_MSTCODE_NACKDAT

Master NACK by slave on data State Code

I2C_STAT_SLVST_ADDR

I2C_STAT_SLVST_RX

I2C_STAT_SLVST_TX

2.27 I2C Master Driver

void I2C_MasterGetDefaultConfig(*i2c_master_config_t* *masterConfig)

Provides a default configuration for the I2C master peripheral.

This function provides the following default configuration for the I2C master peripheral:

```
masterConfig->enableMaster      = true;
masterConfig->baudRate_Bps      = 100000U;
masterConfig->enableTimeout     = false;
```

After calling this function, you can override any settings in order to customize the configuration, prior to initializing the master driver with I2C_MasterInit().

Parameters

- masterConfig – **[out]** User provided configuration structure for default values. Refer to *i2c_master_config_t*.

void I2C_MasterInit(I2C_Type *base, const *i2c_master_config_t* *masterConfig, uint32_t srcClock_Hz)

Initializes the I2C master peripheral.

This function enables the peripheral clock and initializes the I2C master peripheral as described by the user provided configuration. A software reset is performed prior to configuration.

Parameters

- base – The I2C peripheral base address.
- masterConfig – User provided peripheral configuration. Use I2C_MasterGetDefaultConfig() to get a set of defaults that you can override.
- srcClock_Hz – Frequency in Hertz of the I2C functional clock. Used to calculate the baud rate divisors, filter widths, and timeout periods.

void I2C_MasterDeinit(I2C_Type *base)

Deinitializes the I2C master peripheral.

This function disables the I2C master peripheral and gates the clock. It also performs a software reset to restore the peripheral to reset conditions.

Parameters

- base – The I2C peripheral base address.

uint32_t I2C_GetInstance(I2C_Type *base)

Returns an instance number given a base address.

If an invalid base address is passed, debug builds will assert. Release builds will just return instance number 0.

Parameters

- base – The I2C peripheral base address.

Returns

I2C instance number starting from 0.

static inline void I2C_MasterReset(I2C_Type *base)

Performs a software reset.

Restores the I2C master peripheral to reset conditions.

Parameters

- base – The I2C peripheral base address.

static inline void I2C_MasterEnable(I2C_Type *base, bool enable)

Enables or disables the I2C module as master.

Parameters

- base – The I2C peripheral base address.
- enable – Pass true to enable or false to disable the specified I2C as master.

uint32_t I2C_GetStatusFlags(I2C_Type *base)

Gets the I2C status flags.

A bit mask with the state of all I2C status flags is returned. For each flag, the corresponding bit in the return value is set if the flag is asserted.

See also:

[_i2c_status_flags](#).

Parameters

- base – The I2C peripheral base address.

Returns

State of the status flags:

- 1: related status flag is set.
- 0: related status flag is not set.

static inline void I2C_ClearStatusFlags(I2C_Type *base, uint32_t statusMask)

Clears the I2C status flag state.

Refer to `kI2C_CommonAllClearStatusFlags`, `kI2C_MasterAllClearStatusFlags` and `kI2C_SlaveAllClearStatusFlags` to see the clearable flags. Attempts to clear other flags has no effect.

See also:

[_i2c_status_flags](#), [_i2c_master_status_flags](#) and [_i2c_slave_status_flags](#).

Parameters

- base – The I2C peripheral base address.

- `statusMask` – A bitmask of status flags that are to be cleared. The mask is composed of the members in `kI2C_CommonAllClearStatusFlags`, `kI2C_MasterAllClearStatusFlags` and `kI2C_SlaveAllClearStatusFlags`. You may pass the result of a previous call to `I2C_GetStatusFlags()`.

`static inline void I2C_MasterClearStatusFlags(I2C_Type *base, uint32_t statusMask)`

Clears the I2C master status flag state.

Deprecated:

Do not use this function. It has been superseded by `I2C_ClearStatusFlags`. The following status register flags can be cleared:

- `kI2C_MasterArbitrationLostFlag`
- `kI2C_MasterStartStopErrorFlag`

Attempts to clear other flags has no effect.

See also:

`_i2c_status_flags`.

Parameters

- `base` – The I2C peripheral base address.
- `statusMask` – A bitmask of status flags that are to be cleared. The mask is composed of `_i2c_status_flags` enumerators OR'd together. You may pass the result of a previous call to `I2C_GetStatusFlags()`.

`static inline void I2C_EnableInterrupts(I2C_Type *base, uint32_t interruptMask)`

Enables the I2C interrupt requests.

Parameters

- `base` – The I2C peripheral base address.
- `interruptMask` – Bit mask of interrupts to enable. See `_i2c_interrupt_enable` for the set of constants that should be OR'd together to form the bit mask.

`static inline void I2C_DisableInterrupts(I2C_Type *base, uint32_t interruptMask)`

Disables the I2C interrupt requests.

Parameters

- `base` – The I2C peripheral base address.
- `interruptMask` – Bit mask of interrupts to disable. See `_i2c_interrupt_enable` for the set of constants that should be OR'd together to form the bit mask.

`static inline uint32_t I2C_GetEnabledInterrupts(I2C_Type *base)`

Returns the set of currently enabled I2C interrupt requests.

Parameters

- `base` – The I2C peripheral base address.

Returns

A bitmask composed of `_i2c_interrupt_enable` enumerators OR'd together to indicate the set of enabled interrupts.

```
void I2C_MasterSetBaudRate(I2C_Type *base, uint32_t baudRate_Bps, uint32_t srcClock_Hz)
```

Sets the I2C bus frequency for master transactions.

The I2C master is automatically disabled and re-enabled as necessary to configure the baud rate. Do not call this function during a transfer, or the transfer is aborted.

Parameters

- `base` – The I2C peripheral base address.
- `srcClock_Hz` – I2C functional clock frequency in Hertz.
- `baudRate_Bps` – Requested bus frequency in bits per second.

```
void I2C_MasterSetTimeoutValue(I2C_Type *base, uint8_t timeout_Ms, uint32_t srcClock_Hz)
```

Sets the I2C bus timeout value.

If the SCL signal remains low or bus does not have event longer than the timeout value, `kI2C_SclTimeoutFlag` or `kI2C_EventTimeoutFlag` is set. This can indicate the bus is held by slave or any fault occurs to the I2C module.

Parameters

- `base` – The I2C peripheral base address.
- `timeout_Ms` – Timeout value in millisecond.
- `srcClock_Hz` – I2C functional clock frequency in Hertz.

```
static inline bool I2C_MasterGetBusIdleState(I2C_Type *base)
```

Returns whether the bus is idle.

Requires the master mode to be enabled.

Parameters

- `base` – The I2C peripheral base address.

Return values

- `true` – Bus is busy.
- `false` – Bus is idle.

```
status_t I2C_MasterStart(I2C_Type *base, uint8_t address, i2c_direction_t direction)
```

Sends a START on the I2C bus.

This function is used to initiate a new master mode transfer by sending the START signal. The slave address is sent following the I2C START signal.

Parameters

- `base` – I2C peripheral base pointer
- `address` – 7-bit slave device address.
- `direction` – Master transfer directions(transmit/receive).

Return values

- `kStatus_Success` – Successfully send the start signal.
- `kStatus_I2C_Busy` – Current bus is busy.

```
status_t I2C_MasterStop(I2C_Type *base)
```

Sends a STOP signal on the I2C bus.

Return values

- `kStatus_Success` – Successfully send the stop signal.
- `kStatus_I2C_Timeout` – Send stop signal failed, timeout.


```
static inline status_t I2C_MasterRepeatedStart(I2C_Type *base, uint8_t address, i2c_direction_t
                                             direction)
```

Sends a REPEATED START on the I2C bus.

Parameters

- *base* – I2C peripheral base pointer
- *address* – 7-bit slave device address.
- *direction* – Master transfer directions(transmit/receive).

Return values

- *kStatus_Success* – Successfully send the start signal.
- *kStatus_I2C_Busy* – Current bus is busy but not occupied by current I2C master.

```
status_t I2C_MasterWriteBlocking(I2C_Type *base, const void *txBuff, size_t txSize, uint32_t
                                flags)
```

Performs a polling send transfer on the I2C bus.

Sends up to *txSize* number of bytes to the previously addressed slave device. The slave may reply with a NAK to any byte in order to terminate the transfer early. If this happens, this function returns *kStatus_I2C_Nak*.

Parameters

- *base* – The I2C peripheral base address.
- *txBuff* – The pointer to the data to be transferred.
- *txSize* – The length in bytes of the data to be transferred.
- *flags* – Transfer control flag to control special behavior like suppressing start or stop, for normal transfers use *kI2C_TransferDefaultFlag*

Return values

- *kStatus_Success* – Data was sent successfully.
- *kStatus_I2C_Busy* – Another master is currently utilizing the bus.
- *kStatus_I2C_Nak* – The slave device sent a NAK in response to a byte.
- *kStatus_I2C_ArbitrationLost* – Arbitration lost error.

```
status_t I2C_MasterReadBlocking(I2C_Type *base, void *rxBuff, size_t rxSize, uint32_t flags)
```

Performs a polling receive transfer on the I2C bus.

Parameters

- *base* – The I2C peripheral base address.
- *rxBuff* – The pointer to the data to be transferred.
- *rxSize* – The length in bytes of the data to be transferred.
- *flags* – Transfer control flag to control special behavior like suppressing start or stop, for normal transfers use *kI2C_TransferDefaultFlag*

Return values

- *kStatus_Success* – Data was received successfully.
- *kStatus_I2C_Busy* – Another master is currently utilizing the bus.
- *kStatus_I2C_Nak* – The slave device sent a NAK in response to a byte.
- *kStatus_I2C_ArbitrationLost* – Arbitration lost error.

status_t I2C_MasterTransferBlocking(I2C_Type *base, *i2c_master_transfer_t* *xfer)

Performs a master polling transfer on the I2C bus.

Note: The API does not return until the transfer succeeds or fails due to arbitration lost or receiving a NAK.

Parameters

- base – I2C peripheral base address.
- xfer – Pointer to the transfer structure.

Return values

- kStatus_Success – Successfully complete the data transmission.
- kStatus_I2C_Busy – Previous transmission still not finished.
- kStatus_I2C_Timeout – Transfer error, wait signal timeout.
- kStatus_I2C_ArbitrationLost – Transfer error, arbitration lost.
- kStatus_I2C_Nak – Transfer error, receive NAK during transfer.
- kStatus_I2C_Addr_Nak – Transfer error, receive NAK during addressing.

void I2C_MasterTransferCreateHandle(I2C_Type *base, *i2c_master_handle_t* *handle,
i2c_master_transfer_callback_t callback, *void* *userData)

Creates a new handle for the I2C master non-blocking APIs.

The creation of a handle is for use with the non-blocking APIs. Once a handle is created, there is not a corresponding destroy handle. If the user wants to terminate a transfer, the I2C_MasterTransferAbort() API shall be called.

Parameters

- base – The I2C peripheral base address.
- handle – **[out]** Pointer to the I2C master driver handle.
- callback – User provided pointer to the asynchronous callback function.
- userData – User provided pointer to the application callback data.

status_t I2C_MasterTransferNonBlocking(I2C_Type *base, *i2c_master_handle_t* *handle,
i2c_master_transfer_t *xfer)

Performs a non-blocking transaction on the I2C bus.

Parameters

- base – The I2C peripheral base address.
- handle – Pointer to the I2C master driver handle.
- xfer – The pointer to the transfer descriptor.

Return values

- kStatus_Success – The transaction was started successfully.
- kStatus_I2C_Busy – Either another master is currently utilizing the bus, or a non-blocking transaction is already in progress.

status_t I2C_MasterTransferGetCount(I2C_Type *base, *i2c_master_handle_t* *handle, *size_t*
*count)

Returns number of bytes transferred so far.

Parameters

- `base` – The I2C peripheral base address.
- `handle` – Pointer to the I2C master driver handle.
- `count` – **[out]** Number of bytes transferred so far by the non-blocking transaction.

Return values

- `kStatus__Success` –
- `kStatus_I2C_Busy` –

`status_t I2C_MasterTransferAbort(I2C_Type *base, i2c_master_handle_t *handle)`

Terminates a non-blocking I2C master transmission early.

Note: It is not safe to call this function from an IRQ handler that has a higher priority than the I2C peripheral's IRQ priority.

Parameters

- `base` – The I2C peripheral base address.
- `handle` – Pointer to the I2C master driver handle.

Return values

- `kStatus__Success` – A transaction was successfully aborted.
- `kStatus_I2C_Timeout` – Timeout during polling for flags.

`void I2C_MasterTransferHandleIRQ(I2C_Type *base, i2c_master_handle_t *handle)`

Reusable routine to handle master interrupts.

Note: This function does not need to be called unless you are reimplementing the non-blocking API's interrupt handler routines to add special functionality.

Parameters

- `base` – The I2C peripheral base address.
- `handle` – Pointer to the I2C master driver handle.

`enum _i2c_direction`

Direction of master and slave transfers.

Values:

enumerator `kI2C_Write`

Master transmit.

enumerator `kI2C_Read`

Master receive.

`enum _i2c_master_transfer_flags`

Transfer option flags.

Note: These enumerations are intended to be OR'd together to form a bit mask of options for the `_i2c_master_transfer::flags` field.

Values:

enumerator kI2C__TransferDefaultFlag

Transfer starts with a start signal, stops with a stop signal.

enumerator kI2C__TransferNoStartFlag

Don't send a start condition, address, and sub address

enumerator kI2C__TransferRepeatedStartFlag

Send a repeated start condition

enumerator kI2C__TransferNoStopFlag

Don't send a stop condition.

enum __i2c__transfer_states

States for the state machine used by transactional APIs.

Values:

enumerator kIdleState

enumerator kTransmitSubaddrState

enumerator kTransmitDataState

enumerator kReceiveDataBeginState

enumerator kReceiveDataState

enumerator kReceiveLastDataState

enumerator kStartState

enumerator kStopState

enumerator kWaitForCompletionState

typedef enum __i2c__direction i2c__direction_t

Direction of master and slave transfers.

typedef struct __i2c__master_config i2c__master_config_t

Structure with settings to initialize the I2C master module.

This structure holds configuration settings for the I2C peripheral. To initialize this structure to reasonable defaults, call the I2C_MasterGetDefaultConfig() function and pass a pointer to your configuration structure instance.

The configuration structure can be made constant so it resides in flash.

typedef struct __i2c__master_transfer i2c__master_transfer_t

I2C master transfer typedef.

typedef struct __i2c__master_handle i2c__master_handle_t

I2C master handle typedef.

typedef void (*i2c__master_transfer_callback_t)(I2C_Type *base, i2c__master_handle_t *handle, status_t completionStatus, void *userData)

Master completion callback function pointer type.

This callback is used only for the non-blocking master transfer API. Specify the callback you wish to use in the call to I2C_MasterTransferCreateHandle().

Param base

The I2C peripheral base address.

Param completionStatus

Either kStatus_Success or an error code describing how the transfer completed.

Param userData

Arbitrary pointer-sized value passed from the application.

struct `_i2c_master_config`

#include <fsl_i2c.h> Structure with settings to initialize the I2C master module.

This structure holds configuration settings for the I2C peripheral. To initialize this structure to reasonable defaults, call the `I2C_MasterGetDefaultConfig()` function and pass a pointer to your configuration structure instance.

The configuration structure can be made constant so it resides in flash.

Public Members

bool enableMaster

Whether to enable master mode.

uint32_t baudRate_Bps

Desired baud rate in bits per second.

bool enableTimeout

Enable internal timeout function.

uint8_t timeout_Ms

Event timeout and SCL low timeout value.

struct `_i2c_master_transfer`

#include <fsl_i2c.h> Non-blocking transfer descriptor structure.

This structure is used to pass transaction parameters to the `I2C_MasterTransferNonBlocking()` API.

Public Members

uint32_t flags

Bit mask of options for the transfer. See enumeration `_i2c_master_transfer_flags` for available options. Set to 0 or `kI2C_TransferDefaultFlag` for normal transfers.

uint8_t slaveAddress

The 7-bit slave address.

i2c_direction_t direction

Either `kI2C_Read` or `kI2C_Write`.

uint32_t subaddress

Sub address. Transferred MSB first.

size_t subaddressSize

Length of sub address to send in bytes. Maximum size is 4 bytes.

void *data

Pointer to data to transfer.

size_t dataSize

Number of bytes to transfer.

struct `_i2c_master_handle`

#include <fsl_i2c.h> Driver handle for master non-blocking APIs.

Note: The contents of this structure are private and subject to change.

Public Members

uint8_t state

Transfer state machine current state.

uint32_t transferCount

Indicates progress of the transfer

uint32_t remainingBytes

Remaining byte count in current state.

uint8_t *buf

Buffer pointer for current state.

bool checkAddrNack

Whether to check the nack signal is detected during addressing.

i2c_master_transfer_t transfer

Copy of the current transfer info.

i2c_master_transfer_callback_t completionCallback

Callback function pointer.

void *userData

Application data passed to callback.

2.28 I2C Slave Driver

void I2C_SlaveGetDefaultConfig(*i2c_slave_config_t* *slaveConfig)

Provides a default configuration for the I2C slave peripheral.

This function provides the following default configuration for the I2C slave peripheral:

```
slaveConfig->enableSlave = true;
slaveConfig->address0.disable = false;
slaveConfig->address0.address = 0u;
slaveConfig->address1.disable = true;
slaveConfig->address2.disable = true;
slaveConfig->address3.disable = true;
slaveConfig->busSpeed = kI2C_SlaveStandardMode;
```

After calling this function, override any settings to customize the configuration, prior to initializing the master driver with I2C_SlaveInit(). Be sure to override at least the *address0.address* member of the configuration structure with the desired slave address.

Parameters

- slaveConfig – **[out]** User provided configuration structure that is set to default values. Refer to *i2c_slave_config_t*.

status_t I2C_SlaveInit(I2C_Type *base, const *i2c_slave_config_t* *slaveConfig, uint32_t srcClock_Hz)

Initializes the I2C slave peripheral.

This function enables the peripheral clock and initializes the I2C slave peripheral as described by the user provided configuration.

Parameters

- base – The I2C peripheral base address.
- slaveConfig – User provided peripheral configuration. Use I2C_SlaveGetDefaultConfig() to get a set of defaults that you can override.

- `srcClock_Hz` – Frequency in Hertz of the I2C functional clock. Used to calculate `CLKDIV` value to provide enough data setup time for master when slave stretches the clock.

`void I2C_SlaveSetAddress(I2C_Type *base, i2c_slave_address_register_t addressRegister, uint8_t address, bool addressDisable)`

Configures Slave Address register.

This function writes new value to Slave Address register.

Parameters

- `base` – The I2C peripheral base address.
- `addressRegister` – The module supports multiple address registers. The parameter determines which one shall be changed.
- `address` – The slave address to be stored to the address register for matching.
- `addressDisable` – Disable matching of the specified address register.

`void I2C_SlaveDeinit(I2C_Type *base)`

Deinitializes the I2C slave peripheral.

This function disables the I2C slave peripheral and gates the clock. It also performs a software reset to restore the peripheral to reset conditions.

Parameters

- `base` – The I2C peripheral base address.

`static inline void I2C_SlaveEnable(I2C_Type *base, bool enable)`

Enables or disables the I2C module as slave.

Parameters

- `base` – The I2C peripheral base address.
- `enable` – True to enable or false to disable.

`static inline void I2C_SlaveClearStatusFlags(I2C_Type *base, uint32_t statusMask)`

Clears the I2C status flag state.

The following status register flags can be cleared:

- slave deselected flag

Attempts to clear other flags has no effect.

See also:

`_i2c_slave_flags`.

Parameters

- `base` – The I2C peripheral base address.
- `statusMask` – A bitmask of status flags that are to be cleared. The mask is composed of `_i2c_slave_flags` enumerators OR'd together. You may pass the result of a previous call to `I2C_SlaveGetStatusFlags()`.

`status_t I2C_SlaveWriteBlocking(I2C_Type *base, const uint8_t *txBuff, size_t txSize)`

Performs a polling send transfer on the I2C bus.

The function executes blocking address phase and blocking data phase.

Parameters

- `base` – The I2C peripheral base address.
- `txBuff` – The pointer to the data to be transferred.
- `txSize` – The length in bytes of the data to be transferred.

Returns

`kStatus_Success` Data has been sent.

Returns

`kStatus_Fail` Unexpected slave state (master data write while master read from slave is expected).

`status_t` I2C_SlaveReadBlocking(I2C_Type *base, uint8_t *rxBuff, size_t rxSize)

Performs a polling receive transfer on the I2C bus.

The function executes blocking address phase and blocking data phase.

Parameters

- `base` – The I2C peripheral base address.
- `rxBuff` – The pointer to the data to be transferred.
- `rxSize` – The length in bytes of the data to be transferred.

Returns

`kStatus_Success` Data has been received.

Returns

`kStatus_Fail` Unexpected slave state (master data read while master write to slave is expected).

`void` I2C_SlaveTransferCreateHandle(I2C_Type *base, *i2c_slave_handle_t* *handle, *i2c_slave_transfer_callback_t* callback, void *userData)

Creates a new handle for the I2C slave non-blocking APIs.

The creation of a handle is for use with the non-blocking APIs. Once a handle is created, there is not a corresponding destroy handle. If the user wants to terminate a transfer, the `I2C_SlaveTransferAbort()` API shall be called.

Parameters

- `base` – The I2C peripheral base address.
- `handle` – **[out]** Pointer to the I2C slave driver handle.
- `callback` – User provided pointer to the asynchronous callback function.
- `userData` – User provided pointer to the application callback data.

`status_t` I2C_SlaveTransferNonBlocking(I2C_Type *base, *i2c_slave_handle_t* *handle, uint32_t eventMask)

Starts accepting slave transfers.

Call this API after calling `I2C_SlaveInit()` and `I2C_SlaveTransferCreateHandle()` to start processing transactions driven by an I2C master. The slave monitors the I2C bus and pass events to the callback that was passed into the call to `I2C_SlaveTransferCreateHandle()`. The callback is always invoked from the interrupt context.

If no slave Tx transfer is busy, a master read from slave request invokes `kI2C_SlaveTransmitEvent` callback. If no slave Rx transfer is busy, a master write to slave request invokes `kI2C_SlaveReceiveEvent` callback.

The set of events received by the callback is customizable. To do so, set the *eventMask* parameter to the OR'd combination of *i2c_slave_transfer_event_t* enumerators for the events you wish to receive. The `kI2C_SlaveTransmitEvent` and `kI2C_SlaveReceiveEvent` events are always enabled and do not need to be included in the mask. Alternatively, you can pass 0 to get a default set of only the transmit and receive events that are always enabled. In

addition, the `kI2C_SlaveAllEvents` constant is provided as a convenient way to enable all events.

Parameters

- `base` – The I2C peripheral base address.
- `handle` – Pointer to `i2c_slave_handle_t` structure which stores the transfer state.
- `eventMask` – Bit mask formed by OR'ing together `i2c_slave_transfer_event_t` enumerators to specify which events to send to the callback. Other accepted values are 0 to get a default set of only the transmit and receive events, and `kI2C_SlaveAllEvents` to enable all events.

Return values

- `kStatus_Success` – Slave transfers were successfully started.
- `kStatus_I2C_Busy` – Slave transfers have already been started on this handle.

```
status_t I2C_SlaveSetSendBuffer(I2C_Type *base, volatile i2c_slave_transfer_t *transfer, const void *txData, size_t txSize, uint32_t eventMask)
```

Starts accepting master read from slave requests.

The function can be called in response to `kI2C_SlaveTransmitEvent` callback to start a new slave Tx transfer from within the transfer callback.

The set of events received by the callback is customizable. To do so, set the *eventMask* parameter to the OR'd combination of `i2c_slave_transfer_event_t` enumerators for the events you wish to receive. The `kI2C_SlaveTransmitEvent` and `kI2C_SlaveReceiveEvent` events are always enabled and do not need to be included in the mask. Alternatively, you can pass 0 to get a default set of only the transmit and receive events that are always enabled. In addition, the `kI2C_SlaveAllEvents` constant is provided as a convenient way to enable all events.

Parameters

- `base` – The I2C peripheral base address.
- `transfer` – Pointer to `i2c_slave_transfer_t` structure.
- `txData` – Pointer to data to send to master.
- `txSize` – Size of `txData` in bytes.
- `eventMask` – Bit mask formed by OR'ing together `i2c_slave_transfer_event_t` enumerators to specify which events to send to the callback. Other accepted values are 0 to get a default set of only the transmit and receive events, and `kI2C_SlaveAllEvents` to enable all events.

Return values

- `kStatus_Success` – Slave transfers were successfully started.
- `kStatus_I2C_Busy` – Slave transfers have already been started on this handle.

```
status_t I2C_SlaveSetReceiveBuffer(I2C_Type *base, volatile i2c_slave_transfer_t *transfer, void *rxData, size_t rxSize, uint32_t eventMask)
```

Starts accepting master write to slave requests.

The function can be called in response to `kI2C_SlaveReceiveEvent` callback to start a new slave Rx transfer from within the transfer callback.

The set of events received by the callback is customizable. To do so, set the *eventMask* parameter to the OR'd combination of `i2c_slave_transfer_event_t` enumerators for the events

you wish to receive. The `kI2C_SlaveTransmitEvent` and `kI2C_SlaveReceiveEvent` events are always enabled and do not need to be included in the mask. Alternatively, you can pass 0 to get a default set of only the transmit and receive events that are always enabled. In addition, the `kI2C_SlaveAllEvents` constant is provided as a convenient way to enable all events.

Parameters

- `base` – The I2C peripheral base address.
- `transfer` – Pointer to `i2c_slave_transfer_t` structure.
- `rxData` – Pointer to data to store data from master.
- `rxSize` – Size of `rxData` in bytes.
- `eventMask` – Bit mask formed by OR'ing together `i2c_slave_transfer_event_t` enumerators to specify which events to send to the callback. Other accepted values are 0 to get a default set of only the transmit and receive events, and `kI2C_SlaveAllEvents` to enable all events.

Return values

- `kStatus__Success` – Slave transfers were successfully started.
- `kStatus__I2C__Busy` – Slave transfers have already been started on this handle.

```
static inline uint32_t I2C_SlaveGetReceivedAddress(I2C_Type *base, volatile i2c_slave_transfer_t *transfer)
```

Returns the slave address sent by the I2C master.

This function should only be called from the address match event callback `kI2C_SlaveAddressMatchEvent`.

Parameters

- `base` – The I2C peripheral base address.
- `transfer` – The I2C slave transfer.

Returns

The 8-bit address matched by the I2C slave. Bit 0 contains the R/w direction bit, and the 7-bit slave address is in the upper 7 bits.

```
void I2C_SlaveTransferAbort(I2C_Type *base, i2c_slave_handle_t *handle)
```

Aborts the slave non-blocking transfers.

Note: This API could be called at any time to stop slave for handling the bus events.

Parameters

- `base` – The I2C peripheral base address.
- `handle` – Pointer to `i2c_slave_handle_t` structure which stores the transfer state.

Return values

- `kStatus__Success` –
- `kStatus__I2C__Idle` –

```
status_t I2C_SlaveTransferGetCount(I2C_Type *base, i2c_slave_handle_t *handle, size_t *count)
```

Gets the slave transfer remaining bytes during a interrupt non-blocking transfer.

Parameters

- `base` – I2C base pointer.
- `handle` – pointer to `i2c_slave_handle_t` structure.
- `count` – Number of bytes transferred so far by the non-blocking transaction.

Return values

- `kStatus_InvalidArgument` – `count` is Invalid.
- `kStatus_Success` – Successfully return the count.

`void I2C_SlaveTransferHandleIRQ(I2C_Type *base, i2c_slave_handle_t *handle)`

Reusable routine to handle slave interrupts.

Note: This function does not need to be called unless you are reimplementing the non blocking API's interrupt handler routines to add special functionality.

Parameters

- `base` – The I2C peripheral base address.
- `handle` – Pointer to `i2c_slave_handle_t` structure which stores the transfer state.

`enum _i2c_slave_address_register`

I2C slave address register.

Values:

enumerator `kI2C_SlaveAddressRegister0`

Slave Address 0 register.

enumerator `kI2C_SlaveAddressRegister1`

Slave Address 1 register.

enumerator `kI2C_SlaveAddressRegister2`

Slave Address 2 register.

enumerator `kI2C_SlaveAddressRegister3`

Slave Address 3 register.

`enum _i2c_slave_address_qual_mode`

I2C slave address match options.

Values:

enumerator `kI2C_QualModeMask`

The `SLVQUAL0` field (`qualAddress`) is used as a logical mask for matching address0.

enumerator `kI2C_QualModeExtend`

The `SLVQUAL0` (`qualAddress`) field is used to extend address 0 matching in a range of addresses.

`enum _i2c_slave_bus_speed`

I2C slave bus speed options.

Values:

enumerator `kI2C_SlaveStandardMode`

enumerator `kI2C_SlaveFastMode`

enumerator `kI2C_SlaveFastModePlus`

enumerator kI2C_SlaveHsMode

enum _i2c_slave_transfer_event

Set of events sent to the callback for non blocking slave transfers.

These event enumerations are used for two related purposes. First, a bit mask created by OR'ing together events is passed to I2C_SlaveTransferNonBlocking() in order to specify which events to enable. Then, when the slave callback is invoked, it is passed the current event through its *transfer* parameter.

Note: These enumerations are meant to be OR'd together to form a bit mask of events.

Values:

enumerator kI2C_SlaveAddressMatchEvent

Received the slave address after a start or repeated start.

enumerator kI2C_SlaveTransmitEvent

Callback is requested to provide data to transmit (slave-transmitter role).

enumerator kI2C_SlaveReceiveEvent

Callback is requested to provide a buffer in which to place received data (slave-receiver role).

enumerator kI2C_SlaveCompletionEvent

All data in the active transfer have been consumed.

enumerator kI2C_SlaveDeselectedEvent

The slave function has become deselected (SLVSEL flag changing from 1 to 0).

enumerator kI2C_SlaveAllEvents

Bit mask of all available events.

enum _i2c_slave_fsm

I2C slave software finite state machine states.

Values:

enumerator kI2C_SlaveFsmAddressMatch

enumerator kI2C_SlaveFsmReceive

enumerator kI2C_SlaveFsmTransmit

typedef enum _i2c_slave_address_register i2c_slave_address_register_t

I2C slave address register.

typedef struct _i2c_slave_address i2c_slave_address_t

Data structure with 7-bit Slave address and Slave address disable.

typedef enum _i2c_slave_address_qual_mode i2c_slave_address_qual_mode_t

I2C slave address match options.

typedef enum _i2c_slave_bus_speed i2c_slave_bus_speed_t

I2C slave bus speed options.

typedef struct _i2c_slave_config i2c_slave_config_t

Structure with settings to initialize the I2C slave module.

This structure holds configuration settings for the I2C slave peripheral. To initialize this structure to reasonable defaults, call the I2C_SlaveGetDefaultConfig() function and pass a pointer to your configuration structure instance.

The configuration structure can be made constant so it resides in flash.

```
typedef enum _i2c_slave_transfer_event i2c_slave_transfer_event_t
```

Set of events sent to the callback for non blocking slave transfers.

These event enumerations are used for two related purposes. First, a bit mask created by OR'ing together events is passed to I2C_SlaveTransferNonBlocking() in order to specify which events to enable. Then, when the slave callback is invoked, it is passed the current event through its *transfer* parameter.

Note: These enumerations are meant to be OR'd together to form a bit mask of events.

```
typedef struct _i2c_slave_handle i2c_slave_handle_t
```

I2C slave handle typedef.

```
typedef struct _i2c_slave_transfer i2c_slave_transfer_t
```

I2C slave transfer structure.

```
typedef void (*i2c_slave_transfer_callback_t)(I2C_Type *base, volatile i2c_slave_transfer_t  
*transfer, void *userData)
```

Slave event callback function pointer type.

This callback is used only for the slave non-blocking transfer API. To install a callback, use the I2C_SlaveSetCallback() function after you have created a handle.

Param base

Base address for the I2C instance on which the event occurred.

Param transfer

Pointer to transfer descriptor containing values passed to and/or from the callback.

Param userData

Arbitrary pointer-sized value passed from the application.

```
typedef enum _i2c_slave_fsm i2c_slave_fsm_t
```

I2C slave software finite state machine states.

```
typedef void (*flexcomm_i2c_master_irq_handler_t)(I2C_Type *base, i2c_master_handle_t  
*handle)
```

Typedef for master interrupt handler.

```
typedef void (*flexcomm_i2c_slave_irq_handler_t)(I2C_Type *base, i2c_slave_handle_t *handle)
```

Typedef for slave interrupt handler.

```
struct _i2c_slave_address
```

#include <fsl_i2c.h> Data structure with 7-bit Slave address and Slave address disable.

Public Members

uint8_t address

7-bit Slave address SLVADR.

bool addressDisable

Slave address disable SADISABLE.

```
struct _i2c_slave_config
```

#include <fsl_i2c.h> Structure with settings to initialize the I2C slave module.

This structure holds configuration settings for the I2C slave peripheral. To initialize this structure to reasonable defaults, call the I2C_SlaveGetDefaultConfig() function and pass a pointer to your configuration structure instance.

The configuration structure can be made constant so it resides in flash.

Public Members

i2c_slave_address_t address0

Slave's 7-bit address and disable.

i2c_slave_address_t address1

Alternate slave 7-bit address and disable.

i2c_slave_address_t address2

Alternate slave 7-bit address and disable.

i2c_slave_address_t address3

Alternate slave 7-bit address and disable.

i2c_slave_address_qual_mode_t qualMode

Qualify mode for slave address 0.

uint8_t qualAddress

Slave address qualifier for address 0.

i2c_slave_bus_speed_t busSpeed

Slave bus speed mode. If the slave function stretches SCL to allow for software response, it must provide sufficient data setup time to the master before releasing the stretched clock. This is accomplished by inserting one clock time of CLKDIV at that point. The busSpeed value is used to configure CLKDIV such that one clock time is greater than the tSU;DAT value noted in the I2C bus specification for the I2C mode that is being used. If the busSpeed mode is unknown at compile time, use the longest data setup time kI2C_SlaveStandardMode (250 ns)

bool enableSlave

Enable slave mode.

struct *_i2c_slave_transfer*

#include <fsl_i2c.h> I2C slave transfer structure.

Public Members

i2c_slave_handle_t *handle

Pointer to handle that contains this transfer.

i2c_slave_transfer_event_t event

Reason the callback is being invoked.

uint8_t receivedAddress

Matching address send by master. 7-bits plus R/nW bit0

uint32_t eventMask

Mask of enabled events.

uint8_t *rxData

Transfer buffer for receive data

const uint8_t *txData

Transfer buffer for transmit data

size_t txSize

Transfer size

size_t rxSize

Transfer size

`size_t` transferredCount

Number of bytes transferred during this transfer.

`status_t` completionStatus

Success or error code describing how the transfer completed. Only applies for `kI2C_SlaveCompletionEvent`.

`struct _i2c_slave_handle`

`#include <fsl_i2c.h>` I2C slave handle structure.

Note: The contents of this structure are private and subject to change.

Public Members

`volatile i2c_slave_transfer_t` transfer

I2C slave transfer.

`volatile bool` isBusy

Whether transfer is busy.

`volatile i2c_slave_fsm_t` slaveFsm

slave transfer state machine.

`i2c_slave_transfer_callback_t` callback

Callback function called at transfer event.

`void *`userData

Callback parameter passed to callback.

2.29 I2S: I2S Driver

2.30 I2S_BRIDGE: I2S bridging and signal sharing configuration

`enum _i2s_bridge_share_set_index`

I2S Bridge share set.

Values:

enumerator `kI2S_BRIDGE_OriginalSignal`

Original FLEXCOMM I2S signals

enumerator `kI2S_BRIDGE_ShareSet0`

share set 0 signals

enumerator `kI2S_BRIDGE_ShareSet1`

share set 1 signals

`enum _i2s_bridge_signal`

I2S signal.

Values:

enumerator `kI2S_BRIDGE_SignalSCK`

SCK signal

enumerator kI2S_BRIDGE_SignalWS

WS signal

enumerator kI2S_BRIDGE_SignalDataIn

Data in signal

enumerator kI2S_BRIDGE_SignalDataOut

Data out signal

enum _i2s_bridge_share_src

I2S signal source.

Values:

enumerator kI2S_BRIDGE_Flexcomm0

Shared signal comes from FLEXCOMM0

enumerator kI2S_BRIDGE_Flexcomm1

Shared signal comes from FLEXCOMM1

enumerator kI2S_BRIDGE_Flexcomm2

Shared signal comes from FLEXCOMM2

enumerator kI2S_BRIDGE_Flexcomm3

Shared signal comes from FLEXCOMM3

enumerator kI2S_BRIDGE_Flexcomm4

Shared signal comes from FLEXCOMM4

enumerator kI2S_BRIDGE_Flexcomm5

Shared signal comes from FLEXCOMM5

enumerator kI2S_BRIDGE_Flexcomm6

Shared signal comes from FLEXCOMM6

enumerator kI2S_BRIDGE_Flexcomm7

Shared signal comes from FLEXCOMM7

enum _i2s_bridge_dataout_mask

I2S Bridge shared data out mask.

Values:

enumerator kI2S_BRIDGE_Flexcomm0DataOut

FLEXCOMM0 DATAOUT Output Enable

enumerator kI2S_BRIDGE_Flexcomm1DataOut

FLEXCOMM1 DATAOUT Output Enable

enumerator kI2S_BRIDGE_Flexcomm2DataOut

FLEXCOMM2 DATAOUT Output Enable

enumerator kI2S_BRIDGE_Flexcomm3DataOut

FLEXCOMM3 DATAOUT Output Enable

enumerator kI2S_BRIDGE_Flexcomm4DataOut

FLEXCOMM4 DATAOUT Output Enable

enumerator kI2S_BRIDGE_Flexcomm5DataOut

FLEXCOMM5 DATAOUT Output Enable

enumerator kI2S_BRIDGE_Flexcomm6DataOut

FLEXCOMM6 DATAOUT Output Enable

enumerator `ki2S_BRIDGE_Flexcomm7DataOut`
 FLEXCOMM7 DATAOUT Output Enable

typedef enum `_i2s_bridge_signal` `i2s_bridge_signal_t`
 I2S signal.

FSL_I2S_BRIDGE_DRIVER_VERSION
 Group I2S Bridge driver version for SDK.
 Version 2.0.0.

void `I2S_BRIDGE_SetFlexcommShareSet`(uint32_t flexCommIndex, uint32_t sckSet, uint32_t wsSet, uint32_t dataInSet, uint32_t dataOutSet)

I2S Bridge share set selection for flexcomm instance.

Parameters

- flexCommIndex – index of flexcomm, refer to RM for supported FLEXCOMM instances.
- sckSet – share set for sck, refer to `_i2s_bridge_share_set_index`
- wsSet – share set for ws, refer to `_i2s_bridge_share_set_index`
- dataInSet – share set for data in, refer to `_i2s_bridge_share_set_index`
- dataOutSet – share set for data out, refer to `_i2s_bridge_share_set_index`

void `I2S_BRIDGE_SetFlexcommSignalShareSet`(uint32_t flexCommIndex, `i2s_bridge_signal_t` signal, uint32_t set)

I2S Bridge share set selection for a separate signal.

Parameters

- flexCommIndex – index of flexcomm, refer to RM for supported FLEXCOMM instances.
- signal – The signal need to be configured.
- set – share set for the signal, refer to `_i2s_bridge_share_set_index`

void `I2S_BRIDGE_SetShareSetSrc`(uint32_t setIndex, uint32_t sckShareSrc, uint32_t wsShareSrc, uint32_t dataInShareSrc, uint32_t dataOutShareSrc)

I2S Bridge share set source configure.

Parameters

- setIndex – index of share set, refer `_i2s_bridge_share_set_index`
- sckShareSrc – sck source for this share set, refer to `_i2s_bridge_share_src`
- wsShareSrc – ws source for this share set, refer to `_i2s_bridge_share_src`
- dataInShareSrc – data in source for this share set, refer to `_i2s_bridge_share_src`
- dataOutShareSrc – data out source for this share set, refer to `_i2s_bridge_dataout_mask`

void `I2S_BRIDGE_SetShareSignalSrc`(uint32_t setIndex, `i2s_bridge_signal_t` signal, uint32_t shareSrc)

I2S Bridge shared signal source selection for a share set.

Parameters

- setIndex – index of share set, refer to `_i2s_bridge_share_set_index`
- signal – the shared signal to be configured
- shareSrc – the signal selection, refer to `_i2s_bridge_share_src`.

2.31 I2S DMA Driver

```
void I2S_TxTransferCreateHandleDMA(I2S_Type *base, i2s_dma_handle_t *handle, dma_handle_t *dmaHandle, i2s_dma_transfer_callback_t callback, void *userData)
```

Initializes handle for transfer of audio data.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.
- dmaHandle – pointer to dma handle structure.
- callback – function to be called back when transfer is done or fails.
- userData – pointer to data passed to callback.

```
status_t I2S_TxTransferSendDMA(I2S_Type *base, i2s_dma_handle_t *handle, i2s_transfer_t transfer)
```

Begins or queue sending of the given data.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.
- transfer – data buffer.

Return values

- kStatus_Success –
- kStatus_I2S_Busy – if all queue slots are occupied with unsent buffers.

```
void I2S_TransferAbortDMA(I2S_Type *base, i2s_dma_handle_t *handle)
```

Aborts transfer of data.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.

```
void I2S_RxTransferCreateHandleDMA(I2S_Type *base, i2s_dma_handle_t *handle, dma_handle_t *dmaHandle, i2s_dma_transfer_callback_t callback, void *userData)
```

Initializes handle for reception of audio data.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.
- dmaHandle – pointer to dma handle structure.
- callback – function to be called back when transfer is done or fails.
- userData – pointer to data passed to callback.

```
status_t I2S_RxTransferReceiveDMA(I2S_Type *base, i2s_dma_handle_t *handle, i2s_transfer_t transfer)
```

Begins or queue reception of data into given buffer.

Parameters

- base – I2S base pointer.

- handle – pointer to handle structure.
- transfer – data buffer.

Return values

- kStatus__Success –
- kStatus_I2S_Busy – if all queue slots are occupied with buffers which are not full.

void I2S_DMACallback(*dma_handle_t* *handle, void *userData, bool transferDone, uint32_t tcds)

Invoked from DMA interrupt handler.

Parameters

- handle – pointer to DMA handle structure.
- userData – argument for user callback.
- transferDone – if transfer was done.
- tcds –

void I2S_TransferInstallLoopDMADescriptorMemory(*i2s_dma_handle_t* *handle, void *dmaDescriptorAddr, size_t dmaDescriptorNum)

Install DMA descriptor memory for loop transfer only.

This function used to register DMA descriptor memory for the i2s loop dma transfer.

It must be called before I2S_TransferSendLoopDMA/I2S_TransferReceiveLoopDMA and after I2S_RxTransferCreateHandleDMA/I2S_TxTransferCreateHandleDMA.

User should be take care about the address of DMA descriptor pool which required align with 16BYTE at least.

Parameters

- handle – Pointer to i2s DMA transfer handle.
- dmaDescriptorAddr – DMA descriptor start address.
- dmaDescriptorNum – DMA descriptor number.

status_t I2S_TransferSendLoopDMA(I2S_Type *base, *i2s_dma_handle_t* *handle, *i2s_transfer_t* *xfer, uint32_t loopTransferCount)

Send link transfer data using DMA.

This function receives data using DMA. This is a non-blocking function, which returns right away. When all data is received, the receive callback function is called.

This function support loop transfer, such as A->B->...->A, the loop transfer chain will be converted into a chain of descriptor and submit to dma. Application must be aware of that the more counts of the loop transfer, then more DMA descriptor memory required, user can use function I2S_InstallDMADescriptorMemory to register the dma descriptor memory.

As the DMA support maximum 1024 transfer count, so application must be aware of that this transfer function support maximum 1024 samples in each transfer, otherwise assert error or error status will be returned. Once the loop transfer start, application can use function I2S_TransferAbortDMA to stop the loop transfer.

Parameters

- base – I2S peripheral base address.
- handle – Pointer to usart_dma_handle_t structure.
- xfer – I2S DMA transfer structure. See *i2s_transfer_t*.
- loopTransferCount – loop count

Return values

kStatus_Success –

status_t I2S_TransferReceiveLoopDMA(I2S_Type *base, *i2s_dma_handle_t* *handle, *i2s_transfer_t* *xfer, uint32_t loopTransferCount)

Receive link transfer data using DMA.

This function receives data using DMA. This is a non-blocking function, which returns right away. When all data is received, the receive callback function is called.

This function support loop transfer, such as A->B->...->A, the loop transfer chain will be converted into a chain of descriptor and submit to dma. Application must be aware of that the more counts of the loop transfer, then more DMA descriptor memory required, user can use function I2S_InstallDMADescriptorMemory to register the dma descriptor memory.

As the DMA support maximum 1024 transfer count, so application must be aware of that this transfer function support maximum 1024 samples in each transfer, otherwise assert error or error status will be returned. Once the loop transfer start, application can use function I2S_TransferAbortDMA to stop the loop transfer.

Parameters

- base – I2S peripheral base address.
- handle – Pointer to usart_dma_handle_t structure.
- xfer – I2S DMA transfer structure. See i2s_transfer_t.
- loopTransferCount – loop count

Return values

kStatus_Success –

FSL_I2S_DMA_DRIVER_VERSION

I2S DMA driver version 2.3.3.

typedef struct *i2s_dma_handle* *i2s_dma_handle_t*

Members not to be accessed / modified outside of the driver.

typedef void (**i2s_dma_transfer_callback_t*)(I2S_Type *base, *i2s_dma_handle_t* *handle, *status_t* completionStatus, void *userData)

Callback function invoked from DMA API on completion.

Param base

I2S base pointer.

Param handle

pointer to I2S transaction.

Param completionStatus

status of the transaction.

Param userData

optional pointer to user arguments data.

struct *i2s_dma_handle*

#include <fsl_i2s_dma.h> i2s dma handle

Public Members

uint32_t state

Internal state of I2S DMA transfer

uint8_t bytesPerFrame

bytes per frame

i2s_dma_transfer_callback_t completionCallback
Callback function pointer

void *userData
Application data passed to callback

dma_handle_t *dmaHandle
DMA handle

volatile *i2s_transfer_t* i2sQueue[(4U)]
Transfer queue storing transfer buffers

volatile uint8_t queueUser
Queue index where user's next transfer will be stored

volatile uint8_t queueDriver
Queue index of buffer actually used by the driver

dma_descriptor_t *i2sLoopDMADescriptor
descriptor pool pointer

size_t i2sLoopDMADescriptorNum
number of descriptor in descriptors pool

2.32 I2S Driver

void I2S_TxInit(I2S_Type *base, const *i2s_config_t* *config)

Initializes the FLEXCOMM peripheral for I2S transmit functionality.

Ungates the FLEXCOMM clock and configures the module for I2S transmission using a configuration structure. The configuration structure can be custom filled or set with default values by I2S_TxGetDefaultConfig().

Note: This API should be called at the beginning of the application to use the I2S driver.

Parameters

- base – I2S base pointer.
- config – pointer to I2S configuration structure.

void I2S_RxInit(I2S_Type *base, const *i2s_config_t* *config)

Initializes the FLEXCOMM peripheral for I2S receive functionality.

Ungates the FLEXCOMM clock and configures the module for I2S receive using a configuration structure. The configuration structure can be custom filled or set with default values by I2S_RxGetDefaultConfig().

Note: This API should be called at the beginning of the application to use the I2S driver.

Parameters

- base – I2S base pointer.
- config – pointer to I2S configuration structure.

`void I2S_TxGetDefaultConfig(i2s_config_t *config)`

Sets the I2S Tx configuration structure to default values.

This API initializes the configuration structure for use in `I2S_TxInit()`. The initialized structure can remain unchanged in `I2S_TxInit()`, or it can be modified before calling `I2S_TxInit()`.
Example:

```
i2s_config_t config;
I2S_TxGetDefaultConfig(&config);
```

Default values:

```
config->masterSlave = kI2S_MasterSlaveNormalMaster;
config->mode = kI2S_ModeI2sClassic;
config->rightLow = false;
config->leftJust = false;
config->pdmData = false;
config->sckPol = false;
config->wsPol = false;
config->divider = 1;
config->oneChannel = false;
config->dataLength = 16;
config->frameLength = 32;
config->position = 0;
config->watermark = 4;
config->txEmptyZero = true;
config->pack48 = false;
```

Parameters

- `config` – pointer to I2S configuration structure.

`void I2S_RxGetDefaultConfig(i2s_config_t *config)`

Sets the I2S Rx configuration structure to default values.

This API initializes the configuration structure for use in `I2S_RxInit()`. The initialized structure can remain unchanged in `I2S_RxInit()`, or it can be modified before calling `I2S_RxInit()`.
Example:

```
i2s_config_t config;
I2S_RxGetDefaultConfig(&config);
```

Default values:

```
config->masterSlave = kI2S_MasterSlaveNormalSlave;
config->mode = kI2S_ModeI2sClassic;
config->rightLow = false;
config->leftJust = false;
config->pdmData = false;
config->sckPol = false;
config->wsPol = false;
config->divider = 1;
config->oneChannel = false;
config->dataLength = 16;
config->frameLength = 32;
config->position = 0;
config->watermark = 4;
config->txEmptyZero = false;
config->pack48 = false;
```

Parameters

- `config` – pointer to I2S configuration structure.

void I2S_Deinit(I2S_Type *base)

De-initializes the I2S peripheral.

This API gates the FLEXCOMM clock. The I2S module can't operate unless I2S_TxInit or I2S_RxInit is called to enable the clock.

Parameters

- base – I2S base pointer.

void I2S_SetBitClockRate(I2S_Type *base, uint32_t sourceClockHz, uint32_t sampleRate, uint32_t bitWidth, uint32_t channelNumbers)

Transmitter/Receiver bit clock rate configurations.

Parameters

- base – SAI base pointer.
- sourceClockHz – bit clock source frequency.
- sampleRate – audio data sample rate.
- bitWidth – audio data bitWidth.
- channelNumbers – audio channel numbers.

void I2S_TxTransferCreateHandle(I2S_Type *base, i2s_handle_t *handle, i2s_transfer_callback_t callback, void *userData)

Initializes handle for transfer of audio data.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.
- callback – function to be called back when transfer is done or fails.
- userData – pointer to data passed to callback.

status_t I2S_TxTransferNonBlocking(I2S_Type *base, i2s_handle_t *handle, i2s_transfer_t transfer)

Begins or queue sending of the given data.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.
- transfer – data buffer.

Return values

- kStatus_Success –
- kStatus_I2S_Busy – if all queue slots are occupied with unsent buffers.

void I2S_TxTransferAbort(I2S_Type *base, i2s_handle_t *handle)

Aborts sending of data.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.

void I2S_RxTransferCreateHandle(I2S_Type *base, i2s_handle_t *handle, i2s_transfer_callback_t callback, void *userData)

Initializes handle for reception of audio data.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.
- callback – function to be called back when transfer is done or fails.
- userData – pointer to data passed to callback.

status_t I2S_RxTransferNonBlocking(I2S_Type *base, *i2s_handle_t* *handle, *i2s_transfer_t* transfer)

Begins or queue reception of data into given buffer.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.
- transfer – data buffer.

Return values

- kStatus__Success –
- kStatus_I2S_Busy – if all queue slots are occupied with buffers which are not full.

void I2S_RxTransferAbort(I2S_Type *base, *i2s_handle_t* *handle)

Aborts receiving of data.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.

status_t I2S_TransferGetCount(I2S_Type *base, *i2s_handle_t* *handle, *size_t* *count)

Returns number of bytes transferred so far.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.
- count – **[out]** number of bytes transferred so far by the non-blocking transaction.

Return values

- kStatus__Success –
- kStatus_NoTransferInProgress – there is no non-blocking transaction currently in progress.

status_t I2S_TransferGetErrorCount(I2S_Type *base, *i2s_handle_t* *handle, *size_t* *count)

Returns number of buffer underruns or overruns.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.
- count – **[out]** number of transmit errors encountered so far by the non-blocking transaction.

Return values

- kStatus__Success –

- `kStatus_NoTransferInProgress` – there is no non-blocking transaction currently in progress.

`static inline void I2S_Enable(I2S_Type *base)`

Enables I2S operation.

Parameters

- `base` – I2S base pointer.

`void I2S_EnableSecondaryChannel(I2S_Type *base, uint32_t channel, bool oneChannel, uint32_t position)`

Enables I2S secondary channel.

Parameters

- `base` – I2S base pointer.
- `channel` – secondary channel channel number, reference `_i2s_secondary_channel`.
- `oneChannel` – true is treated as single channel, functionality left channel for this pair.
- `position` – define the location within the frame of the data, should not bigger than 0x1FFU.

`static inline void I2S_DisableSecondaryChannel(I2S_Type *base, uint32_t channel)`

Disables I2S secondary channel.

Parameters

- `base` – I2S base pointer.
- `channel` – secondary channel channel number, reference `_i2s_secondary_channel`.

`static inline void I2S_Disable(I2S_Type *base)`

Disables I2S operation.

Parameters

- `base` – I2S base pointer.

`static inline void I2S_EnableInterrupts(I2S_Type *base, uint32_t interruptMask)`

Enables I2S FIFO interrupts.

Parameters

- `base` – I2S base pointer.
- `interruptMask` – bit mask of interrupts to enable. See `i2s_flags_t` for the set of constants that should be OR'd together to form the bit mask.

`static inline void I2S_DisableInterrupts(I2S_Type *base, uint32_t interruptMask)`

Disables I2S FIFO interrupts.

Parameters

- `base` – I2S base pointer.
- `interruptMask` – bit mask of interrupts to enable. See `i2s_flags_t` for the set of constants that should be OR'd together to form the bit mask.

`static inline uint32_t I2S_GetEnabledInterrupts(I2S_Type *base)`

Returns the set of currently enabled I2S FIFO interrupts.

Parameters

- `base` – I2S base pointer.

Returns

A bitmask composed of `i2s_flags_t` enumerators OR'd together to indicate the set of enabled interrupts.

`status_t I2S_EmptyTxFifo(I2S_Type *base)`

Flush the valid data in TX fifo.

Parameters

- `base` – I2S base pointer.

Returns

`kStatus_Fail` empty TX fifo failed, `kStatus_Success` empty tx fifo success.

`void I2S_TxHandleIRQ(I2S_Type *base, i2s_handle_t *handle)`

Invoked from interrupt handler when transmit FIFO level decreases.

Parameters

- `base` – I2S base pointer.
- `handle` – pointer to handle structure.

`void I2S_RxHandleIRQ(I2S_Type *base, i2s_handle_t *handle)`

Invoked from interrupt handler when receive FIFO level decreases.

Parameters

- `base` – I2S base pointer.
- `handle` – pointer to handle structure.

`FSL_I2S_DRIVER_VERSION`

I2S driver version 2.3.2.

`_i2s_status` I2S status codes.

Values:

enumerator `kStatus_I2S_BufferComplete`

Transfer from/into a single buffer has completed

enumerator `kStatus_I2S_Done`

All buffers transfers have completed

enumerator `kStatus_I2S_Busy`

Already performing a transfer and cannot queue another buffer

enum `_i2s_flags`

I2S flags.

Note: These enums are meant to be OR'd together to form a bit mask.

Values:

enumerator `kI2S_TxErrorFlag`

TX error interrupt

enumerator `kI2S_TxLevelFlag`

TX level interrupt

enumerator `kI2S_RxErrorFlag`

RX error interrupt

enumerator kI2S_RxLevelFlag

RX level interrupt

enum _i2s_master_slave

Master / slave mode.

Values:

enumerator kI2S_MasterSlaveNormalSlave

Normal slave

enumerator kI2S_MasterSlaveWsSyncMaster

WS synchronized master

enumerator kI2S_MasterSlaveExtSckMaster

Master using existing SCK

enumerator kI2S_MasterSlaveNormalMaster

Normal master

enum _i2s_mode

I2S mode.

Values:

enumerator kI2S_ModeI2sClassic

I2S classic mode

enumerator kI2S_ModeDspWs50

DSP mode, WS having 50% duty cycle

enumerator kI2S_ModeDspWsShort

DSP mode, WS having one clock long pulse

enumerator kI2S_ModeDspWsLong

DSP mode, WS having one data slot long pulse

_i2s_secondary_channel I2S secondary channel.

Values:

enumerator kI2S_SecondaryChannel1

secondary channel 1

enumerator kI2S_SecondaryChannel2

secondary channel 2

enumerator kI2S_SecondaryChannel3

secondary channel 3

typedef enum _i2s_flags i2s_flags_t

I2S flags.

Note: These enums are meant to be OR'd together to form a bit mask.

typedef enum _i2s_master_slave i2s_master_slave_t

Master / slave mode.

typedef enum _i2s_mode i2s_mode_t

I2S mode.

```
typedef struct _i2s_config i2s_config_t
```

I2S configuration structure.

```
typedef struct _i2s_transfer i2s_transfer_t
```

Buffer to transfer from or receive audio data into.

```
typedef struct _i2s_handle i2s_handle_t
```

Transactional state of the initialized transfer or receive I2S operation.

```
typedef void (*i2s_transfer_callback_t)(I2S_Type *base, i2s_handle_t *handle, status_t  
completionStatus, void *userData)
```

Callback function invoked from transactional API on completion of a single buffer transfer.

Param base

I2S base pointer.

Param handle

pointer to I2S transaction.

Param completionStatus

status of the transaction.

Param userData

optional pointer to user arguments data.

```
I2S_NUM_BUFFERS
```

Number of buffers .

```
struct _i2s_config
```

#include <fsl_i2s.h> I2S configuration structure.

Public Members

i2s_master_slave_t masterSlave

Master / slave configuration

i2s_mode_t mode

I2S mode

bool rightLow

Right channel data in low portion of FIFO

bool leftJust

Left justify data in FIFO

bool pdmData

Data source is the D-Mic subsystem

bool sckPol

SCK polarity

bool wsPol

WS polarity

uint16_t divider

Flexcomm function clock divider (1 - 4096)

bool oneChannel

true mono, false stereo

uint8_t dataLength

Data length (4 - 32)

uint16_t frameLength

Frame width (4 - 512)

uint16_t position

Data position in the frame

uint8_t watermark

FIFO trigger level

bool txEmptyZero

Transmit zero when buffer becomes empty or last item

bool pack48

Packing format for 48-bit data (false - 24 bit values, true - alternating 32-bit and 16-bit values)

struct __i2s_transfer

#include <fsl_i2s.h> Buffer to transfer from or receive audio data into.

Public Members

uint8_t *data

Pointer to data buffer.

size_t dataSize

Buffer size in bytes.

struct __i2s_handle

#include <fsl_i2s.h> Members not to be accessed / modified outside of the driver.

Public Members

volatile uint32_t state

State of transfer

i2s_transfer_callback_t completionCallback

Callback function pointer

void *userData

Application data passed to callback

bool oneChannel

true mono, false stereo

uint8_t dataLength

Data length (4 - 32)

bool pack48

Packing format for 48-bit data (false - 24 bit values, true - alternating 32-bit and 16-bit values)

uint8_t watermark

FIFO trigger level

bool useFifo48H

When dataLength 17-24: true use FIFOWR48H, false use FIFOWR

volatile *i2s_transfer_t* i2sQueue[(4U)]

Transfer queue storing transfer buffers

volatile uint8_t queueUser

Queue index where user's next transfer will be stored

volatile uint8_t queueDriver

Queue index of buffer actually used by the driver

volatile uint32_t errorCount

Number of buffer underruns/overruns

volatile uint32_t transferCount

Number of bytes transferred

2.33 I3C: I3C Driver

FSL_I3C_DRIVER_VERSION

I3C driver version.

I3C status return codes.

Values:

enumerator kStatus_I3C_Busy

The master is already performing a transfer.

enumerator kStatus_I3C_Idle

The slave driver is idle.

enumerator kStatus_I3C_Nak

The slave device sent a NAK in response to an address.

enumerator kStatus_I3C_WriteAbort

The slave device sent a NAK in response to a write.

enumerator kStatus_I3C_Term

The master terminates slave read.

enumerator kStatus_I3C_HdrParityError

Parity error from DDR read.

enumerator kStatus_I3C_CrcError

CRC error from DDR read.

enumerator kStatus_I3C_ReadFifoError

Read from M/SRDATA register when FIFO empty.

enumerator kStatus_I3C_WriteFifoError

Write to M/SWDATA register when FIFO full.

enumerator kStatus_I3C_MsgError

Message SDR/DDR mismatch or read/write message in wrong state

enumerator kStatus_I3C_InvalidReq

Invalid use of request.

enumerator kStatus_I3C_Timeout

The module has stalled too long in a frame.

enumerator kStatus_I3C_SlaveCountExceed

The I3C slave count has exceed the definition in I3C_MAX_DEVCNT.

enumerator kStatus_I3C_IBIWon

The I3C slave event IBI or MR or HJ won the arbitration on a header address.

enumerator kStatus_I3C_OverrunError

Slave internal from-bus buffer/FIFO overrun.

enumerator kStatus_I3C_UnderrunError

Slave internal to-bus buffer/FIFO underrun

enumerator kStatus_I3C_UnderrunNak

Slave internal from-bus buffer/FIFO underrun and NACK error

enumerator kStatus_I3C_InvalidStart

Slave invalid start flag

enumerator kStatus_I3C_SdrParityError

SDR parity error

enumerator kStatus_I3C_S0S1Error

S0 or S1 error

enum _i3c_hdr_mode

I3C HDR modes.

Values:

enumerator kI3C_HDRModeNone

enumerator kI3C_HDRModeDDR

enumerator kI3C_HDRModeTSP

enumerator kI3C_HDRModeTSL

typedef enum _i3c_hdr_mode i3c_hdr_mode_t

I3C HDR modes.

typedef struct _i3c_device_info i3c_device_info_t

I3C device information.

I3C_RETRY_TIMES

Max loops to wait for I3C operation status complete.

This is the maximum number of loops to wait for I3C operation status complete. If set to 0, it will wait indefinitely.

I3C_MAX_DEVCNT

I3C_IBI_BUFF_SIZE

struct _i3c_device_info

#include <fsl_i3c.h> I3C device information.

Public Members

uint8_t dynamicAddr

Device dynamic address.

uint8_t staticAddr

Static address.

uint8_t dcr

Device characteristics register information.

uint8_t bcr

Bus characteristics register information.

uint16_t vendorID

Device vendor ID(manufacture ID).

uint32_t partNumber

Device part number info

uint16_t maxReadLength

Maximum read length.

uint16_t maxWriteLength

Maximum write length.

uint8_t hdrMode

Support hdr mode, could be OR logic in i3c_hdr_mode.

2.34 I3C Common Driver

typedef struct *i3c_config* i3c_config_t

Structure with settings to initialize the I3C module, could both initialize master and slave functionality.

This structure holds configuration settings for the I3C peripheral. To initialize this structure to reasonable defaults, call the I3C_GetDefaultConfig() function and pass a pointer to your configuration structure instance.

The configuration structure can be made constant so it resides in flash.

uint32_t I3C_GetInstance(I3C_Type *base)

Get which instance current I3C is used.

Parameters

- base – The I3C peripheral base address.

void I3C_GetDefaultConfig(*i3c_config_t* *config)

Provides a default configuration for the I3C peripheral, the configuration covers both master functionality and slave functionality.

This function provides the following default configuration for I3C:

```
config->enableMaster      = kI3C_MasterCapable;
config->disableTimeout    = false;
config->hKeep              = kI3C_MasterHighKeeperNone;
config->enableOpenDrainStop = true;
config->enableOpenDrainHigh = true;
config->baudRate_Hz.i2cBaud    = 400000U;
config->baudRate_Hz.i3cPushPullBaud = 12500000U;
config->baudRate_Hz.i3cOpenDrainBaud = 2500000U;
config->masterDynamicAddress = 0x0AU;
config->slowClock_Hz        = 1000000U;
config->enableSlave         = true;
config->vendorID            = 0x11BU;
config->enableRandomPart    = false;
config->partNumber          = 0;
config->dcr                  = 0;
config->bcr = 0;
config->hdrMode             = (uint8_t)kI3C_HDRModeDDR;
config->nakAllRequest        = false;
```

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```
config->ignoreS0S1Error    = false;
config->offline             = false;
config->matchSlaveStartStop = false;
```

After calling this function, you can override any settings in order to customize the configuration, prior to initializing the common I3C driver with `I3C_Init()`.

Parameters

- `config` – **[out]** User provided configuration structure for default values. Refer to `i3c_config_t`.

`void I3C_Init(I3C_Type *base, const i3c_config_t *config, uint32_t sourceClock_Hz)`

Initializes the I3C peripheral. This function enables the peripheral clock and initializes the I3C peripheral as described by the user provided configuration. This will initialize both the master peripheral and slave peripheral so that I3C module could work as pure master, pure slave or secondary master, etc. A software reset is performed prior to configuration.

Parameters

- `base` – The I3C peripheral base address.
- `config` – User provided peripheral configuration. Use `I3C_GetDefaultConfig()` to get a set of defaults that you can override.
- `sourceClock_Hz` – Frequency in Hertz of the I3C functional clock. Used to calculate the baud rate divisors, filter widths, and timeout periods.

`struct _i3c_config`

`#include <fsl_i3c.h>` Structure with settings to initialize the I3C module, could both initialize master and slave functionality.

This structure holds configuration settings for the I3C peripheral. To initialize this structure to reasonable defaults, call the `I3C_GetDefaultConfig()` function and pass a pointer to your configuration structure instance.

The configuration structure can be made constant so it resides in flash.

Public Members

`i3c_master_enable_t enableMaster`

Enable master mode.

`bool disableTimeout`

Whether to disable timeout to prevent the ERRWARN.

`i3c_master_hkeep_t hKeep`

High keeper mode setting.

`bool enableOpenDrainStop`

Whether to emit open-drain speed STOP.

`bool enableOpenDrainHigh`

Enable Open-Drain High to be 1 PPBAUD count for i3c messages, or 1 ODBAUD.

`i3c_baudrate_hz_t baudRate_Hz`

Desired baud rate settings.

`uint8_t masterDynamicAddress`

Main master dynamic address configuration.

`uint32_t maxWriteLength`
Maximum write length.

`uint32_t maxReadLength`
Maximum read length.

`bool enableSlave`
Whether to enable slave.

`uint8_t staticAddr`
Static address.

`uint16_t vendorID`
Device vendor ID(manufacture ID).

`uint32_t partNumber`
Device part number info

`uint8_t dcr`
Device characteristics register information.

`uint8_t bcr`
Bus characteristics register information.

`uint8_t hdrMode`
Support hdr mode, could be OR logic in enumeration:`i3c_hdr_mode_t`.

`bool nakAllRequest`
Whether to reply NAK to all requests except broadcast CCC.

`bool ignoreS0S1Error`
Whether to ignore S0/S1 error in SDR mode.

`bool offline`
Whether to wait 60 us of bus quiet or HDR request to ensure slave track SDR mode safely.

`bool matchSlaveStartStop`
Whether to assert start/stop status only the time slave is addressed.

2.35 I3C Master DMA Driver

```
typedef struct i3c_master_dma_handle i3c_master_dma_handle_t
```

```
typedef struct i3c_master_dma_callback i3c_master_dma_callback_t  
i3c master callback functions.
```

```
void I3C_MasterTransferCreateHandleDMA(I3C_Type *base, i3c_master_dma_handle_t *handle,  
const i3c_master_dma_callback_t *callback, void  
*userData, dma_handle_t *rxDmaHandle,  
dma_handle_t *txDmaHandle)
```

Create a new handle for the I3C master DMA APIs.

The creation of a handle is for use with the DMA APIs. Once a handle is created, there is not a corresponding destroy handle. If the user wants to terminate a transfer, the `I3C_MasterTransferAbortDMA()` API shall be called.

For devices where the I3C send and receive DMA requests are OR'd together, the *txDmaHandle* parameter is ignored and may be set to NULL.

Parameters

- `base` – The I3C peripheral base address.
- `handle` – Pointer to the I3C master driver handle.
- `callback` – User provided pointer to the asynchronous callback function.
- `userData` – User provided pointer to the application callback data.
- `rxDmaHandle` – Handle for the DMA receive channel. Created by the user prior to calling this function.
- `txDmaHandle` – Handle for the DMA transmit channel. Created by the user prior to calling this function.

```
status_t I3C_MasterTransferDMA(I3C_Type *base, i3c_master_dma_handle_t *handle,  
                              i3c_master_transfer_t *transfer)
```

Performs a non-blocking DMA-based transaction on the I3C bus.

The callback specified when the *handle* was created is invoked when the transaction has completed.

Parameters

- `base` – The I3C peripheral base address.
- `handle` – Pointer to the I3C master driver handle.
- `transfer` – The pointer to the transfer descriptor.

Return values

- `kStatus_Success` – The transaction was started successfully.
- `kStatus_I3C_Busy` – Either another master is currently utilizing the bus, or another DMA transaction is already in progress.

```
status_t I3C_MasterTransferGetCountDMA(I3C_Type *base, i3c_master_dma_handle_t *handle,  
                                       size_t *count)
```

Returns number of bytes transferred so far.

Parameters

- `base` – The I3C peripheral base address.
- `handle` – Pointer to the I3C master driver handle.
- `count` – **[out]** Number of bytes transferred so far by the non-blocking transaction.

Return values

- `kStatus_Success` –
- `kStatus_NoTransferInProgress` – There is not a DMA transaction currently in progress.

```
void I3C_MasterTransferAbortDMA(I3C_Type *base, i3c_master_dma_handle_t *handle)
```

Terminates a non-blocking I3C master transmission early.

Note: It is not safe to call this function from an IRQ handler that has a higher priority than the DMA peripheral's IRQ priority.

Parameters

- `base` – The I3C peripheral base address.
- `handle` – Pointer to the I3C master driver handle.

`void I3C_MasterTransferDMAHandleIRQ(I3C_Type *base, void *i3CHandle)`

Reusable routine to handle master interrupts.

Note: This function does not need to be called unless you are reimplementing the non-blocking API's interrupt handler routines to add special functionality.

Parameters

- `base` – The I3C peripheral base address.
- `handle` – Pointer to the I3C master DMA driver handle.

`void (*slave2Master)(I3C_Type *base, void *userData)`

Transfer complete callback

`void (*ibiCallback)(I3C_Type *base, i3c_master_dma_handle_t *handle, i3c_ibi_type_t ibiType, i3c_ibi_state_t ibiState)`

IBI event callback

`void (*transferComplete)(I3C_Type *base, i3c_master_dma_handle_t *handle, status_t status, void *userData)`

Transfer complete callback

`I3C_Type *base`

I3C base pointer.

`uint8_t state`

Transfer state machine current state.

`uint32_t transferCount`

Indicates progress of the transfer

`uint8_t subaddressBuffer[4]`

Saving subaddress command.

`uint8_t subaddressCount`

Saving command count.

`i3c_master_transfer_t transfer`

Copy of the current transfer info.

`i3c_master_dma_callback_t callback`

Callback function pointer.

`void *userData`

Application data passed to callback.

`dma_handle_t *rxDmaHandle`

Handle for receive DMA channel.

`dma_handle_t *txDmaHandle`

Handle for transmit DMA channel.

`uint8_t ibiAddress`

Slave address which request IBI.

`uint8_t *ibiBuff`

Pointer to IBI buffer to keep ibi bytes.

`size_t ibiPayloadSize`

IBI payload size.

i3c_ibi_type_t ibiType
IBI type.

uint32_t transDataSize
Transferred data size.

uint8_t workaroundBuff[16]
Workaround buffer to store temporary data.

uint32_t event
Reason the callback is being invoked.

uint8_t *txData
Transfer buffer

size_t txDataSize
Transfer size

uint8_t *rxData
Transfer buffer

size_t rxDataSize
Transfer size

status_t completionStatus
Success or error code describing how the transfer completed. Only applies for kI3C_SlaveCompletionEvent.

I3C_Type *base
I3C base pointer.

i3c_slave_dma_transfer_t transfer
I3C slave transfer copy.

bool isBusy
Whether transfer is busy.

bool wasTransmit
Whether the last transfer was a transmit.

uint32_t eventMask
Mask of enabled events.

i3c_slave_dma_callback_t callback
Callback function called at transfer event.

dma_handle_t *rxDmaHandle
Handle for receive DMA channel.

dma_handle_t *txDmaHandle
Handle for transmit DMA channel.

void *userData
Callback parameter passed to callback.

struct __i3c_master_dma_callback
#include <fsl_i3c_dma.h> i3c master callback functions.

struct __i3c_master_dma_handle
#include <fsl_i3c_dma.h> Driver handle for master DMA APIs.

Note: The contents of this structure are private and subject to change.

2.36 I3C Master Driver

`void I3C_MasterGetDefaultConfig(i3c_master_config_t *masterConfig)`

Provides a default configuration for the I3C master peripheral.

This function provides the following default configuration for the I3C master peripheral:

```
masterConfig->enableMaster      = kI3C_MasterOn;
masterConfig->disableTimeout    = false;
masterConfig->hKeep              = kI3C_MasterHighKeeperNone;
masterConfig->enableOpenDrainStop = true;
masterConfig->enableOpenDrainHigh = true;
masterConfig->baudRate_Hz        = 100000U;
masterConfig->busType            = kI3C_TypeI2C;
```

After calling this function, you can override any settings in order to customize the configuration, prior to initializing the master driver with `I3C_MasterInit()`.

Parameters

- `masterConfig` – **[out]** User provided configuration structure for default values. Refer to `i3c_master_config_t`.

`void I3C_MasterInit(I3C_Type *base, const i3c_master_config_t *masterConfig, uint32_t sourceClock_Hz)`

Initializes the I3C master peripheral.

This function enables the peripheral clock and initializes the I3C master peripheral as described by the user provided configuration. A software reset is performed prior to configuration.

Parameters

- `base` – The I3C peripheral base address.
- `masterConfig` – User provided peripheral configuration. Use `I3C_MasterGetDefaultConfig()` to get a set of defaults that you can override.
- `sourceClock_Hz` – Frequency in Hertz of the I3C functional clock. Used to calculate the baud rate divisors, filter widths, and timeout periods.

`void I3C_MasterDeinit(I3C_Type *base)`

Deinitializes the I3C master peripheral.

This function disables the I3C master peripheral and gates the clock. It also performs a software reset to restore the peripheral to reset conditions.

Parameters

- `base` – The I3C peripheral base address.

`status_t I3C_MasterCheckAndClearError(I3C_Type *base, uint32_t status)`

`status_t I3C_MasterWaitForCtrlDone(I3C_Type *base, bool waitIdle)`

`status_t I3C_CheckForBusyBus(I3C_Type *base)`

`static inline void I3C_MasterEnable(I3C_Type *base, i3c_master_enable_t enable)`

Set I3C module master mode.

Parameters

- `base` – The I3C peripheral base address.
- `enable` – Enable master mode.

```
void I3C_SlaveGetDefaultConfig(i3c_slave_config_t *slaveConfig)
```

Provides a default configuration for the I3C slave peripheral.

This function provides the following default configuration for the I3C slave peripheral:

```
slaveConfig->enableslave = true;
```

After calling this function, you can override any settings in order to customize the configuration, prior to initializing the slave driver with `I3C_SlaveInit()`.

Parameters

- `slaveConfig` – **[out]** User provided configuration structure for default values. Refer to `i3c_slave_config_t`.

```
void I3C_SlaveInit(I3C_Type *base, const i3c_slave_config_t *slaveConfig, uint32_t slowClock_Hz)
```

Initializes the I3C slave peripheral.

This function enables the peripheral clock and initializes the I3C slave peripheral as described by the user provided configuration.

Parameters

- `base` – The I3C peripheral base address.
- `slaveConfig` – User provided peripheral configuration. Use `I3C_SlaveGetDefaultConfig()` to get a set of defaults that you can override.
- `slowClock_Hz` – Frequency in Hertz of the I3C slow clock. Used to calculate the bus match condition values. If `FSL_FEATURE_I3C_HAS_NO_SCONFIG_BAMATCH` defines as 1, this parameter is useless.

```
void I3C_SlaveDeinit(I3C_Type *base)
```

Deinitializes the I3C slave peripheral.

This function disables the I3C slave peripheral and gates the clock.

Parameters

- `base` – The I3C peripheral base address.

```
static inline void I3C_SlaveEnable(I3C_Type *base, bool isEnabled)
```

Enable/Disable Slave.

Parameters

- `base` – The I3C peripheral base address.
- `isEnabled` – Enable or disable.

```
static inline uint32_t I3C_MasterGetStatusFlags(I3C_Type *base)
```

Gets the I3C master status flags.

A bit mask with the state of all I3C master status flags is returned. For each flag, the corresponding bit in the return value is set if the flag is asserted.

See also:

`_i3c_master_flags`

Parameters

- `base` – The I3C peripheral base address.

Returns

State of the status flags:

- 1: related status flag is set.
- 0: related status flag is not set.

```
static inline void I3C_MasterClearStatusFlags(I3C_Type *base, uint32_t statusMask)
```

Clears the I3C master status flag state.

The following status register flags can be cleared:

- kI3C_MasterSlaveStartFlag
- kI3C_MasterControlDoneFlag
- kI3C_MasterCompleteFlag
- kI3C_MasterArbitrationWonFlag
- kI3C_MasterSlave2MasterFlag

Attempts to clear other flags has no effect.

See also:

`_i3c_master_flags`.

Parameters

- `base` – The I3C peripheral base address.
- `statusMask` – A bitmask of status flags that are to be cleared. The mask is composed of `_i3c_master_flags` enumerators OR'd together. You may pass the result of a previous call to `I3C_MasterGetStatusFlags()`.

```
static inline uint32_t I3C_MasterGetErrorStatusFlags(I3C_Type *base)
```

Gets the I3C master error status flags.

A bit mask with the state of all I3C master error status flags is returned. For each flag, the corresponding bit in the return value is set if the flag is asserted.

See also:

`_i3c_master_error_flags`

Parameters

- `base` – The I3C peripheral base address.

Returns

State of the error status flags:

- 1: related status flag is set.
- 0: related status flag is not set.

```
static inline void I3C_MasterClearErrorStatusFlags(I3C_Type *base, uint32_t statusMask)
```

Clears the I3C master error status flag state.

See also:

`_i3c_master_error_flags`.

Parameters

- `base` – The I3C peripheral base address.
- `statusMask` – A bitmask of error status flags that are to be cleared. The mask is composed of `_i3c_master_error_flags` enumerators OR'd together. You may pass the result of a previous call to `I3C_MasterGetStatusFlags()`.

`i3c_master_state_t` `I3C_MasterGetState(I3C_Type *base)`

Gets the I3C master state.

Parameters

- `base` – The I3C peripheral base address.

Returns

I3C master state.

`static inline uint32_t` `I3C_SlaveGetStatusFlags(I3C_Type *base)`

Gets the I3C slave status flags.

A bit mask with the state of all I3C slave status flags is returned. For each flag, the corresponding bit in the return value is set if the flag is asserted.

See also:

`_i3c_slave_flags`

Parameters

- `base` – The I3C peripheral base address.

Returns

State of the status flags:

- 1: related status flag is set.
- 0: related status flag is not set.

`static inline void` `I3C_SlaveClearStatusFlags(I3C_Type *base, uint32_t statusMask)`

Clears the I3C slave status flag state.

The following status register flags can be cleared:

- `kI3C_SlaveBusStartFlag`
- `kI3C_SlaveMatchedFlag`
- `kI3C_SlaveBusStopFlag`

Attempts to clear other flags has no effect.

See also:

`_i3c_slave_flags`.

Parameters

- `base` – The I3C peripheral base address.
- `statusMask` – A bitmask of status flags that are to be cleared. The mask is composed of `_i3c_slave_flags` enumerators OR'd together. You may pass the result of a previous call to `I3C_SlaveGetStatusFlags()`.

`static inline uint32_t I3C_SlaveGetErrorStatusFlags(I3C_Type *base)`

Gets the I3C slave error status flags.

A bit mask with the state of all I3C slave error status flags is returned. For each flag, the corresponding bit in the return value is set if the flag is asserted.

See also:

`_i3c_slave_error_flags`

Parameters

- `base` – The I3C peripheral base address.

Returns

State of the error status flags:

- 1: related status flag is set.
- 0: related status flag is not set.

`static inline void I3C_SlaveClearErrorStatusFlags(I3C_Type *base, uint32_t statusMask)`

Clears the I3C slave error status flag state.

See also:

`_i3c_slave_error_flags`.

Parameters

- `base` – The I3C peripheral base address.
- `statusMask` – A bitmask of error status flags that are to be cleared. The mask is composed of `_i3c_slave_error_flags` enumerators OR'd together. You may pass the result of a previous call to `I3C_SlaveGetErrorStatusFlags()`.

`i3c_slave_activity_state_t I3C_SlaveGetActivityState(I3C_Type *base)`

Gets the I3C slave state.

Parameters

- `base` – The I3C peripheral base address.

Returns

I3C slave activity state, refer `i3c_slave_activity_state_t`.

`status_t I3C_SlaveCheckAndClearError(I3C_Type *base, uint32_t status)`

`static inline void I3C_MasterEnableInterrupts(I3C_Type *base, uint32_t interruptMask)`

Enables the I3C master interrupt requests.

All flags except `kI3C_MasterBetweenFlag` and `kI3C_MasterNackDetectFlag` can be enabled as interrupts.

Parameters

- `base` – The I3C peripheral base address.
- `interruptMask` – Bit mask of interrupts to enable. See `_i3c_master_flags` for the set of constants that should be OR'd together to form the bit mask.

`static inline void I3C_MasterDisableInterrupts(I3C_Type *base, uint32_t interruptMask)`

Disables the I3C master interrupt requests.

All flags except `kI3C_MasterBetweenFlag` and `kI3C_MasterNackDetectFlag` can be enabled as interrupts.

Parameters

- base – The I3C peripheral base address.
- interruptMask – Bit mask of interrupts to disable. See `_i3c_master_flags` for the set of constants that should be OR'd together to form the bit mask.

```
static inline uint32_t I3C_MasterGetEnabledInterrupts(I3C_Type *base)
```

Returns the set of currently enabled I3C master interrupt requests.

Parameters

- base – The I3C peripheral base address.

Returns

A bitmask composed of `_i3c_master_flags` enumerators OR'd together to indicate the set of enabled interrupts.

```
static inline uint32_t I3C_MasterGetPendingInterrupts(I3C_Type *base)
```

Returns the set of pending I3C master interrupt requests.

Parameters

- base – The I3C peripheral base address.

Returns

A bitmask composed of `_i3c_master_flags` enumerators OR'd together to indicate the set of pending interrupts.

```
static inline void I3C_SlaveEnableInterrupts(I3C_Type *base, uint32_t interruptMask)
```

Enables the I3C slave interrupt requests.

Only below flags can be enabled as interrupts.

- `kI3C_SlaveBusStartFlag`
- `kI3C_SlaveMatchedFlag`
- `kI3C_SlaveBusStopFlag`
- `kI3C_SlaveRxReadyFlag`
- `kI3C_SlaveTxReadyFlag`
- `kI3C_SlaveDynamicAddrChangedFlag`
- `kI3C_SlaveReceivedCCCFlag`
- `kI3C_SlaveErrorFlag`
- `kI3C_SlaveHDRCommandMatchFlag`
- `kI3C_SlaveCCCHandledFlag`
- `kI3C_SlaveEventSentFlag`

Parameters

- base – The I3C peripheral base address.
- interruptMask – Bit mask of interrupts to enable. See `_i3c_slave_flags` for the set of constants that should be OR'd together to form the bit mask.

```
static inline void I3C_SlaveDisableInterrupts(I3C_Type *base, uint32_t interruptMask)
```

Disables the I3C slave interrupt requests.

Only below flags can be disabled as interrupts.

- `kI3C_SlaveBusStartFlag`
- `kI3C_SlaveMatchedFlag`

- kI3C_SlaveBusStopFlag
- kI3C_SlaveRxReadyFlag
- kI3C_SlaveTxReadyFlag
- kI3C_SlaveDynamicAddrChangedFlag
- kI3C_SlaveReceivedCCCFlag
- kI3C_SlaveErrorFlag
- kI3C_SlaveHDRCommandMatchFlag
- kI3C_SlaveCCCHandledFlag
- kI3C_SlaveEventSentFlag

Parameters

- base – The I3C peripheral base address.
- interruptMask – Bit mask of interrupts to disable. See `_i3c_slave_flags` for the set of constants that should be OR'd together to form the bit mask.

static inline uint32_t I3C_SlaveGetEnabledInterrupts(I3C_Type *base)

Returns the set of currently enabled I3C slave interrupt requests.

Parameters

- base – The I3C peripheral base address.

Returns

A bitmask composed of `_i3c_slave_flags` enumerators OR'd together to indicate the set of enabled interrupts.

static inline uint32_t I3C_SlaveGetPendingInterrupts(I3C_Type *base)

Returns the set of pending I3C slave interrupt requests.

Parameters

- base – The I3C peripheral base address.

Returns

A bitmask composed of `_i3c_slave_flags` enumerators OR'd together to indicate the set of pending interrupts.

static inline void I3C_MasterEnableDMA(I3C_Type *base, bool enableTx, bool enableRx, uint32_t width)

Enables or disables I3C master DMA requests.

Parameters

- base – The I3C peripheral base address.
- enableTx – Enable flag for transmit DMA request. Pass true for enable, false for disable.
- enableRx – Enable flag for receive DMA request. Pass true for enable, false for disable.
- width – DMA read/write unit in bytes.

static inline uint32_t I3C_MasterGetTxFifoAddress(I3C_Type *base, uint32_t width)

Gets I3C master transmit data register address for DMA transfer.

Parameters

- base – The I3C peripheral base address.
- width – DMA read/write unit in bytes.

Returns

The I3C Master Transmit Data Register address.

```
static inline uint32_t I3C_MasterGetRxFifoAddress(I3C_Type *base, uint32_t width)
```

Gets I3C master receive data register address for DMA transfer.

Parameters

- *base* – The I3C peripheral base address.
- *width* – DMA read/write unit in bytes.

Returns

The I3C Master Receive Data Register address.

```
static inline void I3C_SlaveEnableDMA(I3C_Type *base, bool enableTx, bool enableRx, uint32_t width)
```

Enables or disables I3C slave DMA requests.

Parameters

- *base* – The I3C peripheral base address.
- *enableTx* – Enable flag for transmit DMA request. Pass true for enable, false for disable.
- *enableRx* – Enable flag for receive DMA request. Pass true for enable, false for disable.
- *width* – DMA read/write unit in bytes.

```
static inline uint32_t I3C_SlaveGetTxFifoAddress(I3C_Type *base, uint32_t width)
```

Gets I3C slave transmit data register address for DMA transfer.

Parameters

- *base* – The I3C peripheral base address.
- *width* – DMA read/write unit in bytes.

Returns

The I3C Slave Transmit Data Register address.

```
static inline uint32_t I3C_SlaveGetRxFifoAddress(I3C_Type *base, uint32_t width)
```

Gets I3C slave receive data register address for DMA transfer.

Parameters

- *base* – The I3C peripheral base address.
- *width* – DMA read/write unit in bytes.

Returns

The I3C Slave Receive Data Register address.

```
static inline void I3C_MasterSetWatermarks(I3C_Type *base, i3c_tx_trigger_level_t txLvl, i3c_rx_trigger_level_t rxLvl, bool flushTx, bool flushRx)
```

Sets the watermarks for I3C master FIFOs.

Parameters

- *base* – The I3C peripheral base address.
- *txLvl* – Transmit FIFO watermark level. The `kI3C_MasterTxReadyFlag` flag is set whenever the number of words in the transmit FIFO reaches *txLvl*.
- *rxLvl* – Receive FIFO watermark level. The `kI3C_MasterRxReadyFlag` flag is set whenever the number of words in the receive FIFO reaches *rxLvl*.

- `flushTx` – true if TX FIFO is to be cleared, otherwise TX FIFO remains unchanged.
- `flushRx` – true if RX FIFO is to be cleared, otherwise RX FIFO remains unchanged.

static inline void I3C_MasterGetFifoCounts(I3C_Type *base, size_t *rxCount, size_t *txCount)

Gets the current number of bytes in the I3C master FIFOs.

Parameters

- `base` – The I3C peripheral base address.
- `txCount` – **[out]** Pointer through which the current number of bytes in the transmit FIFO is returned. Pass NULL if this value is not required.
- `rxCount` – **[out]** Pointer through which the current number of bytes in the receive FIFO is returned. Pass NULL if this value is not required.

static inline void I3C_SlaveSetWatermarks(I3C_Type *base, *i3c_tx_trigger_level_t* txLvl, *i3c_rx_trigger_level_t* rxLvl, bool flushTx, bool flushRx)

Sets the watermarks for I3C slave FIFOs.

Parameters

- `base` – The I3C peripheral base address.
- `txLvl` – Transmit FIFO watermark level. The `kI3C_SlaveTxReadyFlag` flag is set whenever the number of words in the transmit FIFO reaches `txLvl`.
- `rxLvl` – Receive FIFO watermark level. The `kI3C_SlaveRxReadyFlag` flag is set whenever the number of words in the receive FIFO reaches `rxLvl`.
- `flushTx` – true if TX FIFO is to be cleared, otherwise TX FIFO remains unchanged.
- `flushRx` – true if RX FIFO is to be cleared, otherwise RX FIFO remains unchanged.

static inline void I3C_SlaveGetFifoCounts(I3C_Type *base, size_t *rxCount, size_t *txCount)

Gets the current number of bytes in the I3C slave FIFOs.

Parameters

- `base` – The I3C peripheral base address.
- `txCount` – **[out]** Pointer through which the current number of bytes in the transmit FIFO is returned. Pass NULL if this value is not required.
- `rxCount` – **[out]** Pointer through which the current number of bytes in the receive FIFO is returned. Pass NULL if this value is not required.

void I3C_MasterSetBaudRate(I3C_Type *base, const *i3c_baudrate_hz_t* *baudRate_Hz, uint32_t sourceClock_Hz)

Sets the I3C bus frequency for master transactions.

The I3C master is automatically disabled and re-enabled as necessary to configure the baud rate. Do not call this function during a transfer, or the transfer is aborted.

Parameters

- `base` – The I3C peripheral base address.
- `baudRate_Hz` – Pointer to structure of requested bus frequency in Hertz.
- `sourceClock_Hz` – I3C functional clock frequency in Hertz.

```
static inline bool I3C_MasterGetBusIdleState(I3C_Type *base)
```

Returns whether the bus is idle.

Requires the master mode to be enabled.

Parameters

- *base* – The I3C peripheral base address.

Return values

- *true* – Bus is busy.
- *false* – Bus is idle.

```
status_t I3C_MasterStartWithRxSize(I3C_Type *base, i3c_bus_type_t type, uint8_t address,  
                                   i3c_direction_t dir, uint8_t rxSize)
```

Sends a START signal and slave address on the I2C/I3C bus, receive size is also specified in the call.

This function is used to initiate a new master mode transfer. First, the bus state is checked to ensure that another master is not occupying the bus. Then a START signal is transmitted, followed by the 7-bit address specified in the *address* parameter. Note that this function does not actually wait until the START and address are successfully sent on the bus before returning.

Parameters

- *base* – The I3C peripheral base address.
- *type* – The bus type to use in this transaction.
- *address* – 7-bit slave device address, in bits [6:0].
- *dir* – Master transfer direction, either *kI3C_Read* or *kI3C_Write*. This parameter is used to set the R/w bit (bit 0) in the transmitted slave address.
- *rxSize* – Read terminate size for the followed read transfer, limit to 255 bytes.

Return values

- *kStatus_Success* – START signal and address were successfully enqueued in the transmit FIFO.
- *kStatus_I3C_Busy* – Another master is currently utilizing the bus.

```
status_t I3C_MasterStart(I3C_Type *base, i3c_bus_type_t type, uint8_t address, i3c_direction_t  
                        dir)
```

Sends a START signal and slave address on the I2C/I3C bus.

This function is used to initiate a new master mode transfer. First, the bus state is checked to ensure that another master is not occupying the bus. Then a START signal is transmitted, followed by the 7-bit address specified in the *address* parameter. Note that this function does not actually wait until the START and address are successfully sent on the bus before returning.

Parameters

- *base* – The I3C peripheral base address.
- *type* – The bus type to use in this transaction.
- *address* – 7-bit slave device address, in bits [6:0].
- *dir* – Master transfer direction, either *kI3C_Read* or *kI3C_Write*. This parameter is used to set the R/w bit (bit 0) in the transmitted slave address.

Return values

- `kStatus_Success` – START signal and address were successfully enqueued in the transmit FIFO.
- `kStatus_I3C_Busy` – Another master is currently utilizing the bus.

`status_t I3C_MasterRepeatedStartWithRxSize(I3C_Type *base, i3c_bus_type_t type, uint8_t address, i3c_direction_t dir, uint8_t rxSize)`

Sends a repeated START signal and slave address on the I2C/I3C bus, receive size is also specified in the call.

This function is used to send a Repeated START signal when a transfer is already in progress. Like `I3C_MasterStart()`, it also sends the specified 7-bit address. Call this API also configures the read terminate size for the following read transfer. For example, set the `rxSize` = 2, the following read transfer will be terminated after two bytes of data received. Write transfer will not be affected by the `rxSize` configuration.

Note: This function exists primarily to maintain compatible APIs between I3C and I2C drivers, as well as to better document the intent of code that uses these APIs.

Parameters

- `base` – The I3C peripheral base address.
- `type` – The bus type to use in this transaction.
- `address` – 7-bit slave device address, in bits [6:0].
- `dir` – Master transfer direction, either `kI3C_Read` or `kI3C_Write`. This parameter is used to set the R/w bit (bit 0) in the transmitted slave address.
- `rxSize` – Read terminate size for the followed read transfer, limit to 255 bytes.

Return values

`kStatus_Success` – Repeated START signal and address were successfully enqueued in the transmit FIFO.

`static inline status_t I3C_MasterRepeatedStart(I3C_Type *base, i3c_bus_type_t type, uint8_t address, i3c_direction_t dir)`

Sends a repeated START signal and slave address on the I2C/I3C bus.

This function is used to send a Repeated START signal when a transfer is already in progress. Like `I3C_MasterStart()`, it also sends the specified 7-bit address.

Note: This function exists primarily to maintain compatible APIs between I3C and I2C drivers, as well as to better document the intent of code that uses these APIs.

Parameters

- `base` – The I3C peripheral base address.
- `type` – The bus type to use in this transaction.
- `address` – 7-bit slave device address, in bits [6:0].
- `dir` – Master transfer direction, either `kI3C_Read` or `kI3C_Write`. This parameter is used to set the R/w bit (bit 0) in the transmitted slave address.

Return values

`kStatus_Success` – Repeated START signal and address were successfully enqueued in the transmit FIFO.

status_t I3C_MasterSend(I3C_Type *base, const void *txBuff, size_t txSize, uint32_t flags)

Performs a polling send transfer on the I2C/I3C bus.

Sends up to *txSize* number of bytes to the previously addressed slave device. The slave may reply with a NAK to any byte in order to terminate the transfer early. If this happens, this function returns *kStatus_I3C_Nak*.

Parameters

- *base* – The I3C peripheral base address.
- *txBuff* – The pointer to the data to be transferred.
- *txSize* – The length in bytes of the data to be transferred.
- *flags* – Bit mask of options for the transfer. See enumeration *_i3c_master_transfer_flags* for available options.

Return values

- *kStatus_Success* – Data was sent successfully.
- *kStatus_I3C_Busy* – Another master is currently utilizing the bus.
- *kStatus_I3C_Timeout* – The module has stalled too long in a frame.
- *kStatus_I3C_Nak* – The slave device sent a NAK in response to an address.
- *kStatus_I3C_WriteAbort* – The slave device sent a NAK in response to a write.
- *kStatus_I3C_MsgError* – Message SDR/DDR mismatch or read/write message in wrong state.
- *kStatus_I3C_WriteFifoError* – Write to M/SWDATAB register when FIFO full.
- *kStatus_I3C_InvalidReq* – Invalid use of request.

status_t I3C_MasterReceive(I3C_Type *base, void *rxBuff, size_t rxSize, uint32_t flags)

Performs a polling receive transfer on the I2C/I3C bus.

Parameters

- *base* – The I3C peripheral base address.
- *rxBuff* – The pointer to the data to be transferred.
- *rxSize* – The length in bytes of the data to be transferred.
- *flags* – Bit mask of options for the transfer. See enumeration *_i3c_master_transfer_flags* for available options.

Return values

- *kStatus_Success* – Data was received successfully.
- *kStatus_I3C_Busy* – Another master is currently utilizing the bus.
- *kStatus_I3C_Timeout* – The module has stalled too long in a frame.
- *kStatus_I3C_Term* – The master terminates slave read.
- *kStatus_I3C_HdrParityError* – Parity error from DDR read.
- *kStatus_I3C_CrcError* – CRC error from DDR read.
- *kStatus_I3C_MsgError* – Message SDR/DDR mismatch or read/write message in wrong state.
- *kStatus_I3C_ReadFifoError* – Read from M/SRDATAB register when FIFO empty.

- `kStatus_I3C_InvalidReq` – Invalid use of request.

`status_t I3C_MasterStop(I3C_Type *base)`

Sends a STOP signal on the I2C/I3C bus.

This function does not return until the STOP signal is seen on the bus, or an error occurs.

Parameters

- `base` – The I3C peripheral base address.

Return values

- `kStatus_Success` – The STOP signal was successfully sent on the bus and the transaction terminated.
- `kStatus_I3C_Busy` – Another master is currently utilizing the bus.
- `kStatus_I3C_Timeout` – The module has stalled too long in a frame.
- `kStatus_I3C_InvalidReq` – Invalid use of request.

`void I3C_MasterEmitRequest(I3C_Type *base, i3c_bus_request_t masterReq)`

I3C master emit request.

Parameters

- `base` – The I3C peripheral base address.
- `masterReq` – I3C master request of type `i3c_bus_request_t`

`static inline void I3C_MasterEmitIBIResponse(I3C_Type *base, i3c_ibi_response_t ibiResponse)`

I3C master emit request.

Parameters

- `base` – The I3C peripheral base address.
- `ibiResponse` – I3C master emit IBI response of type `i3c_ibi_response_t`

`void I3C_MasterRegisterIBI(I3C_Type *base, i3c_register_ibi_addr_t *ibiRule)`

I3C master register IBI rule.

Parameters

- `base` – The I3C peripheral base address.
- `ibiRule` – Pointer to ibi rule description of type `i3c_register_ibi_addr_t`

`void I3C_MasterGetIBIRules(I3C_Type *base, i3c_register_ibi_addr_t *ibiRule)`

I3C master get IBI rule.

Parameters

- `base` – The I3C peripheral base address.
- `ibiRule` – Pointer to store the read out ibi rule description.

`i3c_ibi_type_t I3C_GetIBIType(I3C_Type *base)`

I3C master get IBI Type.

Parameters

- `base` – The I3C peripheral base address.

Return values

`i3c_ibi_type_t` – Type of `i3c_ibi_type_t`.

```
static inline uint8_t I3C_GetIBIAddress(I3C_Type *base)
```

I3C master get IBI Address.

Parameters

- *base* – The I3C peripheral base address.

Return values

The – 8-bit IBI address.

```
status_t I3C_MasterProcessDAASpecifiedBaudrate(I3C_Type *base, uint8_t *addressList, uint32_t
count, i3c_master_daa_baudrate_t
*daaBaudRate)
```

Performs a DAA in the i3c bus with specified temporary baud rate.

Parameters

- *base* – The I3C peripheral base address.
- *addressList* – The pointer for address list which is used to do DAA.
- *count* – The address count in the address list.
- *daaBaudRate* – The temporary baud rate in DAA process, NULL for using initial setting. The initial setting is set back between the completion of the DAA and the return of this function.

Return values

- *kStatus_Success* – The transaction was started successfully.
- *kStatus_I3C_Busy* – Either another master is currently utilizing the bus, or a non-blocking transaction is already in progress.
- *kStatus_I3C_SlaveCountExceed* – The I3C slave count has exceed the definition in *I3C_MAX_DEVCNT*.

```
static inline status_t I3C_MasterProcessDAA(I3C_Type *base, uint8_t *addressList, uint32_t
count)
```

Performs a DAA in the i3c bus.

Parameters

- *base* – The I3C peripheral base address.
- *addressList* – The pointer for address list which is used to do DAA.
- *count* – The address count in the address list. The initial setting is set back between the completion of the DAA and the return of this function.

Return values

- *kStatus_Success* – The transaction was started successfully.
- *kStatus_I3C_Busy* – Either another master is currently utilizing the bus, or a non-blocking transaction is already in progress.
- *kStatus_I3C_SlaveCountExceed* – The I3C slave count has exceed the definition in *I3C_MAX_DEVCNT*.

```
i3c_device_info_t *I3C_MasterGetDeviceListAfterDAA(I3C_Type *base, uint8_t *count)
```

Get device information list after DAA process is done.

Parameters

- *base* – The I3C peripheral base address.
- *count* – **[out]** The pointer to store the available device count.

Returns

Pointer to the *i3c_device_info_t* array.

`void I3C_MasterClearDeviceCount(I3C_Type *base)`

Clear the global device count which represents current devices number on the bus. When user resets all dynamic addresses on the bus, should call this API.

Parameters

- `base` – The I3C peripheral base address.

`status_t I3C_MasterTransferBlocking(I3C_Type *base, i3c_master_transfer_t *transfer)`

Performs a master polling transfer on the I2C/I3C bus.

Note: The API does not return until the transfer succeeds or fails due to error happens during transfer.

Parameters

- `base` – The I3C peripheral base address.
- `transfer` – Pointer to the transfer structure.

Return values

- `kStatus_Success` – Data was received successfully.
- `kStatus_I3C_Busy` – Another master is currently utilizing the bus.
- `kStatus_I3C_IBIWon` – The I3C slave event IBI or MR or HJ won the arbitration on a header address.
- `kStatus_I3C_Timeout` – The module has stalled too long in a frame.
- `kStatus_I3C_Nak` – The slave device sent a NAK in response to an address.
- `kStatus_I3C_WriteAbort` – The slave device sent a NAK in response to a write.
- `kStatus_I3C_Term` – The master terminates slave read.
- `kStatus_I3C_HdrParityError` – Parity error from DDR read.
- `kStatus_I3C_CrcError` – CRC error from DDR read.
- `kStatus_I3C_MsgError` – Message SDR/DDR mismatch or read/write message in wrong state.
- `kStatus_I3C_ReadFifoError` – Read from M/SRDATAB register when FIFO empty.
- `kStatus_I3C_WriteFifoError` – Write to M/SWDATAB register when FIFO full.
- `kStatus_I3C_InvalidReq` – Invalid use of request.

`status_t I3C_SlaveSend(I3C_Type *base, const void *txBuff, size_t txSize)`

Performs a polling send transfer on the I3C bus.

Parameters

- `base` – The I3C peripheral base address.
- `txBuff` – The pointer to the data to be transferred.
- `txSize` – The length in bytes of the data to be transferred.

Returns

Error or success status returned by API.

status_t I3C_SlaveReceive(I3C_Type *base, void *rxBuff, size_t rxSize)

Performs a polling receive transfer on the I3C bus.

Parameters

- base – The I3C peripheral base address.
- rxBuff – The pointer to the data to be transferred.
- rxSize – The length in bytes of the data to be transferred.

Returns

Error or success status returned by API.

void I3C_MasterTransferCreateHandle(I3C_Type *base, *i3c_master_handle_t* *handle, const *i3c_master_transfer_callback_t* *callback, void *userData)

Creates a new handle for the I3C master non-blocking APIs.

The creation of a handle is for use with the non-blocking APIs. Once a handle is created, there is not a corresponding destroy handle. If the user wants to terminate a transfer, the I3C_MasterTransferAbort() API shall be called.

Note: The function also enables the NVIC IRQ for the input I3C. Need to notice that on some SoCs the I3C IRQ is connected to INTMUX, in this case user needs to enable the associated INTMUX IRQ in application.

Parameters

- base – The I3C peripheral base address.
- handle – **[out]** Pointer to the I3C master driver handle.
- callback – User provided pointer to the asynchronous callback function.
- userData – User provided pointer to the application callback data.

status_t I3C_MasterTransferNonBlocking(I3C_Type *base, *i3c_master_handle_t* *handle, *i3c_master_transfer_t* *transfer)

Performs a non-blocking transaction on the I2C/I3C bus.

Parameters

- base – The I3C peripheral base address.
- handle – Pointer to the I3C master driver handle.
- transfer – The pointer to the transfer descriptor.

Return values

- kStatus_Success – The transaction was started successfully.
- kStatus_I3C_Busy – Either another master is currently utilizing the bus, or a non-blocking transaction is already in progress.

status_t I3C_MasterTransferGetCount(I3C_Type *base, *i3c_master_handle_t* *handle, size_t *count)

Returns number of bytes transferred so far.

Parameters

- base – The I3C peripheral base address.
- handle – Pointer to the I3C master driver handle.
- count – **[out]** Number of bytes transferred so far by the non-blocking transaction.

Return values

- `kStatus_Success` –
- `kStatus_NoTransferInProgress` – There is not a non-blocking transaction currently in progress.

`void I3C_MasterTransferAbort(I3C_Type *base, i3c_master_handle_t *handle)`

Terminates a non-blocking I3C master transmission early.

Note: It is not safe to call this function from an IRQ handler that has a higher priority than the I3C peripheral's IRQ priority.

Parameters

- `base` – The I3C peripheral base address.
- `handle` – Pointer to the I3C master driver handle.

Return values

- `kStatus_Success` – A transaction was successfully aborted.
- `kStatus_I3C_Idle` – There is not a non-blocking transaction currently in progress.

`void I3C_MasterTransferHandleIRQ(I3C_Type *base, void *intHandle)`

Reusable routine to handle master interrupts.

Note: This function does not need to be called unless you are reimplementing the non-blocking API's interrupt handler routines to add special functionality.

Parameters

- `base` – The I3C peripheral base address.
- `intHandle` – Pointer to the I3C master driver handle.

`enum _i3c_master_flags`

I3C master peripheral flags.

The following status register flags can be cleared:

- `kI3C_MasterSlaveStartFlag`
- `kI3C_MasterControlDoneFlag`
- `kI3C_MasterCompleteFlag`
- `kI3C_MasterArbitrationWonFlag`
- `kI3C_MasterSlave2MasterFlag`

All flags except `kI3C_MasterBetweenFlag` and `kI3C_MasterNackDetectFlag` can be enabled as interrupts.

Note: These enums are meant to be OR'd together to form a bit mask.

Values:

enumerator `kI3C_MasterBetweenFlag`

Between messages/DAA's flag

enumerator kI3C_MasterNackDetectFlag
NACK detected flag

enumerator kI3C_MasterSlaveStartFlag
Slave request start flag

enumerator kI3C_MasterControlDoneFlag
Master request complete flag

enumerator kI3C_MasterCompleteFlag
Transfer complete flag

enumerator kI3C_MasterRxReadyFlag
Rx data ready in Rx buffer flag

enumerator kI3C_MasterTxReadyFlag
Tx buffer ready for Tx data flag

enumerator kI3C_MasterArbitrationWonFlag
Header address won arbitration flag

enumerator kI3C_MasterErrorFlag
Error occurred flag

enumerator kI3C_MasterSlave2MasterFlag
Switch from slave to master flag

enumerator kI3C_MasterClearFlags

enum _i3c_master_error_flags
I3C master error flags to indicate the causes.

Note: These enums are meant to be OR'd together to form a bit mask.

Values:

enumerator kI3C_MasterErrorNackFlag
Slave NACKed the last address

enumerator kI3C_MasterErrorWriteAbortFlag
Slave NACKed the write data

enumerator kI3C_MasterErrorParityFlag
Parity error from DDR read

enumerator kI3C_MasterErrorCrcFlag
CRC error from DDR read

enumerator kI3C_MasterErrorReadFlag
Read from MRDATAB register when FIFO empty

enumerator kI3C_MasterErrorWriteFlag
Write to MWDATAB register when FIFO full

enumerator kI3C_MasterErrorMsgFlag
Message SDR/DDR mismatch or read/write message in wrong state

enumerator kI3C_MasterErrorInvalidReqFlag
Invalid use of request

enumerator kI3C_MasterErrorTimeoutFlag
The module has stalled too long in a frame

enumerator kI3C_MasterAllErrorFlags

All error flags

enum _i3c_master_state

I3C working master state.

Values:

enumerator kI3C_MasterStateIdle

Bus stopped.

enumerator kI3C_MasterStateSlvReq

Bus stopped but slave holding SDA low.

enumerator kI3C_MasterStateMsgSdr

In SDR Message mode from using MWMSG_SDR.

enumerator kI3C_MasterStateNormAct

In normal active SDR mode.

enumerator kI3C_MasterStateDdr

In DDR Message mode.

enumerator kI3C_MasterStateDaa

In ENTDAAs mode.

enumerator kI3C_MasterStateIbiAck

Waiting on IBI ACK/NACK decision.

enumerator kI3C_MasterStateIbiRcv

Receiving IBI.

enum _i3c_master_enable

I3C master enable configuration.

Values:

enumerator kI3C_MasterOff

Master off.

enumerator kI3C_MasterOn

Master on.

enumerator kI3C_MasterCapable

Master capable.

enum _i3c_master_hkeep

I3C high keeper configuration.

Values:

enumerator kI3C_MasterHighKeeperNone

Use PUR to hold SCL high.

enumerator kI3C_MasterHighKeeperWiredIn

Use pin_HK controls.

enumerator kI3C_MasterPassiveSDA

Hi-Z for Bus Free and hold SDA.

enumerator kI3C_MasterPassiveSDASCL

Hi-Z both for Bus Free, and can Hi-Z SDA for hold.

enum _i3c_bus_request

Emits the requested operation when doing in pieces vs. by message.

Values:

enumerator kI3C_RequestNone

No request.

enumerator kI3C_RequestEmitStartAddr

Request to emit start and address on bus.

enumerator kI3C_RequestEmitStop

Request to emit stop on bus.

enumerator kI3C_RequestIbiAckNack

Manual IBI ACK or NACK.

enumerator kI3C_RequestProcessDAA

Process DAA.

enumerator kI3C_RequestForceExit

Request to force exit.

enumerator kI3C_RequestAutoIbi

Hold in stopped state, but Auto-emit START,7E.

enum _i3c_bus_type

Bus type with EmitStartAddr.

Values:

enumerator kI3C_TypeI3CSdr

SDR mode of I3C.

enumerator kI3C_TypeI2C

Standard i2c protocol.

enumerator kI3C_TypeI3CDdr

HDR-DDR mode of I3C.

enum _i3c_ibi_response

IBI response.

Values:

enumerator kI3C_IbiRespAck

ACK with no mandatory byte.

enumerator kI3C_IbiRespNack

NACK.

enumerator kI3C_IbiRespAckMandatory

ACK with mandatory byte.

enumerator kI3C_IbiRespManual

Reserved.

enum _i3c_ibi_type

IBI type.

Values:

enumerator kI3C_IbiNormal

In-band interrupt.

enumerator kI3C_IbiHotJoin
slave hot join.

enumerator kI3C_IbiMasterRequest
slave master ship request.

enum _i3c_ibi_state
IBI state.

Values:

enumerator kI3C_IbiReady
In-band interrupt ready state, ready for user to handle.

enumerator kI3C_IbiDataBuffNeed
In-band interrupt need data buffer for data receive.

enumerator kI3C_IbiAckNackPending
In-band interrupt Ack/Nack pending for decision.

enum _i3c_direction
Direction of master and slave transfers.

Values:

enumerator kI3C_Write
Master transmit.

enumerator kI3C_Read
Master receive.

enum _i3c_tx_trigger_level
Watermark of TX int/dma trigger level.

Values:

enumerator kI3C_TxTriggerOnEmpty
Trigger on empty.

enumerator kI3C_TxTriggerUntilOneQuarterOrLess
Trigger on 1/4 full or less.

enumerator kI3C_TxTriggerUntilOneHalfOrLess
Trigger on 1/2 full or less.

enumerator kI3C_TxTriggerUntilOneLessThanFull
Trigger on 1 less than full or less.

enum _i3c_rx_trigger_level
Watermark of RX int/dma trigger level.

Values:

enumerator kI3C_RxTriggerOnNotEmpty
Trigger on not empty.

enumerator kI3C_RxTriggerUntilOneQuarterOrMore
Trigger on 1/4 full or more.

enumerator kI3C_RxTriggerUntilOneHalfOrMore
Trigger on 1/2 full or more.

enumerator kI3C_RxTriggerUntilThreeQuarterOrMore
Trigger on 3/4 full or more.

enum _i3c_rx_term_ops

I3C master read termination operations.

Values:

enumerator kI3C_RxTermDisable

Master doesn't terminate read, used for CCC transfer.

enumerator kI3C_RxAutoTerm

Master auto terminate read after receiving specified bytes(<=255).

enumerator kI3C_RxTermLastByte

Master terminates read at any time after START, no length limitation.

enum _i3c_start_scl_delay

I3C start SCL delay options.

Values:

enumerator kI3C_NoDelay

No delay.

enumerator kI3C_IncreaseSclHalfPeriod

Increases SCL clock period by 1/2.

enumerator kI3C_IncreaseSclOnePeriod

Increases SCL clock period by 1.

enumerator kI3C_IncreaseSclOneAndHalfPeriod

Increases SCL clock period by 1 1/2

enum _i3c_master_transfer_flags

Transfer option flags.

Note: These enumerations are intended to be OR'd together to form a bit mask of options for the `_i3c_master_transfer::flags` field.

Values:

enumerator kI3C_TransferDefaultFlag

Transfer starts with a start signal, stops with a stop signal.

enumerator kI3C_TransferNoStartFlag

Don't send a start condition, address, and sub address

enumerator kI3C_TransferRepeatedStartFlag

Send a repeated start condition

enumerator kI3C_TransferNoStopFlag

Don't send a stop condition.

enumerator kI3C_TransferWordsFlag

Transfer in words, else transfer in bytes.

enumerator kI3C_TransferDisableRxTermFlag

Disable Rx termination. Note: It's for I3C CCC transfer.

enumerator kI3C_TransferRxAutoTermFlag

Set Rx auto-termination. Note: It's adaptive based on Rx size(<=255 bytes) except in `I3C_MasterReceive`.

enumerator `kI3C_TransferStartWithBroadcastAddr`

Start transfer with 0x7E, then read/write data with device address.

typedef enum `_i3c_master_state` `i3c_master_state_t`

I3C working master state.

typedef enum `_i3c_master_enable` `i3c_master_enable_t`

I3C master enable configuration.

typedef enum `_i3c_master_hkeep` `i3c_master_hkeep_t`

I3C high keeper configuration.

typedef enum `_i3c_bus_request` `i3c_bus_request_t`

Emits the requested operation when doing in pieces vs. by message.

typedef enum `_i3c_bus_type` `i3c_bus_type_t`

Bus type with `EmitStartAddr`.

typedef enum `_i3c_ibi_response` `i3c_ibi_response_t`

IBI response.

typedef enum `_i3c_ibi_type` `i3c_ibi_type_t`

IBI type.

typedef enum `_i3c_ibi_state` `i3c_ibi_state_t`

IBI state.

typedef enum `_i3c_direction` `i3c_direction_t`

Direction of master and slave transfers.

typedef enum `_i3c_tx_trigger_level` `i3c_tx_trigger_level_t`

Watermark of TX int/dma trigger level.

typedef enum `_i3c_rx_trigger_level` `i3c_rx_trigger_level_t`

Watermark of RX int/dma trigger level.

typedef enum `_i3c_rx_term_ops` `i3c_rx_term_ops_t`

I3C master read termination operations.

typedef enum `_i3c_start_scl_delay` `i3c_start_scl_delay_t`

I3C start SCL delay options.

typedef struct `_i3c_register_ibi_addr` `i3c_register_ibi_addr_t`

Structure with setting master IBI rules and slave registry.

typedef struct `_i3c_baudrate` `i3c_baudrate_hz_t`

Structure with I3C baudrate settings.

typedef struct `_i3c_master_daa_baudrate` `i3c_master_daa_baudrate_t`

I3C DAA baud rate configuration.

typedef struct `_i3c_master_config` `i3c_master_config_t`

Structure with settings to initialize the I3C master module.

This structure holds configuration settings for the I3C peripheral. To initialize this structure to reasonable defaults, call the `I3C_MasterGetDefaultConfig()` function and pass a pointer to your configuration structure instance.

The configuration structure can be made constant so it resides in flash.

typedef struct `_i3c_master_transfer` `i3c_master_transfer_t`

typedef struct `_i3c_master_handle` `i3c_master_handle_t`

```
typedef struct _i3c_master_transfer_callback i3c_master_transfer_callback_t
```

i3c master callback functions.

```
typedef void (*i3c_master_isr_t)(I3C_Type *base, void *handle)
```

Typedef for master interrupt handler.

```
struct _i3c_register_ibi_addr
```

#include <fsl_i3c.h> Structure with setting master IBI rules and slave registry.

Public Members

```
uint8_t address[5]
```

Address array for registry.

```
bool i3cFastStart
```

Allow the START header to run as push-pull speed if all dynamic addresses take MSB 0.

```
bool ibiHasPayload
```

Whether the address array has mandatory IBI byte.

```
struct _i3c_baudrate
```

#include <fsl_i3c.h> Structure with I3C baudrate settings.

Public Members

```
uint32_t i2cBaud
```

Desired I2C baud rate in Hertz.

```
uint32_t i3cPushPullBaud
```

Desired I3C push-pull baud rate in Hertz.

```
uint32_t i3cOpenDrainBaud
```

Desired I3C open-drain baud rate in Hertz.

```
struct _i3c_master_daa_baudrate
```

#include <fsl_i3c.h> I3C DAA baud rate configuration.

Public Members

```
uint32_t sourceClock_Hz
```

FCLK, function clock in Hertz.

```
uint32_t i3cPushPullBaud
```

Desired I3C push-pull baud rate in Hertz.

```
uint32_t i3cOpenDrainBaud
```

Desired I3C open-drain baud rate in Hertz.

```
struct _i3c_master_config
```

#include <fsl_i3c.h> Structure with settings to initialize the I3C master module.

This structure holds configuration settings for the I3C peripheral. To initialize this structure to reasonable defaults, call the `I3C_MasterGetDefaultConfig()` function and pass a pointer to your configuration structure instance.

The configuration structure can be made constant so it resides in flash.

Public Members

i3c_master_enable_t enableMaster

Enable master mode.

bool disableTimeout

Whether to disable timeout to prevent the ERRWARN.

i3c_master_hkeep_t hKeep

High keeper mode setting.

bool enableOpenDrainStop

Whether to emit open-drain speed STOP.

bool enableOpenDrainHigh

Enable Open-Drain High to be 1 PPBAUD count for i3c messages, or 1 ODBAUD.

i3c_baudrate_hz_t baudRate_Hz

Desired baud rate settings.

struct *_i3c_master_transfer_callback*

#include <fsl_i3c.h> i3c master callback functions.

Public Members

void (*slave2Master)(I3C_Type *base, void *userData)

Transfer complete callback

void (*ibiCallback)(I3C_Type *base, *i3c_master_handle_t* *handle, *i3c_ibi_type_t* ibiType, *i3c_ibi_state_t* ibiState)

IBI event callback

void (*transferComplete)(I3C_Type *base, *i3c_master_handle_t* *handle, *status_t* completionStatus, void *userData)

Transfer complete callback

struct *_i3c_master_transfer*

#include <fsl_i3c.h> Non-blocking transfer descriptor structure.

This structure is used to pass transaction parameters to the I3C_MasterTransferNonBlocking() API.

Public Members

uint32_t flags

Bit mask of options for the transfer. See enumeration *_i3c_master_transfer_flags* for available options. Set to 0 or *kI3C_TransferDefaultFlag* for normal transfers.

uint8_t slaveAddress

The 7-bit slave address.

i3c_direction_t direction

Either *kI3C_Read* or *kI3C_Write*.

uint32_t subaddress

Sub address. Transferred MSB first.

size_t subaddressSize

Length of sub address to send in bytes. Maximum size is 4 bytes.

`void *data`
 Pointer to data to transfer.

`size_t dataSize`
 Number of bytes to transfer.

`i3c_bus_type_t busType`
 bus type.

`i3c_ibi_response_t ibiResponse`
 ibi response during transfer.

`struct __i3c_master_handle`
 #include <fsl_i3c.h> Driver handle for master non-blocking APIs.

Note: The contents of this structure are private and subject to change.

Public Members

`uint8_t state`
 Transfer state machine current state.

`uint32_t remainingBytes`
 Remaining byte count in current state.

`i3c_rx_term_ops_t rxTermOps`
 Read termination operation.

`i3c_master_transfer_t transfer`
 Copy of the current transfer info.

`uint8_t ibiAddress`
 Slave address which request IBI.

`uint8_t *ibiBuff`
 Pointer to IBI buffer to keep ibi bytes.

`size_t ibiPayloadSize`
 IBI payload size.

`i3c_ibi_type_t ibiType`
 IBI type.

`i3c_master_transfer_callback_t callback`
 Callback functions pointer.

`void *userData`
 Application data passed to callback.

2.37 I3C Slave DMA Driver

`void I3C_SlaveTransferCreateHandleDMA(I3C_Type *base, i3c_slave_dma_handle_t *handle, i3c_slave_dma_callback_t callback, void *userData, dma_handle_t *rxDmaHandle, dma_handle_t *txDmaHandle)`

Create a new handle for the I3C slave DMA APIs.

The creation of a handle is for use with the DMA APIs. Once a handle is created, there is not a corresponding destroy handle. If the user wants to terminate a transfer, the `I3C_SlaveTransferAbortDMA()` API shall be called.

For devices where the I3C send and receive DMA requests are OR'd together, the *txDmaHandle* parameter is ignored and may be set to NULL.

Parameters

- *base* – The I3C peripheral base address.
- *handle* – Pointer to the I3C slave driver handle.
- *callback* – User provided pointer to the asynchronous callback function.
- *userData* – User provided pointer to the application callback data.
- *rxDmaHandle* – Handle for the DMA receive channel. Created by the user prior to calling this function.
- *txDmaHandle* – Handle for the DMA transmit channel. Created by the user prior to calling this function.

```
status_t I3C_SlaveTransferDMA(I3C_Type *base, i3c_slave_dma_handle_t *handle,  
                             i3c_slave_dma_transfer_t *transfer, uint32_t eventMask)
```

Prepares for a non-blocking DMA-based transaction on the I3C bus.

The API will do DMA configuration according to the input transfer descriptor, and the data will be transferred when there's bus master requesting transfer from/to this slave. So the timing of call to this API need be aligned with master application to ensure the transfer is executed as expected. Callback specified when the *handle* was created is invoked when the transaction has completed.

Parameters

- *base* – The I3C peripheral base address.
- *handle* – Pointer to the I3C slave driver handle.
- *transfer* – The pointer to the transfer descriptor.
- *eventMask* – Bit mask formed by OR'ing together `i3c_slave_transfer_event_t` enumerators to specify which events to send to the callback. The transmit and receive events is not allowed to be enabled.

Return values

- `kStatus_Success` – The transaction was started successfully.
- `kStatus_I3C_Busy` – Either another master is currently utilizing the bus, or another DMA transaction is already in progress.

```
void I3C_SlaveTransferAbortDMA(I3C_Type *base, i3c_slave_dma_handle_t *handle)
```

Abort a slave dma non-blocking transfer in a early time.

Parameters

- *base* – I3C peripheral base address
- *handle* – pointer to `i3c_slave_dma_handle_t` structure

```
void I3C_SlaveTransferDMAHandleIRQ(I3C_Type *base, void *i3cHandle)
```

Reusable routine to handle slave interrupts.

Note: This function does not need to be called unless you are reimplementing the non-blocking API's interrupt handler routines to add special functionality.

Parameters

- **base** – The I3C peripheral base address.
- **handle** – Pointer to the I3C slave DMA driver handle.

```
typedef struct _i3c_slave_dma_handle i3c_slave_dma_handle_t
```

```
typedef struct _i3c_slave_dma_transfer i3c_slave_dma_transfer_t
```

I3C slave transfer structure.

```
typedef void (*i3c_slave_dma_callback_t)(I3C_Type *base, i3c_slave_dma_transfer_t *transfer, void *userData)
```

Slave event callback function pointer type.

This callback is used only for the slave DMA transfer API.

Param base

Base address for the I3C instance on which the event occurred.

Param handle

Pointer to slave DMA transfer handle.

Param transfer

Pointer to transfer descriptor containing values passed to and/or from the callback.

Param userData

Arbitrary pointer-sized value passed from the application.

```
struct _i3c_slave_dma_transfer
```

```
#include <fsl_i3c_dma.h> I3C slave transfer structure.
```

```
struct _i3c_slave_dma_handle
```

```
#include <fsl_i3c_dma.h> I3C slave dma handle structure.
```

Note: The contents of this structure are private and subject to change.

2.38 I3C Slave Driver

```
void I3C_SlaveGetDefaultConfig(i3c_slave_config_t *slaveConfig)
```

Provides a default configuration for the I3C slave peripheral.

This function provides the following default configuration for the I3C slave peripheral:

```
slaveConfig->enableSlave = true;
```

After calling this function, you can override any settings in order to customize the configuration, prior to initializing the slave driver with I3C_SlaveInit().

Parameters

- **slaveConfig** – **[out]** User provided configuration structure for default values. Refer to i3c_slave_config_t.

```
void I3C_SlaveInit(I3C_Type *base, const i3c_slave_config_t *slaveConfig, uint32_t
    slowClock_Hz)
```

Initializes the I3C slave peripheral.

This function enables the peripheral clock and initializes the I3C slave peripheral as described by the user provided configuration.

Parameters

- base – The I3C peripheral base address.
- slaveConfig – User provided peripheral configuration. Use I3C_SlaveGetDefaultConfig() to get a set of defaults that you can override.
- slowClock_Hz – Frequency in Hertz of the I3C slow clock. Used to calculate the bus match condition values. If FSL_FEATURE_I3C_HAS_NO_SCONFIG_BAMATCH defines as 1, this parameter is useless.

```
void I3C_SlaveDeinit(I3C_Type *base)
```

Deinitializes the I3C slave peripheral.

This function disables the I3C slave peripheral and gates the clock.

Parameters

- base – The I3C peripheral base address.

```
static inline void I3C_SlaveEnable(I3C_Type *base, bool isEnabled)
```

Enable/Disable Slave.

Parameters

- base – The I3C peripheral base address.
- isEnabled – Enable or disable.

```
static inline uint32_t I3C_SlaveGetStatusFlags(I3C_Type *base)
```

Gets the I3C slave status flags.

A bit mask with the state of all I3C slave status flags is returned. For each flag, the corresponding bit in the return value is set if the flag is asserted.

See also:

[_i3c_slave_flags](#)

Parameters

- base – The I3C peripheral base address.

Returns

State of the status flags:

- 1: related status flag is set.
- 0: related status flag is not set.

```
static inline void I3C_SlaveClearStatusFlags(I3C_Type *base, uint32_t statusMask)
```

Clears the I3C slave status flag state.

The following status register flags can be cleared:

- kI3C_SlaveBusStartFlag
- kI3C_SlaveMatchedFlag
- kI3C_SlaveBusStopFlag

Attempts to clear other flags has no effect.

See also:

`_i3c_slave_flags`.

Parameters

- `base` – The I3C peripheral base address.
- `statusMask` – A bitmask of status flags that are to be cleared. The mask is composed of `_i3c_slave_flags` enumerators OR'd together. You may pass the result of a previous call to `I3C_SlaveGetStatusFlags()`.

```
static inline uint32_t I3C_SlaveGetErrorStatusFlags(I3C_Type *base)
```

Gets the I3C slave error status flags.

A bit mask with the state of all I3C slave error status flags is returned. For each flag, the corresponding bit in the return value is set if the flag is asserted.

See also:

`_i3c_slave_error_flags`

Parameters

- `base` – The I3C peripheral base address.

Returns

State of the error status flags:

- 1: related status flag is set.
- 0: related status flag is not set.

```
static inline void I3C_SlaveClearErrorStatusFlags(I3C_Type *base, uint32_t statusMask)
```

Clears the I3C slave error status flag state.

See also:

`_i3c_slave_error_flags`.

Parameters

- `base` – The I3C peripheral base address.
- `statusMask` – A bitmask of error status flags that are to be cleared. The mask is composed of `_i3c_slave_error_flags` enumerators OR'd together. You may pass the result of a previous call to `I3C_SlaveGetErrorStatusFlags()`.

```
i3c_slave_activity_state_t I3C_SlaveGetActivityState(I3C_Type *base)
```

Gets the I3C slave state.

Parameters

- `base` – The I3C peripheral base address.

Returns

I3C slave activity state, refer `i3c_slave_activity_state_t`.

```
status_t I3C_SlaveCheckAndClearError(I3C_Type *base, uint32_t status)
```

```
static inline void I3C_SlaveEnableInterrupts(I3C_Type *base, uint32_t interruptMask)
```

Enables the I3C slave interrupt requests.

Only below flags can be enabled as interrupts.

- kI3C_SlaveBusStartFlag
- kI3C_SlaveMatchedFlag
- kI3C_SlaveBusStopFlag
- kI3C_SlaveRxReadyFlag
- kI3C_SlaveTxReadyFlag
- kI3C_SlaveDynamicAddrChangedFlag
- kI3C_SlaveReceivedCCCFlag
- kI3C_SlaveErrorFlag
- kI3C_SlaveHDRCommandMatchFlag
- kI3C_SlaveCCCHandledFlag
- kI3C_SlaveEventSentFlag

Parameters

- base – The I3C peripheral base address.
- interruptMask – Bit mask of interrupts to enable. See `_i3c_slave_flags` for the set of constants that should be OR'd together to form the bit mask.

```
static inline void I3C_SlaveDisableInterrupts(I3C_Type *base, uint32_t interruptMask)
```

Disables the I3C slave interrupt requests.

Only below flags can be disabled as interrupts.

- kI3C_SlaveBusStartFlag
- kI3C_SlaveMatchedFlag
- kI3C_SlaveBusStopFlag
- kI3C_SlaveRxReadyFlag
- kI3C_SlaveTxReadyFlag
- kI3C_SlaveDynamicAddrChangedFlag
- kI3C_SlaveReceivedCCCFlag
- kI3C_SlaveErrorFlag
- kI3C_SlaveHDRCommandMatchFlag
- kI3C_SlaveCCCHandledFlag
- kI3C_SlaveEventSentFlag

Parameters

- base – The I3C peripheral base address.
- interruptMask – Bit mask of interrupts to disable. See `_i3c_slave_flags` for the set of constants that should be OR'd together to form the bit mask.

```
static inline uint32_t I3C_SlaveGetEnabledInterrupts(I3C_Type *base)
```

Returns the set of currently enabled I3C slave interrupt requests.

Parameters

- `base` – The I3C peripheral base address.

Returns

A bitmask composed of `_i3c_slave_flags` enumerators OR'd together to indicate the set of enabled interrupts.

```
static inline uint32_t I3C_SlaveGetPendingInterrupts(I3C_Type *base)
```

Returns the set of pending I3C slave interrupt requests.

Parameters

- `base` – The I3C peripheral base address.

Returns

A bitmask composed of `_i3c_slave_flags` enumerators OR'd together to indicate the set of pending interrupts.

```
static inline void I3C_SlaveEnableDMA(I3C_Type *base, bool enableTx, bool enableRx, uint32_t width)
```

Enables or disables I3C slave DMA requests.

Parameters

- `base` – The I3C peripheral base address.
- `enableTx` – Enable flag for transmit DMA request. Pass true for enable, false for disable.
- `enableRx` – Enable flag for receive DMA request. Pass true for enable, false for disable.
- `width` – DMA read/write unit in bytes.

```
static inline uint32_t I3C_SlaveGetTxFifoAddress(I3C_Type *base, uint32_t width)
```

Gets I3C slave transmit data register address for DMA transfer.

Parameters

- `base` – The I3C peripheral base address.
- `width` – DMA read/write unit in bytes.

Returns

The I3C Slave Transmit Data Register address.

```
static inline uint32_t I3C_SlaveGetRxFifoAddress(I3C_Type *base, uint32_t width)
```

Gets I3C slave receive data register address for DMA transfer.

Parameters

- `base` – The I3C peripheral base address.
- `width` – DMA read/write unit in bytes.

Returns

The I3C Slave Receive Data Register address.

```
static inline void I3C_SlaveSetWatermarks(I3C_Type *base, i3c_tx_trigger_level_t txLvl, i3c_rx_trigger_level_t rxLvl, bool flushTx, bool flushRx)
```

Sets the watermarks for I3C slave FIFOs.

Parameters

- `base` – The I3C peripheral base address.
- `txLvl` – Transmit FIFO watermark level. The `kI3C_SlaveTxReadyFlag` flag is set whenever the number of words in the transmit FIFO reaches `txLvl`.

- `rxLvl` – Receive FIFO watermark level. The `kI3C_SlaveRxReadyFlag` flag is set whenever the number of words in the receive FIFO reaches `rxLvl`.
- `flushTx` – true if TX FIFO is to be cleared, otherwise TX FIFO remains unchanged.
- `flushRx` – true if RX FIFO is to be cleared, otherwise RX FIFO remains unchanged.

`static inline void I3C_SlaveGetFifoCounts(I3C_Type *base, size_t *rxCount, size_t *txCount)`

Gets the current number of bytes in the I3C slave FIFOs.

Parameters

- `base` – The I3C peripheral base address.
- `txCount` – **[out]** Pointer through which the current number of bytes in the transmit FIFO is returned. Pass NULL if this value is not required.
- `rxCount` – **[out]** Pointer through which the current number of bytes in the receive FIFO is returned. Pass NULL if this value is not required.

`status_t I3C_SlaveSend(I3C_Type *base, const void *txBuff, size_t txSize)`

Performs a polling send transfer on the I3C bus.

Parameters

- `base` – The I3C peripheral base address.
- `txBuff` – The pointer to the data to be transferred.
- `txSize` – The length in bytes of the data to be transferred.

Returns

Error or success status returned by API.

`status_t I3C_SlaveReceive(I3C_Type *base, void *rxBuff, size_t rxSize)`

Performs a polling receive transfer on the I3C bus.

Parameters

- `base` – The I3C peripheral base address.
- `rxBuff` – The pointer to the data to be transferred.
- `rxSize` – The length in bytes of the data to be transferred.

Returns

Error or success status returned by API.

`void I3C_SlaveTransferCreateHandle(I3C_Type *base, i3c_slave_handle_t *handle, i3c_slave_transfer_callback_t callback, void *userData)`

Creates a new handle for the I3C slave non-blocking APIs.

The creation of a handle is for use with the non-blocking APIs. Once a handle is created, there is not a corresponding destroy handle. If the user wants to terminate a transfer, the `I3C_SlaveTransferAbort()` API shall be called.

Note: The function also enables the NVIC IRQ for the input I3C. Need to notice that on some SoCs the I3C IRQ is connected to INTMUX, in this case user needs to enable the associated INTMUX IRQ in application.

Parameters

- `base` – The I3C peripheral base address.
- `handle` – **[out]** Pointer to the I3C slave driver handle.

- `callback` – User provided pointer to the asynchronous callback function.
- `userData` – User provided pointer to the application callback data.

`status_t I3C_SlaveTransferNonBlocking(I3C_Type *base, i3c_slave_handle_t *handle, uint32_t eventMask)`

Starts accepting slave transfers.

Call this API after calling `I2C_SlaveInit()` and `I3C_SlaveTransferCreateHandle()` to start processing transactions driven by an I2C master. The slave monitors the I2C bus and pass events to the callback that was passed into the call to `I3C_SlaveTransferCreateHandle()`. The callback is always invoked from the interrupt context.

The set of events received by the callback is customizable. To do so, set the `eventMask` parameter to the OR'd combination of `i3c_slave_transfer_event_t` enumerators for the events you wish to receive. The `kI3C_SlaveTransmitEvent` and `kI3C_SlaveReceiveEvent` events are always enabled and do not need to be included in the mask. Alternatively, you can pass 0 to get a default set of only the transmit and receive events that are always enabled. In addition, the `kI3C_SlaveAllEvents` constant is provided as a convenient way to enable all events.

Parameters

- `base` – The I3C peripheral base address.
- `handle` – Pointer to struct: `_i3c_slave_handle` structure which stores the transfer state.
- `eventMask` – Bit mask formed by OR'ing together `i3c_slave_transfer_event_t` enumerators to specify which events to send to the callback. Other accepted values are 0 to get a default set of only the transmit and receive events, and `kI3C_SlaveAllEvents` to enable all events.

Return values

- `kStatus__Success` – Slave transfers were successfully started.
- `kStatus_I3C_Busy` – Slave transfers have already been started on this handle.

`status_t I3C_SlaveTransferGetCount(I3C_Type *base, i3c_slave_handle_t *handle, size_t *count)`

Gets the slave transfer status during a non-blocking transfer.

Parameters

- `base` – The I3C peripheral base address.
- `handle` – Pointer to `i2c_slave_handle_t` structure.
- `count` – **[out]** Pointer to a value to hold the number of bytes transferred. May be NULL if the count is not required.

Return values

- `kStatus__Success` –
- `kStatus_NoTransferInProgress` –

`void I3C_SlaveTransferAbort(I3C_Type *base, i3c_slave_handle_t *handle)`

Aborts the slave non-blocking transfers.

Note: This API could be called at any time to stop slave for handling the bus events.

Parameters

- `base` – The I3C peripheral base address.

- handle – Pointer to struct: `_i3c_slave_handle` structure which stores the transfer state.

Return values

- `kStatus__Success` –
- `kStatus_I3C_Idle` –

`void I3C_SlaveTransferHandleIRQ(I3C_Type *base, void *intHandle)`

Reusable routine to handle slave interrupts.

Note: This function does not need to be called unless you are reimplementing the non blocking API's interrupt handler routines to add special functionality.

Parameters

- base – The I3C peripheral base address.
- intHandle – Pointer to struct: `_i3c_slave_handle` structure which stores the transfer state.

`enum _i3c_slave_flags`

I3C slave peripheral flags.

The following status register flags can be cleared:

- `kI3C_SlaveBusStartFlag`
- `kI3C_SlaveMatchedFlag`
- `kI3C_SlaveBusStopFlag`

Only below flags can be enabled as interrupts.

- `kI3C_SlaveBusStartFlag`
- `kI3C_SlaveMatchedFlag`
- `kI3C_SlaveBusStopFlag`
- `kI3C_SlaveRxReadyFlag`
- `kI3C_SlaveTxReadyFlag`
- `kI3C_SlaveDynamicAddrChangedFlag`
- `kI3C_SlaveReceivedCCCFlag`
- `kI3C_SlaveErrorFlag`
- `kI3C_SlaveHDRCommandMatchFlag`
- `kI3C_SlaveCCCHandledFlag`
- `kI3C_SlaveEventSentFlag`

Note: These enums are meant to be OR'd together to form a bit mask.

Values:

enumerator `kI3C_SlaveNotStopFlag`

Slave status not stop flag

enumerator `kI3C_SlaveMessageFlag`

Slave status message, indicating slave is listening to the bus traffic or responding

enumerator kI3C_SlaveRequiredReadFlag

Slave status required, either is master doing SDR read from slave, or is IBI pushing out.

enumerator kI3C_SlaveRequiredWriteFlag

Slave status request write, master is doing SDR write to slave, except slave in ENTDAAMode

enumerator kI3C_SlaveBusDAAFlag

I3C bus is in ENTDAAMode

enumerator kI3C_SlaveBusHDRModeFlag

I3C bus is in HDR mode

enumerator kI3C_SlaveBusStartFlag

Start/Re-start event is seen since the bus was last cleared

enumerator kI3C_SlaveMatchedFlag

Slave address(dynamic/static) matched since last cleared

enumerator kI3C_SlaveBusStopFlag

Stop event is seen since the bus was last cleared

enumerator kI3C_SlaveRxReadyFlag

Rx data ready in rx buffer flag

enumerator kI3C_SlaveTxReadyFlag

Tx buffer ready for Tx data flag

enumerator kI3C_SlaveDynamicAddrChangedFlag

Slave dynamic address has been assigned, re-assigned, or lost

enumerator kI3C_SlaveReceivedCCCFlag

Slave received Common command code

enumerator kI3C_SlaveErrorFlag

Error occurred flag

enumerator kI3C_SlaveHDRCommandMatchFlag

High data rate command match

enumerator kI3C_SlaveCCCHandledFlag

Slave received Common command code is handled by I3C module

enumerator kI3C_SlaveEventSentFlag

Slave IBI/P2P/MR/HJ event has been sent

enumerator kI3C_SlaveIbiDisableFlag

Slave in band interrupt is disabled.

enumerator kI3C_SlaveMasterRequestDisabledFlag

Slave master request is disabled.

enumerator kI3C_SlaveHotJoinDisabledFlag

Slave Hot-Join is disabled.

enumerator kI3C_SlaveClearFlags

All flags which are cleared by the driver upon starting a transfer.

enumerator kI3C_SlaveAllIrqFlags

enum `_i3c_slave_error_flags`

I3C slave error flags to indicate the causes.

Note: These enums are meant to be OR'd together to form a bit mask.

Values:

enumerator `kI3C_SlaveErrorOvrerrunFlag`

Slave internal from-bus buffer/FIFO overrun.

enumerator `kI3C_SlaveErrorUnderrunFlag`

Slave internal to-bus buffer/FIFO underrun

enumerator `kI3C_SlaveErrorUnderrunNakFlag`

Slave internal from-bus buffer/FIFO underrun and NACK error

enumerator `kI3C_SlaveErrorTermFlag`

Terminate error from master

enumerator `kI3C_SlaveErrorInvalidStartFlag`

Slave invalid start flag

enumerator `kI3C_SlaveErrorSdrParityFlag`

SDR parity error

enumerator `kI3C_SlaveErrorHdrParityFlag`

HDR parity error

enumerator `kI3C_SlaveErrorHdrCRCFlag`

HDR-DDR CRC error

enumerator `kI3C_SlaveErrorS0S1Flag`

S0 or S1 error

enumerator `kI3C_SlaveErrorOverreadFlag`

Over-read error

enumerator `kI3C_SlaveErrorOverwriteFlag`

Over-write error

enum `_i3c_slave_event`

I3C slave.event.

Values:

enumerator `kI3C_SlaveEventNormal`

Normal mode.

enumerator `kI3C_SlaveEventIBI`

In band interrupt event.

enumerator `kI3C_SlaveEventMasterReq`

Master request event.

enumerator `kI3C_SlaveEventHotJoinReq`

Hot-join event.

enum `_i3c_slave_activity_state`

I3C slave.activity state.

Values:

enumerator kI3C_SlaveNoLatency

Normal bus operation

enumerator kI3C_SlaveLatency1Ms

1ms of latency.

enumerator kI3C_SlaveLatency100Ms

100ms of latency.

enumerator kI3C_SlaveLatency10S

10s latency.

enum _i3c_slave_transfer_event

Set of events sent to the callback for non blocking slave transfers.

These event enumerations are used for two related purposes. First, a bit mask created by OR'ing together events is passed to I3C_SlaveTransferNonBlocking() in order to specify which events to enable. Then, when the slave callback is invoked, it is passed the current event through its *transfer* parameter.

Note: These enumerations are meant to be OR'd together to form a bit mask of events.

Values:

enumerator kI3C_SlaveAddressMatchEvent

Received the slave address after a start or repeated start.

enumerator kI3C_SlaveTransmitEvent

Callback is requested to provide data to transmit (slave-transmitter role).

enumerator kI3C_SlaveReceiveEvent

Callback is requested to provide a buffer in which to place received data (slave-receiver role).

enumerator kI3C_SlaveRequiredTransmitEvent

Callback is requested to provide a buffer in which to place received data (slave-receiver role).

enumerator kI3C_SlaveStartEvent

A start/repeated start was detected.

enumerator kI3C_SlaveHDRCommandMatchEvent

Slave Match HDR Command.

enumerator kI3C_SlaveCompletionEvent

A stop was detected, completing the transfer.

enumerator kI3C_SlaveRequestSentEvent

Slave request event sent.

enumerator kI3C_SlaveReceivedCCCEvent

Slave received CCC event, need to handle by application.

enumerator kI3C_SlaveAllEvents

Bit mask of all available events.

typedef enum _i3c_slave_event i3c_slave_event_t

I3C slave.event.

typedef enum _i3c_slave_activity_state i3c_slave_activity_state_t

I3C slave.activity state.

```
typedef struct _i3c_slave_config i3c_slave_config_t
```

Structure with settings to initialize the I3C slave module.

This structure holds configuration settings for the I3C peripheral. To initialize this structure to reasonable defaults, call the I3C_SlaveGetDefaultConfig() function and pass a pointer to your configuration structure instance.

The configuration structure can be made constant so it resides in flash.

```
typedef enum _i3c_slave_transfer_event i3c_slave_transfer_event_t
```

Set of events sent to the callback for non blocking slave transfers.

These event enumerations are used for two related purposes. First, a bit mask created by OR'ing together events is passed to I3C_SlaveTransferNonBlocking() in order to specify which events to enable. Then, when the slave callback is invoked, it is passed the current event through its *transfer* parameter.

Note: These enumerations are meant to be OR'd together to form a bit mask of events.

```
typedef struct _i3c_slave_transfer i3c_slave_transfer_t
```

I3C slave transfer structure.

```
typedef struct _i3c_slave_handle i3c_slave_handle_t
```

```
typedef void (*i3c_slave_transfer_callback_t)(I3C_Type *base, i3c_slave_transfer_t *transfer, void *userData)
```

Slave event callback function pointer type.

This callback is used only for the slave non-blocking transfer API. To install a callback, use the I3C_SlaveSetCallback() function after you have created a handle.

Param base

Base address for the I3C instance on which the event occurred.

Param transfer

Pointer to transfer descriptor containing values passed to and/or from the callback.

Param userData

Arbitrary pointer-sized value passed from the application.

```
typedef void (*i3c_slave_isr_t)(I3C_Type *base, void *handle)
```

Typedef for slave interrupt handler.

```
struct _i3c_slave_config
```

#include <fsl_i3c.h> Structure with settings to initialize the I3C slave module.

This structure holds configuration settings for the I3C peripheral. To initialize this structure to reasonable defaults, call the I3C_SlaveGetDefaultConfig() function and pass a pointer to your configuration structure instance.

The configuration structure can be made constant so it resides in flash.

Public Members

bool enableSlave

Whether to enable slave.

uint8_t staticAddr

Static address.

`uint16_t` vendorID
Device vendor ID(manufacture ID).

`uint32_t` partNumber
Device part number info

`uint8_t` dcr
Device characteristics register information.

`uint8_t` bcr
Bus characteristics register information.

`uint8_t` hdrMode
Support hdr mode, could be OR logic in enumeration:`i3c_hdr_mode_t`.

`bool` nakAllRequest
Whether to reply NAK to all requests except broadcast CCC.

`bool` ignoreS0S1Error
Whether to ignore S0/S1 error in SDR mode.

`bool` offline
Whether to wait 60 us of bus quiet or HDR request to ensure slave track SDR mode safely.

`bool` matchSlaveStartStop
Whether to assert start/stop status only the time slave is addressed.

`uint32_t` maxWriteLength
Maximum write length.

`uint32_t` maxReadLength
Maximum read length.

`struct _i3c_slave_transfer`
#include <fsl_i3c.h> I3C slave transfer structure.

Public Members

`uint32_t` event
Reason the callback is being invoked.

`uint8_t *txData`
Transfer buffer

`size_t` txDataSize
Transfer size

`uint8_t *rxData`
Transfer buffer

`size_t` rxDataSize
Transfer size

`status_t` completionStatus
Success or error code describing how the transfer completed. Only applies for `kI3C_SlaveCompletionEvent`.

`size_t` transferredCount
Number of bytes actually transferred since start or last repeated start.

struct `_i3c_slave_handle`
#include <fsl_i3c.h> I3C slave handle structure.

Note: The contents of this structure are private and subject to change.

Public Members

i3c_slave_transfer_t transfer
I3C slave transfer copy.

bool isBusy
Whether transfer is busy.

bool wasTransmit
Whether the last transfer was a transmit.

uint32_t eventMask
Mask of enabled events.

uint32_t transferredCount
Count of bytes transferred.

i3c_slave_transfer_callback_t callback
Callback function called at transfer event.

void *userData
Callback parameter passed to callback.

uint8_t txFifoSize
Tx Fifo size

2.39 IAP Boot Driver

typedef struct *iap_boot_option* iap_boot_option_t
IAP boot option.

void IAP_RunBootLoader(*iap_boot_option_t* *option)
Invoke into ROM with specified boot parameters.

Parameters

- option – Boot parameters. Refer to *iap_boot_option_t*.

IAP_BOOT_OPTION_TAG
IAP boot option tag

IAP_BOOT_OPTION_MODE_MASTER
IAP boot option mode

IAP_BOOT_OPTION_MODE_ISP

struct *_iap_boot_option*
#include <fsl_iap.h> IAP boot option.

union option

Public Members

struct *_iap_boot_option* B

uint32_t U

struct B

Public Members

uint32_t bootImageIndex

reserved field.

uint32_t instance

FlexSPI boot image index for FlexSPI NOR flash.

uint32_t bootInterface

Only used when boot interface is FlexSPI/SD/MMC.

uint32_t mode

RT500: 0: USART 2: SPI 3: USB HID 4:FlexSPI 6:SD 7:MMC. RT600: 0: USART 1: I2C 2: SPI 3: USB HID 4:FlexSPI 7:SD 8:MMC

2.40 IAP: In Application Programming Driver

FSL_IAP_DRIVER_VERSION

IAP driver version.

2.41 IAP FlexSPI Driver

FlexSPI Driver status group.

Values:

enumerator kStatusGroup_FlexSPI

enumerator kStatusGroup_FlexSPINOR

enum *_flexspi_status*

FlexSPI Driver status.

Values:

enumerator kStatus_FLEXSPI_Success

API is executed successfully

enumerator kStatus_FLEXSPI_Fail

API is executed fails

enumerator kStatus_FLEXSPI_InvalidArgument

Invalid argument

enumerator kStatus_FLEXSPI_SequenceExecutionTimeout

The FlexSPI Sequence Execution timeout

enumerator kStatus_FLEXSPI_InvalidSequence
The FlexSPI LUT sequence invalid

enumerator kStatus_FLEXSPI_DeviceTimeout
The FlexSPI device timeout

enumerator kStatus_FLEXSPINOR_ProgramFail
Status for Page programming failure

enumerator kStatus_FLEXSPINOR_EraseSectorFail
Status for Sector Erase failure

enumerator kStatus_FLEXSPINOR_EraseAllFail
Status for Chip Erase failure

enumerator kStatus_FLEXSPINOR_WaitTimeout
Status for timeout

enumerator kStatus_FLEXSPINOR_NotSupported

enumerator kStatus_FLEXSPINOR_WriteAlignmentError
Status for Alignment error

enumerator kStatus_FLEXSPINOR_CommandFailure
Status for Erase/Program Verify Error

enumerator kStatus_FLEXSPINOR_SFDP_NotFound
Status for SFDP read failure

enumerator kStatus_FLEXSPINOR_Unsupported_SFDP_Version
Status for Unrecognized SFDP version

enumerator kStatus_FLEXSPINOR_Flash_NotFound
Status for Flash detection failure

enumerator kStatus_FLEXSPINOR_DTRRead_DummyProbeFailed
Status for DDR Read dummy probe failure

Flash Configuration Option0 device_type.

Values:

enumerator kSerialNorCfgOption_Tag

enumerator kSerialNorCfgOption_DeviceType_ReadSFDP_SDR

enumerator kSerialNorCfgOption_DeviceType_ReadSFDP_DDR

enumerator kSerialNorCfgOption_DeviceType_HyperFLASH1V8

enumerator kSerialNorCfgOption_DeviceType_HyperFLASH3V0

enumerator kSerialNorCfgOption_DeviceType_MacronixOctalDDR

enumerator kSerialNorCfgOption_DeviceType_MacronixOctalSDR

enumerator kSerialNorCfgOption_DeviceType_MicronOctalDDR

enumerator kSerialNorCfgOption_DeviceType_MicronOctalSDR

enumerator kSerialNorCfgOption_DeviceType_AdestoOctalDDR

enumerator kSerialNorCfgOption_DeviceType_AdestoOctalSDR

Flash Configuration Option0 quad_mode_setting.

Values:

enumerator kSerialNorQuadMode__NotConfig

enumerator kSerialNorQuadMode__StatusReg1__Bit6

enumerator kSerialNorQuadMode__StatusReg2__Bit1

enumerator kSerialNorQuadMode__StatusReg2__Bit7

enumerator kSerialNorQuadMode__StatusReg2__Bit1_0x31

Flash Configuration Option0 misc_mode.

Values:

enumerator kSerialNorEnhanceMode__Disabled

enumerator kSerialNorEnhanceMode__0_4_4_Mode

enumerator kSerialNorEnhanceMode__0_8_8_Mode

enumerator kSerialNorEnhanceMode__DataOrderSwapped

enumerator kSerialNorEnhanceMode__2ndPinMux

FLEXSPI_RESET_PIN boot configurations in OTP.

Values:

enumerator kFlashResetLogic__Disabled

enumerator kFlashResetLogic__ResetPin

enumerator kFlashResetLogic__JedecHwReset

Flash Configuration Option1 flash_connection.

Values:

enumerator kSerialNorConnection__SinglePortA

enumerator kSerialNorConnection__Parallel

enumerator kSerialNorConnection__SinglePortB

enumerator kSerialNorConnection__BothPorts

Flash Device Mode Configuration Sequence.

Values:

enumerator kRestoreSequence__None

enumerator kRestoreSequence__HW__Reset

enumerator kRestoreSequence__4QPI_FF

enumerator kRestoreSequence__5QPI_FF

enumerator kRestoreSequence_8QPI_FF
enumerator kRestoreSequence_Send_F0
enumerator kRestoreSequence_Send_66_99
enumerator kRestoreSequence_Send_6699_9966
enumerator kRestoreSequence_Send_06_FF

Flash Config Mode Definition.

Values:

enumerator kFlashInstMode_ExtendedSpi
enumerator kFlashInstMode_0_4_4_SDR
enumerator kFlashInstMode_0_4_4_DDR
enumerator kFlashInstMode_QPI_SDR
enumerator kFlashInstMode_QPI_DDR
enumerator kFlashInstMode_OPI_SDR
enumerator kFlashInstMode_OPI_DDR

Flash Device Type Definition.

Values:

enumerator kFlexSpiDeviceType_SerialNOR
Flash devices are Serial NOR
enumerator kFlexSpiDeviceType_SerialNAND
Flash devices are Serial NAND
enumerator kFlexSpiDeviceType_SerialRAM
Flash devices are Serial RAM/HyperFLASH
enumerator kFlexSpiDeviceType_MCP_NOR_NAND
Flash device is MCP device, A1 is Serial NOR, A2 is Serial NAND
enumerator kFlexSpiDeviceType_MCP_NOR_RAM
Flash device is MCP device, A1 is Serial NOR, A2 is Serial RAMs

Flash Pad Definitions.

Values:

enumerator kSerialFlash_1Pad
enumerator kSerialFlash_2Pads
enumerator kSerialFlash_4Pads
enumerator kSerialFlash_8Pads

Flash Configuration Command Type.

Values:

enumerator kDeviceConfigCmdType_Generic

Generic command, for example: configure dummy cycles, drive strength, etc

enumerator kDeviceConfigCmdType_QuadEnable

Quad Enable command

enumerator kDeviceConfigCmdType_Spi2Xpi

Switch from SPI to DPI/QPI/OPI mode

enumerator kDeviceConfigCmdType_Xpi2Spi

Switch from DPI/QPI/OPI to SPI mode

enumerator kDeviceConfigCmdType_Spi2NoCmd

Switch to 0-4-4/0-8-8 mode

enumerator kDeviceConfigCmdType_Reset

Reset device command

enum _FlexSPIOperationType

FlexSPI Operation Type.

Values:

enumerator kFlexSpiOperation_Command

FlexSPI operation: Only command, both TX and

enumerator kFlexSpiOperation_Config

RX buffer are ignored. FlexSPI operation: Configure device mode, the

enumerator kFlexSpiOperation_Write

TX FIFO size is fixed in LUT. FlexSPI operation: Write, only TX buffer is

enumerator kFlexSpiOperation_Read

effective FlexSPI operation: Read, only Rx Buffer is

enumerator kFlexSpiOperation_End

effective.

typedef struct _serial_nor_config_option serial_nor_config_option_t

Serial NOR Configuration Option.

typedef struct _lut_sequence flexspi_lut_seq_t

FlexSPI LUT Sequence structure.

typedef struct _FlexSPIConfig flexspi_mem_config_block_t

FlexSPI Memory Configuration Block.

typedef enum _FlexSPIOperationType flexspi_operation_t

FlexSPI Operation Type.

typedef struct _FlexSpiXfer flexspi_xfer_t

FlexSPI Transfer Context.

typedef struct _flexspi_nor_config flexspi_nor_config_t

Serial NOR configuration block.

AT_QUICKACCESS_SECTION_CODE (status_t IAP_FlexspiNorInit(uint32_t instance,
flexspi_nor_config_t *config))

Initialize Serial NOR devices via FlexSPI.

This function configures the FlexSPI controller with the arguments pointed by param config.

Parameters

- `instance` – FlexSPI controller instance, only support 0.
- `config` – The Flash configuration block. Refer to `flexspi_nor_config_t`.

Returns

The status flags. This is a member of the enumeration `_flexspi_status`

`status_t` IAP_FlexspiNorPageProgram(`uint32_t` instance, *flexspi_nor_config_t* *config, `uint32_t` dstAddr, const `uint32_t` *src)

Program data to Serial NOR via FlexSPI.

This function Program data to specified destination address.

Parameters

- `instance` – FlexSPI controller instance, only support 0.
- `config` – The Flash configuration block. Refer to `flexspi_nor_config_t`.
- `dstAddr` – The destination address to be programmed.
- `src` – Points to the buffer which hold the data to be programmed.

Returns

The status flags. This is a member of the enumeration `_flexspi_status`

`status_t` IAP_FlexspiNorEraseAll(`uint32_t` instance, *flexspi_nor_config_t* *config)

Erase all the Serial NOR devices connected on FlexSPI.

Parameters

- `instance` – FlexSPI controller instance, only support 0.
- `config` – The Flash configuration block. Refer to `flexspi_nor_config_t`.

Returns

The status flags. This is a member of the enumeration `_flexspi_status`

`status_t` IAP_FlexspiNorErase(`uint32_t` instance, *flexspi_nor_config_t* *config, `uint32_t` start, `uint32_t` length)

Erase Flash Region specified by address and length.

Parameters

- `instance` – FlexSPI controller instance, only support 0.
- `config` – The Flash configuration block. Refer to `flexspi_nor_config_t`.
- `start` – The start address to be erased.
- `length` – The length to be erased.

Returns

The status flags. This is a member of the enumeration `_flexspi_status`

`status_t` IAP_FlexspiNorEraseSector(`uint32_t` instance, *flexspi_nor_config_t* *config, `uint32_t` address)

Erase one sector specified by address.

Parameters

- `instance` – FlexSPI controller instance, only support 0.
- `config` – The Flash configuration block. Refer to `flexspi_nor_config_t`.
- `address` – The address of the sector to be erased.

Returns

The status flags. This is a member of the enumeration `_flexspi_status`

status_t IAP_FlexspiNorEraseBlock(uint32_t instance, *flexspi_nor_config_t* *config, uint32_t address)

Erase one block specified by address.

Parameters

- instance – FlexSPI controller instance, only support 0.
- config – The Flash configuration block. Refer to *flexspi_nor_config_t*.
- address – The address of the block to be erased.

Returns

The status flags. This is a member of the enumeration *_flexspi_status*

status_t IAP_FlexspiNorGetConfig(uint32_t instance, *flexspi_nor_config_t* *config, *serial_nor_config_option_t* *option)

Get FlexSPI NOR Configuration Block based on specified option.

Parameters

- instance – FlexSPI controller instance, only support 0.
- config – The Flash configuration block. Refer to *flexspi_nor_config_t*.
- option – The Flash Configuration Option block. Refer to *serial_nor_config_option_t*.

Returns

The status flags. This is a member of the enumeration *_flexspi_status*

status_t IAP_FlexspiNorRead(uint32_t instance, *flexspi_nor_config_t* *config, uint32_t *dst, uint32_t start, uint32_t bytes)

Read data from Flexspi NOR Flash.

Parameters

- instance – FlexSPI controller instance, only support 0.
- config – The Flash configuration block. Refer to *flexspi_nor_config_t*.
- dst – Buffer address used to store the read data.
- start – The Read address.
- bytes – The Read size

Returns

The status flags. This is a member of the enumeration *_flexspi_status*

status_t IAP_FlexspiXfer(uint32_t instance, *flexspi_xfer_t* *xfer)

Get FlexSPI Xfer data.

Parameters

- instance – FlexSPI controller instance, only support 0.
- xfer – The FlexSPI Transfer Context block. Refer to *flexspi_xfer_t*.

Returns

The status flags. This is a member of the enumeration *_flexspi_status*

status_t IAP_FlexspiUpdateLut(uint32_t instance, uint32_t seqIndex, const uint32_t *lutBase, uint32_t numberOfSeq)

Update FlexSPI Lookup table.

Parameters

- instance – FlexSPI controller instance, only support 0.
- seqIndex – The index of FlexSPI LUT to be updated.

- lutBase – Points to the buffer which hold the LUT data to be programmed.
- numberOfSeq – The number of LUT seq that need to be updated.

Returns

The status flags. This is a member of the enumeration `_flexspi_status`

`status_t IAP_FlexspiSetClockSource(uint32_t clockSrc)`

Set the clock source for FlexSPI.

Parameters

- clockSrc – Clock source for flexspi interface.

Returns

The status flags. This is a member of the enumeration `_flexspi_status`

`void IAP_FlexspiConfigClock(uint32_t instance, uint32_t freqOption, uint32_t sampleClkMode)`

Configure the flexspi interface clock frequency and data sample mode.

Parameters

- instance – FlexSPI controller instance, only support 0.
- freqOption – FlexSPI interface clock frequency selection.
- sampleClkMode – FlexSPI controller data sample mode.

Returns

The status flags. This is a member of the enumeration `_flexspi_status`

`AT_QUICKACCESS_SECTION_CODE (status_t IAP_FlexspiNorAutoConfig(uint32_t instance, flexspi_nor_config_t *config, serial_nor_config_option_t *option))`

Configure flexspi nor automatically.

Parameters

- instance – FlexSPI controller instance, only support 0.
- config – The Flash configuration block. Refer to `flexspi_nor_config_t`.
- option – The Flash Configuration Option block. Refer to `serial_nor_config_option_t`.

Returns

The status flags. This is a member of the enumeration `_flexspi_status`

`NOR_CMD_INDEX_READ`

FlexSPI LUT command.

0

`NOR_CMD_INDEX_READSTATUS`

1

`NOR_CMD_INDEX_WRITEENABLE`

2

`NOR_CMD_INDEX_ERASESECTOR`

3

`NOR_CMD_INDEX_PAGEPROGRAM`

4

`NOR_CMD_INDEX_CHIPERASE`

5

NOR_CMD_INDEX_DUMMY

6

NOR_CMD_INDEX_ERASEBLOCK

7

NOR_CMD_LUT_SEQ_IDX_READ

0 READ LUT sequence id in lookupTable stored in config block

NOR_CMD_LUT_SEQ_IDX_READSTATUS

1 Read Status LUT sequence id in lookupTable stored in config block

NOR_CMD_LUT_SEQ_IDX_READSTATUS_XPI

2 Read status DPI/QPI/OPI sequence id in lookupTable stored in config block

NOR_CMD_LUT_SEQ_IDX_WRITEENABLE

3 Write Enable sequence id in lookupTable stored in config block

NOR_CMD_LUT_SEQ_IDX_WRITEENABLE_XPI

4 Write Enable DPI/QPI/OPI sequence id in lookupTable stored in config block

NOR_CMD_LUT_SEQ_IDX_ERASESECTOR

5 Erase Sector sequence id in lookupTable stored in config block

NOR_CMD_LUT_SEQ_IDX_ERASEBLOCK

8 Erase Block sequence id in lookupTable stored in config block

NOR_CMD_LUT_SEQ_IDX_PAGEPROGRAM

9 Program sequence id in lookupTable stored in config block

NOR_CMD_LUT_SEQ_IDX_CHIPERASE

11 Chip Erase sequence in lookupTable id stored in config block

NOR_CMD_LUT_SEQ_IDX_READ_SFDP

13 Read SFDP sequence in lookupTable id stored in config block

NOR_CMD_LUT_SEQ_IDX_RESTORE_NOCMD

14 Restore 0-4-4/0-8-8 mode sequence id in lookupTable stored in config block

NOR_CMD_LUT_SEQ_IDX_EXIT_NOCMD

15 Exit 0-4-4/0-8-8 mode sequence id in lookupTable stored in config block

struct _serial_nor_config_option

#include <fsl_iap.h> Serial NOR Configuration Option.

union flash_run_context_t

#include <fsl_iap.h> Flash Run Context.

Public Members

struct *flash_run_context_t* B

uint32_t U

struct _lut_sequence

#include <fsl_iap.h> FlexSPI LUT Sequence structure.

Public Members

`uint8_t seqNum`
Sequence Number, valid number: 1-16

`uint8_t seqId`
Sequence Index, valid number: 0-15

`struct flexspi_dll_time_t`
#include <fsl_iap.h> FlexSPI Dll Time Block.

`struct __FlexSPIConfig`
#include <fsl_iap.h> FlexSPI Memory Configuration Block.

Public Members

`uint32_t tag`
[0x000-0x003] Tag, fixed value 0x42464346UL

`uint32_t version`
[0x004-0x007] Version, [31:24] - 'V', [23:16] - Major, [15:8] - Minor, [7:0] - bugfix

`uint32_t reserved0`
[0x008-0x00b] Reserved for future use

`uint8_t readSampleClkSrc`
[0x00c-0x00c] Read Sample Clock Source, valid value: 0/1/3

`uint8_t csHoldTime`
[0x00d-0x00d] CS hold time, default value: 3

`uint8_t csSetupTime`
[0x00e-0x00e] CS setup time, default value: 3

`uint8_t columnAddressWidth`
[0x00f-0x00f] Column Address with, for HyperBus protocol, it is fixed to 3, For

`uint8_t deviceModeCfgEnable`
Serial NAND, need to refer to datasheet [0x010-0x010] Device Mode Configure enable flag, 1 - Enable, 0 - Disable

`uint8_t deviceModeType`
[0x011-0x011] Specify the configuration command type: Quad Enable, DPI/QPI/OPI switch,

`uint16_t waitTimeCfgCommands`
Generic configuration, etc. [0x012-0x013] Wait time for all configuration commands, unit: 100us, Used for

flexspi_lut_seq_t deviceModeSeq
DPI/QPI/OPI switch or reset command [0x014-0x017] Device mode sequence info, [7:0] - LUT sequence id, [15:8] - LUT

`uint32_t deviceModeArg`
sequence number, [31:16] Reserved [0x018-0x01b] Argument/Parameter for device configuration

`uint8_t configCmdEnable`
[0x01c-0x01c] Configure command Enable Flag, 1 - Enable, 0 - Disable

`uint8_t configModeType[3]`
[0x01d-0x01f] Configure Mode Type, similar as `deviceModeType`

`flexspi_lut_seq_t configCmdSeqs[3]`
[0x020-0x02b] Sequence info for Device Configuration command, similar as `deviceModeSeq`

`uint32_t reserved1`
[0x02c-0x02f] Reserved for future use

`uint32_t configCmdArgs[3]`
[0x030-0x03b] Arguments/Parameters for device Configuration commands

`uint32_t reserved2`
[0x03c-0x03f] Reserved for future use

`uint32_t controllerMiscOption`
[0x040-0x043] Controller Misc Options, see Misc feature bit definitions for more

`uint8_t deviceType`
details [0x044-0x044] Device Type: See Flash Type Definition for more details

`uint8_t sflashPadType`
[0x045-0x045] Serial Flash Pad Type: 1 - Single, 2 - Dual, 4 - Quad, 8 - Octal

`uint8_t serialClkFreq`
[0x046-0x046] Serial Flash Frequency, device specific definitions, See System Boot

`uint8_t lutCustomSeqEnable`
Chapter for more details [0x047-0x047] LUT customization Enable, it is required if the program/erase cannot

`uint32_t reserved3[2]`
be done using 1 LUT sequence, currently, only applicable to HyperFLASH [0x048-0x04f] Reserved for future use

`uint32_t sflashA1Size`
[0x050-0x053] Size of Flash connected to A1

`uint32_t sflashA2Size`
[0x054-0x057] Size of Flash connected to A2

`uint32_t sflashB1Size`
[0x058-0x05b] Size of Flash connected to B1

`uint32_t sflashB2Size`
[0x05c-0x05f] Size of Flash connected to B2

`uint32_t csPadSettingOverride`
[0x060-0x063] CS pad setting override value

`uint32_t sclkPadSettingOverride`
[0x064-0x067] SCK pad setting override value

`uint32_t dataPadSettingOverride`
[0x068-0x06b] data pad setting override value

`uint32_t dqsPadSettingOverride`
[0x06c-0x06f] DQS pad setting override value

`uint32_t timeoutInMs`
[0x070-0x073] Timeout threshold for read status command

`uint32_t` `commandInterval`
[0x074-0x077] CS deselect interval between two commands

`flexspi_dll_time_t` `dataValidTime[2]`
[0x078-0x07b] CLK edge to data valid time for PORT A and PORT B

`uint16_t` `busyOffset`
[0x07c-0x07d] Busy offset, valid value: 0-31

`uint16_t` `busyBitPolarity`
[0x07e-0x07f] Busy flag polarity, 0 - busy flag is 1 when flash device is busy, 1 -

`uint32_t` `lookupTable[64]`
busy flag is 0 when flash device is busy [0x080-0x17f] Lookup table holds Flash command sequences

`flexspi_lut_seq_t` `lutCustomSeq[12]`
[0x180-0x1af] Customizable LUT Sequences

`uint32_t` `reserved4[4]`
[0x1b0-0x1bf] Reserved for future use

`struct _FlexSpiXfer`
#include <fsl_iap.h> FlexSPI Transfer Context.

Public Members

`flexspi_operation_t` `operation`
FlexSPI operation

`uint32_t` `baseAddress`
FlexSPI operation base address

`uint32_t` `seqId`
Sequence Id

`uint32_t` `seqNum`
Sequence Number

`bool` `isParallelModeEnable`
Is a parallel transfer

`uint32_t` `*txBuffer`
Tx buffer

`uint32_t` `txSize`
Tx size in bytes

`uint32_t` `*rxBuffer`
Rx buffer

`uint32_t` `rxSize`
Rx size in bytes

`struct _flexspi_nor_config`
#include <fsl_iap.h> Serial NOR configuration block.

Public Members

flexspi_mem_config_block_t memConfig
Common memory configuration info via FlexSPI

uint32_t pageSize
Page size of Serial NOR

uint32_t sectorSize
Sector size of Serial NOR

uint8_t ipcmdSerialClkFreq
Clock frequency for IP command

uint8_t isUniformBlockSize
Sector/Block size is the same

uint8_t isDataOrderSwapped
Data order (D0, D1, D2, D3) is swapped (D1,D0, D3, D2)

uint8_t reserved0[1]
Reserved for future use

uint8_t serialNorType
Serial NOR Flash type: 0/1/2/3

uint8_t needExitNoCmdMode
Need to exit NoCmd mode before other IP command

uint8_t halfClkForNonReadCmd
Half the Serial Clock for non-read command: true/false

uint8_t needRestoreNoCmdMode
Need to Restore NoCmd mode after IP commmand execution

uint32_t blockSize
Block size

uint32_t flashStateCtx
Flash State Context

uint32_t reserve2[10]
Reserved for future use

union option0

Public Members

struct *_serial_nor_config_option* B

uint32_t U

struct B

Public Members

uint32_t max_freq
Maximum supported Frequency

uint32_t misc_mode
miscellaneous mode

uint32_t quad_mode_setting

Quad mode setting

uint32_t cmd_pads

Command pads

uint32_t query_pads

SFDP read pads

uint32_t device_type

Device type

uint32_t option_size

Option size, in terms of uint32_t, size = (option_size + 1) * 4

uint32_t tag

Tag, must be 0x0C

union option1

Public Members

struct *_serial_nor_config_option* B

uint32_t U

struct B

Public Members

uint32_t dummy_cycles

Dummy cycles before read

uint32_t status_override

Override status register value during device mode configuration

uint32_t pinmux_group

The pinmux group selection

uint32_t dqs_pinmux_group

The DQS Pinmux Group Selection

uint32_t drive_strength

The Drive Strength of FlexSPI Pads

uint32_t flash_connection

Flash connection option: 0 - Single Flash connected to port A, 1 -

struct B

2.42 IAP OTP Driver

OTP Status Group.

Values:

enumerator kStatusGroup_OtpGroup

OTP Error Status definitions.

Values:

enumerator kStatus_OTP_InvalidAddress
Invalid OTP address

enumerator kStatus_OTP_ProgramFail
Program Fail

enumerator kStatus_OTP_CrcFail
CrcCheck Fail

enumerator kStatus_OTP_Error
Errors happened during OTP operation

enumerator kStatus_OTP_EccCheckFail
Ecc Check failed during OTP operation

enumerator kStatus_OTP_Locked
OTP Fuse field has been locked

enumerator kStatus_OTP_Timeout
OTP operation time out

enumerator kStatus_OTP_CrcCheckPass
OTP CRC Check Pass

status_t IAP_OtpInit(uint32_t src_clk_freq)

Initialize OTP controller.

This function enables OTP Controller clock.

Parameters

- src_clk_freq – The Frequency of the source clock of OTP controller

Returns

kStatus_Success

status_t IAP_OtpDeinit(void)

De-Initialize OTP controller.

This function disables OTP Controller Clock.

Returns

kStatus_Success

status_t IAP_OtpFuseRead(uint32_t addr, uint32_t *data)

Read Fuse value from OTP Fuse Block.

This function read fuse data from OTP Fuse block to specified data buffer.

Parameters

- addr – Fuse address
- data – Buffer to hold the data read from OTP Fuse block

Returns

kStatus_Success - Data read from OTP Fuse block successfully
kStatus_InvalidArgument - data pointer is invalid
kStatus_OTP_EccCheckFail - Ecc Check Failed
kStatus_OTP_Error - Other Errors

status_t IAP_OtpFuseProgram(uint32_t addr, uint32_t data, bool lock)

Program value to OTP Fuse block.

This function program data to specified OTP Fuse address.

Parameters

- addr – Fuse address
- data – data to be programmed into OTP Fuse block
- lock – lock the fuse field or not

Returns

kStatus_Success - Data has been programmed into OTP Fuse block successfully
kStatus_OTP_ProgramFail - Fuse programming failed
kStatus_OTP_Locked - The address to be programmed into is locked
kStatus_OTP_Error - Other Errors

status_t IAP_OtpShadowRegisterReload(void)

Reload all shadow registers from OTP fuse block.

This function reloads all the shadow registers from OTP Fuse block

Returns

kStatus_Success - Shadow registers' reloading succeeded.
kStatus_OTP_EccCheckFail - Ecc Check Failed
kStatus_OTP_Error - Other Errors

status_t IAP_OtpCrcCheck(uint32_t start_addr, uint32_t end_addr, uint32_t crc_addr)

Do CRC Check via OTP controller.

This function checks whether data in specified fuse address ranges match the crc value in the specified CRC address and return the actual crc value as needed.

Parameters

- start_addr – Start address of selected Fuse address range
- end_addr – End address of selected Fuse address range
- crc_addr – Address that hold CRC data

Returns

kStatus_Success CRC check succeeded, CRC value matched.
kStatus_InvalidArgument - Invalid Argument
kStatus_OTP_EccCheckFail Ecc Check Failed
kStatus_OTP_CrcFail CRC Check Failed

status_t IAP_OtpCrcCalc(uint32_t *src, uint32_t numberOfWords, uint32_t *crcChecksum)

Calculate the CRC checksum for specified data for OTP.

This function calculates the CRC checksum for specified data for OTP

Parameters

- src – the source address of data
- numberOfWords – number of Fuse words
- crcChecksum – Buffer to store the CRC checksum

Returns

kStatus_Success CRC checksum is computed successfully.
kStatus_InvalidArgument - Invalid Argument

2.43 INPUTMUX: Input Multiplexing Driver

FSL_INPUTMUX_DRIVER_VERSION

Group interrupt driver version for SDK.

enum __inputmux_connection_t

INPUTMUX connections type.

Values:

enumerator kINPUTMUX_Sct0PinInp0ToSct0
SCT INMUX.

enumerator kINPUTMUX_Sct0PinInp1ToSct0

enumerator kINPUTMUX_Sct0PinInp2ToSct0

enumerator kINPUTMUX_Sct0PinInp3ToSct0

enumerator kINPUTMUX_Sct0PinInp4ToSct0

enumerator kINPUTMUX_Sct0PinInp5ToSct0

enumerator kINPUTMUX_Sct0PinInp6ToSct0

enumerator kINPUTMUX_Sct0PinInp7ToSct0

enumerator kINPUTMUX_Ctimer0Mat0ToSct0

enumerator kINPUTMUX_Ctimer1Mat0ToSct0

enumerator kINPUTMUX_Ctimer2Mat0ToSct0

enumerator kINPUTMUX_Ctimer3Mat0ToSct0

enumerator kINPUTMUX_Ctimer4Mat0ToSct0

enumerator kINPUTMUX_AdcIrqToSct0

enumerator kINPUTMUX_GpioIntBmatchToSct0

enumerator kINPUTMUX_Usb1FrameToggleToSct0

enumerator kINPUTMUX_Cmp0OutToSct0

enumerator kINPUTMUX_SharedI2s0SclkToSct0

enumerator kINPUTMUX_SharedI2s1SclkToSct0

enumerator kINPUTMUX_SharedI2s0WsToSct0

enumerator kINPUTMUX_SharedI2s1WsToSct0

enumerator kINPUTMUX_MclkToSct0

enumerator kINPUTMUX_ArmTxevToSct0

enumerator kINPUTMUX_DebugHaltedToSct0

Pin Interrupt.

enumerator kINPUTMUX_GpioPort0Pin0ToPintsel

enumerator kINPUTMUX_GpioPort0Pin1ToPintsel

enumerator kINPUTMUX_GpioPort0Pin2ToPintsel

enumerator kINPUTMUX_GpioPort0Pin3ToPintsel

enumerator kINPUTMUX_GpioPort0Pin4ToPintsel
enumerator kINPUTMUX_GpioPort0Pin5ToPintsel
enumerator kINPUTMUX_GpioPort0Pin6ToPintsel
enumerator kINPUTMUX_GpioPort0Pin7ToPintsel
enumerator kINPUTMUX_GpioPort0Pin8ToPintsel
enumerator kINPUTMUX_GpioPort0Pin9ToPintsel
enumerator kINPUTMUX_GpioPort0Pin10ToPintsel
enumerator kINPUTMUX_GpioPort0Pin11ToPintsel
enumerator kINPUTMUX_GpioPort0Pin12ToPintsel
enumerator kINPUTMUX_GpioPort0Pin13ToPintsel
enumerator kINPUTMUX_GpioPort0Pin14ToPintsel
enumerator kINPUTMUX_GpioPort0Pin15ToPintsel
enumerator kINPUTMUX_GpioPort0Pin16ToPintsel
enumerator kINPUTMUX_GpioPort0Pin17ToPintsel
enumerator kINPUTMUX_GpioPort0Pin18ToPintsel
enumerator kINPUTMUX_GpioPort0Pin19ToPintsel
enumerator kINPUTMUX_GpioPort0Pin20ToPintsel
enumerator kINPUTMUX_GpioPort0Pin21ToPintsel
enumerator kINPUTMUX_GpioPort0Pin22ToPintsel
enumerator kINPUTMUX_GpioPort0Pin23ToPintsel
enumerator kINPUTMUX_GpioPort0Pin24ToPintsel
enumerator kINPUTMUX_GpioPort0Pin25ToPintsel
enumerator kINPUTMUX_GpioPort0Pin26ToPintsel
enumerator kINPUTMUX_GpioPort0Pin27ToPintsel
enumerator kINPUTMUX_GpioPort0Pin28ToPintsel
enumerator kINPUTMUX_GpioPort0Pin29ToPintsel
enumerator kINPUTMUX_GpioPort0Pin30ToPintsel
enumerator kINPUTMUX_GpioPort0Pin31ToPintsel
enumerator kINPUTMUX_GpioPort1Pin0ToPintsel
enumerator kINPUTMUX_GpioPort1Pin1ToPintsel
enumerator kINPUTMUX_GpioPort1Pin2ToPintsel
enumerator kINPUTMUX_GpioPort1Pin3ToPintsel
enumerator kINPUTMUX_GpioPort1Pin4ToPintsel

enumerator kINPUTMUX_GpioPort1Pin5ToPintsel
enumerator kINPUTMUX_GpioPort1Pin6ToPintsel
enumerator kINPUTMUX_GpioPort1Pin7ToPintsel
enumerator kINPUTMUX_GpioPort1Pin8ToPintsel
enumerator kINPUTMUX_GpioPort1Pin9ToPintsel
enumerator kINPUTMUX_GpioPort1Pin10ToPintsel
enumerator kINPUTMUX_GpioPort1Pin11ToPintsel
enumerator kINPUTMUX_GpioPort1Pin12ToPintsel
enumerator kINPUTMUX_GpioPort1Pin13ToPintsel
enumerator kINPUTMUX_GpioPort1Pin14ToPintsel
enumerator kINPUTMUX_GpioPort1Pin15ToPintsel
enumerator kINPUTMUX_GpioPort1Pin16ToPintsel
enumerator kINPUTMUX_GpioPort1Pin17ToPintsel
enumerator kINPUTMUX_GpioPort1Pin18ToPintsel
enumerator kINPUTMUX_GpioPort1Pin19ToPintsel
enumerator kINPUTMUX_GpioPort1Pin20ToPintsel
enumerator kINPUTMUX_GpioPort1Pin21ToPintsel
enumerator kINPUTMUX_GpioPort1Pin22ToPintsel
enumerator kINPUTMUX_GpioPort1Pin23ToPintsel
enumerator kINPUTMUX_GpioPort1Pin24ToPintsel
enumerator kINPUTMUX_GpioPort1Pin25ToPintsel
enumerator kINPUTMUX_GpioPort1Pin26ToPintsel
enumerator kINPUTMUX_GpioPort1Pin27ToPintsel
enumerator kINPUTMUX_GpioPort1Pin28ToPintsel
enumerator kINPUTMUX_GpioPort1Pin29ToPintsel
enumerator kINPUTMUX_GpioPort1Pin30ToPintsel
enumerator kINPUTMUX_GpioPort1Pin31ToPintsel
 DSP Interrupt.
enumerator kINPUTMUX_Flexcomm0ToDspInterrupt
enumerator kINPUTMUX_Flexcomm1ToDspInterrupt
enumerator kINPUTMUX_Flexcomm2ToDspInterrupt
enumerator kINPUTMUX_Flexcomm3ToDspInterrupt
enumerator kINPUTMUX_Flexcomm4ToDspInterrupt

enumerator kINPUTMUX_Flexcomm5ToDspInterrupt
enumerator kINPUTMUX_Flexcomm6ToDspInterrupt
enumerator kINPUTMUX_Flexcomm7ToDspInterrupt
enumerator kINPUTMUX_GpioInt0ToDspInterrupt
enumerator kINPUTMUX_GpioInt1ToDspInterrupt
enumerator kINPUTMUX_GpioInt2ToDspInterrupt
enumerator kINPUTMUX_GpioInt3ToDspInterrupt
enumerator kINPUTMUX_GpioInt4ToDspInterrupt
enumerator kINPUTMUX_GpioInt5ToDspInterrupt
enumerator kINPUTMUX_GpioInt6ToDspInterrupt
enumerator kINPUTMUX_GpioInt7ToDspInterrupt
enumerator kINPUTMUX_NsHsGpioInt0ToDspInterrupt
enumerator kINPUTMUX_NsHsGpioInt1ToDspInterrupt
enumerator kINPUTMUX_Wdt1ToDspInterrupt
enumerator kINPUTMUX_Dmac0ToDspInterrupt
enumerator kINPUTMUX_Dmac1ToDspInterrupt
enumerator kINPUTMUX_MuBToDspInterrupt
enumerator kINPUTMUX_Utick0ToDspInterrupt
enumerator kINPUTMUX_Mrt0ToDspInterrupt
enumerator kINPUTMUX_OsEventTimerToDspInterrupt
enumerator kINPUTMUX_Ctimer0ToDspInterrupt
enumerator kINPUTMUX_Ctimer1ToDspInterrupt
enumerator kINPUTMUX_Ctimer2ToDspInterrupt
enumerator kINPUTMUX_Ctimer3ToDspInterrupt
enumerator kINPUTMUX_Ctimer4ToDspInterrupt
enumerator kINPUTMUX_RtcToDspInterrupt
enumerator kINPUTMUX_I3c0ToDspInterrupt
enumerator kINPUTMUX_Dmic0ToDspInterrupt
enumerator kINPUTMUX_Hwvad0ToDspInterrupt
enumerator kINPUTMUX_FlexspiToDspInterrupt
 Frequency measure.
enumerator kINPUTMUX_XtalinToFreqmeas
enumerator kINPUTMUX_SfroToFreqmeas

enumerator kINPUTMUX_FfroToFreqmeas
enumerator kINPUTMUX_LposcToFreqmeas
enumerator kINPUTMUX_Rtc32KhzOscToFreqmeas
enumerator kINPUTMUX_MainSysClkToFreqmeas
enumerator kINPUTMUX_FreqmeGpioClkToFreqmeas
 CTmier0 capture input mux.
enumerator kINPUTMUX_CtInp0ToTimer0CaptureChannels
enumerator kINPUTMUX_CtInp1ToTimer0CaptureChannels
enumerator kINPUTMUX_CtInp2ToTimer0CaptureChannels
enumerator kINPUTMUX_CtInp3ToTimer0CaptureChannels
enumerator kINPUTMUX_CtInp4ToTimer0CaptureChannels
enumerator kINPUTMUX_CtInp5ToTimer0CaptureChannels
enumerator kINPUTMUX_CtInp6ToTimer0CaptureChannels
enumerator kINPUTMUX_CtInp7ToTimer0CaptureChannels
enumerator kINPUTMUX_CtInp8ToTimer0CaptureChannels
enumerator kINPUTMUX_CtInp9ToTimer0CaptureChannels
enumerator kINPUTMUX_CtInp10ToTimer0CaptureChannels
enumerator kINPUTMUX_CtInp11ToTimer0CaptureChannels
enumerator kINPUTMUX_CtInp12ToTimer0CaptureChannels
enumerator kINPUTMUX_CtInp13ToTimer0CaptureChannels
enumerator kINPUTMUX_CtInp14ToTimer0CaptureChannels
enumerator kINPUTMUX_CtInp15ToTimer0CaptureChannels
enumerator kINPUTMUX_SharedI2s0WsToTimer0CaptureChannels
enumerator kINPUTMUX_SharedI2s1WsToTimer0CaptureChannels
enumerator kINPUTMUX_Usb1FrameToggleToTimer0CaptureChannels
 CTmier1 capture input mux.
enumerator kINPUTMUX_CtInp0ToTimer1CaptureChannels
enumerator kINPUTMUX_CtInp1ToTimer1CaptureChannels
enumerator kINPUTMUX_CtInp2ToTimer1CaptureChannels
enumerator kINPUTMUX_CtInp3ToTimer1CaptureChannels
enumerator kINPUTMUX_CtInp4ToTimer1CaptureChannels
enumerator kINPUTMUX_CtInp5ToTimer1CaptureChannels
enumerator kINPUTMUX_CtInp6ToTimer1CaptureChannels
enumerator kINPUTMUX_CtInp7ToTimer1CaptureChannels

enumerator kINPUTMUX_CtInp8ToTimer1CaptureChannels
enumerator kINPUTMUX_CtInp9ToTimer1CaptureChannels
enumerator kINPUTMUX_CtInp10ToTimer1CaptureChannels
enumerator kINPUTMUX_CtInp11ToTimer1CaptureChannels
enumerator kINPUTMUX_CtInp12ToTimer1CaptureChannels
enumerator kINPUTMUX_CtInp13ToTimer1CaptureChannels
enumerator kINPUTMUX_CtInp14ToTimer1CaptureChannels
enumerator kINPUTMUX_CtInp15ToTimer1CaptureChannels
enumerator kINPUTMUX_SharedI2s0WsToTimer1CaptureChannels
enumerator kINPUTMUX_SharedI2s1WsToTimer1CaptureChannels
enumerator kINPUTMUX_Usb1FrameToggleToTimer1CaptureChannels
 CTmier2 capture input mux.
enumerator kINPUTMUX_CtInp0ToTimer2CaptureChannels
enumerator kINPUTMUX_CtInp1ToTimer2CaptureChannels
enumerator kINPUTMUX_CtInp2ToTimer2CaptureChannels
enumerator kINPUTMUX_CtInp3ToTimer2CaptureChannels
enumerator kINPUTMUX_CtInp4ToTimer2CaptureChannels
enumerator kINPUTMUX_CtInp5ToTimer2CaptureChannels
enumerator kINPUTMUX_CtInp6ToTimer2CaptureChannels
enumerator kINPUTMUX_CtInp7ToTimer2CaptureChannels
enumerator kINPUTMUX_CtInp8ToTimer2CaptureChannels
enumerator kINPUTMUX_CtInp9ToTimer2CaptureChannels
enumerator kINPUTMUX_CtInp10ToTimer2CaptureChannels
enumerator kINPUTMUX_CtInp11ToTimer2CaptureChannels
enumerator kINPUTMUX_CtInp12ToTimer2CaptureChannels
enumerator kINPUTMUX_CtInp13ToTimer2CaptureChannels
enumerator kINPUTMUX_CtInp14ToTimer2CaptureChannels
enumerator kINPUTMUX_CtInp15ToTimer2CaptureChannels
enumerator kINPUTMUX_SharedI2s0WsToTimer2CaptureChannels
enumerator kINPUTMUX_SharedI2s1WsToTimer2CaptureChannels
enumerator kINPUTMUX_Usb1FrameToggleToTimer2CaptureChannels
 CTmier3 capture input mux.
enumerator kINPUTMUX_CtInp0ToTimer3CaptureChannels
enumerator kINPUTMUX_CtInp1ToTimer3CaptureChannels

enumerator kINPUTMUX_CtInp2ToTimer3CaptureChannels
enumerator kINPUTMUX_CtInp3ToTimer3CaptureChannels
enumerator kINPUTMUX_CtInp4ToTimer3CaptureChannels
enumerator kINPUTMUX_CtInp5ToTimer3CaptureChannels
enumerator kINPUTMUX_CtInp6ToTimer3CaptureChannels
enumerator kINPUTMUX_CtInp7ToTimer3CaptureChannels
enumerator kINPUTMUX_CtInp8ToTimer3CaptureChannels
enumerator kINPUTMUX_CtInp9ToTimer3CaptureChannels
enumerator kINPUTMUX_CtInp10ToTimer3CaptureChannels
enumerator kINPUTMUX_CtInp11ToTimer3CaptureChannels
enumerator kINPUTMUX_CtInp12ToTimer3CaptureChannels
enumerator kINPUTMUX_CtInp13ToTimer3CaptureChannels
enumerator kINPUTMUX_CtInp14ToTimer3CaptureChannels
enumerator kINPUTMUX_CtInp15ToTimer3CaptureChannels
enumerator kINPUTMUX_SharedI2s0WsToTimer3CaptureChannels
enumerator kINPUTMUX_SharedI2s1WsToTimer3CaptureChannels
enumerator kINPUTMUX_Usb1FrameToggleToTimer3CaptureChannels
CTmier4 capture input mux.
enumerator kINPUTMUX_CtInp0ToTimer4CaptureChannels
enumerator kINPUTMUX_CtInp1ToTimer4CaptureChannels
enumerator kINPUTMUX_CtInp2ToTimer4CaptureChannels
enumerator kINPUTMUX_CtInp3ToTimer4CaptureChannels
enumerator kINPUTMUX_CtInp4ToTimer4CaptureChannels
enumerator kINPUTMUX_CtInp5ToTimer4CaptureChannels
enumerator kINPUTMUX_CtInp6ToTimer4CaptureChannels
enumerator kINPUTMUX_CtInp7ToTimer4CaptureChannels
enumerator kINPUTMUX_CtInp8ToTimer4CaptureChannels
enumerator kINPUTMUX_CtInp9ToTimer4CaptureChannels
enumerator kINPUTMUX_CtInp10ToTimer4CaptureChannels
enumerator kINPUTMUX_CtInp11ToTimer4CaptureChannels
enumerator kINPUTMUX_CtInp12ToTimer4CaptureChannels
enumerator kINPUTMUX_CtInp13ToTimer4CaptureChannels
enumerator kINPUTMUX_CtInp14ToTimer4CaptureChannels

enumerator kINPUTMUX__CtInp15ToTimer4CaptureChannels
enumerator kINPUTMUX__SharedI2s0WsToTimer4CaptureChannels
enumerator kINPUTMUX__SharedI2s1WsToTimer4CaptureChannels
enumerator kINPUTMUX__Usb1FrameToggleToTimer4CaptureChannels
DMA0 ITRIG.
enumerator kINPUTMUX__NsGpioPint0Int0ToDma0
enumerator kINPUTMUX__NsGpioPint0Int1ToDma0
enumerator kINPUTMUX__NsGpioPint0Int2ToDma0
enumerator kINPUTMUX__NsGpioPint0Int3ToDma0
enumerator kINPUTMUX__Ctimer0M0ToDma0
enumerator kINPUTMUX__Ctimer0M1ToDma0
enumerator kINPUTMUX__Ctimer1M0ToDma0
enumerator kINPUTMUX__Ctimer1M1ToDma0
enumerator kINPUTMUX__Ctimer2M0ToDma0
enumerator kINPUTMUX__Ctimer2M1ToDma0
enumerator kINPUTMUX__Ctimer3M0ToDma0
enumerator kINPUTMUX__Ctimer3M1ToDma0
enumerator kINPUTMUX__Ctimer4M0ToDma0
enumerator kINPUTMUX__Ctimer4M1ToDma0
enumerator kINPUTMUX__Dma0TrigOutAToDma0
enumerator kINPUTMUX__Dma0TrigOutBToDma0
enumerator kINPUTMUX__Dma0TrigOutCToDma0
enumerator kINPUTMUX__Dma0TrigOutDToDma0
enumerator kINPUTMUX__Sct0Dmac0ToDma0
enumerator kINPUTMUX__Sct0Dmac1ToDma0
enumerator kINPUTMUX__HashCryptOutToDma0
enumerator kINPUTMUX__AcmpToDma0
enumerator kINPUTMUX__AdcToDma0
enumerator kINPUTMUX__FlexspiRxToDma0
enumerator kINPUTMUX__FlexspiTxToDma0
DMA1 ITRIG.
enumerator kINPUTMUX__NsGpioPint0Int0ToDma1
enumerator kINPUTMUX__NsGpioPint0Int1ToDma1
enumerator kINPUTMUX__NsGpioPint0Int2ToDma1

enumerator kINPUTMUX_NsGpioPint0Int3ToDma1
enumerator kINPUTMUX_Ctimer0M0ToDma1
enumerator kINPUTMUX_Ctimer0M1ToDma1
enumerator kINPUTMUX_Ctimer1M0ToDma1
enumerator kINPUTMUX_Ctimer1M1ToDma1
enumerator kINPUTMUX_Ctimer2M0ToDma1
enumerator kINPUTMUX_Ctimer2M1ToDma1
enumerator kINPUTMUX_Ctimer3M0ToDma1
enumerator kINPUTMUX_Ctimer3M1ToDma1
enumerator kINPUTMUX_Ctimer4M0ToDma1
enumerator kINPUTMUX_Ctimer4M1ToDma1
enumerator kINPUTMUX_Dma1TrigOutAToDma1
enumerator kINPUTMUX_Dma1TrigOutBToDma1
enumerator kINPUTMUX_Dma1TrigOutCToDma1
enumerator kINPUTMUX_Dma1TrigOutDToDma1
enumerator kINPUTMUX_Sct0Dmac0ToDma1
enumerator kINPUTMUX_Sct0Dmac1ToDma1
enumerator kINPUTMUX_HashCryptOutToDma1
enumerator kINPUTMUX_AcmpToDma1
enumerator kINPUTMUX_AdcToDma1
enumerator kINPUTMUX_FlexspiRxToDma1
enumerator kINPUTMUX_FlexspiTxToDma1
DMA0 OTRIG.
enumerator kINPUTMUX_Dma0OtrigChannel0ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel1ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel2ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel3ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel4ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel5ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel6ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel7ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel8ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel9ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel10ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel11ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel12ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel13ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel14ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel15ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel16ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel17ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel18ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel19ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel20ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel21ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel22ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel23ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel24ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel25ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel26ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel27ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel28ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel29ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel30ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel31ToTriginChannels
enumerator kINPUTMUX_Dma0OtrigChannel32ToTriginChannels
DMA1 OTRIG.

enumerator kINPUTMUX_Dma1OtrigChannel0ToTriginChannels
enumerator kINPUTMUX_Dma1OtrigChannel1ToTriginChannels
enumerator kINPUTMUX_Dma1OtrigChannel2ToTriginChannels
enumerator kINPUTMUX_Dma1OtrigChannel3ToTriginChannels
enumerator kINPUTMUX_Dma1OtrigChannel4ToTriginChannels
enumerator kINPUTMUX_Dma1OtrigChannel5ToTriginChannels
enumerator kINPUTMUX_Dma1OtrigChannel6ToTriginChannels
enumerator kINPUTMUX_Dma1OtrigChannel7ToTriginChannels
enumerator kINPUTMUX_Dma1OtrigChannel8ToTriginChannels

enumerator kINPUTMUX__Dma1OtrigChannel9ToTriginChannels
enumerator kINPUTMUX__Dma1OtrigChannel10ToTriginChannels
enumerator kINPUTMUX__Dma1OtrigChannel11ToTriginChannels
enumerator kINPUTMUX__Dma1OtrigChannel12ToTriginChannels
enumerator kINPUTMUX__Dma1OtrigChannel13ToTriginChannels
enumerator kINPUTMUX__Dma1OtrigChannel14ToTriginChannels
enumerator kINPUTMUX__Dma1OtrigChannel15ToTriginChannels
enumerator kINPUTMUX__Dma1OtrigChannel16ToTriginChannels
enumerator kINPUTMUX__Dma1OtrigChannel17ToTriginChannels
enumerator kINPUTMUX__Dma1OtrigChannel18ToTriginChannels
enumerator kINPUTMUX__Dma1OtrigChannel19ToTriginChannels
enumerator kINPUTMUX__Dma1OtrigChannel20ToTriginChannels
enumerator kINPUTMUX__Dma1OtrigChannel21ToTriginChannels
enumerator kINPUTMUX__Dma1OtrigChannel22ToTriginChannels
enumerator kINPUTMUX__Dma1OtrigChannel23ToTriginChannels
enumerator kINPUTMUX__Dma1OtrigChannel24ToTriginChannels
enumerator kINPUTMUX__Dma1OtrigChannel25ToTriginChannels
enumerator kINPUTMUX__Dma1OtrigChannel26ToTriginChannels
enumerator kINPUTMUX__Dma1OtrigChannel27ToTriginChannels
enumerator kINPUTMUX__Dma1OtrigChannel28ToTriginChannels
enumerator kINPUTMUX__Dma1OtrigChannel29ToTriginChannels
enumerator kINPUTMUX__Dma1OtrigChannel30ToTriginChannels
enumerator kINPUTMUX__Dma1OtrigChannel31ToTriginChannels
enumerator kINPUTMUX__Dma1OtrigChannel32ToTriginChannels

enum __inputmux_signal_t

INPUTMUX signal enable/disable type.

Values:

enumerator kINPUTMUX__Dmac0InputTriggerPint0Ena
DMA0 input trigger source enable.

enumerator kINPUTMUX__Dmac0InputTriggerPint1Ena

enumerator kINPUTMUX__Dmac0InputTriggerPint2Ena

enumerator kINPUTMUX__Dmac0InputTriggerPint3Ena

enumerator kINPUTMUX__Dmac0InputTriggerCtimer0M0Ena

enumerator kINPUTMUX__Dmac0InputTriggerCtimer0M1Ena

enumerator kINPUTMUX_Dmac0InputTriggerCtimer1M0Ena
enumerator kINPUTMUX_Dmac0InputTriggerCtimer1M1Ena
enumerator kINPUTMUX_Dmac0InputTriggerCtimer2M0Ena
enumerator kINPUTMUX_Dmac0InputTriggerCtimer2M1Ena
enumerator kINPUTMUX_Dmac0InputTriggerCtimer3M0Ena
enumerator kINPUTMUX_Dmac0InputTriggerCtimer3M1Ena
enumerator kINPUTMUX_Dmac0InputTriggerCtimer4M0Ena
enumerator kINPUTMUX_Dmac0InputTriggerCtimer4M1Ena
enumerator kINPUTMUX_Dmac0InputTriggerDma0OutAEna
enumerator kINPUTMUX_Dmac0InputTriggerDma0OutBEna
enumerator kINPUTMUX_Dmac0InputTriggerDma0OutCEna
enumerator kINPUTMUX_Dmac0InputTriggerDma0OutDEna
enumerator kINPUTMUX_Dmac0InputTriggerSctDmac0Ena
enumerator kINPUTMUX_Dmac0InputTriggerSctDmac1Ena
enumerator kINPUTMUX_Dmac0InputTriggerHashOutEna
enumerator kINPUTMUX_Dmac0InputTriggerAcmpEna
enumerator kINPUTMUX_Dmac0InputTriggerAdcEna
enumerator kINPUTMUX_Dmac0InputTriggerFlexspiRxEna
enumerator kINPUTMUX_Dmac0InputTriggerFlexspiTxEna
DMA1 input trigger source enable.

enumerator kINPUTMUX_Dmac1InputTriggerPint0Ena
enumerator kINPUTMUX_Dmac1InputTriggerPint1Ena
enumerator kINPUTMUX_Dmac1InputTriggerPint2Ena
enumerator kINPUTMUX_Dmac1InputTriggerPint3Ena
enumerator kINPUTMUX_Dmac1InputTriggerCtimer0M0Ena
enumerator kINPUTMUX_Dmac1InputTriggerCtimer0M1Ena
enumerator kINPUTMUX_Dmac1InputTriggerCtimer1M0Ena
enumerator kINPUTMUX_Dmac1InputTriggerCtimer1M1Ena
enumerator kINPUTMUX_Dmac1InputTriggerCtimer2M0Ena
enumerator kINPUTMUX_Dmac1InputTriggerCtimer2M1Ena
enumerator kINPUTMUX_Dmac1InputTriggerCtimer3M0Ena
enumerator kINPUTMUX_Dmac1InputTriggerCtimer3M1Ena
enumerator kINPUTMUX_Dmac1InputTriggerCtimer4M0Ena

enumerator kINPUTMUX__Dmac1InputTriggerCtimer4M1Ena

enumerator kINPUTMUX__Dmac1InputTriggerDma1OutAEna

enumerator kINPUTMUX__Dmac1InputTriggerDma1OutBEna

enumerator kINPUTMUX__Dmac1InputTriggerDma1OutCEna

enumerator kINPUTMUX__Dmac1InputTriggerDma1OutDEna

enumerator kINPUTMUX__Dmac1InputTriggerSctDmac0Ena

enumerator kINPUTMUX__Dmac1InputTriggerSctDmac1Ena

enumerator kINPUTMUX__Dmac1InputTriggerHashOutEna

enumerator kINPUTMUX__Dmac1InputTriggerAcmpEna

enumerator kINPUTMUX__Dmac1InputTriggerAdcEna

enumerator kINPUTMUX__Dmac1InputTriggerFlexspiRxEna

enumerator kINPUTMUX__Dmac1InputTriggerFlexspiTxEna

DMA0 REQ signal.

enumerator kINPUTMUX__Flexcomm0RxToDmac0Ch0RequestEna

enumerator kINPUTMUX__Flexcomm0TxToDmac0Ch1RequestEna

enumerator kINPUTMUX__Flexcomm1RxToDmac0Ch2RequestEna

enumerator kINPUTMUX__Flexcomm1TxToDmac0Ch3RequestEna

enumerator kINPUTMUX__Flexcomm2RxToDmac0Ch4RequestEna

enumerator kINPUTMUX__Flexcomm2TxToDmac0Ch5RequestEna

enumerator kINPUTMUX__Flexcomm3RxToDmac0Ch6RequestEna

enumerator kINPUTMUX__Flexcomm3TxToDmac0Ch7RequestEna

enumerator kINPUTMUX__Flexcomm4RxToDmac0Ch8RequestEna

enumerator kINPUTMUX__Flexcomm4TxToDmac0Ch9RequestEna

enumerator kINPUTMUX__Flexcomm5RxToDmac0Ch10RequestEna

enumerator kINPUTMUX__Flexcomm5TxToDmac0Ch11RequestEna

enumerator kINPUTMUX__Flexcomm6RxToDmac0Ch12RequestEna

enumerator kINPUTMUX__Flexcomm6TxToDmac0Ch13RequestEna

enumerator kINPUTMUX__Flexcomm7RxToDmac0Ch14RequestEna

enumerator kINPUTMUX__Flexcomm7TxToDmac0Ch15RequestEna

enumerator kINPUTMUX__Dmic0Ch0ToDmac0Ch16RequestEna

enumerator kINPUTMUX__Dmic0Ch1ToDmac0Ch17RequestEna

enumerator kINPUTMUX__Dmic0Ch2ToDmac0Ch18RequestEna

enumerator kINPUTMUX__Dmic0Ch3ToDmac0Ch19RequestEna

enumerator kINPUTMUX__Dmic0Ch4ToDmac0Ch20RequestEna
enumerator kINPUTMUX__Dmic0Ch5ToDmac0Ch21RequestEna
enumerator kINPUTMUX__Dmic0Ch6ToDmac0Ch22RequestEna
enumerator kINPUTMUX__Dmic0Ch7ToDmac0Ch23RequestEna
enumerator kINPUTMUX__I3c0RxToDmac0Ch24RequestEna
enumerator kINPUTMUX__I3c0TxToDmac0Ch25RequestEna
enumerator kINPUTMUX__Flexcomm14RxToDmac0Ch26RequestEna
enumerator kINPUTMUX__Flexcomm14TxToDmac0Ch27RequestEna
enumerator kINPUTMUX__HashCryptToDmac0Ch30RequestEna
DMA1 REQ signal.
enumerator kINPUTMUX__Flexcomm0RxToDmac1Ch0RequestEna
enumerator kINPUTMUX__Flexcomm0TxToDmac1Ch1RequestEna
enumerator kINPUTMUX__Flexcomm1RxToDmac1Ch2RequestEna
enumerator kINPUTMUX__Flexcomm1TxToDmac1Ch3RequestEna
enumerator kINPUTMUX__Flexcomm2RxToDmac1Ch4RequestEna
enumerator kINPUTMUX__Flexcomm2TxToDmac1Ch5RequestEna
enumerator kINPUTMUX__Flexcomm3RxToDmac1Ch6RequestEna
enumerator kINPUTMUX__Flexcomm3TxToDmac1Ch7RequestEna
enumerator kINPUTMUX__Flexcomm4RxToDmac1Ch8RequestEna
enumerator kINPUTMUX__Flexcomm4TxToDmac1Ch9RequestEna
enumerator kINPUTMUX__Flexcomm5RxToDmac1Ch10RequestEna
enumerator kINPUTMUX__Flexcomm5TxToDmac1Ch11RequestEna
enumerator kINPUTMUX__Flexcomm6RxToDmac1Ch12RequestEna
enumerator kINPUTMUX__Flexcomm6TxToDmac1Ch13RequestEna
enumerator kINPUTMUX__Flexcomm7RxToDmac1Ch14RequestEna
enumerator kINPUTMUX__Flexcomm7TxToDmac1Ch15RequestEna
enumerator kINPUTMUX__Dmic0Ch0ToDmac1Ch16RequestEna
enumerator kINPUTMUX__Dmic0Ch1ToDmac1Ch17RequestEna
enumerator kINPUTMUX__Dmic0Ch2ToDmac1Ch18RequestEna
enumerator kINPUTMUX__Dmic0Ch3ToDmac1Ch19RequestEna
enumerator kINPUTMUX__Dmic0Ch4ToDmac1Ch20RequestEna
enumerator kINPUTMUX__Dmic0Ch5ToDmac1Ch21RequestEna
enumerator kINPUTMUX__Dmic0Ch6ToDmac1Ch22RequestEna

enumerator kINPUTMUX_Dmic0Ch7ToDmac1Ch23RequestEna

enumerator kINPUTMUX_I3c0RxToDmac1Ch24RequestEna

enumerator kINPUTMUX_I3c0TxToDmac1Ch25RequestEna

enumerator kINPUTMUX_Flexcomm14RxToDmac1Ch26RequestEna

enumerator kINPUTMUX_Flexcomm14TxToDmac1Ch27RequestEna

enumerator kINPUTMUX_HashCryptToDmac1Ch30RequestEna

typedef enum *inputmux_connection_t* inputmux_connection_t
INPUTMUX connections type.

typedef enum *inputmux_signal_t* inputmux_signal_t
INPUTMUX signal enable/disable type.

void INPUTMUX_Init(void *base)
Initialize INPUTMUX peripheral.
This function enables the INPUTMUX clock.

Parameters

- base – Base address of the INPUTMUX peripheral.

Return values

None. –

void INPUTMUX_AttachSignal(void *base, uint32_t index, *inputmux_connection_t* connection)
Attaches a signal.

This function attaches multiplexed signals from INPUTMUX to target signals. For example, to attach GPIO PORT0 Pin 5 to PINT peripheral, do the following:

```
INPUTMUX_AttachSignal(INPUTMUX, 2, kINPUTMUX_GpioPort0Pin5ToPintsel);
```

In this example, INTMUX has 8 registers for PINT, PINT_SEL0~PINT_SEL7. With parameter index specified as 2, this function configures register PINT_SEL2.

Parameters

- base – Base address of the INPUTMUX peripheral.
- index – The serial number of destination register in the group of INPUTMUX registers with same name.
- connection – Applies signal from source signals collection to target signal.

Return values

None. –

void INPUTMUX_EnableSignal(void *base, *inputmux_signal_t* signal, bool enable)
Enable/disable a signal.

This function gates the INPUTMUX clock.

Parameters

- base – Base address of the INPUTMUX peripheral.
- signal – Enable signal register id and bit offset.
- enable – Selects enable or disable.

Return values

None. –

`void INPUTMUX_Deinit(void *base)`

Deinitialize INPUTMUX peripheral.

This function disables the INPUTMUX clock.

Parameters

- `base` – Base address of the INPUTMUX peripheral.

Return values

None. –

`SCT0_PMUX_ID`

Periphinmux IDs.

`SHSGPIO_PMUX_ID`

`PINTSEL_PMUX_ID`

`DSP_INT_PMUX_ID`

`DMA0_ITRIG_PMUX_ID`

`DMA0_OTRIG_PMUX_ID`

`DMA1_ITRIG_PMUX_ID`

`DMA1_OTRIG_PMUX_ID`

`CT32BIT0_CAP_PMUX_ID`

`CT32BIT1_CAP_PMUX_ID`

`CT32BIT2_CAP_PMUX_ID`

`CT32BIT3_CAP_PMUX_ID`

`CT32BIT4_CAP_PMUX_ID`

`FREQMEAS_PMUX_ID`

`DMA0_REQ_ENA0_ID`

`DMA1_REQ_ENA0_ID`

`DMA0_ITRIG_EN0_ID`

`DMA1_ITRIG_EN0_ID`

`ENA_SHIFT`

`PMUX_SHIFT`

2.44 IOPCTL: Input/Output Pad Controller

`LPC_IOPCTL_DRIVER_VERSION`

IOPCTL driver version 2.0.0.

`typedef struct iopctl_group iopctl_group_t`

Array of IOPCTL pin definitions passed to `IOPCTL_SetPinMuxing()` must be in this format.

```
__STATIC_INLINE void IOPCTL_PinMuxSet (IOPCTL_Type *base, uint8_t port, uint8_t pin,
uint32_t modefunc)
```

Sets I/O Pad Control pin mux.

Parameters

- base – : The base of IOPCTL peripheral on the chip
- port – : Port to mux
- pin – : Pin to mux
- modefunc – : OR'ed values of type IOPCTL_*

Returns

Nothing

```
__STATIC_INLINE void IOPCTL_SetPinMuxing (IOPCTL_Type *base,
const iopctl_group_t *pinArray, uint32_t arrayLength)
```

Set all I/O Control pin muxing.

Parameters

- base – : The base of IOPCTL peripheral on the chip
- pinArray – : Pointer to array of pin mux selections
- arrayLength – : Number of entries in pinArray

Returns

Nothing

FSL_COMPONENT_ID

IOPCTL_FUNC0

IOPCTL function and mode selection definitions.

Note: See the User Manual for specific modes and functions supported by the various pins.
Selects pin function 0

IOPCTL_FUNC1

Selects pin function 1

IOPCTL_FUNC2

Selects pin function 2

IOPCTL_FUNC3

Selects pin function 3

IOPCTL_FUNC4

Selects pin function 4

IOPCTL_FUNC5

Selects pin function 5

IOPCTL_FUNC6

Selects pin function 6

IOPCTL_FUNC7

Selects pin function 7

IOPCTL_FUNC8

Selects pin function 8

IOPCTL_FUNC9

Selects pin function 9

IOPCTL_FUNC10

Selects pin function 10

IOPCTL_FUNC11

Selects pin function 11

IOPCTL_FUNC12

Selects pin function 12

IOPCTL_FUNC13

Selects pin function 13

IOPCTL_FUNC14

Selects pin function 14

IOPCTL_FUNC15

Selects pin function 15

IOPCTL_PUPD_EN

Enables Pullup / Pulldown

IOPCTL_PULLDOWN_EN

Selects pull-down function

IOPCTL_PULLUP_EN

Selects pull-up function

IOPCTL_INBUF_EN

Enables buffer function on input

IOPCTL_SLEW_RATE

Slew Rate Control

IOPCTL_FULLDRIVE_EN

Selects full drive

IOPCTL_ANAMUX_EN

Enables analog mux function by setting 0 to bit 7

IOPCTL_PSEDRAIN_EN

Enables pseudo output drain function

IOPCTL_INV_EN

Enables invert function on input

struct `_iopctl_group`

#include <fsl_iopctl.h> Array of IOPCTL pin definitions passed to IOPCTL_SetPinMuxing() must be in this format.

2.45 Common Driver

FSL_COMMON_DRIVER_VERSION

common driver version.

DEBUG_CONSOLE_DEVICE_TYPE_NONE

No debug console.

DEBUG_CONSOLE_DEVICE_TYPE_UART

Debug console based on UART.

DEBUG_CONSOLE_DEVICE_TYPE_LPUART

Debug console based on LPUART.

DEBUG_CONSOLE_DEVICE_TYPE_LPSCI

Debug console based on LPSCI.

DEBUG_CONSOLE_DEVICE_TYPE_USBCDC

Debug console based on USB CDC.

DEBUG_CONSOLE_DEVICE_TYPE_FLEXCOMM

Debug console based on FLEXCOMM.

DEBUG_CONSOLE_DEVICE_TYPE_IUART

Debug console based on i.MX UART.

DEBUG_CONSOLE_DEVICE_TYPE_VUSART

Debug console based on LPC_VUSART.

DEBUG_CONSOLE_DEVICE_TYPE_MINI_UART

Debug console based on LPC_UART.

DEBUG_CONSOLE_DEVICE_TYPE_SWO

Debug console based on SWO.

DEBUG_CONSOLE_DEVICE_TYPE_QSCI

Debug console based on QSCI.

MIN(*a*, *b*)

Computes the minimum of *a* and *b*.

MAX(*a*, *b*)

Computes the maximum of *a* and *b*.

UINT16_MAX

Max value of uint16_t type.

UINT32_MAX

Max value of uint32_t type.

SDK_ATOMIC_LOCAL_ADD(addr, val)

Add value *val* from the variable at address *address*.

SDK_ATOMIC_LOCAL_SUB(addr, val)

Subtract value *val* to the variable at address *address*.

SDK_ATOMIC_LOCAL_SET(addr, bits)

Set the bits specified by *bits* to the variable at address *address*.

SDK_ATOMIC_LOCAL_CLEAR(addr, bits)

Clear the bits specified by *bits* to the variable at address *address*.

SDK_ATOMIC_LOCAL_TOGGLE(addr, bits)

Toggle the bits specified by *bits* to the variable at address *address*.

SDK_ATOMIC_LOCAL_CLEAR_AND_SET(addr, clearBits, setBits)

For the variable at address *address*, clear the bits specified by *clearBits* and set the bits specified by *setBits*.

SDK_ATOMIC_LOCAL_COMPARE_AND_SET(addr, expected, newValue)

For the variable at address *address*, check whether the value equal to *expected*. If value same as *expected* then update *newValue* to address and return **true** , else return **false** .

SDK_ATOMIC_LOCAL_TEST_AND_SET(addr, newValue)

For the variable at address *address*, set as *newValue* value and return old value.

USEC_TO_COUNT(us, clockFreqInHz)

Macro to convert a microsecond period to raw count value

COUNT_TO_USEC(count, clockFreqInHz)

Macro to convert a raw count value to microsecond

MSEC_TO_COUNT(ms, clockFreqInHz)

Macro to convert a millisecond period to raw count value

COUNT_TO_MSEC(count, clockFreqInHz)

Macro to convert a raw count value to millisecond

SDK_ISR_EXIT_BARRIER

SDK_SIZEALIGN(var, alignbytes)

Macro to define a variable with L1 d-cache line size alignment

Macro to define a variable with L2 cache line size alignment

Macro to change a value to a given size aligned value

AT_NONCACHEABLE_SECTION(var)

Define a variable *var*, and place it in non-cacheable section.

AT_NONCACHEABLE_SECTION_ALIGN(var, alignbytes)

Define a variable *var*, and place it in non-cacheable section, the start address of the variable is aligned to *alignbytes*.

AT_NONCACHEABLE_SECTION_INIT(var)

Define a variable *var* with initial value, and place it in non-cacheable section.

AT_NONCACHEABLE_SECTION_ALIGN_INIT(var, alignbytes)

Define a variable *var* with initial value, and place it in non-cacheable section, the start address of the variable is aligned to *alignbytes*.

enum _status_groups

Status group numbers.

Values:

enumerator kStatusGroup_Generic

Group number for generic status codes.

enumerator kStatusGroup_FLASH

Group number for FLASH status codes.

enumerator kStatusGroup_LPSPI

Group number for LPSPI status codes.

enumerator kStatusGroup_FLEXIO_SPI

Group number for FLEXIO SPI status codes.

enumerator kStatusGroup_DSPI

Group number for DSPI status codes.

enumerator kStatusGroup_FLEXIO_UART

Group number for FLEXIO UART status codes.

enumerator kStatusGroup_FLEXIO_I2C
Group number for FLEXIO I2C status codes.

enumerator kStatusGroup_LPI2C
Group number for LPI2C status codes.

enumerator kStatusGroup_UART
Group number for UART status codes.

enumerator kStatusGroup_I2C
Group number for UART status codes.

enumerator kStatusGroup_LPSCI
Group number for LPSCI status codes.

enumerator kStatusGroup_LPUART
Group number for LPUART status codes.

enumerator kStatusGroup_SPI
Group number for SPI status code.

enumerator kStatusGroup_XRDC
Group number for XRDC status code.

enumerator kStatusGroup_SEMA42
Group number for SEMA42 status code.

enumerator kStatusGroup_SDHC
Group number for SDHC status code

enumerator kStatusGroup_SDMMC
Group number for SDMMC status code

enumerator kStatusGroup_SAI
Group number for SAI status code

enumerator kStatusGroup_MCG
Group number for MCG status codes.

enumerator kStatusGroup_SCG
Group number for SCG status codes.

enumerator kStatusGroup_SDSPI
Group number for SDSPI status codes.

enumerator kStatusGroup_FLEXIO_I2S
Group number for FLEXIO I2S status codes

enumerator kStatusGroup_FLEXIO_MCULCD
Group number for FLEXIO LCD status codes

enumerator kStatusGroup_FLASHIAP
Group number for FLASHIAP status codes

enumerator kStatusGroup_FLEXCOMM_I2C
Group number for FLEXCOMM I2C status codes

enumerator kStatusGroup_I2S
Group number for I2S status codes

enumerator kStatusGroup_IUART
Group number for IUART status codes

enumerator `kStatusGroup_CSI`
Group number for CSI status codes

enumerator `kStatusGroup_MIPI_DSI`
Group number for MIPI DSI status codes

enumerator `kStatusGroup_SDRAMC`
Group number for SDRAMC status codes.

enumerator `kStatusGroup_POWER`
Group number for POWER status codes.

enumerator `kStatusGroup_ENET`
Group number for ENET status codes.

enumerator `kStatusGroup_PHY`
Group number for PHY status codes.

enumerator `kStatusGroup_TRGMUX`
Group number for TRGMUX status codes.

enumerator `kStatusGroup_SMARTCARD`
Group number for SMARTCARD status codes.

enumerator `kStatusGroup_LMEM`
Group number for LMEM status codes.

enumerator `kStatusGroup_QSPI`
Group number for QSPI status codes.

enumerator `kStatusGroup_DMA`
Group number for DMA status codes.

enumerator `kStatusGroup_EDMA`
Group number for EDMA status codes.

enumerator `kStatusGroup_DMAMGR`
Group number for DMAMGR status codes.

enumerator `kStatusGroup_FLEXCAN`
Group number for FlexCAN status codes.

enumerator `kStatusGroup_LTC`
Group number for LTC status codes.

enumerator `kStatusGroup_FLEXIO_CAMERA`
Group number for FLEXIO CAMERA status codes.

enumerator `kStatusGroup_LPC_SPI`
Group number for LPC_SPI status codes.

enumerator `kStatusGroup_LPC_USART`
Group number for LPC_USART status codes.

enumerator `kStatusGroup_DMIC`
Group number for DMIC status codes.

enumerator `kStatusGroup_SDIF`
Group number for SDIF status codes.

enumerator `kStatusGroup_SPIFI`
Group number for SPIFI status codes.

enumerator kStatusGroup_OTP
Group number for OTP status codes.

enumerator kStatusGroup_MCAN
Group number for MCAN status codes.

enumerator kStatusGroup_CAAM
Group number for CAAM status codes.

enumerator kStatusGroup_ECSPI
Group number for ECSPI status codes.

enumerator kStatusGroup_USDHC
Group number for USDHC status codes.

enumerator kStatusGroup_LPC_I2C
Group number for LPC_I2C status codes.

enumerator kStatusGroup_DCP
Group number for DCP status codes.

enumerator kStatusGroup_MSCAN
Group number for MSCAN status codes.

enumerator kStatusGroup_ESAI
Group number for ESAI status codes.

enumerator kStatusGroup_FLEXSPI
Group number for FLEXSPI status codes.

enumerator kStatusGroup_MMDC
Group number for MMDC status codes.

enumerator kStatusGroup_PDM
Group number for MIC status codes.

enumerator kStatusGroup_SDMA
Group number for SDMA status codes.

enumerator kStatusGroup_ICS
Group number for ICS status codes.

enumerator kStatusGroup_SPDIF
Group number for SPDIF status codes.

enumerator kStatusGroup_LPC_MINISPI
Group number for LPC_MINISPI status codes.

enumerator kStatusGroup_HASHCRYPT
Group number for Hashcrypt status codes

enumerator kStatusGroup_LPC_SPI_SSP
Group number for LPC_SPI_SSP status codes.

enumerator kStatusGroup_I3C
Group number for I3C status codes

enumerator kStatusGroup_LPC_I2C_1
Group number for LPC_I2C_1 status codes.

enumerator kStatusGroup_NOTIFIER
Group number for NOTIFIER status codes.

enumerator kStatusGroup__DebugConsole
Group number for debug console status codes.

enumerator kStatusGroup__SEMC
Group number for SEMC status codes.

enumerator kStatusGroup__ApplicationRangeStart
Starting number for application groups.

enumerator kStatusGroup__IAP
Group number for IAP status codes

enumerator kStatusGroup__SFA
Group number for SFA status codes

enumerator kStatusGroup__SPC
Group number for SPC status codes.

enumerator kStatusGroup__PUF
Group number for PUF status codes.

enumerator kStatusGroup__TOUCH_PANEL
Group number for touch panel status codes

enumerator kStatusGroup__VBAT
Group number for VBAT status codes

enumerator kStatusGroup__XSPI
Group number for XSPI status codes

enumerator kStatusGroup__PNGDEC
Group number for PNGDEC status codes

enumerator kStatusGroup__JPEGDEC
Group number for JPEGDEC status codes

enumerator kStatusGroup__AUDMIX
Group number for AUDMIX status codes

enumerator kStatusGroup__HAL_GPIO
Group number for HAL GPIO status codes.

enumerator kStatusGroup__HAL_UART
Group number for HAL UART status codes.

enumerator kStatusGroup__HAL_TIMER
Group number for HAL TIMER status codes.

enumerator kStatusGroup__HAL_SPI
Group number for HAL SPI status codes.

enumerator kStatusGroup__HAL_I2C
Group number for HAL I2C status codes.

enumerator kStatusGroup__HAL_FLASH
Group number for HAL FLASH status codes.

enumerator kStatusGroup__HAL_PWM
Group number for HAL PWM status codes.

enumerator kStatusGroup__HAL_RNG
Group number for HAL RNG status codes.

enumerator kStatusGroup_HAL_I2S
Group number for HAL I2S status codes.

enumerator kStatusGroup_HAL_ADC_SENSOR
Group number for HAL ADC SENSOR status codes.

enumerator kStatusGroup_TIMERMANAGER
Group number for TiMER MANAGER status codes.

enumerator kStatusGroup_SERIALMANAGER
Group number for SERIAL MANAGER status codes.

enumerator kStatusGroup_LED
Group number for LED status codes.

enumerator kStatusGroup_BUTTON
Group number for BUTTON status codes.

enumerator kStatusGroup_EXTERN_EEPROM
Group number for EXTERN EEPROM status codes.

enumerator kStatusGroup_SHELL
Group number for SHELL status codes.

enumerator kStatusGroup_MEM_MANAGER
Group number for MEM MANAGER status codes.

enumerator kStatusGroup_LIST
Group number for List status codes.

enumerator kStatusGroup_OSA
Group number for OSA status codes.

enumerator kStatusGroup_COMMON_TASK
Group number for Common task status codes.

enumerator kStatusGroup_MSG
Group number for messaging status codes.

enumerator kStatusGroup_SDK_OCOTP
Group number for OCOTP status codes.

enumerator kStatusGroup_SDK_FLEXSPINOR
Group number for FLEXSPINOR status codes.

enumerator kStatusGroup_CODEC
Group number for codec status codes.

enumerator kStatusGroup_ASRC
Group number for codec status ASRC.

enumerator kStatusGroup_OTFAD
Group number for codec status codes.

enumerator kStatusGroup_SDIOSLV
Group number for SDIOSLV status codes.

enumerator kStatusGroup_MECC
Group number for MECC status codes.

enumerator kStatusGroup_ENET_QOS
Group number for ENET_QOS status codes.

enumerator kStatusGroup_LOG
Group number for LOG status codes.

enumerator kStatusGroup_I3CBUS
Group number for I3CBUS status codes.

enumerator kStatusGroup_QSCI
Group number for QSCI status codes.

enumerator kStatusGroup_ELEMU
Group number for ELEMU status codes.

enumerator kStatusGroup_QUEUEDSPI
Group number for QSPI status codes.

enumerator kStatusGroup_POWER_MANAGER
Group number for POWER_MANAGER status codes.

enumerator kStatusGroup_IPED
Group number for IPED status codes.

enumerator kStatusGroup_ELS_PKC
Group number for ELS PKC status codes.

enumerator kStatusGroup_CSS_PKC
Group number for CSS PKC status codes.

enumerator kStatusGroup_HOSTIF
Group number for HOSTIF status codes.

enumerator kStatusGroup_CLIF
Group number for CLIF status codes.

enumerator kStatusGroup_BMA
Group number for BMA status codes.

enumerator kStatusGroup_NETC
Group number for NETC status codes.

enumerator kStatusGroup_ELE
Group number for ELE status codes.

enumerator kStatusGroup_GLIKEY
Group number for GLIKEY status codes.

enumerator kStatusGroup_AON_POWER
Group number for AON_POWER status codes.

enumerator kStatusGroup_AON_COMMON
Group number for AON_COMMON status codes.

enumerator kStatusGroup_ENDAT3
Group number for ENDAT3 status codes.

enumerator kStatusGroup_HIPERFACE
Group number for HIPERFACE status codes.

enumerator kStatusGroup_NPX
Group number for NPX status codes.

enumerator kStatusGroup_ELA_CSEC
Group number for ELA_CSEC status codes.

enumerator kStatusGroup_FLEXIO_T_FORMAT

Group number for T-format status codes.

enumerator kStatusGroup_FLEXIO_A_FORMAT

Group number for A-format status codes.

Generic status return codes.

Values:

enumerator kStatus_Success

Generic status for Success.

enumerator kStatus_Fail

Generic status for Fail.

enumerator kStatus_ReadOnly

Generic status for read only failure.

enumerator kStatus_OutOfRange

Generic status for out of range access.

enumerator kStatus_InvalidArgument

Generic status for invalid argument check.

enumerator kStatus_Timeout

Generic status for timeout.

enumerator kStatus_NoTransferInProgress

Generic status for no transfer in progress.

enumerator kStatus_Busy

Generic status for module is busy.

enumerator kStatus_NoData

Generic status for no data is found for the operation.

typedef int32_t status_t

Type used for all status and error return values.

void *SDK_Malloc(size_t size, size_t alignbytes)

Allocate memory with given alignment and aligned size.

This is provided to support the dynamically allocated memory used in cache-able region.

Parameters

- size – The length required to malloc.
- alignbytes – The alignment size.

Return values

The – allocated memory.

void SDK_Free(void *ptr)

Free memory.

Parameters

- ptr – The memory to be release.

void SDK_DelayAtLeastUs(uint32_t delayTime_us, uint32_t coreClock_Hz)

Delay at least for some time. Please note that, this API uses while loop for delay, different run-time environments make the time not precise, if precise delay count was needed, please implement a new delay function with hardware timer.

Parameters

- `delayTime_us` – Delay time in unit of microsecond.
- `coreClock_Hz` – Core clock frequency with Hz.

static inline *status_t* EnableIRQ(IRQn_Type interrupt)

Enable specific interrupt.

Enable LEVEL1 interrupt. For some devices, there might be multiple interrupt levels. For example, there are NVIC and intmux. Here the interrupts connected to NVIC are the LEVEL1 interrupts, because they are routed to the core directly. The interrupts connected to intmux are the LEVEL2 interrupts, they are routed to NVIC first then routed to core.

This function only enables the LEVEL1 interrupts. The number of LEVEL1 interrupts is indicated by the feature macro `FSL_FEATURE_NUMBER_OF_LEVEL1_INT_VECTORS`.

Parameters

- `interrupt` – The IRQ number.

Return values

- `kStatus_Success` – Interrupt enabled successfully
- `kStatus_Fail` – Failed to enable the interrupt

static inline *status_t* DisableIRQ(IRQn_Type interrupt)

Disable specific interrupt.

Disable LEVEL1 interrupt. For some devices, there might be multiple interrupt levels. For example, there are NVIC and intmux. Here the interrupts connected to NVIC are the LEVEL1 interrupts, because they are routed to the core directly. The interrupts connected to intmux are the LEVEL2 interrupts, they are routed to NVIC first then routed to core.

This function only disables the LEVEL1 interrupts. The number of LEVEL1 interrupts is indicated by the feature macro `FSL_FEATURE_NUMBER_OF_LEVEL1_INT_VECTORS`.

Parameters

- `interrupt` – The IRQ number.

Return values

- `kStatus_Success` – Interrupt disabled successfully
- `kStatus_Fail` – Failed to disable the interrupt

static inline *status_t* EnableIRQWithPriority(IRQn_Type interrupt, uint8_t priNum)

Enable the IRQ, and also set the interrupt priority.

Only handle LEVEL1 interrupt. For some devices, there might be multiple interrupt levels. For example, there are NVIC and intmux. Here the interrupts connected to NVIC are the LEVEL1 interrupts, because they are routed to the core directly. The interrupts connected to intmux are the LEVEL2 interrupts, they are routed to NVIC first then routed to core.

This function only handles the LEVEL1 interrupts. The number of LEVEL1 interrupts is indicated by the feature macro `FSL_FEATURE_NUMBER_OF_LEVEL1_INT_VECTORS`.

Parameters

- `interrupt` – The IRQ to Enable.
- `priNum` – Priority number set to interrupt controller register.

Return values

- `kStatus_Success` – Interrupt priority set successfully
- `kStatus_Fail` – Failed to set the interrupt priority.

```
static inline status_t IRQ_SetPriority(IRQn_Type interrupt, uint8_t priNum)
```

Set the IRQ priority.

Only handle LEVEL1 interrupt. For some devices, there might be multiple interrupt levels. For example, there are NVIC and intmux. Here the interrupts connected to NVIC are the LEVEL1 interrupts, because they are routed to the core directly. The interrupts connected to intmux are the LEVEL2 interrupts, they are routed to NVIC first then routed to core.

This function only handles the LEVEL1 interrupts. The number of LEVEL1 interrupts is indicated by the feature macro FSL_FEATURE_NUMBER_OF_LEVEL1_INT_VECTORS.

Parameters

- interrupt – The IRQ to set.
- priNum – Priority number set to interrupt controller register.

Return values

- kStatus_Success – Interrupt priority set successfully
- kStatus_Fail – Failed to set the interrupt priority.

```
static inline status_t IRQ_ClearPendingIRQ(IRQn_Type interrupt)
```

Clear the pending IRQ flag.

Only handle LEVEL1 interrupt. For some devices, there might be multiple interrupt levels. For example, there are NVIC and intmux. Here the interrupts connected to NVIC are the LEVEL1 interrupts, because they are routed to the core directly. The interrupts connected to intmux are the LEVEL2 interrupts, they are routed to NVIC first then routed to core.

This function only handles the LEVEL1 interrupts. The number of LEVEL1 interrupts is indicated by the feature macro FSL_FEATURE_NUMBER_OF_LEVEL1_INT_VECTORS.

Parameters

- interrupt – The flag which IRQ to clear.

Return values

- kStatus_Success – Interrupt priority set successfully
- kStatus_Fail – Failed to set the interrupt priority.

```
static inline uint32_t DisableGlobalIRQ(void)
```

Disable the global IRQ.

Disable the global interrupt and return the current primask register. User is required to provided the primask register for the EnableGlobalIRQ().

Returns

Current primask value.

```
static inline void EnableGlobalIRQ(uint32_t primask)
```

Enable the global IRQ.

Set the primask register with the provided primask value but not just enable the primask. The idea is for the convenience of integration of RTOS. some RTOS get its own management mechanism of primask. User is required to use the EnableGlobalIRQ() and DisableGlobalIRQ() in pair.

Parameters

- primask – value of primask register to be restored. The primask value is supposed to be provided by the DisableGlobalIRQ().

```
static inline bool __SDK_AtomicLocalCompareAndSet(uint32_t *addr, uint32_t expected, uint32_t  
newValue)
```

`static inline uint32_t _SDK_AtomicTestAndSet(uint32_t *addr, uint32_t newValue)`

`FSL_DRIVER_TRANSFER_DOUBLE_WEAK_IRQ`

Macro to use the default weak IRQ handler in drivers.

`MAKE_STATUS(group, code)`

Construct a status code value from a group and code number.

`MAKE_VERSION(major, minor, bugfix)`

Construct the version number for drivers.

The driver version is a 32-bit number, for both 32-bit platforms(such as Cortex M) and 16-bit platforms(such as DSC).

Unused		Major Version		Minor Version		Bug Fix	
31	25 24	17 16	9 8	0			

`ARRAY_SIZE(x)`

Computes the number of elements in an array.

`UINT64_H(X)`

Macro to get upper 32 bits of a 64-bit value

`UINT64_L(X)`

Macro to get lower 32 bits of a 64-bit value

`SUPPRESS_FALL_THROUGH_WARNING()`

For switch case code block, if case section ends without “break;” statement, there will be fallthrough warning with compiler flag -Wextra or -Wimplicit-fallthrough=n when using armgcc. To suppress this warning, “SUPPRESS_FALL_THROUGH_WARNING();” need to be added at the end of each case section which misses “break;”statement.

`MSDK_REG_SECURE_ADDR(x)`

Convert the register address to the one used in secure mode.

`MSDK_REG_NONSECURE_ADDR(x)`

Convert the register address to the one used in non-secure mode.

`MSDK_INVALID_IRQ_HANDLER`

Invalid IRQ handler address.

2.46 LPADC: 12-bit SAR Analog-to-Digital Converter Driver

`enum __lpadc_status_flags`

Define hardware flags of the module.

Values:

enumerator `kLPADC_ResultFIFO0OverflowFlag`

Indicates that more data has been written to the Result FIFO 0 than it can hold.

enumerator `kLPADC_ResultFIFO0ReadyFlag`

Indicates when the number of valid datawords in the result FIFO 0 is greater than the setting watermark level.

enumerator `kLPADC_TriggerExceptionFlag`

Indicates that a trigger exception event has occurred.

enumerator `kLPADC_TriggerCompletionFlag`

Indicates that a trigger completion event has occurred.

enumerator kLPADC_CalibrationReadyFlag

Indicates that the calibration process is done.

enumerator kLPADC_ActiveFlag

Indicates that the ADC is in active state.

enumerator kLPADC_ResultFIFOOverflowFlag

To compilitable with old version, do not recommend using this, please use kLPADC_ResultFIFO0OverflowFlag as instead.

enumerator kLPADC_ResultFIFOReadyFlag

To compilitable with old version, do not recommend using this, please use kLPADC_ResultFIFO0ReadyFlag as instead.

enum __lpadc_interrupt_enable

Define interrupt switchers of the module.

Note: LPADC of different chips supports different number of trigger sources, please check the Reference Manual for details.

Values:

enumerator kLPADC_ResultFIFO0OverflowInterruptEnable

Configures ADC to generate overflow interrupt requests when FOF0 flag is asserted.

enumerator kLPADC_FIFO0WatermarkInterruptEnable

Configures ADC to generate watermark interrupt requests when RDY0 flag is asserted.

enumerator kLPADC_ResultFIFOOverflowInterruptEnable

To compilitable with old version, do not recommend using this, please use kLPADC_ResultFIFO0OverflowInterruptEnable as instead.

enumerator kLPADC_FIFOWatermarkInterruptEnable

To compilitable with old version, do not recommend using this, please use kLPADC_FIFO0WatermarkInterruptEnable as instead.

enumerator kLPADC_TriggerExceptionInterruptEnable

Configures ADC to generate trigger exception interrupt.

enumerator kLPADC_Trigger0CompletionInterruptEnable

Configures ADC to generate interrupt when trigger 0 completion.

enumerator kLPADC_Trigger1CompletionInterruptEnable

Configures ADC to generate interrupt when trigger 1 completion.

enumerator kLPADC_Trigger2CompletionInterruptEnable

Configures ADC to generate interrupt when trigger 2 completion.

enumerator kLPADC_Trigger3CompletionInterruptEnable

Configures ADC to generate interrupt when trigger 3 completion.

enumerator kLPADC_Trigger4CompletionInterruptEnable

Configures ADC to generate interrupt when trigger 4 completion.

enumerator kLPADC_Trigger5CompletionInterruptEnable

Configures ADC to generate interrupt when trigger 5 completion.

enumerator kLPADC_Trigger6CompletionInterruptEnable

Configures ADC to generate interrupt when trigger 6 completion.

enumerator kLPADC_Trigger7CompletionInterruptEnable

Configures ADC to generate interrupt when trigger 7 completion.

enumerator kLPADC_Trigger8CompletionInterruptEnable
Configures ADC to generate interrupt when trigger 8 completion.

enumerator kLPADC_Trigger9CompletionInterruptEnable
Configures ADC to generate interrupt when trigger 9 completion.

enumerator kLPADC_Trigger10CompletionInterruptEnable
Configures ADC to generate interrupt when trigger 10 completion.

enumerator kLPADC_Trigger11CompletionInterruptEnable
Configures ADC to generate interrupt when trigger 11 completion.

enumerator kLPADC_Trigger12CompletionInterruptEnable
Configures ADC to generate interrupt when trigger 12 completion.

enumerator kLPADC_Trigger13CompletionInterruptEnable
Configures ADC to generate interrupt when trigger 13 completion.

enumerator kLPADC_Trigger14CompletionInterruptEnable
Configures ADC to generate interrupt when trigger 14 completion.

enumerator kLPADC_Trigger15CompletionInterruptEnable
Configures ADC to generate interrupt when trigger 15 completion.

enum _lpadc_trigger_status_flags

The enumerator of lpadc trigger status flags, including interrupted flags and completed flags.

Note: LPADC of different chips supports different number of trigger sources, please check the Reference Manual for details.

Values:

enumerator kLPADC_Trigger0InterruptedFlag
Trigger 0 is interrupted by a high priority exception.

enumerator kLPADC_Trigger1InterruptedFlag
Trigger 1 is interrupted by a high priority exception.

enumerator kLPADC_Trigger2InterruptedFlag
Trigger 2 is interrupted by a high priority exception.

enumerator kLPADC_Trigger3InterruptedFlag
Trigger 3 is interrupted by a high priority exception.

enumerator kLPADC_Trigger4InterruptedFlag
Trigger 4 is interrupted by a high priority exception.

enumerator kLPADC_Trigger5InterruptedFlag
Trigger 5 is interrupted by a high priority exception.

enumerator kLPADC_Trigger6InterruptedFlag
Trigger 6 is interrupted by a high priority exception.

enumerator kLPADC_Trigger7InterruptedFlag
Trigger 7 is interrupted by a high priority exception.

enumerator kLPADC_Trigger8InterruptedFlag
Trigger 8 is interrupted by a high priority exception.

enumerator kLPADC_Trigger9InterruptedFlag
Trigger 9 is interrupted by a high priority exception.

enumerator kLPADC_Trigger10InterruptedFlag

Trigger 10 is interrupted by a high priority exception.

enumerator kLPADC_Trigger11InterruptedFlag

Trigger 11 is interrupted by a high priority exception.

enumerator kLPADC_Trigger12InterruptedFlag

Trigger 12 is interrupted by a high priority exception.

enumerator kLPADC_Trigger13InterruptedFlag

Trigger 13 is interrupted by a high priority exception.

enumerator kLPADC_Trigger14InterruptedFlag

Trigger 14 is interrupted by a high priority exception.

enumerator kLPADC_Trigger15InterruptedFlag

Trigger 15 is interrupted by a high priority exception.

enumerator kLPADC_Trigger0CompletedFlag

Trigger 0 is completed and trigger 0 has enabled completion interrupts.

enumerator kLPADC_Trigger1CompletedFlag

Trigger 1 is completed and trigger 1 has enabled completion interrupts.

enumerator kLPADC_Trigger2CompletedFlag

Trigger 2 is completed and trigger 2 has enabled completion interrupts.

enumerator kLPADC_Trigger3CompletedFlag

Trigger 3 is completed and trigger 3 has enabled completion interrupts.

enumerator kLPADC_Trigger4CompletedFlag

Trigger 4 is completed and trigger 4 has enabled completion interrupts.

enumerator kLPADC_Trigger5CompletedFlag

Trigger 5 is completed and trigger 5 has enabled completion interrupts.

enumerator kLPADC_Trigger6CompletedFlag

Trigger 6 is completed and trigger 6 has enabled completion interrupts.

enumerator kLPADC_Trigger7CompletedFlag

Trigger 7 is completed and trigger 7 has enabled completion interrupts.

enumerator kLPADC_Trigger8CompletedFlag

Trigger 8 is completed and trigger 8 has enabled completion interrupts.

enumerator kLPADC_Trigger9CompletedFlag

Trigger 9 is completed and trigger 9 has enabled completion interrupts.

enumerator kLPADC_Trigger10CompletedFlag

Trigger 10 is completed and trigger 10 has enabled completion interrupts.

enumerator kLPADC_Trigger11CompletedFlag

Trigger 11 is completed and trigger 11 has enabled completion interrupts.

enumerator kLPADC_Trigger12CompletedFlag

Trigger 12 is completed and trigger 12 has enabled completion interrupts.

enumerator kLPADC_Trigger13CompletedFlag

Trigger 13 is completed and trigger 13 has enabled completion interrupts.

enumerator kLPADC_Trigger14CompletedFlag

Trigger 14 is completed and trigger 14 has enabled completion interrupts.

enumerator kLPADC_Trigger15CompletedFlag

Trigger 15 is completed and trigger 15 has enabled completion interrupts.

enum __lpadc_sample_scale_mode

Define enumeration of sample scale mode.

The sample scale mode is used to reduce the selected ADC analog channel input voltage level by a factor. The maximum possible voltage on the ADC channel input should be considered when selecting a scale mode to ensure that the reducing factor always results voltage level at or below the VREFH reference. This reducing capability allows conversion of analog inputs higher than VREFH. A-side and B-side channel inputs are both scaled using the scale mode.

Values:

enumerator kLPADC_SamplePartScale

Use divided input voltage signal. (For scale select, please refer to the reference manual).

enumerator kLPADC_SampleFullScale

Full scale (Factor of 1).

enum __lpadc_sample_channel_mode

Define enumeration of channel sample mode.

The channel sample mode configures the channel with single-end/differential/dual-single-end, side A/B.

Values:

enumerator kLPADC_SampleChannelSingleEndSideA

Single-end mode, only A-side channel is converted.

enumerator kLPADC_SampleChannelSingleEndSideB

Single-end mode, only B-side channel is converted.

enumerator kLPADC_SampleChannelDiffBothSideAB

Differential mode, the ADC result is (CHnA-CHnB).

enumerator kLPADC_SampleChannelDiffBothSideBA

Differential mode, the ADC result is (CHnB-CHnA).

enumerator kLPADC_SampleChannelDiffBothSide

Differential mode, the ADC result is (CHnA-CHnB).

enumerator kLPADC_SampleChannelDualSingleEndBothSide

Dual-Single-Ended Mode. Both A side and B side channels are converted independently.

enum __lpadc_hardware_average_mode

Define enumeration of hardware average selection.

It Selects how many ADC conversions are averaged to create the ADC result. An internal storage buffer is used to capture temporary results while the averaging iterations are executed.

Note: Some enumerator values are not available on some devices, mainly depends on the size of AVGS field in CMDH register.

Values:

enumerator kLPADC_HardwareAverageCount1

Single conversion.

enumerator kLPADC__HardwareAverageCount2
2 conversions averaged.

enumerator kLPADC__HardwareAverageCount4
4 conversions averaged.

enumerator kLPADC__HardwareAverageCount8
8 conversions averaged.

enumerator kLPADC__HardwareAverageCount16
16 conversions averaged.

enumerator kLPADC__HardwareAverageCount32
32 conversions averaged.

enumerator kLPADC__HardwareAverageCount64
64 conversions averaged.

enumerator kLPADC__HardwareAverageCount128
128 conversions averaged.

enum _lpadc_sample_time_mode

Define enumeration of sample time selection.

The shortest sample time maximizes conversion speed for lower impedance inputs. Extending sample time allows higher impedance inputs to be accurately sampled. Longer sample times can also be used to lower overall power consumption when command looping and sequencing is configured and high conversion rates are not required.

Values:

enumerator kLPADC__SampleTimeADCK3
3 ADCK cycles total sample time.

enumerator kLPADC__SampleTimeADCK5
5 ADCK cycles total sample time.

enumerator kLPADC__SampleTimeADCK7
7 ADCK cycles total sample time.

enumerator kLPADC__SampleTimeADCK11
11 ADCK cycles total sample time.

enumerator kLPADC__SampleTimeADCK19
19 ADCK cycles total sample time.

enumerator kLPADC__SampleTimeADCK35
35 ADCK cycles total sample time.

enumerator kLPADC__SampleTimeADCK67
69 ADCK cycles total sample time.

enumerator kLPADC__SampleTimeADCK131
131 ADCK cycles total sample time.

enum _lpadc_hardware_compare_mode

Define enumeration of hardware compare mode.

After an ADC channel input is sampled and converted and any averaging iterations are performed, this mode setting guides operation of the automatic compare function to optionally only store when the compare operation is true. When compare is enabled, the conversion result is compared to the compare values.

Values:

enumerator kLPADC_HardwareCompareDisabled

Compare disabled.

enumerator kLPADC_HardwareCompareStoreOnTrue

Compare enabled. Store on true.

enumerator kLPADC_HardwareCompareRepeatUntilTrue

Compare enabled. Repeat channel acquisition until true.

enum _lpadc_conversion_resolution_mode

Define enumeration of conversion resolution mode.

Configure the resolution bit in specific conversion type. For detailed resolution accuracy, see to `lpadc_sample_channel_mode_t`

Values:

enumerator kLPADC_ConversionResolutionStandard

Standard resolution. Single-ended 12-bit conversion, Differential 13-bit conversion with 2's complement output.

enumerator kLPADC_ConversionResolutionHigh

High resolution. Single-ended 16-bit conversion; Differential 16-bit conversion with 2's complement output.

enum _lpadc_conversion_average_mode

Define enumeration of conversion averages mode.

Configure the conversion average number for auto-calibration.

Note: Some enumerator values are not available on some devices, mainly depends on the size of CAL_AVGS field in CTRL register.

Values:

enumerator kLPADC_ConversionAverage1

Single conversion.

enumerator kLPADC_ConversionAverage2

2 conversions averaged.

enumerator kLPADC_ConversionAverage4

4 conversions averaged.

enumerator kLPADC_ConversionAverage8

8 conversions averaged.

enumerator kLPADC_ConversionAverage16

16 conversions averaged.

enumerator kLPADC_ConversionAverage32

32 conversions averaged.

enumerator kLPADC_ConversionAverage64

64 conversions averaged.

enumerator kLPADC_ConversionAverage128

128 conversions averaged.

enum `_lpadc_reference_voltage_mode`

Define enumeration of reference voltage source.

For detail information, need to check the SoC's specification.

Values:

enumerator `kLPADC_ReferenceVoltageAlt1`

Option 1 setting.

enumerator `kLPADC_ReferenceVoltageAlt2`

Option 2 setting.

enumerator `kLPADC_ReferenceVoltageAlt3`

Option 3 setting.

enum `_lpadc_power_level_mode`

Define enumeration of power configuration.

Configures the ADC for power and performance. In the highest power setting the highest conversion rates will be possible. Refer to the device data sheet for power and performance capabilities for each setting.

Values:

enumerator `kLPADC_PowerLevelAlt1`

Lowest power setting.

enumerator `kLPADC_PowerLevelAlt2`

Next lowest power setting.

enumerator `kLPADC_PowerLevelAlt3`

...

enumerator `kLPADC_PowerLevelAlt4`

Highest power setting.

enum `_lpadc_offset_calibration_mode`

Define enumeration of offset calibration mode.

Values:

enumerator `kLPADC_OffsetCalibration12bitMode`

12 bit offset calibration mode.

enumerator `kLPADC_OffsetCalibration16bitMode`

16 bit offset calibration mode.

enum `_lpadc_trigger_priority_policy`

Define enumeration of trigger priority policy.

This selection controls how higher priority triggers are handled.

Note: `kLPADC_TriggerPriorityPreemptSubsequently` is not available on some devices, mainly depends on the size of `TPRCTRL` field in `CFG` register.

Values:

enumerator `kLPADC_ConvPreemptImmediatelyNotAutoResumed`

If a higher priority trigger is detected during command processing, the current conversion is aborted and the new command specified by the trigger is started, when higher priority conversion finishes, the preempted conversion is not automatically resumed or restarted.

enumerator `kLPADC_ConvPreemptSoftlyNotAutoResumed`

If a higher priority trigger is received during command processing, the current conversion is completed (including averaging iterations and compare function if enabled) and stored to the result FIFO before the higher priority trigger/command is initiated, when higher priority conversion finishes, the preempted conversion is not resumed or restarted.

enumerator `kLPADC_ConvPreemptImmediatelyAutoRestarted`

If a higher priority trigger is detected during command processing, the current conversion is aborted and the new command specified by the trigger is started, when higher priority conversion finishes, the preempted conversion will automatically be restarted.

enumerator `kLPADC_ConvPreemptSoftlyAutoRestarted`

If a higher priority trigger is received during command processing, the current conversion is completed (including averaging iterations and compare function if enabled) and stored to the result FIFO before the higher priority trigger/command is initiated, when higher priority conversion finishes, the preempted conversion will automatically be restarted.

enumerator `kLPADC_ConvPreemptImmediatelyAutoResumed`

If a higher priority trigger is detected during command processing, the current conversion is aborted and the new command specified by the trigger is started, when higher priority conversion finishes, the preempted conversion will automatically be resumed.

enumerator `kLPADC_ConvPreemptSoftlyAutoResumed`

If a higher priority trigger is received during command processing, the current conversion is completed (including averaging iterations and compare function if enabled) and stored to the result FIFO before the higher priority trigger/command is initiated, when higher priority conversion finishes, the preempted conversion will be automatically be resumed.

enumerator `kLPADC_TriggerPriorityPreemptImmediately`

Legacy support is not recommended as it only ensures compatibility with older versions.

enumerator `kLPADC_TriggerPriorityPreemptSoftly`

Legacy support is not recommended as it only ensures compatibility with older versions.

enumerator `kLPADC_TriggerPriorityExceptionDisabled`

High priority trigger exception disabled.

typedef enum `_lpadc_sample_scale_mode` `lpadc_sample_scale_mode_t`

Define enumeration of sample scale mode.

The sample scale mode is used to reduce the selected ADC analog channel input voltage level by a factor. The maximum possible voltage on the ADC channel input should be considered when selecting a scale mode to ensure that the reducing factor always results voltage level at or below the VREFH reference. This reducing capability allows conversion of analog inputs higher than VREFH. A-side and B-side channel inputs are both scaled using the scale mode.

typedef enum `_lpadc_sample_channel_mode` `lpadc_sample_channel_mode_t`

Define enumeration of channel sample mode.

The channel sample mode configures the channel with single-end/differential/dual-single-end, side A/B.

typedef enum `_lpadc_hardware_average_mode` `lpadc_hardware_average_mode_t`

Define enumeration of hardware average selection.

It Selects how many ADC conversions are averaged to create the ADC result. An internal storage buffer is used to capture temporary results while the averaging iterations are executed.

Note: Some enumerator values are not available on some devices, mainly depends on the size of AVGS field in CMDH register.

`typedef enum _lpadc_sample_time_mode lpadc_sample_time_mode_t`

Define enumeration of sample time selection.

The shortest sample time maximizes conversion speed for lower impedance inputs. Extending sample time allows higher impedance inputs to be accurately sampled. Longer sample times can also be used to lower overall power consumption when command looping and sequencing is configured and high conversion rates are not required.

`typedef enum _lpadc_hardware_compare_mode lpadc_hardware_compare_mode_t`

Define enumeration of hardware compare mode.

After an ADC channel input is sampled and converted and any averaging iterations are performed, this mode setting guides operation of the automatic compare function to optionally only store when the compare operation is true. When compare is enabled, the conversion result is compared to the compare values.

`typedef enum _lpadc_conversion_resolution_mode lpadc_conversion_resolution_mode_t`

Define enumeration of conversion resolution mode.

Configure the resolution bit in specific conversion type. For detailed resolution accuracy, see to `lpadc_sample_channel_mode_t`

`typedef enum _lpadc_conversion_average_mode lpadc_conversion_average_mode_t`

Define enumeration of conversion averages mode.

Configure the conversion average number for auto-calibration.

Note: Some enumerator values are not available on some devices, mainly depends on the size of CAL_AVGS field in CTRL register.

`typedef enum _lpadc_reference_voltage_mode lpadc_reference_voltage_source_t`

Define enumeration of reference voltage source.

For detail information, need to check the SoC's specification.

`typedef enum _lpadc_power_level_mode lpadc_power_level_mode_t`

Define enumeration of power configuration.

Configures the ADC for power and performance. In the highest power setting the highest conversion rates will be possible. Refer to the device data sheet for power and performance capabilities for each setting.

`typedef enum _lpadc_offset_calibration_mode lpadc_offset_calibration_mode_t`

Define enumeration of offset calibration mode.

`typedef enum _lpadc_trigger_priority_policy lpadc_trigger_priority_policy_t`

Define enumeration of trigger priority policy.

This selection controls how higher priority triggers are handled.

Note: `kLPADC_TriggerPriorityPreemptSubsequently` is not available on some devices, mainly depends on the size of TPRICTRL field in CFG register.

`typedef struct lpadc_calibration_value lpadc_calibration_value_t`

A structure of calibration value.

`LPADC_CONVERSION_COMPLETE_TIMEOUT`

Max loops to wait for LPADC conversion complete.

When doing calibration, driver will wait for the completion of conversion. This parameter defines how many loops to check completion before return timeout. If defined as 0, driver will wait forever until completion.

`LPADC_CALIBRATION_READY_TIMEOUT`

Max loops to wait for LPADC calibration ready.

Before doing calibration, driver will wait for the calibration ready. This parameter defines how many loops to check the calibration ready. If defined as 0, driver will wait forever until ready.

`LPADC_GAIN_CAL_READY_TIMEOUT`

Max loops to wait for LPADC gain calibration GAIN_CAL ready.

Before doing calibration, driver will wait for the gain calibration GAIN_CAL ready. This parameter defines how many loops to check the gain calibration GAIN_CAL ready. If defined as 0, driver will wait forever until ready.

`LPADC_GET_ACTIVE_COMMAND_STATUS(statusVal)`

Define the MACRO function to get command status from status value.

The statusVal is the return value from LPADC_GetStatusFlags().

`LPADC_GET_ACTIVE_TRIGGER_STATUE(statusVal)`

Define the MACRO function to get trigger status from status value.

The statusVal is the return value from LPADC_GetStatusFlags().

`void LPADC_Init(ADC_Type *base, const lpadc_config_t *config)`

Initializes the LPADC module.

Parameters

- base – LPADC peripheral base address.
- config – Pointer to configuration structure. See “*lpadc_config_t*”.

`void LPADC_GetDefaultConfig(lpadc_config_t *config)`

Gets an available pre-defined settings for initial configuration.

This function initializes the converter configuration structure with an available settings. The default values are:

```
config->enableInDozeMode      = true;
config->enableAnalogPreliminary = false;
config->powerUpDelay           = 0x80;
config->referenceVoltageSource  = kLPADC_ReferenceVoltageAlt1;
config->powerLevelMode         = kLPADC_PowerLevelAlt1;
config->triggerPriorityPolicy    = kLPADC_TriggerPriorityPreemptImmediately;
config->enableConvPause        = false;
config->convPauseDelay          = 0U;
config->FIFOWatermark           = 0U;
```

Parameters

- config – Pointer to configuration structure.

`void LPADC_Deinit(ADC_Type *base)`
De-initializes the LPADC module.

Parameters

- `base` – LPADC peripheral base address.

`static inline void LPADC_Enable(ADC_Type *base, bool enable)`
Switch on/off the LPADC module.

Parameters

- `base` – LPADC peripheral base address.
- `enable` – switcher to the module.

`static inline void LPADC_DoResetFIFO(ADC_Type *base)`
Do reset the conversion FIFO.

Parameters

- `base` – LPADC peripheral base address.

`static inline void LPADC_DoResetConfig(ADC_Type *base)`
Do reset the module's configuration.

Reset all ADC internal logic and registers, except the Control Register (ADCx_CTRL).

Parameters

- `base` – LPADC peripheral base address.

`static inline uint32_t LPADC_GetStatusFlags(ADC_Type *base)`
Get status flags.

Parameters

- `base` – LPADC peripheral base address.

Returns

status flags' mask. See to `_lpadc_status_flags`.

`static inline void LPADC_ClearStatusFlags(ADC_Type *base, uint32_t mask)`
Clear status flags.

Only the flags can be cleared by writing ADCx_STATUS register would be cleared by this API.

Parameters

- `base` – LPADC peripheral base address.
- `mask` – Mask value for flags to be cleared. See to `_lpadc_status_flags`.

`static inline uint32_t LPADC_GetTriggerStatusFlags(ADC_Type *base)`
Get trigger status flags to indicate which trigger sequences have been completed or interrupted by a high priority trigger exception.

Parameters

- `base` – LPADC peripheral base address.

Returns

The OR'ed value of `_lpadc_trigger_status_flags`.

`static inline void LPADC_ClearTriggerStatusFlags(ADC_Type *base, uint32_t mask)`
Clear trigger status flags.

Parameters

- `base` – LPADC peripheral base address.

- `mask` – The mask of trigger status flags to be cleared, should be the OR'ed value of `_lpadc_trigger_status_flags`.

static inline void LPADC__EnableInterrupts(ADC_Type *base, uint32_t mask)

Enable interrupts.

Parameters

- `base` – LPADC peripheral base address.
- `mask` – Mask value for interrupt events. See to `_lpadc_interrupt_enable`.

static inline void LPADC__DisableInterrupts(ADC_Type *base, uint32_t mask)

Disable interrupts.

Parameters

- `base` – LPADC peripheral base address.
- `mask` – Mask value for interrupt events. See to `_lpadc_interrupt_enable`.

static inline void LPADC__EnableFIFOWatermarkDMA(ADC_Type *base, bool enable)

Switch on/off the DMA trigger for FIFO watermark event.

Parameters

- `base` – LPADC peripheral base address.
- `enable` – Switcher to the event.

static inline uint32_t LPADC__GetConvResultCount(ADC_Type *base)

Get the count of result kept in conversion FIFO.

Parameters

- `base` – LPADC peripheral base address.

Returns

The count of result kept in conversion FIFO.

bool LPADC__GetConvResult(ADC_Type *base, *lpadc_conv_result_t* *result)

Get the result in conversion FIFO.

Parameters

- `base` – LPADC peripheral base address.
- `result` – Pointer to structure variable that keeps the conversion result in conversion FIFO.

Returns

Status whether FIFO entry is valid.

void LPADC__GetConvResultBlocking(ADC_Type *base, *lpadc_conv_result_t* *result)

Get the result in conversion FIFO using blocking method.

Parameters

- `base` – LPADC peripheral base address.
- `result` – Pointer to structure variable that keeps the conversion result in conversion FIFO.

void LPADC__SetConvTriggerConfig(ADC_Type *base, uint32_t triggerId, const *lpadc_conv_trigger_config_t* *config)

Configure the conversion trigger source.

Each programmable trigger can launch the conversion command in command buffer.

Parameters

- base – LPADC peripheral base address.
- triggerId – ID for each trigger. Typically, the available value range is from 0.
- config – Pointer to configuration structure. See to `lpadc_conv_trigger_config_t`.

void LPADC_GetDefaultConvTriggerConfig(*lpadc_conv_trigger_config_t* *config)

Gets an available pre-defined settings for trigger's configuration.

This function initializes the trigger's configuration structure with an available settings. The default values are:

```
config->targetCommandId    = 0U;
config->delayPower         = 0U;
config->priority            = 0U;
config->channelAFIFOSelect  = 0U;
config->channelBFIFOSelect  = 0U;
config->enableHardwareTrigger = false;
```

Parameters

- config – Pointer to configuration structure.

static inline void LPADC_DoSoftwareTrigger(ADC_Type *base, uint32_t triggerIdMask)

Do software trigger to conversion command.

Parameters

- base – LPADC peripheral base address.
- triggerIdMask – Mask value for software trigger indexes, which count from zero.

void LPADC_SetConvCommandConfig(ADC_Type *base, uint32_t commandId, const *lpadc_conv_command_config_t* *config)

Configure conversion command.

Note: The number of compare value register on different chips is different, that is mean in some chips, some command buffers do not have the compare functionality.

Parameters

- base – LPADC peripheral base address.
- commandId – ID for command in command buffer. Typically, the available value range is 1 - 15.
- config – Pointer to configuration structure. See to `lpadc_conv_command_config_t`.

void LPADC_GetDefaultConvCommandConfig(*lpadc_conv_command_config_t* *config)

Gets an available pre-defined settings for conversion command's configuration.

This function initializes the conversion command's configuration structure with an available settings. The default values are:

```
config->sampleScaleMode    = kLPADC_SampleFullScale;
config->channelBScaleMode  = kLPADC_SampleFullScale;
config->sampleChannelMode  = kLPADC_SampleChannelSingleEndSideA;
config->channelNumber       = 0U;
config->channelBNumber     = 0U;
```

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```

config->chainedNextCommandNumber = 0U;
config->enableAutoChannelIncrement = false;
config->loopCount = 0U;
config->hardwareAverageMode = kLPADC_HardwareAverageCount1;
config->sampleTimeMode = kLPADC_SampleTimeADCK3;
config->hardwareCompareMode = kLPADC_HardwareCompareDisabled;
config->hardwareCompareValueHigh = 0U;
config->hardwareCompareValueLow = 0U;
config->conversionResolutionMode = kLPADC_ConversionResolutionStandard;
config->enableWaitTrigger = false;
config->enableChannelB = false;

```

Parameters

- config – Pointer to configuration structure.

`void LPADC_EnableCalibration(ADC_Type *base, bool enable)`

Enable the calibration function.

When CALOFS is set, the ADC is configured to perform a calibration function anytime the ADC executes a conversion. Any channel selected is ignored and the value returned in the RESFIFO is a signed value between -31 and 31. -32 is not a valid and is never a returned value. Software should copy the lower 6- bits of the conversion result stored in the RESFIFO after a completed calibration conversion to the OFSTRIM field. The OFSTRIM field is used in normal operation for offset correction.

Parameters

- base – LPADC peripheral base address.
- enable – switcher to the calibration function.

`static inline void LPADC_SetOffsetValue(ADC_Type *base, uint32_t value)`

Set proper offset value to trim ADC.

To minimize the offset during normal operation, software should read the conversion result from the RESFIFO calibration operation and write the lower 6 bits to the OFSTRIM register.

Parameters

- base – LPADC peripheral base address.
- value – Setting offset value.

`status_t LPADC_DoAutoCalibration(ADC_Type *base)`

Do auto calibration.

Calibration function should be executed before using converter in application. It used the software trigger and a dummy conversion, get the offset and write them into the OFSTRIM register. It called some of functional API including: -LPADC_EnableCalibration(...) -LPADC_LPADC_SetOffsetValue(...) -LPADC_SetConvCommandConfig(...) -LPADC_SetConvTriggerConfig(...)

Parameters

- base – LPADC peripheral base address.
- base – LPADC peripheral base address.

Return values

- kStatus_Success – Successfully configured.
- kStatus_Timeout – Timeout occurs while waiting completion.

static inline void LPADC_EnableOffsetCalibration(ADC_Type *base, bool enable)

Enable the offset calibration function.

Parameters

- base – LPADC peripheral base address.
- enable – switcher to the calibration function.

static inline void LPADC_SetOffsetCalibrationMode(ADC_Type *base,
lpadc_offset_calibration_mode_t mode)

Set offset calibration mode.

Parameters

- base – LPADC peripheral base address.
- mode – set offset calibration mode.see to lpadc_offset_calibration_mode_t .

status_t LPADC_DoOffsetCalibration(ADC_Type *base)

Do offset calibration.

Parameters

- base – LPADC peripheral base address.

Return values

- kStatus_Success – Successfully configured.
- kStatus_Timeout – Timeout occurs while waiting completion.

void LPADC_PrepareAutoCalibration(ADC_Type *base)

Prepare auto calibration, LPADC_FinishAutoCalibration has to be called before using the LPADC. LPADC_DoAutoCalibration has been split in two API to avoid to be stuck too long in the function.

Parameters

- base – LPADC peripheral base address.

status_t LPADC_FinishAutoCalibration(ADC_Type *base)

Finish auto calibration start with LPADC_PrepareAutoCalibration.

Note: This feature is used for LPADC with CTRL[CALOFSMODE].

Parameters

- base – LPADC peripheral base address.

Return values

- kStatus_Success – Successfully configured.
- kStatus_Timeout – Timeout occurs while waiting completion.

void LPADC_GetCalibrationValue(ADC_Type *base, lpadc_calibration_value_t
*ptrCalibrationValue)

Get calibration value into the memory which is defined by invoker.

Note: Please note the ADC will be disabled temporary.

Note: This function should be used after finish calibration.

Parameters

- base – LPADC peripheral base address.
- ptrCalibrationValue – Pointer to lpadc_calibration_value_t structure, this memory block should be always powered on even in low power modes.

status_t LPADC_SetCalibrationValue(ADC_Type *base, const *lpadc_calibration_value_t* *ptrCalibrationValue)

Set calibration value into ADC calibration registers.

Note: Please note the ADC will be disabled temporary.

Parameters

- base – LPADC peripheral base address.
- ptrCalibrationValue – Pointer to lpadc_calibration_value_t structure which contains ADC's calibration value.

Return values

- kStatus_Success – Successfully configured.
- kStatus_Timeout – Timeout occurs while waiting completion.

FSL_LPADC_DRIVER_VERSION

LPADC driver version 2.9.3.

struct lpadc_config_t

#include <fsl_lpadc.h> LPADC global configuration.

This structure would used to keep the settings for initialization.

Public Members

bool enableInternalClock

Enables the internally generated clock source. The clock source is used in clock selection logic at the chip level and is optionally used for the ADC clock source.

bool enableVref1LowVoltage

If voltage reference option1 input is below 1.8V, it should be “true”. If voltage reference option1 input is above 1.8V, it should be “false”.

bool enableInDozeMode

Control system transition to Stop and Wait power modes while ADC is converting. When enabled in Doze mode, immediate entries to Wait or Stop are allowed. When disabled, the ADC will wait for the current averaging iteration/FIFO storage to complete before acknowledging stop or wait mode entry.

lpadc_conversion_average_mode_t conversionAverageMode

Auto-Calibration Averages.

bool enableAnalogPreliminary

ADC analog circuits are pre-enabled and ready to execute conversions without startup delays(at the cost of higher DC current consumption).

uint32_t powerUpDelay

When the analog circuits are not pre-enabled, the ADC analog circuits are only powered while the ADC is active and there is a counted delay defined by this field after an initial trigger transitions the ADC from its Idle state to allow time for the analog circuits

to stabilize. The startup delay count of (powerUpDelay * 4) ADCK cycles must result in a longer delay than the analog startup time.

lpadc_reference_voltage_source_t referenceVoltageSource

Selects the voltage reference high used for conversions.

lpadc_power_level_mode_t powerLevelMode

Power Configuration Selection.

lpadc_trigger_priority_policy_t triggerPriorityPolicy

Control how higher priority triggers are handled, see to *lpadc_trigger_priority_policy_t*.

bool enableConvPause

Enables the ADC pausing function. When enabled, a programmable delay is inserted during command execution sequencing between LOOP iterations, between commands in a sequence, and between conversions when command is executing in “Compare Until True” configuration.

uint32_t convPauseDelay

Controls the duration of pausing during command execution sequencing. The pause delay is a count of (convPauseDelay*4) ADCK cycles. Only available when ADC pausing function is enabled. The available value range is in 9-bit.

uint32_t FIFOWatermark

FIFOWatermark is a programmable threshold setting. When the number of datawords stored in the ADC Result FIFO is greater than the value in this field, the ready flag would be asserted to indicate stored data has reached the programmable threshold.

struct *lpadc_conv_command_config_t*

#include <fsl_lpadc.h> Define structure to keep the configuration for conversion command.

Public Members

lpadc_sample_scale_mode_t sampleScaleMode

Sample scale mode.

lpadc_sample_scale_mode_t channelBScaleMode

Alternate channel B Scale mode.

lpadc_sample_channel_mode_t sampleChannelMode

Channel sample mode.

uint32_t channelNumber

Channel number; select the channel or channel pair.

uint32_t channelBNumber

Alternate Channel B number; select the channel.

uint32_t chainedNextCommandNumber

Selects the next command to be executed after this command completes. 1-15 is available, 0 is to terminate the chain after this command.

bool enableAutoChannelIncrement

Loop with increment: when disabled, the “loopCount” field selects the number of times the selected channel is converted consecutively; when enabled, the “loopCount” field defines how many consecutive channels are converted as part of the command execution.

uint32_t loopCount

Selects how many times this command executes before finish and transition to the next command or Idle state. Command executes LOOP+1 times. 0-15 is available.

lpadc_hardware_average_mode_t hardwareAverageMode

Hardware average selection.

lpadc_sample_time_mode_t sampleTimeMode

Sample time selection.

lpadc_hardware_compare_mode_t hardwareCompareMode

Hardware compare selection.

uint32_t hardwareCompareValueHigh

Compare Value High. The available value range is in 16-bit.

uint32_t hardwareCompareValueLow

Compare Value Low. The available value range is in 16-bit.

lpadc_conversion_resolution_mode_t conversionResolutionMode

Conversion resolution mode.

bool enableWaitTrigger

Wait for trigger assertion before execution: when disabled, this command will be automatically executed; when enabled, the active trigger must be asserted again before executing this command.

struct lpadc_conv_trigger_config_t

#include <fsl_lpadc.h> Define structure to keep the configuration for conversion trigger.

Public Members

uint32_t targetCommandId

Select the command from command buffer to execute upon detect of the associated trigger event.

uint32_t delayPower

Select the trigger delay duration to wait at the start of servicing a trigger event. When this field is clear, then no delay is incurred. When this field is set to a non-zero value, the duration for the delay is $2^{\text{delayPower}}$ ADCK cycles. The available value range is 4-bit.

uint32_t priority

Sets the priority of the associated trigger source. If two or more triggers have the same priority level setting, the lower order trigger event has the higher priority. The lower value for this field is for the higher priority, the available value range is 1-bit.

bool enableHardwareTrigger

Enable hardware trigger source to initiate conversion on the rising edge of the input trigger source or not. The software trigger is always available.

struct lpadc_conv_result_t

#include <fsl_lpadc.h> Define the structure to keep the conversion result.

Public Members

uint32_t commandIdSource

Indicate the command buffer being executed that generated this result.

uint32_t loopCountIndex

Indicate the loop count value during command execution that generated this result.

uint32_t triggerIdSource

Indicate the trigger source that initiated a conversion and generated this result.

uint16_t convValue

Data result.

struct __lpadc_calibration_value

#include <fsl_lpadc.h> A structure of calibration value.

2.47 GPIO: General Purpose I/O

void GPIO_PortInit(GPIO_Type *base, uint32_t port)

Initializes the GPIO peripheral.

This function ungates the GPIO clock.

Parameters

- base – GPIO peripheral base pointer.
- port – GPIO port number.

void GPIO_PinInit(GPIO_Type *base, uint32_t port, uint32_t pin, const *gpio_pin_config_t* *config)

Initializes a GPIO pin used by the board.

To initialize the GPIO, define a pin configuration, either input or output, in the user file. Then, call the GPIO_PinInit() function.

This is an example to define an input pin or output pin configuration:

```
Define a digital input pin configuration,
gpio_pin_config_t config =
{
    kGPIO_DigitalInput,
    0,
}
Define a digital output pin configuration,
gpio_pin_config_t config =
{
    kGPIO_DigitalOutput,
    0,
}
```

Parameters

- base – GPIO peripheral base pointer(Typically GPIO)
- port – GPIO port number
- pin – GPIO pin number
- config – GPIO pin configuration pointer

static inline void GPIO_PinWrite(GPIO_Type *base, uint32_t port, uint32_t pin, uint8_t output)

Sets the output level of the one GPIO pin to the logic 1 or 0.

Parameters

- base – GPIO peripheral base pointer(Typically GPIO)

- port – GPIO port number
- pin – GPIO pin number
- output – GPIO pin output logic level.
 - 0: corresponding pin output low-logic level.
 - 1: corresponding pin output high-logic level.

static inline uint32_t GPIO_PinRead(GPIO_Type *base, uint32_t port, uint32_t pin)

Reads the current input value of the GPIO PIN.

Parameters

- base – GPIO peripheral base pointer(Typically GPIO)
- port – GPIO port number
- pin – GPIO pin number

Return values

GPIO – port input value

- 0: corresponding pin input low-logic level.
- 1: corresponding pin input high-logic level.

FSL_GPIO_DRIVER_VERSION

LPC GPIO driver version.

enum _gpio_pin_direction

LPC GPIO direction definition.

Values:

enumerator kGPIO_DigitalInput

Set current pin as digital input

enumerator kGPIO_DigitalOutput

Set current pin as digital output

enum _gpio_pin_enable_mode

GPIO Pin Interrupt enable mode.

Values:

enumerator kGPIO_PinIntEnableLevel

Generate Pin Interrupt on level mode

enumerator kGPIO_PinIntEnableEdge

Generate Pin Interrupt on edge mode

enum _gpio_pin_enable_polarity

GPIO Pin Interrupt enable polarity.

Values:

enumerator kGPIO_PinIntEnableHighOrRise

Generate Pin Interrupt on high level or rising edge

enumerator kGPIO_PinIntEnableLowOrFall

Generate Pin Interrupt on low level or falling edge

enum _gpio_interrupt_index

LPC GPIO interrupt index definition.

Values:

enumerator kGPIO_InterruptA

Set current pin as interrupt A

enumerator kGPIO_InterruptB

Set current pin as interrupt B

typedef enum *_gpio_pin_direction* gpio_pin_direction_t

LPC GPIO direction definition.

typedef struct *_gpio_pin_config* gpio_pin_config_t

The GPIO pin configuration structure.

Every pin can only be configured as either output pin or input pin at a time. If configured as a input pin, then leave the outputConfig unused.

typedef enum *_gpio_pin_enable_mode* gpio_pin_enable_mode_t

GPIO Pin Interrupt enable mode.

typedef enum *_gpio_pin_enable_polarity* gpio_pin_enable_polarity_t

GPIO Pin Interrupt enable polarity.

typedef enum *_gpio_interrupt_index* gpio_interrupt_index_t

LPC GPIO interrupt index definition.

typedef struct *_gpio_interrupt_config* gpio_interrupt_config_t

Configures the interrupt generation condition.

static inline void GPIO_PortSet(GPIO_Type *base, uint32_t port, uint32_t mask)

Sets the output level of the multiple GPIO pins to the logic 1.

Parameters

- base – GPIO peripheral base pointer(Typically GPIO)
- port – GPIO port number
- mask – GPIO pin number macro

static inline void GPIO_PortClear(GPIO_Type *base, uint32_t port, uint32_t mask)

Sets the output level of the multiple GPIO pins to the logic 0.

Parameters

- base – GPIO peripheral base pointer(Typically GPIO)
- port – GPIO port number
- mask – GPIO pin number macro

static inline void GPIO_PortToggle(GPIO_Type *base, uint32_t port, uint32_t mask)

Reverses current output logic of the multiple GPIO pins.

Parameters

- base – GPIO peripheral base pointer(Typically GPIO)
- port – GPIO port number
- mask – GPIO pin number macro

GPIO_PIN_INT_LEVEL

GPIO_PIN_INT_EDGE

PINT_PIN_INT_HIGH_OR_RISE_TRIGGER

PINT_PIN_INT_LOW_OR_FALL_TRIGGER

```
struct _gpio_pin_config
```

#include <fsl_gpio.h> The GPIO pin configuration structure.

Every pin can only be configured as either output pin or input pin at a time. If configured as a input pin, then leave the outputConfig unused.

Public Members

gpio_pin_direction_t pinDirection

GPIO direction, input or output

uint8_t outputLogic

Set default output logic, no use in input

```
struct _gpio_interrupt_config
```

#include <fsl_gpio.h> Configures the interrupt generation condition.

2.48 MRT: Multi-Rate Timer

```
void MRT_Init(MRT_Type *base, const mrt_config_t *config)
```

Ungates the MRT clock and configures the peripheral for basic operation.

Note: This API should be called at the beginning of the application using the MRT driver.

Parameters

- *base* – Multi-Rate timer peripheral base address
- *config* – Pointer to user's MRT config structure. If MRT has MULTITASK bit field in MODCFG register, param config is useless.

```
void MRT_Deinit(MRT_Type *base)
```

Gate the MRT clock.

Parameters

- *base* – Multi-Rate timer peripheral base address

```
static inline void MRT_GetDefaultConfig(mrt_config_t *config)
```

Fill in the MRT config struct with the default settings.

The default values are:

```
config->enableMultiTask = false;
```

Parameters

- *config* – Pointer to user's MRT config structure.

```
static inline void MRT_SetupChannelMode(MRT_Type *base, mrt_chnl_t channel, const  
mrt_timer_mode_t mode)
```

Sets up an MRT channel mode.

Parameters

- *base* – Multi-Rate timer peripheral base address
- *channel* – Channel that is being configured.
- *mode* – Timer mode to use for the channel.

```
static inline void MRT_EnableInterrupts(MRT_Type *base, mrt_chnl_t channel, uint32_t mask)
```

Enables the MRT interrupt.

Parameters

- base – Multi-Rate timer peripheral base address
- channel – Timer channel number
- mask – The interrupts to enable. This is a logical OR of members of the enumeration `mrt_interrupt_enable_t`

```
static inline void MRT_DisableInterrupts(MRT_Type *base, mrt_chnl_t channel, uint32_t mask)
```

Disables the selected MRT interrupt.

Parameters

- base – Multi-Rate timer peripheral base address
- channel – Timer channel number
- mask – The interrupts to disable. This is a logical OR of members of the enumeration `mrt_interrupt_enable_t`

```
static inline uint32_t MRT_GetEnabledInterrupts(MRT_Type *base, mrt_chnl_t channel)
```

Gets the enabled MRT interrupts.

Parameters

- base – Multi-Rate timer peripheral base address
- channel – Timer channel number

Returns

The enabled interrupts. This is the logical OR of members of the enumeration `mrt_interrupt_enable_t`

```
static inline uint32_t MRT_GetStatusFlags(MRT_Type *base, mrt_chnl_t channel)
```

Gets the MRT status flags.

Parameters

- base – Multi-Rate timer peripheral base address
- channel – Timer channel number

Returns

The status flags. This is the logical OR of members of the enumeration `mrt_status_flags_t`

```
static inline void MRT_ClearStatusFlags(MRT_Type *base, mrt_chnl_t channel, uint32_t mask)
```

Clears the MRT status flags.

Parameters

- base – Multi-Rate timer peripheral base address
- channel – Timer channel number
- mask – The status flags to clear. This is a logical OR of members of the enumeration `mrt_status_flags_t`

```
void MRT_UpdateTimerPeriod(MRT_Type *base, mrt_chnl_t channel, uint32_t count, bool  
                           immediateLoad)
```

Used to update the timer period in units of count.

The new value will be immediately loaded or will be loaded at the end of the current time interval. For one-shot interrupt mode the new value will be immediately loaded.

Note: User can call the utility macros provided in `fsl_common.h` to convert to ticks

Parameters

- `base` – Multi-Rate timer peripheral base address
- `channel` – Timer channel number
- `count` – Timer period in units of ticks
- `immediateLoad` – `true`: Load the new value immediately into the TIMER register; `false`: Load the new value at the end of current timer interval

static inline uint32_t MRT_GetCurrentTimerCount(MRT_Type *base, *mrt_chnl_t* channel)

Reads the current timer counting value.

This function returns the real-time timer counting value, in a range from 0 to a timer period.

Note: User can call the utility macros provided in `fsl_common.h` to convert ticks to usec or msec

Parameters

- `base` – Multi-Rate timer peripheral base address
- `channel` – Timer channel number

Returns

Current timer counting value in ticks

static inline void MRT_StartTimer(MRT_Type *base, *mrt_chnl_t* channel, uint32_t count)

Starts the timer counting.

After calling this function, timers load period value, counts down to 0 and depending on the timer mode it will either load the respective start value again or stop.

Note: User can call the utility macros provided in `fsl_common.h` to convert to ticks

Parameters

- `base` – Multi-Rate timer peripheral base address
- `channel` – Timer channel number.
- `count` – Timer period in units of ticks. Count can contain the LOAD bit, which control the force load feature.

static inline void MRT_StopTimer(MRT_Type *base, *mrt_chnl_t* channel)

Stops the timer counting.

This function stops the timer from counting.

Parameters

- `base` – Multi-Rate timer peripheral base address
- `channel` – Timer channel number.

static inline uint32_t MRT_GetIdleChannel(MRT_Type *base)

Find the available channel.

This function returns the lowest available channel number.

Parameters

- base – Multi-Rate timer peripheral base address

static inline void MRT__ReleaseChannel(MRT_Type *base, *mrt_chnl_t* channel)

Release the channel when the timer is using the multi-task mode.

In multi-task mode, the INUSE flags allow more control over when MRT channels are released for further use. The user can hold on to a channel acquired by calling MRT_GetIdleChannel() for as long as it is needed and release it by calling this function. This removes the need to ask for an available channel for every use.

Parameters

- base – Multi-Rate timer peripheral base address
- channel – Timer channel number.

FSL_MRT_DRIVER_VERSION

enum __mrt_chnl

List of MRT channels.

Values:

enumerator kMRT_Channel_0

MRT channel number 0

enumerator kMRT_Channel_1

MRT channel number 1

enumerator kMRT_Channel_2

MRT channel number 2

enumerator kMRT_Channel_3

MRT channel number 3

enum __mrt_timer_mode

List of MRT timer modes.

Values:

enumerator kMRT_RepeatMode

Repeat Interrupt mode

enumerator kMRT_OneShotMode

One-shot Interrupt mode

enumerator kMRT_OneShotStallMode

One-shot stall mode

enum __mrt_interrupt_enable

List of MRT interrupts.

Values:

enumerator kMRT_TimerInterruptEnable

Timer interrupt enable

enum __mrt_status_flags

List of MRT status flags.

Values:

enumerator kMRT_TimerInterruptFlag

Timer interrupt flag

enumerator kMRT_TimerRunFlag

Indicates state of the timer

typedef enum *_mrt_chnl* mrt_chnl_t

List of MRT channels.

typedef enum *_mrt_timer_mode* mrt_timer_mode_t

List of MRT timer modes.

typedef enum *_mrt_interrupt_enable* mrt_interrupt_enable_t

List of MRT interrupts.

typedef enum *_mrt_status_flags* mrt_status_flags_t

List of MRT status flags.

typedef struct *_mrt_config* mrt_config_t

MRT configuration structure.

This structure holds the configuration settings for the MRT peripheral. To initialize this structure to reasonable defaults, call the `MRT_GetDefaultConfig()` function and pass a pointer to your config structure instance.

The config struct can be made const so it resides in flash

struct *_mrt_config*

#include <fsl_mrt.h> MRT configuration structure.

This structure holds the configuration settings for the MRT peripheral. To initialize this structure to reasonable defaults, call the `MRT_GetDefaultConfig()` function and pass a pointer to your config structure instance.

The config struct can be made const so it resides in flash

Public Members

bool enableMultiTask

true: Timers run in multi-task mode; false: Timers run in hardware status mode

2.49 MU: Messaging Unit

void MU_Init(MU_Type *base)

Initializes the MU module.

This function enables the MU clock only.

Parameters

- base – MU peripheral base address.

void MU_Deinit(MU_Type *base)

De-initializes the MU module.

This function disables the MU clock only.

Parameters

- base – MU peripheral base address.

```
static inline void MU_SendMsgNonBlocking(MU_Type *base, uint32_t regIndex, uint32_t msg)
```

Writes a message to the TX register.

This function writes a message to the specific TX register. It does not check whether the TX register is empty or not. The upper layer should make sure the TX register is empty before calling this function. This function can be used in ISR for better performance.

```
while (!(kMU_Tx0EmptyFlag & MU_GetStatusFlags(base))) { } Wait for TX0 register empty.
MU_SendMsgNonBlocking(base, kMU_MsgReg0, MSG_VAL); Write message to the TX0 register.
```

Parameters

- base – MU peripheral base address.
- regIndex – TX register index, see `mu_msg_reg_index_t`.
- msg – Message to send.

```
status_t MU_SendMsg(MU_Type *base, uint32_t regIndex, uint32_t msg)
```

Blocks to send a message.

This function waits until the TX register is empty and sends the message. If `MU_BUSY_POLL_COUNT` is defined and non-zero, the function will timeout after the specified number of polling iterations and returns `kStatus_Timeout`.

Parameters

- base – MU peripheral base address.
- regIndex – MU message register, see `mu_msg_reg_index_t`.
- msg – Message to send.

Return values

- `kStatus_Success` – Message sent successfully.
- `kStatus_Timeout` – Timeout occurred while waiting for TX register to be empty.

Returns

`status_t`

```
static inline uint32_t MU_ReceiveMsgNonBlocking(MU_Type *base, uint32_t regIndex)
```

Reads a message from the RX register.

This function reads a message from the specific RX register. It does not check whether the RX register is full or not. The upper layer should make sure the RX register is full before calling this function. This function can be used in ISR for better performance.

```
uint32_t msg;
while (!(kMU_Rx0FullFlag & MU_GetStatusFlags(base)))
{
} Wait for the RX0 register full.

msg = MU_ReceiveMsgNonBlocking(base, kMU_MsgReg0); Read message from RX0 register.
```

Parameters

- base – MU peripheral base address.
- regIndex – RX register index, see `mu_msg_reg_index_t`.

Returns

The received message.

`status_t MU_ReceiveMsgTimeout(MU_Type *base, uint32_t regIndex, uint32_t *readValue)`

Blocks to receive a message with timeout protection.

This function waits until the RX register is full and receives the message. If MU_BUSY_POLL_COUNT is defined and non-zero, the function will timeout after the specified number of polling iterations and return kStatus_Timeout.

This function provides the same blocking behavior as MU_ReceiveMsg() but with additional timeout protection to prevent system hangs if the other core becomes unresponsive or if hardware issues occur.

Note: Both MU_ReceiveMsg() and MU_ReceiveMsgTimeout() are blocking functions. The difference is that this function includes timeout protection while MU_ReceiveMsg() waits indefinitely.

Parameters

- base – MU peripheral base address.
- regIndex – RX register index, see mu_msg_reg_index_t.
- readValue – Pointer to store the received message.

Return values

- kStatus_Success – Message received successfully.
- kStatus_InvalidArgument – Invalid readValue pointer.
- kStatus_Timeout – Timeout occurred while waiting for RX register to be full.

Returns

status_t

`uint32_t MU_ReceiveMsg(MU_Type *base, uint32_t regIndex)`

Blocks to receive a message (infinite wait, no timeout protection).

This function waits until the RX register is full and receives the message. This function will wait indefinitely until a message is received.

Note: Both MU_ReceiveMsg() and MU_ReceiveMsgTimeout() are blocking functions. The difference is that MU_ReceiveMsgTimeout() includes timeout protection while this function waits indefinitely.

Warning: This function does not include timeout protection and may cause system hangs if the other core becomes unresponsive. For applications requiring timeout protection, use MU_ReceiveMsgTimeout() instead.

Parameters

- base – MU peripheral base address.
- regIndex – RX register index, see mu_msg_reg_index_t.

Returns

The received message.

static inline void MU_SetFlagsNonBlocking(MU_Type *base, uint32_t flags)

Sets the 3-bit MU flags reflect on the other MU side.

This function sets the 3-bit MU flags directly. Every time the 3-bit MU flags are changed, the status flag kMU_FlagsUpdatingFlag asserts indicating the 3-bit MU flags are updating to the other side. After the 3-bit MU flags are updated, the status flag kMU_FlagsUpdatingFlag is cleared by hardware. During the flags updating period, the flags cannot be changed. The upper layer should make sure the status flag kMU_FlagsUpdatingFlag is cleared before calling this function.

```
while (kMU_FlagsUpdatingFlag & MU_GetStatusFlags(base))
{
    } Wait for previous MU flags updating.
    MU_SetFlagsNonBlocking(base, 0U); Set the mU flags.
```

Parameters

- base – MU peripheral base address.
- flags – The 3-bit MU flags to set.

status_t MU_SetFlags(MU_Type *base, uint32_t flags)

Blocks setting the 3-bit MU flags reflect on the other MU side.

This function blocks setting the 3-bit MU flags. Every time the 3-bit MU flags are changed, the status flag kMU_FlagsUpdatingFlag asserts indicating the 3-bit MU flags are updating to the other side. After the 3-bit MU flags are updated, the status flag kMU_FlagsUpdatingFlag is cleared by hardware. During the flags updating period, the flags cannot be changed. This function waits for the MU status flag kMU_FlagsUpdatingFlag cleared and sets the 3-bit MU flags.

If MU_BUSY_POLL_COUNT is defined and non-zero, the function will timeout after the specified number of polling iterations and return kStatus_Timeout.

Parameters

- base – MU peripheral base address.
- flags – The 3-bit MU flags to set.

Return values

- kStatus_Success – Flags were set successfully.
- kStatus_Timeout – Timeout occurred while waiting for flags to update.

Returns

status_t

static inline uint32_t MU_GetFlags(MU_Type *base)

Gets the current value of the 3-bit MU flags set by the other side.

This function gets the current 3-bit MU flags on the current side.

Parameters

- base – MU peripheral base address.

Returns

flags Current value of the 3-bit flags.

static inline uint32_t MU_GetStatusFlags(MU_Type *base)

Gets the MU status flags.

This function returns the bit mask of the MU status flags. See _mu_status_flags.

```

uint32_t flags;
flags = MU_GetStatusFlags(base); Get all status flags.
if (kMU_Tx0EmptyFlag & flags)
{
    The TX0 register is empty. Message can be sent.
    MU_SendMsgNonBlocking(base, kMU_MsgReg0, MSG0_VAL);
}
if (kMU_Tx1EmptyFlag & flags)
{
    The TX1 register is empty. Message can be sent.
    MU_SendMsgNonBlocking(base, kMU_MsgReg1, MSG1_VAL);
}

```

Parameters

- base – MU peripheral base address.

Returns

Bit mask of the MU status flags, see `_mu_status_flags`.

static inline uint32_t MU_GetRxStatusFlags(MU_Type *base)

Return the RX status flags.

This function return the RX status flags. Note: RFn bits of SR[27-24](mu status register) are mapped in reverse numerical order: RF0 -> SR[27] RF1 -> SR[26] RF2 -> SR[25] RF3 -> SR[24]

```
status_reg = MU_GetRxStatusFlags(base);
```

Parameters

- base – MU peripheral base address.

Returns

MU RX status

static inline uint32_t MU_GetInterruptsPending(MU_Type *base)

Gets the MU IRQ pending status of enabled interrupts.

This function returns the bit mask of the pending MU IRQs of enabled interrupts. Only these flags are checked. kMU_Tx0EmptyFlag kMU_Tx1EmptyFlag kMU_Tx2EmptyFlag kMU_Tx3EmptyFlag kMU_Rx0FullFlag kMU_Rx1FullFlag kMU_Rx2FullFlag kMU_Rx3FullFlag kMU_GenInt0Flag kMU_GenInt1Flag kMU_GenInt2Flag kMU_GenInt3Flag

Parameters

- base – MU peripheral base address.

Returns

Bit mask of the MU IRQs pending.

static inline void MU_ClearStatusFlags(MU_Type *base, uint32_t mask)

Clears the specific MU status flags.

This function clears the specific MU status flags. The flags to clear should be passed in as bit mask. See `_mu_status_flags`.

```

Clear general interrupt 0 and general interrupt 1 pending flags.
MU_ClearStatusFlags(base, kMU_GenInt0Flag | kMU_GenInt1Flag);

```

Parameters

- base – MU peripheral base address.

- **mask** – Bit mask of the MU status flags. See `_mu_status_flags`. The following flags are cleared by hardware, this function could not clear them.
 - `kMU_Tx0EmptyFlag`
 - `kMU_Tx1EmptyFlag`
 - `kMU_Tx2EmptyFlag`
 - `kMU_Tx3EmptyFlag`
 - `kMU_Rx0FullFlag`
 - `kMU_Rx1FullFlag`
 - `kMU_Rx2FullFlag`
 - `kMU_Rx3FullFlag`
 - `kMU_EventPendingFlag`
 - `kMU_FlagsUpdatingFlag`
 - `kMU_OtherSideInResetFlag`

`static inline void MU_EnableInterrupts(MU_Type *base, uint32_t mask)`

Enables the specific MU interrupts.

This function enables the specific MU interrupts. The interrupts to enable should be passed in as bit mask. See `_mu_interrupt_enable`.

```
Enable general interrupt 0 and TX0 empty interrupt.
MU_EnableInterrupts(base, kMU_GenInt0InterruptEnable | kMU_Tx0EmptyInterruptEnable);
```

Parameters

- **base** – MU peripheral base address.
- **mask** – Bit mask of the MU interrupts. See `_mu_interrupt_enable`.

`static inline void MU_DisableInterrupts(MU_Type *base, uint32_t mask)`

Disables the specific MU interrupts.

This function disables the specific MU interrupts. The interrupts to disable should be passed in as bit mask. See `_mu_interrupt_enable`.

```
Disable general interrupt 0 and TX0 empty interrupt.
MU_DisableInterrupts(base, kMU_GenInt0InterruptEnable | kMU_Tx0EmptyInterruptEnable);
```

Parameters

- **base** – MU peripheral base address.
- **mask** – Bit mask of the MU interrupts. See `_mu_interrupt_enable`.

`status_t MU_TriggerInterrupts(MU_Type *base, uint32_t mask)`

Triggers interrupts to the other core.

This function triggers the specific interrupts to the other core. The interrupts to trigger are passed in as bit mask. See `_mu_interrupt_trigger`. The MU should not trigger an interrupt to the other core when the previous interrupt has not been processed by the other core. This function checks whether the previous interrupts have been processed. If not, it returns an error.

```
if (kStatus_Success != MU_TriggerInterrupts(base, kMU_GenInt0InterruptTrigger | kMU_
↪ GenInt2InterruptTrigger))
{
```

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```
    Previous general purpose interrupt 0 or general purpose interrupt 2
    has not been processed by the other core.
}
```

Parameters

- base – MU peripheral base address.
- mask – Bit mask of the interrupts to trigger. See `_mu_interrupt_trigger`.

Return values

- `kStatus_Success` – Interrupts have been triggered successfully.
- `kStatus_Fail` – Previous interrupts have not been accepted.

```
static inline void MU_MaskHardwareReset(MU_Type *base, bool mask)
```

Mask hardware reset by the other core.

The other core could call `MU_HardwareResetOtherCore()` to reset current core. To mask the reset, call this function and pass in true.

Parameters

- base – MU peripheral base address.
- mask – Pass true to mask the hardware reset, pass false to unmask it.

```
static inline mu_power_mode_t MU_GetOtherCorePowerMode(MU_Type *base)
```

Gets the power mode of the other core.

This function gets the power mode of the other core.

Parameters

- base – MU peripheral base address.

Returns

Power mode of the other core.

```
FSL_MU_DRIVER_VERSION
```

MU driver version.

```
enum _mu_status_flags
```

MU status flags.

Values:

```
enumerator kMU_Tx0EmptyFlag
```

TX0 empty.

```
enumerator kMU_Tx1EmptyFlag
```

TX1 empty.

```
enumerator kMU_Tx2EmptyFlag
```

TX2 empty.

```
enumerator kMU_Tx3EmptyFlag
```

TX3 empty.

```
enumerator kMU_Rx0FullFlag
```

RX0 full.

```
enumerator kMU_Rx1FullFlag
```

RX1 full.

enumerator kMU_Rx2FullFlag
RX2 full.

enumerator kMU_Rx3FullFlag
RX3 full.

enumerator kMU_GenInt0Flag
General purpose interrupt 0 pending.

enumerator kMU_GenInt1Flag
General purpose interrupt 1 pending.

enumerator kMU_GenInt2Flag
General purpose interrupt 2 pending.

enumerator kMU_GenInt3Flag
General purpose interrupt 3 pending.

enumerator kMU_EventPendingFlag
MU event pending.

enumerator kMU_FlagsUpdatingFlag
MU flags update is on-going.

enumerator kMU_ResetAssertInterruptFlag
The other core reset assert interrupt pending.

enumerator kMU_ResetDeassertInterruptFlag
The other core reset de-assert interrupt pending.

enumerator kMU_OtherSideInResetFlag
The other side is in reset.

enumerator kMU_MuResetInterruptFlag
The other side initializes MU reset.

enumerator kMU_HardwareResetInterruptFlag
Current side has been hardware reset by the other side.

enum _mu_interrupt_enable
MU interrupt source to enable.

Values:

enumerator kMU_Tx0EmptyInterruptEnable
TX0 empty.

enumerator kMU_Tx1EmptyInterruptEnable
TX1 empty.

enumerator kMU_Tx2EmptyInterruptEnable
TX2 empty.

enumerator kMU_Tx3EmptyInterruptEnable
TX3 empty.

enumerator kMU_Rx0FullInterruptEnable
RX0 full.

enumerator kMU_Rx1FullInterruptEnable
RX1 full.

enumerator kMU_Rx2FullInterruptEnable
RX2 full.

enumerator kMU_Rx3FullInterruptEnable
RX3 full.

enumerator kMU_GenInt0InterruptEnable
General purpose interrupt 0.

enumerator kMU_GenInt1InterruptEnable
General purpose interrupt 1.

enumerator kMU_GenInt2InterruptEnable
General purpose interrupt 2.

enumerator kMU_GenInt3InterruptEnable
General purpose interrupt 3.

enumerator kMU_ResetAssertInterruptEnable
The other core reset assert interrupt.

enumerator kMU_ResetDeassertInterruptEnable
The other core reset de-assert interrupt.

enumerator kMU_MuResetInterruptEnable
The other side initializes MU reset. The interrupt is ORed with the general purpose interrupt 3. The general purpose interrupt 3 is issued when the other side set the MU reset and this interrupt is enabled.

enumerator kMU_HardwareResetInterruptEnable
Current side has been hardware reset by the other side.

enum __mu_interrupt_trigger
MU interrupt that could be triggered to the other core.

Values:

enumerator kMU_GenInt0InterruptTrigger
General purpose interrupt 0.

enumerator kMU_GenInt1InterruptTrigger
General purpose interrupt 1.

enumerator kMU_GenInt2InterruptTrigger
General purpose interrupt 2.

enumerator kMU_GenInt3InterruptTrigger
General purpose interrupt 3.

enum __mu_msg_reg_index
MU message register.

Values:

enumerator kMU_MsgReg0

enumerator kMU_MsgReg1

enumerator kMU_MsgReg2

enumerator kMU_MsgReg3

typedef enum __mu_msg_reg_index mu_msg_reg_index_t
MU message register.

MU_CR_NMI_MASK

FSL_FEATURE_MU_HAS_RESET_ASSERT_INT

FSL_FEATURE_MU_HAS_RESET_DEASSERT_INT

MU_BUSY_POLL_COUNT

Maximum polling iterations for MU waiting loops.

This parameter defines the maximum number of iterations for any polling loop in the MU code before timing out and returning an error.

It applies to all waiting loops in MU driver, such as waiting for TX register to be empty or waiting for RX register to be full.

This is a count of loop iterations, not a time-based value.

If defined as 0, polling loops will continue indefinitely until their exit condition is met, which could potentially cause the system to hang if a core becomes unresponsive.

MU_GET_CORE_FLAG(flags)

MU_GET_STAT_FLAG(flags)

MU_GET_TX_FLAG(flags)

MU_GET_RX_FLAG(flags)

MU_GET_GI_FLAG(flags)

2.50 OSTIMER: OS Event Timer Driver

void OSTIMER_Init(OSTIMER_Type *base)

Initializes an OSTIMER by turning its bus clock on.

void OSTIMER_Deinit(OSTIMER_Type *base)

Deinitializes a OSTIMER instance.

This function shuts down OSTIMER bus clock

Parameters

- base – OSTIMER peripheral base address.

uint64_t OSTIMER_GrayToDecimal(uint64_t gray)

Translate the value from gray-code to decimal.

Parameters

- gray – The gray value input.

Returns

The decimal value.

static inline uint64_t OSTIMER_DecimalToGray(uint64_t dec)

Translate the value from decimal to gray-code.

Parameters

- dec – The decimal value.

Returns

The gray code of the input value.

uint32_t OSTIMER_GetStatusFlags(OSTIMER_Type *base)

Get OSTIMER status Flags.

This returns the status flag. Currently, only match interrupt flag can be got.

Parameters

- base – OSTIMER peripheral base address.

Returns

status register value

void OSTIMER_ClearStatusFlags(OSTIMER_Type *base, uint32_t mask)

Clear Status Interrupt Flags.

This clears intrrupt status flag. Currently, only match interrupt flag can be cleared.

Parameters

- base – OSTIMER peripheral base address.
- mask – Clear bit mask.

Returns

none

status_t OSTIMER_SetMatchRawValue(OSTIMER_Type *base, uint64_t count, *ostimer_callback_t* cb)

Set the match raw value for OSTIMER.

This function will set a match value for OSTIMER with an optional callback. And this callback will be called while the data in dedicated pair match register is equals to the value of central EVTIMER. Please note that, the data format may be gray-code, if so, please using OSTIMER_SetMatchValue().

Parameters

- base – OSTIMER peripheral base address.
- count – OSTIMER timer match value.(Value may be gray-code format)
- cb – OSTIMER callback (can be left as NULL if none, otherwise should be a void func(void)).

Return values

- kStatus_Success -- Set match raw value and enable interrupt Successfully.
- kStatus_Fail -- Set match raw value fail.

status_t OSTIMER_SetMatchValue(OSTIMER_Type *base, uint64_t count, *ostimer_callback_t* cb)

Set the match value for OSTIMER.

This function will set a match value for OSTIMER with an optional callback. And this callback will be called while the data in dedicated pair match register is equals to the value of central OS TIMER.

Parameters

- base – OSTIMER peripheral base address.
- count – OSTIMER timer match value.(Value is decimal format, and this value will be translate to Gray code in API if the IP counter is gray encoded.)
- cb – OSTIMER callback (can be left as NULL if none, otherwise should be a void func(void)).

Return values

- kStatus_Success -- Set match value and enable interrupt Successfully.

- kStatus_Fail – - Set match value fail.

static inline void OSTIMER_SetMatchRegister(OSTIMER_Type *base, uint64_t value)

Set value to OSTIMER MATCH register directly.

This function writes the input value to OSTIMER MATCH register directly, it does not touch any other registers. Note that, the data format is gray-code. The function OSTIMER_DecimalToGray could convert decimal value to gray code.

Parameters

- base – OSTIMER peripheral base address.
- value – OSTIMER timer match value (Value is gray-code format).

static inline uint64_t OSTIMER_GetMatchRegister(OSTIMER_Type *base)

Get the match value from OSTIMER.

This function will get the match value from OSTIMER. The value of timer match is gray code format.

Parameters

- base – OSTIMER peripheral base address.

Returns

Value of match register, data format is gray code.

static inline uint64_t OSTIMER_GetMatchValue(OSTIMER_Type *base)

Get the match value from OSTIMER.

This function will get a match value from OSTIMER.

Parameters

- base – OSTIMER peripheral base address.

Returns

Value of match register.

static inline void OSTIMER_EnableMatchInterrupt(OSTIMER_Type *base)

Enable the OSTIMER counter match interrupt.

Enable the timer counter match interrupt. The interrupt happens when OSTIMER counter matches the value in MATCH registers.

Parameters

- base – OSTIMER peripheral base address.

static inline void OSTIMER_DisableMatchInterrupt(OSTIMER_Type *base)

Disable the OSTIMER counter match interrupt.

Disable the timer counter match interrupt. The interrupt happens when OSTIMER counter matches the value in MATCH registers.

Parameters

- base – OSTIMER peripheral base address.

static inline uint64_t OSTIMER_GetCurrentTimerRawValue(OSTIMER_Type *base)

Get current timer raw count value from OSTIMER.

This function will get the timer count value from OS timer register. The raw value of timer count may be gray code format.

Parameters

- base – OSTIMER peripheral base address.

Returns

Raw value of OSTIMER, may be gray code format.

uint64_t OSTIMER_GetCurrentValue(OSTIMER_Type *base)

Get current timer count value from OSTIMER.

This function will get a decimal timer count value. If the RAW value of timer count is gray code format, it will be translated to decimal data internally.

Parameters

- base – OSTIMER peripheral base address.

Returns

Value of OSTIMER which will be formatted to decimal value.

static inline uint64_t OSTIMER_GetCaptureRawValue(OSTIMER_Type *base)

Get the capture value from OSTIMER.

This function will get a captured value from OSTIMER. The Raw value of timer capture may be gray code format.

Parameters

- base – OSTIMER peripheral base address.

Returns

Raw value of capture register, data format may be gray code.

uint64_t OSTIMER_GetCaptureValue(OSTIMER_Type *base)

Get the capture value from OSTIMER.

This function will get a capture decimal-value from OSTIMER. If the RAW value of timer count is gray code format, it will be translated to decimal data internally.

Parameters

- base – OSTIMER peripheral base address.

Returns

Value of capture register, data format is decimal.

void OSTIMER_HandleIRQ(OSTIMER_Type *base, *ostimer_callback_t* cb)

OS timer interrupt Service Handler.

This function handles the interrupt and refers to the callback array in the driver to callback user (as per request in OSTIMER_SetMatchValue()). if no user callback is scheduled, the interrupt will simply be cleared.

Parameters

- base – OS timer peripheral base address.
- cb – callback scheduled for this instance of OS timer

Returns

none

FSL_OSTIMER_DRIVER_VERSION

OSTIMER driver version.

enum *_ostimer_flags*

OSTIMER status flags.

Values:

enumerator kOSTIMER_MatchInterruptFlag

Match interrupt flag bit, sets if the match value was reached.

typedef void (*ostimer_callback_t)(void)
ostimer callback function.

2.51 OTFAD: On The Fly AES-128 Decryption Driver

void OTFAD_GetDefaultConfig(*otfad_config_t* *config)
OTFAD module initialization function.

Parameters

- config – OTFAD configuration.

AT_QUICKACCESS_SECTION_CODE (void OTFAD_Init(OTFAD_Type *base,
const *otfad_config_t* *config))
OTFAD module initialization function.

Parameters

- base – OTFAD base address.
- config – OTFAD configuration.

AT_QUICKACCESS_SECTION_CODE (void OTFAD_Deinit(OTFAD_Type *base))
Deinitializes the OTFAD.

static inline uint32_t OTFAD_GetOperateMode(OTFAD_Type *base)
OTFAD module get operate mode.

Parameters

- base – OTFAD base address.

static inline uint32_t OTFAD_GetStatus(OTFAD_Type *base)
OTFAD module get status.

Parameters

- base – OTFAD base address.

status_t OTFAD_SetEncryptionConfig(OTFAD_Type *base, const *otfad_encryption_config_t*
*config)
OTFAD module set encryption configuration.

Note: if enable keyblob process, the first 256 bytes external memory is use for keyblob data, so this region shouldn't be in OTFAD region.

Parameters

- base – OTFAD base address.
- config – encryption configuration.

status_t OTFAD_GetEncryptionConfig(OTFAD_Type *base, *otfad_encryption_config_t* *config)
OTFAD module get encryption configuration.

Note: if enable keyblob process, the first 256 bytes external memory is use for keyblob data, so this region shouldn't be in OTFAD region.

Parameters

- base – OTFAD base address.

- config – encryption configuration.

status_t OTFAD_HitDetermination(OTFAD_Type *base, uint32_t address, uint8_t *contextIndex)
OTFAD module do hit determination.

Parameters

- base – OTFAD base address.
- address – the physical address space assigned to the QuadSPI(FlexSPI) module.
- contextIndex – hitted context region index.

Returns

status, such as kStatus_Success or kStatus_OTFAD_ResRegAccessMode.

FSL_OTFAD_DRIVER_VERSION

Driver version.

Status codes for the OTFAD driver.

Values:

enumerator kStatus_OTFAD_ResRegAccessMode

Restricted register mode

enumerator kStatus_OTFAD_AddressError

End address less than start address

enumerator kStatus_OTFAD_RegionOverlap

the OTFAD does not support any form of memory region overlap, for system accesses that hit in multiple contexts or no contexts, the fetched data is simply bypassed

enumerator kStatus_OTFAD_RegionMiss

For accesses that hit in a single context, but not the selected one

OTFAD context type.

Values:

enumerator kOTFAD_Context_0

context 0

enumerator kOTFAD_Context_1

context 1

enumerator kOTFAD_Context_2

context 2

enumerator kOTFAD_Context_3

context 3

OTFAD operate mode.

Values:

enumerator kOTFAD_NRM

Normal Mode

enumerator kOTFAD_SVM

Security Violation Mode

enumerator kOTFAD_LDM

Logically Disabled Mode

typedef struct *_otfad_encryption_config* otfad_encryption_config_t

OTFAD encryption configuration structure.

typedef struct *_otfad_config* otfad_config_t

OTFAD configuration structure.

struct *_otfad_encryption_config*

#include <fsl_otfad.h> OTFAD encryption configuration structure.

Public Members

bool valid

The context is valid or not

bool AESdecryption

AES decryption enable

uint8_t readOnly

read write attribute for the entire set of context registers

uint8_t contextIndex

OTFAD context index

uint32_t startAddr

Start address

uint32_t endAddr

End address

uint32_t key[4]

Encryption key

uint32_t counter[2]

Encryption counter

struct *_otfad_config*

#include <fsl_otfad.h> OTFAD configuration structure.

Public Members

bool enableIntRequest

Interrupt request enable

bool forceError

Forces the OTFAD's key blob error flag (SR[KBERR]) to be asserted

bool forceSVM

Force entry into SVM after a write

bool forceLDM

Force entry into LDM after a write

bool keyBlobScramble

Key blob KEK scrambling

bool keyBlobProcess

Key blob processing

`bool startKeyBlobProcessing`
key blob processing is initiated

`bool restrictedRegAccess`
Restricted register access enable

`bool enableOTFAD`
OTFAD has decryption enabled

2.52 PINT: Pin Interrupt and Pattern Match Driver

`FSL_PINT_DRIVER_VERSION`

`enum _pint_pin_enable`
PINT Pin Interrupt enable type.

Values:

`enumerator kPINT_PinIntEnableNone`
Do not generate Pin Interrupt

`enumerator kPINT_PinIntEnableRiseEdge`
Generate Pin Interrupt on rising edge

`enumerator kPINT_PinIntEnableFallEdge`
Generate Pin Interrupt on falling edge

`enumerator kPINT_PinIntEnableBothEdges`
Generate Pin Interrupt on both edges

`enumerator kPINT_PinIntEnableLowLevel`
Generate Pin Interrupt on low level

`enumerator kPINT_PinIntEnableHighLevel`
Generate Pin Interrupt on high level

`enum _pint_int`
PINT Pin Interrupt type.

Values:

`enumerator kPINT_PinInt0`
Pin Interrupt 0

`enum _pint_pmatch_input_src`
PINT Pattern Match bit slice input source type.

Values:

`enumerator kPINT_PatternMatchInp0Src`
Input source 0

`enumerator kPINT_PatternMatchInp1Src`
Input source 1

`enumerator kPINT_PatternMatchInp2Src`
Input source 2

`enumerator kPINT_PatternMatchInp3Src`
Input source 3

enumerator kPINT_PatternMatchInp4Src
Input source 4

enumerator kPINT_PatternMatchInp5Src
Input source 5

enumerator kPINT_PatternMatchInp6Src
Input source 6

enumerator kPINT_PatternMatchInp7Src
Input source 7

enumerator kPINT_SecPatternMatchInp0Src
Input source 0

enumerator kPINT_SecPatternMatchInp1Src
Input source 1

enum _pint_pmatch_bslic
PINT Pattern Match bit slice type.

Values:

enumerator kPINT_PatternMatchBSlice0
Bit slice 0

enum _pint_pmatch_bslic_cfg
PINT Pattern Match configuration type.

Values:

enumerator kPINT_PatternMatchAlways
Always Contributes to product term match

enumerator kPINT_PatternMatchStickyRise
Sticky Rising edge

enumerator kPINT_PatternMatchStickyFall
Sticky Falling edge

enumerator kPINT_PatternMatchStickyBothEdges
Sticky Rising or Falling edge

enumerator kPINT_PatternMatchHigh
High level

enumerator kPINT_PatternMatchLow
Low level

enumerator kPINT_PatternMatchNever
Never contributes to product term match

enumerator kPINT_PatternMatchBothEdges
Either rising or falling edge

typedef enum _pint_pin_enable pint_pin_enable_t
PINT Pin Interrupt enable type.

typedef enum _pint_int pint_pin_int_t
PINT Pin Interrupt type.

typedef enum _pint_pmatch_input_src pint_pmatch_input_src_t
PINT Pattern Match bit slice input source type.

```
typedef enum _pint_pmatch_bslice pint_pmatch_bslice_t
```

PINT Pattern Match bit slice type.

```
typedef enum _pint_pmatch_bslice_cfg pint_pmatch_bslice_cfg_t
```

PINT Pattern Match configuration type.

```
typedef struct _pint_status pint_status_t
```

PINT event status.

```
typedef void (*pint_cb_t)(pint_pin_int_t pintr, pint_status_t *status)
```

PINT Callback function.

```
typedef struct _pint_pmatch_cfg pint_pmatch_cfg_t
```

```
void PINT_Init(PINT_Type *base)
```

Initialize PINT peripheral.

This function initializes the PINT peripheral and enables the clock.

Parameters

- base – Base address of the PINT peripheral.

Return values

None. –

```
void PINT_SetCallback(PINT_Type *base, pint_cb_t callback)
```

Set PINT callback.

This function set the callback for PINT interrupt handler.

Parameters

- base – Base address of the PINT peripheral.
- callback – Callback.

Return values

None. –

```
void PINT_PinInterruptConfig(PINT_Type *base, pint_pin_int_t intr, pint_pin_enable_t enable)
```

Configure PINT peripheral pin interrupt.

This function configures a given pin interrupt.

Parameters

- base – Base address of the PINT peripheral.
- intr – Pin interrupt.
- enable – Selects detection logic.

Return values

None. –

```
void PINT_PinInterruptGetConfig(PINT_Type *base, pint_pin_int_t pintr, pint_pin_enable_t *enable)
```

Get PINT peripheral pin interrupt configuration.

This function returns the configuration of a given pin interrupt.

Parameters

- base – Base address of the PINT peripheral.
- pintr – Pin interrupt.
- enable – Pointer to store the detection logic.

Return values

None. –

void PINT_PinInterruptClrStatus(PINT_Type *base, *pintr*)

Clear Selected pin interrupt status only when the pin was triggered by edge-sensitive.

This function clears the selected pin interrupt status.

Parameters

- base – Base address of the PINT peripheral.
- pintr – Pin interrupt.

Return values

None. –

static inline uint32_t PINT_PinInterruptGetStatus(PINT_Type *base, *pintr*)

Get Selected pin interrupt status.

This function returns the selected pin interrupt status.

Parameters

- base – Base address of the PINT peripheral.
- pintr – Pin interrupt.

Return values

status – = 0 No pin interrupt request. = 1 Selected Pin interrupt request active.

void PINT_PinInterruptClrStatusAll(PINT_Type *base)

Clear all pin interrupts status only when pins were triggered by edge-sensitive.

This function clears the status of all pin interrupts.

Parameters

- base – Base address of the PINT peripheral.

Return values

None. –

static inline uint32_t PINT_PinInterruptGetStatusAll(PINT_Type *base)

Get all pin interrupts status.

This function returns the status of all pin interrupts.

Parameters

- base – Base address of the PINT peripheral.

Return values

status – Each bit position indicates the status of corresponding pin interrupt.
= 0 No pin interrupt request. = 1 Pin interrupt request active.

static inline void PINT_PinInterruptClrFallFlag(PINT_Type *base, *pintr*)

Clear Selected pin interrupt fall flag.

This function clears the selected pin interrupt fall flag.

Parameters

- base – Base address of the PINT peripheral.
- pintr – Pin interrupt.

Return values

None. –

```
static inline uint32_t PINT_PinInterruptGetFallFlag(PINT_Type *base, pintr)
```

Get selected pin interrupt fall flag.

This function returns the selected pin interrupt fall flag.

Parameters

- *base* – Base address of the PINT peripheral.
- *pintr* – Pin interrupt.

Return values

flag – = 0 Falling edge has not been detected. = 1 Falling edge has been detected.

```
static inline void PINT_PinInterruptClrFallFlagAll(PINT_Type *base)
```

Clear all pin interrupt fall flags.

This function clears the fall flag for all pin interrupts.

Parameters

- *base* – Base address of the PINT peripheral.

Return values

None. –

```
static inline uint32_t PINT_PinInterruptGetFallFlagAll(PINT_Type *base)
```

Get all pin interrupt fall flags.

This function returns the fall flag of all pin interrupts.

Parameters

- *base* – Base address of the PINT peripheral.

Return values

flags – Each bit position indicates the falling edge detection of the corresponding pin interrupt. 0 Falling edge has not been detected. = 1 Falling edge has been detected.

```
static inline void PINT_PinInterruptClrRiseFlag(PINT_Type *base, pintr)
```

Clear Selected pin interrupt rise flag.

This function clears the selected pin interrupt rise flag.

Parameters

- *base* – Base address of the PINT peripheral.
- *pintr* – Pin interrupt.

Return values

None. –

```
static inline uint32_t PINT_PinInterruptGetRiseFlag(PINT_Type *base, pintr)
```

Get selected pin interrupt rise flag.

This function returns the selected pin interrupt rise flag.

Parameters

- *base* – Base address of the PINT peripheral.
- *pintr* – Pin interrupt.

Return values

flag – = 0 Rising edge has not been detected. = 1 Rising edge has been detected.

```
static inline void PINT_PinInterruptClrRiseFlagAll(PINT_Type *base)
```

Clear all pin interrupt rise flags.

This function clears the rise flag for all pin interrupts.

Parameters

- *base* – Base address of the PINT peripheral.

Return values

None. –

```
static inline uint32_t PINT_PinInterruptGetRiseFlagAll(PINT_Type *base)
```

Get all pin interrupt rise flags.

This function returns the rise flag of all pin interrupts.

Parameters

- *base* – Base address of the PINT peripheral.

Return values

flags – Each bit position indicates the rising edge detection of the corresponding pin interrupt. 0 Rising edge has not been detected. = 1 Rising edge has been detected.

```
void PINT_PatternMatchConfig(PINT_Type *base, pint_pmatch_bslice_t bslice, pint_pmatch_cfg_t *cfg)
```

Configure PINT pattern match.

This function configures a given pattern match bit slice.

Parameters

- *base* – Base address of the PINT peripheral.
- *bslice* – Pattern match bit slice number.
- *cfg* – Pointer to bit slice configuration.

Return values

None. –

```
void PINT_PatternMatchGetConfig(PINT_Type *base, pint_pmatch_bslice_t bslice, pint_pmatch_cfg_t *cfg)
```

Get PINT pattern match configuration.

This function returns the configuration of a given pattern match bit slice.

Parameters

- *base* – Base address of the PINT peripheral.
- *bslice* – Pattern match bit slice number.
- *cfg* – Pointer to bit slice configuration.

Return values

None. –

```
static inline uint32_t PINT_PatternMatchGetStatus(PINT_Type *base, pint_pmatch_bslice_t bslice)
```

Get pattern match bit slice status.

This function returns the status of selected bit slice.

Parameters

- *base* – Base address of the PINT peripheral.
- *bslice* – Pattern match bit slice number.

Return values

status – = 0 Match has not been detected. = 1 Match has been detected.

static inline uint32_t PINT_PatternMatchGetStatusAll(PINT_Type *base)

Get status of all pattern match bit slices.

This function returns the status of all bit slices.

Parameters

- base – Base address of the PINT peripheral.

Return values

status – Each bit position indicates the match status of corresponding bit slice.
= 0 Match has not been detected. = 1 Match has been detected.

uint32_t PINT_PatternMatchResetDetectLogic(PINT_Type *base)

Reset pattern match detection logic.

This function resets the pattern match detection logic if any of the product term is matching.

Parameters

- base – Base address of the PINT peripheral.

Return values

pmstatus – Each bit position indicates the match status of corresponding bit slice.
= 0 Match was detected. = 1 Match was not detected.

static inline void PINT_PatternMatchEnable(PINT_Type *base)

Enable pattern match function.

This function enables the pattern match function.

Parameters

- base – Base address of the PINT peripheral.

Return values

None. –

static inline void PINT_PatternMatchDisable(PINT_Type *base)

Disable pattern match function.

This function disables the pattern match function.

Parameters

- base – Base address of the PINT peripheral.

Return values

None. –

static inline void PINT_PatternMatchEnableRXEV(PINT_Type *base)

Enable RXEV output.

This function enables the pattern match RXEV output.

Parameters

- base – Base address of the PINT peripheral.

Return values

None. –

static inline void PINT_PatternMatchDisableRXEV(PINT_Type *base)

Disable RXEV output.

This function disables the pattern match RXEV output.

Parameters

- base – Base address of the PINT peripheral.

Return values

None. –

void PINT_EnableCallback(PINT_Type *base)

Enable callback.

This function enables the interrupt for the selected PINT peripheral. Although the pin(s) are monitored as soon as they are enabled, the callback function is not enabled until this function is called.

Parameters

- base – Base address of the PINT peripheral.

Return values

None. –

void PINT_DisableCallback(PINT_Type *base)

Disable callback.

This function disables the interrupt for the selected PINT peripheral. Although the pins are still being monitored but the callback function is not called.

Parameters

- base – Base address of the peripheral.

Return values

None. –

void PINT_Deinit(PINT_Type *base)

Deinitialize PINT peripheral.

This function disables the PINT clock.

Parameters

- base – Base address of the PINT peripheral.

Return values

None. –

void PINT_EnableCallbackByIndex(PINT_Type *base, *pint_pin_int_t* pintIdx)

enable callback by pin index.

This function enables callback by pin index instead of enabling all pins.

Parameters

- base – Base address of the peripheral.
- pintIdx – pin index.

Return values

None. –

void PINT_DisableCallbackByIndex(PINT_Type *base, *pint_pin_int_t* pintIdx)

disable callback by pin index.

This function disables callback by pin index instead of disabling all pins.

Parameters

- base – Base address of the peripheral.
- pintIdx – pin index.

Return values

None. –

```
PINT_USE_LEGACY_CALLBACK
PININT_BITSLICE_SRC_START
PININT_BITSLICE_SRC_MASK
PININT_BITSLICE_CFG_START
PININT_BITSLICE_CFG_MASK
PININT_BITSLICE_ENDP_MASK
PINT_PIN_INT_LEVEL
PINT_PIN_INT_EDGE
PINT_PIN_INT_FALL_OR_HIGH_LEVEL
PINT_PIN_INT_RISE
PINT_PIN_RISE_EDGE
PINT_PIN_FALL_EDGE
PINT_PIN_BOTH_EDGE
PINT_PIN_LOW_LEVEL
PINT_PIN_HIGH_LEVEL

struct _pint_status
    #include <fsl_pint.h> PINT event status.

struct _pint_pmatch_cfg
    #include <fsl_pint.h>
```

2.53 Power Driver

```
enum _pmc_interrupt
    PMC event flags.
```

Note: These enums are meant to be OR'd together to form a bit mask.

Values:

```
enumerator kPMC_INT_LVDCORE
    Vddcore Low-Voltage Detector Interrupt Enable.

enumerator kPMC_INT_HVDCORE
    Vddcore High-Voltage Detector Interrupt Enable.

enumerator kPMC_INT_HVD1V8
    Vdd1v8 High-Voltage Detector Interrupt Enable.

enumerator kPMC_INT_AUTOWK
    PMC automatic wakeup enable and interrupt enable.

enumerator kPMC_INT_INTRPAD
    Interrupt pad deep powerdown and deep sleep wake up & interrupt enable.
```

enum _pmc_event_flags
PMC event flags.

Note: These enums are meant to be OR'd together to form a bit mask.

Values:

enumerator kPMC_FLAGS_PORCORE

POR triggered by the vddcore POR monitor (0 = no, 1 = yes).

enumerator kPMC_FLAGS_POR1V8

vdd1v8 power on event detected since last cleared(0 = no, 1 = yes).

enumerator kPMC_FLAGS_PORAO18

vdd_ao18 power on event detected since last cleared (0 = no, 1 = yes).

enumerator kPMC_FLAGS_LVDCORE

LVD tripped since last time this bit was cleared (0 = no, 1 = yes).

enumerator kPMC_FLAGS_HVDCORE

HVD tripped since last time this bit was cleared (0 = no, 1 = yes).

enumerator kPMC_FLAGS_HVD1V8

vdd1v8 HVD tripped since last time this bit was cleared (0 = no, 1 = yes).

enumerator kPMC_FLAGS_RTC

RTC wakeup detected since last time flag was cleared (0 = no, 1 = yes).

enumerator kPMC_FLAGS_AUTOWK

PMC Auto wakeup caused a deep sleep wakeup and interrupt (0 = no, 1 = yes).

enumerator kPMC_FLAGS_INTNPADF

Pad interrupt caused a wakeup or interrupt event since the last time this flag was cleared (0 = no, 1 = yes).

enumerator kPMC_FLAGS_RESETPAD

Reset pad wakeup caused a wakeup or reset event since the last time this bit was cleared. (0 = no, 1 = yes).

enumerator kPMC_FLAGS_DEEPPD

Deep powerdown was entered since the last time this flag was cleared (0 = no, 1 = yes).

enum pd_bits

Values:

enumerator kPDRUNCFG_PMC_MODE0

enumerator kPDRUNCFG_PMC_MODE1

enumerator kPDRUNCFG_LP_VDD_COREREG

enumerator kPDRUNCFG_LP_PMCREF

enumerator kPDRUNCFG_PD_HVD1V8

enumerator kPDRUNCFG_LP_PORCORE

enumerator kPDRUNCFG_LP_LVDCORE

enumerator kPDRUNCFG_PD_HVDCORE

enumerator kPDRUNCFG_PD_SYSXTAL

enumerator kPDRUNCFG_PD_LPOSC
enumerator kPDRUNCFG_PD_SFRO
enumerator kPDRUNCFG_PD_FFRO
enumerator kPDRUNCFG_PD_SYSPLL_LDO
enumerator kPDRUNCFG_PD_SYSPLL_ANA
enumerator kPDRUNCFG_PD_AUDPLL_LDO
enumerator kPDRUNCFG_PD_AUDPLL_ANA
enumerator kPDRUNCFG_PD_ADC
enumerator kPDRUNCFG_LP_ADC
enumerator kPDRUNCFG_PD_ADC_TEMPSNS
enumerator kPDRUNCFG_PD_ACOMP
enumerator kPDRUNCFG_LP_HSPAD_VDET
enumerator kPDRUNCFG_PD_HSPAD_REF
enumerator kPDRUNCFG_APD_PQ_SRAM
enumerator kPDRUNCFG_PPD_PQ_SRAM
enumerator kPDRUNCFG_APD_FLEXSPI_SRAM
enumerator kPDRUNCFG_PPD_FLEXSPI_SRAM
enumerator kPDRUNCFG_APD_USBHS_SRAM
enumerator kPDRUNCFG_PPD_USBHS_SRAM
enumerator kPDRUNCFG_APD_USDHC0_SRAM
enumerator kPDRUNCFG_PPD_USDHC0_SRAM
enumerator kPDRUNCFG_APD_USDHC1_SRAM
enumerator kPDRUNCFG_PPD_USDHC1_SRAM
enumerator kPDRUNCFG_APD_CASPER_SRAM
enumerator kPDRUNCFG_PPD_CASPER_SRAM
enumerator kPDRUNCFG_APD_DSP_CACHE_REGF
enumerator kPDRUNCFG_PPD_DSP_CACHE_REGF
enumerator kPDRUNCFG_APD_DSP_TCM_REGF
enumerator kPDRUNCFG_PPD_DSP_TCM_REGF
enumerator kPDRUNCFG_PD_ROM
enumerator kPDRUNCFG_SRAM_SLEEP
enumerator kPDRUNCFG_APD_SRAM_IF0
enumerator kPDRUNCFG_APD_SRAM_IF1

enumerator kPDRUNCFG_APD_SRAM_IF2
enumerator kPDRUNCFG_APD_SRAM_IF3
enumerator kPDRUNCFG_APD_SRAM_IF4
enumerator kPDRUNCFG_APD_SRAM_IF5
enumerator kPDRUNCFG_APD_SRAM_IF6
enumerator kPDRUNCFG_APD_SRAM_IF7
enumerator kPDRUNCFG_APD_SRAM_IF8
enumerator kPDRUNCFG_APD_SRAM_IF9
enumerator kPDRUNCFG_APD_SRAM_IF10
enumerator kPDRUNCFG_APD_SRAM_IF11
enumerator kPDRUNCFG_APD_SRAM_IF12
enumerator kPDRUNCFG_APD_SRAM_IF13
enumerator kPDRUNCFG_APD_SRAM_IF14
enumerator kPDRUNCFG_APD_SRAM_IF15
enumerator kPDRUNCFG_APD_SRAM_IF16
enumerator kPDRUNCFG_APD_SRAM_IF17
enumerator kPDRUNCFG_APD_SRAM_IF18
enumerator kPDRUNCFG_APD_SRAM_IF19
enumerator kPDRUNCFG_APD_SRAM_IF20
enumerator kPDRUNCFG_APD_SRAM_IF21
enumerator kPDRUNCFG_APD_SRAM_IF22
enumerator kPDRUNCFG_APD_SRAM_IF23
enumerator kPDRUNCFG_APD_SRAM_IF24
enumerator kPDRUNCFG_APD_SRAM_IF25
enumerator kPDRUNCFG_APD_SRAM_IF26
enumerator kPDRUNCFG_APD_SRAM_IF27
enumerator kPDRUNCFG_APD_SRAM_IF28
enumerator kPDRUNCFG_APD_SRAM_IF29
enumerator kPDRUNCFG_PPD_SRAM_IF0
enumerator kPDRUNCFG_PPD_SRAM_IF1
enumerator kPDRUNCFG_PPD_SRAM_IF2
enumerator kPDRUNCFG_PPD_SRAM_IF3
enumerator kPDRUNCFG_PPD_SRAM_IF4

enumerator kPDRUNCFG_PPD_SRAM_IF5
enumerator kPDRUNCFG_PPD_SRAM_IF6
enumerator kPDRUNCFG_PPD_SRAM_IF7
enumerator kPDRUNCFG_PPD_SRAM_IF8
enumerator kPDRUNCFG_PPD_SRAM_IF9
enumerator kPDRUNCFG_PPD_SRAM_IF10
enumerator kPDRUNCFG_PPD_SRAM_IF11
enumerator kPDRUNCFG_PPD_SRAM_IF12
enumerator kPDRUNCFG_PPD_SRAM_IF13
enumerator kPDRUNCFG_PPD_SRAM_IF14
enumerator kPDRUNCFG_PPD_SRAM_IF15
enumerator kPDRUNCFG_PPD_SRAM_IF16
enumerator kPDRUNCFG_PPD_SRAM_IF17
enumerator kPDRUNCFG_PPD_SRAM_IF18
enumerator kPDRUNCFG_PPD_SRAM_IF19
enumerator kPDRUNCFG_PPD_SRAM_IF20
enumerator kPDRUNCFG_PPD_SRAM_IF21
enumerator kPDRUNCFG_PPD_SRAM_IF22
enumerator kPDRUNCFG_PPD_SRAM_IF23
enumerator kPDRUNCFG_PPD_SRAM_IF24
enumerator kPDRUNCFG_PPD_SRAM_IF25
enumerator kPDRUNCFG_PPD_SRAM_IF26
enumerator kPDRUNCFG_PPD_SRAM_IF27
enumerator kPDRUNCFG_PPD_SRAM_IF28
enumerator kPDRUNCFG_PPD_SRAM_IF29
enumerator kPDRUNCFG_ForceUnsigned

enum __power_mode_config

Power mode configuration API parameter.

Values:

enumerator kPmu_Sleep
enumerator kPmu_Deep_Sleep
enumerator kPmu_Deep_PowerDown
enumerator kPmu_Full_Deep_PowerDown

enum __body_bias_mode

Body Bias mode definition.

Values:

enumerator kPmu_Fbb

enumerator kPmu_Rbb

enumerator kPmu_Nbb

enum __pmic_mode_reg

Values:

enumerator kCfg_Run

enumerator kCfg_Sleep

enum __power_pad_vrange_val

pad voltage range value.

Values:

enumerator kPadVol_171_360

Voltage from 1.71V to 3.60V.

enumerator kPadVol_171_198

Voltage from 1.71V to 1.98V.

enumerator kPadVol_300_360

Voltage from 3.00V to 3.60V.

enum __power_lvd_falling_trip_vol_val

LVD falling trip voltage value.

Values:

enumerator kLvdFallingTripVol_720

Voltage 720mV.

enumerator kLvdFallingTripVol_735

Voltage 735mV.

enumerator kLvdFallingTripVol_750

Voltage 750mV.

enumerator kLvdFallingTripVol_765

Voltage 765mV.

enumerator kLvdFallingTripVol_780

Voltage 780mV.

enumerator kLvdFallingTripVol_795

Voltage 795mV.

enumerator kLvdFallingTripVol_810

Voltage 810mV.

enumerator kLvdFallingTripVol_825

Voltage 825mV.

enumerator kLvdFallingTripVol_840

Voltage 840mV.

enumerator kLvdFallingTripVol_855
Voltage 855mV.

enumerator kLvdFallingTripVol_870
Voltage 870mV.

enumerator kLvdFallingTripVol_885
Voltage 885mV.

enumerator kLvdFallingTripVol_900
Voltage 900mV.

enumerator kLvdFallingTripVol_915
Voltage 915mV.

enumerator kLvdFallingTripVol_930
Voltage 930mV.

enumerator kLvdFallingTripVol_945
Voltage 945mV.

enum __power__part__temp__range
Part temperature range.

Values:

enumerator kPartTemp_0C_P85C
Part temp range 0C - 85C.

enumerator kPartTemp_N20C_P85C
Part temp range -20C - 85C.

enum __power__volt__op__range
Voltage operation range.

Values:

enumerator kVoltOpLowRange
Voltage operation range is (0.7V, 0.8V, 0.9V). Maximum supported CM33 frequency is 220MHz for 0C-85C part and 215MHz for -20C-85C part. Maximum supported DSP frequency is 375MHz for 0C-85C part and 355MHz for -20C-85C part.

enumerator kVoltOpFullRange
Voltage operation range is (0.7V, 0.8V, 0.9V, 1.0V, 1.13V). This range can support full CM33/DSP speed clarified in Data Sheet.

enum __power__vddcore__src
VDDCORE supply source.

Values:

enumerator kVddCoreSrc_LDO
VDDCORE is supplied by onchip regulator.

enumerator kVddCoreSrc_PMIC
VDDCORE is supplied by external PMIC.

enum __power__control__for__pmic__mode
vddcore or vdd1v8 power on selection for different PMIC mode. vddcore and vdd1v8 are always on in mode0. Refer to PMC->PMICCFG.

Values:

```

enumerator kVddCoreOnMode1
    VDDCORE is powered in PMIC mode1.
enumerator kVddCoreOnMode2
    VDDCORE is powered in PMIC mode2.
enumerator kVddCoreOnMode3
    VDDCORE is powered in PMIC mode3.
enumerator kVdd1v8OnMode1
    VDD1V8 is powered in PMIC mode1.
enumerator kVdd1v8OnMode2
    VDD1V8 is powered in PMIC mode2.
enumerator kVdd1v8OnMode3
    VDD1V8 is powered in PMIC mode3.
typedef enum pd_bits pd_bit_t

typedef enum _power_mode_config power_mode_cfg_t
    Power mode configuration API parameter.
typedef enum _body_bias_mode body_bias_mode_t
    Body Bias mode definition.
typedef enum _pmic_mode_reg pmic_mode_reg_t

typedef enum _power_pad_vrange_val power_pad_vrange_val_t
    pad voltage range value.
typedef struct _power_pad_vrange power_pad_vrange_t
    pad voltage range configuration.
typedef enum _power_lvd_falling_trip_vol_val power_lvd_falling_trip_vol_val_t
    LVD falling trip voltage value.
typedef enum _power_part_temp_range power_part_temp_range_t
    Part temperature range.
typedef enum _power_volt_op_range power_volt_op_range_t
    Voltage operation range.
typedef enum _power_vddcore_src power_vddcore_src_t
    VDDCORE supply source.
typedef enum _power_control_for_pmic_mode power_control_for_pmic_mode
    vddcore or vdd1v8 power on selection for different PMIC mode. vddcore and vdd1v8 are
    always on in mode0. Refer to PMC->PMICCFG.
typedef void (*power_vddcore_set_func_t)(uint32_t millivolt)
    Callback function used to change VDDCORE when the VDDCORE is supplied by external
    PMIC. Refer to POWER_SetVddCoreSupplySrc()
void POWER_PmicPowerModeSelectControl(uint32_t vddSelect)
    API to set vddcore or vdd1v8 power on for PMIC modes which is responded to
    PDRUNCFG0[PMIC_MODE] or PDSLEEPCFG0[PMIC_MODE] select pin values. If not set, the
    driver will use default configurations for different PMIC mode. The default configuration
    is as below. PMIC_MODE: power mode select 0b00 run mode, all supplies on. 0b01 deep
    sleep mode, all supplies on. 0b10 deep powerdown mode, vddcore off. 0b11 full deep pow-
    erdown mode vdd1v8 and vddcore off.

```

Note, be cautious to modify the VDD state in different PMIC mode. When the default configuration is changed, use `exclude_from_pd[0]` to configure the PMIC mode for deep sleep and power down mode.

Parameters

- `vddSelect` – the ORd value of `power_control_for_pmic_mode`. Defines run (all supplies on), deep power-down (VDDCORE off), and true deep power-down (VDD1V8 and VDDCORE off).

static inline void `POWER_EnablePD(pd_bit_t en)`

API to enable PDRUNCFG bit in the Sysctl0. Note that enabling the bit powers down the peripheral.

Parameters

- `en` – peripheral for which to enable the PDRUNCFG bit

static inline void `POWER_DisablePD(pd_bit_t en)`

API to disable PDRUNCFG bit in the Sysctl0. Note that disabling the bit powers up the peripheral.

Parameters

- `en` – peripheral for which to disable the PDRUNCFG bit

static inline void `POWER_EnableDeepSleep(void)`

API to enable deep sleep bit in the ARM Core.

static inline void `POWER_DisableDeepSleep(void)`

API to disable deep sleep bit in the ARM Core.

void `POWER_UpdateOscSettlingTime(uint32_t osc_delay)`

API to update XTAL oscillator settling time .

Parameters

- `osc_delay` – : OSC stabilization time in unit of microsecond

void `POWER_UpdatePmicRecoveryTime(uint32_t pmic_delay)`

API to update on-board PMIC vddcore recovery time.

NOTE: If LDO is used instead of PMIC, don't call it. Otherwise it must be called to allow power library to well handle the deep sleep process.

Parameters

- `pmic_delay` – : PMIC stabilization time in unit of microsecond, or `PMIC_VDDCORE_RECOVERY_TIME_IGNORE` if not care.

void `POWER_ApplyPD(void)`

API to apply updated PMC PDRUNCFG bits in the Sysctl0.

void `POWER_ClearEventFlags(uint32_t statusMask)`

Clears the PMC event flags state.

Parameters

- `statusMask` – : A bitmask of event flags that are to be cleared.

uint32_t `POWER_GetEventFlags(void)`

Get the PMC event flags state.

Returns

PMC FLAGS register value

`void POWER_EnableInterrupts(uint32_t interruptMask)`

Enable the PMC interrupt requests.

Parameters

- `interruptMask` – : A bitmask of of interrupts to enable.

`void POWER_DisableInterrupts(uint32_t interruptMask)`

Disable the PMC interrupt requests.

Parameters

- `interruptMask` – : A bitmask of of interrupts to disable.

`void POWER_SetAnalogBuffer(bool enable)`

Set the PMC analog buffer for references or ATX2.

Parameters

- `enable` – : Set to true to enable analog buffer for references or ATX2, false to disable.

`static inline uint32_t POWER_GetPmicMode(pmic_mode_reg_t reg)`

Get PMIC_MODE pins configure value.

Parameters

- `reg` – : PDSLEEPCFG0 or PDRUNCFG0 register offset

Returns

PMIC_MODE pins value in PDSLEEPCFG0

`static inline body_bias_mode_t POWER_GetBodyBiasMode(pmic_mode_reg_t reg)`

Get RBB/FBB bit value.

Parameters

- `reg` – : PDSLEEPCFG0 or PDRUNCFG0 register offset

Returns

Current body bias mode

`void POWER_SetPadVolRange(const power_pad_vrange_t *config)`

Configure pad voltage level. Wide voltage range cost more power due to enabled voltage detector.

NOTE: BE CAUTIOUS TO CALL THIS API. IF THE PAD SUPPLY IS BEYOND THE SET RANGE, SILICON MIGHT BE DAMAGED.

Parameters

- `config` – pad voltage range configuration.

`AT_QUICKACCESS_SECTION_CODE (void POWER_EnterRbb(void))`

PMC Enter Rbb mode function call.

PMC exit Rbb & Fbb mode function call.

PMC Enter Fbb mode function call.

`bool POWER_SetLdoVoltageForFreq(power_part_temp_range_t tempRange,
 power_volt_op_range_t voltOpRange, uint32_t cm33Freq,
 uint32_t dspFreq)`

Deprecated and replaced by `POWER_SetVoltageForFreq()`! PMC Set Ldo volatage for particular frequency. NOTE: The API is only valid when `MAINPLLCLKDIV[7:0]` and `DSPPLLCLKDIV[7:0]` are 0. If LVD falling trip voltage is higher than the required core voltage for particular frequency, LVD voltage will be decreased to safe level to avoid unexpected LVD reset or interrupt event.

Parameters

- tempRange – : part temperature range
- voltOpRange – : voltage operation range.
- cm33Freq – : CM33 CPU clock frequency value
- dspFreq – : DSP CPU clock frequency value

Returns

true for success and false for CPU frequency out of specified voltOpRange.

void POWER_SetVddCoreSupplySrc(*power_vddcore_src_t* src)

Set VDDCORE supply source, PMIC or on-chip regulator.

Parameters

- src – : power_vddcore_src_t, VDDCore supply source

void POWER_SetPmicCoreSupplyFunc(*power_vddcore_set_func_t* func)

Set the core supply setting function if PMIC is used. The function is not needed and ignored when using the onchip regulator to supply VDDCORE.

Parameters

- func – : power_vddcore_set_func_t, the PMIC core supply voltage set function.

bool POWER_SetVoltageForFreq(*power_part_temp_range_t* tempRange, *power_volt_op_range_t* voltOpRange, uint32_t cm33Freq, uint32_t dspFreq, uint32_t mini_volt)

PMC Set volatage for particular frequency with given minimum value. POWER_SetVddCoreSupplySrc should be called in advance to tell power driver the supply source. If PMIC is used, the VDDCORE setting function should be set by POWER_SetPmicCoreSupplyFunc before this API is called. NOTE: The API is only valid when MAINPLLCLKDIV[7:0] and DSPPLLCLKDIV[7:0] are 0. If LVD falling trip voltage is higher than therequired core voltage for particular frequency, LVD voltage will be decreased to safe level to avoid unexpected LVD reset or interrupt event.

Parameters

- tempRange – : part temperature range
- voltOpRange – : voltage operation range.
- cm33Freq – : CM33 CPU clock frequency value
- dspFreq – : DSP CPU clock frequency value
- mini_volt – : minimum voltage in millivolt(mV) for VDDCORE. Should <= 1130mV, 0 means use the core frequency to calculate voltage.

Returns

true for success and false for CPU frequency out of specified voltOpRange or failed to set voltage.

void POWER_SetLvdFallingTripVoltage(*power_lvd_falling_trip_vol_val_t* volt)

Set vddcore low voltage detection falling trip voltage.

Parameters

- volt – target LVD voltage to set.

power_lvd_falling_trip_vol_val_t POWER_GetLvdFallingTripVoltage(void)

Get current vddcore low voltage detection falling trip voltage.

Returns

Current LVD voltage.

void POWER_DisableLVD(void)

Disable low voltage detection, no reset or interrupt is triggered when vddcore voltage drops below threshold. NOTE: This API is for internal use only. Application should not touch it.

void POWER_RestoreLVD(void)

Restore low voltage detection setting. NOTE: This API is for internal use only. Application should not touch it.

void POWER_SetPmicMode(uint32_t mode, pmic_mode_reg_t reg)

Set PMIC_MODE pins configure value.

Parameters

- mode – : PMIC MODE pin value
- reg – : PDSLEEPCFG0 or PDRUNCFG0 register offset

Returns

PMIC_MODE pins value in PDSLEEPCFG0

void POWER_EnterSleep(void)

Configures and enters in SLEEP low power mode.

AT_QUICKACCESS_SECTION_CODE (void POWER_EnterDeepSleep(const uint32_t exclude_from_pd[4]))

PMC Deep Sleep function call.

Parameters

- exclude_from_pd – Bit mask of the PDRUNCFG0 ~ PDRUNCFG3 that needs to be powered on during Deep Sleep mode selected.

void POWER_EnterDeepPowerDown(const uint32_t exclude_from_pd[4])

PMC Deep Power Down function call.

Parameters

- exclude_from_pd – Bit mask of the PDRUNCFG0 ~ PDRUNCFG3 that needs to be powered on during Deep Power Down mode selected.

void POWER_EnterFullDeepPowerDown(const uint32_t exclude_from_pd[4])

PMC Full Deep Power Down function call.

Parameters

- exclude_from_pd – Bit mask of the PDRUNCFG0 ~ PDRUNCFG3 that needs to be powered on during Full Deep Power Down mode selected.

void POWER_EnterPowerMode(power_mode_cfg_t mode, const uint32_t exclude_from_pd[4])

Power Library API to enter different power mode.

Parameters

- mode – Power mode to enter.
- exclude_from_pd – Bit mask of the PDRUNCFG0 ~ PDRUNCFG3 that needs to be powered on during power mode selected.

void EnableDeepSleepIRQ(IRQn_Type interrupt)

Enable specific interrupt for wake-up from deep-sleep mode. Enable the interrupt for wake-up from deep sleep mode. Some interrupts are typically used in sleep mode only and will not occur during deep-sleep mode because relevant clocks are stopped. However, it is possible to enable those clocks (significantly increasing power consumption in the reduced power mode), making these wake-ups possible.

Note: This function also enables the interrupt in the NVIC (EnableIRQ() is called internally).

Parameters

- interrupt – The IRQ number.

void DisableDeepSleepIRQ(IRQn_Type interrupt)

Disable specific interrupt for wake-up from deep-sleep mode. Disable the interrupt for wake-up from deep sleep mode. Some interrupts are typically used in sleep mode only and will not occur during deep-sleep mode because relevant clocks are stopped. However, it is possible to enable those clocks (significantly increasing power consumption in the reduced power mode), making these wake-ups possible.

Note: This function also disables the interrupt in the NVIC (DisableIRQ() is called internally).

Parameters

- interrupt – The IRQ number.

uint32_t POWER_GetLibVersion(void)

Power Library API to return the library version.

Returns

version number of the power library

FSL_POWER_DRIVER_VERSION

power driver version 2.5.0.

MAKE_PD_BITS(reg, slot)

SYSCTL0_PDRCFGSET_REG(x)

SYSCTL0_PDRCFGCLR_REG(x)

PDRCFG0

PDRCFG1

PDRCFG2

PDRCFG3

PMIC_VDDCORE_RECOVERY_TIME_IGNORE

PMIC is used but vddcore supply is always above LVD threshold.

SYSCTL0_TUPLE_REG(reg)

PMIC mode pin configuration API parameter.

uint32_t Vdde0Range

VDDE0 voltage range for VDDIO_0. power_pad_vrange_val_t

uint32_t Vdde1Range

VDDE1 voltage range for VDDIO_1. power_pad_vrange_val_t

uint32_t Vdde2Range

VDDE2 voltage range for VDDIO_2. power_pad_vrange_val_t

uint32_t __pad0__

Reserved.

```
struct __power_pad_vrange
    #include <fsl_power.h> pad voltage range configuration.
```

2.54 POWERQUAD: PowerQuad hardware accelerator

```
void PQ_GetDefaultConfig(pq_config_t *config)
```

Get default configuration.

This function initializes the POWERQUAD configuration structure to a default value. FORMAT register field definitions Bits[15:8] scaler (for scaled 'q31' formats) Bits[5:4] external format. 00b=q15, 01b=q31, 10b=float Bits[1:0] internal format. 00b=q15, 01b=q31, 10b=float POWERQUAD->INAFORMAT = (config->inputAPrescale « 8U) | (config->inputAFormat « 4U) | config->machineFormat

For all Powerquad operations internal format must be float (with the only exception being the FFT related functions, ie FFT/IFFT/DCT/IDCT which must be set to q31). The default values are: config->inputAFormat = kPQ_Float; config->inputAPrescale = 0; config->inputBFormat = kPQ_Float; config->inputBPrescale = 0; config->outputFormat = kPQ_Float; config->outputPrescale = 0; config->tmpFormat = kPQ_Float; config->tmpPrescale = 0; config->machineFormat = kPQ_Float; config->tmpBase = 0xE0000000;

Parameters

- config – Pointer to “pq_config_t” structure.

```
void PQ_SetConfig(POWERQUAD_Type *base, const pq_config_t *config)
```

Set configuration with format/prescale.

Parameters

- base – POWERQUAD peripheral base address
- config – Pointer to “pq_config_t” structure.

```
static inline void PQ_SetCoproprocessorScaler(POWERQUAD_Type *base, const pq_prescale_t
                                             *prescale)
```

set coprocessor scaler for coprocessor instructions, this function is used to set output saturation and scaling for input/output.

Parameters

- base – POWERQUAD peripheral base address
- prescale – Pointer to “pq_prescale_t” structure.

```
void PQ_Init(POWERQUAD_Type *base)
```

Initializes the POWERQUAD module.

Parameters

- base – POWERQUAD peripheral base address.

```
void PQ_Deinit(POWERQUAD_Type *base)
```

De-initializes the POWERQUAD module.

Parameters

- base – POWERQUAD peripheral base address.

```
void PQ_SetFormat(POWERQUAD_Type *base, pq_computationengine_t engine, pq_format_t
                  format)
```

Set format for non-coprocessor instructions.

Parameters

- base – POWERQUAD peripheral base address
- engine – Computation engine
- format – Data format

static inline void PQ_WaitDone(POWERQUAD_Type *base)

Wait for the completion.

Parameters

- base – POWERQUAD peripheral base address

static inline void PQ_LnF32(float *pSrc, float *pDst)

Processing function for the floating-point natural log.

Parameters

- *pSrc – points to the block of input data. The range of the input value is (0 +INFINITY).
- *pDst – points to the block of output data

static inline void PQ_InvF32(float *pSrc, float *pDst)

Processing function for the floating-point reciprocal.

Parameters

- *pSrc – points to the block of input data. The range of the input value is non-zero.
- *pDst – points to the block of output data

static inline void PQ_SqrtF32(float *pSrc, float *pDst)

Processing function for the floating-point square-root.

Parameters

- *pSrc – points to the block of input data. The range of the input value is [0 +INFINITY).
- *pDst – points to the block of output data

static inline void PQ_InvSqrtF32(float *pSrc, float *pDst)

Processing function for the floating-point inverse square-root.

Parameters

- *pSrc – points to the block of input data. The range of the input value is (0 +INFINITY).
- *pDst – points to the block of output data

static inline void PQ_EtoxF32(float *pSrc, float *pDst)

Processing function for the floating-point natural exponent.

Parameters

- *pSrc – points to the block of input data. The range of the input value is (-INFINITY +INFINITY).
- *pDst – points to the block of output data

static inline void PQ_EtonxF32(float *pSrc, float *pDst)

Processing function for the floating-point natural exponent with negative parameter.

Parameters

- *pSrc – points to the block of input data. The range of the input value is (-INFINITY +INFINITY).

- *pDst – points to the block of output data

static inline void PQ_SinF32(float *pSrc, float *pDst)

Processing function for the floating-point sine.

Parameters

- *pSrc – points to the block of input data. The input value is in radians, the range is (-INFINITY +INFINITY).
- *pDst – points to the block of output data

static inline void PQ_CosF32(float *pSrc, float *pDst)

Processing function for the floating-point cosine.

Parameters

- *pSrc – points to the block of input data. The input value is in radians, the range is (-INFINITY +INFINITY).
- *pDst – points to the block of output data

static inline void PQ_BiquadF32(float *pSrc, float *pDst)

Processing function for the floating-point biquad.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data

static inline void PQ_DivF32(float *x1, float *x2, float *pDst)

Processing function for the floating-point division.

Get x1 / x2.

Parameters

- x1 – x1
- x2 – x2
- *pDst – points to the block of output data

static inline void PQ_Biquad1F32(float *pSrc, float *pDst)

Processing function for the floating-point biquad.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data

static inline int32_t PQ_LnFixed(int32_t val)

Processing function for the fixed natural log.

Parameters

- val – value to be calculated. The range of the input value is (0 +INFINITY).

Returns

returns ln(val).

static inline int32_t PQ_InvFixed(int32_t val)

Processing function for the fixed reciprocal.

Parameters

- val – value to be calculated. The range of the input value is non-zero.

Returns

returns inv(val).

static inline uint32_t PQ_SqrtFixed(uint32_t val)

Processing function for the fixed square-root.

Parameters

- val – value to be calculated. The range of the input value is [0 +INFINITY).

Returns

returns sqrt(val).

static inline int32_t PQ_InvSqrtFixed(int32_t val)

Processing function for the fixed inverse square-root.

Parameters

- val – value to be calculated. The range of the input value is (0 +INFINITY).

Returns

returns 1/sqrt(val).

static inline int32_t PQ_EtoxFixed(int32_t val)

Processing function for the Fixed natural exponent.

Parameters

- val – value to be calculated. The range of the input value is (-INFINITY +INFINITY).

Returns

returns etox^(val).

static inline int32_t PQ_EtonxFixed(int32_t val)

Processing function for the fixed natural exponent with negative parameter.

Parameters

- val – value to be calculated. The range of the input value is (-INFINITY +INFINITY).

Returns

returns etonx^(val).

static inline int32_t PQ_SinQ31(int32_t val)

Processing function for the fixed sine.

Parameters

- val – value to be calculated. The input value is [-1, 1] in Q31 format, which means [-pi, pi].

Returns

returns sin(val).

static inline int16_t PQ_SinQ15(int16_t val)

Processing function for the fixed sine.

Parameters

- val – value to be calculated. The input value is [-1, 1] in Q15 format, which means [-pi, pi].

Returns

returns sin(val).

static inline int32_t PQ_CosQ31(int32_t val)

Processing function for the fixed cosine.

Parameters

- `val` – value to be calculated. The input value is [-1, 1] in Q31 format, which means [-pi, pi].

Returns

returns `cos(val)`.

`static inline int16_t PQ_CosQ15(int16_t val)`

Processing function for the fixed sine.

Parameters

- `val` – value to be calculated. The input value is [-1, 1] in Q15 format, which means [-pi, pi].

Returns

returns `sin(val)`.

`static inline int32_t PQ_BiquadFixed(int32_t val)`

Processing function for the fixed biquad.

Parameters

- `val` – value to be calculated

Returns

returns `biquad(val)`.

`void PQ_VectorLnF32(float *pSrc, float *pDst, int32_t length)`

Processing function for the floating-point vectorised natural log.

Parameters

- `*pSrc` – points to the block of input data
- `*pDst` – points to the block of output data
- `length` – the block of input data.

`void PQ_VectorInvF32(float *pSrc, float *pDst, int32_t length)`

Processing function for the floating-point vectorised reciprocal.

Parameters

- `*pSrc` – points to the block of input data
- `*pDst` – points to the block of output data
- `length` – the block of input data.

`void PQ_VectorSqrtF32(float *pSrc, float *pDst, int32_t length)`

Processing function for the floating-point vectorised square-root.

Parameters

- `*pSrc` – points to the block of input data
- `*pDst` – points to the block of output data
- `length` – the block of input data.

`void PQ_VectorInvSqrtF32(float *pSrc, float *pDst, int32_t length)`

Processing function for the floating-point vectorised inverse square-root.

Parameters

- `*pSrc` – points to the block of input data
- `*pDst` – points to the block of output data
- `length` – the block of input data.

void PQ_VectorEtoxF32(float *pSrc, float *pDst, int32_t length)

Processing function for the floating-point vectorised natural exponent.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorEtonxF32(float *pSrc, float *pDst, int32_t length)

Processing function for the floating-point vectorised natural exponent with negative parameter.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorSinF32(float *pSrc, float *pDst, int32_t length)

Processing function for the floating-point vectorised sine.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorCosF32(float *pSrc, float *pDst, int32_t length)

Processing function for the floating-point vectorised cosine.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorLnFixed32(int32_t *pSrc, int32_t *pDst, int32_t length)

Processing function for the Q31 vectorised natural log.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorInvFixed32(int32_t *pSrc, int32_t *pDst, int32_t length)

Processing function for the Q31 vectorised reciprocal.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorSqrtFixed32(int32_t *pSrc, int32_t *pDst, int32_t length)

Processing function for the 32-bit integer vectorised square-root.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorInvSqrtFixed32(int32_t *pSrc, int32_t *pDst, int32_t length)

Processing function for the 32-bit integer vectorised inverse square-root.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorEtoxFixed32(int32_t *pSrc, int32_t *pDst, int32_t length)

Processing function for the 32-bit integer vectorised natural exponent.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorEtonxFixed32(int32_t *pSrc, int32_t *pDst, int32_t length)

Processing function for the 32-bit integer vectorised natural exponent with negative parameter.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorSinQ15(int16_t *pSrc, int16_t *pDst, int32_t length)

Processing function for the Q15 vectorised sine.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorCosQ15(int16_t *pSrc, int16_t *pDst, int32_t length)

Processing function for the Q15 vectorised cosine.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorSinQ31(int32_t *pSrc, int32_t *pDst, int32_t length)

Processing function for the Q31 vectorised sine.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorCosQ31(int32_t *pSrc, int32_t *pDst, int32_t length)

Processing function for the Q31 vectorised cosine.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorLnFixed16(int16_t *pSrc, int16_t *pDst, int32_t length)

Processing function for the 16-bit integer vectorised natural log.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorInvFixed16(int16_t *pSrc, int16_t *pDst, int32_t length)

Processing function for the 16-bit integer vectorised reciprocal.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorSqrtFixed16(int16_t *pSrc, int16_t *pDst, int32_t length)

Processing function for the 16-bit integer vectorised square-root.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorInvSqrtFixed16(int16_t *pSrc, int16_t *pDst, int32_t length)

Processing function for the 16-bit integer vectorised inverse square-root.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorEtoxFixed16(int16_t *pSrc, int16_t *pDst, int32_t length)

Processing function for the 16-bit integer vectorised natural exponent.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorEtonxFixed16(int16_t *pSrc, int16_t *pDst, int32_t length)

Processing function for the 16-bit integer vectorised natural exponent with negative parameter.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorBiquadDf2F32(float *pSrc, float *pDst, int32_t length)

Processing function for the floating-point vectorised biquad direct form II.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block size of input data.

void PQ_VectorBiquadDf2Fixed32(int32_t *pSrc, int32_t *pDst, int32_t length)

Processing function for the 32-bit integer vectorised biquad direct form II.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block size of input data

void PQ_VectorBiquadDf2Fixed16(int16_t *pSrc, int16_t *pDst, int32_t length)

Processing function for the 16-bit integer vectorised biquad direct form II.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block size of input data

void PQ_VectorBiquadCascadeDf2F32(float *pSrc, float *pDst, int32_t length)

Processing function for the floating-point vectorised biquad direct form II.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block size of input data

void PQ_VectorBiquadCascadeDf2Fixed32(int32_t *pSrc, int32_t *pDst, int32_t length)

Processing function for the 32-bit integer vectorised biquad direct form II.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block size of input data

void PQ_VectorBiquadCascadeDf2Fixed16(int16_t *pSrc, int16_t *pDst, int32_t length)

Processing function for the 16-bit integer vectorised biquad direct form II.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block size of input data

int32_t PQ_ArctanFixed(POWERQUAD_Type *base, int32_t x, int32_t y, *pq_cordic_iter_t* iteration)

Processing function for the fixed inverse trigonometric.

Get the inverse tangent, the behavior is like c function atan.

Note: The sum of x and y should not exceed the range of int32_t.

Note: Larger input number gets higher output accuracy, for example the arctan(0.5), the result of PQ_ArctanFixed(POWERQUAD, 100000, 200000, kPQ_Iteration_24) is more accurate than PQ_ArctanFixed(POWERQUAD, 1, 2, kPQ_Iteration_24).

Parameters

- base – POWERQUAD peripheral base address
- x – value of opposite
- y – value of adjacent
- iteration – iteration times

Returns

The return value is in the range of -2^{26} to 2^{26} , which means $-\pi/2$ to $\pi/2$.

int32_t PQ_ArctanhFixed(POWERQUAD_Type *base, int32_t x, int32_t y, *pq_cordic_iter_t* iteration)

Processing function for the fixed inverse trigonometric.

Note: The sum of x and y should not exceed the range of int32_t.

Note: Larger input number gets higher output accuracy, for example the arctanh(0.5), the result of PQ_ArctanhFixed(POWERQUAD, 100000, 200000, kPQ_Iteration_24) is more accurate than PQ_ArctanhFixed(POWERQUAD, 1, 2, kPQ_Iteration_24).

Parameters

- base – POWERQUAD peripheral base address
- x – value of opposite
- y – value of adjacent
- iteration – iteration times

Returns

The return value is radians, 2^{27} means π . The range is -1.118 to 1.118 radians.

int32_t PQ_Arctan2Fixed(POWERQUAD_Type *base, int32_t x, int32_t y, *pq_cordic_iter_t* iteration)

Processing function for the fixed inverse trigonometric.

Get the inverse tangent, it calculates the angle in radians for the quadrant. The behavior is like c function atan2.

Note: The sum of x and y should not exceed the range of int32_t.

Note: Larger input number gets higher output accuracy, for example the `arctan(0.5)`, the result of `PQ_Arctan2Fixed(POWERQUAD, 100000, 200000, kPQ_Iteration_24)` is more accurate than `PQ_Arctan2Fixed(POWERQUAD, 1, 2, kPQ_Iteration_24)`.

Parameters

- `base` – POWERQUAD peripheral base address
- `x` – value of opposite
- `y` – value of adjacent
- `iteration` – iteration times

Returns

The return value is in the range of -2^{27} to 2^{27} , which means $-\pi$ to π .

`static inline int32_t PQ_Biquad1Fixed(int32_t val)`

Processing function for the fixed biquad.

Parameters

- `val` – value to be calculated

Returns

returns `biquad(val)`.

`void PQ_TransformCFFT(POWERQUAD_Type *base, uint32_t length, void *pData, void *pResult)`

Processing function for the complex FFT.

Parameters

- `base` – POWERQUAD peripheral base address
- `length` – number of input samples
- `pData` – input data
- `pResult` – output data.

`void PQ_TransformRFFT(POWERQUAD_Type *base, uint32_t length, void *pData, void *pResult)`

Processing function for the real FFT.

Parameters

- `base` – POWERQUAD peripheral base address
- `length` – number of input samples
- `pData` – input data
- `pResult` – output data.

`void PQ_TransformIFFT(POWERQUAD_Type *base, uint32_t length, void *pData, void *pResult)`

Processing function for the inverse complex FFT.

Parameters

- `base` – POWERQUAD peripheral base address
- `length` – number of input samples
- `pData` – input data
- `pResult` – output data.

```
void PQ_TransformCDCT(POWERQUAD_Type *base, uint32_t length, void *pData, void *pResult)
```

Processing function for the complex DCT.

Parameters

- base – POWERQUAD peripheral base address
- length – number of input samples
- pData – input data
- pResult – output data.

```
void PQ_TransformRDCT(POWERQUAD_Type *base, uint32_t length, void *pData, void *pResult)
```

Processing function for the real DCT.

Parameters

- base – POWERQUAD peripheral base address
- length – number of input samples
- pData – input data
- pResult – output data.

```
void PQ_TransformIDCT(POWERQUAD_Type *base, uint32_t length, void *pData, void *pResult)
```

Processing function for the inverse complex DCT.

Parameters

- base – POWERQUAD peripheral base address
- length – number of input samples
- pData – input data
- pResult – output data.

```
void PQ_BiquadBackUpInternalState(POWERQUAD_Type *base, int32_t biquad_num, pq_biquad_state_t *state)
```

Processing function for backup biquad context.

Parameters

- base – POWERQUAD peripheral base address
- biquad_num – biquad side
- state – point to states.

```
void PQ_BiquadRestoreInternalState(POWERQUAD_Type *base, int32_t biquad_num, pq_biquad_state_t *state)
```

Processing function for restore biquad context.

Parameters

- base – POWERQUAD peripheral base address
- biquad_num – biquad side
- state – point to states.

```
void PQ_BiquadCascadeDf2Init(pq_biquad_cascade_df2_instance *S, uint8_t numStages, pq_biquad_state_t *pState)
```

Initialization function for the direct form II Biquad cascade filter.

Parameters

- *S – **[inout]** points to an instance of the filter data structure.
- numStages – **[in]** number of 2nd order stages in the filter.
- *pState – **[in]** points to the state buffer.

```
void PQ_BiquadCascadeDf2F32(const pq_biquad_cascade_df2_instance *S, float *pSrc, float
                           *pDst, uint32_t blockSize)
```

Processing function for the floating-point direct form II Biquad cascade filter.

Parameters

- *S – **[in]** points to an instance of the filter data structure.
- *pSrc – **[in]** points to the block of input data.
- *pDst – **[out]** points to the block of output data
- blockSize – **[in]** number of samples to process.

```
void PQ_BiquadCascadeDf2Fixed32(const pq_biquad_cascade_df2_instance *S, int32_t *pSrc,
                                int32_t *pDst, uint32_t blockSize)
```

Processing function for the Q31 direct form II Biquad cascade filter.

Parameters

- *S – **[in]** points to an instance of the filter data structure.
- *pSrc – **[in]** points to the block of input data.
- *pDst – **[out]** points to the block of output data
- blockSize – **[in]** number of samples to process.

```
void PQ_BiquadCascadeDf2Fixed16(const pq_biquad_cascade_df2_instance *S, int16_t *pSrc,
                                int16_t *pDst, uint32_t blockSize)
```

Processing function for the Q15 direct form II Biquad cascade filter.

Parameters

- *S – **[in]** points to an instance of the filter data structure.
- *pSrc – **[in]** points to the block of input data.
- *pDst – **[out]** points to the block of output data
- blockSize – **[in]** number of samples to process.

```
void PQ_FIR(POWERQUAD_Type *base, const void *pAData, int32_t ALength, const void
            *pBData, int32_t BLength, void *pResult, uint32_t opType)
```

Processing function for the FIR.

Parameters

- base – POWERQUAD peripheral base address
- pAData – the first input sequence
- ALength – number of the first input sequence
- pBData – the second input sequence
- BLength – number of the second input sequence
- pResult – array for the output data
- opType – operation type, could be PQ_FIR_FIR, PQ_FIR_CONVOLUTION, PQ_FIR_CORRELATION.

```
void PQ_FIRIncrement(POWERQUAD_Type *base, int32_t ALength, int32_t BLength, int32_t xOffset)
```

Processing function for the incremental FIR. This function can be used after `pq_fir()` for incremental FIR operation when new x data are available.

Parameters

- `base` – POWERQUAD peripheral base address
- `ALength` – number of input samples
- `BLength` – number of taps
- `xOffset` – offset for number of input samples

```
void PQ_MatrixAddition(POWERQUAD_Type *base, uint32_t length, void *pAData, void *pBData, void *pResult)
```

Processing function for the matrix addition.

Parameters

- `base` – POWERQUAD peripheral base address
- `length` – rows and cols for matrix. LENGTH register configuration: `LENGTH[23:16] = M2 cols` `LENGTH[15:8] = M1 cols` `LENGTH[7:0] = M1 rows` This could be constructed using macro `POWERQUAD_MAKE_MATRIX_LEN`.
- `pAData` – input matrix A
- `pBData` – input matrix B
- `pResult` – array for the output data.

```
void PQ_MatrixSubtraction(POWERQUAD_Type *base, uint32_t length, void *pAData, void *pBData, void *pResult)
```

Processing function for the matrix subtraction.

Parameters

- `base` – POWERQUAD peripheral base address
- `length` – rows and cols for matrix. LENGTH register configuration: `LENGTH[23:16] = M2 cols` `LENGTH[15:8] = M1 cols` `LENGTH[7:0] = M1 rows` This could be constructed using macro `POWERQUAD_MAKE_MATRIX_LEN`.
- `pAData` – input matrix A
- `pBData` – input matrix B
- `pResult` – array for the output data.

```
void PQ_MatrixMultiplication(POWERQUAD_Type *base, uint32_t length, void *pAData, void *pBData, void *pResult)
```

Processing function for the matrix multiplication.

Parameters

- `base` – POWERQUAD peripheral base address
- `length` – rows and cols for matrix. LENGTH register configuration: `LENGTH[23:16] = M2 cols` `LENGTH[15:8] = M1 cols` `LENGTH[7:0] = M1 rows` This could be constructed using macro `POWERQUAD_MAKE_MATRIX_LEN`.
- `pAData` – input matrix A
- `pBData` – input matrix B

- pResult – array for the output data.

```
void PQ_MatrixProduct(POWERQUAD_Type *base, uint32_t length, void *pAData, void *pBData,  
void *pResult)
```

Processing function for the matrix product.

Parameters

- base – POWERQUAD peripheral base address
- length – rows and cols for matrix. LENGTH register configuration: LENGTH[23:16] = M2 cols LENGTH[15:8] = M1 cols LENGTH[7:0] = M1 rows This could be constructed using macro POWERQUAD_MAKE_MATRIX_LEN.
- pAData – input matrix A
- pBData – input matrix B
- pResult – array for the output data.

```
void PQ_VectorDotProduct(POWERQUAD_Type *base, uint32_t length, void *pAData, void  
*pBData, void *pResult)
```

Processing function for the vector dot product.

Parameters

- base – POWERQUAD peripheral base address
- length – length of vector
- pAData – input vector A
- pBData – input vector B
- pResult – array for the output data.

```
void PQ_MatrixInversion(POWERQUAD_Type *base, uint32_t length, void *pData, void  
*pTmpData, void *pResult)
```

Processing function for the matrix inverse.

Parameters

- base – POWERQUAD peripheral base address
- length – rows and cols for matrix. LENGTH register configuration: LENGTH[23:16] = M2 cols LENGTH[15:8] = M1 cols LENGTH[7:0] = M1 rows This could be constructed using macro POWERQUAD_MAKE_MATRIX_LEN.
- pData – input matrix
- pTmpData – input temporary matrix, pTmpData length not less than pData length and 1024 words is sufficient for the largest supported matrix.
- pResult – array for the output data, round down for fixed point.

```
void PQ_MatrixTranspose(POWERQUAD_Type *base, uint32_t length, void *pData, void  
*pResult)
```

Processing function for the matrix transpose.

Parameters

- base – POWERQUAD peripheral base address
- length – rows and cols for matrix. LENGTH register configuration: LENGTH[23:16] = M2 cols LENGTH[15:8] = M1 cols LENGTH[7:0] = M1 rows This could be constructed using macro POWERQUAD_MAKE_MATRIX_LEN.

- pData – input matrix
- pResult – array for the output data.

void PQ_MatrixScale(POWERQUAD_Type *base, uint32_t length, float misc, const void *pData, void *pResult)

Processing function for the matrix scale.

Parameters

- base – POWERQUAD peripheral base address
- length – rows and cols for matrix. LENGTH register configuration: LENGTH[23:16] = M2 cols LENGTH[15:8] = M1 cols LENGTH[7:0] = M1 rows This could be constructed using macro POWERQUAD_MAKE_MATRIX_LEN.
- misc – scaling parameters
- pData – input matrix
- pResult – array for the output data.

FSL_POWERQUAD_DRIVER_VERSION

Version.

enum pq_computationengine_t

powerquad computation engine

Values:

enumerator kPQ_CP_PQ

Math engine.

enumerator kPQ_CP_MTX

Matrix engine.

enumerator kPQ_CP_FFT

FFT engine.

enumerator kPQ_CP_FIR

FIR engine.

enumerator kPQ_CP_CORDIC

CORDIC engine.

enum pq_format_t

powerquad data structure format type

Values:

enumerator kPQ_16Bit

Int16 Fixed point.

enumerator kPQ_32Bit

Int32 Fixed point.

enumerator kPQ_Float

Float point.

enum pq_cordic_iter_t

CORDIC iteration.

Values:

enumerator kPQ_Iteration_8

Iterate 8 times.

enumerator kPQ_Iteration_16

Iterate 16 times.

enumerator kPQ_Iteration_24

Iterate 24 times.

typedef struct *pq_biquad_param* pq_biquad_param_t

Struct to save biquad parameters.

typedef struct *pq_biquad_state* pq_biquad_state_t

Struct to save biquad state.

typedef union *pq_float* pq_float_t

Conversion between integer and float type.

PQ_VectorBiquadDf2F32

PQ_VectorBiquadDf2Fixed32

PQ_VectorBiquadDf2Fixed16

PQ_VectorBiquadCascadeDf2F32

PQ_VectorBiquadCascadeDf2Fixed32

PQ_VectorBiquadCascadeDf2Fixed16

PQ_Vector8BiquadDf2CascadeF32

PQ_Vector8BiquadDf2CascadeFixed32

PQ_Vector8BiquadDf2CascadeFixed16

PQ_FLOAT32

PQ_FIXEDPT

CP_PQ

CP_MTX

CP_FFT

CP_FIR

CP_CORDIC

PQ_TRANS

PQ_TRIG

PQ_BIQUAD

PQ_TRANS_FIXED

PQ_TRIG_FIXED

PQ_BIQUAD_FIXED

PQ_INV

PQ_LN

PQ_SQRT
PQ_INVSQRT
PQ_ETOX
PQ_ETONX
PQ_DIV
PQ_SIN
PQ_COS
PQ_BIQ0_CALC
PQ_BIQ1_CALC
PQ_COMP0_ONLY
PQ_COMP1_ONLY
CORDIC_ITER(x)
CORDIC_MIU(x)
CORDIC_T(x)
CORDIC_ARCTAN
CORDIC_ARCTANH
INST_BUSY
PQ_ERRSTAT_OVERFLOW
PQ_ERRSTAT_NAN
PQ_ERRSTAT_FIXEDOVERFLOW
PQ_ERRSTAT_UNDERFLOW
PQ_TRANS_CFFT
PQ_TRANS_IFFT
PQ_TRANS_CDCT
PQ_TRANS_IDCT
PQ_TRANS_RFFT
PQ_TRANS_RDCT
PQ_MTX_SCALE
PQ_MTX_MULT
PQ_MTX_ADD
PQ_MTX_INV
PQ_MTX_PROD
PQ_MTX_SUB

PQ_VEC_DOTP
PQ_MTX_TRAN
PQ_FIR_FIR
PQ_FIR_CONVOLUTION
PQ_FIR_CORRELATION
PQ_FIR_INCREMENTAL
_pq_ln0(x)
_pq_inv0(x)
_pq_sqrt0(x)
_pq_invsqrt0(x)
_pq_etox0(x)
_pq_etonx0(x)
_pq_sin0(x)
_pq_cos0(x)
_pq_biquad0(x)
_pq_ln_fx0(x)
_pq_inv_fx0(x)
_pq_sqrt_fx0(x)
_pq_invsqrt_fx0(x)
_pq_etox_fx0(x)
_pq_etonx_fx0(x)
_pq_sin_fx0(x)
_pq_cos_fx0(x)
_pq_biquad0_fx(x)
_pq_div0(x)
_pq_div1(x)
_pq_ln1(x)
_pq_inv1(x)
_pq_sqrt1(x)
_pq_invsqrt1(x)
_pq_etox1(x)
_pq_etonx1(x)
_pq_sin1(x)

`_pq_cos1(x)`

`_pq_biquad1(x)`

`_pq_ln_fx1(x)`

`_pq_inv_fx1(x)`

`_pq_sqrt_fx1(x)`

`_pq_invsqrt_fx1(x)`

`_pq_etox_fx1(x)`

`_pq_etonx_fx1(x)`

`_pq_sin_fx1(x)`

`_pq_cos_fx1(x)`

`_pq_biquad1_fx(x)`

`_pq_readMult0()`

`_pq_readAdd0()`

`_pq_readMult1()`

`_pq_readAdd1()`

`_pq_readMult0_fx()`

`_pq_readAdd0_fx()`

`_pq_readMult1_fx()`

`_pq_readAdd1_fx()`

`PQ_LN_INF`

Parameter used for vector $\ln(x)$

`PQ_INV_INF`

Parameter used for vector $1/x$

`PQ_SQRT_INF`

Parameter used for vector $\sqrt{x}$

`PQ_ISQRT_INF`

Parameter used for vector $1/\sqrt{x}$

`PQ_ETOX_INF`

Parameter used for vector e^x

`PQ_ETONX_INF`

Parameter used for vector e^{-x}

`PQ_SIN_INF`

Parameter used for vector $\sin(x)$

`PQ_COS_INF`

Parameter used for vector $\cos(x)$

`PQ_RUN_OPCODE_R3_R2(BATCH_OPCODE, BATCH_MACHINE)`

`PQ_RUN_OPCODE_R5_R4(BATCH_OPCODE, BATCH_MACHINE)`

PQ_RUN_OPCODE_R7_R6(BATCH_OPCODE, BATCH_MACHINE)

PQ_Vector8_FP(middle, last, BATCH_OPCODE, DOUBLE_READ_ADDERS, BATCH_MACHINE)

PQ_RUN_OPCODE_R2_R3(BATCH_OPCODE, BATCH_MACHINE)

PQ_RUN_OPCODE_R4_R5(BATCH_OPCODE, BATCH_MACHINE)

PQ_RUN_OPCODE_R6_R7(BATCH_OPCODE, BATCH_MACHINE)

PQ_Vector8_FX(middle, last, BATCH_OPCODE, DOUBLE_READ_ADDERS, BATCH_MACHINE)

PQ_Initiate_Vector_Func(pSrc, pDst)

Start 32-bit data vector calculation.

Start the vector calculation, the input data could be float, int32_t or Q31.

Parameters

- pSrc – Pointer to the source data.
- pDst – Pointer to the destination data.

PQ_End_Vector_Func()

End vector calculation.

This function should be called after vector calculation.

PQ_StartVector(PSRC, PDST, LENGTH)

Start 32-bit data vector calculation.

Start the vector calculation, the input data could be float, int32_t or Q31.

Parameters

- PSRC – Pointer to the source data.
- PDST – Pointer to the destination data.
- LENGTH – Number of the data, must be multiple of 8.

PQ_StartVectorFixed16(PSRC, PDST, LENGTH)

Start 16-bit data vector calculation.

Start the vector calculation, the input data could be int16_t. This function should be use with PQ_Vector8Fixed16.

Parameters

- PSRC – Pointer to the source data.
- PDST – Pointer to the destination data.
- LENGTH – Number of the data, must be multiple of 8.

PQ_StartVectorQ15(PSRC, PDST, LENGTH)

Start Q15-bit data vector calculation.

Start the vector calculation, the input data could be Q15. This function should be use with PQ_Vector8Q15. This function is dedicate for SinQ15/CosQ15 vector calculation. Because PowerQuad only supports Q31 Sin/Cos fixed function, so the input Q15 data is left shift 16 bits first, after Q31 calculation, the output data is right shift 16 bits.

Parameters

- PSRC – Pointer to the source data.
- PDST – Pointer to the destination data.
- LENGTH – Number of the data, must be multiple of 8.

PQ_EndVector()

End vector calculation.

This function should be called after vector calculation.

PQ_Vector8F32(BATCH_OPCODE, DOUBLE_READ_ADDERS, BATCH_MACHINE)

Float data vector calculation.

Float data vector calculation, the input data should be float. The parameter could be PQ_LN_INF, PQ_INV_INF, PQ_SQRT_INF, PQ_ISQRT_INF, PQ_ETOX_INF, PQ_ETONX_INF. For example, to calculate sqrt of a vector, use like this:

```
#define VECTOR_LEN 8
float input[VECTOR_LEN] = {1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0};
float output[VECTOR_LEN];

PQ_StartVector(input, output, VECTOR_LEN);
PQ_Vector8F32(PQ_SQRT_INF);
PQ_EndVector();
```

PQ_Vector8Fixed32(BATCH_OPCODE, DOUBLE_READ_ADDERS, BATCH_MACHINE)

Fixed 32bits data vector calculation.

Float data vector calculation, the input data should be 32-bit integer. The parameter could be PQ_LN_INF, PQ_INV_INF, PQ_SQRT_INF, PQ_ISQRT_INF, PQ_ETOX_INF, PQ_ETONX_INF, PQ_SIN_INF, PQ_COS_INF. When this function is used for sin/cos calculation, the input data should be in the format Q1.31. For example, to calculate sqrt of a vector, use like this:

```
#define VECTOR_LEN 8
int32_t input[VECTOR_LEN] = {1, 4, 9, 16, 25, 36, 49, 64};
int32_t output[VECTOR_LEN];

PQ_StartVector(input, output, VECTOR_LEN);
PQ_Vector8F32(PQ_SQRT_INF);
PQ_EndVector();
```

PQ_Vector8Fixed16(BATCH_OPCODE, DOUBLE_READ_ADDERS, BATCH_MACHINE)

Fixed 32bits data vector calculation.

Float data vector calculation, the input data should be 16-bit integer. The parameter could be PQ_LN_INF, PQ_INV_INF, PQ_SQRT_INF, PQ_ISQRT_INF, PQ_ETOX_INF, PQ_ETONX_INF. For example, to calculate sqrt of a vector, use like this:

```
#define VECTOR_LEN 8
int16_t input[VECTOR_LEN] = {1, 4, 9, 16, 25, 36, 49, 64};
int16_t output[VECTOR_LEN];

PQ_StartVector(input, output, VECTOR_LEN);
PQ_Vector8F32(PQ_SQRT_INF);
PQ_EndVector();
```

PQ_Vector8Q15(BATCH_OPCODE, DOUBLE_READ_ADDERS, BATCH_MACHINE)

Q15 data vector calculation.

Q15 data vector calculation, this function should only be used for sin/cos Q15 calculation, and the coprocessor output prescaler must be set to 31 before this function. This function loads Q15 data and left shift 16 bits, calculate and right shift 16 bits, then stores to the output array. The input range -1 to 1 means -pi to pi. For example, to calculate sin of a vector, use like this:

```
#define VECTOR_LEN 8
int16_t input[VECTOR_LEN] = {...}
```

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```

int16_t output[VECTOR_LEN];
const pq_prescale_t prescale =
{
    .inputPrescale = 0,
    .outputPrescale = 31,
    .outputSaturate = 0
};

PQ_SetCoproprocessorScaler(POWERQUAD, const pq_prescale_t *prescale);

PQ_StartVectorQ15(pSrc, pDst, length);
PQ_Vector8Q15(PQ_SQRT_INF);
PQ_EndVector();

```

PQ_DF2_Vector8_FP(middle, last)

Float data vector biquad direct form II calculation.

Biquad filter, the input and output data are float data. Biquad side 0 is used. Example:

```

#define VECTOR_LEN 16
float input[VECTOR_LEN] = {1024.0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0};
float output[VECTOR_LEN];
pq_biquad_state_t state =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

PQ_BiquadRestoreInternalState(POWERQUAD, 0, &state);

PQ_Initiate_Vector_Func(pSrc, pDst);
PQ_DF2_Vector8_FP(false, false);
PQ_DF2_Vector8_FP(true, true);
PQ_End_Vector_Func();

```

PQ_DF2_Vector8_FX(middle, last)

Fixed data vector biquad direct form II calculation.

Biquad filter, the input and output data are fixed data. Biquad side 0 is used. Example:

```

#define VECTOR_LEN 16
int32_t input[VECTOR_LEN] = {1024, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0};
int32_t output[VECTOR_LEN];
pq_biquad_state_t state =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

```

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```
PQ_BiquadRestoreInternalState(POWERQUAD, 0, &state);

PQ_Initiate_Vector_Func(pSrc,pDst);
PQ_DF2_Vector8_FX(false,false);
PQ_DF2_Vector8_FX(true,true);
PQ_End_Vector_Func();
```

PQ_Vector8BiquadDf2F32()

Float data vector biquad direct form II calculation.

Biquad filter, the input and output data are float data. Biquad side 0 is used. Example:

```
#define VECTOR_LEN 8
float input[VECTOR_LEN] = {1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0};
float output[VECTOR_LEN];
pq_biquad_state_t state =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

PQ_BiquadRestoreInternalState(POWERQUAD, 0, &state);

PQ_StartVector(input, output, VECTOR_LEN);
PQ_Vector8BiquadDf2F32();
PQ_EndVector();
```

PQ_Vector8BiquadDf2Fixed32()

Fixed 32-bit data vector biquad direct form II calculation.

Biquad filter, the input and output data are Q31 or 32-bit integer. Biquad side 0 is used. Example:

```
#define VECTOR_LEN 8
int32_t input[VECTOR_LEN] = {1, 2, 3, 4, 5, 6, 7, 8};
int32_t output[VECTOR_LEN];
pq_biquad_state_t state =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

PQ_BiquadRestoreInternalState(POWERQUAD, 0, &state);

PQ_StartVector(input, output, VECTOR_LEN);
PQ_Vector8BiquadDf2Fixed32();
PQ_EndVector();
```

PQ_Vector8BiquadDf2Fixed16()

Fixed 16-bit data vector biquad direct form II calculation.

Biquad filter, the input and output data are Q15 or 16-bit integer. Biquad side 0 is used.
Example:

```
#define VECTOR_LEN 8
int16_t input[VECTOR_LEN] = {1, 2, 3, 4, 5, 6, 7, 8};
int16_t output[VECTOR_LEN];
pq_biquad_state_t state =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

PQ_BiquadRestoreInternalState(POWERQUAD, 0, &state);

PQ_StartVector(input, output, VECTOR_LEN);
PQ_Vector8BiquadDf2Fixed16();
PQ_EndVector();
```

PQ_DF2_Cascade_Vector8_FP(middle, last)

Float data vector direct form II biquad cascade filter.

The input and output data are float data. The data flow is input -> biquad side 1 -> biquad side 0 -> output.

```
#define VECTOR_LEN 16
float input[VECTOR_LEN] = {1024.0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0};
float output[VECTOR_LEN];
pq_biquad_state_t state0 =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

pq_biquad_state_t state1 =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

PQ_BiquadRestoreInternalState(POWERQUAD, 0, &state0);
PQ_BiquadRestoreInternalState(POWERQUAD, 1, &state1);

PQ_Initiate_Vector_Func(pSrc, pDst);
PQ_DF2_Cascade_Vector8_FP(false, false);
```

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```
PQ_DF2_Cascade_Vector8_FP(true, true);
PQ_End_Vector_Func();
```

PQ_DF2_Cascade_Vector8_FX(middle, last)

Fixed data vector direct form II biquad cascade filter.

The input and output data are fixed data. The data flow is input -> biquad side 1 -> biquad side 0 -> output.

```
#define VECTOR_LEN 16
int32_t input[VECTOR_LEN] = {1024.0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0};
int32_t output[VECTOR_LEN];
pq_biquad_state_t state0 =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

pq_biquad_state_t state1 =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

PQ_BiquadRestoreInternalState(POWERQUAD, 0, &state0);
PQ_BiquadRestoreInternalState(POWERQUAD, 1, &state1);

PQ_Initiate_Vector_Func(pSrc, pDst);
PQ_DF2_Cascade_Vector8_FX(false, false);
PQ_DF2_Cascade_Vector8_FX(true, true);
PQ_End_Vector_Func();
```

PQ_Vector8BiquadDf2CascadeF32()

Float data vector direct form II biquad cascade filter.

The input and output data are float data. The data flow is input -> biquad side 1 -> biquad side 0 -> output.

```
#define VECTOR_LEN 8
float input[VECTOR_LEN] = {1, 2, 3, 4, 5, 6, 7, 8};
float output[VECTOR_LEN];
pq_biquad_state_t state0 =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
```

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```

        .b_2 = xxx,
    },
};

pq_biquad_state_t state1 =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

PQ_BiquadRestoreInternalState(POWERQUAD, 0, &state0);
PQ_BiquadRestoreInternalState(POWERQUAD, 1, &state1);

PQ_StartVector(input, output, VECTOR_LEN);
PQ_Vector8BiquadDf2CascadeF32();
PQ_EndVector();

```

PQ_Vector8BiquadDf2CascadeFixed32()

Fixed 32-bit data vector direct form II biquad cascade filter.

The input and output data are fixed 32-bit data. The data flow is input -> biquad side 1 -> biquad side 0 -> output.

```

#define VECTOR_LEN 8
int32_t input[VECTOR_LEN] = {1, 2, 3, 4, 5, 6, 7, 8};
int32_t output[VECTOR_LEN];
pq_biquad_state_t state0 =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

pq_biquad_state_t state1 =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

PQ_BiquadRestoreInternalState(POWERQUAD, 0, &state0);
PQ_BiquadRestoreInternalState(POWERQUAD, 1, &state1);

PQ_StartVector(input, output, VECTOR_LEN);
PQ_Vector8BiquadDf2CascadeFixed32();
PQ_EndVector();

```

PQ_Vector8BiquadDf2CascadeFixed16()

Fixed 16-bit data vector direct form II biquad cascade filter.

The input and output data are fixed 16-bit data. The data flow is input -> biquad side 1 -> biquad side 0 -> output.

```
#define VECTOR_LEN 8
int32_t input[VECTOR_LEN] = {1, 2, 3, 4, 5, 6, 7, 8};
int32_t output[VECTOR_LEN];
pq_biquad_state_t state0 =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

pq_biquad_state_t state1 =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

PQ_BiquadRestoreInternalState(POWERQUAD, 0, &state0);
PQ_BiquadRestoreInternalState(POWERQUAD, 1, &state1);

PQ_StartVector(input, output, VECTOR_LEN);
PQ_Vector8BiquadDf2CascadeFixed16();
PQ_EndVector();
```

POWERQUAD_MAKE_MATRIX_LEN(mat1Row, mat1Col, mat2Col)

Make the length used for matrix functions.

PQ_Q31_2_FLOAT(x)

Convert Q31 to float.

PQ_Q15_2_FLOAT(x)

Convert Q15 to float.

struct pq_prescale_t

#include <fsl_powerquad.h> Coprocessor prescale.

Public Members

int8_t inputPrescale

Input prescale.

int8_t outputPrescale

Output prescale.

int8_t outputSaturate

Output saturate at n bits, for example 0x11 is 8 bit space, the value will be truncated at +127 or -128.

struct pq_config_t

#include <fsl_powerquad.h> powerquad data structure format

Public Members

pq_format_t inputAFormat

Input A format.

int8_t inputAPrescale

Input A prescale, for example 1.5 can be $1.5 \cdot 2^n$ if you scale by 'shifting' ('scaling' by a factor of n).

pq_format_t inputBFormat

Input B format.

int8_t inputBPrescale

Input B prescale.

pq_format_t outputFormat

Out format.

int8_t outputPrescale

Out prescale.

pq_format_t tmpFormat

Temp format.

int8_t tmpPrescale

Temp prescale.

pq_format_t machineFormat

Machine format.

uint32_t *tmpBase

Tmp base address.

struct __pq_biquad_param

#include <fsl_powerquad.h> Struct to save biquad parameters.

Public Members

float v_n_1

v[n-1], set to 0 when initialization.

float v_n

v[n], set to 0 when initialization.

float a_1

a[1]

float a_2

a[2]

float b_0

b[0]

float b_1

b[1]

float b_2

b[2]

struct __pq_biquad_state

#include <fsl_powerquad.h> Struct to save biquad state.

Public Members

pq_biquad_param_t param

Filter parameter.

uint32_t compreg

Internal register, set to 0 when initialization.

struct pq_biquad_cascade_df2_instance

#include <fsl_powerquad.h> Instance structure for the direct form II Biquad cascade filter.

Public Members

uint8_t numStages

Number of 2nd order stages in the filter.

pq_biquad_state_t *pState

Points to the array of state coefficients.

union __pq_float

#include <fsl_powerquad.h> Conversion between integer and float type.

Public Members

float floatX

Float type.

uint32_t integerX

Unsigned interger type.

2.55 PUF: Physical Unclonable Function

FSL_PUF_DRIVER_VERSION

PUF driver version. Version 2.2.0.

Current version: 2.2.0

Change log:

- 2.0.0
 - Initial version.
- 2.0.1
 - Fixed puf_wait_usec function optimization issue.
- 2.0.2

- Add PUF configuration structure and support for PUF SRAM controller. Remove magic constants.
- 2.0.3
 - Fix MISRA C-2012 issue.
- 2.1.0
 - Align driver with PUF SRAM controller registers on LPCXpresso55s16.
 - Update initialization logic .
- 2.1.1
 - Fix ARMGCC build warning .
- 2.1.2
 - Update: Add automatic big to little endian swap for user (pre-shared) keys destined to secret hardware bus (PUF key index 0).
- 2.1.3
 - Fix MISRA C-2012 issue.
- 2.1.4
 - Replace register uint32_t ticksCount with volatile uint32_t ticksCount in puf_wait_usec() to prevent optimization out delay loop.
- 2.1.5
 - Use common SDK delay in puf_wait_usec()
- 2.1.6
 - Changed wait time in PUF_Init(), when initialization fails it will try PUF_Powercycle() with shorter time. If this shorter time will also fail, initialization will be tried with worst case time as before.
- 2.2.0
- Add support for kPUF_KeySlot4.
- Add new PUF_ClearKey() function, that clears a desired PUF internal HW key register.

enum __puf_key_index_register

Values:

enumerator kPUF_KeyIndex_00

enumerator kPUF_KeyIndex_01

enumerator kPUF_KeyIndex_02

enumerator kPUF_KeyIndex_03

enumerator kPUF_KeyIndex_04

enumerator kPUF_KeyIndex_05

enumerator kPUF_KeyIndex_06

enumerator kPUF_KeyIndex_07

enumerator kPUF_KeyIndex_08

enumerator kPUF_KeyIndex_09

```
enumerator kPUF__KeyIndex__10
enumerator kPUF__KeyIndex__11
enumerator kPUF__KeyIndex__12
enumerator kPUF__KeyIndex__13
enumerator kPUF__KeyIndex__14
enumerator kPUF__KeyIndex__15
enum __puf_min_max
    Values:
    enumerator kPUF__KeySizeMin
    enumerator kPUF__KeySizeMax
    enumerator kPUF__KeyIndexMax
enum __puf_key_slot
    PUF key slot.
    Values:
    enumerator kPUF__KeySlot0
        PUF key slot 0
    enumerator kPUF__KeySlot1
        PUF key slot 1

    PUF status return codes.
    Values:
    enumerator kStatus__EnrollNotAllowed
    enumerator kStatus__StartNotAllowed

typedef enum _puf_key_index_register puf_key_index_register_t
typedef enum _puf_min_max puf_min_max_t
typedef enum _puf_key_slot puf_key_slot_t
    PUF key slot.
PUF_GET_KEY_CODE_SIZE_FOR_KEY_SIZE(x)
    Get Key Code size in bytes from key size in bytes at compile time.
PUF_MIN_KEY_CODE_SIZE
PUF_ACTIVATION_CODE_SIZE
KEystore_PUF_DISCHARGE_TIME_FIRST_TRY_MS
KEystore_PUF_DISCHARGE_TIME_MAX_MS
struct puf_config_t
    #include <fsl_puf.h>
```

2.56 Reset Driver

enum _RSTCTL_RSTn

Enumeration for peripheral reset control bits.

Defines the enumeration for peripheral reset control bits in RSTCTLx registers

Values:

enumerator kDSP_RST_SHIFT_RSTn

DSP reset control

enumerator kPOWERQUAD_RST_SHIFT_RSTn

POWERQUAD reset control

enumerator kCASPER_RST_SHIFT_RSTn

CASPER reset control

enumerator kHASHCRYPT_RST_SHIFT_RSTn

HASHCRYPT reset control

enumerator kPUF_RST_SHIFT_RSTn

Physical unclonable function reset control

enumerator kRNG_RST_SHIFT_RSTn

Random number generator (RNG) reset control

enumerator kFLEXSPI_RST_SHIFT_RSTn

FLEXSPI reset control

enumerator kUSBHS_PHY_RST_SHIFT_RSTn

High speed USB PHY reset control

enumerator kUSBHS_DEVICE_RST_SHIFT_RSTn

High speed USB Device reset control

enumerator kUSBHS_HOST_RST_SHIFT_RSTn

High speed USB Host reset control

enumerator kUSBHS_SRAM_RST_SHIFT_RSTn

High speed USB SRAM reset control

enumerator kSCT_RST_SHIFT_RSTn

Standard ctimers reset control

enumerator kSDIO0_RST_SHIFT_RSTn

SDIO0 reset control

enumerator kSDIO1_RST_SHIFT_RSTn

SDIO1 reset control

enumerator kACMP0_RST_SHIFT_RSTn

Grouped interrupt (PINT) reset control.

enumerator kADC0_RST_SHIFT_RSTn

ADC0 reset control

enumerator kSHSGPIO0_RST_SHIFT_RSTn

Security HSGPIO 0 reset control

enumerator kUTICK0_RST_SHIFT_RSTn

Micro-tick timer reset control

enumerator kWWDT0_RST_SHIFT_RSTn
Windowed Watchdog timer 0 reset control

enumerator kFC0_RST_SHIFT_RSTn
Flexcomm Interface 0 reset control

enumerator kFC1_RST_SHIFT_RSTn
Flexcomm Interface 1 reset control

enumerator kFC2_RST_SHIFT_RSTn
Flexcomm Interface 2 reset control

enumerator kFC3_RST_SHIFT_RSTn
Flexcomm Interface 3 reset control

enumerator kFC4_RST_SHIFT_RSTn
Flexcomm Interface 4 reset control

enumerator kFC5_RST_SHIFT_RSTn
Flexcomm Interface 5 reset control

enumerator kFC6_RST_SHIFT_RSTn
Flexcomm Interface 6 reset control

enumerator kFC7_RST_SHIFT_RSTn
Flexcomm Interface 7 reset control

enumerator kFC14_RST_SHIFT_RSTn
Flexcomm Interface 14 reset control

enumerator kFC15_RST_SHIFT_RSTn
Flexcomm Interface 15 reset control

enumerator kDMIC_RST_SHIFT_RSTn
Digital microphone interface reset control

enumerator kOSEVENT_TIMER_RST_SHIFT_RSTn
Osevent Timer reset control

enumerator kHSGPIO0_RST_SHIFT_RSTn
HSGPIO 0 reset control

enumerator kHSGPIO1_RST_SHIFT_RSTn
HSGPIO 1 reset control

enumerator kHSGPIO2_RST_SHIFT_RSTn
HSGPIO 2 reset control

enumerator kHSGPIO3_RST_SHIFT_RSTn
HSGPIO 3 reset control

enumerator kHSGPIO4_RST_SHIFT_RSTn
HSGPIO 4 reset control

enumerator kHSGPIO5_RST_SHIFT_RSTn
HSGPIO 5 reset control

enumerator kHSGPIO6_RST_SHIFT_RSTn
HSGPIO 6 reset control

enumerator kHSGPIO7_RST_SHIFT_RSTn
HSGPIO 7 reset control

```

enumerator kCRC_RST_SHIFT_RSTn
    CRC reset control
enumerator kDMAC0_RST_SHIFT_RSTn
    DMA Controller 0 reset control
enumerator kDMAC1_RST_SHIFT_RSTn
    DMA Controller 1 reset control
enumerator kMU_RST_SHIFT_RSTn
    Message Unit reset control
enumerator kSEMA_RST_SHIFT_RSTn
    Semaphore reset control
enumerator kFREQME_RST_SHIFT_RSTn
    Frequency Measure reset control
enumerator kCT32B0_RST_SHIFT_RSTn
    CT32B0 reset control
enumerator kCT32B1_RST_SHIFT_RSTn
    CT32B1 reset control
enumerator kCT32B2_RST_SHIFT_RSTn
    CT32B3 reset control
enumerator kCT32B3_RST_SHIFT_RSTn
    CT32B4 reset control
enumerator kCT32B4_RST_SHIFT_RSTn
    CT32B4 reset control
enumerator kMRT0_RST_SHIFT_RSTn
    Multi-rate timer (MRT) reset control
enumerator kWWDT1_RST_SHIFT_RSTn
    Windowed Watchdog timer 1 reset control
enumerator kI3C0_RST_SHIFT_RSTn
    I3C reset control
enumerator kPINT_RST_SHIFT_RSTn
    GPIO Pin interrupt reset control
enumerator kINPUTMUX_RST_SHIFT_RSTn
    Peripheral input muxes reset control
typedef enum _RSTCTL_RSTn RSTCTL_RSTn_t
    Enumeration for peripheral reset control bits.
    Defines the enumeration for peripheral reset control bits in RSTCTLx registers
typedef RSTCTL_RSTn_t reset_ip_name_t
    IP reset handle.
void RESET_SetPeripheralReset(reset_ip_name_t peripheral)
    Assert reset to peripheral.
    Asserts reset signal to specified peripheral module.

```

Parameters

- `peripheral` – Assert reset to this peripheral. The enum argument contains encoding of reset register and reset bit position in the reset register.

`void RESET_ClearPeripheralReset(reset_ip_name_t peripheral)`

Clear reset to peripheral.

Clears reset signal to specified peripheral module, allows it to operate.

Parameters

- `peripheral` – Clear reset to this peripheral. The enum argument contains encoding of reset register and reset bit position in the reset register.

`void RESET_PeripheralReset(reset_ip_name_t peripheral)`

Reset peripheral module.

Reset peripheral module.

Parameters

- `peripheral` – Peripheral to reset. The enum argument contains encoding of reset register and reset bit position in the reset register.

`static inline void RESET_ReleasePeripheralReset(reset_ip_name_t peripheral)`

Release peripheral module.

Release peripheral module.

Parameters

- `peripheral` – Peripheral to release. The enum argument contains encoding of reset register and reset bit position in the reset register.

`FSL_RESET_DRIVER_VERSION`

reset driver version 2.2.1.

`RST_CTL0_PSCCTL0`

Reset control registers index.

`RST_CTL0_PSCCTL1`

`RST_CTL0_PSCCTL2`

`RST_CTL1_PSCCTL0`

`RST_CTL1_PSCCTL1`

`RST_CTL1_PSCCTL2`

`ADC_RSTS`

Array initializers with peripheral reset bits

`CASPER_RSTS`

`CRC_RSTS`

`DMA_RSTS_N`

`DMIC_RSTS`

`FLEXCOMM_RSTS`

`GPIO_RSTS_N`

`HASHCRYPT_RSTS`

`I3C_RSTS`

`INPUTMUX_RSTS`

MRT_RSTS
MU_RSTS
PINT_RSTS
SCT_RSTS
CTIMER_RSTS
USB_RSTS
USDHC_RSTS
UTICK_RSTS
WWDT_RSTS
OSTIMER_RSTS
POWERQUAD_RSTS
PUF_RSTS
TRNG_RSTS

2.57 RTC: Real Time Clock

`void RTC_Init(RTC_Type *base)`

Un-gate the RTC clock and enable the RTC oscillator.

Note: This API should be called at the beginning of the application using the RTC driver.

Parameters

- `base` – RTC peripheral base address

`static inline void RTC_Deinit(RTC_Type *base)`

Stop the timer and gate the RTC clock.

Parameters

- `base` – RTC peripheral base address

`status_t RTC_SetDatetime(RTC_Type *base, const rtc_datetime_t *datetime)`

Set the RTC date and time according to the given time structure.

The RTC counter must be stopped prior to calling this function as writes to the RTC seconds register will fail if the RTC counter is running.

Parameters

- `base` – RTC peripheral base address
- `datetime` – Pointer to structure where the date and time details to set are stored

Returns

`kStatus_Success`: Success in setting the time and starting the RTC
`kStatus_InvalidArgument`: Error because the datetime format is incorrect

```
void RTC_GetDatetime(RTC_Type *base, rtc_datetime_t *datetime)
```

Get the RTC time and stores it in the given time structure.

Parameters

- base – RTC peripheral base address
- datetime – Pointer to structure where the date and time details are stored.

```
status_t RTC_SetAlarm(RTC_Type *base, const rtc_datetime_t *alarmTime)
```

Set the RTC alarm time.

The function checks whether the specified alarm time is greater than the present time. If not, the function does not set the alarm and returns an error.

Parameters

- base – RTC peripheral base address
- alarmTime – Pointer to structure where the alarm time is stored.

Returns

kStatus_Success: success in setting the RTC alarm
kStatus_InvalidArgument: Error because the alarm datetime format is incorrect
kStatus_Fail: Error because the alarm time has already passed

```
void RTC_GetAlarm(RTC_Type *base, rtc_datetime_t *datetime)
```

Return the RTC alarm time.

Parameters

- base – RTC peripheral base address
- datetime – Pointer to structure where the alarm date and time details are stored.

```
static inline void RTC_EnableWakeupTimer(RTC_Type *base, bool enable)
```

Enable the RTC wake-up timer (1KHZ).

After calling this function, the RTC driver will use/un-use the RTC wake-up (1KHZ) at the same time.

Parameters

- base – RTC peripheral base address
- enable – Use/Un-use the RTC wake-up timer.
 - true: Use RTC wake-up timer at the same time.
 - false: Un-use RTC wake-up timer, RTC only use the normal seconds timer by default.

```
static inline uint32_t RTC_GetEnabledWakeupTimer(RTC_Type *base)
```

Get the enabled status of the RTC wake-up timer (1KHZ).

Parameters

- base – RTC peripheral base address

Returns

The enabled status of RTC wake-up timer (1KHZ).

```
static inline void RTC_EnableSubsecCounter(RTC_Type *base, bool enable)
```

Enable the RTC Sub-second counter (32KHZ).

Note: Only enable sub-second counter after RTC_ENA bit has been set to 1.

Parameters

- base – RTC peripheral base address
- enable – Enable/Disable RTC sub-second counter.
 - true: Enable RTC sub-second counter.
 - false: Disable RTC sub-second counter.

static inline uint32_t RTC_GetSubsecValue(const RTC_Type *base)

A read of 32KHZ sub-seconds counter.

Parameters

- base – RTC peripheral base address

Returns

Current value of the SUBSEC register

static inline void RTC_EnableWakeUpTimerInterruptFromDPD(RTC_Type *base, bool enable)

Enable the wake-up timer interrupt from deep power down mode.

Parameters

- base – RTC peripheral base address
- enable – Enable/Disable wake-up timer interrupt from deep power down mode.
 - true: Enable wake-up timer interrupt from deep power down mode.
 - false: Disable wake-up timer interrupt from deep power down mode.

static inline void RTC_EnableAlarmTimerInterruptFromDPD(RTC_Type *base, bool enable)

Enable the alarm timer interrupt from deep power down mode.

Parameters

- base – RTC peripheral base address
- enable – Enable/Disable alarm timer interrupt from deep power down mode.
 - true: Enable alarm timer interrupt from deep power down mode.
 - false: Disable alarm timer interrupt from deep power down mode.

static inline void RTC_EnableInterrupts(RTC_Type *base, uint32_t mask)

Enables the selected RTC interrupts.

Deprecated:

Do not use this function. It has been superseded by RTC_EnableAlarmTimerInterruptFromDPD and RTC_EnableWakeUpTimerInterruptFromDPD

Parameters

- base – RTC peripheral base address
- mask – The interrupts to enable. This is a logical OR of members of the enumeration rtc_interrupt_enable_t

static inline void RTC_DisableInterrupts(RTC_Type *base, uint32_t mask)

Disables the selected RTC interrupts.

Deprecated:

Do not use this function. It has been superceded by `RTC_EnableAlarmTimerInterruptFromDPD` and `RTC_EnableWakeUpTimerInterruptFromDPD`

Parameters

- `base` – RTC peripheral base address
- `mask` – The interrupts to enable. This is a logical OR of members of the enumeration `rtc_interrupt_enable_t`

```
static inline uint32_t RTC_GetEnabledInterrupts(RTC_Type *base)
```

Get the enabled RTC interrupts.

Deprecated:

Do not use this function. It will be deleted in next release version.

Parameters

- `base` – RTC peripheral base address

Returns

The enabled interrupts. This is the logical OR of members of the enumeration `rtc_interrupt_enable_t`

```
static inline uint32_t RTC_GetStatusFlags(RTC_Type *base)
```

Get the RTC status flags.

Parameters

- `base` – RTC peripheral base address

Returns

The status flags. This is the logical OR of members of the enumeration `rtc_status_flags_t`

```
static inline void RTC_ClearStatusFlags(RTC_Type *base, uint32_t mask)
```

Clear the RTC status flags.

Parameters

- `base` – RTC peripheral base address
- `mask` – The status flags to clear. This is a logical OR of members of the enumeration `rtc_status_flags_t`

```
static inline void RTC_EnableTimer(RTC_Type *base, bool enable)
```

Enable the RTC timer counter.

After calling this function, the RTC inner counter increments once a second when only using the RTC seconds timer (1hz), while the RTC inner wake-up timer countdown once a millisecond when using RTC wake-up timer (1KHZ) at the same time. RTC timer contain two timers, one is the RTC normal seconds timer, the other one is the RTC wake-up timer, the RTC enable bit is the master switch for the whole RTC timer, so user can use the RTC seconds (1HZ) timer independly, but they can't use the RTC wake-up timer (1KHZ) independently.

Parameters

- `base` – RTC peripheral base address
- `enable` – Enable/Disable RTC Timer counter.
 - `true`: Enable RTC Timer counter.
 - `false`: Disable RTC Timer counter.

```
static inline void RTC_StartTimer(RTC_Type *base)
```

Starts the RTC time counter.

Deprecated:

Do not use this function. It has been superceded by RTC_EnableTimer

After calling this function, the timer counter increments once a second provided SR[TOF] or SR[TIF] are not set.

Parameters

- base – RTC peripheral base address

```
static inline void RTC_StopTimer(RTC_Type *base)
```

Stops the RTC time counter.

Deprecated:

Do not use this function. It has been superceded by RTC_EnableTimer

RTC's seconds register can be written to only when the timer is stopped.

Parameters

- base – RTC peripheral base address

```
FSL_RTC_DRIVER_VERSION
```

Version 2.2.0

```
enum _rtc_interrupt_enable
```

List of RTC interrupts.

Values:

```
enumerator kRTC_AlarmInterruptEnable
```

Alarm interrupt.

```
enumerator kRTC_WakeupInterruptEnable
```

Wake-up interrupt.

```
enum _rtc_status_flags
```

List of RTC flags.

Values:

```
enumerator kRTC_AlarmFlag
```

Alarm flag

```
enumerator kRTC_WakeupFlag
```

1kHz wake-up timer flag

```
typedef enum _rtc_interrupt_enable rtc_interrupt_enable_t
```

List of RTC interrupts.

```
typedef enum _rtc_status_flags rtc_status_flags_t
```

List of RTC flags.

```
typedef struct _rtc_datetime rtc_datetime_t
```

Structure is used to hold the date and time.

```
static inline void RTC__SetSecondsTimerMatch(RTC_Type *base, uint32_t matchValue)
```

Set the RTC seconds timer (1HZ) MATCH value.

Parameters

- base – RTC peripheral base address
- matchValue – The value to be set into the RTC MATCH register

```
static inline uint32_t RTC__GetSecondsTimerMatch(RTC_Type *base)
```

Read actual RTC seconds timer (1HZ) MATCH value.

Parameters

- base – RTC peripheral base address

Returns

The actual RTC seconds timer (1HZ) MATCH value.

```
static inline void RTC__SetSecondsTimerCount(RTC_Type *base, uint32_t countValue)
```

Set the RTC seconds timer (1HZ) COUNT value.

Parameters

- base – RTC peripheral base address
- countValue – The value to be loaded into the RTC COUNT register

```
static inline uint32_t RTC__GetSecondsTimerCount(RTC_Type *base)
```

Read the actual RTC seconds timer (1HZ) COUNT value.

Parameters

- base – RTC peripheral base address

Returns

The actual RTC seconds timer (1HZ) COUNT value.

```
static inline void RTC__SetWakeupCount(RTC_Type *base, uint16_t wakeupValue)
```

Enable the RTC wake-up timer (1KHZ) and set countdown value to the RTC WAKE register.

Parameters

- base – RTC peripheral base address
- wakeupValue – The value to be loaded into the WAKE register in RTC wake-up timer (1KHZ).

```
static inline uint16_t RTC__GetWakeupCount(RTC_Type *base)
```

Read the actual value from the WAKE register value in RTC wake-up timer (1KHZ)

Read the WAKE register twice and compare the result, if the value match, the time can be used.

Parameters

- base – RTC peripheral base address

Returns

The actual value of the WAKE register value in RTC wake-up timer (1KHZ).

```
static inline void RTC__Reset(RTC_Type *base)
```

Perform a software reset on the RTC module.

This resets all RTC registers to their reset value. The bit is cleared by software explicitly clearing it.

Parameters

- base – RTC peripheral base address

struct _rtc_datetime

#include <fsl_rtc.h> Structure is used to hold the date and time.

Public Members

uint16_t year

Range from 1970 to 2099.

uint8_t month

Range from 1 to 12.

uint8_t day

Range from 1 to 31 (depending on month).

uint8_t hour

Range from 0 to 23.

uint8_t minute

Range from 0 to 59.

uint8_t second

Range from 0 to 59.

2.58 SCTimer: SCTimer/PWM (SCT)

status_t SCTIMER_Init(SCT_Type *base, const sctimer_config_t *config)

Ungates the SCTimer clock and configures the peripheral for basic operation.

Note: This API should be called at the beginning of the application using the SCTimer driver.

Parameters

- base – SCTimer peripheral base address
- config – Pointer to the user configuration structure.

Returns

kStatus_Success indicates success; Else indicates failure.

void SCTIMER_Deinit(SCT_Type *base)

Gates the SCTimer clock.

Parameters

- base – SCTimer peripheral base address

void SCTIMER_GetDefaultConfig(sctimer_config_t *config)

Fills in the SCTimer configuration structure with the default settings.

The default values are:

```
config->enableCounterUnify = true;
config->clockMode = kSCTIMER_System_ClockMode;
config->clockSelect = kSCTIMER_Clock_On_Rise_Input_0;
config->enableBidirection_l = false;
config->enableBidirection_h = false;
config->prescale_l = 0U;
```

(continues on next page)

(continued from previous page)

```
config->prescale_h = 0U;  
config->outInitState = 0U;  
config->inputsync = 0xFU;
```

Parameters

- config – Pointer to the user configuration structure.

```
status_t SCTIMER_SetupPwm(SCT_Type *base, const sctimer_pwm_signal_param_t  
                          *pwmParams, sctimer_pwm_mode_t mode, uint32_t  
                          pwmFreq_Hz, uint32_t srcClock_Hz, uint32_t *event)
```

Configures the PWM signal parameters.

Call this function to configure the PWM signal period, mode, duty cycle, and edge. This function will create 2 events; one of the events will trigger on match with the pulse value and the other will trigger when the counter matches the PWM period. The PWM period event is also used as a limit event to reset the counter or change direction. Both events are enabled for the same state. The state number can be retrieved by calling the function `SCTIMER_GetCurrentStateNumber()`. The counter is set to operate as one 32-bit counter (unify bit is set to 1). The counter operates in bi-directional mode when generating a center-aligned PWM.

Note: When setting PWM output from multiple output pins, they all should use the same PWM mode i.e all PWM's should be either edge-aligned or center-aligned. When using this API, the PWM signal frequency of all the initialized channels must be the same. Otherwise all the initialized channels' PWM signal frequency is equal to the last call to the API's `pwmFreq_Hz`.

Parameters

- base – SCTimer peripheral base address
- pwmParams – PWM parameters to configure the output
- mode – PWM operation mode, options available in enumeration `sctimer_pwm_mode_t`
- pwmFreq_Hz – PWM signal frequency in Hz
- srcClock_Hz – SCTimer counter clock in Hz
- event – Pointer to a variable where the PWM period event number is stored

Returns

`kStatus_Success` on success `kStatus_Fail` If we have hit the limit in terms of number of events created or if an incorrect PWM duty cycle is passed in.

```
void SCTIMER_UpdatePwmDutycycle(SCT_Type *base, sctimer_out_t output, uint8_t  
                                dutyCyclePercent, uint32_t event)
```

Updates the duty cycle of an active PWM signal.

Before calling this function, the counter is set to operate as one 32-bit counter (unify bit is set to 1).

Parameters

- base – SCTimer peripheral base address
- output – The output to configure
- dutyCyclePercent – New PWM pulse width; the value should be between 1 to 100

- `event` – Event number associated with this PWM signal. This was returned to the user by the function `SCTIMER_SetupPwm()`.

`static inline void SCTIMER_EnableInterrupts(SCT_Type *base, uint32_t mask)`

Enables the selected SCTimer interrupts.

Parameters

- `base` – SCTimer peripheral base address
- `mask` – The interrupts to enable. This is a logical OR of members of the enumeration `sctimer_interrupt_enable_t`

`static inline void SCTIMER_DisableInterrupts(SCT_Type *base, uint32_t mask)`

Disables the selected SCTimer interrupts.

Parameters

- `base` – SCTimer peripheral base address
- `mask` – The interrupts to enable. This is a logical OR of members of the enumeration `sctimer_interrupt_enable_t`

`static inline uint32_t SCTIMER_GetEnabledInterrupts(SCT_Type *base)`

Gets the enabled SCTimer interrupts.

Parameters

- `base` – SCTimer peripheral base address

Returns

The enabled interrupts. This is the logical OR of members of the enumeration `sctimer_interrupt_enable_t`

`static inline uint32_t SCTIMER_GetStatusFlags(SCT_Type *base)`

Gets the SCTimer status flags.

Parameters

- `base` – SCTimer peripheral base address

Returns

The status flags. This is the logical OR of members of the enumeration `sctimer_status_flags_t`

`static inline void SCTIMER_ClearStatusFlags(SCT_Type *base, uint32_t mask)`

Clears the SCTimer status flags.

Parameters

- `base` – SCTimer peripheral base address
- `mask` – The status flags to clear. This is a logical OR of members of the enumeration `sctimer_status_flags_t`

`static inline void SCTIMER_StartTimer(SCT_Type *base, uint32_t countertoStart)`

Starts the SCTimer counter.

Note: In 16-bit mode, we can enable both Counter_L and Counter_H, In 32-bit mode, we only can select Counter_U.

Parameters

- `base` – SCTimer peripheral base address
- `countertoStart` – The SCTimer counters to enable. This is a logical OR of members of the enumeration `sctimer_counter_t`.

```
static inline void SCTIMER_StopTimer(SCT_Type *base, uint32_t countertoStop)
```

Halts the SCTimer counter.

Parameters

- base – SCTimer peripheral base address
- countertoStop – The SCTimer counters to stop. This is a logical OR of members of the enumeration `sctimer_counter_t`.

```
status_t SCTIMER_CreateAndScheduleEvent(SCT_Type *base, sctimer_event_t howToMonitor,  
                                         uint32_t matchValue, uint32_t whichIO,  
                                         sctimer_counter_t whichCounter, uint32_t *event)
```

Create an event that is triggered on a match or IO and schedule in current state.

This function will configure an event using the options provided by the user. If the event type uses the counter match, then the function will set the user provided match value into a match register and put this match register number into the event control register. The event is enabled for the current state and the event number is increased by one at the end. The function returns the event number; this event number can be used to configure actions to be done when this event is triggered.

Parameters

- base – SCTimer peripheral base address
- howToMonitor – Event type; options are available in the enumeration `sctimer_interrupt_enable_t`
- matchValue – The match value that will be programmed to a match register
- whichIO – The input or output that will be involved in event triggering. This field is ignored if the event type is “match only”
- whichCounter – SCTimer counter to use. In 16-bit mode, we can select Counter_L and Counter_H, In 32-bit mode, we can select Counter_U.
- event – Pointer to a variable where the new event number is stored

Returns

`kStatus_Success` on success `kStatus_Error` if we have hit the limit in terms of number of events created or if we have reached the limit in terms of number of match registers

```
void SCTIMER_ScheduleEvent(SCT_Type *base, uint32_t event)
```

Enable an event in the current state.

This function will allow the event passed in to trigger in the current state. The event must be created earlier by either calling the function `SCTIMER_SetupPwm()` or function `SCTIMER_CreateAndScheduleEvent()`.

Parameters

- base – SCTimer peripheral base address
- event – Event number to enable in the current state

```
status_t SCTIMER_IncreaseState(SCT_Type *base)
```

Increase the state by 1.

All future events created by calling the function `SCTIMER_ScheduleEvent()` will be enabled in this new state.

Parameters

- base – SCTimer peripheral base address

Returns

kStatus_Success on success kStatus_Error if we have hit the limit in terms of states used

uint32_t SCTIMER_GetCurrentState(SCT_Type *base)

Provides the current state.

User can use this to set the next state by calling the function SCTIMER_SetupNextStateAction().

Parameters

- base – SCTimer peripheral base address

Returns

The current state

static inline void SCTIMER_SetCounterState(SCT_Type *base, *sctimer_counter_t* whichCounter, uint32_t state)

Set the counter current state.

The function is to set the state variable bit field of STATE register. Writing to the STATE_L, STATE_H, or unified register is only allowed when the corresponding counter is halted (HALT bits are set to 1 in the CTRL register).

Parameters

- base – SCTimer peripheral base address
- whichCounter – SCTimer counter to use. In 16-bit mode, we can select Counter_L and Counter_H, In 32-bit mode, we can select Counter_U.
- state – The counter current state number (only support range from 0~31).

static inline uint16_t SCTIMER_GetCounterState(SCT_Type *base, *sctimer_counter_t* whichCounter)

Get the counter current state value.

The function is to get the state variable bit field of STATE register.

Parameters

- base – SCTimer peripheral base address
- whichCounter – SCTimer counter to use. In 16-bit mode, we can select Counter_L and Counter_H, In 32-bit mode, we can select Counter_U.

Returns

The the counter current state value.

status_t SCTIMER_SetupCaptureAction(SCT_Type *base, *sctimer_counter_t* whichCounter, uint32_t *captureRegister, uint32_t event)

Setup capture of the counter value on trigger of a selected event.

Parameters

- base – SCTimer peripheral base address
- whichCounter – SCTimer counter to use. In 16-bit mode, we can select Counter_L and Counter_H, In 32-bit mode, we can select Counter_U.
- captureRegister – Pointer to a variable where the capture register number will be returned. User can read the captured value from this register when the specified event is triggered.
- event – Event number that will trigger the capture

Returns

kStatus_Success on success kStatus_Error if we have hit the limit in terms of number of match/capture registers available

void SCTIMER_SetCallback(SCT_Type *base, *sctimer_event_callback_t* callback, uint32_t event)

Receive notification when the event trigger an interrupt.

If the interrupt for the event is enabled by the user, then a callback can be registered which will be invoked when the event is triggered

Parameters

- base – SCTimer peripheral base address
- event – Event number that will trigger the interrupt
- callback – Function to invoke when the event is triggered

static inline void SCTIMER_SetupStateLdMethodAction(SCT_Type *base, uint32_t event, bool fgLoad)

Change the load method of transition to the specified state.

Change the load method of transition, it will be triggered by the event number that is passed in by the user.

Parameters

- base – SCTimer peripheral base address
- event – Event number that will change the method to trigger the state transition
- fgLoad – The method to load highest-numbered event occurring for that state to the STATE register.
 - true: Load the STATEV value to STATE when the event occurs to be the next state.
 - false: Add the STATEV value to STATE when the event occurs to be the next state.

static inline void SCTIMER_SetupNextStateActionwithLdMethod(SCT_Type *base, uint32_t nextState, uint32_t event, bool fgLoad)

Transition to the specified state with Load method.

This transition will be triggered by the event number that is passed in by the user, the method decide how to load the highest-numbered event occurring for that state to the STATE register.

Parameters

- base – SCTimer peripheral base address
- nextState – The next state SCTimer will transition to
- event – Event number that will trigger the state transition
- fgLoad – The method to load the highest-numbered event occurring for that state to the STATE register.
 - true: Load the STATEV value to STATE when the event occurs to be the next state.
 - false: Add the STATEV value to STATE when the event occurs to be the next state.

```
static inline void SCTIMER_SetupNextStateAction(SCT_Type *base, uint32_t nextState, uint32_t event)
```

Transition to the specified state.

Deprecated:

Do not use this function. It has been superceded by SCTIMER_SetupNextStateActionwithLdMethod

This transition will be triggered by the event number that is passed in by the user.

Parameters

- base – SCTimer peripheral base address
- nextState – The next state SCTimer will transition to
- event – Event number that will trigger the state transition

```
static inline void SCTIMER_SetupEventActiveDirection(SCT_Type *base,
                                                    sctimer_event_active_direction_t
                                                    activeDirection, uint32_t event)
```

Setup event active direction when the counters are operating in BIDIR mode.

Parameters

- base – SCTimer peripheral base address
- activeDirection – Event generation active direction, see sctimer_event_active_direction_t.
- event – Event number that need setup the active direction.

```
static inline void SCTIMER_SetupOutputSetAction(SCT_Type *base, uint32_t whichIO, uint32_t event)
```

Set the Output.

This output will be set when the event number that is passed in by the user is triggered.

Parameters

- base – SCTimer peripheral base address
- whichIO – The output to set
- event – Event number that will trigger the output change

```
static inline void SCTIMER_SetupOutputClearAction(SCT_Type *base, uint32_t whichIO,
                                                  uint32_t event)
```

Clear the Output.

This output will be cleared when the event number that is passed in by the user is triggered.

Parameters

- base – SCTimer peripheral base address
- whichIO – The output to clear
- event – Event number that will trigger the output change

```
void SCTIMER_SetupOutputToggleAction(SCT_Type *base, uint32_t whichIO, uint32_t event)
```

Toggle the output level.

This change in the output level is triggered by the event number that is passed in by the user.

Parameters

- base – SCTimer peripheral base address
- whichIO – The output to toggle
- event – Event number that will trigger the output change

```
static inline void SCTIMER_SetupCounterLimitAction(SCT_Type *base, sctimer_counter_t  
                                                  whichCounter, uint32_t event)
```

Limit the running counter.

The counter is limited when the event number that is passed in by the user is triggered.

Parameters

- base – SCTimer peripheral base address
- whichCounter – SCTimer counter to use. In 16-bit mode, we can select Counter_L and Counter_H, In 32-bit mode, we can select Counter_U.
- event – Event number that will trigger the counter to be limited

```
static inline void SCTIMER_SetupCounterStopAction(SCT_Type *base, sctimer_counter_t  
                                                  whichCounter, uint32_t event)
```

Stop the running counter.

The counter is stopped when the event number that is passed in by the user is triggered.

Parameters

- base – SCTimer peripheral base address
- whichCounter – SCTimer counter to use. In 16-bit mode, we can select Counter_L and Counter_H, In 32-bit mode, we can select Counter_U.
- event – Event number that will trigger the counter to be stopped

```
static inline void SCTIMER_SetupCounterStartAction(SCT_Type *base, sctimer_counter_t  
                                                  whichCounter, uint32_t event)
```

Re-start the stopped counter.

The counter will re-start when the event number that is passed in by the user is triggered.

Parameters

- base – SCTimer peripheral base address
- whichCounter – SCTimer counter to use. In 16-bit mode, we can select Counter_L and Counter_H, In 32-bit mode, we can select Counter_U.
- event – Event number that will trigger the counter to re-start

```
static inline void SCTIMER_SetupCounterHaltAction(SCT_Type *base, sctimer_counter_t  
                                                  whichCounter, uint32_t event)
```

Halt the running counter.

The counter is disabled (halted) when the event number that is passed in by the user is triggered. When the counter is halted, all further events are disabled. The HALT condition can only be removed by calling the SCTIMER_StartTimer() function.

Parameters

- base – SCTimer peripheral base address
- whichCounter – SCTimer counter to use. In 16-bit mode, we can select Counter_L and Counter_H, In 32-bit mode, we can select Counter_U.
- event – Event number that will trigger the counter to be halted

```
static inline void SCTIMER_SetupDmaTriggerAction(SCT_Type *base, uint32_t dmaNumber,
                                                uint32_t event)
```

Generate a DMA request.

DMA request will be triggered by the event number that is passed in by the user.

Parameters

- base – SCTimer peripheral base address
- dmaNumber – The DMA request to generate
- event – Event number that will trigger the DMA request

```
static inline void SCTIMER_SetCOUNTValue(SCT_Type *base, sctimer_counter_t whichCounter,
                                          uint32_t value)
```

Set the value of counter.

The function is to set the value of Count register, Writing to the COUNT_L, COUNT_H, or unified register is only allowed when the corresponding counter is halted (HALT bits are set to 1 in the CTRL register).

Parameters

- base – SCTimer peripheral base address
- whichCounter – SCTimer counter to use. In 16-bit mode, we can select Counter_L and Counter_H, In 32-bit mode, we can select Counter_U.
- value – the counter value update to the COUNT register.

```
static inline uint32_t SCTIMER_GetCOUNTValue(SCT_Type *base, sctimer_counter_t
                                              whichCounter)
```

Get the value of counter.

The function is to read the value of Count register, software can read the counter registers at any time..

Parameters

- base – SCTimer peripheral base address
- whichCounter – SCTimer counter to use. In 16-bit mode, we can select Counter_L and Counter_H, In 32-bit mode, we can select Counter_U.

Returns

The value of counter selected.

```
static inline void SCTIMER_SetEventInState(SCT_Type *base, uint32_t event, uint32_t state)
```

Set the state mask bit field of EV_STATE register.

Parameters

- base – SCTimer peripheral base address
- event – The EV_STATE register be set.
- state – The state value in which the event is enabled to occur.

```
static inline void SCTIMER_ClearEventInState(SCT_Type *base, uint32_t event, uint32_t state)
```

Clear the state mask bit field of EV_STATE register.

Parameters

- base – SCTimer peripheral base address
- event – The EV_STATE register be clear.
- state – The state value in which the event is disabled to occur.

```
static inline bool SCTIMER_GetEventInState(SCT_Type *base, uint32_t event, uint32_t state)
```

Get the state mask bit field of EV_STATE register.

Note: This function is to check whether the event is enabled in a specific state.

Parameters

- base – SCTimer peripheral base address
- event – The EV_STATE register be read.
- state – The state value.

Returns

The the state mask bit field of EV_STATE register.

- true: The event is enable in state.
- false: The event is disable in state.

```
static inline uint32_t SCTIMER_GetCaptureValue(SCT_Type *base, sctimer_counter_t  
whichCounter, uint8_t capChannel)
```

Get the value of capture register.

This function returns the captured value upon occurrence of the events selected by the corresponding Capture Control registers occurred.

Parameters

- base – SCTimer peripheral base address
- whichCounter – SCTimer counter to use. In 16-bit mode, we can select Counter_L and Counter_H, In 32-bit mode, we can select Counter_U.
- capChannel – SCTimer capture register of capture channel.

Returns

The SCTimer counter value at which this register was last captured.

```
void SCTIMER_EventHandleIRQ(SCT_Type *base)
```

SCTimer interrupt handler.

Parameters

- base – SCTimer peripheral base address.

```
FSL_SCTIMER_DRIVER_VERSION
```

Version

```
enum _sctimer_pwm_mode
```

SCTimer PWM operation modes.

Values:

```
enumerator kSCTIMER_EdgeAlignedPwm
```

Edge-aligned PWM

```
enumerator kSCTIMER_CenterAlignedPwm
```

Center-aligned PWM

```
enum _sctimer_counter
```

SCTimer counters type.

Values:

enumerator kSCTIMER_Counter_L
16-bit Low counter.

enumerator kSCTIMER_Counter_H
16-bit High counter.

enumerator kSCTIMER_Counter_U
32-bit Unified counter.

enum _sctimer_input

List of SCTimer input pins.

Values:

enumerator kSCTIMER_Input_0
SCTIMER input 0

enumerator kSCTIMER_Input_1
SCTIMER input 1

enumerator kSCTIMER_Input_2
SCTIMER input 2

enumerator kSCTIMER_Input_3
SCTIMER input 3

enumerator kSCTIMER_Input_4
SCTIMER input 4

enumerator kSCTIMER_Input_5
SCTIMER input 5

enumerator kSCTIMER_Input_6
SCTIMER input 6

enumerator kSCTIMER_Input_7
SCTIMER input 7

enum _sctimer_out

List of SCTimer output pins.

Values:

enumerator kSCTIMER_Out_0
SCTIMER output 0

enumerator kSCTIMER_Out_1
SCTIMER output 1

enumerator kSCTIMER_Out_2
SCTIMER output 2

enumerator kSCTIMER_Out_3
SCTIMER output 3

enumerator kSCTIMER_Out_4
SCTIMER output 4

enumerator kSCTIMER_Out_5
SCTIMER output 5

enumerator kSCTIMER_Out_6
SCTIMER output 6

enumerator kSCTIMER_Out_7

SCTIMER output 7

enumerator kSCTIMER_Out_8

SCTIMER output 8

enumerator kSCTIMER_Out_9

SCTIMER output 9

enum _sctimer_pwm_level_select

SCTimer PWM output pulse mode: high-true, low-true or no output.

Values:

enumerator kSCTIMER_LowTrue

Low true pulses

enumerator kSCTIMER_HighTrue

High true pulses

enum _sctimer_clock_mode

SCTimer clock mode options.

Values:

enumerator kSCTIMER_System_ClockMode

System Clock Mode

enumerator kSCTIMER_Sampled_ClockMode

Sampled System Clock Mode

enumerator kSCTIMER_Input_ClockMode

SCT Input Clock Mode

enumerator kSCTIMER_Asynchronous_ClockMode

Asynchronous Mode

enum _sctimer_clock_select

SCTimer clock select options.

Values:

enumerator kSCTIMER_Clock_On_Rise_Input_0

Rising edges on input 0

enumerator kSCTIMER_Clock_On_Fall_Input_0

Falling edges on input 0

enumerator kSCTIMER_Clock_On_Rise_Input_1

Rising edges on input 1

enumerator kSCTIMER_Clock_On_Fall_Input_1

Falling edges on input 1

enumerator kSCTIMER_Clock_On_Rise_Input_2

Rising edges on input 2

enumerator kSCTIMER_Clock_On_Fall_Input_2

Falling edges on input 2

enumerator kSCTIMER_Clock_On_Rise_Input_3

Rising edges on input 3

enumerator kSCTIMER_Clock_On_Fall_Input_3

Falling edges on input 3

enumerator kSCTIMER_Clock_On_Rise_Input_4

Rising edges on input 4

enumerator kSCTIMER_Clock_On_Fall_Input_4

Falling edges on input 4

enumerator kSCTIMER_Clock_On_Rise_Input_5

Rising edges on input 5

enumerator kSCTIMER_Clock_On_Fall_Input_5

Falling edges on input 5

enumerator kSCTIMER_Clock_On_Rise_Input_6

Rising edges on input 6

enumerator kSCTIMER_Clock_On_Fall_Input_6

Falling edges on input 6

enumerator kSCTIMER_Clock_On_Rise_Input_7

Rising edges on input 7

enumerator kSCTIMER_Clock_On_Fall_Input_7

Falling edges on input 7

enum _sctimer_conflict_resolution

SCTimer output conflict resolution options.

Specifies what action should be taken if multiple events dictate that a given output should be both set and cleared at the same time

Values:

enumerator kSCTIMER_ResolveNone

No change

enumerator kSCTIMER_ResolveSet

Set output

enumerator kSCTIMER_ResolveClear

Clear output

enumerator kSCTIMER_ResolveToggle

Toggle output

enum _sctimer_event_active_direction

List of SCTimer event generation active direction when the counters are operating in BIDIR mode.

Values:

enumerator kSCTIMER_ActiveIndependent

This event is triggered regardless of the count direction.

enumerator kSCTIMER_ActiveInCountUp

This event is triggered only during up-counting when BIDIR = 1.

enumerator kSCTIMER_ActiveInCountDown

This event is triggered only during down-counting when BIDIR = 1.

enum _sctimer_event

List of SCTimer event types.

Values:

enumerator kSCTIMER_InputLowOrMatchEvent
enumerator kSCTIMER_InputRiseOrMatchEvent
enumerator kSCTIMER_InputFallOrMatchEvent
enumerator kSCTIMER_InputHighOrMatchEvent
enumerator kSCTIMER_MatchEventOnly
enumerator kSCTIMER_InputLowEvent
enumerator kSCTIMER_InputRiseEvent
enumerator kSCTIMER_InputFallEvent
enumerator kSCTIMER_InputHighEvent
enumerator kSCTIMER_InputLowAndMatchEvent
enumerator kSCTIMER_InputRiseAndMatchEvent
enumerator kSCTIMER_InputFallAndMatchEvent
enumerator kSCTIMER_InputHighAndMatchEvent
enumerator kSCTIMER_OutputLowOrMatchEvent
enumerator kSCTIMER_OutputRiseOrMatchEvent
enumerator kSCTIMER_OutputFallOrMatchEvent
enumerator kSCTIMER_OutputHighOrMatchEvent
enumerator kSCTIMER_OutputLowEvent
enumerator kSCTIMER_OutputRiseEvent
enumerator kSCTIMER_OutputFallEvent
enumerator kSCTIMER_OutputHighEvent
enumerator kSCTIMER_OutputLowAndMatchEvent
enumerator kSCTIMER_OutputRiseAndMatchEvent
enumerator kSCTIMER_OutputFallAndMatchEvent
enumerator kSCTIMER_OutputHighAndMatchEvent

enum _sctimer_interrupt_enable

List of SCTimer interrupts.

Values:

enumerator kSCTIMER_Event0InterruptEnable
 Event 0 interrupt
enumerator kSCTIMER_Event1InterruptEnable
 Event 1 interrupt

enumerator kSCTIMER_Event2InterruptEnable

Event 2 interrupt

enumerator kSCTIMER_Event3InterruptEnable

Event 3 interrupt

enumerator kSCTIMER_Event4InterruptEnable

Event 4 interrupt

enumerator kSCTIMER_Event5InterruptEnable

Event 5 interrupt

enumerator kSCTIMER_Event6InterruptEnable

Event 6 interrupt

enumerator kSCTIMER_Event7InterruptEnable

Event 7 interrupt

enumerator kSCTIMER_Event8InterruptEnable

Event 8 interrupt

enumerator kSCTIMER_Event9InterruptEnable

Event 9 interrupt

enumerator kSCTIMER_Event10InterruptEnable

Event 10 interrupt

enumerator kSCTIMER_Event11InterruptEnable

Event 11 interrupt

enumerator kSCTIMER_Event12InterruptEnable

Event 12 interrupt

enum _sctimer_status_flags

List of SCTimer flags.

Values:

enumerator kSCTIMER_Event0Flag

Event 0 Flag

enumerator kSCTIMER_Event1Flag

Event 1 Flag

enumerator kSCTIMER_Event2Flag

Event 2 Flag

enumerator kSCTIMER_Event3Flag

Event 3 Flag

enumerator kSCTIMER_Event4Flag

Event 4 Flag

enumerator kSCTIMER_Event5Flag

Event 5 Flag

enumerator kSCTIMER_Event6Flag

Event 6 Flag

enumerator kSCTIMER_Event7Flag

Event 7 Flag

enumerator `kSCTIMER_Event8Flag`
Event 8 Flag

enumerator `kSCTIMER_Event9Flag`
Event 9 Flag

enumerator `kSCTIMER_Event10Flag`
Event 10 Flag

enumerator `kSCTIMER_Event11Flag`
Event 11 Flag

enumerator `kSCTIMER_Event12Flag`
Event 12 Flag

enumerator `kSCTIMER_BusErrorLFlag`
Bus error due to write when L counter was not halted

enumerator `kSCTIMER_BusErrorHFlag`
Bus error due to write when H counter was not halted

typedef enum `_sctimer_pwm_mode` `sctimer_pwm_mode_t`
SCTimer PWM operation modes.

typedef enum `_sctimer_counter` `sctimer_counter_t`
SCTimer counters type.

typedef enum `_sctimer_input` `sctimer_input_t`
List of SCTimer input pins.

typedef enum `_sctimer_out` `sctimer_out_t`
List of SCTimer output pins.

typedef enum `_sctimer_pwm_level_select` `sctimer_pwm_level_select_t`
SCTimer PWM output pulse mode: high-true, low-true or no output.

typedef struct `_sctimer_pwm_signal_param` `sctimer_pwm_signal_param_t`
Options to configure a SCTimer PWM signal.

typedef enum `_sctimer_clock_mode` `sctimer_clock_mode_t`
SCTimer clock mode options.

typedef enum `_sctimer_clock_select` `sctimer_clock_select_t`
SCTimer clock select options.

typedef enum `_sctimer_conflict_resolution` `sctimer_conflict_resolution_t`
SCTimer output conflict resolution options.

Specifies what action should be taken if multiple events dictate that a given output should be both set and cleared at the same time

typedef enum `_sctimer_event_active_direction` `sctimer_event_active_direction_t`
List of SCTimer event generation active direction when the counters are operating in BIDIR mode.

typedef enum `_sctimer_event` `sctimer_event_t`
List of SCTimer event types.

typedef void (*`sctimer_event_callback_t`)(void)
SCTimer callback typedef.

typedef enum `_sctimer_interrupt_enable` `sctimer_interrupt_enable_t`
List of SCTimer interrupts.

```
typedef enum _sctimer_status_flags sctimer_status_flags_t
```

List of SCTimer flags.

```
typedef struct _sctimer_config sctimer_config_t
```

SCTimer configuration structure.

This structure holds the configuration settings for the SCTimer peripheral. To initialize this structure to reasonable defaults, call the SCTMR_GetDefaultConfig() function and pass a pointer to the configuration structure instance.

The configuration structure can be made constant so as to reside in flash.

```
SCT_EV_STATE_STATEMSK(x)
```

```
struct _sctimer_pwm_signal_param
```

#include <fsl_sctimer.h> Options to configure a SCTimer PWM signal.

Public Members

```
sctimer_out_t output
```

The output pin to use to generate the PWM signal

```
sctimer_pwm_level_select_t level
```

PWM output active level select.

```
uint8_t dutyCyclePercent
```

PWM pulse width, value should be between 0 to 100 0 = always inactive signal (0% duty cycle) 100 = always active signal (100% duty cycle).

```
struct _sctimer_config
```

#include <fsl_sctimer.h> SCTimer configuration structure.

This structure holds the configuration settings for the SCTimer peripheral. To initialize this structure to reasonable defaults, call the SCTMR_GetDefaultConfig() function and pass a pointer to the configuration structure instance.

The configuration structure can be made constant so as to reside in flash.

Public Members

```
bool enableCounterUnify
```

true: SCT operates as a unified 32-bit counter; false: SCT operates as two 16-bit counters. User can use the 16-bit low counter and the 16-bit high counters at the same time; for Hardware limit, user can not use unified 32-bit counter and any 16-bit low/high counter at the same time.

```
sctimer_clock_mode_t clockMode
```

SCT clock mode value

```
sctimer_clock_select_t clockSelect
```

SCT clock select value

```
bool enableBidirection_l
```

true: Up-down count mode for the L or unified counter false: Up count mode only for the L or unified counter

```
bool enableBidirection_h
```

true: Up-down count mode for the H or unified counter false: Up count mode only for the H or unified counter. This field is used only if the enableCounterUnify is set to false

uint8_t prescale_l

Prescale value to produce the L or unified counter clock

uint8_t prescale_h

Prescale value to produce the H counter clock. This field is used only if the enable-CounterUnify is set to false

uint8_t outInitState

Defines the initial output value

uint8_t inputsync

SCT INSYNC value, INSYNC field in the CONFIG register, from bit9 to bit 16. it is used to define synchronization for input N: bit 9 = input 0 bit 10 = input 1 bit 11 = input 2 bit 12 = input 3 All other bits are reserved (bit13 ~bit 16). How User to set the the value for the member inputsync. IE: delay for input0, and input 1, bypasses for input 2 and input 3 MACRO definition in user level. #define INPUTSYNC0 (0U) #define INPUTSYNC1 (1U) #define INPUTSYNC2 (2U) #define INPUTSYNC3 (3U) User Code. sctimerInfo.inputsync = (1 « INPUTSYNC2) | (1 « INPUTSYNC3);

2.59 SEMA42: Hardware Semaphores Driver

FSL_SEMA42_DRIVER_VERSION

SEMA42 driver version.

SEMA42 status return codes.

Values:

enumerator kStatus_SEMA42_Busy

SEMA42 gate has been locked by other processor.

enumerator kStatus_SEMA42_Reseting

SEMA42 gate reseting is ongoing.

enum __sema42_gate_status

SEMA42 gate lock status.

Values:

enumerator kSEMA42_Unlocked

The gate is unlocked.

enumerator kSEMA42_LockedByProc0

The gate is locked by processor 0.

enumerator kSEMA42_LockedByProc1

The gate is locked by processor 1.

enumerator kSEMA42_LockedByProc2

The gate is locked by processor 2.

enumerator kSEMA42_LockedByProc3

The gate is locked by processor 3.

enumerator kSEMA42_LockedByProc4

The gate is locked by processor 4.

enumerator kSEMA42_LockedByProc5

The gate is locked by processor 5.

enumerator kSEMA42_LockedByProc6

The gate is locked by processor 6.

enumerator kSEMA42_LockedByProc7

The gate is locked by processor 7.

enumerator kSEMA42_LockedByProc8

The gate is locked by processor 8.

enumerator kSEMA42_LockedByProc9

The gate is locked by processor 9.

enumerator kSEMA42_LockedByProc10

The gate is locked by processor 10.

enumerator kSEMA42_LockedByProc11

The gate is locked by processor 11.

enumerator kSEMA42_LockedByProc12

The gate is locked by processor 12.

enumerator kSEMA42_LockedByProc13

The gate is locked by processor 13.

enumerator kSEMA42_LockedByProc14

The gate is locked by processor 14.

typedef enum *_sema42_gate_status* sema42_gate_status_t

SEMA42 gate lock status.

void SEMA42_Init(SEMA42_Type *base)

Initializes the SEMA42 module.

This function initializes the SEMA42 module. It only enables the clock but does not reset the gates because the module might be used by other processors at the same time. To reset the gates, call either SEMA42_ResetGate or SEMA42_ResetAllGates function.

Parameters

- base – SEMA42 peripheral base address.

void SEMA42_Deinit(SEMA42_Type *base)

De-initializes the SEMA42 module.

This function de-initializes the SEMA42 module. It only disables the clock.

Parameters

- base – SEMA42 peripheral base address.

status_t SEMA42_TryLock(SEMA42_Type *base, uint8_t gateNum, uint8_t procNum)

Tries to lock the SEMA42 gate.

This function tries to lock the specific SEMA42 gate. If the gate has been locked by another processor, this function returns an error code.

Parameters

- base – SEMA42 peripheral base address.
- gateNum – Gate number to lock.
- procNum – Current processor number.

Return values

- kStatus_Success – Lock the sema42 gate successfully.

- `kStatus_SEMA42_Busy` – Sema42 gate has been locked by another processor.

status_t SEMA42_Lock(SEMA42_Type *base, uint8_t gateNum, uint8_t procNum)

Locks the SEMA42 gate.

This function locks the specific SEMA42 gate. If the gate has been locked by other processors, this function waits until it is unlocked and then lock it.

If SEMA42_BUSY_POLL_COUNT is defined and non-zero, the function will timeout after the specified number of polling iterations and return `kStatus_Timeout`.

Parameters

- `base` – SEMA42 peripheral base address.
- `gateNum` – Gate number to lock.
- `procNum` – Current processor number.

Return values

- `kStatus_Success` – The gate was successfully locked.
- `kStatus_Timeout` – Timeout occurred while waiting for the gate to be unlocked.

Returns

status_t

static inline void SEMA42_Unlock(SEMA42_Type *base, uint8_t gateNum)

Unlocks the SEMA42 gate.

This function unlocks the specific SEMA42 gate. It only writes unlock value to the SEMA42 gate register. However, it does not check whether the SEMA42 gate is locked by the current processor or not. As a result, if the SEMA42 gate is not locked by the current processor, this function has no effect.

Parameters

- `base` – SEMA42 peripheral base address.
- `gateNum` – Gate number to unlock.

static inline *sema42_gate_status_t* SEMA42_GetGateStatus(SEMA42_Type *base, uint8_t gateNum)

Gets the status of the SEMA42 gate.

This function checks the lock status of a specific SEMA42 gate.

Parameters

- `base` – SEMA42 peripheral base address.
- `gateNum` – Gate number.

Returns

status_t Current status.

status_t SEMA42_ResetGate(SEMA42_Type *base, uint8_t gateNum)

Resets the SEMA42 gate to an unlocked status.

This function resets a SEMA42 gate to an unlocked status.

Parameters

- `base` – SEMA42 peripheral base address.
- `gateNum` – Gate number.

Return values

- `kStatus_Success` – SEMA42 gate is reset successfully.
- `kStatus_SEMA42_Reseting` – Some other reset process is ongoing.

static inline *status_t* SEMA42_ResetAllGates(SEMA42_Type *base)

Resets all SEMA42 gates to an unlocked status.

This function resets all SEMA42 gate to an unlocked status.

Parameters

- `base` – SEMA42 peripheral base address.

Return values

- `kStatus_Success` – SEMA42 is reset successfully.
- `kStatus_SEMA42_Reseting` – Some other reset process is ongoing.

SEMA42_GATE_NUM_RESET_ALL

The number to reset all SEMA42 gates.

SEMA42_GATE_n(base, n)

SEMA42 gate *n* register address.

The SEMA42 gates are sorted in the order 3, 2, 1, 0, 7, 6, 5, 4, ... not in the order 0, 1, 2, 3, 4, 5, 6, 7, ... The macro SEMA42_GATE_n gets the SEMA42 gate based on the gate index.

The input gate index is XOR'ed with 3U: $0 \wedge 3 = 3$ $1 \wedge 3 = 2$ $2 \wedge 3 = 1$ $3 \wedge 3 = 0$ $4 \wedge 3 = 7$ $5 \wedge 3 = 6$ $6 \wedge 3 = 5$ $7 \wedge 3 = 4$...

SEMA42_BUSY_POLL_COUNT

Maximum polling iterations for SEMA42 waiting loops.

This parameter defines the maximum number of iterations for any polling loop in the SEMA42 driver code before timing out and returning an error.

It applies to all waiting loops in SEMA42 driver, such as waiting for a gate to be unlocked, waiting for a reset to complete, or waiting for a resource to become available.

This is a count of loop iterations, not a time-based value.

If defined as 0, polling loops will continue indefinitely until their exit condition is met, which could potentially cause the system to hang if hardware doesn't respond or if a resource is never released.

2.60 SPI: Serial Peripheral Interface Driver

2.61 SPI DMA Driver

status_t SPI_MasterTransferCreateHandleDMA(SPI_Type *base, *spi_dma_handle_t* *handle, *spi_dma_callback_t* callback, void *userData, *dma_handle_t* *txHandle, *dma_handle_t* *rxHandle)

Initialize the SPI master DMA handle.

This function initializes the SPI master DMA handle which can be used for other SPI master transactional APIs. Usually, for a specified SPI instance, user need only call this API once to get the initialized handle.

Parameters

- `base` – SPI peripheral base address.

- `handle` – SPI handle pointer.
- `callback` – User callback function called at the end of a transfer.
- `userData` – User data for callback.
- `txHandle` – DMA handle pointer for SPI Tx, the handle shall be static allocated by users.
- `rxHandle` – DMA handle pointer for SPI Rx, the handle shall be static allocated by users.

`status_t SPI_MasterTransferDMA(SPI_Type *base, spi_dma_handle_t *handle, spi_transfer_t *xfer)`

Perform a non-blocking SPI transfer using DMA.

Note: This interface returned immediately after transfer initiates, users should call `SPI_GetTransferStatus` to poll the transfer status to check whether SPI transfer finished.

Parameters

- `base` – SPI peripheral base address.
- `handle` – SPI DMA handle pointer.
- `xfer` – Pointer to dma transfer structure.

Return values

- `kStatus_Success` – Successfully start a transfer.
- `kStatus_InvalidArgument` – Input argument is invalid.
- `kStatus_SPI_Busy` – SPI is not idle, is running another transfer.

`status_t SPI_MasterHalfDuplexTransferDMA(SPI_Type *base, spi_dma_handle_t *handle, spi_half_duplex_transfer_t *xfer)`

Transfers a block of data using a DMA method.

This function using polling way to do the first half transimission and using DMA way to do the srcond half transimission, the transfer mechanism is half-duplex. When do the second half transimission, code will return right away. When all data is transferred, the callback function is called.

Parameters

- `base` – SPI base pointer
- `handle` – A pointer to the `spi_master_dma_handle_t` structure which stores the transfer state.
- `xfer` – A pointer to the `spi_half_duplex_transfer_t` structure.

Returns

status of `status_t`.

`static inline status_t SPI_SlaveTransferCreateHandleDMA(SPI_Type *base, spi_dma_handle_t *handle, spi_dma_callback_t callback, void *userData, dma_handle_t *txHandle, dma_handle_t *rxHandle)`

Initialize the SPI slave DMA handle.

This function initializes the SPI slave DMA handle which can be used for other SPI master transactional APIs. Usually, for a specified SPI instance, user need only call this API once to get the initialized handle.

Parameters

- base – SPI peripheral base address.
- handle – SPI handle pointer.
- callback – User callback function called at the end of a transfer.
- userData – User data for callback.
- txHandle – DMA handle pointer for SPI Tx, the handle shall be static allocated by users.
- rxHandle – DMA handle pointer for SPI Rx, the handle shall be static allocated by users.

```
static inline status_t SPI_SlaveTransferDMA(SPI_Type *base, spi_dma_handle_t *handle,  
                                           spi_transfer_t *xfer)
```

Perform a non-blocking SPI transfer using DMA.

Note: This interface returned immediately after transfer initiates, users should call SPI_GetTransferStatus to poll the transfer status to check whether SPI transfer finished.

Parameters

- base – SPI peripheral base address.
- handle – SPI DMA handle pointer.
- xfer – Pointer to dma transfer structure.

Return values

- kStatus_Success – Successfully start a transfer.
- kStatus_InvalidArgument – Input argument is invalid.
- kStatus_SPI_Busy – SPI is not idle, is running another transfer.

```
void SPI_MasterTransferAbortDMA(SPI_Type *base, spi_dma_handle_t *handle)
```

Abort a SPI transfer using DMA.

Parameters

- base – SPI peripheral base address.
- handle – SPI DMA handle pointer.

```
status_t SPI_MasterTransferGetCountDMA(SPI_Type *base, spi_dma_handle_t *handle, size_t  
                                       *count)
```

Gets the master DMA transfer remaining bytes.

This function gets the master DMA transfer remaining bytes.

Parameters

- base – SPI peripheral base address.
- handle – A pointer to the spi_dma_handle_t structure which stores the transfer state.
- count – A number of bytes transferred by the non-blocking transaction.

Returns

status of status_t.

```
static inline void SPI_SlaveTransferAbortDMA(SPI_Type *base, spi_dma_handle_t *handle)
```

Abort a SPI transfer using DMA.

Parameters

- base – SPI peripheral base address.
- handle – SPI DMA handle pointer.

```
static inline status_t SPI_SlaveTransferGetCountDMA(SPI_Type *base, spi_dma_handle_t
                                                    *handle, size_t *count)
```

Gets the slave DMA transfer remaining bytes.

This function gets the slave DMA transfer remaining bytes.

Parameters

- base – SPI peripheral base address.
- handle – A pointer to the *spi_dma_handle_t* structure which stores the transfer state.
- count – A number of bytes transferred by the non-blocking transaction.

Returns

status of *status_t*.

FSL_SPI_DMA_DRIVER_VERSION

SPI DMA driver version 2.1.1.

```
typedef struct _spi_dma_handle spi_dma_handle_t
```

```
typedef void (*spi_dma_callback_t)(SPI_Type *base, spi_dma_handle_t *handle, status_t status,
void *userData)
```

SPI DMA callback called at the end of transfer.

```
struct _spi_dma_handle
```

#include <fsl_spi_dma.h> SPI DMA transfer handle, users should not touch the content of the handle.

Public Members

volatile bool txInProgress

Send transfer finished

volatile bool rxInProgress

Receive transfer finished

uint8_t bytesPerFrame

Bytes in a frame for SPI transfer

uint8_t lastwordBytes

The Bytes of lastword for master

dma_handle_t *txHandle

DMA handler for SPI send

dma_handle_t *rxHandle

DMA handler for SPI receive

spi_dma_callback_t callback

Callback for SPI DMA transfer

void *userData

User Data for SPI DMA callback

uint32_t state

Internal state of SPI DMA transfer

`size_t` transferSize
Bytes need to be transfer

`uint32_t` instance
Index of SPI instance

`const uint8_t *txNextData`
The pointer of next time tx data

`const uint8_t *txEndData`
The pointer of end of data

`uint8_t *rxNextData`
The pointer of next time rx data

`uint8_t *rxEndData`
The pointer of end of rx data

`uint32_t` dataBytesEveryTime
Bytes in a time for DMA transfer, default is DMA_MAX_TRANSFER_COUNT

2.62 SPI Driver

`FSL_SPI_DRIVER_VERSION`

SPI driver version.

`enum _spi_xfer_option`

SPI transfer option.

Values:

`enumerator kSPI_FrameDelay`

A delay may be inserted, defined in the DLY register.

`enumerator kSPI_FrameAssert`

SSEL will be deasserted at the end of a transfer

`enum _spi_shift_direction`

SPI data shifter direction options.

Values:

`enumerator kSPI_MsbFirst`

Data transfers start with most significant bit.

`enumerator kSPI_LsbFirst`

Data transfers start with least significant bit.

`enum _spi_clock_polarity`

SPI clock polarity configuration.

Values:

`enumerator kSPI_ClockPolarityActiveHigh`

Active-high SPI clock (idles low).

`enumerator kSPI_ClockPolarityActiveLow`

Active-low SPI clock (idles high).

enum `_spi_clock_phase`

SPI clock phase configuration.

Values:

enumerator `kSPI_ClockPhaseFirstEdge`

First edge on SCK occurs at the middle of the first cycle of a data transfer.

enumerator `kSPI_ClockPhaseSecondEdge`

First edge on SCK occurs at the start of the first cycle of a data transfer.

enum `_spi_txfifo_watermark`

txFIFO watermark values

Values:

enumerator `kSPI_TxFifo0`

SPI tx watermark is empty

enumerator `kSPI_TxFifo1`

SPI tx watermark at 1 item

enumerator `kSPI_TxFifo2`

SPI tx watermark at 2 items

enumerator `kSPI_TxFifo3`

SPI tx watermark at 3 items

enumerator `kSPI_TxFifo4`

SPI tx watermark at 4 items

enumerator `kSPI_TxFifo5`

SPI tx watermark at 5 items

enumerator `kSPI_TxFifo6`

SPI tx watermark at 6 items

enumerator `kSPI_TxFifo7`

SPI tx watermark at 7 items

enum `_spi_rxfifo_watermark`

rxFIFO watermark values

Values:

enumerator `kSPI_RxFifo1`

SPI rx watermark at 1 item

enumerator `kSPI_RxFifo2`

SPI rx watermark at 2 items

enumerator `kSPI_RxFifo3`

SPI rx watermark at 3 items

enumerator `kSPI_RxFifo4`

SPI rx watermark at 4 items

enumerator `kSPI_RxFifo5`

SPI rx watermark at 5 items

enumerator `kSPI_RxFifo6`

SPI rx watermark at 6 items

enumerator kSPI_RxFifo7
SPI rx watermark at 7 items
enumerator kSPI_RxFifo8
SPI rx watermark at 8 items

enum _spi_data_width
Transfer data width.

Values:

enumerator kSPI_Data4Bits
4 bits data width
enumerator kSPI_Data5Bits
5 bits data width
enumerator kSPI_Data6Bits
6 bits data width
enumerator kSPI_Data7Bits
7 bits data width
enumerator kSPI_Data8Bits
8 bits data width
enumerator kSPI_Data9Bits
9 bits data width
enumerator kSPI_Data10Bits
10 bits data width
enumerator kSPI_Data11Bits
11 bits data width
enumerator kSPI_Data12Bits
12 bits data width
enumerator kSPI_Data13Bits
13 bits data width
enumerator kSPI_Data14Bits
14 bits data width
enumerator kSPI_Data15Bits
15 bits data width
enumerator kSPI_Data16Bits
16 bits data width

enum _spi_ssel
Slave select.

Values:

enumerator kSPI_Ssel0
Slave select 0
enumerator kSPI_Ssel1
Slave select 1
enumerator kSPI_Ssel2
Slave select 2

enumerator kSPI_Ssel3
Slave select 3

enum _spi_spol
ssel polarity

Values:

enumerator kSPI_Spol0ActiveHigh

enumerator kSPI_Spol1ActiveHigh

enumerator kSPI_Spol3ActiveHigh

enumerator kSPI_SpolActiveAllHigh

enumerator kSPI_SpolActiveAllLow

SPI transfer status.

Values:

enumerator kStatus_SPI_Busy

SPI bus is busy

enumerator kStatus_SPI_Idle

SPI is idle

enumerator kStatus_SPI_Error

SPI error

enumerator kStatus_SPI_BaudrateNotSupport

Baudrate is not support in current clock source

enumerator kStatus_SPI_Timeout

SPI timeout polling status flags.

enum _spi_interrupt_enable
SPI interrupt sources.

Values:

enumerator kSPI_RxLvlIrq

Rx level interrupt

enumerator kSPI_TxLvlIrq

Tx level interrupt

enum _spi_statusflags
SPI status flags.

Values:

enumerator kSPI_TxEmptyFlag

txFifo is empty

enumerator kSPI_TxNotFullFlag

txFifo is not full

enumerator kSPI_RxNotEmptyFlag

rxFIFO is not empty

enumerator kSPI_RxFullFlag

rxFIFO is full

`typedef enum _spi_xfer_option spi_xfer_option_t`
SPI transfer option.

`typedef enum _spi_shift_direction spi_shift_direction_t`
SPI data shifter direction options.

`typedef enum _spi_clock_polarity spi_clock_polarity_t`
SPI clock polarity configuration.

`typedef enum _spi_clock_phase spi_clock_phase_t`
SPI clock phase configuration.

`typedef enum _spi_txfifo_watermark spi_txfifo_watermark_t`
txFIFO watermark values

`typedef enum _spi_rxfifo_watermark spi_rxfifo_watermark_t`
rxFIFO watermark values

`typedef enum _spi_data_width spi_data_width_t`
Transfer data width.

`typedef enum _spi_ssel spi_ssel_t`
Slave select.

`typedef enum _spi_spol spi_spol_t`
ssel polarity

`typedef struct _spi_delay_config spi_delay_config_t`
SPI delay time configure structure. Note: The DLY register controls several programmable delays related to SPI signalling, it stands for how many SPI clock time will be inserted. The maximum value of these delay time is 15.

`typedef struct _spi_master_config spi_master_config_t`
SPI master user configure structure.

`typedef struct _spi_slave_config spi_slave_config_t`
SPI slave user configure structure.

`typedef struct _spi_transfer spi_transfer_t`
SPI transfer structure.

`typedef struct _spi_half_duplex_transfer spi_half_duplex_transfer_t`
SPI half-duplex(master only) transfer structure.

`typedef struct _spi_config spi_config_t`
Internal configuration structure used in 'spi' and 'spi_dma' driver.

`typedef struct _spi_master_handle spi_master_handle_t`
Master handle type.

`typedef spi_master_handle_t spi_slave_handle_t`
Slave handle type.

`typedef void (*spi_master_callback_t)(SPI_Type *base, spi_master_handle_t *handle, status_t status, void *userData)`
SPI master callback for finished transmit.

`typedef void (*spi_slave_callback_t)(SPI_Type *base, spi_slave_handle_t *handle, status_t status, void *userData)`
SPI slave callback for finished transmit.

```
typedef void (*flexcomm_spi_master_irq_handler_t)(SPI_Type *base, spi_master_handle_t *handle)
```

Typedef for master interrupt handler.

```
typedef void (*flexcomm_spi_slave_irq_handler_t)(SPI_Type *base, spi_slave_handle_t *handle)
```

Typedef for slave interrupt handler.

```
volatile uint8_t s_dummyData[]
```

SPI default SSEL COUNT.

Global variable for dummy data value setting.

```
SPI_DUMMYDATA
```

SPI dummy transfer data, the data is sent while txBuff is NULL.

```
SPI_RETRY_TIMES
```

Retry times for waiting flag.

```
SPI_DATA(n)
```

```
SPI_CTRLMASK
```

```
SPI_ASSERTNUM_SSEL(n)
```

```
SPI_DEASSERTNUM_SSEL(n)
```

```
SPI_DEASSERT_ALL
```

```
SPI_FIFOWR_FLAGS_MASK
```

```
SPI_FIFOTRIG_TXLVL_GET(base)
```

```
SPI_FIFOTRIG_RXLVL_GET(base)
```

```
struct __spi_delay_config
```

#include <fsl_spi.h> SPI delay time configure structure. Note: The DLY register controls several programmable delays related to SPI signalling, it stands for how many SPI clock time will be inserted. The maximum value of these delay time is 15.

Public Members

```
uint8_t preDelay
```

Delay between SSEL assertion and the beginning of transfer.

```
uint8_t postDelay
```

Delay between the end of transfer and SSEL deassertion.

```
uint8_t frameDelay
```

Delay between frame to frame.

```
uint8_t transferDelay
```

Delay between transfer to transfer.

```
struct __spi_master_config
```

#include <fsl_spi.h> SPI master user configure structure.

Public Members

```
bool enableLoopback
```

Enable loopback for test purpose

`bool enableMaster`
 Enable SPI at initialization time

`spi_clock_polarity_t polarity`
 Clock polarity

`spi_clock_phase_t phase`
 Clock phase

`spi_shift_direction_t direction`
 MSB or LSB

`uint32_t baudRate_Bps`
 Baud Rate for SPI in Hz

`spi_data_width_t dataWidth`
 Width of the data

`spi_ssel_t sselNum`
 Slave select number

`spi_spol_t sselPol`
 Configure active CS polarity

`uint8_t txWatermark`
 txFIFO watermark

`uint8_t rxWatermark`
 rxFIFO watermark

`spi_delay_config_t delayConfig`
 Delay configuration.

`struct __spi_slave_config`
 #include <fsl_spi.h> SPI slave user configure structure.

Public Members

`bool enableSlave`
 Enable SPI at initialization time

`spi_clock_polarity_t polarity`
 Clock polarity

`spi_clock_phase_t phase`
 Clock phase

`spi_shift_direction_t direction`
 MSB or LSB

`spi_data_width_t dataWidth`
 Width of the data

`spi_spol_t sselPol`
 Configure active CS polarity

`uint8_t txWatermark`
 txFIFO watermark

`uint8_t rxWatermark`
 rxFIFO watermark

`struct __spi_transfer`
 #include <fsl_spi.h> SPI transfer structure.

Public Members

const uint8_t *txData

Send buffer

uint8_t *rxData

Receive buffer

uint32_t configFlags

Additional option to control transfer, spi_xfer_option_t.

size_t dataSize

Transfer bytes

struct __spi_half_duplex_transfer

#include <fsl_spi.h> SPI half-duplex(master only) transfer structure.

Public Members

const uint8_t *txData

Send buffer

uint8_t *rxData

Receive buffer

size_t txDataSize

Transfer bytes for transmit

size_t rxDataSize

Transfer bytes

uint32_t configFlags

Transfer configuration flags, spi_xfer_option_t.

bool isPcsAssertInTransfer

If PCS pin keep assert between transmit and receive. true for assert and false for de-assert.

bool isTransmitFirst

True for transmit first and false for receive first.

struct __spi_config

#include <fsl_spi.h> Internal configuration structure used in 'spi' and 'spi_dma' driver.

struct __spi_master_handle

#include <fsl_spi.h> SPI transfer handle structure.

Public Members

const uint8_t *volatile txData

Transfer buffer

uint8_t *volatile rxData

Receive buffer

volatile size_t txRemainingBytes

Number of data to be transmitted [in bytes]

volatile size_t rxRemainingBytes

Number of data to be received [in bytes]

`volatile int8_t toReceiveCount`

The number of data expected to receive in data width. Since the received count and sent count should be the same to complete the transfer, if the sent count is x and the received count is y, toReceiveCount is x-y.

`size_t totalByteCount`

A number of transfer bytes

`volatile uint32_t state`

SPI internal state

`spi_master_callback_t callback`

SPI callback

`void *userData`

Callback parameter

`uint8_t dataWidth`

Width of the data [Valid values: 1 to 16]

`uint8_t sselNum`

Slave select number to be asserted when transferring data [Valid values: 0 to 3]

`uint32_t configFlags`

Additional option to control transfer

`uint8_t txWatermark`

txFIFO watermark

`uint8_t rxWatermark`

rxFIFO watermark

2.63 TRNG: True Random Number Generator

`FSL_TRNG_DRIVER_VERSION`

TRNG driver version 2.0.18.

Current version: 2.0.18

Change log:

- version 2.0.18
 - TRNG health checks now done in software on RT5xx and RT6xx.
- version 2.0.17
 - Added support for RT700.
- version 2.0.16
 - Added support for Dual oscillator mode.
- version 2.0.15
 - Changed `TRNG_USER_CONFIG_DEFAULT_XXX` values according to latest recommended by design team.
- version 2.0.14
 - add support for RW610 and RW612
- version 2.0.13

- After deepsleep it might return error, added clearing bits in TRNG_GetRandomData() and generating new entropy.
 - Modified reloading entropy in TRNG_GetRandomData(), for some data length it doesn't reloading entropy correctly.
- version 2.0.12
 - For KW34A4_SERIES, KW35A4_SERIES, KW36A4_SERIES set TRNG_USER_CONFIG_DEFAULT_OSC_DIV to kTRNG_RingOscDiv8.
- version 2.0.11
 - Add clearing pending errors in TRNG_Init().
- version 2.0.10
 - Fixed doxygen issues.
- version 2.0.9
 - Fix HIS_CCM metrics issues.
- version 2.0.8
 - For K32L2A41A_SERIES set TRNG_USER_CONFIG_DEFAULT_OSC_DIV to kTRNG_RingOscDiv4.
- version 2.0.7
 - Fix MISRA 2004 issue rule 12.5.
- version 2.0.6
 - For KW35Z4_SERIES set TRNG_USER_CONFIG_DEFAULT_OSC_DIV to kTRNG_RingOscDiv8.
- version 2.0.5
 - Add possibility to define default TRNG configuration by device specific preprocessor macros for FRQMIN, FRQMAX and OSCDIV.
- version 2.0.4
 - Fix MISRA-2012 issues.
- Version 2.0.3
 - update TRNG_Init to restart entropy generation
- Version 2.0.2
 - fix MISRA issues
- Version 2.0.1
 - add support for KL8x and KL28Z
 - update default OSCDIV for K81 to divide by 2

enum __trng_sample_mode

TRNG sample mode. Used by trng_config_t.

Values:

enumerator kTRNG_SampleModeVonNeumann

Use von Neumann data in both Entropy shifter and Statistical Checker.

enumerator kTRNG_SampleModeRaw

Use raw data into both Entropy shifter and Statistical Checker.

enumerator kTRNG_SampleModeVonNeumannRaw

Use von Neumann data in Entropy shifter. Use raw data into Statistical Checker.

enum _trng_clock_mode

TRNG clock mode. Used by trng_config_t.

Values:

enumerator kTRNG_ClockModeRingOscillator

Ring oscillator is used to operate the TRNG (default).

enumerator kTRNG_ClockModeSystem

System clock is used to operate the TRNG. This is for test use only, and indeterminate results may occur.

enum _trng_ring_osc_div

TRNG ring oscillator divide. Used by trng_config_t.

Values:

enumerator kTRNG_RingOscDiv0

Ring oscillator with no divide

enumerator kTRNG_RingOscDiv2

Ring oscillator divided-by-2.

enumerator kTRNG_RingOscDiv4

Ring oscillator divided-by-4.

enumerator kTRNG_RingOscDiv8

Ring oscillator divided-by-8.

typedef enum _trng_sample_mode trng_sample_mode_t

TRNG sample mode. Used by trng_config_t.

typedef enum _trng_clock_mode trng_clock_mode_t

TRNG clock mode. Used by trng_config_t.

typedef enum _trng_ring_osc_div trng_ring_osc_div_t

TRNG ring oscillator divide. Used by trng_config_t.

typedef struct _trng_statistical_check_limit trng_statistical_check_limit_t

Data structure for definition of statistical check limits. Used by trng_config_t.

typedef struct _trng_user_config trng_config_t

Data structure for the TRNG initialization.

This structure initializes the TRNG by calling the TRNG_Init() function. It contains all TRNG configurations.

status_t TRNG_GetDefaultConfig(trng_config_t *userConfig)

Initializes the user configuration structure to default values.

This function initializes the configuration structure to default values. The default values are platform dependent.

Parameters

- userConfig – User configuration structure.

Returns

If successful, returns the kStatus_TRNG_Success. Otherwise, it returns an error.

status_t TRNG_Init(TRNG_Type *base, const *trng_config_t* *userConfig)

Initializes the TRNG.

This function initializes the TRNG. When called, the TRNG entropy generation starts immediately.

Parameters

- base – TRNG base address
- userConfig – Pointer to the initialization configuration structure.

Returns

If successful, returns the *kStatus_TRNG_Success*. Otherwise, it returns an error.

void TRNG_Deinit(TRNG_Type *base)

Shuts down the TRNG.

This function shuts down the TRNG.

Parameters

- base – TRNG base address.

status_t TRNG_GetRandomData(TRNG_Type *base, void *data, *size_t* dataSize)

Gets random data.

This function gets random data from the TRNG.

Parameters

- base – TRNG base address.
- data – Pointer address used to store random data.
- dataSize – Size of the buffer pointed by the data parameter.

Returns

random data

struct *_trng_statistical_check_limit*

#include <fsl_trng.h> Data structure for definition of statistical check limits. Used by *trng_config_t*.

Public Members

uint32_t maximum

Maximum limit.

int32_t minimum

Minimum limit.

struct *_trng_user_config*

#include <fsl_trng.h> Data structure for the TRNG initialization.

This structure initializes the TRNG by calling the TRNG_Init() function. It contains all TRNG configurations.

Public Members

bool lock

Disable programmability of TRNG registers.

trng_clock_mode_t clockMode

Clock mode used to operate TRNG.

trng_ring_osc_div_t ringOscDiv

Ring oscillator divide used by TRNG.

trng_sample_mode_t sampleMode

Sample mode of the TRNG ring oscillator.

uint16_t entropyDelay

Entropy Delay. Defines the length (in system clocks) of each Entropy sample taken.

uint16_t sampleSize

Sample Size. Defines the total number of Entropy samples that will be taken during Entropy generation.

uint16_t sparseBitLimit

Sparse Bit Limit which defines the maximum number of consecutive samples that may be discarded before an error is generated. This limit is used only for during von Neumann sampling (enabled by `TRNG_HAL_SetSampleMode()`). Samples are discarded if two consecutive raw samples are both 0 or both 1. If this discarding occurs for a long period of time, it indicates that there is insufficient Entropy.

uint8_t retryCount

Retry count. It defines the number of times a statistical check may fails during the TRNG Entropy Generation before generating an error.

uint8_t longRunMaxLimit

Largest allowable number of consecutive samples of all 1, or all 0, that is allowed during the Entropy generation.

trng_statistical_check_limit_t monobitLimit

Maximum and minimum limits for statistical check of number of ones/zero detected during entropy generation.

trng_statistical_check_limit_t runBit1Limit

Maximum and minimum limits for statistical check of number of runs of length 1 detected during entropy generation.

trng_statistical_check_limit_t runBit2Limit

Maximum and minimum limits for statistical check of number of runs of length 2 detected during entropy generation.

trng_statistical_check_limit_t runBit3Limit

Maximum and minimum limits for statistical check of number of runs of length 3 detected during entropy generation.

trng_statistical_check_limit_t runBit4Limit

Maximum and minimum limits for statistical check of number of runs of length 4 detected during entropy generation.

trng_statistical_check_limit_t runBit5Limit

Maximum and minimum limits for statistical check of number of runs of length 5 detected during entropy generation.

trng_statistical_check_limit_t runBit6PlusLimit

Maximum and minimum limits for statistical check of number of runs of length 6 or more detected during entropy generation.

trng_statistical_check_limit_t pokerLimit

Maximum and minimum limits for statistical check of “Poker Test”.

trng_statistical_check_limit_t frequencyCountLimit

Maximum and minimum limits for statistical check of entropy sample frequency count.

2.64 USART: Universal Synchronous/Asynchronous Receiver/Transmitter Driver

2.65 USART DMA Driver

status_t USART_TransferCreateHandleDMA(USART_Type *base, *usart_dma_handle_t* *handle, *usart_dma_transfer_callback_t* callback, void *userData, *dma_handle_t* *txDmaHandle, *dma_handle_t* *rxDmaHandle)

Initializes the USART handle which is used in transactional functions.

Parameters

- base – USART peripheral base address.
- handle – Pointer to *usart_dma_handle_t* structure.
- callback – Callback function.
- userData – User data.
- txDmaHandle – User-requested DMA handle for TX DMA transfer.
- rxDmaHandle – User-requested DMA handle for RX DMA transfer.

status_t USART_TransferSendDMA(USART_Type *base, *usart_dma_handle_t* *handle, *usart_transfer_t* *xfer)

Sends data using DMA.

This function sends data using DMA. This is a non-blocking function, which returns right away. When all data is sent, the send callback function is called.

Parameters

- base – USART peripheral base address.
- handle – USART handle pointer.
- xfer – USART DMA transfer structure. See *usart_transfer_t*.

Return values

- kStatus_Success – if succeed, others failed.
- kStatus_USART_TxBusy – Previous transfer on going.
- kStatus_InvalidArgument – Invalid argument.

status_t USART_TransferReceiveDMA(USART_Type *base, *usart_dma_handle_t* *handle, *usart_transfer_t* *xfer)

Receives data using DMA.

This function receives data using DMA. This is a non-blocking function, which returns right away. When all data is received, the receive callback function is called.

Parameters

- base – USART peripheral base address.
- handle – Pointer to *usart_dma_handle_t* structure.

- `xfer` – USART DMA transfer structure. See `usart_transfer_t`.

Return values

- `kStatus_Success` – if succeed, others failed.
- `kStatus_USART_RxBusy` – Previous transfer on going.
- `kStatus_InvalidArgument` – Invalid argument.

`void USART_TransferAbortSendDMA(USART_Type *base, usart_dma_handle_t *handle)`

Aborts the sent data using DMA.

This function aborts send data using DMA.

Parameters

- `base` – USART peripheral base address
- `handle` – Pointer to `usart_dma_handle_t` structure

`void USART_TransferAbortReceiveDMA(USART_Type *base, usart_dma_handle_t *handle)`

Aborts the received data using DMA.

This function aborts the received data using DMA.

Parameters

- `base` – USART peripheral base address
- `handle` – Pointer to `usart_dma_handle_t` structure

`status_t USART_TransferGetReceiveCountDMA(USART_Type *base, usart_dma_handle_t *handle, uint32_t *count)`

Get the number of bytes that have been received.

This function gets the number of bytes that have been received.

Parameters

- `base` – USART peripheral base address.
- `handle` – USART handle pointer.
- `count` – Receive bytes count.

Return values

- `kStatus_NoTransferInProgress` – No receive in progress.
- `kStatus_InvalidArgument` – Parameter is invalid.
- `kStatus_Success` – Get successfully through the parameter `count`;

`status_t USART_TransferGetSendCountDMA(USART_Type *base, usart_dma_handle_t *handle, uint32_t *count)`

Get the number of bytes that have been sent.

This function gets the number of bytes that have been sent.

Parameters

- `base` – USART peripheral base address.
- `handle` – USART handle pointer.
- `count` – Sent bytes count.

Return values

- `kStatus_NoTransferInProgress` – No receive in progress.
- `kStatus_InvalidArgument` – Parameter is invalid.

- `kStatus_Success` – Get successfully through the parameter count;

`FSL_USART_DMA_DRIVER_VERSION`

USART dma driver version.

`typedef struct _usart_dma_handle usart_dma_handle_t`

`typedef void (*usart_dma_transfer_callback_t)(USART_Type *base, usart_dma_handle_t *handle, status_t status, void *userData)`

UART transfer callback function.

`struct _usart_dma_handle`

`#include <fsl_usart_dma.h>` UART DMA handle.

Public Members

`USART_Type *base`

UART peripheral base address.

`usart_dma_transfer_callback_t` callback

Callback function.

`void *userData`

UART callback function parameter.

`size_t rxDataSizeAll`

Size of the data to receive.

`size_t txDataSizeAll`

Size of the data to send out.

`dma_handle_t *txDmaHandle`

The DMA TX channel used.

`dma_handle_t *rxDmaHandle`

The DMA RX channel used.

`volatile uint8_t txState`

TX transfer state.

`volatile uint8_t rxState`

RX transfer state

2.66 USART Driver

`status_t USART_Init(USART_Type *base, const usart_config_t *config, uint32_t srcClock_Hz)`

Initializes a USART instance with user configuration structure and peripheral clock.

This function configures the USART module with the user-defined settings. The user can configure the configuration structure and also get the default configuration by using the `USART_GetDefaultConfig()` function. Example below shows how to use this API to configure USART.

```
usart_config_t usartConfig;
usartConfig.baudRate_Bps = 115200U;
usartConfig.parityMode = kUSART_ParityDisabled;
usartConfig.stopBitCount = kUSART_OneStopBit;
USART_Init(USART1, &usartConfig, 20000000U);
```

Parameters

- base – USART peripheral base address.
- config – Pointer to user-defined configuration structure.
- srcClock_Hz – USART clock source frequency in HZ.

Return values

- kStatus_USART_BaudrateNotSupport – Baudrate is not support in current clock source.
- kStatus_InvalidArgument – USART base address is not valid
- kStatus_Success – Status USART initialize succeed

void USART_Deinit(USART_Type *base)

Deinitializes a USART instance.

This function waits for TX complete, disables TX and RX, and disables the USART clock.

Parameters

- base – USART peripheral base address.

void USART_GetDefaultConfig(usart_config_t *config)

Gets the default configuration structure.

This function initializes the USART configuration structure to a default value. The default values are: usartConfig->baudRate_Bps = 115200U; usartConfig->parityMode = kUSART_ParityDisabled; usartConfig->stopBitCount = kUSART_OneStopBit; usartConfig->bitCountPerChar = kUSART_8BitsPerChar; usartConfig->loopback = false; usartConfig->enableTx = false; usartConfig->enableRx = false;

Parameters

- config – Pointer to configuration structure.

status_t USART_SetBaudRate(USART_Type *base, uint32_t baudrate_Bps, uint32_t srcClock_Hz)

Sets the USART instance baud rate.

This function configures the USART module baud rate. This function is used to update the USART module baud rate after the USART module is initialized by the USART_Init.

```
USART_SetBaudRate(USART1, 115200U, 20000000U);
```

Parameters

- base – USART peripheral base address.
- baudrate_Bps – USART baudrate to be set.
- srcClock_Hz – USART clock source frequency in HZ.

Return values

- kStatus_USART_BaudrateNotSupport – Baudrate is not support in current clock source.
- kStatus_Success – Set baudrate succeed.
- kStatus_InvalidArgument – One or more arguments are invalid.

status_t USART_Enable32kMode(USART_Type *base, uint32_t baudRate_Bps, bool enableMode32k, uint32_t srcClock_Hz)

Enable 32 kHz mode which USART uses clock from the RTC oscillator as the clock source.

Please note that in order to use a 32 kHz clock to operate USART properly, the RTC oscillator and its 32 kHz output must be manually enabled by user, by calling RTC_Init and setting

SYSCON_RTCCSCCTRL_EN bit to 1. And in 32kHz clocking mode the USART can only work at 9600 baudrate or at the baudrate that 9600 can evenly divide, eg: 4800, 3200.

Parameters

- base – USART peripheral base address.
- baudRate_Bps – USART baudrate to be set..
- enableMode32k – true is 32k mode, false is normal mode.
- srcClock_Hz – USART clock source frequency in HZ.

Return values

- kStatus_USART_BaudrateNotSupport – Baudrate is not support in current clock source.
- kStatus_Success – Set baudrate succeed.
- kStatus_InvalidArgument – One or more arguments are invalid.

void USART_Enable9bitMode(USART_Type *base, bool enable)

Enable 9-bit data mode for USART.

This function set the 9-bit mode for USART module. The 9th bit is not used for parity thus can be modified by user.

Parameters

- base – USART peripheral base address.
- enable – true to enable, false to disable.

static inline void USART_SetMatchAddress(USART_Type *base, uint8_t address)

Set the USART slave address.

This function configures the address for USART module that works as slave in 9-bit data mode. When the address detection is enabled, the frame it receives with MSB being 1 is considered as an address frame, otherwise it is considered as data frame. Once the address frame matches slave's own addresses, this slave is addressed. This address frame and its following data frames are stored in the receive buffer, otherwise the frames will be discarded. To un-address a slave, just send an address frame with unmatched address.

Note: Any USART instance joined in the multi-slave system can work as slave. The position of the address mark is the same as the parity bit when parity is enabled for 8 bit and 9 bit data formats.

Parameters

- base – USART peripheral base address.
- address – USART slave address.

static inline void USART_EnableMatchAddress(USART_Type *base, bool match)

Enable the USART match address feature.

Parameters

- base – USART peripheral base address.
- match – true to enable match address, false to disable.

```
static inline uint32_t USART_GetStatusFlags(USART_Type *base)
```

Get USART status flags.

This function get all USART status flags, the flags are returned as the logical OR value of the enumerators `_usart_flags`. To check a specific status, compare the return value with enumerators in `_usart_flags`. For example, to check whether the TX is empty:

```
if (kUSART_TxFifoNotFullFlag & USART_GetStatusFlags(USART1))
{
    ...
}
```

Parameters

- `base` – USART peripheral base address.

Returns

USART status flags which are ORed by the enumerators in the `_usart_flags`.

```
static inline void USART_ClearStatusFlags(USART_Type *base, uint32_t mask)
```

Clear USART status flags.

This function clear supported USART status flags. The mask is a logical OR of enumeration members. See `kUSART_AllClearFlags`. For example:

```
USART_ClearStatusFlags(USART1, kUSART_TxError | kUSART_RxError)
```

Parameters

- `base` – USART peripheral base address.
- `mask` – status flags to be cleared.

```
static inline void USART_EnableInterrupts(USART_Type *base, uint32_t mask)
```

Enables USART interrupts according to the provided mask.

This function enables the USART interrupts according to the provided mask. The mask is a logical OR of enumeration members. See `_usart_interrupt_enable`. For example, to enable TX empty interrupt and RX full interrupt:

```
USART_EnableInterrupts(USART1, kUSART_TxLevelInterruptEnable | kUSART_
↳ RxLevelInterruptEnable);
```

Parameters

- `base` – USART peripheral base address.
- `mask` – The interrupts to enable. Logical OR of `_usart_interrupt_enable`.

```
static inline void USART_DisableInterrupts(USART_Type *base, uint32_t mask)
```

Disables USART interrupts according to a provided mask.

This function disables the USART interrupts according to a provided mask. The mask is a logical OR of enumeration members. See `_usart_interrupt_enable`. This example shows how to disable the TX empty interrupt and RX full interrupt:

```
USART_DisableInterrupts(USART1, kUSART_TxLevelInterruptEnable | kUSART_
↳ RxLevelInterruptEnable);
```

Parameters

- `base` – USART peripheral base address.
- `mask` – The interrupts to disable. Logical OR of `_usart_interrupt_enable`.

static inline uint32_t USART_GetEnabledInterrupts(USART_Type *base)

Returns enabled USART interrupts.

This function returns the enabled USART interrupts.

Parameters

- base – USART peripheral base address.

static inline void USART_EnableTxDMA(USART_Type *base, bool enable)

Enable DMA for Tx.

static inline void USART_EnableRxDMA(USART_Type *base, bool enable)

Enable DMA for Rx.

static inline void USART_EnableCTS(USART_Type *base, bool enable)

Enable CTS. This function will determine whether CTS is used for flow control.

Parameters

- base – USART peripheral base address.
- enable – Enable CTS or not, true for enable and false for disable.

static inline void USART_EnableContinuousSCLK(USART_Type *base, bool enable)

Continuous Clock generation. By default, SCLK is only output while data is being transmitted in synchronous mode. Enable this function, SCLK will run continuously in synchronous mode, allowing characters to be received on Un_RxD independently from transmission on Un_TXD).

Parameters

- base – USART peripheral base address.
- enable – Enable Continuous Clock generation mode or not, true for enable and false for disable.

static inline void USART_EnableAutoClearSCLK(USART_Type *base, bool enable)

Enable Continuous Clock generation bit auto clear. While enable this function, the Continuous Clock bit is automatically cleared when a complete character has been received. This bit is cleared at the same time.

Parameters

- base – USART peripheral base address.
- enable – Enable auto clear or not, true for enable and false for disable.

static inline void USART_SetRxFifoWatermark(USART_Type *base, uint8_t water)

Sets the rx FIFO watermark.

Parameters

- base – USART peripheral base address.
- water – Rx FIFO watermark.

static inline void USART_SetTxFifoWatermark(USART_Type *base, uint8_t water)

Sets the tx FIFO watermark.

Parameters

- base – USART peripheral base address.
- water – Tx FIFO watermark.

static inline void USART_WriteByte(USART_Type *base, uint8_t data)

Writes to the FIFOWR register.

This function writes data to the txFIFO directly. The upper layer must ensure that txFIFO has space for data to write before calling this function.

Parameters

- base – USART peripheral base address.
- data – The byte to write.

static inline uint8_t USART_ReadByte(USART_Type *base)

Reads the FIFORD register directly.

This function reads data from the rxFIFO directly. The upper layer must ensure that the rxFIFO is not empty before calling this function.

Parameters

- base – USART peripheral base address.

Returns

The byte read from USART data register.

static inline uint8_t USART_GetRxFifoCount(USART_Type *base)

Gets the rx FIFO data count.

Parameters

- base – USART peripheral base address.

Returns

rx FIFO data count.

static inline uint8_t USART_GetTxFifoCount(USART_Type *base)

Gets the tx FIFO data count.

Parameters

- base – USART peripheral base address.

Returns

tx FIFO data count.

void USART_SendAddress(USART_Type *base, uint8_t address)

Transmit an address frame in 9-bit data mode.

Parameters

- base – USART peripheral base address.
- address – USART slave address.

status_t USART_WriteBlocking(USART_Type *base, const uint8_t *data, size_t length)

Writes to the TX register using a blocking method.

This function polls the TX register, waits for the TX register to be empty or for the TX FIFO to have room and writes data to the TX buffer.

Parameters

- base – USART peripheral base address.
- data – Start address of the data to write.
- length – Size of the data to write.

Return values

- kStatus_USART_Timeout – Transmission timed out and was aborted.

- `kStatus_InvalidArgument` – Invalid argument.
- `kStatus_Success` – Successfully wrote all data.

`status_t` USART_ReadBlocking(USART_Type *base, uint8_t *data, size_t length)

Read RX data register using a blocking method.

This function polls the RX register, waits for the RX register to be full or for RX FIFO to have data and read data from the TX register.

Parameters

- `base` – USART peripheral base address.
- `data` – Start address of the buffer to store the received data.
- `length` – Size of the buffer.

Return values

- `kStatus_USART_FramingError` – Receiver overrun happened while receiving data.
- `kStatus_USART_ParityError` – Noise error happened while receiving data.
- `kStatus_USART_NoiseError` – Framing error happened while receiving data.
- `kStatus_USART_RxError` – Overflow or underflow rxFIFO happened.
- `kStatus_USART_Timeout` – Transmission timed out and was aborted.
- `kStatus_Success` – Successfully received all data.

`status_t` USART_TransferCreateHandle(USART_Type *base, usart_handle_t *handle, usart_transfer_callback_t callback, void *userData)

Initializes the USART handle.

This function initializes the USART handle which can be used for other USART transactional APIs. Usually, for a specified USART instance, call this API once to get the initialized handle.

Parameters

- `base` – USART peripheral base address.
- `handle` – USART handle pointer.
- `callback` – The callback function.
- `userData` – The parameter of the callback function.

`status_t` USART_TransferSendNonBlocking(USART_Type *base, usart_handle_t *handle, usart_transfer_t *xfer)

Transmits a buffer of data using the interrupt method.

This function sends data using an interrupt method. This is a non-blocking function, which returns directly without waiting for all data to be written to the TX register. When all data is written to the TX register in the IRQ handler, the USART driver calls the callback function and passes the `kStatus_USART_TxIdle` as status parameter.

Parameters

- `base` – USART peripheral base address.
- `handle` – USART handle pointer.
- `xfer` – USART transfer structure. See `usart_transfer_t`.

Return values

- `kStatus_Success` – Successfully start the data transmission.

- `kStatus_USART_TxBusy` – Previous transmission still not finished, data not all written to TX register yet.
- `kStatus_InvalidArgument` – Invalid argument.

```
void USART__TransferStartRingBuffer(USART_Type *base, usart_handle_t *handle, uint8_t  
                                   *ringBuffer, size_t ringBufferSize)
```

Sets up the RX ring buffer.

This function sets up the RX ring buffer to a specific USART handle.

When the RX ring buffer is used, data received are stored into the ring buffer even when the user doesn't call the `USART_TransferReceiveNonBlocking()` API. If there is already data received in the ring buffer, the user can get the received data from the ring buffer directly.

Note: When using the RX ring buffer, one byte is reserved for internal use. In other words, if `ringBufferSize` is 32, then only 31 bytes are used for saving data.

Parameters

- `base` – USART peripheral base address.
- `handle` – USART handle pointer.
- `ringBuffer` – Start address of the ring buffer for background receiving. Pass `NULL` to disable the ring buffer.
- `ringBufferSize` – size of the ring buffer.

```
void USART__TransferStopRingBuffer(USART_Type *base, usart_handle_t *handle)
```

Aborts the background transfer and uninstalls the ring buffer.

This function aborts the background transfer and uninstalls the ring buffer.

Parameters

- `base` – USART peripheral base address.
- `handle` – USART handle pointer.

```
size_t USART__TransferGetRxRingBufferLength(usart_handle_t *handle)
```

Get the length of received data in RX ring buffer.

Parameters

- `handle` – USART handle pointer.

Returns

Length of received data in RX ring buffer.

```
void USART__TransferAbortSend(USART_Type *base, usart_handle_t *handle)
```

Aborts the interrupt-driven data transmit.

This function aborts the interrupt driven data sending. The user can get the `remainBytes` to find out how many bytes are still not sent out.

Parameters

- `base` – USART peripheral base address.
- `handle` – USART handle pointer.

```
status_t USART__TransferGetSendCount(USART_Type *base, usart_handle_t *handle, uint32_t  
                                     *count)
```

Get the number of bytes that have been sent out to bus.

This function gets the number of bytes that have been sent out to bus by interrupt method.

Parameters

- base – USART peripheral base address.
- handle – USART handle pointer.
- count – Send bytes count.

Return values

- kStatus_NoTransferInProgress – No send in progress.
- kStatus_InvalidArgument – Parameter is invalid.
- kStatus_Success – Get successfully through the parameter count;

status_t USART_TransferReceiveNonBlocking(USART_Type *base, *usart_handle_t* *handle, *usart_transfer_t* *xfer, *size_t* *receivedBytes)

Receives a buffer of data using an interrupt method.

This function receives data using an interrupt method. This is a non-blocking function, which returns without waiting for all data to be received. If the RX ring buffer is used and not empty, the data in the ring buffer is copied and the parameter `receivedBytes` shows how many bytes are copied from the ring buffer. After copying, if the data in the ring buffer is not enough to read, the receive request is saved by the USART driver. When the new data arrives, the receive request is serviced first. When all data is received, the USART driver notifies the upper layer through a callback function and passes the status parameter `kStatus_USART_RxIdle`. For example, the upper layer needs 10 bytes but there are only 5 bytes in the ring buffer. The 5 bytes are copied to the `xfer->data` and this function returns with the parameter `receivedBytes` set to 5. For the left 5 bytes, newly arrived data is saved from the `xfer->data[5]`. When 5 bytes are received, the USART driver notifies the upper layer. If the RX ring buffer is not enabled, this function enables the RX and RX interrupt to receive data to the `xfer->data`. When all data is received, the upper layer is notified.

Parameters

- base – USART peripheral base address.
- handle – USART handle pointer.
- xfer – USART transfer structure, see `usart_transfer_t`.
- receivedBytes – Bytes received from the ring buffer directly.

Return values

- kStatus_Success – Successfully queue the transfer into transmit queue.
- kStatus_USART_RxBusy – Previous receive request is not finished.
- kStatus_InvalidArgument – Invalid argument.

void USART_TransferAbortReceive(USART_Type *base, *usart_handle_t* *handle)

Aborts the interrupt-driven data receiving.

This function aborts the interrupt-driven data receiving. The user can get the `remainBytes` to find out how many bytes not received yet.

Parameters

- base – USART peripheral base address.
- handle – USART handle pointer.

status_t USART_TransferGetReceiveCount(USART_Type *base, *usart_handle_t* *handle, *uint32_t* *count)

Get the number of bytes that have been received.

This function gets the number of bytes that have been received.

Parameters

- base – USART peripheral base address.
- handle – USART handle pointer.
- count – Receive bytes count.

Return values

- kStatus_NoTransferInProgress – No receive in progress.
- kStatus_InvalidArgument – Parameter is invalid.
- kStatus_Success – Get successfully through the parameter count;

void USART_TransferHandleIRQ(USART_Type *base, usart_handle_t *handle)
USART IRQ handle function.

This function handles the USART transmit and receive IRQ request.

Parameters

- base – USART peripheral base address.
- handle – USART handle pointer.

FSL_USART_DRIVER_VERSION
USART driver version.

Error codes for the USART driver.

Values:

enumerator kStatus_USART_TxBusy
Transmitter is busy.

enumerator kStatus_USART_RxBusy
Receiver is busy.

enumerator kStatus_USART_TxIdle
USART transmitter is idle.

enumerator kStatus_USART_RxIdle
USART receiver is idle.

enumerator kStatus_USART_TxError
Error happens on txFIFO.

enumerator kStatus_USART_RxError
Error happens on rxFIFO.

enumerator kStatus_USART_RxRingBufferOverrun
Error happens on rx ring buffer

enumerator kStatus_USART_NoiseError
USART noise error.

enumerator kStatus_USART_FramingError
USART framing error.

enumerator kStatus_USART_ParityError
USART parity error.

enumerator kStatus_USART_BaudrateNotSupport
Baudrate is not support in current clock source

enum `_usart_sync_mode`

USART synchronous mode.

Values:

enumerator `kUSART_SyncModeDisabled`

Asynchronous mode.

enumerator `kUSART_SyncModeSlave`

Synchronous slave mode.

enumerator `kUSART_SyncModeMaster`

Synchronous master mode.

enum `_usart_parity_mode`

USART parity mode.

Values:

enumerator `kUSART_ParityDisabled`

Parity disabled

enumerator `kUSART_ParityEven`

Parity enabled, type even, bit setting: PE|PT = 10

enumerator `kUSART_ParityOdd`

Parity enabled, type odd, bit setting: PE|PT = 11

enum `_usart_stop_bit_count`

USART stop bit count.

Values:

enumerator `kUSART_OneStopBit`

One stop bit

enumerator `kUSART_TwoStopBit`

Two stop bits

enum `_usart_data_len`

USART data size.

Values:

enumerator `kUSART_7BitsPerChar`

Seven bit mode

enumerator `kUSART_8BitsPerChar`

Eight bit mode

enum `_usart_clock_polarity`

USART clock polarity configuration, used in sync mode.

Values:

enumerator `kUSART_RxSampleOnFallingEdge`

Un_RXD is sampled on the falling edge of SCLK.

enumerator `kUSART_RxSampleOnRisingEdge`

Un_RXD is sampled on the rising edge of SCLK.

enum `_usart_txfifo_watermark`

txFIFO watermark values

Values:

enumerator kUSART_TxFifo0
 USART tx watermark is empty

enumerator kUSART_TxFifo1
 USART tx watermark at 1 item

enumerator kUSART_TxFifo2
 USART tx watermark at 2 items

enumerator kUSART_TxFifo3
 USART tx watermark at 3 items

enumerator kUSART_TxFifo4
 USART tx watermark at 4 items

enumerator kUSART_TxFifo5
 USART tx watermark at 5 items

enumerator kUSART_TxFifo6
 USART tx watermark at 6 items

enumerator kUSART_TxFifo7
 USART tx watermark at 7 items

enum _usart_rxfifo_watermark
 rxFIFO watermark values

Values:

enumerator kUSART_RxFifo1
 USART rx watermark at 1 item

enumerator kUSART_RxFifo2
 USART rx watermark at 2 items

enumerator kUSART_RxFifo3
 USART rx watermark at 3 items

enumerator kUSART_RxFifo4
 USART rx watermark at 4 items

enumerator kUSART_RxFifo5
 USART rx watermark at 5 items

enumerator kUSART_RxFifo6
 USART rx watermark at 6 items

enumerator kUSART_RxFifo7
 USART rx watermark at 7 items

enumerator kUSART_RxFifo8
 USART rx watermark at 8 items

enum _usart_interrupt_enable
 USART interrupt configuration structure, default settings all disabled.

Values:

enumerator kUSART_TxErrorInterruptEnable

enumerator kUSART_RxErrorInterruptEnable

enumerator kUSART_TxLevelInterruptEnable

enumerator kUSART_RxLevelInterruptEnable

enumerator kUSART_TxIdleInterruptEnable
Transmitter idle.

enumerator kUSART_CtsChangeInterruptEnable
Change in the state of the CTS input.

enumerator kUSART_RxBreakChangeInterruptEnable
Break condition asserted or deasserted.

enumerator kUSART_RxStartInterruptEnable
Rx start bit detected.

enumerator kUSART_FramingErrorInterruptEnable
Framing error detected.

enumerator kUSART_ParityErrorInterruptEnable
Parity error detected.

enumerator kUSART_NoiseErrorInterruptEnable
Noise error detected.

enumerator kUSART_AutoBaudErrorInterruptEnable
Auto baudrate error detected.

enumerator kUSART_AllInterruptEnables

enum _usart_flags

USART status flags.

This provides constants for the USART status flags for use in the USART functions.

Values:

enumerator kUSART_TxError
TXERR bit, sets if TX buffer is error

enumerator kUSART_RxError
RXERR bit, sets if RX buffer is error

enumerator kUSART_TxFifoEmptyFlag
TXEMPTY bit, sets if TX buffer is empty

enumerator kUSART_TxFifoNotFullFlag
TXNOTFULL bit, sets if TX buffer is not full

enumerator kUSART_RxFifoNotEmptyFlag
RXNOEMPTY bit, sets if RX buffer is not empty

enumerator kUSART_RxFifoFullFlag
RXFULL bit, sets if RX buffer is full

enumerator kUSART_RxIdleFlag
Receiver idle.

enumerator kUSART_TxIdleFlag
Transmitter idle.

enumerator kUSART_CtsAssertFlag
CTS signal high.

enumerator kUSART_CtsChangeFlag
CTS signal changed interrupt status.

enumerator `kUSART_BreakDetectFlag`
Break detected. Self cleared when rx pin goes high again.

enumerator `kUSART_BreakDetectChangeFlag`
Break detect change interrupt flag. A change in the state of receiver break detection.

enumerator `kUSART_RxStartFlag`
Rx start bit detected interrupt flag.

enumerator `kUSART_FramingErrorFlag`
Framing error interrupt flag.

enumerator `kUSART_ParityErrorFlag`
parity error interrupt flag.

enumerator `kUSART_NoiseErrorFlag`
Noise error interrupt flag.

enumerator `kUSART_AutobaudErrorFlag`
Auto baudrate error interrupt flag, caused by the baudrate counter timeout before the end of start bit.

enumerator `kUSART_AllClearFlags`

typedef enum `_usart_sync_mode` `usart_sync_mode_t`
USART synchronous mode.

typedef enum `_usart_parity_mode` `usart_parity_mode_t`
USART parity mode.

typedef enum `_usart_stop_bit_count` `usart_stop_bit_count_t`
USART stop bit count.

typedef enum `_usart_data_len` `usart_data_len_t`
USART data size.

typedef enum `_usart_clock_polarity` `usart_clock_polarity_t`
USART clock polarity configuration, used in sync mode.

typedef enum `_usart_txfifo_watermark` `usart_txfifo_watermark_t`
txFIFO watermark values

typedef enum `_usart_rxfifo_watermark` `usart_rxfifo_watermark_t`
rxFIFO watermark values

typedef struct `_usart_config` `usart_config_t`
USART configuration structure.

typedef struct `_usart_transfer` `usart_transfer_t`
USART transfer structure.

typedef struct `_usart_handle` `usart_handle_t`

typedef void (*`usart_transfer_callback_t`)(`USART_Type` *`base`, `usart_handle_t` *`handle`, `status_t` `status`, void *`userData`)
USART transfer callback function.

typedef void (*`flexcomm_usart_irq_handler_t`)(`USART_Type` *`base`, `usart_handle_t` *`handle`)
Typedef for usart interrupt handler.

uint32_t `USART_GetInstance(USART_Type *base)`
Returns instance number for USART peripheral base address.

USART_FIFOTRIG_TXLVL_GET(base)

USART_FIFOTRIG_RXLVL_GET(base)

UART_RETRY_TIMES

Retry times for waiting flag.

Defining to zero means to keep waiting for the flag until it is assert/deassert in blocking transfer, otherwise the program will wait until the UART_RETRY_TIMES counts down to 0, if the flag still remains unchanged then program will return kStatus_USART_Timeout. It is not advised to use this macro in formal application to prevent any hardware error because the actual wait period is affected by the compiler and optimization.

struct _usart_config

#include <fsl_usart.h> USART configuration structure.

Public Members

uint32_t baudRate_Bps

USART baud rate

usart_parity_mode_t parityMode

Parity mode, disabled (default), even, odd

usart_stop_bit_count_t stopBitCount

Number of stop bits, 1 stop bit (default) or 2 stop bits

usart_data_len_t bitCountPerChar

Data length - 7 bit, 8 bit

bool loopback

Enable peripheral loopback

bool enableRx

Enable RX

bool enableTx

Enable TX

bool enableContinuousSCLK

USART continuous Clock generation enable in synchronous master mode.

bool enableMode32k

USART uses 32 kHz clock from the RTC oscillator as the clock source.

bool enableHardwareFlowControl

Enable hardware control RTS/CTS

usart_txfifo_watermark_t txWatermark

txFIFO watermark

usart_rxfifo_watermark_t rxWatermark

rxFIFO watermark

usart_sync_mode_t syncMode

Transfer mode select - asynchronous, synchronous master, synchronous slave.

usart_clock_polarity_t clockPolarity

Selects the clock polarity and sampling edge in synchronous mode.

struct _usart_transfer

#include <fsl_usart.h> USART transfer structure.

Public Members

size_t dataSize

The byte count to be transfer.

struct __usart_handle

#include <fsl_usart.h> USART handle structure.

Public Members

const uint8_t *volatile txData

Address of remaining data to send.

volatile size_t txDataSize

Size of the remaining data to send.

size_t txDataSizeAll

Size of the data to send out.

uint8_t *volatile rxData

Address of remaining data to receive.

volatile size_t rxDataSize

Size of the remaining data to receive.

size_t rxDataSizeAll

Size of the data to receive.

uint8_t *rxRingBuffer

Start address of the receiver ring buffer.

size_t rxRingBufferSize

Size of the ring buffer.

volatile uint16_t rxRingBufferHead

Index for the driver to store received data into ring buffer.

volatile uint16_t rxRingBufferTail

Index for the user to get data from the ring buffer.

usart_transfer_callback_t callback

Callback function.

void *userData

USART callback function parameter.

volatile uint8_t txState

TX transfer state.

volatile uint8_t rxState

RX transfer state

uint8_t txWatermark

txFIFO watermark

uint8_t rxWatermark

rxFIFO watermark

union __unnamed61__

Public Members

uint8_t *data

The buffer of data to be transfer.

uint8_t *rxData

The buffer to receive data.

const uint8_t *txData

The buffer of data to be sent.

2.67 USDHC: Ultra Secured Digital Host Controller Driver

void USDHC_Init(USDHC_Type *base, const *usdhc_config_t* *config)

USDHC module initialization function.

Configures the USDHC according to the user configuration.

Example:

```
usdhc_config_t config;
config.cardDetectDat3 = false;
config.endianMode = kUSDHC_EndianModeLittle;
config.dmaMode = kUSDHC_DmaModeAdma2;
config.readWatermarkLevel = 128U;
config.writeWatermarkLevel = 128U;
USDHC_Init(USDHC, &config);
```

Parameters

- base – USDHC peripheral base address.
- config – USDHC configuration information.

Return values

kStatus_Success – Operate successfully.

void USDHC_Deinit(USDHC_Type *base)

Deinitializes the USDHC.

Parameters

- base – USDHC peripheral base address.

bool USDHC_Reset(USDHC_Type *base, uint32_t mask, uint32_t timeout)

Resets the USDHC.

Parameters

- base – USDHC peripheral base address.
- mask – The reset type mask(*_usdhc_reset*).
- timeout – Timeout for reset.

Return values

- true – Reset successfully.
- false – Reset failed.

status_t USDHC_SetAdmaTableConfig(USDHC_Type *base, *usdhc_adma_config_t* *dmaConfig, *usdhc_data_t* *dataConfig, uint32_t flags)

Sets the DMA descriptor table configuration. A high level DMA descriptor configuration function.

Parameters

- base – USDHC peripheral base address.
- dmaConfig – ADMA configuration
- dataConfig – Data descriptor
- flags – ADAM descriptor flag, used to indicate to create multiple or single descriptor, please refer to enum _usdhc_adma_flag.

Return values

- kStatus_OutOfRange – ADMA descriptor table length isn't enough to describe data.
- kStatus_Success – Operate successfully.

status_t USDHC_SetInternalDmaConfig(USDHC_Type *base, *usdhc_adma_config_t* *dmaConfig, const uint32_t *dataAddr, bool enAutoCmd23)

Internal DMA configuration. This function is used to config the USDHC DMA related registers.

Parameters

- base – USDHC peripheral base address.
- dmaConfig – ADMA configuration.
- dataAddr – Transfer data address, a simple DMA parameter, if ADMA is used, leave it to NULL.
- enAutoCmd23 – Flag to indicate Auto CMD23 is enable or not, a simple DMA parameter, if ADMA is used, leave it to false.

Return values

- kStatus_OutOfRange – ADMA descriptor table length isn't enough to describe data.
- kStatus_Success – Operate successfully.

status_t USDHC_SetADMA2Descriptor(uint32_t *admaTable, uint32_t admaTableWords, const uint32_t *dataBufferAddr, uint32_t dataBytes, uint32_t flags)

Sets the ADMA2 descriptor table configuration.

Parameters

- admaTable – ADMA table address.
- admaTableWords – ADMA table length.
- dataBufferAddr – Data buffer address.
- dataBytes – Data Data length.
- flags – ADAM descriptor flag, used to indicate to create multiple or single descriptor, please refer to enum _usdhc_adma_flag.

Return values

- kStatus_OutOfRange – ADMA descriptor table length isn't enough to describe data.
- kStatus_Success – Operate successfully.

status_t USDHC_SetADMA1Descriptor(uint32_t *admaTable, uint32_t admaTableWords, const uint32_t *dataBufferAddr, uint32_t dataBytes, uint32_t flags)

Sets the ADMA1 descriptor table configuration.

Parameters

- `admaTable` – ADMA table address.
- `admaTableWords` – ADMA table length.
- `dataBufferAddr` – Data buffer address.
- `dataBytes` – Data length.
- `flags` – ADAM descriptor flag, used to indicate to create multiple or single descriptor, please refer to enum `_usdhc_adma_flag`.

Return values

- `kStatus_OutOfRange` – ADMA descriptor table length isn't enough to describe data.
- `kStatus_Success` – Operate successfully.

`static inline void USDHC_EnableInternalDMA(USDHC_Type *base, bool enable)`

Enables internal DMA.

Parameters

- `base` – USDHC peripheral base address.
- `enable` – enable or disable flag

`static inline void USDHC_EnableInterruptStatus(USDHC_Type *base, uint32_t mask)`

Enables the interrupt status.

Parameters

- `base` – USDHC peripheral base address.
- `mask` – Interrupt status flags mask(`_usdhc_interrupt_status_flag`).

`static inline void USDHC_DisableInterruptStatus(USDHC_Type *base, uint32_t mask)`

Disables the interrupt status.

Parameters

- `base` – USDHC peripheral base address.
- `mask` – The interrupt status flags mask(`_usdhc_interrupt_status_flag`).

`static inline void USDHC_EnableInterruptSignal(USDHC_Type *base, uint32_t mask)`

Enables the interrupt signal corresponding to the interrupt status flag.

Parameters

- `base` – USDHC peripheral base address.
- `mask` – The interrupt status flags mask(`_usdhc_interrupt_status_flag`).

`static inline void USDHC_DisableInterruptSignal(USDHC_Type *base, uint32_t mask)`

Disables the interrupt signal corresponding to the interrupt status flag.

Parameters

- `base` – USDHC peripheral base address.
- `mask` – The interrupt status flags mask(`_usdhc_interrupt_status_flag`).

`static inline uint32_t USDHC_GetEnabledInterruptStatusFlags(USDHC_Type *base)`

Gets the enabled interrupt status.

Parameters

- `base` – USDHC peripheral base address.

Returns

Current interrupt status flags mask(_usdhc_interrupt_status_flag).

```
static inline uint32_t USDHC_GetInterruptStatusFlags(USDHC_Type *base)
```

Gets the current interrupt status.

Parameters

- base – USDHC peripheral base address.

Returns

Current interrupt status flags mask(_usdhc_interrupt_status_flag).

```
static inline void USDHC_ClearInterruptStatusFlags(USDHC_Type *base, uint32_t mask)
```

Clears a specified interrupt status. write 1 clears.

Parameters

- base – USDHC peripheral base address.
- mask – The interrupt status flags mask(_usdhc_interrupt_status_flag).

```
static inline uint32_t USDHC_GetAutoCommand12ErrorStatusFlags(USDHC_Type *base)
```

Gets the status of auto command 12 error.

Parameters

- base – USDHC peripheral base address.

Returns

Auto command 12 error status flags mask(_usdhc_auto_command12_error_status_flag).

```
static inline uint32_t USDHC_GetAdmaErrorStatusFlags(USDHC_Type *base)
```

Gets the status of the ADMA error.

Parameters

- base – USDHC peripheral base address.

Returns

ADMA error status flags mask(_usdhc_adma_error_status_flag).

```
static inline uint32_t USDHC_GetPresentStatusFlags(USDHC_Type *base)
```

Gets a present status.

This function gets the present USDHC's status except for an interrupt status and an error status.

Parameters

- base – USDHC peripheral base address.

Returns

Present USDHC's status flags mask(_usdhc_present_status_flag).

```
void USDHC_GetCapability(USDHC_Type *base, usdhc_capability_t *capability)
```

Gets the capability information.

Parameters

- base – USDHC peripheral base address.
- capability – Structure to save capability information.

```
static inline void USDHC_ForceClockOn(USDHC_Type *base, bool enable)
```

Forces the card clock on.

Parameters

- base – USDHC peripheral base address.

- enable – enable/disable flag

uint32_t USDHC_SetSdClock(USDHC_Type *base, uint32_t srcClock_Hz, uint32_t busClock_Hz)

Sets the SD bus clock frequency.

Parameters

- base – USDHC peripheral base address.
- srcClock_Hz – USDHC source clock frequency united in Hz.
- busClock_Hz – SD bus clock frequency united in Hz.

Returns

The nearest frequency of busClock_Hz configured for SD bus.

bool USDHC_SetCardActive(USDHC_Type *base, uint32_t timeout)

Sends 80 clocks to the card to set it to the active state.

This function must be called each time the card is inserted to ensure that the card can receive the command correctly.

Parameters

- base – USDHC peripheral base address.
- timeout – Timeout to initialize card.

Return values

- true – Set card active successfully.
- false – Set card active failed.

static inline void USDHC_AssertHardwareReset(USDHC_Type *base, bool high)

Triggers a hardware reset.

Parameters

- base – USDHC peripheral base address.
- high – 1 or 0 level

static inline void USDHC_SetDataBusWidth(USDHC_Type *base, *usdhc_data_bus_width_t* width)

Sets the data transfer width.

Parameters

- base – USDHC peripheral base address.
- width – Data transfer width.

static inline void USDHC_WriteData(USDHC_Type *base, uint32_t data)

Fills the data port.

This function is used to implement the data transfer by Data Port instead of DMA.

Parameters

- base – USDHC peripheral base address.
- data – The data about to be sent.

static inline uint32_t USDHC_ReadData(USDHC_Type *base)

Retrieves the data from the data port.

This function is used to implement the data transfer by Data Port instead of DMA.

Parameters

- base – USDHC peripheral base address.

Returns

The data has been read.

void USDHC_SendCommand(USDHC_Type *base, *usdhc_command_t* *command)

Sends command function.

Parameters

- base – USDHC peripheral base address.
- command – configuration

static inline void USDHC_EnableWakeupEvent(USDHC_Type *base, uint32_t mask, bool enable)

Enables or disables a wakeup event in low-power mode.

Parameters

- base – USDHC peripheral base address.
- mask – Wakeup events mask(*_usdhc_wakeup_event*).
- enable – True to enable, false to disable.

static inline void USDHC_CardDetectByData3(USDHC_Type *base, bool enable)

Detects card insert status.

Parameters

- base – USDHC peripheral base address.
- enable – enable/disable flag

static inline bool USDHC_DetectCardInsert(USDHC_Type *base)

Detects card insert status.

Parameters

- base – USDHC peripheral base address.

static inline void USDHC_EnableSdioControl(USDHC_Type *base, uint32_t mask, bool enable)

Enables or disables the SDIO card control.

Parameters

- base – USDHC peripheral base address.
- mask – SDIO card control flags mask(*_usdhc_sdio_control_flag*).
- enable – True to enable, false to disable.

static inline void USDHC_SetContinueRequest(USDHC_Type *base)

Restarts a transaction which has stopped at the block GAP for the SDIO card.

Parameters

- base – USDHC peripheral base address.

static inline void USDHC_RequestStopAtBlockGap(USDHC_Type *base, bool enable)

Request stop at block gap function.

Parameters

- base – USDHC peripheral base address.
- enable – True to stop at block gap, false to normal transfer.

void USDHC_SetMmcBootConfig(USDHC_Type *base, const *usdhc_boot_config_t* *config)

Configures the MMC boot feature.

Example:

```
usdhc_boot_config_t config;
config.ackTimeoutCount = 4;
config.bootMode = kUSDHC_BootModeNormal;
config.blockCount = 5;
config.enableBootAck = true;
config.enableBoot = true;
config.enableAutoStopAtBlockGap = true;
USDHC_SetMmcBootConfig(USDHC, &config);
```

Parameters

- base – USDHC peripheral base address.
- config – The MMC boot configuration information.

static inline void USDHC_EnableMmcBoot(USDHC_Type *base, bool enable)

Enables or disables the mmc boot mode.

Parameters

- base – USDHC peripheral base address.
- enable – True to enable, false to disable.

static inline void USDHC_SetForceEvent(USDHC_Type *base, uint32_t mask)

Forces generating events according to the given mask.

Parameters

- base – USDHC peripheral base address.
- mask – The force events bit position (_usdhc_force_event).

static inline bool USDHC_RequestTuningForSDR50(USDHC_Type *base)

Checks the SDR50 mode request tuning bit. When this bit set, application shall perform tuning for SDR50 mode.

Parameters

- base – USDHC peripheral base address.

static inline bool USDHC_RequestReTuning(USDHC_Type *base)

Checks the request re-tuning bit. When this bit is set, user should do manual tuning or standard tuning function.

Parameters

- base – USDHC peripheral base address.

static inline void USDHC_EnableAutoTuning(USDHC_Type *base, bool enable)

The SDR104 mode auto tuning enable and disable. This function should be called after tuning function execute pass, auto tuning will handle by hardware.

Parameters

- base – USDHC peripheral base address.
- enable – enable/disable flag

void USDHC_EnableAutoTuningForCmdAndData(USDHC_Type *base)

The auto tuning enable for CMD/DATA line.

Parameters

- base – USDHC peripheral base address.

`void USDHC_EnableManualTuning(USDHC_Type *base, bool enable)`

Manual tuning trigger or abort. User should handle the tuning cmd and find the boundary of the delay then calculate a average value which will be configured to the **CLK_TUNE_CTRL_STATUS**. This function should be called before function **USDHC_AdjustDelayForManualTuning**.

Parameters

- base – USDHC peripheral base address.
- enable – tuning enable flag

`static inline uint32_t USDHC_GetTuningDelayStatus(USDHC_Type *base)`

Get the tuning delay cell setting.

Parameters

- base – USDHC peripheral base address.

Return values

CLK – Tuning Control and Status register value.

`status_t USDHC_SetTuningDelay(USDHC_Type *base, uint32_t preDelay, uint32_t outDelay, uint32_t postDelay)`

The tuning delay cell setting.

Parameters

- base – USDHC peripheral base address.
- preDelay – Set the number of delay cells on the feedback clock between the feedback clock and CLK_PRE.
- outDelay – Set the number of delay cells on the feedback clock between CLK_PRE and CLK_OUT.
- postDelay – Set the number of delay cells on the feedback clock between CLK_OUT and CLK_POST.

Return values

- kStatus_Fail – config the delay setting fail
- kStatus_Success – config the delay setting success

`status_t USDHC_AdjustDelayForManualTuning(USDHC_Type *base, uint32_t delay)`

Adjusts delay for manual tuning.

Deprecated:

Do not use this function. It has been superseded by **USDHC_SetTuningDelay**

Parameters

- base – USDHC peripheral base address.
- delay – setting configuration

Return values

- kStatus_Fail – config the delay setting fail
- kStatus_Success – config the delay setting success

`static inline void USDHC_SetStandardTuningCounter(USDHC_Type *base, uint8_t counter)`

set tuning counter tuning.

Parameters

- base – USDHC peripheral base address.
- counter – tuning counter

Return values

- kStatus_Fail – config the delay setting fail
- kStatus_Success – config the delay setting success

void USDHC__EnableStandardTuning(USDHC_Type *base, uint32_t tuningStartTap, uint32_t step, bool enable)

The enable standard tuning function. The standard tuning window and tuning counter using the default config tuning cmd is sent by the software, user need to check whether the tuning result can be used for SDR50, SDR104, and HS200 mode tuning.

Parameters

- base – USDHC peripheral base address.
- tuningStartTap – start tap
- step – tuning step
- enable – enable/disable flag

static inline uint32_t USDHC__GetExecuteStdTuningStatus(USDHC_Type *base)

Gets execute STD tuning status.

Parameters

- base – USDHC peripheral base address.

static inline uint32_t USDHC__CheckStdTuningResult(USDHC_Type *base)

Checks STD tuning result.

Parameters

- base – USDHC peripheral base address.

static inline uint32_t USDHC__CheckTuningError(USDHC_Type *base)

Checks tuning error.

Parameters

- base – USDHC peripheral base address.

void USDHC__EnableDDRMode(USDHC_Type *base, bool enable, uint32_t nibblePos)

The enable/disable DDR mode.

Parameters

- base – USDHC peripheral base address.
- enable – enable/disable flag
- nibblePos – nibble position

static inline void USDHC__EnableHS400Mode(USDHC_Type *base, bool enable)

The enable/disable HS400 mode.

Parameters

- base – USDHC peripheral base address.
- enable – enable/disable flag

static inline void USDHC__ResetStrobeDLL(USDHC_Type *base)

Resets the strobe DLL.

Parameters

- base – USDHC peripheral base address.

static inline void USDHC_EnableStrobeDLL(USDHC_Type *base, bool enable)

Enables/disables the strobe DLL.

Parameters

- base – USDHC peripheral base address.
- enable – enable/disable flag

void USDHC_ConfigStrobeDLL(USDHC_Type *base, uint32_t delayTarget, uint32_t updateInterval)

Configs the strobe DLL delay target and update interval.

Parameters

- base – USDHC peripheral base address.
- delayTarget – delay target
- updateInterval – update interval

static inline void USDHC_SetStrobeDllOverride(USDHC_Type *base, uint32_t delayTaps)

Enables manual override for slave delay chain using **STROBE_SLV_OVERRIDE_VAL**.

Parameters

- base – USDHC peripheral base address.
- delayTaps – Valid delay taps range from 1 - 128 taps. A value of 0 selects tap 1, and a value of 0x7F selects tap 128.

static inline uint32_t USDHC_GetStrobeDLLStatus(USDHC_Type *base)

Gets the strobe DLL status.

Parameters

- base – USDHC peripheral base address.

void USDHC_SetDataConfig(USDHC_Type *base, *usdhc_transfer_direction_t* dataDirection, uint32_t blockCount, uint32_t blockSize)

USDHC data configuration.

Parameters

- base – USDHC peripheral base address.
- dataDirection – Data direction, tx or rx.
- blockCount – Data block count.
- blockSize – Data block size.

void USDHC_TransferCreateHandle(USDHC_Type *base, *usdhc_handle_t* *handle, const *usdhc_transfer_callback_t* *callback, void *userData)

Creates the USDHC handle.

Parameters

- base – USDHC peripheral base address.
- handle – USDHC handle pointer.
- callback – Structure pointer to contain all callback functions.
- userData – Callback function parameter.

```
status_t USDHC_TransferNonBlocking(USDHC_Type *base, usdhc_handle_t *handle,  
                                   usdhc_adma_config_t *dmaConfig, usdhc_transfer_t  
                                   *transfer)
```

Transfers the command/data using an interrupt and an asynchronous method.

This function sends a command and data and returns immediately. It doesn't wait for the transfer to complete or to encounter an error. The application must not call this API in multiple threads at the same time. Because of that this API doesn't support the re-entry mechanism.

Note: Call API USDHC_TransferCreateHandle when calling this API.

Parameters

- base – USDHC peripheral base address.
- handle – USDHC handle.
- dmaConfig – ADMA configuration.
- transfer – Transfer content.

Return values

- kStatus_InvalidArgument – Argument is invalid.
- kStatus_USDHC_BusyTransferring – Busy transferring.
- kStatus_USDHC_PrepareAdmaDescriptorFailed – Prepare ADMA descriptor failed.
- kStatus_Success – Operate successfully.

```
status_t USDHC_TransferBlocking(USDHC_Type *base, usdhc_adma_config_t *dmaConfig,  
                                usdhc_transfer_t *transfer)
```

Transfers the command/data using a blocking method.

This function waits until the command response/data is received or the USDHC encounters an error by polling the status flag.

The application must not call this API in multiple threads at the same time. Because this API doesn't support the re-entry mechanism.

Note: There is no need to call API USDHC_TransferCreateHandle when calling this API.

Parameters

- base – USDHC peripheral base address.
- dmaConfig – adma configuration
- transfer – Transfer content.

Return values

- kStatus_InvalidArgument – Argument is invalid.
- kStatus_USDHC_PrepareAdmaDescriptorFailed – Prepare ADMA descriptor failed.
- kStatus_USDHC_SendCommandFailed – Send command failed.
- kStatus_USDHC_TransferDataFailed – Transfer data failed.

- kStatus_Success – Operate successfully.

void USDHC_TransferHandleIRQ(USDHC_Type *base, *usdhc_handle_t* *handle)
IRQ handler for the USDHC.

This function deals with the IRQs on the given host controller.

Parameters

- base – USDHC peripheral base address.
- handle – USDHC handle.

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Enum_usdhc_status. USDHC status.

Values:

enumerator kStatus_USDHC_BusyTransferring

Transfer is on-going.

enumerator kStatus_USDHC_PrepareAdmaDescriptorFailed

Set DMA descriptor failed.

enumerator kStatus_USDHC_SendCommandFailed

Send command failed.

enumerator kStatus_USDHC_TransferDataFailed

Transfer data failed.

enumerator kStatus_USDHC_DMADDataAddrNotAlign

Data address not aligned.

enumerator kStatus_USDHC_ReTuningRequest

Re-tuning request.

enumerator kStatus_USDHC_TuningError

Tuning error.

enumerator kStatus_USDHC_NotSupport

Not support.

enumerator kStatus_USDHC_TransferDataComplete

Transfer data complete.

enumerator kStatus_USDHC_SendCommandSuccess

Transfer command complete.

enumerator kStatus_USDHC_TransferDMAComplete

Transfer DMA complete.

Enum_usdhc_capability_flag. Host controller capabilities flag mask. .

Values:

enumerator kUSDHC_SupportAdmaFlag

Support ADMA.

enumerator kUSDHC_SupportHighSpeedFlag

Support high-speed.

enumerator kUSDHC_SupportDmaFlag
Support DMA.

enumerator kUSDHC_SupportSuspendResumeFlag
Support suspend/resume.

enumerator kUSDHC_SupportV330Flag
Support voltage 3.3V.

enumerator kUSDHC_SupportV300Flag
Support voltage 3.0V.

enumerator kUSDHC_Support4BitFlag
Flag in HTCAPBLT_MBL's position, supporting 4-bit mode.

enumerator kUSDHC_Support8BitFlag
Flag in HTCAPBLT_MBL's position, supporting 8-bit mode.

enumerator kUSDHC_SupportDDR50Flag
SD version 3.0 new feature, supporting DDR50 mode.

enumerator kUSDHC_SupportSDR104Flag
Support SDR104 mode.

enumerator kUSDHC_SupportSDR50Flag
Support SDR50 mode.

Enum _usdhc_wakeup_event. Wakeup event mask. .

Values:

enumerator kUSDHC_WakeupEventOnCardInt
Wakeup on card interrupt.

enumerator kUSDHC_WakeupEventOnCardInsert
Wakeup on card insertion.

enumerator kUSDHC_WakeupEventOnCardRemove
Wakeup on card removal.

enumerator kUSDHC_WakeupEventsAll
All wakeup events

Enum _usdhc_reset. Reset type mask. .

Values:

enumerator kUSDHC_ResetAll
Reset all except card detection.

enumerator kUSDHC_ResetCommand
Reset command line.

enumerator kUSDHC_ResetData
Reset data line.

enumerator kUSDHC_ResetTuning
Reset tuning circuit.

enumerator kUSDHC_ResetsAll
All reset types

Enum _usdhc_transfer_flag. Transfer flag mask.

Values:

enumerator kUSDHC_EnableDmaFlag

Enable DMA.

enumerator kUSDHC_CommandTypeSuspendFlag

Suspend command.

enumerator kUSDHC_CommandTypeResumeFlag

Resume command.

enumerator kUSDHC_CommandTypeAbortFlag

Abort command.

enumerator kUSDHC_EnableBlockCountFlag

Enable block count.

enumerator kUSDHC_EnableAutoCommand12Flag

Enable auto CMD12.

enumerator kUSDHC_DataReadFlag

Enable data read.

enumerator kUSDHC_MultipleBlockFlag

Multiple block data read/write.

enumerator kUSDHC_EnableAutoCommand23Flag

Enable auto CMD23.

enumerator kUSDHC_ResponseLength136Flag

136-bit response length.

enumerator kUSDHC_ResponseLength48Flag

48-bit response length.

enumerator kUSDHC_ResponseLength48BusyFlag

48-bit response length with busy status.

enumerator kUSDHC_EnableCrcCheckFlag

Enable CRC check.

enumerator kUSDHC_EnableIndexCheckFlag

Enable index check.

enumerator kUSDHC_DataPresentFlag

Data present flag.

Enum _usdhc_present_status_flag. Present status flag mask. .

Values:

enumerator kUSDHC_CommandInhibitFlag

Command inhibit.

enumerator kUSDHC_DataInhibitFlag

Data inhibit.

enumerator kUSDHC_DataLineActiveFlag

Data line active.

enumerator kUSDHC_SdClockStableFlag
SD bus clock stable.

enumerator kUSDHC_WriteTransferActiveFlag
Write transfer active.

enumerator kUSDHC_ReadTransferActiveFlag
Read transfer active.

enumerator kUSDHC_BufferWriteEnableFlag
Buffer write enable.

enumerator kUSDHC_BufferReadEnableFlag
Buffer read enable.

enumerator kUSDHC_ReTuningRequestFlag
Re-tuning request flag, only used for SDR104 mode.

enumerator kUSDHC_DelaySettingFinishedFlag
Delay setting finished flag.

enumerator kUSDHC_CardInsertedFlag
Card inserted.

enumerator kUSDHC_CommandLineLevelFlag
Command line signal level.

enumerator kUSDHC_Data0LineLevelFlag
Data0 line signal level.

enumerator kUSDHC_Data1LineLevelFlag
Data1 line signal level.

enumerator kUSDHC_Data2LineLevelFlag
Data2 line signal level.

enumerator kUSDHC_Data3LineLevelFlag
Data3 line signal level.

enumerator kUSDHC_Data4LineLevelFlag
Data4 line signal level.

enumerator kUSDHC_Data5LineLevelFlag
Data5 line signal level.

enumerator kUSDHC_Data6LineLevelFlag
Data6 line signal level.

enumerator kUSDHC_Data7LineLevelFlag
Data7 line signal level.

Enum _usdhc_interrupt_status_flag. Interrupt status flag mask. .
Values:

enumerator kUSDHC_CommandCompleteFlag
Command complete.

enumerator kUSDHC_DataCompleteFlag
Data complete.

enumerator kUSDHC_BlockGapEventFlag
Block gap event.

enumerator kUSDHC_DmaCompleteFlag
DMA interrupt.

enumerator kUSDHC_BufferWriteReadyFlag
Buffer write ready.

enumerator kUSDHC_BufferReadReadyFlag
Buffer read ready.

enumerator kUSDHC_CardInsertionFlag
Card inserted.

enumerator kUSDHC_CardRemovalFlag
Card removed.

enumerator kUSDHC_CardInterruptFlag
Card interrupt.

enumerator kUSDHC_ReTuningEventFlag
Re-Tuning event, only for SD3.0 SDR104 mode.

enumerator kUSDHC_TuningPassFlag
SDR104 mode tuning pass flag.

enumerator kUSDHC_TuningErrorFlag
SDR104 tuning error flag.

enumerator kUSDHC_CommandTimeoutFlag
Command timeout error.

enumerator kUSDHC_CommandCrcErrorFlag
Command CRC error.

enumerator kUSDHC_CommandEndBitErrorFlag
Command end bit error.

enumerator kUSDHC_CommandIndexErrorFlag
Command index error.

enumerator kUSDHC_DataTimeoutFlag
Data timeout error.

enumerator kUSDHC_DataCrcErrorFlag
Data CRC error.

enumerator kUSDHC_DataEndBitErrorFlag
Data end bit error.

enumerator kUSDHC_AutoCommand12ErrorFlag
Auto CMD12 error.

enumerator kUSDHC_DmaErrorFlag
DMA error.

enumerator kUSDHC_CommandErrorFlag
Command error

enumerator kUSDHC_DataErrorFlag
Data error

enumerator kUSDHC_ErrorFlag

All error

enumerator kUSDHC_DataFlag

Data interrupts

enumerator kUSDHC_DataDMAFlag

Data interrupts

enumerator kUSDHC_CommandFlag

Command interrupts

enumerator kUSDHC_CardDetectFlag

Card detection interrupts

enumerator kUSDHC_SDR104TuningFlag

SDR104 tuning flag.

enumerator kUSDHC_AllInterruptFlags

All flags mask

Enum _usdhc_auto_command12_error_status_flag. Auto CMD12 error status flag mask. .

Values:

enumerator kUSDHC_AutoCommand12NotExecutedFlag

Not executed error.

enumerator kUSDHC_AutoCommand12TimeoutFlag

Timeout error.

enumerator kUSDHC_AutoCommand12EndBitErrorFlag

End bit error.

enumerator kUSDHC_AutoCommand12CrcErrorFlag

CRC error.

enumerator kUSDHC_AutoCommand12IndexErrorFlag

Index error.

enumerator kUSDHC_AutoCommand12NotIssuedFlag

Not issued error.

Enum _usdhc_standard_tuning. Standard tuning flag.

Values:

enumerator kUSDHC_ExecuteTuning

Used to start tuning procedure.

enumerator kUSDHC_TuningSampleClockSel

When **std_tuning_en** bit is set, this bit is used to select sampling clock.

Enum _usdhc_adma_error_status_flag. ADMA error status flag mask. .

Values:

enumerator kUSDHC_AdmaLenghMismatchFlag

Length mismatch error.

enumerator kUSDHC_AdmaDescriptorErrorFlag
Descriptor error.

Enum _usdhc_adma_error_state. ADMA error state.

This state is the detail state when ADMA error has occurred.

Values:

enumerator kUSDHC_AdmaErrorStateStopDma
Stop DMA, previous location set in the ADMA system address is errored address.

enumerator kUSDHC_AdmaErrorStateFetchDescriptor
Fetch descriptor, current location set in the ADMA system address is errored address.

enumerator kUSDHC_AdmaErrorStateChangeAddress
Change address, no DMA error has occurred.

enumerator kUSDHC_AdmaErrorStateTransferData
Transfer data, previous location set in the ADMA system address is errored address.

enumerator kUSDHC_AdmaErrorStateInvalidLength
Invalid length in ADMA descriptor.

enumerator kUSDHC_AdmaErrorStateInvalidDescriptor
Invalid descriptor fetched by ADMA.

enumerator kUSDHC_AdmaErrorState
ADMA error state

Enum _usdhc_force_event. Force event bit position. .

Values:

enumerator kUSDHC_ForceEventAutoCommand12NotExecuted
Auto CMD12 not executed error.

enumerator kUSDHC_ForceEventAutoCommand12Timeout
Auto CMD12 timeout error.

enumerator kUSDHC_ForceEventAutoCommand12CrcError
Auto CMD12 CRC error.

enumerator kUSDHC_ForceEventEndBitError
Auto CMD12 end bit error.

enumerator kUSDHC_ForceEventAutoCommand12IndexError
Auto CMD12 index error.

enumerator kUSDHC_ForceEventAutoCommand12NotIssued
Auto CMD12 not issued error.

enumerator kUSDHC_ForceEventCommandTimeout
Command timeout error.

enumerator kUSDHC_ForceEventCommandCrcError
Command CRC error.

enumerator kUSDHC_ForceEventCommandEndBitError
Command end bit error.

enumerator kUSDHC_ForceEventCommandIndexError
Command index error.

enumerator kUSDHC_ForceEventDataTimeout
Data timeout error.

enumerator kUSDHC_ForceEventDataCrcError
Data CRC error.

enumerator kUSDHC_ForceEventDataEndBitError
Data end bit error.

enumerator kUSDHC_ForceEventAutoCommand12Error
Auto CMD12 error.

enumerator kUSDHC_ForceEventCardInt
Card interrupt.

enumerator kUSDHC_ForceEventDmaError
Dma error.

enumerator kUSDHC_ForceEventTuningError
Tuning error.

enumerator kUSDHC_ForceEventsAll
All force event flags mask.

enum __usdhc_transfer_direction
Data transfer direction.

Values:

enumerator kUSDHC_TransferDirectionReceive
USDHC transfer direction receive.

enumerator kUSDHC_TransferDirectionSend
USDHC transfer direction send.

enum __usdhc_data_bus_width
Data transfer width.

Values:

enumerator kUSDHC_DataBusWidth1Bit
1-bit mode

enumerator kUSDHC_DataBusWidth4Bit
4-bit mode

enumerator kUSDHC_DataBusWidth8Bit
8-bit mode

enum __usdhc_endian_mode
Endian mode.

Values:

enumerator kUSDHC_EndianModeBig
Big endian mode.

enumerator kUSDHC_EndianModeHalfWordBig
Half word big endian mode.

enumerator kUSDHC_EndianModeLittle
Little endian mode.

enum __usdhc_dma_mode
DMA mode.

Values:

enumerator kUSDHC_DmaModeSimple
External DMA.

enumerator kUSDHC_DmaModeAdma1
ADMA1 is selected.

enumerator kUSDHC_DmaModeAdma2
ADMA2 is selected.

enumerator kUSDHC_ExternalDMA
External DMA mode selected.

Enum __usdhc_sdio_control_flag. SDIO control flag mask. .

Values:

enumerator kUSDHC_StopAtBlockGapFlag
Stop at block gap.

enumerator kUSDHC_ReadWaitControlFlag
Read wait control.

enumerator kUSDHC_InterruptAtBlockGapFlag
Interrupt at block gap.

enumerator kUSDHC_ReadDoneNo8CLK
Read done without 8 clk for block gap.

enumerator kUSDHC_ExactBlockNumberReadFlag
Exact block number read.

enum __usdhc_boot_mode
MMC card boot mode.

Values:

enumerator kUSDHC_BootModeNormal
Normal boot

enumerator kUSDHC_BootModeAlternative
Alternative boot

enum __usdhc_card_command_type
The command type.

Values:

enumerator kCARD_CommandTypeNormal
Normal command

enumerator kCARD_CommandTypeSuspend
Suspend command

enumerator kCARD_CommandTypeResume
Resume command

enumerator kCARD_CommandTypeAbort
Abort command

enumerator kCARD_CommandTypeEmpty
Empty command

enum __usdhc_card_response_type

The command response type.

Defines the command response type from card to host controller.

Values:

enumerator kCARD_ResponseTypeNone
Response type: none

enumerator kCARD_ResponseTypeR1
Response type: R1

enumerator kCARD_ResponseTypeR1b
Response type: R1b

enumerator kCARD_ResponseTypeR2
Response type: R2

enumerator kCARD_ResponseTypeR3
Response type: R3

enumerator kCARD_ResponseTypeR4
Response type: R4

enumerator kCARD_ResponseTypeR5
Response type: R5

enumerator kCARD_ResponseTypeR5b
Response type: R5b

enumerator kCARD_ResponseTypeR6
Response type: R6

enumerator kCARD_ResponseTypeR7
Response type: R7

Enum __usdhc_adma1_descriptor_flag. The mask for the control/status field in ADMA1 descriptor.

Values:

enumerator kUSDHC_Adma1DescriptorValidFlag
Valid flag.

enumerator kUSDHC_Adma1DescriptorEndFlag
End flag.

enumerator kUSDHC_Adma1DescriptorInterruptFlag
Interrupt flag.

enumerator kUSDHC_Adma1DescriptorActivity1Flag
Activity 1 flag.

enumerator kUSDHC_Adma1DescriptorActivity2Flag
Activity 2 flag.

enumerator kUSDHC_Adma1DescriptorTypeNop

No operation.

enumerator kUSDHC_Adma1DescriptorTypeTransfer

Transfer data.

enumerator kUSDHC_Adma1DescriptorTypeLink

Link descriptor.

enumerator kUSDHC_Adma1DescriptorTypeSetLength

Set data length.

Enum _usdhc_adma2_descriptor_flag. ADMA1 descriptor control and status mask.

Values:

enumerator kUSDHC_Adma2DescriptorValidFlag

Valid flag.

enumerator kUSDHC_Adma2DescriptorEndFlag

End flag.

enumerator kUSDHC_Adma2DescriptorInterruptFlag

Interrupt flag.

enumerator kUSDHC_Adma2DescriptorActivity1Flag

Activity 1 mask.

enumerator kUSDHC_Adma2DescriptorActivity2Flag

Activity 2 mask.

enumerator kUSDHC_Adma2DescriptorTypeNop

No operation.

enumerator kUSDHC_Adma2DescriptorTypeReserved

Reserved.

enumerator kUSDHC_Adma2DescriptorTypeTransfer

Transfer type.

enumerator kUSDHC_Adma2DescriptorTypeLink

Link type.

Enum _usdhc_adma_flag. ADMA descriptor configuration flag. .

Values:

enumerator kUSDHC_AdmaDescriptorSingleFlag

Try to finish the transfer in a single ADMA descriptor. If transfer size is bigger than one ADMA descriptor's ability, new another descriptor for data transfer.

enumerator kUSDHC_AdmaDescriptorMultipleFlag

Create multiple ADMA descriptors within the ADMA table, this is used for mmc boot mode specifically, which need to modify the ADMA descriptor on the fly, so the flag should be used combining with stop at block gap feature.

enum _usdhc_burst_len

DMA transfer burst len config.

Values:

enumerator `kUSDHC_EnBurstLenForINCR`

Enable burst len for INCR.

enumerator `kUSDHC_EnBurstLenForINCR4816`

Enable burst len for INCR4/INCR8/INCR16.

enumerator `kUSDHC_EnBurstLenForINCR4816WRAP`

Enable burst len for INCR4/8/16 WRAP.

Enum `_usdhc_transfer_data_type`. Transfer data type definition.

Values:

enumerator `kUSDHC_TransferDataNormal`

Transfer normal read/write data.

enumerator `kUSDHC_TransferDataTuning`

Transfer tuning data.

enumerator `kUSDHC_TransferDataBoot`

Transfer boot data.

enumerator `kUSDHC_TransferDataBootcontinuous`

Transfer boot data continuously.

typedef enum `_usdhc_transfer_direction` `usdhc_transfer_direction_t`

Data transfer direction.

typedef enum `_usdhc_data_bus_width` `usdhc_data_bus_width_t`

Data transfer width.

typedef enum `_usdhc_endian_mode` `usdhc_endian_mode_t`

Endian mode.

typedef enum `_usdhc_dma_mode` `usdhc_dma_mode_t`

DMA mode.

typedef enum `_usdhc_boot_mode` `usdhc_boot_mode_t`

MMC card boot mode.

typedef enum `_usdhc_card_command_type` `usdhc_card_command_type_t`

The command type.

typedef enum `_usdhc_card_response_type` `usdhc_card_response_type_t`

The command response type.

Defines the command response type from card to host controller.

typedef enum `_usdhc_burst_len` `usdhc_burst_len_t`

DMA transfer burst len config.

typedef uint32_t `usdhc_adma1_descriptor_t`

Defines the ADMA1 descriptor structure.

typedef struct `_usdhc_adma2_descriptor` `usdhc_adma2_descriptor_t`

Defines the ADMA2 descriptor structure.

typedef struct `_usdhc_capability` `usdhc_capability_t`

USDHC capability information.

Defines a structure to save the capability information of USDHC.

`typedef struct _usdhc_boot_config` `usdhc_boot_config_t`
Data structure to configure the MMC boot feature.

`typedef struct _usdhc_config` `usdhc_config_t`
Data structure to initialize the USDHC.

`typedef struct _usdhc_command` `usdhc_command_t`
Card command descriptor.
Defines card command-related attribute.

`typedef struct _usdhc_adma_config` `usdhc_adma_config_t`
ADMA configuration.

`typedef struct _usdhc_scatter_gather_data_list` `usdhc_scatter_gather_data_list_t`
Card scatter gather data list.
Allow application register uncontinuous data buffer for data transfer.

`typedef struct _usdhc_scatter_gather_data` `usdhc_scatter_gather_data_t`
Card scatter gather data descriptor.
Defines a structure to contain data-related attribute. The 'enableIgnoreError' is used when upper card driver wants to ignore the error event to read/write all the data and not to stop read/write immediately when an error event happens. For example, bus testing procedure for MMC card.

`typedef struct _usdhc_scatter_gather_transfer` `usdhc_scatter_gather_transfer_t`
usdhc scatter gather transfer.

`typedef struct _usdhc_data` `usdhc_data_t`
Card data descriptor.
Defines a structure to contain data-related attribute. The 'enableIgnoreError' is used when upper card driver wants to ignore the error event to read/write all the data and not to stop read/write immediately when an error event happens. For example, bus testing procedure for MMC card.

`typedef struct _usdhc_transfer` `usdhc_transfer_t`
Transfer state.

`typedef struct _usdhc_handle` `usdhc_handle_t`
USDHC handle typedef.

`typedef struct _usdhc_transfer_callback` `usdhc_transfer_callback_t`
USDHC callback functions.

`typedef status_t (*usdhc_transfer_function_t)(USDHC_Type *base, usdhc_transfer_t *content)`
USDHC transfer function.

`typedef struct _usdhc_host` `usdhc_host_t`
USDHC host descriptor.

`USDHC_MAX_BLOCK_COUNT`
Maximum block count can be set one time.

`FSL_USDHC_ENABLE_SCATTER_GATHER_TRANSFER`
USDHC scatter gather feature control macro.

`USDHC_ADMA1_ADDRESS_ALIGN`
The alignment size for ADDRESS field in ADMA1's descriptor.

`USDHC_ADMA1_LENGTH_ALIGN`
The alignment size for LENGTH field in ADMA1's descriptor.

USDHC_ADMA2_ADDRESS_ALIGN

The alignment size for ADDRESS field in ADMA2's descriptor.

USDHC_ADMA2_LENGTH_ALIGN

The alignment size for LENGTH field in ADMA2's descriptor.

USDHC_ADMA1_DESCRIPTOR_ADDRESS_SHIFT

The bit shift for ADDRESS field in ADMA1's descriptor.

Address/page field	Reserved	Attribute					
31 12	11 6	05	04	03	02	01	00
address or data length	000000	Act2	Act1	0	Int	End	Valid

Act2	Act1	Comment	31-28	27-12
0	0	No op	Don't care	
0	1	Set data length	0000	Data Length
1	0	Transfer data	Data address	
1	1	Link descriptor	Descriptor address	

USDHC_ADMA1_DESCRIPTOR_ADDRESS_MASK

The bit mask for ADDRESS field in ADMA1's descriptor.

USDHC_ADMA1_DESCRIPTOR_LENGTH_SHIFT

The bit shift for LENGTH field in ADMA1's descriptor.

USDHC_ADMA1_DESCRIPTOR_LENGTH_MASK

The mask for LENGTH field in ADMA1's descriptor.

USDHC_ADMA1_DESCRIPTOR_MAX_LENGTH_PER_ENTRY

The maximum value of LENGTH field in ADMA1's descriptor. Since the max transfer size ADMA1 support is 65535 which is indivisible by 4096, so to make sure a large data load transfer (>64KB) continuously (require the data address be always align with 4096), software will set the maximum data length for ADMA1 to (64 - 4)KB.

USDHC_ADMA2_DESCRIPTOR_LENGTH_SHIFT

The bit shift for LENGTH field in ADMA2's descriptor.

Address field	Length	Reserved	Attribute					
63 32	31 16	15 06	05	04	03	02	01	00
32-bit address	16-bit length	0000000000	Act2	Act1	0	Int	End	Valid

Act2	Act1	Comment	Operation
0	0	No op	Don't care
0	1	Reserved	Read this line and go to next one
1	0	Transfer data	Transfer data with address and length set in this descriptor line
1	1	Link descriptor	Link to another descriptor

USDHC_ADMA2_DESCRIPTOR_LENGTH_MASK

The bit mask for LENGTH field in ADMA2's descriptor.

USDHC_ADMA2_DESCRIPTOR_MAX_LENGTH_PER_ENTRY

The maximum value of LENGTH field in ADMA2's descriptor.

struct __usdhc_adma2_descriptor

#include <fsl_usdhc.h> Defines the ADMA2 descriptor structure.

Public Members

uint32_t attribute

The control and status field.

uint32_t address

The address field.

struct __usdhc_capability

#include <fsl_usdhc.h> USDHC capability information.

Defines a structure to save the capability information of USDHC.

Public Members

uint32_t sdVersion

Support SD card/sdio version.

uint32_t mmcVersion

Support EMMC card version.

uint32_t maxBlockLength

Maximum block length united as byte.

uint32_t maxBlockCount

Maximum block count can be set one time.

uint32_t flags

Capability flags to indicate the support information(_usdhc_capability_flag).

struct __usdhc_boot_config

#include <fsl_usdhc.h> Data structure to configure the MMC boot feature.

Public Members

uint32_t ackTimeoutCount

Timeout value for the boot ACK. The available range is 0 ~ 15.

usdhc_boot_mode_t bootMode

Boot mode selection.

uint32_t blockCount

Stop at block gap value of automatic mode. Available range is 0 ~ 65535.

size_t blockSize

Block size.

bool enableBootAck

Enable or disable boot ACK.

bool enableAutoStopAtBlockGap

Enable or disable auto stop at block gap function in boot period.

struct __usdhc_config

#include <fsl_usdhc.h> Data structure to initialize the USDHC.

Public Members

uint32_t dataTimeout

Data timeout value.

usdhc_endian_mode_t endianMode

Endian mode.

uint8_t readWatermarkLevel

Watermark level for DMA read operation. Available range is 1 ~ 128.

uint8_t writeWatermarkLevel

Watermark level for DMA write operation. Available range is 1 ~ 128.

struct __usdhc_command

#include <fsl_usdhc.h> Card command descriptor.

Defines card command-related attribute.

Public Members

uint32_t index

Command index.

uint32_t argument

Command argument.

usdhc_card_command_type_t type

Command type.

usdhc_card_response_type_t responseType

Command response type.

uint32_t response[4U]

Response for this command.

uint32_t responseErrorFlags

Response error flag, which need to check the command reponse.

uint32_t flags

Cmd flags.

struct __usdhc_adma_config

#include <fsl_usdhc.h> ADMA configuration.

Public Members

usdhc_dma_mode_t dmaMode

DMA mode.

uint32_t *admaTable

ADMA table address, can't be null if transfer way is ADMA1/ADMA2.

uint32_t admaTableWords

ADMA table length united as words, can't be 0 if transfer way is ADMA1/ADMA2.

struct __usdhc_scatter_gather_data_list

#include <fsl_usdhc.h> Card scatter gather data list.

Allow application register uncontinuous data buffer for data transfer.

struct __usdhc_scatter_gather_data

#include <fsl_usdhc.h> Card scatter gather data descriptor.

Defines a structure to contain data-related attribute. The 'enableIgnoreError' is used when upper card driver wants to ignore the error event to read/write all the data and not to stop read/write immediately when an error event happens. For example, bus testing procedure for MMC card.

Public Members

bool enableAutoCommand12

Enable auto CMD12.

bool enableAutoCommand23

Enable auto CMD23.

bool enableIgnoreError

Enable to ignore error event to read/write all the data.

usdhc_transfer_direction_t dataDirection

data direction

uint8_t dataType

this is used to distinguish the normal/tuning/boot data.

size_t blockSize

Block size.

usdhc_scatter_gather_data_list_t sgData

scatter gather data

struct __usdhc_scatter_gather_transfer

#include <fsl_usdhc.h> usdhc scatter gather transfer.

Public Members

usdhc_scatter_gather_data_t *data

Data to transfer.

usdhc_command_t *command

Command to send.

struct __usdhc_data

#include <fsl_usdhc.h> Card data descriptor.

Defines a structure to contain data-related attribute. The 'enableIgnoreError' is used when upper card driver wants to ignore the error event to read/write all the data and not to stop read/write immediately when an error event happens. For example, bus testing procedure for MMC card.

Public Members

`bool enableAutoCommand12`
Enable auto CMD12.

`bool enableAutoCommand23`
Enable auto CMD23.

`bool enableIgnoreError`
Enable to ignore error event to read/write all the data.

`uint8_t dataType`
this is used to distinguish the normal/tuning/boot data.

`size_t blockSize`
Block size.

`uint32_t blockCount`
Block count.

`uint32_t *rxData`
Buffer to save data read.

`const uint32_t *txData`
Data buffer to write.

`struct __usdhc__transfer`
#include <fsl_usdhc.h> Transfer state.

Public Members

`usdhc_data_t *data`
Data to transfer.

`usdhc_command_t *command`
Command to send.

`struct __usdhc__transfer__callback`
#include <fsl_usdhc.h> USDHC callback functions.

Public Members

`void (*CardInserted)(USDHC_Type *base, void *userData)`
Card inserted occurs when DAT3/CD pin is for card detect

`void (*CardRemoved)(USDHC_Type *base, void *userData)`
Card removed occurs

`void (*SdioInterrupt)(USDHC_Type *base, void *userData)`
SDIO card interrupt occurs

`void (*BlockGap)(USDHC_Type *base, void *userData)`
stopped at block gap event

`void (*TransferComplete)(USDHC_Type *base, usdhc_handle_t *handle, status_t status, void *userData)`
Transfer complete callback.

`void (*ReTuning)(USDHC_Type *base, void *userData)`
Handle the re-tuning.

struct __usdhc_handle

#include <fsl_usdhc.h> USDHC handle.

Defines the structure to save the USDHC state information and callback function.

Note: All the fields except interruptFlags and transferredWords must be allocated by the user.

Public Members

usdhc_data_t *volatile data

Transfer parameter. Data to transfer.

usdhc_command_t *volatile command

Transfer parameter. Command to send.

volatile uint32_t transferredWords

Transfer status. Words transferred by DATAPORT way.

usdhc_transfer_callback_t callback

Callback function.

void *userData

Parameter for transfer complete callback.

struct __usdhc_host

#include <fsl_usdhc.h> USDHC host descriptor.

Public Members

USDHC_Type *base

USDHC peripheral base address.

uint32_t sourceClock_Hz

USDHC source clock frequency united in Hz.

usdhc_config_t config

USDHC configuration.

usdhc_capability_t capability

USDHC capability information.

usdhc_transfer_function_t transfer

USDHC transfer function.

2.68 UTICK: MictoTick Timer Driver

void UTICK_Init(UTICK_Type *base)

Initializes an UTICK by turning its bus clock on.

void UTICK_Deinit(UTICK_Type *base)

Deinitializes a UTICK instance.

This function shuts down Utick bus clock

Parameters

- base – UTICK peripheral base address.

uint32_t UTICK_GetStatusFlags(UTICK_Type *base)

Get Status Flags.

This returns the status flag

Parameters

- base – UTICK peripheral base address.

Returns

status register value

void UTICK_ClearStatusFlags(UTICK_Type *base)

Clear Status Interrupt Flags.

This clears intr status flag

Parameters

- base – UTICK peripheral base address.

Returns

none

void UTICK_SetTick(UTICK_Type *base, *utick_mode_t* mode, uint32_t count, *utick_callback_t* cb)

Starts UTICK.

This function starts a repeat/onetime countdown with an optional callback

Parameters

- base – UTICK peripheral base address.
- mode – UTICK timer mode (ie kUTICK_onetime or kUTICK_repeat)
- count – UTICK timer mode (ie kUTICK_onetime or kUTICK_repeat)
- cb – UTICK callback (can be left as NULL if none, otherwise should be a void func(void))

Returns

none

void UTICK_HandleIRQ(UTICK_Type *base, *utick_callback_t* cb)

UTICK Interrupt Service Handler.

This function handles the interrupt and refers to the callback array in the driver to callback user (as per request in UTICK_SetTick()). if no user callback is scheduled, the interrupt will simply be cleared.

Parameters

- base – UTICK peripheral base address.
- cb – callback scheduled for this instance of UTICK

Returns

none

FSL_UTICK_DRIVER_VERSION

UTICK driver version 2.0.5.

enum *_utick_mode*

UTICK timer operational mode.

Values:

```

enumerator kUTICK__Onetime
    Trigger once
enumerator kUTICK__Repeat
    Trigger repeatedly
typedef enum _utick_mode utick_mode_t
    UTICK timer operational mode.
typedef void (*utick_callback_t)(void)
    UTICK callback function.

```

2.69 WWDT: Windowed Watchdog Timer Driver

`void WWDT_GetDefaultConfig(wwdt_config_t *config)`

Initializes WWDT configure structure.

This function initializes the WWDT configure structure to default value. The default value are:

```

config->enableWwdt = true;
config->enableWatchdogReset = false;
config->enableWatchdogProtect = false;
config->enableLockOscillator = false;
config->windowValue = 0xFFFFFfU;
config->timeoutValue = 0xFFFFFfU;
config->warningValue = 0;

```

See also:

`wwdt_config_t`

Parameters

- `config` – Pointer to WWDT config structure.

`void WWDT_Init(WWDT_Type *base, const wwdt_config_t *config)`

Initializes the WWDT.

This function initializes the WWDT. When called, the WWDT runs according to the configuration.

Example:

```

wwdt_config_t config;
WWDT_GetDefaultConfig(&config);
config.timeoutValue = 0x7ffU;
WWDT_Init(wwdt_base,&config);

```

Parameters

- `base` – WWDT peripheral base address
- `config` – The configuration of WWDT

`void WWDT_Deinit(WWDT_Type *base)`

Shuts down the WWDT.

This function shuts down the WWDT.

Parameters

- base – WWDT peripheral base address

static inline void WWDT_Enable(WWDT_Type *base)

Enables the WWDT module.

This function write value into WWDT_MOD register to enable the WWDT, it is a write-once bit; once this bit is set to one and a watchdog feed is performed, the watchdog timer will run permanently.

Parameters

- base – WWDT peripheral base address

static inline void WWDT_Disable(WWDT_Type *base)

Disables the WWDT module.

Deprecated:

Do not use this function. It will be deleted in next release version, for once the bit field of WDEN written with a 1, it can not be re-written with a 0.

This function write value into WWDT_MOD register to disable the WWDT.

Parameters

- base – WWDT peripheral base address

static inline uint32_t WWDT_GetStatusFlags(WWDT_Type *base)

Gets all WWDT status flags.

This function gets all status flags.

Example for getting Timeout Flag:

```
uint32_t status;
status = WWDT_GetStatusFlags(wwdt_base) & kWWDT_TimeoutFlag;
```

Parameters

- base – WWDT peripheral base address

Returns

The status flags. This is the logical OR of members of the enumeration `_wwdt_status_flags_t`

void WWDT_ClearStatusFlags(WWDT_Type *base, uint32_t mask)

Clear WWDT flag.

This function clears WWDT status flag.

Example for clearing warning flag:

```
WWDT_ClearStatusFlags(wwdt_base, kWWDT_WarningFlag);
```

Parameters

- base – WWDT peripheral base address
- mask – The status flags to clear. This is a logical OR of members of the enumeration `_wwdt_status_flags_t`

static inline void WWDT_SetWarningValue(WWDT_Type *base, uint32_t warningValue)

Set the WWDT warning value.

The WDWARNINT register determines the watchdog timer counter value that will generate a watchdog interrupt. When the watchdog timer counter is no longer greater than the value defined by WARNINT, an interrupt will be generated after the subsequent WDCLK.

Parameters

- base – WWDT peripheral base address
- warningValue – WWDT warning value.

static inline void WWDT_SetTimeoutValue(WWDT_Type *base, uint32_t timeoutCount)

Set the WWDT timeout value.

This function sets the timeout value. Every time a feed sequence occurs the value in the TC register is loaded into the Watchdog timer. Writing a value below 0xFF will cause 0xFF to be loaded into the TC register. Thus the minimum time-out interval is $TWDCLK * 256 * 4$. If enableWatchdogProtect flag is true in wwdt_config_t config structure, any attempt to change the timeout value before the watchdog counter is below the warning and window values will cause a watchdog reset and set the WDTOF flag.

Parameters

- base – WWDT peripheral base address
- timeoutCount – WWDT timeout value, count of WWDT clock tick.

static inline void WWDT_SetWindowValue(WWDT_Type *base, uint32_t windowValue)

Sets the WWDT window value.

The WINDOW register determines the highest TV value allowed when a watchdog feed is performed. If a feed sequence occurs when timer value is greater than the value in WINDOW, a watchdog event will occur. To disable windowing, set windowValue to 0xFFFF (maximum possible timer value) so windowing is not in effect.

Parameters

- base – WWDT peripheral base address
- windowValue – WWDT window value.

void WWDT_Refresh(WWDT_Type *base)

Refreshes the WWDT timer.

This function feeds the WWDT. This function should be called before WWDT timer is in timeout. Otherwise, a reset is asserted.

Parameters

- base – WWDT peripheral base address

FSL_WWDT_DRIVER_VERSION

Defines WWDT driver version.

WWDT_FIRST_WORD_OF_REFRESH

First word of refresh sequence

WWDT_SECOND_WORD_OF_REFRESH

Second word of refresh sequence

enum __wwdt_status_flags_t

WWDT status flags.

This structure contains the WWDT status flags for use in the WWDT functions.

Values:

enumerator kWWDT_TimeoutFlag

Time-out flag, set when the timer times out

enumerator kWWDT_WarningFlag

Warning interrupt flag, set when timer is below the value WDWARNINT

```
typedef struct _wwdt_config wwdt_config_t
```

Describes WWDT configuration structure.

```
struct _wwdt_config
```

#include <fsl_wwdt.h> Describes WWDT configuration structure.

Public Members

```
bool enableWwdt
```

Enables or disables WWDT

```
bool enableWatchdogReset
```

true: Watchdog timeout will cause a chip reset false: Watchdog timeout will not cause a chip reset

```
bool enableWatchdogProtect
```

true: Enable watchdog protect i.e timeout value can only be changed after counter is below warning & window values false: Disable watchdog protect; timeout value can be changed at any time

```
uint32_t windowValue
```

Window value, set this to 0xFFFFFFFF if windowing is not in effect

```
uint32_t timeoutValue
```

Timeout value

```
uint32_t warningValue
```

Watchdog time counter value that will generate a warning interrupt. Set this to 0 for no warning

```
uint32_t clockFreq_Hz
```

Watchdog clock source frequency.

Chapter 3

Middleware

3.1 Boot

3.1.1 MCUXpresso SDK : mcuxsdk-middleware-mcuboot_opensource

Overview

This repository is a fork of MCUboot (<https://github.com/mcu-tools/mcuboot>) for MCUXpresso SDK delivery and it contains the components officially provided in NXP MCUXpresso SDK. This repository is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository (mcuxsdk-manifests) for the complete delivery of MCUXpresso SDK.

Documentation

Overall details can be reviewed here: [MCUXpresso SDK Online Documentation](#)

Visit [MCUboot - Documentation](#) to review details on the contents in this sub-repo.

Setup

Instructions on how to install the MCUXpresso SDK provided from GitHub via west manifest [Getting Started with SDK - Detailed Installation Instructions](#)

Contribution

Contributions are not currently accepted. If the intended contribution is not related to NXP specific code, consider contributing directly to the upstream MCUboot project. Once this MCUboot fork is synchronized with the upstream project, such contributions will end up here as well. If the intended contribution is a bugfix or improvement for NXP porting layer or for code added or modified by NXP, please open an issue or contact NXP support.

NXP Fork

This fork of MCUboot contains specific modifications and enhancements for NXP MCUXpresso SDK integration.

See *changelog* for details.

3.1.2 MCUboot



This is MCUboot version 2.2.0

MCUboot is a secure bootloader for 32-bits microcontrollers. It defines a common infrastructure for the bootloader and the system flash layout on microcontroller systems, and provides a secure bootloader that enables easy software upgrade.

MCUboot is not dependent on any specific operating system and hardware and relies on hardware porting layers from the operating system it works with. Currently, MCUboot works with the following operating systems and SoCs:

- [Zephyr](#)
- [Apache Mynewt](#)
- [Apache NuttX](#)
- [RIOT](#)
- [Mbed OS](#)
- [Espressif](#)
- [Cypress/Infineon](#)

RIOT is supported only as a boot target. We will accept any new port contributed by the community once it is good enough.

MCUboot How-tos

See the following pages for instructions on using MCUboot with different operating systems and SoCs:

- [Zephyr](#)
- [Apache Mynewt](#)
- [Apache NuttX](#)
- [RIOT](#)
- [Mbed OS](#)
- [Espressif](#)
- [Cypress/Infineon](#)

There are also instructions for the *Simulator*.

Roadmap

The issues being planned and worked on are tracked using GitHub issues. To give your input, visit [MCUboot GitHub Issues](#).

Source files

You can find additional documentation on the bootloader in the source files. For more information, use the following links:

- [boot/bootutil](#) - The core of the bootloader itself.
- [boot/boot_serial](#) - Support for serial upgrade within the bootloader itself.
- [boot/zephyr](#) - Port of the bootloader to Zephyr.
- [boot/mynewt](#) - Bootloader application for Apache Mynewt.
- [boot/nuttX](#) - Bootloader application and port of MCUboot interfaces for Apache NuttX.
- [boot/mbed](#) - Port of the bootloader to Mbed OS.
- [boot/espressif](#) - Bootloader application and MCUboot port for Espressif SoCs.
- [boot/cypress](#) - Bootloader application and MCUboot port for Cypress/Infineon SoCs.
- [imgtool](#) - A tool to securely sign firmware images for booting by MCUboot.
- [sim](#) - A bootloader simulator for testing and regression.

Joining the project

Developers are welcome!

Use the following links to join or see more about the project:

- [Our developer mailing list](#)
- [Our Discord channel](#) [Get your invite](#)

3.2 Cloud

3.2.1 AWS IoT

Device Shadow Library

AWS IoT Device Shadow library The AWS IoT Device Shadow library enables you to store and retrieve the current state (the “shadow”) of every registered device. The device’s shadow is a persistent, virtual representation of your device that you can interact with from AWS IoT Core even if the device is offline. The device state is captured as its “shadow” within a [JSON](#) document. The device can send commands over MQTT to get, update and delete its latest state as well as receive notifications over MQTT about changes in its state. Each device’s shadow is uniquely identified by the name of the corresponding “thing”, a representation of a specific device or logical entity on the AWS Cloud. See [Managing Devices with AWS IoT](#) for more information on IoT “thing”. More details about AWS IoT Device Shadow can be found in [AWS IoT documentation](#). This library is distributed under the *MIT Open Source License*.

Note: From [v1.1.0](#) release onwards, you can use named shadow, a feature of the AWS IoT Device Shadow service that allows you to create multiple shadows for a single IoT device.

This library has gone through code quality checks including verification that no function has a [GNU Complexity](#) score over 8, and checks against deviations from mandatory rules in the [MISRA coding standard](#). Deviations from the MISRA C:2012 guidelines are documented under *MISRA Deviations*. This library has also undergone both static code analysis from [Coverity static analysis](#), and validation of memory safety through the [CBMC automated reasoning tool](#).

See memory requirements for this library [here](#).

AWS IoT Device Shadow v1.3.0 source code is part of the FreeRTOS 202210.00 LTS release.

AWS IoT Device Shadow v1.0.2 source code is part of the FreeRTOS 202012.00 LTS release.

AWS IoT Device Shadow Config File The AWS IoT Device Shadow library exposes configuration macros that are required for building the library. A list of all the configurations and their default values are defined in *shadow_config_defaults.h*. To provide custom values for the configuration macros, a custom config file named *shadow_config.h* can be provided by the user application to the library.

By default, a *shadow_config.h* custom config is required to build the library. To disable this requirement and build the library with default configuration values, provide `SHADOW_DO_NOT_USE_CUSTOM_CONFIG` as a compile time preprocessor macro.

Building the Library The *shadowFilePaths.cmake* file contains the information of all source files and the header include path required to build the AWS IoT Device Shadow library.

As mentioned in the [previous section](#), either a custom config file (i.e. *shadow_config.h*) OR the `SHADOW_DO_NOT_USE_CUSTOM_CONFIG` macro needs to be provided to build the AWS IoT Device Shadow library.

For a CMake example of building the AWS IoT Device Shadow library with the *shadowFilePaths.cmake* file, refer to the *coverity_analysis* library target in *test/CMakeLists.txt* file.

Building Unit Tests

Checkout CMock Submodule By default, the submodules in this repository are configured with `update=none` in *.gitmodules* to avoid increasing clone time and disk space usage of other repositories (like [amazon-freertos](#) that submodules this repository).

To build unit tests, the submodule dependency of CMock is required. Use the following command to clone the submodule:

```
git submodule update --checkout --init --recursive --test/unit-test/CMock
```

Platform Prerequisites

- For building the library, **CMake 3.13.0** or later and a **C90 compiler**.
- For running unit tests, **Ruby 2.0.0** or later is additionally required for the CMock test framework (that we use).
- For running the coverage target, **gcov** and **lcov** are additionally required.

Steps to build unit tests

1. Go to the root directory of this repository. (Make sure that the **CMock** submodule is cloned as described [above](#).)
2. Run the *cmake* command: `cmake -S test -B build`

3. Run this command to build the library and unit tests: `make -C build all`
4. The generated test executables will be present in `build/bin/tests` folder.
5. Run `cd build && ctest` to execute all tests and view the test run summary.

CBMC To learn more about CBMC and proofs specifically, review the training material [here](#).

The `test/cbmc/proofs` directory contains CBMC proofs.

In order to run these proofs you will need to install CBMC and other tools by following the instructions [here](#).

Reference examples Please refer to the demos of the AWS IoT Device Shadow library in the following locations for reference examples on POSIX and FreeRTOS platforms:

Platform	Location	Transport Interface Implementation (for coreMQTT stack)
POSIX	AWS IoT Device SDK for Embedded C	POSIX sockets for TCP/IP and OpenSSL for TLS stack
FreeRTOS	FreeRTOS/FreeRTOS	FreeRTOS+TCP for TCP/IP and mbedTLS for TLS stack
FreeRTOS	FreeRTOS AWS Reference Integrations	Based on Secure Sockets Abstraction

Documentation

Existing Documentation For pre-generated documentation, please see the documentation linked in the locations below:

Location
AWS IoT Device SDK for Embedded C FreeRTOS.org

Note that the latest included version of IoT Device Shadow library may differ across repositories.

Generating documentation The Doxygen references were created using Doxygen version 1.9.2. To generate the Doxygen pages, please run the following command from the root of this repository:

```
doxygen docs/doxygen/config.doxyfile
```

Contributing See *CONTRIBUTING.md* for information on contributing.

Device Defender Library

AWS IoT Device Defender Library The Device Defender library enables you to send device metrics to the [AWS IoT Device Defender Service](#). This library also supports custom metrics, a feature that helps you monitor operational health metrics that are unique to your fleet or use case. For example, you can define a new metric to monitor the memory usage or CPU usage

on your devices. This library has no dependencies on any additional libraries other than the standard C library, and therefore, can be used with any MQTT client library. This library is distributed under the *MIT Open Source License*.

This library has gone through code quality checks including verification that no function has a [GNU Complexity](#) score over 8, and checks against deviations from mandatory rules in the [MISRA coding standard](#). Deviations from the MISRA C:2012 guidelines are documented under *MISRA Deviations*. This library has also undergone static code analysis using [Coverity static analysis](#), and validation of memory safety through the [CBMC automated reasoning tool](#).

See memory requirements for this library [here](#).

AWS IoT Device Defender v1.3.0 source code is part of the [FreeRTOS 202210.00 LTS](#) release.

AWS IoT Device Defender v1.1.0 source code is part of the [FreeRTOS 202012.01 LTS](#) release.

AWS IoT Device Defender Client Config File The AWS IoT Device Defender Client Library exposes build configuration macros that are required for building the library. A list of all the configurations and their default values are defined in *defender_config_defaults.h*. To provide custom values for the configuration macros, a config file named *defender_config.h* can be provided by the application to the library.

By default, a *defender_config.h* config file is required to build the library. To disable this requirement and build the library with default configuration values, provide `DEFENDER_DO_NOT_USE_CUSTOM_CONFIG` as a compile time preprocessor macro.

Thus, the Device Defender client library can be built by either:

- Defining a *defender_config.h* file in the application, and adding it to the include directories list of the library.

OR

- Defining the `DEFENDER_DO_NOT_USE_CUSTOM_CONFIG` preprocessor macro for the library build.

Building the Library The *defenderFilePaths.cmake* file contains the information of all source files and the header include paths required to build the Device Defender client library.

As mentioned in the previous section, either a custom config file (i.e. *defender_config.h*) or `DEFENDER_DO_NOT_USE_CUSTOM_CONFIG` macro needs to be provided to build the Device Defender client library.

For a CMake example of building the Device Defender client library with the *defenderFilePaths.cmake* file, refer to the *coverity_analysis* library target in *test/CMakeLists.txt* file.

Building Unit Tests

Platform Prerequisites

- For running unit tests:
 - **C90 compiler** like gcc.
 - **CMake 3.13.0 or later**.
 - **Ruby 2.0.0 or later** is additionally required for the CMock test framework (that we use).
- For running the coverage target, **gcov** and **lcov** are additionally required.

Steps to build Unit Tests

1. Go to the root directory of this repository.
2. Run the `cmake` command: `cmake -S test -B build -DBUILD_CLONE_SUBMODULES=ON`.
3. Run this command to build the library and unit tests: `make -C build all`.
4. The generated test executables will be present in `build/bin/tests` folder.
5. Run `cd build && ctest` to execute all tests and view the test run summary.

CBMC To learn more about CBMC and proofs specifically, review the training material [here](#).

The `test/cbmc/proofs` directory contains CBMC proofs.

In order to run these proofs you will need to install CBMC and other tools by following the instructions [here](#).

Reference examples The AWS IoT Embedded C-SDK repository contains a demo showing the use of AWS IoT Device Defender Client Library [here](#) on a POSIX platform.

Documentation

Existing documentation For pre-generated documentation, please see the documentation linked in the locations below:

Location
AWS IoT Device SDK for Embedded C FreeRTOS.org

Note that the latest included version of the AWS IoT Device Defender library may differ across repositories.

Generating documentation The Doxygen references were created using Doxygen version 1.9.2. To generate the Doxygen pages, please run the following command from the root of this repository:

```
doxygen docs/doxygen/config.doxyfile
```

Contributing See *CONTRIBUTING.md* for information on contributing.

Jobs Library

README

AWS IoT Jobs library The AWS IoT Jobs library helps you notify connected IoT devices of a pending **Job**. A Job can be used to manage your fleet of devices, update firmware and security certificates on your devices, or perform administrative tasks such as restarting devices and performing diagnostics. It interacts with the [AWS IoT Jobs service](#) using MQTT, a lightweight publish-subscribe protocol. This library provides a convenience API to compose and recognize the MQTT topic strings used by the Jobs service. The library is written in C compliant with ISO C90 and MISRA C:2012, and is distributed under the *MIT Open Source License*.

This library has gone through code quality checks including verification that no function has a [GNU Complexity](#) score over 8, and checks against deviations from mandatory rules in the [MISRA coding standard](#). Deviations from the MISRA C:2012 guidelines are documented under *MISRA Deviations*. This library has also undergone both static code analysis from [Coverity](#), and validation of memory safety with the [CBMC bounded model checker](#).

See memory requirements for this library [here](#).

AWS IoT Jobs v1.3.0 source code is part of the FreeRTOS 202210.00 LTS release.

AWS IoT Jobs v1.1.0 source code is part of the FreeRTOS 202012.01 LTS release.

Building the Jobs library A compiler that supports **C90 or later** such as *gcc* is required to build the library.

Given an application in a file named `example.c`, *gcc* can be used like so:

```
gcc -I source/include example.c source/jobs.c -o example
```

gcc can also produce an object file to be linked later:

```
gcc -I source/include -c source/jobs.c
```

CBMC To learn more about CBMC and proofs specifically, review the training material [here](#).

The `test/cbmc/proofs` directory contains CBMC proofs.

In order to run these proofs you will need to install CBMC and other tools by following the instructions [here](#).

Reference example The AWS IoT Device SDK for Embedded C repository contains a demo using the jobs library on a POSIX platform. https://github.com/aws/aws-iot-device-sdk-embedded-C/tree/main/demos/jobs/jobs_demo_mosquitto

Documentation

Existing Documentation For pre-generated documentation, please see the documentation linked in the locations below:

Location
AWS IoT Device SDK for Embedded C FreeRTOS.org

Note that the latest included version of the AWS IoT Jobs library may differ across repositories.

Generating Documentation The Doxygen references were created using Doxygen version 1.9.2. To generate the Doxygen pages, please run the following command from the root of this repository:

```
doxygen docs/doxygen/config.doxyfile
```

Building unit tests

Checkout Unity Submodule By default, the submodules in this repository are configured with `update=none` in `.gitmodules` to avoid increasing clone time and disk space usage of other repositories that submodule this repository.

To build unit tests, the submodule dependency of Unity is required. Use the following command to clone the submodule:

```
git submodule update --checkout --init --recursive --test/unit-test/Unity
```

Platform Prerequisites

- For running unit tests
 - C90 compiler like gcc
 - CMake 3.13.0 or later
 - Ruby 2.0.0 or later is additionally required for the Unity test framework (that we use).
- For running the coverage target, lcov is additionally required.

Steps to build Unit Tests

1. Go to the root directory of this repository. (Make sure that the **Unity** submodule is cloned as described [above](#).)
2. Create build directory: `mkdir build && cd build`
3. Run `cmake` while inside build directory: `cmake -S ../test`
4. Run this command to build the library and unit tests: `make all`
5. The generated test executables will be present in `build/bin/tests` folder.
6. Run `ctest` to execute all tests and view the test run summary.

Contributing See *CONTRIBUTING.md* for information on contributing.

Over-the-air Update Library

AWS IoT Over-the-air Update Library The OTA library enables you to manage the notification of a newly available update, download the update, and perform cryptographic verification of the firmware update. Using the library, you can logically separate firmware updates from the application running on your devices. The OTA library can share a network connection with the application, saving memory in resource-constrained devices. In addition, the OTA library lets you define application-specific logic for testing, committing, or rolling back a firmware update. The library supports different application protocols like Message Queuing Telemetry Transport (MQTT) and Hypertext Transfer Protocol (HTTP), and provides various configuration options you can fine tune depending on network type and conditions. This library is distributed under the *MIT Open Source License*.

This library has gone through code quality checks including verification that no function has a [GNU Complexity](#) score over 8. This library has also undergone static code analysis from [Coverity static analysis](#).

See memory requirements for this library [here](#).

AWS IoT Over-the-air Update Library v3.4.0 source code is part of the [FreeRTOS 202210.00 LTS](#) release.

AWS IoT Over-the-air Update Library v3.3.0 source code is part of the [FreeRTOS 202012.01 LTS](#) release.

AWS IoT Over-the-air Updates Config File The AWS IoT Over-the-air Updates library exposes configuration macros that are required for building the library. A list of all the configurations and their default values are defined in *ota_config_defaults.h*. To provide custom values for the configuration macros, a custom config file named *ota_config.h* can be provided by the user application to the library.

By default, a *ota_config.h* custom config is required to build the library. To disable this requirement and build the library with default configuration values, provide `OTA_DO_NOT_USE_CUSTOM_CONFIG` as a compile time preprocessor macro.

Building the Library The *otaFilePaths.cmake* file contains the information of all source files and the header include paths required to build the AWS IoT Over-the-air Updates library.

As mentioned in the previous section, either a custom config file (i.e. *ota_config.h*) OR the `OTA_DO_NOT_USE_CUSTOM_CONFIG` macro needs to be provided to build the AWS IoT Over-the-air Updates library.

For a CMake example of building the AWS IoT Over-the-air Updates library with the *otaFilePaths.cmake* file, refer to the *coverity_analysis* library target in the *test/CMakeLists.txt* file.

Building Unit Tests

Checkout CMock Submodule By default, the submodules in this repository are configured with `update=none` in *.gitmodules* to avoid increasing clone time and disk space usage of other repositories (like [AWS IoT Device SDK for Embedded C](#) that submodules this repository).

To build unit tests, the submodule dependency of CMock is required. Use the following command to clone the submodule:

```
git submodule update --checkout --init --recursive test/unit-test/CMock
```

Platform Prerequisites

- For building the library, **CMake 3.13.0** or later and a **C90 compiler**.
- For running unit tests, **Ruby 2.0.0** or later is additionally required for the CMock test framework (that we use).
- For running the coverage target, **gcov** and **lcov** are additionally required.

Steps to build unit tests

1. Go to the root directory of this repository. (Make sure that the **CMock** submodule is cloned as described [above](#).)
2. Run the *cmake* command: `cmake -S test -B build`

3. Run this command to build the library and unit tests: `make -C build all`
4. The generated test executables will be present in `build/bin/tests` folder.
5. Run `cd build && ctest` to execute all tests and view the test run summary.

Migration Guide

How to migrate from v2.0.0 (Release Candidate) to v3.4.0 The following table lists equivalent API function signatures in v2.0.0 (Release Candidate) and v3.4.0 declared in `ota.h`

v2.0.0 (Release Candidate)	v3.4.0	Notes
<code>OtaState_t</code> <code>OTA_Shutdown(</code> <code>uint32_t tick-</code> <code>sToWait);</code>	<code>OtaState_t</code> <code>OTA_Shutdown(</code> <code>uint32_t ticksToWait,</code> <code>uint8_t unsubscribeFlag</code> <code>);</code>	<code>unsubscribeFlag</code> indicates if unsubscribe operations should be performed from the job topics when shutdown is called. Set this as 1 to unsubscribe, 0 otherwise.

How to migrate from version 1.0.0 to version 3.4.0 for OTA applications Refer to [OTA Migration document](#) for the summary of updates to the API. [Migration document for OTA PAL](#) also provides a summary of updates required for upgrading the OTA-PAL to work with v3.4.0 of the library.

Porting In order to support AWS IoT Over-the-air Updates on your device, it is necessary to provide the following components:

1. [Port for the OTA Portable Abstraction Layer \(PAL\).](#)
2. [OS Interface](#)
3. [MQTT Interface](#)

For enabling data transfer over HTTP dataplane the following component should also be provided:

1. [HTTP Interface](#)

NOTE When using OTA over HTTP dataplane, MQTT is required for control plane operations and should also be provided.

CBMC To learn more about CBMC and proofs specifically, review the training material [here](#).

The `test/cbmc/proofs` directory contains CBMC proofs.

In order to run these proofs you will need to install CBMC and other tools by following the instructions [here](#).

Reference examples Please refer to the demos of the AWS IoT Over-the-air Updates library in the following location for reference examples on POSIX and FreeRTOS:

Platform	Location
POSIX	AWS IoT Device SDK for Embedded C
FreeRTOS	FreeRTOS/FreeRTOS
FreeRTOS	FreeRTOS AWS Reference Integrations

Documentation

Existing Documentation For pre-generated documentation, please see the documentation linked in the locations below:

Location
AWS IoT Device SDK for Embedded C FreeRTOS.org

Note that the latest included version of coreMQTT may differ across repositories.

Generating documentation The Doxygen references were created using Doxygen version 1.9.2. To generate the Doxygen pages, please run the following command from the root of this repository:

```
doxygen docs/doxygen/config.doxyfile
```

Contributing See *CONTRIBUTING.md* for information on contributing.

3.3 Connectivity

3.3.1 lwIP

This is the NXP fork of the [lwIP networking stack](#).

- For details about changes and additions made by NXP, see CHANGELOG.
- For details about the NXP porting layer, see [The NXP lwIP Port](#).
- For usage and API of lwIP, use official documentation at <http://www.nongnu.org/lwip/>.

The NXP lwIP Port

Below is description of possible settings of the port layer and an overview of a few helper functions.

The best place for redefinition of any mentioned macro is `lwipopts.h`.

The declaration of every mentioned function is in `ethernetif.h`. Please check the doxygen comments of those functions before.

Link state Physical link state (up/down) and its speed and duplex must be read out from PHY over MDIO bus. Especially link information is useful for lwIP stack so it can for example send DHCP discovery immediately when a link becomes up.

To simplify this port layer offers a function `ethernetif_probe_link()` which reads those data from PHY and forwards them into lwIP stack.

In almost all examples this function is called every `ETH_LINK_POLLING_INTERVAL_MS` (1500ms) by a function `probe_link_cyclic()`.

By setting `ETH_LINK_POLLING_INTERVAL_MS` to 0 polling will be disabled. On FreeRTOS, `probe_link_cyclic()` will be then called on an interrupt generated by PHY. GPIO port and pin for

the interrupt line must be set in the `ethernetifConfig` struct passed to `ethernetif_init()`. On bare metal interrupts are not supported right now.

Rx task To improve the reaction time of the app, reception of packets is done in a dedicated task. The rx task stack size can be set by `ETH_RX_TASK_STACK_SIZE` macro, its priority by `ETH_RX_TASK_PRIO`.

If you want to save memory you can set reception to be done in an interrupt by setting `ETH_DO_RX_IN_SEPARATE_TASK` macro to 0.

Disabling Rx interrupt when out of buffers If `ETH_DISABLE_RX_INT_WHEN_OUT_OF_BUFFERS` is set to 1, then when the port gets out of Rx buffers, Rx enet interrupt will be disabled for a particular controller. Everytime Rx buffer is freed, Rx interrupt will be enabled.

This prevents your app from never getting out of Rx interrupt when the network is flooded with traffic.

`ETH_DISABLE_RX_INT_WHEN_OUT_OF_BUFFERS` is by default turned on, on FreeRTOS and off on bare metal.

Limit the number of packets read out from the driver at once on bare metal. You may define macro `ETH_MAX_RX_PKTS_AT_ONCE` to limit the number of received packets read out from the driver at once.

In case of heavy Rx traffic, lowering this number improves the realtime behaviour of an app. Increasing improves Rx throughput.

Setting it to value < 1 or not defining means “no limit”.

Helper functions If your application needs to wait for the link to become up you can use one of the following functions:

- `ethernetif_wait_linkup()` - Blocks until the link on the passed netif is not up.
- `ethernetif_wait_linkup_array()` - Blocks until the link on at least one netif from the passed list of netifs becomes up.

If your app needs to wait for the IPv4 address on a particular netif to become different than “ANY” address (255.255.255.255) function `ethernetif_wait_ipv4_valid()` does this.

3.4 File System

3.4.1 FatFs

MCUXpresso SDK : mcuxsdk-middleware-fatfs

Overview This repository is for FatFs middleware delivery and it contains the components officially provided in NXP MCUXpresso SDK. This repository is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository (`mcuxsdk-manifests`) for the complete delivery of MCUXpresso SDK.

Documentation Overall details can be reviewed here: [MCUXpresso SDK Online Documentation](#)

Visit [FatFs - Documentation](#) to review details on the contents in this sub-repo.

Setup Instructions on how to install the MCUXpresso SDK provided from GitHub via west manifest [Getting Started with SDK - Detailed Installation Instructions](#)

Contribution Contributions are not currently accepted. Guidelines to contribute will be posted in the future.

Repo Specific Content This is MCUXpresso SDK fork of FatFs (FAT file system created by ChaN). Official documentation is available at <http://elm-chan.org/fsw/ff/>

MCUXpresso version is extending original content by following hardware specific porting layers:

- mmc_disk
- nand_disk
- ram_disk
- sd_disk
- sdspi_disk
- usb_disk

Changelog FatFs

All notable changes to this project will be documented in this file.

The format is based on [Keep a Changelog](#)

[R0.15_rev0]

- Upgraded to version 0.15
- Applied patches from <http://elm-chan.org/fsw/ff/patches.html>

[R0.14b_rev1]

- Applied patches from <http://elm-chan.org/fsw/ff/patches.html>

[R0.14b_rev0]

- Upgraded to version 0.14b

[R0.14a_rev0]

- Upgraded to version 0.14a
- Applied patch ff14a_p1.diff and ff14a_p2.diff

[R0.14_rev0]

- Upgraded to version 0.14
- Applied patch ff14_p1.diff and ff14_p2.diff

[R0.13c_rev0]

- Upgraded to version 0.13c
- Applied patches ff_13c_p1.diff,ff_13c_p2.diff, ff_13c_p3.diff and ff_13c_p4.diff.

[R0.13b_rev0]

- Upgraded to version 0.13b

[R0.13a_rev0]

- Upgraded to version 0.13a. Added patch ff_13a_p1.diff.

[R0.12c_rev1]

- Add NAND disk support.

[R0.12c_rev0]

- Upgraded to version 0.12c and applied patches ff_12c_p1.diff and ff_12c_p2.diff.

[R0.12b_rev0]

- Upgraded to version 0.12b.

[R0.11a]

- Added glue functions for low-level drivers (SDHC, SDSPI, RAM, MMC). Modified diskio.c.
- Added RTOS wrappers to make FatFs thread safe. Modified syscall.c.
- Renamed ffconf.h to ffconf_template.h. Each application should contain its own ffconf.h.
- Included ffconf.h into diskio.c to enable the selection of physical disk from ffconf.h by macro definition.
- Conditional compilation of physical disk interfaces in diskio.c.

3.5 Motor Control

3.5.1 FreeMASTER

Communication Driver User Guide

Introduction

What is FreeMASTER? **FreeMASTER** is a PC-based application developed by NXP for NXP customers. It is a versatile tool usable as a real-time monitor, visualization tool, and a graphical control panel of embedded applications based on the NXP processing units.

This document describes the embedded-side software driver which implements an interface between the application and the host PC. The interface covers the following communication:

- **Serial** UART communication either over plain RS232 interface or more typically over a USB-to-Serial either external or built in a debugger probe.

- **USB** direct connection to target microcontroller
- **CAN bus**
- **TCP/IP network** wired or WiFi
- **Segger J-Link RTT**
- **JTAG** debug port communication
- ...and all of the above also using a **Zephyr** generic drivers.

The driver also supports so-called “packet-driven BDM” interface which enables a protocol-based communication over a debugging port. The BDM stands for Background Debugging Module and its physical implementation is different on each platform. Some platforms leverage a semi-standard JTAG interface, other platforms provide a custom implementation called BDM. Regardless of the name, this debugging interface enables non-intrusive access to the memory space while the target CPU is running. For basic memory read and write operations, there is no communication driver required on the target when communicating with the host PC. Use this driver to get more advanced FreeMASTER protocol features over the BDM interface. The driver must be configured for the packet-driven BDM mode, in which the host PC uses the debugging interface to write serial command frames directly to the target memory buffer. The same method is then used to read response frames from that memory buffer.

Similar to “packet-driven BDM”, the FreeMASTER also supports a communication over [J-Link RTT](<https://www.segger.com/products/debug-probes/j-link/technology/about-real-time-transfer/>) interface defined by SEGGER Microcontroller GmbH for ARM CortexM-based microcontrollers. This method also uses JTAG physical interface and enables high-speed real time communication to run over the same channel as used for application debugging.

Driver version 3 This document describes version 3 of the FreeMASTER Communication Driver. This version features the implementation of the new Serial Protocol, which significantly extends the features and security of its predecessor. The new protocol internal number is v4 and its specification is available in the documentation accompanying the driver code.

Driver V3 is deployed to modern 32-bit MCU platforms first, so the portfolio of supported platforms is smaller than for the previous V2 versions. It is recommended to keep using the V2 driver for legacy platforms, such as S08, S12, ColdFire, or Power Architecture. Reach out to [FreeMASTER community](#) or to the local NXP representative with requests for more information or to port the V3 driver to legacy MCU devices.

Thanks to a layered approach, the new driver simplifies the porting of the driver to new UART, CAN or networking communication interfaces significantly. Users are encouraged to port the driver to more NXP MCU platforms and contribute the code back to NXP for integration into future releases. Existing code and low-level driver layers may be used as an example when porting to new targets.

Note: Using the FreeMASTER tool and FreeMASTER Communication Driver is only allowed in systems based on NXP microcontroller or microprocessor unit. Use with non-NXP MCU platforms is **not permitted** by the license terms.

Target platforms The driver implementation uses the following abstraction mechanisms which simplify driver porting and supporting new communication modules:

- **General CPU Platform** (see source code in the `src/platforms` directory). The code in this layer is only specific to native data type sizes and CPU architectures (for example; alignment-aware memory copy routines). This driver version brings two generic implementations of 32-bit platforms supporting both little-endian and big-endian architectures. There are also implementations customized for the 56F800E family of digital signal controllers and S12Z MCUs. **Zephyr** is treated as a specific CPU platform as it brings unified

user configuration (Kconfig) and generic hardware device drivers. With Zephyr, the transport layer and low-level communication layers described below are configured automatically using Kconfig and Device Tree technologies.

- **Transport Communication Layer** - The Serial, CAN, Networking, PD-BDM, and other methods of transport logic are implemented as a driver layer called FMSTR_TRANSPORT with a uniform API. A support of the Network transport also extends single-client modes of operation which are native for Serial, USB and CAN by a concept of multiple client sessions.
- **Low-level Communication Driver** - Each type of transport further defines a low-level API used to access the physical communication module. For example, the Serial transport defines a character-oriented API implemented by different serial communication modules like UART, LPUART, USART, and also USB-CDC. Similarly, the CAN transport defines a message-oriented API implemented by the FlexCAN or MCAN modules. Moreover, there are multiple different implementations for the same kind of communication peripherals. The difference between the implementation is in the way the low-level hardware registers are accessed. The *mcuxsdk* folder contains implementations which use MCUXpresso SDK drivers. These drivers should be used in applications based on the NXP MCUXpresso SDK. The “ampsdk” drivers target automotive-specific MCUs and their respective SDKs. The “dreg” implementations use a plain C-language access to hardware register addresses which makes it a universal and the most portable solution. In this case, users are encouraged to add more drivers for other communication modules or other respective SDKs and contribute the code back to NXP for integration.

The low-level drivers defined for the Networking transport enable datagram-oriented UDP and stream TCP communication. This implementation is demonstrated using the lwIP software stack but shall be portable to other TCP/IP stacks. It may sound surprisingly, but also the Segger J-Link RTT communication driver is linked to the Networking transport (RTT is stream oriented communication handled similarly to TCP).

Replacing existing drivers For all supported platforms, the driver described in this document replaces the V2 implementation and also older driver implementations that were available separately for individual platforms (PC Master SCI drivers).

Clocks, pins, and peripheral initialization The FreeMASTER communication driver is only responsible for runtime processing of the communication and must be integrated with an user application code to function properly. The user application code is responsible for general initialization of clock sources, pin multiplexers, and peripheral registers related to the communication speed. Such initialization should be done before calling the FMSTR_Init function.

It is recommended to develop the user application using one of the Software Development Kits (SDKs) available from third parties or directly from NXP, such as MCUXpresso SDK, MCUXpresso IDE, and related tools. This approach simplifies the general configuration process significantly.

MCUXpresso SDK The MCUXpresso SDK is a software package provided by NXP which contains the device initialization code, linker files, and software drivers with example applications for the NXP family of MCUs. The MCUXpresso Config Tools may be used to generate the clock-setup and pin-multiplexer setup code suitable for the selected processor.

The MCUXpresso SDK also contains this FreeMASTER communication driver as a “middleware” component which may be downloaded along with the example applications from <https://mcuxpresso.nxp.com/en/welcome>.

MCUXpresso SDK on GitHub The FreeMASTER communication driver is also released as one of the middleware components of the MCUXpresso SDK on the GitHub. This release enables direct integration of the FreeMASTER source code Git repository into a target applications including Zephyr applications.

Related links:

- [The official FreeMASTER middleware repository.](#)
- [Online version of this document](#)

FreeMASTER in Zephyr The FreeMASTER middleware repository can be used with MCUXpresso SDK as well as a Zephyr module. Zephyr-specific samples which include examples of Kconfig and Device Tree configurations for Serial, USB and Network communications are available in separate repository. West manifest in this sample repository fetches the full Zephyr package including the FreeMASTER middleware repository used as a Zephyr module.

Example applications

MCUX SDK Example applications There are several example applications available for each supported MCU platform.

- **fmstr_uart** demonstrates a plain serial transmission, typically connecting to a computer's physical or virtual COM port. The typical transmission speed is 115200 bps.
- **fmstr_can** demonstrates CAN bus communication. This requires a suitable CAN interface connected to the computer and interconnected with the target MCU using a properly terminated CAN bus. The typical transmission speed is 500 kbps. A FreeMASTER-over-CAN communication plug-in must be used.
- **fmstr_usb_cdc** uses an on-chip USB controller to implement a CDC communication class. It is connected directly to a computer's USB port and creates a virtual COM port device. The typical transmission speed is above 1 Mbps.
- **fmstr_net** demonstrates the Network communication over UDP or TCP protocol. Existing examples use lwIP stack to implement the communication, but in general, it shall be possible to use any other TCP/IP stack to achieve the same functionality.
- **fmstr_wifi** is the fmstr_net application modified to use a WiFi network interface instead of a wired Ethernet connection.
- **fmstr_rtt** demonstrates the communication over SEGGER J-Link RTT interface. Both fmstr_net and fmstr_rtt examples require the FreeMASTER TCP/UDP communication plug-in to be used on the PC host side.
- **fmstr_eonce** uses the real-time data unit on the JTAG EOnCE module of the 56F800E family to implement pseudo-serial communication over the JTAG port. The typical transmission speed is around 10 kbps. This communication requires FreeMASTER JTAG/EOnCE communication plug-in.
- **fmstr_pdbdm** uses JTAG or BDM debugging interface to access the target RAM directly while the CPU is running. Note that such approach can be used with any MCU application, even without any special driver code. The computer reads from and writes into the RAM directly without CPU intervention. The Packet-Driven BDM (PD-BDM) communication uses the same memory access to exchange command and response frames. With PD-BDM, the FreeMASTER tool is able to go beyond basic memory read/write operations and accesses also advanced features like Recorder, TSA, or Pipes. The typical transmission speed is around 10 kbps. A PD-BDM communication plug-in must be used in FreeMASTER and configured properly for the selected debugging interface. Note that this communication cannot be used while a debugging interface is used by a debugger session.
- **fmstr_any** is a special example application which demonstrates how the NXP MCUXpresso Config Tools can be used to configure pins, clocks, peripherals, interrupts, and even the FreeMASTER "middleware" driver features in a graphical and user friendly way. The user can switch between the Serial, CAN, and other ways of communication and generate the required initialization code automatically.

Zephyr sample applications Zephyr sample applications demonstrate Kconfig and Device Tree configuration which configure the FreeMASTER middleware module for a selected communication option (Serial, CAN, Network or RTT).

Refer to *readme.md* files in each sample directory for description of configuration options required to implement FreeMASTER connectivity.

Description

This section shows how to add the FreeMASTER Communication Driver into application and how to configure the connection to the FreeMASTER visualization tool.

Features The FreeMASTER driver implements the FreeMASTER protocol V4 and provides the following features which may be accessed using the FreeMASTER visualization tool:

- Read/write access to any memory location on the target.
- Optional password protection of the read, read/write, and read/write/flash access levels.
- Atomic bit manipulation on the target memory (bit-wise write access).
- Optimal size-aligned access to memory which is also suitable to access the peripheral register space.
- Oscilloscope access—real-time access to target variables. The sample rate may be limited by the communication speed.
- Recorder— access to the fast transient recorder running on the board as a part of the FreeMASTER driver. The sample rate is only limited by the MCU CPU speed. The length of the data recorded depends on the amount of available memory.
- Multiple instances of Oscilloscopes and Recorders without the limitation of maximum number of variables.
- Application commands—high-level message delivery from the PC to the application.
- TSA tables—describing the data types, variables, files, or hyperlinks exported by the target application. The TSA newly supports also non-memory mapped resources like external EEPROM or SD Card files.
- Pipes—enabling the buffered stream-oriented data exchange for a general-purpose terminal-like communication, diagnostic data streaming, or other data exchange.

The FreeMASTER driver features:

- Full FreeMASTER protocol V4 implementation with a new V4 style of CRC used.
- Layered approach supporting Serial, CAN, Network, PD-BDM, and other transports.
- Layered low-level Serial transport driver architecture enabling to select UART, LPUART, USART, and other physical implementations of serial interfaces, including USB-CDC.
- Layered low-level CAN transport driver architecture enabling to select FlexCAN, msCAN, MCAN, and other physical implementations of the CAN interface.
- Layered low-level Networking transport enabling to select TCP, UDP or J-Link RTT communication.
- TSA support to write-protect memory regions or individual variables and to deny the access to the unsafe memory.
- The pipe callback handlers are invoked whenever new data is available for reading from the pipe.

- Two Serial Single-Wire modes of operation are enabled. The “external” mode has the RX and TX shorted on-board. The “true” single-wire mode interconnects internally when the MCU or UART modules support it.

The following sections briefly describe all FreeMASTER features implemented by the driver. See the PC-based FreeMASTER User Manual for more details on how to use the features to monitor, tune, or control an embedded application.

Board Detection The FreeMASTER protocol V4 defines the standard set of configuration values which the host PC tool reads to identify the target and to access other target resources properly. The configuration includes the following parameters:

- Version of the driver and the version of the protocol implemented.
- MTU as the Maximum size of the Transmission Unit (for example; communication buffer size).
- Application name, description, and version strings.
- Application build date and time as a string.
- Target processor byte ordering (little/big endian).
- Protection level that requires password authentication.
- Number of the Recorder and Oscilloscope instances.
- RAM Base Address for optimized memory access commands.

Memory Read This basic feature enables the host PC to read any data memory location by specifying the address and size of the required memory area. The device response frame must be shorter than the MTU to fit into the outgoing communication buffer. To read a device memory of any size, the host uses the information retrieved during the Board Detection and splits the large-block request to multiple partial requests.

The driver uses size-aligned operations to read the target memory (for example; uses proper read-word instruction when an address is aligned to 4 bytes).

Memory Write Similarly to the Memory Read operation, the Memory Write feature enables to write to any RAM memory location on the target device. A single write command frame must be shorter than the MTU to fit into the target communication buffer. Larger requests must be split into smaller ones.

The driver uses size-aligned operations to write to the target memory (for example; uses proper write-word instruction when an address is aligned to 4 bytes).

Masked Memory Write To implement the write access to a single bit or a group of bits of target variables, the Masked Memory Write feature is available in the FreeMASTER protocol and it is supported by the driver using the Read-Modify-Write approach.

Be careful when writing to bit fields of volatile variables that are also modified in an application interrupt. The interrupt may be serviced in the middle of a read-modify-write operation and it may cause data corruption.

Oscilloscope The protocol and driver enables any number of variables to be read at once with a single request from the host. This feature is called Oscilloscope and the FreeMASTER tool uses it to display a real-time graph of variable values.

The driver can be configured to support any number of Oscilloscope instances and enable simultaneously running graphs to be displayed on the host computer screen.

Recorder The protocol enables the host to select target variables whose values are then periodically recorded into a dedicated on-board memory buffer. After such data sampling stops (either on a host request or by evaluating a threshold-crossing condition), the data buffer is downloaded to the host and displayed as a graph. The data sampling rate is not limited by the speed of the communication line, so it enables displaying the variable transitions in a very high resolution.

The driver can be configured to support multiple Recorder instances and enable multiple recorder graphs to be displayed on the host screen. Having multiple recorders also enables setting the recording point differently for each instance. For example; one instance may be recording data in a general timer interrupt while another instance may record at a specific control algorithm time in the PWM interrupt.

TSA With the TSA feature, data types and variables can be described directly in the application source code. Such information is later provided to the FreeMASTER tool which may use it instead of reading symbol data from the application ELF executable file.

The information is encoded as so-called TSA tables which become direct part of the application code. The TSA tables contain descriptors of variables that shall be visible to the host tool. The descriptors can describe the memory areas by specifying the address and size of the memory block or more conveniently using the C variable names directly. Different set of TSA descriptors can be used to encode information about the structure types, unions, enumerations, or arrays.

The driver also supports special types of TSA table entries to describe user resources like external EEPROM and SD Card files, memory-mapped files, virtual directories, web URL hyperlinks, and constant enumerations.

TSA Safety When the TSA is enabled in the application, the TSA Safety can be enabled and validate the memory accesses directly by the embedded-side driver. When the TSA Safety is turned on, any memory request received from the host is validated and accepted only if it belongs to a TSA-described object. The TSA entries can be declared as Read-Write or Read-Only so that the driver can actively deny the write access to the Read-Only objects.

Application commands The Application Commands are high-level messages that can be delivered from the PC Host to the embedded application for further processing. The embedded application can either poll the status, or be called back when a new Application Command arrives to be processed. After the embedded application acknowledges that the command is handled, the host receives the Result Code and reads the other return data from memory. Both the Application Commands and the Result Codes are specific to a given application and it is user's responsibility to define them. The FreeMASTER protocol and the FreeMASTER driver only implement the delivery channel and a set of API calls to enable the Application Command processing in general.

Pipes The Pipes enable buffered and stream-oriented data exchange between the PC Host and the target application. Any pipe can be written to and read from at both ends (either on the PC or the MCU). The data transmission is acknowledged using the special FreeMASTER protocol commands. It is guaranteed that the data bytes are delivered from the writer to the reader in a proper order and without losses.

Serial single-wire operation The MCU Serial Communication Driver natively supports normal dual-wire operation. Because the protocol is half-duplex only, the driver can also operate in two single-wire modes:

- “External” single-wire operation where the Receiver and Transmitter pins are shorted on the board. This mode is supported by default in the MCU driver because the Receiver and Transmitter units are enabled or disabled whenever needed. It is also easy to extend this operation for the RS485 communication.

- “True” single-wire mode which uses only a single pin and the direction switching is made by the UART module. This mode of operation must be enabled by defining the FMSTR_SERIAL_SINGLEWIRE configuration option.

Multi-session support With networking interface it is possible for multiple clients to access the target MCU simultaneously. Reading and writing of target memory is processed atomically so there is no risk of data corruption. The state-full resources such as Recorders or Oscilloscopes are locked to a client session upon first use and access is denied to other clients until lock is released..

Zephyr-specific

Dedicated communication task FreeMASTER communication may run isolated in a dedicated task. The task automates the FMSTR_Init and FMSTR_Poll calls together with periodic activities enabling the FreeMASTER UI to fetch information about tasks and CPU utilization. The task can be started automatically or manually, and it must be assigned a priority to be able to react on interrupts and other communication events. Refer to Zephyr FreeMASTER sample applications which all use this communication task.

Zephyr shell and logging over FreeMASTER pipe FreeMASTER implements a shell backend which may use FreeMASTER pipe as a I/O terminal and logging output. Refer to Zephyr FreeMASTER sample applications which all use this feature.

Automatic TSA tables TSA tables can be declared as “automatic” in Zephyr which make them automatically registered in the table list. This may be very useful when there are many TSA tables or when the tables are defined in different (often unrelated) libraries linked together. In this case user does not need to build a list of all tables manually.

Driver files The driver source files can be found in a top-level src folder, further divided into the sub-folders:

- **src/platforms** platform-specific folder—one folder exists for each supported processor platform (for example; 32-bit Little Endian platform). Each such folder contains a platform header file with data types and a code which implements the potentially platform-specific operations, such as aligned memory access.
- **src/common** folder—contains the common driver source files shared by the driver for all supported platforms. All the .c files must be added to the project, compiled, and linked together with the application.
 - *freemaster.h* - master driver header file, which declares the common data types, macros, and prototypes of the FreeMASTER driver API functions.
 - *freemaster_cfg.h.example* - this file can serve as an example of the FreeMASTER driver configuration file. Save this file into a project source code folder and rename it to *freemaster_cfg.h*. The FreeMASTER driver code includes this file to get the project-specific configuration options and to optimize the compilation of the driver.
 - *freemaster_defcfg.h* - defines the default values for each FreeMASTER configuration option if the option is not set in the *freemaster_cfg.h* file.
 - *freemaster_protocol.h* - defines the FreeMASTER protocol constants used internally by the driver.
 - *freemaster_protocol.c* - implements the FreeMASTER protocol decoder and handles the basic Get Configuration Value, Memory Read, and Memory Write commands.

- *freemaster_rec.c* - handles the Recorder-specific commands and implements the Recorder sampling and triggering routines. When the Recorder is disabled by the FreeMASTER driver configuration file, this file only compiles to empty API functions.
- *freemaster_scope.c* - handles the Oscilloscope-specific commands. If the Oscilloscope is disabled by the FreeMASTER driver configuration file, this file compiles as void.
- *freemaster_pipes.c* - implements the Pipes functionality when the Pipes feature is enabled.
- *freemaster_appcmd.c* - handles the communication commands used to deliver and execute the Application Commands within the context of the embedded application. When the Application Commands are disabled by the FreeMASTER driver configuration file, this file only compiles to empty API functions.
- *freemaster_tsa.c* - handles the commands specific to the TSA feature. This feature enables the FreeMASTER host tool to obtain the TSA memory descriptors declared in the embedded application. If the TSA is disabled by the FreeMASTER driver configuration file, this file compiles as void.
- *freemaster_tsa.h* - contains the declaration of the macros used to define the TSA memory descriptors. This file is indirectly included into the user application code (via *freemaster.h*).
- *freemaster_sha.c* - implements the SHA-1 hash code used in the password authentication algorithm.
- *freemaster_private.h* - contains the declarations of functions and data types used internally in the driver. It also contains the C pre-processor statements to perform the compile-time verification of the user configuration provided in the *freemaster_cfg.h* file.
- *freemaster_serial.c* - implements the serial protocol logic including the CRC, FIFO queuing, and other communication-related operations. This code calls the functions of the low-level communication driver indirectly via a character-oriented API exported by the specific low-level driver.
- *freemaster_serial.h* - defines the low-level character-oriented Serial API.
- *freemaster_can.c* - implements the CAN protocol logic including the CAN message preparation, signalling using the first data byte in the CAN frame, and other communication-related operations. This code calls the functions of the low-level communication driver indirectly via a message-oriented API exported by the specific low-level driver.
- *freemaster_can.h* - defines the low-level message-oriented CAN API.
- *freemaster_net.c* - implements the Network protocol transport logic including multiple session management code.
- *freemaster_net.h* - definitions related to the Network transport.
- *freemaster_pdbdm.c* - implements the packet-driven BDM communication buffer and other communication-related operations.
- *freemaster_utils.c* - aligned memory copy routines, circular buffer management and other utility functions
- *freemaster_utils.h* - definitions related to utility code.
- ***src/drivers/[sdk]/serial*** - contains the code related to the serial communication implemented using one of the supported SDK frameworks.
 - *freemaster_serial_XXX.c* and *.h* - implement low-level access to the communication peripheral registers. Different files exist for the UART, LPUART, USART, and other kinds of Serial communication modules.

- **src/drivers/[sdk]/can** - contains the code related to the serial communication implemented using one of the supported SDK frameworks.
 - *freemaster_XXX.c* and *.h* - implement low-level access to the communication peripheral registers. Different files exist for the FlexCAN, msCAN, MCAN, and other kinds of CAN communication modules.
- **src/drivers/[sdk]/network** - contains low-level code adapting the FreeMASTER Network transport to an underlying TCP/IP or RTT stack.
 - *freemaster_net_lwip_tcp.c* and *_udp.c* - default networking implementation of TCP and UDP transports using lwIP stack.
 - *freemaster_net_segger_rtt.c* - implementation of network transport using Segger J-Link RTT interface

Driver configuration The driver is configured using a single header file (*freemaster_cfg.h*). Create this file and save it together with other project source files before compiling the driver code. All FreeMASTER driver source files include the *freemaster_cfg.h* file and use the macros defined here for the conditional and parameterized compilation. The C compiler must locate the configuration file when compiling the driver files. Typically, it can be achieved by putting this file into a folder where the other project-specific included files are stored.

As a starting point to create the configuration file, get the *freemaster_cfg.h.example* file, rename it to *freemaster_cfg.h*, and save it into the project area.

Note: It is NOT recommended to leave the *freemaster_cfg.h* file in the FreeMASTER driver source code folder. The configuration file must be placed at a project-specific location, so that it does not affect the other applications that use the same driver.

Configurable items This section describes the configuration options which can be defined in *freemaster_cfg.h*.

Interrupt modes

```
#define FMSTR_LONG_INTR    [0|1]
#define FMSTR_SHORT_INTR  [0|1]
#define FMSTR_POLL_DRIVEN [0|1]
```

Value Type boolean (0 or 1)

Description Exactly one of the three macros must be defined to non-zero. The others must be defined to zero or left undefined. The non-zero-defined constant selects the interrupt mode of the driver. See [Driver interrupt modes](#).

- FMSTR_LONG_INTR — long interrupt mode
- FMSTR_SHORT_INTR — short interrupt mode
- FMSTR_POLL_DRIVEN — poll-driven mode

Note: Some options may not be supported by all communication interfaces. For example, the FMSTR_SHORT_INTR option is not supported by the USB_CDC interface.

Protocol transport

```
#define FMSTR_TRANSPORT [identifier]
```


Value Type Driver identifiers are structure instance names defined in FreeMASTER source code. Specify one of existing instances to make use of the protocol transport.

Description Use one of the pre-defined constants, as implemented by the FreeMASTER code. The current driver supports the following transports:

- **FMSTR_SERIAL** - serial communication protocol
- **FMSTR_CAN** - using CAN communication
- **FMSTR_PDBDM** - using packet-driven BDM communication
- **FMSTR_NET** - network communication using TCP or UDP protocol

Serial transport This section describes configuration parameters used when serial transport is used:

```
#define FMSTR_TRANSPORT FMSTR_SERIAL
```

FMSTR_SERIAL_DRV Select what low-level driver interface will be used when implementing the Serial communication.

```
#define FMSTR_SERIAL_DRV [identifier]
```

Value Type Driver identifiers are structure instance names defined in FreeMASTER drivers code. Specify one of existing serial driver instances.

Description When using MCUXpresso SDK, use one of the following constants (see */drivers/mcuxsdk/serial* implementation):

- **FMSTR_SERIAL_MCUX_UART** - UART driver
- **FMSTR_SERIAL_MCUX_LPUART** - LPUART driver
- **FMSTR_SERIAL_MCUX_USART** - USART driver
- **FMSTR_SERIAL_MCUX_MINIUSART** - miniUSART driver
- **FMSTR_SERIAL_MCUX_QSCI** - DSC QSCI driver
- **FMSTR_SERIAL_MCUX_USB** - USB/CDC class driver (also see code in the */support/mcuxsdk_usb* folder)
- **FMSTR_SERIAL_56F800E_EONCE** - DSC JTAG EOnCE driver

Other SDKs or BSPs may define custom low-level driver interface structure which may be used as **FMSTR_SERIAL_DRV**. For example:

- **FMSTR_SERIAL_DREG_UART** - demonstrates the low-level interface implemented without the MCUXpresso SDK and using direct access to peripheral registers.

FMSTR_SERIAL_BASE

```
#define FMSTR_SERIAL_BASE [address|symbol]
```

Value Type Optional address value (numeric or symbolic)

Description Specify the base address of the UART, LPUART, USART, or other serial peripheral module to be used for the communication. This value is not defined by default. User application should call `FMSTR_SetSerialBaseAddress()` to select the peripheral module.

FMSTR_COMM_BUFFER_SIZE

```
#define FMSTR_COMM_BUFFER_SIZE [number]
```

Value Type 0 or a value in range 32...255

Description Specify the size of the communication buffer to be allocated by the driver. Default value, which suits all driver features, is used when this option is defined as 0.

FMSTR_COMM_QUEUE_SIZE

```
#define FMSTR_COMM_QUEUE_SIZE [number]
```

Value Type Value in range 0...255

Description Specify the size of the FIFO receiver queue used to quickly receive and store characters in the `FMSTR_SHORT_INTR` interrupt mode. The default value is 32 B.

FMSTR_SERIAL_SINGLEWIRE

```
#define FMSTR_SERIAL_SINGLEWIRE [0|1]
```

Value Type Boolean 0 or 1.

Description Set to non-zero to enable the “True” single-wire mode which uses a single MCU pin to communicate. The low-level driver enables the pin direction switching when the MCU peripheral supports it.

CAN Bus transport This section describes configuration parameters used when CAN transport is used:

```
#define FMSTR_TRANSPORT FMSTR_CAN
```

FMSTR_CAN_DRV Select what low-level driver interface will be used when implementing the CAN communication.

```
#define FMSTR_CAN_DRV [identifier]
```

Value Type Driver identifiers are structure instance names defined in FreeMASTER drivers code. Specify one of existing CAN driver instances.

Description When using MCUXpresso SDK, use one of the following constants (see */drivers/mcuxsdk/can implementation*):

- **FMSTR_CAN_MCUX_FLEXCAN** - FlexCAN driver
- **FMSTR_CAN_MCUX_MCAN** - MCAN driver
- **FMSTR_CAN_MCUX_MSCAN** - msCAN driver
- **FMSTR_CAN_MCUX_DSCFLEXCAN** - DSC FlexCAN driver
- **FMSTR_CAN_MCUX_DSCMSCAN** - DSC msCAN driver

Other SDKs or BSPs may define the custom low-level driver interface structure which may be used as FMSTR_CAN_DRV.

FMSTR_CAN_BASE

```
#define FMSTR_CAN_BASE [address|symbol]
```

Value Type Optional address value (numeric or symbolic)

Description Specify the base address of the FlexCAN, msCAN, or other CAN peripheral module to be used for the communication. This value is not defined by default. User application should call FMSTR_SetCanBaseAddress() to select the peripheral module.

FMSTR_CAN_CMDID

```
#define FMSTR_CAN_CMDID [number]
```

Value Type CAN identifier (11-bit or 29-bit number)

Description CAN message identifier used for FreeMASTER commands (direction from PC Host tool to target application). When declaring 29-bit identifier, combine the numeric value with FMSTR_CAN_EXTID bit. Default value is 0x7AA.

FMSTR_CAN_RSPID

```
#define FMSTR_CAN_RSPID [number]
```

Value Type CAN identifier (11-bit or 29-bit number)

Description CAN message identifier used for responding messages (direction from target application to PC Host tool). When declaring 29-bit identifier, combine the numeric value with FMSTR_CAN_EXTID bit. Note that both *CMDID* and *RSPID* values may be the same. Default value is 0x7AA.

FMSTR_FLEXCAN_TXMB

```
#define FMSTR_FLEXCAN_TXMB [number]
```

Value Type Number in range of 0..N where N is number of CAN message-buffers supported by HW module.

Description Only used when the FlexCAN low-level driver is used. Define the FlexCAN message buffer for CAN frame transmission. Default value is 0.

FMSTR_FLEXCAN_RXMB

```
#define FMSTR_FLEXCAN_RXMB [number]
```

Value Type Number in range of 0..N where N is number of CAN message-buffers supported by HW module.

Description Only used when the FlexCAN low-level driver is used. Define the FlexCAN message buffer for CAN frame reception. Note that the FreeMASTER driver may also operate with a common message buffer used by both TX and RX directions. Default value is 1.

Network transport This section describes configuration parameters used when Network transport is used:

```
#define FMSTR_TRANSPORT FMSTR_NET
```

FMSTR_NET_DRV Select network interface implementation.

```
#define FMSTR_NET_DRV [identifier]
```

Value Type Identifiers are structure instance names defined in FreeMASTER drivers code. Specify one of existing NET driver instances.

Description When using MCUXpresso SDK, use one of the following constants (see */drivers/mcuxsdk/network implementation*):

- **FMSTR_NET_LWIP_TCP** - TCP communication using lwIP stack
- **FMSTR_NET_LWIP_UDP** - UDP communication using lwIP stack
- **FMSTR_NET_SEGGER_RTT** - Communication using SEGGER J-Link RTT interface

Other SDKs or BSPs may define the custom networking interface which may be used as FMSTR_CAN_DRV.

Add another row below:

FMSTR_NET_PORT

```
#define FMSTR_NET_PORT [number]
```

Value Type TCP or UDP port number (short integer)

Description Specifies the server port number used by TCP or UDP protocols.

FMSTR_NET_BLOCKING_TIMEOUT

```
#define FMSTR_NET_BLOCKING_TIMEOUT [number]
```

Value Type Timeout as number of milliseconds

Description This value specifies a timeout in milliseconds for which the network socket operations may block the execution inside *FMSTR_Poll*. This may be set high (e.g. 250) when a dedicated RTOS task is used to handle FreeMASTER protocol polling. Set to a lower value when the polling task is also responsible for other operations. Set to 0 to attempt to use non-blocking socket operations.

FMSTR_NET_AUTODISCOVERY

```
#define FMSTR_NET_AUTODISCOVERY [0|1]
```

Value Type Boolean 0 or 1.

Description This option enables the FreeMASTER driver to use a separate UDP socket to broadcast auto-discovery messages to network. This helps the FreeMASTER tool to discover the target device address, port and protocol options.

Debugging options

FMSTR_DISABLE

```
#define FMSTR_DISABLE [0|1]
```

Value Type boolean (0 or 1)

Description Define as non-zero to disable all FreeMASTER features, exclude the driver code from build, and compile all its API functions empty. This may be useful to remove FreeMASTER without modifying any application source code. Default value is 0 (false).

FMSTR_DEBUG_TX

```
#define FMSTR_DEBUG_TX [0|1]
```

Value Type Boolean 0 or 1.

Description Define as non-zero to enable the driver to periodically transmit test frames out on the selected communication interface (SCI or CAN). With the debug transmission enabled, it is simpler to detect problems in the baudrate or other communication configuration settings.

The test frames are transmitted until the first valid command frame is received from the PC Host tool. The test frame is a valid error status frame, as defined by the protocol format. On the serial line, the test frame consists of three printable characters (+©W) which are easy to capture using the serial terminal tools.

This feature requires the FMSTR_Poll() function to be called periodically. Default value is 0 (false).

FMSTR_APPLICATION_STR

```
#define FMSTR_APPLICATION_STR
```

Value Type String.

Description Name of the application visible in FreeMASTER host application.

Memory access**FMSTR_USE_READMEM**

```
#define FMSTR_USE_READMEM [0|1]
```

Value Type Boolean 0 or 1.

Description Define as non-zero to implement the Memory Read command and enable FreeMASTER to have read access to memory and variables. The access can be further restricted by using a TSA feature.
Default value is 1 (true).

FMSTR_USE_WRITEMEM

```
#define FMSTR_USE_WRITEMEM [0|1]
```

Value Type Boolean 0 or 1.

Description Define as non-zero to implement the Memory Write command.
The default value is 1 (true).

Oscilloscope options**FMSTR_USE_SCOPE**

```
#define FMSTR_USE_SCOPE [number]
```

Value Type Integer number.

Description Number of Oscilloscope instances to be supported. Set to 0 to disable the Oscilloscope feature.
Default value is 0.

FMSTR_MAX_SCOPE_VARS

```
#define FMSTR_MAX_SCOPE_VARS [number]
```

Value Type Integer number larger than 2.

Description Number of variables to be supported by each Oscilloscope instance.
Default value is 8.

Recorder options

FMSTR_USE_RECORDER

```
#define FMSTR_USE_RECORDER [number]
```

Value Type Integer number.

Description Number of Recorder instances to be supported. Set to 0 to disable the Recorder feature.
Default value is 0.

FMSTR_REC_BUFF_SIZE

```
#define FMSTR_REC_BUFF_SIZE [number]
```

Value Type Integer number larger than 2.

Description Defines the size of the memory buffer used by the Recorder instance #0.
Default: not defined, user shall call 'FMSTR_RecorderCreate()' API function to specify this parameter in run time.

FMSTR_REC_TIMEBASE

```
#define FMSTR_REC_TIMEBASE [time specification]
```

Value Type Number (nanoseconds time).

Description Defines the base sampling rate in nanoseconds (sampling speed) Recorder instance #0.

Use one of the following macros:

- FMSTR_REC_BASE_SECONDS(x)
- FMSTR_REC_BASE_MILLISEC(x)
- FMSTR_REC_BASE_MICROSEC(x)
- FMSTR_REC_BASE_NANOSEC(x)

Default: not defined, user shall call 'FMSTR_RecorderCreate()' API function to specify this parameter in run time.

FMSTR_REC_FLOAT_TRIG

```
#define FMSTR_REC_FLOAT_TRIG [0|1]
```

Value Type Boolean 0 or 1.

Description Define as non-zero to implement the floating-point triggering. Be aware that floating-point triggering may grow the code size by linking the floating-point standard library. Default value is 0 (false).

Application Commands options

FMSTR_USE_APPCMD

```
#define FMSTR_USE_APPCMD [0|1]
```

Value Type Boolean 0 or 1.

Description Define as non-zero to implement the Application Commands feature. Default value is 0 (false).

FMSTR_APPCMD_BUFF_SIZE

```
#define FMSTR_APPCMD_BUFF_SIZE [size]
```

Value Type Numeric buffer size in range 1..255

Description The size of the Application Command data buffer allocated by the driver. The buffer stores the (optional) parameters of the Application Command which waits to be processed.

FMSTR_MAX_APPCMD_CALLS

```
#define FMSTR_MAX_APPCMD_CALLS [number]
```

Value Type Number in range 0..255

Description The number of different Application Commands that can be assigned a callback handler function using FMSTR_RegisterAppCmdCall(). Default value is 0.

TSA options

FMSTR_USE_TSA

```
#define FMSTR_USE_TSA [0|1]
```

Value Type Boolean 0 or 1.

Description Enable the FreeMASTER TSA feature to be used. With this option enabled, the TSA tables defined in the applications are made available to the FreeMASTER host tool. Default value is 0 (false).

FMSTR_USE_TSA_SAFETY

```
#define FMSTR_USE_TSA_SAFETY [0|1]
```

Value Type Boolean 0 or 1.

Description Enable the memory access validation in the FreeMASTER driver. With this option, the host tool is not able to access the memory which is not described by at least one TSA descriptor. Also a write access is denied for objects defined as read-only in TSA tables. Default value is 0 (false).

FMSTR_USE_TSA_INROM

```
#define FMSTR_USE_TSA_INROM [0|1]
```

Value Type Boolean 0 or 1.

Description Declare all TSA descriptors as *const*, which enables the linker to put the data into the flash memory. The actual result depends on linker settings or the linker commands used in the project. Default value is 0 (false).

FMSTR_USE_TSA_DYNAMIC

```
#define FMSTR_USE_TSA_DYNAMIC [0|1]
```

Value Type Boolean 0 or 1.

Description Enable runtime-defined TSA entries to be added to the TSA table by the FMSTR_SetUpTsaBuff() and FMSTR_TsaAddVar() functions. Default value is 0 (false).

Pipes options

FMSTR_USE_PIPES

```
#define FMSTR_USE_PIPES [0|1]
```

Value Type Boolean 0 or 1.

Description Enable the FreeMASTER Pipes feature to be used. Default value is 0 (false).

FMSTR_MAX_PIPES_COUNT

```
#define FMSTR_MAX_PIPES_COUNT [number]
```

Value Type Number in range 1..63.

Description The number of simultaneous pipe connections to support. The default value is 1.

Driver interrupt modes To implement the communication, the FreeMASTER driver handles the Serial or CAN module's receive and transmit requests. Use the *freemaster_cfg.h* configuration file to select whether the driver processes the communication automatically in the interrupt service routine handler or if it only polls the status of the module (typically during the application idle time).

This section describes each of the interrupt mode in more details.

Completely Interrupt-Driven operation Activated using:

```
#define FMSTR_LONG_INTR 1
```

In this mode, both the communication and the FreeMASTER protocol decoding is done in the *FMSTR_SerialIsr*, *FMSTR_CanIsr*, or other interrupt service routine. Because the protocol execution may be a lengthy task (especially with the TSA-Safety enabled) it is recommended to use this mode only if the interrupt prioritization scheme is possible in the application and the FreeMASTER interrupt is assigned to a lower (the lowest) priority.

In this mode, the application code must register its own interrupt handler for all interrupt vectors related to the selected communication interface and call the *FMSTR_SerialIsr* or *FMSTR_CanIsr* functions from that handler.

Mixed Interrupt and Polling Modes Activated using:

```
#define FMSTR_SHORT_INTR 1
```

In this mode, the communication processing time is split between the interrupt routine and the main application loop or task. The raw communication is handled by the *FMSTR_SerialIsr*, *FMSTR_CanIsr*, or other interrupt service routine, while the protocol decoding and execution is handled by the *FMSTR_Poll* routine. Call *FMSTR_Poll* during the idle time in the application main loop.

The interrupt processing in this mode is relatively fast and deterministic. Upon a serial-receive event, the received character is only placed into a FIFO-like queue and it is not further processed. Upon a CAN receive event, the received frame is stored into a receive buffer. When transmitting, the characters are fetched from the prepared transmit buffer.

In this mode, the application code must register its own interrupt handler for all interrupt vectors related to the selected communication interface and call the *FMSTR_SerialIsr* or *FMSTR_CanIsr* functions from that handler.

When the serial interface is used as the serial communication interface, ensure that the *FMSTR_Poll* function is called at least once per *N* character time periods. *N* is the length of the FreeMASTER FIFO queue (*FMSTR_COMM_QUEUE_SIZE*) and the character time is the time needed to transmit or receive a single byte over the SCI line.

Completely Poll-driven

```
#define FMSTR_POLL_DRIVEN 1
```

In this mode, both the communication and the FreeMASTER protocol decoding are done in the *FMSTR_Poll* routine. No interrupts are needed and the *FMSTR_SerialIsr*, *FMSTR_CanIsr*, and similar handlers compile to an empty code.

When using this mode, ensure that the *FMSTR_Poll* function is called by the application at least once per the serial “character time” which is the time needed to transmit or receive a single character.

In the latter two modes (*FMSTR_SHORT_INTR* and *FMSTR_POLL_DRIVEN*), the protocol handling takes place in the *FMSTR_Poll* routine. An application interrupt can occur in the middle of the Read Memory or Write Memory commands’ execution and corrupt the variable being accessed by the FreeMASTER driver. In these two modes, some issues or glitches may occur when using FreeMASTER to visualize or monitor volatile variables modified in interrupt servicing code.

The same issue may appear even in the full interrupt mode (*FMSTR_LONG_INTR*), if volatile variables are modified in the interrupt code with a priority higher than the priority of the communication interrupt.

Data types Simple portability was one of the main requirements when writing the FreeMASTER driver. This is why the driver code uses the privately-declared data types and the vast majority of the platform-dependent code is separated in the platform-dependent source files. The data types used in the driver API are all defined in the platform-specific header file.

To prevent name conflicts with the symbols used in the application, all data types, macros, and functions have the *FMSTR_* prefix. The only global variables used in the driver are the transport and low-level API structures exported from the driver-implementation layer to upper layers. Other than that, all private variables are declared as static and named using the *fmstr_* prefix.

Communication interface initialization The FreeMASTER driver does not perform neither the initialization nor the configuration of the peripheral module that it uses to communicate. It is the application startup code responsibility to configure the communication module before the FreeMASTER driver is initialized by the *FMSTR_Init* call.

When the Serial communication module is used as the FreeMASTER communication interface, configure the UART receive and transmit pins, the serial communication baud rate, parity (no-parity), the character length (eight bits), and the number of stop bits (one) before initializing the FreeMASTER driver. For either the long or the short interrupt modes of the driver (see *Driver interrupt modes*), configure the interrupt controller and register an application-specific interrupt handler for all interrupt sources related to the selected serial peripheral module. Call the *FMSTR_SerialIsr* function from the application handler.

When a CAN module is used as the FreeMASTER communication interface, configure the CAN receive and transmit pins and the CAN module bit rate before initializing the FreeMASTER driver. For either the long or the short interrupt modes of the driver (see *Driver interrupt modes*), configure the interrupt controller and register an application-specific interrupt handler for all interrupt sources related to the selected CAN peripheral module. Call the *FMSTR_CanIsr* function from the application handler.

Note: It is not necessary to enable or unmask the serial nor the CAN interrupts before initializing the FreeMASTER driver. The driver enables or disables the interrupts and communication lines, as required during runtime.

FreeMASTER Recorder calls When using the FreeMASTER Recorder in the application (*FMSTR_USE_RECORDER* > 0), call the *FMSTR_RecorderCreate* function early after *FMSTR_Init* to set

up each recorder instance to be used in the application. Then call the `FMSTR_Recorder` function periodically in the code where the data recording should occur. A typical place to call the Recorder routine is at the timer or PWM interrupts, but it can be anywhere else. The example applications provided together with the driver code call the `FMSTR_Recorder` in the main application loop.

In applications where `FMSTR_Recorder` is called periodically with a constant period, specify the period in the Recorder configuration structure before calling `FMSTR_RecorderCreate`. This setting enables the PC Host FreeMASTER tool to display the X-axis of the Recorder graph properly scaled for the time domain.

Driver usage Start using or evaluating FreeMASTER by opening some of the example applications available in the driver setup package.

Follow these steps to enable the basic FreeMASTER connectivity in the application:

- Make sure that all `*.c` files of the FreeMASTER driver from the `src/common/platforms/[your_platform]` folder are a part of the project. See [Driver files](#) for more details.
- Configure the FreeMASTER driver by creating or editing the `freemaster_cfg.h` file and by saving it into the application project directory. See [Driver configuration](#) for more details.
- Include the `freemaster.h` file into any application source file that makes the FreeMASTER API calls.
- Initialize the Serial or CAN modules. Set the baud rate, parity, and other parameters of the communication. Do not enable the communication interrupts in the interrupt mask registers.
- For the `FMSTR_LONG_INTR` and `FMSTR_SHORT_INTR` modes, install the application-specific interrupt routine and call the `FMSTR_SerialIsr` or `FMSTR_CanIsr` functions from this handler.
- Call the `FMSTR_Init` function early on in the application initialization code.
- Call the `FMSTR_RecorderCreate` functions for each Recorder instance to enable the Recorder feature.
- In the main application loop, call the `FMSTR_Poll` API function periodically when the application is idle.
- For the `FMSTR_SHORT_INTR` and `FMSTR_LONG_INTR` modes, enable the interrupts globally so that the interrupts can be handled by the CPU.

Communication troubleshooting The most common problem that causes communication issues is a wrong baud rate setting or a wrong pin multiplexer setting of the target MCU. When a communication between the PC Host running FreeMASTER and the target MCU cannot be established, try enabling the `FMSTR_DEBUG_TX` option in the `freemaster_cfg.h` file and call the `FMSTR_Poll` function periodically in the main application task loop.

With this feature enabled, the FreeMASTER driver periodically transmits a test frame through the Serial or CAN lines. Use a logic analyzer or an oscilloscope to monitor the signals at the communication pins of the CPU device to examine whether the bit rate and signal polarity are configured properly.

Driver API

This section describes the driver Application Programmers' Interface (API) needed to initialize and use the FreeMASTER serial communication driver.

Control API There are three key functions to initialize and use the driver.

FMSTR_Init

Prototype

```
FMSTR_BOOL FMSTR_Init(void);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_protocol.c*

Description This function initializes the internal variables of the FreeMASTER driver and enables the communication interface. This function does not change the configuration of the selected communication module. The hardware module must be initialized before the *FMSTR_Init* function is called.

A call to this function must occur before calling any other FreeMASTER driver API functions.

FMSTR_Poll

Prototype

```
void FMSTR_Poll(void);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_protocol.c*

Description In the poll-driven or short interrupt modes, this function handles the protocol decoding and execution (see *Driver interrupt modes*). In the poll-driven mode, this function also handles the communication interface with the PC. Typically, the *FMSTR_Poll* function is called during the “idle” time in the main application task loop.

To prevent the receive data overflow (loss) on a serial interface, make sure that the *FMSTR_Poll* function is called at least once per the time calculated as:

$$N * Tchar$$

where:

- *N* is equal to the length of the receive FIFO queue (configured by the *FMSTR_COMM_QUEUE_SIZE* macro). *N* is 1 for the poll-driven mode.
- *Tchar* is the character time, which is the time needed to transmit or receive a single byte over the SCI line.

Note: In the long interrupt mode, this function typically compiles as an empty function and can still be called. It is worthwhile to call this function regardless of the interrupt mode used in the application. This approach enables a convenient switching between the different interrupt modes only by changing the configuration macros in the *freemaster_cfg.h* file.

FMSTR_SerialIsr / FMSTR_CanIsr

Prototype

```
void FMSTR_SerialIsr(void);  
void FMSTR_CanIsr(void);
```

- Declaration: *freemaster.h*
- Implementation: *hw-specific low-level driver C file*

Description This function contains the interrupt-processing code of the FreeMASTER driver. In long or short interrupt modes (see [Driver interrupt modes](#)), this function must be called from the application interrupt service routine registered for the communication interrupt vector. On platforms where the communication module uses multiple interrupt vectors, the application should register a handler for all vectors and call this function at each interrupt.

Note: In a poll-driven mode, this function is compiled as an empty function and does not have to be used.

Recorder API

FMSTR_RecorderCreate

Prototype

```
FMSTR_BOOL FMSTR_RecorderCreate(FMSTR_INDEX recIndex, FMSTR_REC_BUFF* buffCfg);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_rec.c*

Description This function registers a recorder instance and enables it to be used by the PC Host tool. Call this function for all recorder instances from 0 to the maximum number defined by the FMSTR_USE_RECORDER configuration option (minus one). An exception to this requirement is the recorder of instance 0 which may be automatically configured by FMSTR_Init when the *freemaster_cfg.h* configuration file defines the *FMSTR_REC_BUFF_SIZE* and *FMSTR_REC_TIMEBASE* options.

For more information, see [Configurable items](#).

FMSTR_Recorder

Prototype

```
void FMSTR_Recorder(FMSTR_INDEX recIndex);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_rec.c*

Description This function takes a sample of the variables being recorded using the FreeMASTER Recorder instance *recIndex*. If the selected Recorder is not active when the *FMSTR_Recorder* function is being called, the function returns immediately. When the Recorder is active, the values of the variables being recorded are copied into the recorder buffer and the trigger conditions are evaluated.

If a trigger condition is satisfied, the Recorder enters the post-trigger mode, where it counts down the follow-up samples (number of *FMSTR_Recorder* function calls) and de-activates the Recorder when the required post-trigger samples are finished.

The *FMSTR_Recorder* function is typically called in the timer or PWM interrupt service routines. This function can also be called in the application main loop (for testing purposes).

FMSTR_RecorderTrigger

Prototype

```
void FMSTR_RecorderTrigger(FMSTR_INDEX recIndex);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_rec.c*

Description This function forces the Recorder trigger condition to happen, which causes the Recorder to be automatically deactivated after the post-trigger samples are sampled. Use this function in the application code for programmatic control over the Recorder triggering. This can be useful when a more complex triggering conditions need to be used.

Fast Recorder API The Fast Recorder feature is not available in the FreeMASTER driver version 3. This feature was heavily dependent on the target platform and it was only available for the 56F8xxx DSCs.

TSA Tables When the TSA is enabled in the FreeMASTER driver configuration file (by setting the *FMSTR_USE_TSA* macro to a non-zero value), it defines the so-called TSA tables in the application. This section describes the macros that must to be used to define the TSA tables.

There can be any number of TSA tables spread across the application source files. There must be always exactly one TSA Table List defined, which informs the FreeMASTER driver about the active TSA tables.

When there is at least one TSA table and one TSA Table List defined in the application, the TSA information automatically appears in the FreeMASTER symbols list. The symbols can then be used to create FreeMASTER variables for visualization or control.

TSA table definition The TSA table describes the static or global variables together with their address, size, type, and access-protection information. If the TSA-described variables are of a structure type, the TSA table may also describe this type and provide an access to the individual structure members of the variable.

The TSA table definition begins with the *FMSTR_TSA_TABLE_BEGIN* macro with a *table_id* identifying the table. The *table_id* shall be a valid C-language symbol.

```
FMSTR_TSA_TABLE_BEGIN(table_id)
```

After this opening macro, the TSA descriptors are placed using these macros:

```
/* Adding variable descriptors */
FMSTR_TSA_RW_VAR(name, type) /* read/write variable entry */
FMSTR_TSA_RO_VAR(name, type) /* read-only variable entry */

/* Description of complex data types */
FMSTR_TSA_STRUCT(struct_name) /* structure or union type entry */
```

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```

FMSTR_TSA_MEMBER(struct_name, member_name, type) /* structure member entry */

/* Memory blocks */
FMSTR_TSA_RW_MEM(name, type, address, size) /* read/write memory block */
FMSTR_TSA_RO_MEM(name, type, address, size) /* read-only memory block */

```

The table is closed using the FMSTR_TSA_TABLE_END macro:

```
FMSTR_TSA_TABLE_END()
```

TSA descriptor parameters The TSA descriptor macros accept these parameters:

- *name* — variable name. The variable must be defined before the TSA descriptor references it.
- *type* — variable or member type. Only one of the pre-defined type constants may be used (see below).
- *struct_name* — structure type name. The type must be defined (typedef) before the TSA descriptor references it.
- *member_name* — structure member name.

Note: The structure member descriptors (FMSTR_TSA_MEMBER) must immediately follow the parent structure descriptor (FMSTR_TSA_STRUCT) in the table.

Note: To write-protect the variables in the FreeMASTER driver (FMSTR_TSA_RO_VAR), enable the TSA-Safety feature in the configuration file.

TSA variable types The table lists *type* identifiers which can be used in TSA descriptors:

Constant	Description
FMSTR_TSA_UINTn	Unsigned integer type of size <i>n</i> bits (n=8,16,32,64)
FMSTR_TSA_SINTn	Signed integer type of size <i>n</i> bits (n=8,16,32,64)
FMSTR_TSA_FRACn	Fractional number of size <i>n</i> bits (n=16,32,64).
FMSTR_TSA_FRAC_Q(<i>m,n</i>)	Signed fractional number in general Q form (m+n+1 total bits)
FMSTR_TSA_FRAC_UQ(<i>m,n</i>)	Unsigned fractional number in general UQ form (m+n total bits)
FMSTR_TSA_FLOAT	4-byte standard IEEE floating-point type
FMSTR_TSA_DOUBLE	8-byte standard IEEE floating-point type
FMSTR_TSA_POINTER	Generic pointer type defined (platform-specific 16 or 32 bit)
FM-STR_TSA_USERTYPE(<i>name</i>)	Structure or union type declared with FMSTR_TSA_STRUCT record

TSA table list There shall be exactly one TSA Table List in the application. The list contains one entry for each TSA table defined anywhere in the application.

The TSA Table List begins with the FMSTR_TSA_TABLE_LIST_BEGIN macro and continues with the TSA table entries for each table.

```

FMSTR_TSA_TABLE_LIST_BEGIN()

FMSTR_TSA_TABLE(table_id)
FMSTR_TSA_TABLE(table_id2)
FMSTR_TSA_TABLE(table_id3)
...

```

The list is closed with the FMSTR_TSA_TABLE_LIST_END macro:

```
FMSTR_TSA_TABLE_LIST_END()
```

TSA Active Content entries FreeMASTER v2.0 and higher supports TSA Active Content, enabling the TSA tables to describe the memory-mapped files, virtual directories, and URL hyperlinks. FreeMASTER can access such objects similarly to accessing the files and folders on the local hard drive.

With this set of TSA entries, the FreeMASTER pages can be embedded directly into the target MCU flash and accessed by FreeMASTER directly over the communication line. The HTML-coded pages rendered inside the FreeMASTER window can access the TSA Active Content resources using a special URL referencing the *fmstr:* protocol.

This example provides an overview of the supported TSA Active Content entries:

```
FMSTR_TSA_TABLE_BEGIN(files_and_links)

/* Directory entry applies to all subsequent MEMFILE entries */
FMSTR_TSA_DIRECTORY("/text_files") /* entering a new virtual directory */

/* The readme.txt file will be accessible at the fmstr://text_files/readme.txt URL */
FMSTR_TSA_MEMFILE("readme.txt", readme_txt, sizeof(readme_txt)) /* memory-mapped file */

/* Files can also be specified with a full path so the DIRECTORY entry does not apply */
FMSTR_TSA_MEMFILE("/index.htm", index, sizeof(index)) /* memory-mapped file */
FMSTR_TSA_MEMFILE("/prj/demo.pmp", demo_pmp, sizeof(demo_pmp)) /* memory-mapped file */

/* Hyperlinks can point to a local MEMFILE object or to the Internet */
FMSTR_TSA_HREF("Board's Built-in Welcome Page", "/index.htm")
FMSTR_TSA_HREF("FreeMASTER Home Page", "http://www.nxp.com/freemaster")

/* Project file links simplify opening the projects from any URLs */
FMSTR_TSA_PROJECT("Demonstration Project (embedded)", "/prj/demo.pmp")
FMSTR_TSA_PROJECT("Full Project (online)", "http://mycompany.com/prj/demo.pmp")

FMSTR_TSA_TABLE_END()
```

TSA API

FMSTR_SetUpTsaBuff

Prototype

```
FMSTR_BOOL FMSTR_SetUpTsaBuff(FMSTR_ADDR buffAddr, FMSTR_SIZE buffSize);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_tsa.c*

Arguments

- *buffAddr* [in] - address of the memory buffer for the dynamic TSA table
- *buffSize* [in] - size of the memory buffer which determines the maximum number of TSA entries to be added in the runtime

Description This function must be used to assign the RAM memory buffer to the TSA subsystem when FMSTR_USE_TSA_DYNAMIC is enabled. The memory buffer is then used to store the TSA entries added dynamically to the runtime TSA table using the FMSTR_TsaAddVar function call. The runtime TSA table is processed by the FreeMASTER PC Host tool along with all static tables as soon as the communication port is open.

The size of the memory buffer determines the number of TSA entries that can be added dynamically. Depending on the MCU platform, one TSA entry takes either 8 or 16 bytes.

FMSTR_TsaAddVar

Prototype

```
FMSTR_BOOL FMSTR_TsaAddVar(FMSTR_TSATBL_STRPTR tsaName, FMSTR_TSATBL_STRPTR ↵
↵ tsaType,
    FMSTR_TSATBL_VOIDPTR varAddr, FMSTR_SIZE32 varSize,
    FMSTR_SIZE flags);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_tsa.c*

Arguments

- *tsaName* [in] - name of the object
- *tsaType* [in] - name of the object type
- *varAddr* [in] - address of the object
- *varSize* [in] - size of the object
- *flags* [in] - access flags; a combination of these values:
 - FMSTR_TSA_INFO_RO_VAR — read-only memory-mapped object (typically a variable)
 - FMSTR_TSA_INFO_RW_VAR — read/write memory-mapped object
 - FMSTR_TSA_INFO_NON_VAR — other entry, describing structure types, structure members, enumerations, and other types

Description This function can be called only when the dynamic TSA table is enabled by the FMSTR_USE_TSA_DYNAMIC configuration option and when the FMSTR_SetUpTsaBuff function call is made to assign the dynamic TSA table memory. This function adds an entry into the dynamic TSA table. It can be used to register a read-only or read/write memory object or describe an item of the user-defined type.

See [TSA table definition](#) for more details about the TSA table entries.

Application Commands API

FMSTR_GetAppCmd

Prototype

```
FMSTR_APPCMD_CODE FMSTR_GetAppCmd(void);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_appcmd.c*

Description This function can be used to detect if there is an Application Command waiting to be processed by the application. If no command is pending, this function returns the FMSTR_APPCMDRESULT_NOCMD constant. Otherwise, this function returns the code of the Application Command that must be processed. Use the FMSTR_AppCmdAck call to acknowledge the Application Command after it is processed and to return the appropriate result code to the host.

The FMSTR_GetAppCmd function does not report the commands for which a callback handler function exists. If the FMSTR_GetAppCmd function is called when a callback-registered command is pending (and before it is actually processed by the callback function), this function returns FMSTR_APPCMDRESULT_NOCMD.

FMSTR_GetAppCmdData

Prototype

```
FMSTR_APPCMD_PDATA FMSTR_GetAppCmdData(FMSTR_SIZE* dataLen);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_appcmd.c*

Arguments

- *dataLen* [out] - pointer to the variable that receives the length of the data available in the buffer. It can be NULL when this information is not needed.

Description This function can be used to retrieve the Application Command data when the application determines that an Application Command is pending (see [FMSTR_GetAppCmd](#)).

There is just a single buffer to hold the Application Command data (the buffer length is FMSTR_APPCMD_BUFF_SIZE bytes). If the data are to be used in the application after the command is processed by the FMSTR_AppCmdAck call, copy the data out to a private buffer.

FMSTR_AppCmdAck

Prototype

```
void FMSTR_AppCmdAck(FMSTR_APPCMD_RESULT resultCode);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_appcmd.c*

Arguments

- *resultCode* [in] - the result code which is to be returned to FreeMASTER

Description This function is used when the Application Command processing finishes in the application. The resultCode passed to this function is returned back to the host and the driver is re-initialized to expect the next Application Command.

After this function is called and before the next Application Command arrives, the return value of the FMSTR_GetAppCmd function is FMSTR_APPCMDRESULT_NOCMD.

FMSTR_AppCmdSetResponseData

Prototype

```
void FMSTR_AppCmdSetResponseData(FMSTR_ADDR resultDataAddr, FMSTR_SIZE resultDataLen);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_appcmd.c*

Arguments

- *resultDataAddr* [in] - pointer to the data buffer that is to be copied to the Application Command data buffer
- *resultDataLen* [in] - length of the data to be copied. It must not exceed the FMSTR_APPCMD_BUFF_SIZE value.

Description This function can be used before the Application Command processing finishes, when there are data to be returned back to the PC.

The response data buffer is copied into the Application Command data buffer, from where it is accessed when the host requires it. Do not use FMSTR_GetAppCmdData and the data buffer after FMSTR_AppCmdSetResponseData is called.

Note: The current version of FreeMASTER does not support the Application Command response data.

FMSTR_RegisterAppCmdCall

Prototype

```
FMSTR_BOOL FMSTR_RegisterAppCmdCall(FMSTR_APPCMD_CODE appCmdCode, FMSTR_
↳PAPPCMDFUNC callbackFunc);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_appcmd.c*

Arguments

- *appCmdCode* [in] - the Application Command code for which the callback is to be registered
- *callbackFunc* [in] - pointer to the callback function that is to be registered. Use NULL to unregister a callback registered previously with this Application Command.

Return value This function returns a non-zero value when the callback function was successfully registered or unregistered. It can return zero when trying to register a callback function for more than FMSTR_MAX_APPCMD_CALLS different Application Commands.

Description This function can be used to register the given function as a callback handler for the Application Command. The Application Command is identified using single-byte code. The callback function is invoked automatically by the FreeMASTER driver when the protocol decoder obtains a request to get the application command result code.

The prototype of the callback function is

```
FMSTR_APPCMD_RESULT HandlerFunction(FMSTR_APPCMD_CODE nAppcmd,
FMSTR_APPCMD_PDATA pData, FMSTR_SIZE nDataLen);
```

Where:

- *nAppcmd* -Application Command code
- *pData* —points to the Application Command data received (if any)
- *nDataLen* —information about the Application Command data length

The return value of the callback function is used as the Application Command Result Code and returned to FreeMASTER.

Note: The FMSTR_MAX_APPCMD_CALLS configuration macro defines how many different Application Commands may be handled by a callback function. When FMSTR_MAX_APPCMD_CALLS is undefined or defined as zero, the FMSTR_RegisterAppCmdCall function always fails.

Pipes API

FMSTR_PipeOpen

Prototype

```
FMSTR_HPIPE FMSTR_PipeOpen(FMSTR_PIPE_PORT pipePort, FMSTR_PPIPEFUNC pipeCallback,
    FMSTR_ADDR pipeRxBuff, FMSTR_PIPE_SIZE pipeRxSize,
    FMSTR_ADDR pipeTxBuff, FMSTR_PIPE_SIZE pipeTxSize,
    FMSTR_U8 type, const FMSTR_CHAR *name);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_pipes.c*

Arguments

- *pipePort* [in] - port number that identifies the pipe for the client
- *pipeCallback* [in] - pointer to the callback function that is called whenever a pipe data status changes
- *pipeRxBuff* [in] - address of the receive memory buffer
- *pipeRxSize* [in] - size of the receive memory buffer
- *pipeTxBuff* [in] - address of the transmit memory buffer
- *pipeTxSize* [in] - size of the transmit memory buffer
- *type* [in] - a combination of FMSTR_PIPE_MODE_xxx and FMSTR_PIPE_SIZE_xxx constants describing primary pipe data format and usage. This type helps FreeMASTER decide how to access the pipe by default. Optional, use 0 when undetermined.
- *name* [in] - user name of the pipe port. This name is visible to the FreeMASTER user when creating the graphical pipe interface.

Description This function initializes a new pipe and makes it ready to accept or send the data to the PC Host client. The receive memory buffer is used to store the received data before they are read out by the FMSTR_PipeRead call. When this buffer gets full, the PC Host client denies the data transmission into this pipe until there is enough free space again. The transmit memory buffer is used to store the data transmitted by the application to the PC Host client using the FMSTR_PipeWrite call. The transmit buffer can get full when the PC Host is disconnected or when it is slow in receiving and reading out the pipe data.

The function returns the pipe handle which must be stored and used in the subsequent calls to manage the pipe object.

The callback function (if specified) is called whenever new data are received through the pipe and available for reading. This callback is also called when the data waiting in the transmit buffer are successfully pushed to the PC Host and the transmit buffer free space increases. The prototype of the callback function provided by the user application must be as follows. The *PipeHandler* name is only a placeholder and must be defined by the application.

```
void PipeHandler(FMSTR_HPIPE pipeHandle);
```

FMSTR_PipeClose

Prototype

```
void FMSTR_PipeClose(FMSTR_HPIPE pipeHandle);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_pipes.c*

Arguments

- *pipeHandle* [in] - pipe handle returned from the FMSTR_PipeOpen function call

Description This function de-initializes the pipe object. No data can be received or sent on the pipe after this call.

FMSTR_PipeWrite

Prototype

```
FMSTR_PIPE_SIZE FMSTR_PipeWrite(FMSTR_HPIPE pipeHandle, FMSTR_ADDR pipeData,  
    FMSTR_PIPE_SIZE pipeDataLen, FMSTR_PIPE_SIZE writeGranularity);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_pipes.c*

Arguments

- *pipeHandle* [in] - pipe handle returned from the FMSTR_PipeOpen function call
- *pipeData* [in] - address of the data to be written
- *pipeDataLen* [in] - length of the data to be written
- *writeGranularity* [in] - size of the minimum unit of data which is to be written

Description This function puts the user-specified data into the pipe's transmit memory buffer and schedules it for transmission. This function returns the number of bytes that were successfully written into the buffer. This number may be smaller than the number of the requested bytes if there is not enough free space in the transmit buffer.

The *writeGranularity* argument can be used to split the data into smaller chunks, each of the size given by the *writeGranularity* value. The FMSTR_PipeWrite function writes as many data chunks as possible into the transmit buffer and does not attempt to write an incomplete chunk.

This feature can prove to be useful to avoid the intermediate caching when writing an array of integer values or other multi-byte data items. When making the `nGranularity` value equal to the `nLength` value, all data are considered as one chunk which is either written successfully as a whole or not at all. The `nGranularity` value of 0 or 1 disables the data-chunk approach.

FMSTR_PipeRead

Prototype

```
FMSTR_PIPE_SIZE FMSTR_PipeRead(FMSTR_HPIPE pipeHandle, FMSTR_ADDR pipeData,
    FMSTR_PIPE_SIZE pipeDataLen, FMSTR_PIPE_SIZE readGranularity);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_pipes.c*

Arguments

- *pipeHandle* [in] - pipe handle returned from the `FMSTR_PipeOpen` function call
- *pipeData* [in] - address of the data buffer to be filled with the received data
- *pipeDataLen* [in] - length of the data to be read
- *readGranularity* [in] - size of the minimum unit of data which is to be read

Description This function copies the data received from the pipe from its receive buffer to the user buffer for further processing. The function returns the number of bytes that were successfully copied to the buffer. This number may be smaller than the number of the requested bytes if there is not enough data bytes available in the receive buffer.

The `readGranularity` argument can be used to copy the data in larger chunks in the same way as described in the `FMSTR_PipeWrite` function.

API data types This section describes the data types used in the FreeMASTER driver. The information provided here can be useful when modifying or porting the FreeMASTER Communication Driver to new NXP platforms.

Note: The licensing conditions prohibit use of FreeMASTER and the FreeMASTER Communication Driver with non-NXP MPU or MCU products.

Public common types The table below describes the public data types used in the FreeMASTER driver API calls. The data types are declared in the *freemaster.h* header file.

Type name	Description
<i>FM-STR_ADDR</i> For example, this type is defined as long integer on the 56F8xxx platform where the 24-bit addresses must be supported, but the C-pointer may be only 16 bits wide in some compiler configurations.	Data type used to hold the memory address. On most platforms, this is normally a C-pointer, but it may also be a pure integer type.
<i>FM-STR_SIZE</i> It is required that this type is unsigned and at least 16 bits wide integer.	Data type used to hold the memory block size.
<i>FM-STR_BOOL</i> This type is used only in zero/non-zero conditions in the driver code.	Data type used as a general boolean type.
<i>FM-STR_APPCM</i> Generally, this is an unsigned 8-bit value.	Data type used to hold the Application Command code.
<i>FM-STR_APPCM</i> Generally, this is an unsigned 8-bit value.	Data type used to create the Application Command data buffer.
<i>FM-STR_APPCM</i> Generally, this is an unsigned 8-bit value.	Data type used to hold the Application Command result code.

Public TSA types The table describes the TSA-specific public data types. These types are declared in the *freemaster_tsa.h* header file, which is included in the user application indirectly by the *freemaster.h* file.

<i>FM-STR_TSA_TII</i>	Data type used to hold a descriptor index in the TSA table or a table index in the list of TSA tables. By default, this is defined as <i>FM-STR_SIZE</i> .
<i>FM-STR_TSA_TS</i>	Data type used to hold a memory block size, as used in the TSA descriptors. By default, this is defined as <i>FM-STR_SIZE</i> .

Public Pipes types The table describes the data types used by the FreeMASTER Pipes API:

<i>FM-STR_HPIPE</i>	Pipe handle that identifies the open-pipe object. Generally, this is a pointer to a void type.
<i>FM-STR_PIPE_PC</i>	Integer type required to hold at least 7 bits of data. Generally, this is an unsigned 8-bit or 16-bit type.
<i>FM-STR_PIPE_SI</i>	Integer type required to hold at least 16 bits of data. This is used to store the data buffer sizes.
<i>FM-STR_PPIPEF</i>	Pointer to the pipe handler function. See FM-STR_PipeOpen for more details.

Internal types The table describes the data types used internally by the FreeMASTER driver. The data types are declared in the platform-specific header file and they are not available in the application code.

<i>FMSTR_U8</i>	The smallest memory entity.
On the vast majority of platforms, this is an unsigned 8-bit integer.	
On the 56F8xx DSP platform, this is defined as an unsigned 16-bit integer.	
<i>FMSTR_U16</i>	Unsigned 16-bit integer.
<i>FMSTR_U32</i>	Unsigned 32-bit integer.
<i>FMSTR_S8</i>	Signed 8-bit integer.
<i>FMSTR_S16</i>	Signed 16-bit integer.
<i>FMSTR_S32</i>	Signed 32-bit integer.
<i>FMSTR_FLOAT</i>	4-byte standard IEEE floating-point type.
<i>FMSTR_FLAGS</i>	Data type forming a union with a structure of flag bit-fields.
<i>FMSTR_SIZE8</i>	Data type holding a general size value, at least 8 bits wide.
<i>FMSTR_INDEX</i>	General for-loop index. Must be signed, at least 16 bits wide.
<i>FMSTR_BCHR</i>	A single character in the communication buffer.
Typically, this is an 8-bit unsigned integer, except for the DSP platforms where it is a 16-bit integer.	
<i>FMSTR_BPTR</i>	A pointer to the communication buffer (an array of <i>FMSTR_BCHR</i>).

Document references

Links

- This document online: <https://mcuxpresso.nxp.com/mcuxsdk/latest/html/middleware/freemaster/doc/index.html>

- FreeMASTER tool home: www.nxp.com/freemaster
- FreeMASTER community area: community.nxp.com/community/freemaster
- FreeMASTER GitHub code repo: <https://github.com/nxp-mcuxpresso/mcux-freemaster>
- MCUXpresso SDK home: www.nxp.com/mcuxpresso
- MCUXpresso SDK builder: mcuxpresso.nxp.com/en

Documents

- *FreeMASTER Usage Serial Driver Implementation* (document [AN4752](#))
- *Integrating FreeMASTER Time Debugging Tool With CodeWarrior For Microcontrollers v10.X Project* (document [AN4771](#))
- *Flash Driver Library For MC56F847xx And MC56F827xx DSC Family* (document [AN4860](#))

Revision history This Table summarizes the changes done to this document since the initial release.

Revision	Date	Description
1.0	03/2006	Limited initial release
2.0	09/2007	Updated for FreeMASTER version. New Freescale document template used.
2.1	12/2007	Added description of the new Fast Recorder feature and its API.
2.2	04/2010	Added support for MPC56xx platform, Added new API for use CAN interface.
2.3	04/2011	Added support for Kxx Kinetis platform and MQX operating system.
2.4	06/2011	Serial driver update, adds support for USB CDC interface.
2.5	08/2011	Added Packet Driven BDM interface.
2.7	12/2013	Added FLEXCAN32 interface, byte access and isr callback configuration option.
2.8	06/2014	Removed obsolete license text, see the software package content for up-to-date license.
2.9	03/2015	Update for driver version 1.8.2 and 1.9: FreeMASTER Pipes, TSA Active Content, LIN Transport Layer support, DEBUG-TX communication troubleshooting, Kinetis SDK support.
3.0	08/2016	Update for driver version 2.0: Added support for MPC56xx, MPC57xx, KEAxx and S32Kxx platforms. New NXP document template as well as new license agreement used. added MCAN interface. Folders structure at the installation destination was rearranged.
4.0	04/2019	Update for driver released as part of FreeMASTER v3.0 and MCUXpresso SDK 2.6. Updated to match new V4 serial communication protocol and new configuration options. This version of the document removes substantial portion of outdated information related to S08, S12, ColdFire, Power and other legacy platforms.
4.1	04/2020	Minor update for FreeMASTER driver included in MCUXpresso SDK 2.8.
4.2	09/2020	Added example applications description and information about the MCUXpresso Config Tools. Fixed the pipe-related API description.
4.3	10/2024	Added description of Network and Segger J-Link RTT interface configuration. Accompanying the MCUXpresso SDK version 24.12.00.
4.4	04/2025	Added Zephyr-specific information. Accompanying the MCUXpresso SDK version 25.06.00.

3.6 MultiCore

3.6.1 Multicore SDK

Multicore Software Development Kit (MCSDK) is a Software Development Kit that provides comprehensive software support for NXP dual/multicore devices. The MCSDK is combined with the MCUXpresso SDK to make the software framework for easy development of multicore applications.

Multicore SDK (MCSDK) Release Notes

Overview These are the release notes for the NXP Multicore Software Development Kit (MCSDK) version 25.06.00.

This software package contains components for efficient work with multicore devices as well as for the multiprocessor communication.

What is new

- eRPC [CHANGELOG](#)
- RPMsg-Lite [CHANGELOG](#)
- MCMgr [CHANGELOG](#)
- Supported evaluation boards (multicore examples):
 - LPCXpresso55S69
 - FRDM-K32L3A6
 - MIMXRT1170-EVKB
 - MIMXRT1160-EVK
 - MIMXRT1180-EVK
 - MCX-N5XX-EVK
 - MCX-N9XX-EVK
 - FRDM-MCXN947
 - MIMXRT700-EVK
 - KW47-EVK
 - KW47-LOC
 - FRDM-MCXW72
 - MCX-W72-EVK
- Supported evaluation boards (multiprocessor examples):
 - LPCXpresso55S36
 - FRDM-K22F
 - FRDM-K32L2B
 - MIMXRT685-EVK
 - MIMXRT1170-EVKB
 - MIMXRT1180
 - FRDM-MCXN236
 - FRDM-MCXC242
 - FRDM-MCXC444
 - MCX-N9XX-EVK
 - FRDM-MCXN947
 - MIMXRT700-EVK

Development tools The Multicore SDK (MCSDK) was compiled and tested with development tools referred in: [Development tools](#)

Release contents This table describes the release contents. Not all MCUXpresso SDK packages contain the whole set of these components.

Deliverable	Location
Multicore SDK location	<MCUXpressoSDK_install_dir>/middleware/multicore/
Documentation	<MCSDK_dir>/mcuxsdk-doc/
Embedded Remote Procedure Call component	<MCSDK_dir>/erpc/
Multicore Manager component	<MCSDK_dir>/mcmgr/
RPMsg-Lite	<MCSDK_dir>/rpmsg_lite/
Multicore demo applications	<MCUXpressoSDK_install_dir>/examples/multicore_examples/
Multiprocessor demo applications	<MCUXpressoSDK_install_dir>/examples/multiprocessor_examples/

Multicore SDK release overview Together, the Multicore SDK (MCSDK) and the MCUXpresso SDK (SDK) form a framework for the development of software for NXP multicore devices. The MCSDK release consists of the following elementary software components for multicore:

- Embedded Remote Procedure Call (eRPC)
- Multicore Manager (MCMGR) - included just in SDK for multicore devices
- Remote Processor Messaging - Lite (RPMsg-Lite) - included just in SDK for multicore devices

The MCSDK is also accompanied with documentation and several multicore and multiprocessor demo applications.

Demo applications The multicore demo applications demonstrate the usage of the MCSDK software components on supported multicore development boards.

The following multicore demo applications are located together with other MCUXpresso SDK examples in

the <MCUXpressoSDK_install_dir>/examples/multicore_examples subdirectories.

- erpc_matrix_multiply_mu
- erpc_matrix_multiply_mu_rtos
- erpc_matrix_multiply_rpmsg
- erpc_matrix_multiply_rpmsg_rtos
- erpc_two_way_rpc_rpmsg_rtos
- freertos_message_buffers
- hello_world
- multicore_manager
- rpmsg_lite_pingpong
- rpmsg_lite_pingpong_rtos
- rpmsg_lite_pingpong_tzm

The eRPC multicore component can be leveraged for inter-processor communication and remote procedure calls between SoCs / development boards.

The following multiprocessor demo applications are located together with other MCUXpresso SDK examples in

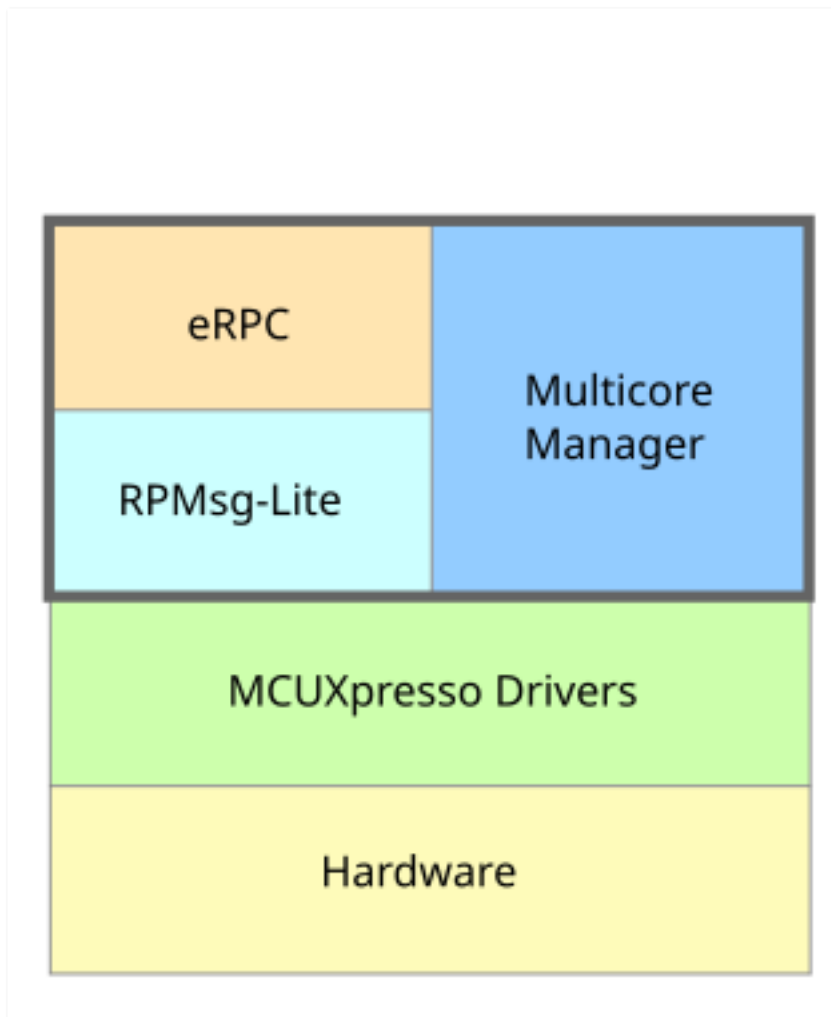
the <MCUXpressoSDK_install_dir>/examples/multiprocessor_examples subdirectories.

- erpc_client_matrix_multiply_spi
- erpc_server_matrix_multiply_spi
- erpc_client_matrix_multiply_uart
- erpc_server_matrix_multiply_uart
- erpc_server_dac_adc
- erpc_remote_control

Getting Started with Multicore SDK (MCSDK)

Overview Multicore Software Development Kit (MCSDK) is a Software Development Kit that provides comprehensive software support for NXP dual/multicore devices. The MCSDK is combined with the MCUXpresso SDK to make the software framework for easy development of multicore applications.

The following figure highlights the layers and main software components of the MCSDK.

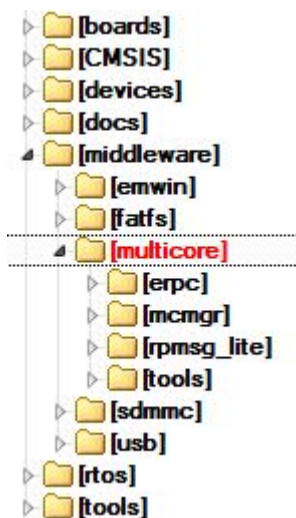


All the MCSDK-related files are located in `<MCUXpressoSDK_install_dir>/middleware/multicore` folder.

For supported toolchain versions, see the *Multicore SDK v25.06.00 Release Notes* (document MCS-DKRN). For the latest version of this and other MCSDK documents, visit www.nxp.com.

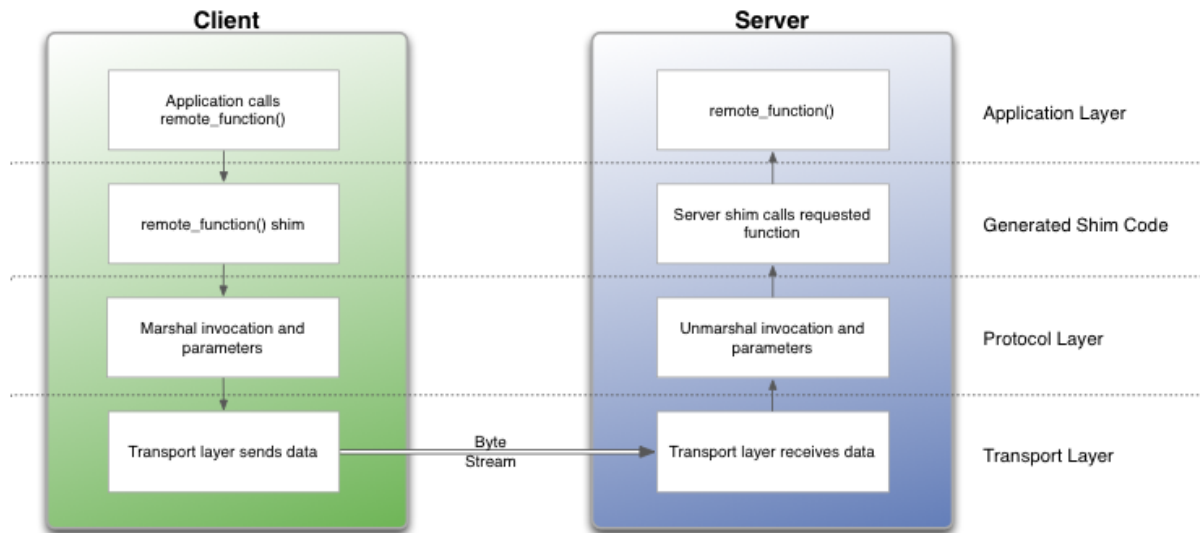
Multicore SDK (MCSDK) components The MCSDK consists of the following software components:

- **Embedded Remote Procedure Call (eRPC):** This component is a combination of a library and code generator tool that implements a transparent function call interface to remote services (running on a different core).
- **Multicore Manager (MCMGR):** This library maintains information about all cores and starts up secondary/auxiliary cores.
- **Remote Processor Messaging - Lite (RPMsg-Lite):** Inter-Processor Communication library.



Embedded Remote Procedure Call (eRPC) The Embedded Remote Procedure Call (eRPC) is the RPC system created by NXP. The RPC is a mechanism used to invoke a software routine on a remote system via a simple local function call.

When a remote function is called by the client, the function's parameters and an identifier for the called routine are marshaled (or serialized) into a stream of bytes. This byte stream is transported to the server through a communications channel (IPC, TPC/IP, UART, and so on). The server unmarshals the parameters, determines which function was invoked, and calls it. If the function returns a value, it is marshaled and sent back to the client.



RPC implementations typically use a combination of a tool (erpcgen) and IDL (interface definition language) file to generate source code to handle the details of marshaling a function's parameters and building the data stream.

Main eRPC features:

- Scalable from BareMetal to Linux OS - configurable memory and threading policies.
- Focus on embedded systems - intrinsic support for C, modular, and lightweight implementation.
- Abstracted transport interface - RPMsg is the primary transport for multicore, UART, or SPI-based solutions can be used for multichip.

The eRPC library is located in the `<MCUXpressoSDK_install_dir>/middleware/multicore/erpc` folder. For detailed information about the eRPC, see the documentation available in the `<MCUXpressoSDK_install_dir>/middleware/multicore/erpc/doc` folder.

Multicore Manager (MCMGR) The Multicore Manager (MCMGR) software library provides a number of services for multicore systems.

The main MCMGR features:

- Maintains information about all cores in system.
- Secondary/auxiliary cores startup and shutdown.
- Remote core monitoring and event handling.

The MCMGR library is located in the `<MCUXpressoSDK_install_dir>/middleware/multicore/mcmgr` folder. For detailed information about the MCMGR library, see the documentation available in the `<MCUXpressoSDK_install_dir>/middleware/multicore/mcmgr/doc` folder.

Remote Processor Messaging Lite (RPMsg-Lite) RPMsg-Lite is a lightweight implementation of the RPMsg protocol. The RPMsg protocol defines a standardized binary interface used to communicate between multiple cores in a heterogeneous multicore system. Compared to the legacy OpenAMP implementation, RPMsg-Lite offers a code size reduction, API simplification, and improved modularity.

The main RPMsg protocol features:

- Shared memory interprocessor communication.
- Virtio-based messaging bus.
- Application-defined messages sent between endpoints.

- Portable to different environments/platforms.
- Available in upstream Linux OS.

The RPMsg-Lite library is located in the `<MCUXpressoSDK_install_dir>/middleware/multicore/rpmsg-lite` folder. For detailed information about the RPMsg-Lite, see the RPMsg-Lite User's Guide located in the `<MCUXpressoSDK_install_dir>/middleware/multicore/rpmsg_lite/doc` folder.

MCSDK demo applications Multicore and multiprocessor example applications are stored together with other MCUXpresso SDK examples, in the dedicated multicore subfolder.

Location		Folder
Multicore projects	example	<code><MCUXpressoSDK_install_dir>/examples/multicore_examples/<application_name>/</code>
Multiprocessor projects	example	<code><MCUXpressoSDK_install_dir>/examples/multiprocessor_examples/<application_name>/</code>

See the *Getting Started with MCUXpresso SDK* (document MCUXSDKGSUG) and *Getting Started with MCUXpresso SDK for XXX Derivatives* documents for more information about the MCUXpresso SDK example folder structure and the location of individual files that form the example application projects. These documents also contain information about building, running, and debugging multicore demo applications in individual supported IDEs. Each example application also contains a readme file that describes the operation of the example and required setup steps.

Inter-Processor Communication (IPC) levels The MCSDK provides several mechanisms for Inter-Processor Communication (IPC). Particular ways and levels of IPC are described in this chapter.

IPC using low-level drivers

The NXP multicore SoCs are equipped with peripheral modules dedicated for data exchange between individual cores. They deal with the Mailbox peripheral for LPC parts and the Messaging Unit (MU) peripheral for Kinetis and i.MX parts. The common attribute of both modules is the ability to provide a means of IPC, allowing multiple CPUs to share resources and communicate with each other in a simple manner.

The most lightweight method of IPC uses the MCUXpresso SDK low-level drivers for these peripherals. Using the Mailbox/MU driver API functions, it is possible to pass a value from core to core via the dedicated registers (could be a scalar or a pointer to shared memory) and also to trigger inter-core interrupts for notifications.

For details about individual driver API functions, see the MCUXpresso SDK API Reference Manual of the specific multicore device. The MCUXpresso SDK is accompanied with the RPMsg-Lite documentation that shows how to use this API in multicore applications.

Messaging mechanism

On top of Mailbox/MU drivers, a messaging system can be implemented, allowing messages to send between multiple endpoints created on each of the CPUs. The RPMsg-Lite library of the MCSDK provides this ability and serves as the preferred MCUXpresso SDK messaging library. It implements ring buffers in shared memory for messages exchange without the need of a locking mechanism.

The RPMsg-Lite provides the abstraction layer and can be easily ported to different multicore platforms and environments (Operating Systems). The advantages of such a messaging system are ease of use (there is no need to study behavior of the used underlying hardware) and smooth application code portability between platforms due to unified messaging API.

However, this costs several kB of code and data memory. The MCUXpresso SDK is accompanied by the RPMsg-Lite documentation and several multicore examples. You can also obtain the latest RPMsg-Lite code from the GitHub account github.com/nxp-mcuxpresso/rpmsg-lite.

Remote procedure calls

To facilitate the IPC even more and to allow the remote functions invocation, the remote procedure call mechanism can be implemented. The eRPC of the MCSDK serves for these purposes and allows the ability to invoke a software routine on a remote system via a simple local function call. Utilizing different transport layers, it is possible to communicate between individual cores of multicore SoCs (via RPMsg-Lite) or between separate processors (via SPI, UART, or TCP/IP). The eRPC is mostly applicable to the MPU parts with enough of memory resources like i.MX parts.

The eRPC library allows you to export existing C functions without having to change their prototypes (in most cases). It is accompanied by the code generator tool that generates the shim code for serialization and invocation based on the IDL file with definitions of data types and remote interfaces (API).

If the communicating peer is running as a Linux OS user-space application, the generated code can be either in C/C++ or Python.

Using the eRPC simplifies the access to services implemented on individual cores. This way, the following types of applications running on dedicated cores can be easily interfaced:

- Communication stacks (USB, Thread, Bluetooth Low Energy, Zigbee)
- Sensor aggregation/fusion applications
- Encryption algorithms
- Virtual peripherals

The eRPC is publicly available from the following GitHub account: github.com/EmbeddedRPC/erpc. Also, the MCUXpresso SDK is accompanied by the eRPC code and several multicore and multiprocessor eRPC examples.

The mentioned IPC levels demonstrate the scalability of the Multicore SDK library. Based on application needs, different IPC techniques can be used. It depends on the complexity, required speed, memory resources, system design, and so on. The MCSDK brings users the possibility for quick and easy development of multicore and multiprocessor applications.

Changelog Multicore SDK

All notable changes to this project will be documented in this file.

The format is based on [Keep a Changelog](#), and this project adheres to [Semantic Versioning](#).

[25.06.00]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.14.0
 - eRPC generator (erpcgen) v1.14.0
 - Multicore Manager (MCMgr) v5.0.0
 - RPMsg-Lite v5.2.0

[25.03.00]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.13.0

- eRPC generator (erpcgen) v1.13.0
- Multicore Manager (MCMgr) v4.1.7
- RPPMsg-Lite v5.1.4

[24.12.00]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.13.0
 - eRPC generator (erpcgen) v1.13.0
 - Multicore Manager (MCMgr) v4.1.6
 - RPPMsg-Lite v5.1.3

[2.16.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.13.0
 - eRPC generator (erpcgen) v1.13.0
 - Multicore Manager (MCMgr) v4.1.5
 - RPPMsg-Lite v5.1.2

[2.15.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.12.0
 - eRPC generator (erpcgen) v1.12.0
 - Multicore Manager (MCMgr) v4.1.5
 - RPPMsg-Lite v5.1.1

[2.14.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.11.0
 - eRPC generator (erpcgen) v1.11.0
 - Multicore Manager (MCMgr) v4.1.4
 - RPPMsg-Lite v5.1.0

[2.13.0_imxrt1180a0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.10.0
 - eRPC generator (erpcgen) v1.10.0
 - Multicore Manager (MCMgr) v4.1.3
 - RPPMsg-Lite v5.0.0

[2.13.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.10.0
 - eRPC generator (erpcgen) v1.10.0
 - Multicore Manager (MCMgr) v4.1.3
 - RPSMsg-Lite v5.0.0

[2.12.0_imx93]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.9.1
 - eRPC generator (erpcgen) v1.9.1
 - Multicore Manager (MCMgr) v4.1.2
 - RPSMsg-Lite v4.0.1

[2.12.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.9.1
 - eRPC generator (erpcgen) v1.9.1
 - Multicore Manager (MCMgr) v4.1.2
 - RPSMsg-Lite v4.0.0

[2.11.1]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.9.0
 - eRPC generator (erpcgen) v1.9.0
 - Multicore Manager (MCMgr) v4.1.1
 - RPSMsg-Lite v3.2.1

[2.11.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.9.0
 - eRPC generator (erpcgen) v1.9.0
 - Multicore Manager (MCMgr) v4.1.1
 - RPSMsg-Lite v3.2.0

[2.10.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.8.1
 - eRPC generator (erpcgen) v1.8.1
 - Multicore Manager (MCMgr) v4.1.1
 - RPSMsg-Lite v3.1.2

[2.9.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.8.0
 - eRPC generator (erpcgen) v1.8.0
 - Multicore Manager (MCMgr) v4.1.1
 - RPSMsg-Lite v3.1.1

[2.8.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.7.4
 - eRPC generator (erpcgen) v1.7.4
 - Multicore Manager (MCMgr) v4.1.0
 - RPSMsg-Lite v3.1.0

[2.7.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.7.3
 - eRPC generator (erpcgen) v1.7.3
 - Multicore Manager (MCMgr) v4.1.0
 - RPSMsg-Lite v3.0.0

[2.6.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.7.2
 - eRPC generator (erpcgen) v1.7.2
 - Multicore Manager (MCMgr) v4.0.3
 - RPSMsg-Lite v2.2.0

[2.5.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.7.1
 - eRPC generator (erpcgen) v1.7.1
 - Multicore Manager (MCMgr) v4.0.2
 - RPSMsg-Lite v2.0.2

[2.4.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.7.0
 - eRPC generator (erpcgen) v1.7.0
 - Multicore Manager (MCMgr) v4.0.1
 - RPSMsg-Lite v2.0.1

[2.3.1]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.6.0
 - eRPC generator (erpcgen) v1.6.0
 - Multicore Manager (MCMgr) v4.0.0
 - RPSMsg-Lite v1.2.0

[2.3.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.5.0
 - eRPC generator (erpcgen) v1.5.0
 - Multicore Manager (MCMgr) v3.0.0
 - RPSMsg-Lite v1.2.0

[2.2.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.4.0
 - eRPC generator (erpcgen) v1.4.0
 - Multicore Manager (MCMgr) v2.0.1
 - RPSMsg-Lite v1.1.0

[2.1.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.3.0
 - eRPC generator (erpcgen) v1.3.0

[2.0.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.2.0
 - eRPC generator (erpcgen) v1.2.0
 - Multicore Manager (MCMgr) v2.0.0
 - RPMMsg-Lite v1.0.0

[1.1.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.1.0
 - Multicore Manager (MCMgr) v1.1.0
 - Open-AMP / RPMMsg based on SHA1 ID 44b5f3c0a6458f3cf80 rev01

[1.0.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.0.0
 - Multicore Manager (MCMgr) v1.0.0
 - Open-AMP / RPMMsg based on SHA1 ID 44b5f3c0a6458f3cf80 rev00

Multicore SDK Components

RPMSG-Lite

MCUXpresso SDK : mcuxsdk-middleware-rpmsg-lite

Overview This repository is for MCUXpresso SDK RPMSG-Lite middleware delivery and it contains RPMSG-Lite component officially provided in NXP MCUXpresso SDK. This repository is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository [mcuxsdk](#) for the complete delivery of MCUXpresso SDK to be able to build and run RPMSG-Lite examples that are based on mcux-sdk-middleware-rpmsg-lite component.

Documentation Overall details can be reviewed here: [MCUXpresso SDK Online Documentation](#)

Visit [RPMSG-Lite - Documentation](#) to review details on the contents in this sub-repo.

Setup Instructions on how to install the MCUXpresso SDK provided from GitHub via west manifest [Getting Started with SDK - Detailed Installation Instructions](#)

Contribution We welcome and encourage the community to submit patches directly to the rpmsg-lite project placed on github. Contributing can be managed via pull-requests. Before a pull-request is created the code should be tested and properly formatted.

RPMSG-Lite This documentation describes the RPMsg-Lite component, which is a lightweight implementation of the Remote Processor Messaging (RPMsg) protocol. The RPMsg protocol defines a standardized binary interface used to communicate between multiple cores in a heterogeneous multicore system.

Compared to the RPMsg implementation of the Open Asymmetric Multi Processing (OpenAMP) framework (<https://github.com/OpenAMP/open-amp>), the RPMsg-Lite offers a code size reduction, API simplification, and improved modularity. On smaller Cortex-M0+ based systems, it is recommended to use RPMsg-Lite.

The RPMsg-Lite is an open-source component developed by NXP Semiconductors and released under the BSD-compatible license.

For Further documentation, please look at doxygen documentation at: <https://nxp-mcuxpresso.github.io/rpmsg-lite/>

For overview please read RPMSG-Lite VirtIO Overview.

For RPMSG-Lite Design Considerations please read RPMSG-Lite Design Considerations.

Motivation to create RPMsg-Lite There are multiple reasons why RPMsg-Lite was developed. One reason is the need for the small footprint of the RPMsg protocol-compatible communication component, another reason is the simplification of extensive API of OpenAMP RPMsg implementation.

RPMsg protocol was not documented, and its only definition was given by the Linux Kernel and legacy OpenAMP implementations. This has changed with [1] which is a standardization protocol allowing multiple different implementations to coexist and still be mutually compatible.

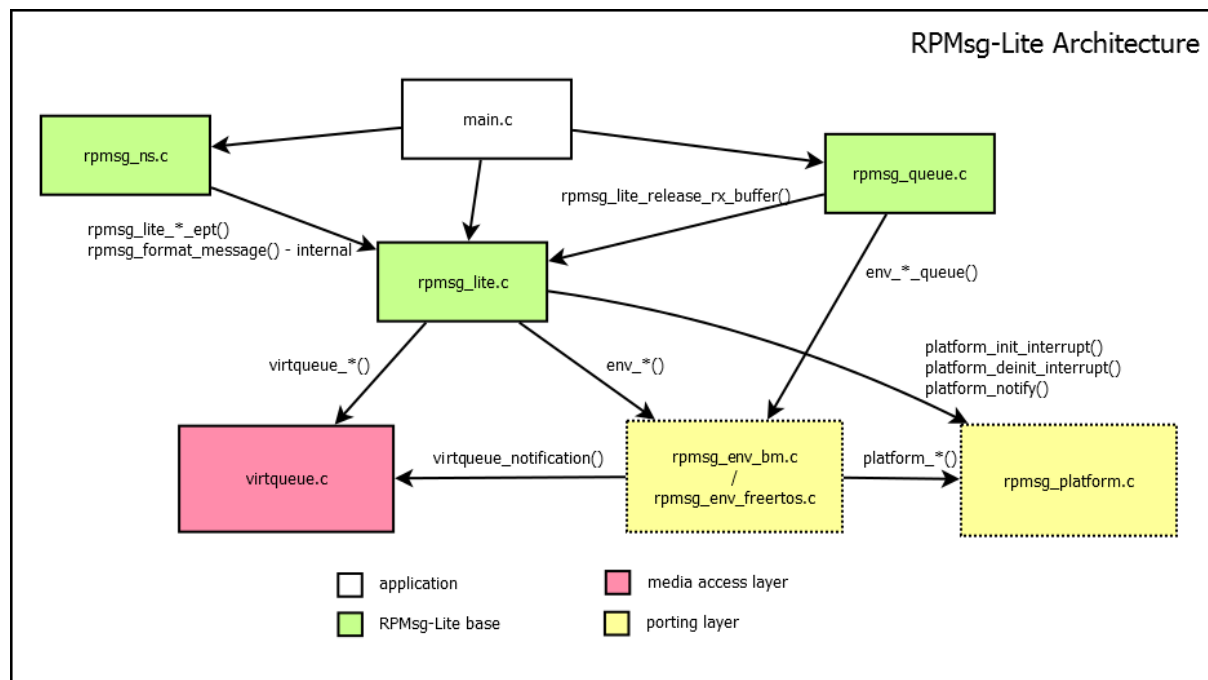
Small MCU-based systems often do not implement dynamic memory allocation. The creation of static API in RPMsg-Lite enables another reduction of resource usage. Not only does the dynamic allocation adds another 5 KB of code size, but also communication is slower and less deterministic, which is a property introduced by dynamic memory. The following table shows some rough comparison data between the OpenAMP RPMsg implementation and new RPMsg-Lite implementation:

Component / Configuration	Flash [B]	RAM [B]
OpenAMP RPMsg / Release (reference)	5547	456 + dynamic
RPMsg-Lite / Dynamic API, Release	3462	56 + dynamic
Relative Difference [%]	~62.4%	~12.3%
RPMsg-Lite / Static API (no malloc), Release	2926	352
Relative Difference [%]	~52.7%	~77.2%

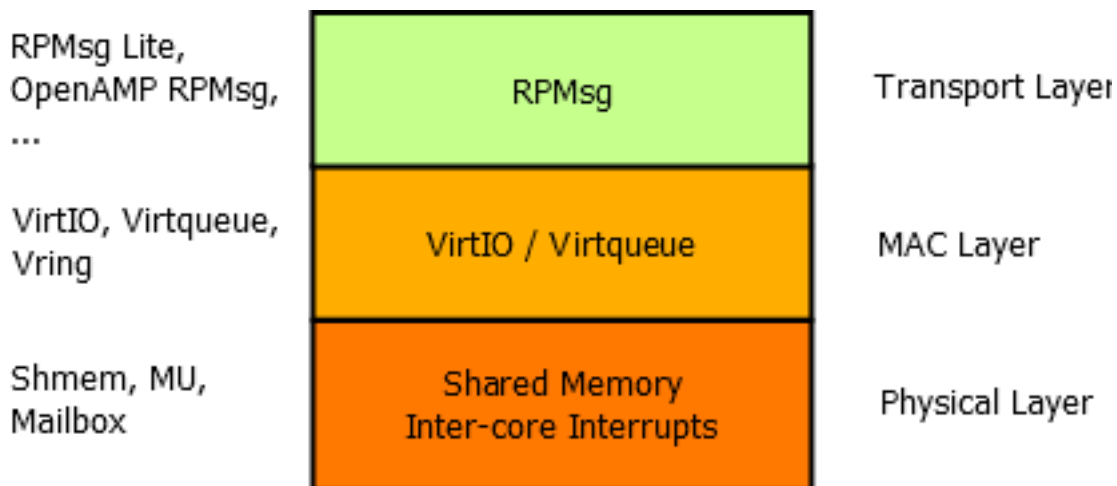
Implementation The implementation of RPMsg-Lite can be divided into three sub-components, from which two are optional. The core component is situated in `rpmsg_lite.c`. Two optional components are used to implement a blocking receive API (in `rpmsg_queue.c`) and dynamic “named” endpoint creation and deletion announcement service (in `rpmsg_ns.c`).

The actual “media access” layer is implemented in `virtqueue.c`, which is one of the few files shared with the OpenAMP implementation. This layer mainly defines the shared memory model, and internally defines used components such as `vring` or `virtqueue`.

The porting layer is split into two sub-layers: the environment layer and the platform layer. The first sublayer is to be implemented separately for each environment. (The bare metal environment already exists and is implemented in `rpmsg_env_bm.c`, and the FreeRTOS environment is implemented in `rpmsg_env_freertos.c` etc.) Only the source file, which matches the used environment, is included in the target application project. The second sublayer is implemented in `rpmsg_platform.c` and defines low-level functions for interrupt enabling, disabling, and triggering mainly. The situation is described in the following figure:



RPMsg-Lite core sub-component This subcomponent implements a blocking send API and callback-based receive API. The RPMsg protocol is part of the transport layer. This is realized by using so-called endpoints. Each endpoint can be assigned a different receive callback function. However, it is important to notice that the callback is executed in an interrupt environment in current design. Therefore, certain actions like memory allocation are discouraged to execute in the callback. The following figure shows the role of RPMsg in an ISO/OSI-like layered model:



Queue sub-component (optional) This subcomponent is optional and requires implementation of the `env_*_queue()` functions in the environment porting layer. It uses a blocking receive API, which is common in RTOS-environments. It supports both copy and nocopy blocking receive functions.

Name Service sub-component (optional) This subcomponent is a minimum implementation of the name service which is present in the Linux Kernel implementation of RPMsg. It allows the communicating node both to send announcements about “named” endpoint (in other words, channel) creation or deletion and to receive these announcement taking any user-defined action

in an application callback. The endpoint address used to receive name service announcements is arbitrarily fixed to be 53 (0x35).

Usage The application should put the `/rpmmsg_lite/lib/include` directory to the include path and in the application, include either the `rpmmsg_lite.h` header file, or optionally also include the `rpmmsg_queue.h` and/or `rpmmsg_ns.h` files. Both porting sublayers should be provided for you by NXP, but if you plan to use your own RTOS, all you need to do is to implement your own environment layer (in other words, `rpmmsg_env_myrtos.c`) and to include it in the project build.

The initialization of the stack is done by calling the `rpmmsg_lite_master_init()` on the master side and the `rpmmsg_lite_remote_init()` on the remote side. This initialization function must be called prior to any RPMMsg-Lite API call. After the init, it is wise to create a communication endpoint, otherwise communication is not possible. This can be done by calling the `rpmmsg_lite_create_ept()` function. It optionally accepts a last argument, where an internal context of the endpoint is created, just in case the `RL_USE_STATIC_API` option is set to 1. If not, the stack internally calls `env_alloc()` to allocate dynamic memory for it. In case a callback-based receiving is to be used, an ISR-callback is registered to each new endpoint with user-defined callback data pointer. If a blocking receive is desired (in case of RTOS environment), the `rpmmsg_queue_create()` function must be called before calling `rpmmsg_lite_create_ept()`. The queue handle is passed to the endpoint creation function as a callback data argument and the callback function is set to `rpmmsg_queue_rx_cb()`. Then, it is possible to use `rpmmsg_queue_receive()` function to listen on a queue object for incoming messages. The `rpmmsg_lite_send()` function is used to send messages to the other side.

The RPMMsg-Lite also implements no-copy mechanisms for both sending and receiving operations. These methods require specifics that have to be considered when used in an application.

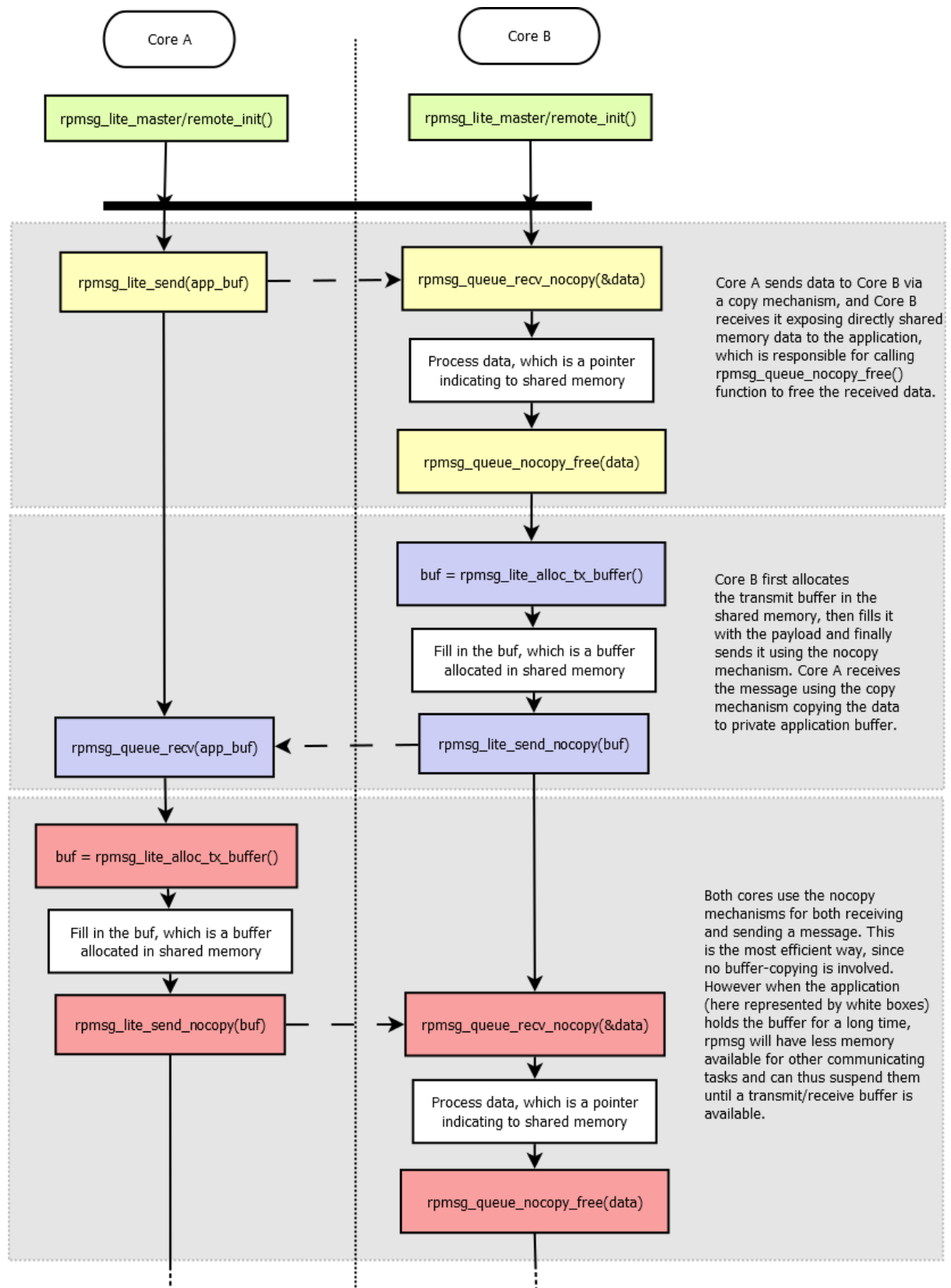
no-copy-send mechanism: This mechanism allows sending messages without the cost for copying data from the application buffer to the RPMMsg/virtio buffer in the shared memory. The sequence of no-copy sending steps to be performed is as follows:

- Call the `rpmmsg_lite_alloc_tx_buffer()` function to get the virtio buffer and provide the buffer pointer to the application.
- Fill the data to be sent into the pre-allocated virtio buffer. Ensure that the filled data does not exceed the buffer size (provided as the `rpmmsg_lite_alloc_tx_buffer()` size output parameter).
- Call the `rpmmsg_lite_send_nocopy()` function to send the message to the destination endpoint. Consider the cache functionality and the virtio buffer alignment. See the `rpmmsg_lite_send_nocopy()` function description below.

no-copy-receive mechanism: This mechanism allows reading messages without the cost for copying data from the virtio buffer in the shared memory to the application buffer. The sequence of no-copy receiving steps to be performed is as follows:

- Call the `rpmmsg_queue_rcv_nocopy()` function to get the virtio buffer pointer to the received data.
- Read received data directly from the shared memory.
- Call the `rpmmsg_queue_nocopy_free()` function to release the virtio buffer and to make it available for the next data transfer.

The user is responsible for destroying any RPMMsg-Lite objects he has created in case of deinitialization. In order to do this, the function `rpmmsg_queue_destroy()` is used to destroy a queue, `rpmmsg_lite_destroy_ept()` is used to destroy an endpoint and finally, `rpmmsg_lite_deinit()` is used to deinitialize the RPMMsg-Lite intercore communication stack. Deinitialize all endpoints using a queue before deinitializing the queue. Otherwise, you are actively invalidating the used queue handle, which is not allowed. RPMMsg-Lite does not check this internally, since its main aim is to be lightweight.



Examples RPSMsg Lite multicore examples are part of NXP MCUXpressoSDK packages. Visit <https://mcuxpresso.nxp.com> to configure, build and download these packages. To get the board list with multicore support (RPSMsg Lite included) use filtering based on Middleware and search for 'multicore' string. Once the selected package with the multicore middleware is downloaded,

see

<MCUXpressoSDK_install_dir>/boards/<board_name>/multicore_examples for RPMsg_Lite multicore examples with 'rpmsg_lite_' name prefix.

Another way of getting NXP MCUXpressoSDK RPMsg_Lite multicore examples is using the [mcuxsdk-manifests](#) Github repo. Follow the description how to use the West tool to clone and update the mcuxsdk-manifests repo in [readme section](#). Once done the armgcc rpmsg_lite examples can be found in

mcuxsdk/examples/_<board_name>/multicore_examples

You can use the evkmimxrt1170 as the board_name for instance. Similar to MCUXpressoSDK packages the RPMsg_Lite examples use the 'rpmsg_lite_' name prefix.

Notes

Environment layers implementation Several environment layers are provided in lib/rpmsg_lite/porting/environment folder. Not all of them are fully tested however. Here is the list of environment layers that passed testing:

- rpmsg_env_bm.c
- rpmsg_env_freertos.c
- rpmsg_env_xos.c
- rpmsg_env_threadx.c

The rest of environment layers has been created and used in some experimental projects, it has been running well at the time of creation but due to the lack of unit testing there is no guarantee it is still fully functional.

Shared memory configuration It is important to correctly initialize/configure the shared memory for data exchange in the application. The shared memory must be accessible from both the master and the remote core and it needs to be configured as Non-Cacheable memory. Dedicated shared memory section in linker file is also a good practise, it is recommended to use linker files from MCUXpressoSDK packages for NXP devices based applications. It needs to be ensured no other application part/component is unintentionally accessing this part of memory.

Configuration options The RPMsg-Lite can be configured at the compile time. The default configuration is defined in the rpmsg_default_config.h header file. This configuration can be customized by the user by including rpmsg_config.h file with custom settings. The following table summarizes all possible RPMsg-Lite configuration options.

Config- uration option	De- fault value	Usage
RL_MS_PE (1)		Delay in milliseconds used in non-blocking API functions for polling.
RL_BUFFE (496)		Size of the buffer payload, it must be equal to (240, 496, 1008, ...) $[2^n - 16]$
RL_BUFFE (2)		Number of the buffers, it must be power of two (2, 4, ...)
RL_API_H (1)		Zero-copy API functions enabled/disabled.
RL_USE_S' (0)		Static API functions (no dynamic allocation) enabled/disabled.
RL_USE_D (0)		Memory cache management of shared memory. Use in case of data cache is enabled for shared memory.
RL_CLEAF (0)		Clearing used buffers before returning back to the pool of free buffers enabled/disabled.
RL_USE_M (0)		When enabled IPC interrupts are managed by the Multicore Manager (IPC interrupts router), when disabled RPMsg-Lite manages IPC interrupts by itself.
RL_USE_E (0)		When enabled the environment layer uses its own context. Required for some environments (QNX). The default value is 0 (no context, saves some RAM).
RL_DEBU (0)		When enabled buffer pointers passed to <code>rpmsg_lite_send_nocopy()</code> and <code>rpmsg_lite_release_rx_buffer()</code> functions (enabled by <code>RL_API_HAS_ZEROCOPY</code> config) are checked to avoid passing invalid buffer pointer. The default value is 0 (disabled). Do not use in RPMsg-Lite to Linux configuration.
RL_ALLO (0)		When enabled the opposite side is notified each time received buffers are consumed and put into the queue of available buffers. Enable this option in RPMsg-Lite to Linux configuration to allow unblocking of the Linux blocking send. The default value is 0 (RPMsg-Lite to RPMsg-Lite communication).
RL_ALLO (0)		It allows to define custom shared memory configuration and replacing the shared memory related global settings from <code>rpmsg_config.h</code> . This is useful when multiple instances are running in parallel but different shared memory arrangement (vring size & alignment, buffers size & count) is required. The default value is 0 (all RPMsg-Lite instances use the same shared memory arrangement as defined by common config macros).
RL_ASSERT	see <code>rpmsg</code>	Assert implementation.

How to format rpmsg-lite code To format code, use the application developed by Google, named *clang-format*. This tool is part of the [llvm](#) project. Currently, the clang-format 10.0.0 version is used for rpmsg-lite. The set of style settings used for clang-format is defined in the `.clang-format` file, placed in a root of the rpmsg-lite directory where Python script `run_clang_format.py` can be executed. This script executes the application named *clang-format.exe*. You need to have the path of this application in the OS's environment path, or you need to change the script.

References

[1] M. Novak, M. Cingel, **Lockless Shared Memory Based Multicore Communication Protocol**
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Changelog RPMSG-Lite All notable changes to this project will be documented in this file. The format is based on [Keep a Changelog](#), and this project adheres to [Semantic Versioning](#).

Unreleased

Fixed

- Fixed CERT-C INT31-C violation in platform_notify function in rpmsg_platform.c for imxrt700_m33, imxrt700_hifi4, imxrt700_hifi1 platforms

v5.2.0

Added

- Add MCXL20 porting layer and unit testing
- New utility macro RL_CALCULATE_BUFFER_COUNT_DOWN_SAFE to safely determine maximum buffer count within shared memory while preventing integer underflow.
- RT700 platform add support for MCMGR in DSPs

Changed

- Change rpmsg_platform.c to support new MCMGR API
- Improved input validation in initialization functions to properly handle insufficient memory size conditions.
- Refactored repeated buffer count calculation pattern for better code maintainability.
- To make sure that remote has already registered IRQ there is required App level IPC mechanism to notify master about it

Fixed

- Fixed env_wait_for_link_up function to handle timeout in link state checks for baremetal and qnx environment, RL_BLOCK mode can be used to wait indefinitely.
- Fixed CERT-C INT31-C violation by adding compile-time check to ensure RL_PLATFORM_HIGHEST_LINK_ID remains within safe range for 16-bit casting in virtqueue ID creation.
- Fixed CERT-C INT30-C violations by adding protection against unsigned integer underflow in shared memory calculations, specifically in shmem_length - (uint32_t)RL_VRING_OVERHEAD and shmem_length - 2U * shmem_config.vring_size expressions.
- Fixed CERT INT31-C violation in platform_interrupt_disable() and similar functions by replacing unsafe cast from uint32_t to int32_t with a return of 0 constant.
- Fixed unsigned integer underflow in rpmsg_lite_alloc_tx_buffer() where subtracting header size from buffer size could wrap around if buffer was too small, potentially leading to incorrect buffer sizing.
- Fixed CERT-C INT31-C violation in rpmsg_lite.c where size parameter was cast from uint32_t to uint16_t without proper validation.
 - Applied consistent masking approach to both size and flags parameters: (uint16_t)(value & 0xFFFFU).
 - This fix prevents potential data loss when size values exceed 65535.

- Fixed CERT INT31-C violation in `env_memset` functions by explicitly converting `int32_t` values to unsigned char using bit masking. This prevents potential data loss or misinterpretation when passing values outside the unsigned char range (0-255) to the standard `memset()` function.
- Fixed CERT-C INT31-C violations in RPMsg-Lite environment porting: Added validation checks for signed-to-unsigned integer conversions to prevent data loss and misinterpretation.
 - `rpmsg_env_freertos.c`: Added validation before converting `int32_t` to `UBaseType_t`.
 - `rpmsg_env_qnx.c`: Fixed format string and added validation before assigning to `mqstat` fields.
 - `rpmsg_env_threadx.c`: Added validation to prevent integer overflow and negative values.
 - `rpmsg_env_xos.c`: Added range checking before casting to `uint16_t`.
 - `rpmsg_env_zephyr.c`: Added validation before passing values to `k_msgq_init`.
- Fixed a CERT INT31-C compliance issue in `env_get_current_queue_size()` function where an unsigned queue count was cast to a signed `int32_t` without proper validation, which could lead to lost or misinterpreted data if queue size exceeded `INT32_MAX`.
- Fixed CERT INT31-C violation in `rpmsg_platform.c` where `memcmp()` return value (signed int) was compared with unsigned constant without proper type handling.
- Fixed CERT INT31-C violation in `rpmsg_platform.c` where casting from `uint32_t` to `uint16_t` could potentially result in data loss. Changed length variable type from `uint16_t` to `uint32_t` to properly handle memory address differences without truncation.
- Fixed potential integer overflow in `env_sleep_msec()` function in ThreadX environment implementation by rearranging calculation order in the sleep duration formula.
- Fixed CERT-C INT31-C violation in RPMsg-Lite where bitwise NOT operations on integer constants were performed in signed integer context before being cast to unsigned. This could potentially lead to misinterpreted data on `imx943` platform.
- Added `RL_MAX_BUFFER_COUNT` (32768U) and `RL_MAX_VRING_ALIGN` (65536U) limit to ensure alignment values cannot contribute to integer overflow
- Fixed CERT INT31-C violation in `vring_need_event()`, added cast to `uint16_t` for each operand.

v5.1.4 - 27-Mar-2025

Added

- Add KW43B43 porting layer

Changed

- Doxygen bump to version 1.9.6

v5.1.3 - 13-Jan-2025

Added

- Memory cache management of shared memory. Enable with `#define RL_USE_DCACHE (1)` in `rpmsg_config.h` in case of data cache is used.
- Cmake/Kconfig support added.
- Porting layers for imx95, imxrt700, mcmxw71x, mcmxw72x, kw47b42 added.

v5.1.2 - 08-Jul-2024

Changed

- Zephyr-related changes.
- Minor Misra corrections.

v5.1.1 - 19-Jan-2024

Added

- Test suite provided.
- Zephyr support added.

Changed

- Minor changes in platform and env. layers, minor test code updates.

v5.1.0 - 02-Aug-2023

Added

- RPMsg-Lite: Added aarch64 support.

Changed

- RPMsg-Lite: Increased the queue size to $(2 * RL\_BUFFER\_COUNT)$ to cover zero copy cases.
- Code formatting using LLVM16.

Fixed

- Resolved issues in ThreadX env. layer implementation.

v5.0.0 - 19-Jan-2023

Added

- Timeout parameter added to `rpmsg_lite_wait_for_link_up` API function.

Changed

- Improved debug check buffers implementation - instead of checking the pointer fits into shared memory check the presence in the VirtIO ring descriptors list.
- VRING_SIZE is set based on number of used buffers now (as calculated in vring_init) - updated for all platforms that are not communicating to Linux rpmsg counterpart.

Fixed

- Fixed wrong RL_VRING_OVERHEAD macro comment in platform.h files
- Misra corrections.

v4.0.0 - 20-Jun-2022

Added

- Added support for custom shared memory arrangement per the RPMsg_Lite instance.
- Introduced new rpmsg_lite_wait_for_link_up() API function - this allows to avoid using busy loops in rtos environments, GitHub PR [#21](#).

Changed

- Adjusted rpmsg_lite_is_link_up() to return RL_TRUE/RL_FALSE.

v3.2.0 - 17-Jan-2022

Added

- Added support for i.MX8 MP multicore platform.

Changed

- Improved static allocations - allow OS-specific objects being allocated statically, GitHub PR [#14](#).
- Aligned rpmsg_env_xos.c and some platform layers to latest static allocation support.

Fixed

- Minor Misra and typo corrections, GitHub PR [#19](#), [#20](#).

v3.1.2 - 16-Jul-2021

Added

- Addressed MISRA 21.6 rule violation in rpmsg_env.h (use SDK's PRINTF in MCUXpressoSDK examples, otherwise stdio printf is used).
- Added environment layers for XOS.
- Added support for i.MX RT500, i.MX RT1160 and i.MX RT1170 multicore platforms.

Fixed

- Fixed incorrect description of the `rpmsg_lite_get_endpoint_from_addr` function.

Changed

- Updated `RL_BUFFER_COUNT` documentation (issue [#10](#)).
- Updated `imxrt600_hifi4` platform layer.

v3.1.1 - 15-Jan-2021

Added

- Introduced `RL_ALLOW_CONSUMED_BUFFERS_NOTIFICATION` config option to allow opposite side notification sending each time received buffers are consumed and put into the queue of available buffers.
- Added environment layers for Threadx.
- Added support for i.MX8QM multicore platform.

Changed

- Several MISRA C-2012 violations addressed.

v3.1.0 - 22-Jul-2020

Added

- Added support for several new multicore platforms.

Fixed

- MISRA C-2012 violations fixed (7.4).
- Fixed missing lock in `rpmsg_lite_rx_callback()` for QNX env.
- Correction of `rpmsg_lite_instance` structure members description.
- Address -Waddress-of-packed-member warnings in GCC9.

Changed

- Clang update to v10.0.0, code re-formatted.

v3.0.0 - 20-Dec-2019

Added

- Added support for several new multicore platforms.

Fixed

- MISRA C-2012 violations fixed, incl. data types consolidation.
- Code formatted.

v2.2.0 - 20-Mar-2019

Added

- Added configuration macro `RL_DEBUG_CHECK_BUFFERS`.
- Several MISRA violations fixed.
- Added environment layers for QNX and Zephyr.
- Allow environment context required for some environment (controlled by the `RL_USE_ENVIRONMENT_CONTEXT` configuration macro).
- Data types consolidation.

v1.1.0 - 28-Apr-2017

Added

- Supporting i.MX6SX and i.MX7D MPU platforms.
- Supporting LPC5411x MCU platform.
- Baremetal and FreeRTOS support.
- Support of copy and zero-copy transfer.
- Support of static API (without dynamic allocations).

Multicore Manager

MCUXpresso SDK : `mcuxsdk-middleware-mcmgr` (Multicore Manager)

Overview This repository is for MCUXpresso SDK Multicore Manager middleware delivery and it contains Multicore Manager component officially provided in NXP MCUXpresso SDK. This repository is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository [mcuxsdk](#) for the complete delivery of MCUXpresso SDK to be able to build and run Multicore Manager examples that are based on `mcux-sdk-middleware-mcmgr` component.

Documentation Overall details can be reviewed here: [MCUXpresso SDK Online Documentation](#)

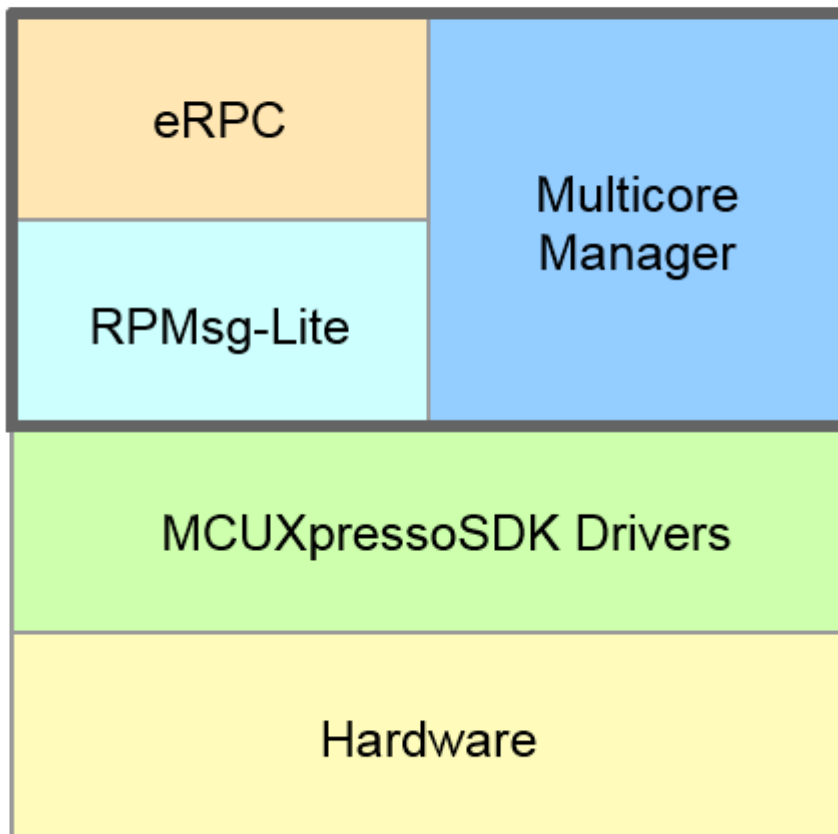
Visit [Multicore Manager - Documentation](#) to review details on the contents in this sub-repo.

Setup Instructions on how to install the MCUXpresso SDK provided from GitHub via west manifest [Getting Started with SDK - Detailed Installation Instructions](#)

Contribution We welcome and encourage the community to submit patches directly to the mcmgr project placed on github. Contributing can be managed via pull-requests. Before a pull-request is created the code should be tested and properly formatted.

Multicore Manager (MCMGR) The Multicore Manager (MCMGR) software library provides a number of services for multicore systems. This library is distributed as a part of the Multicore SDK (MCSDK). Together, the MCSDK and the MCUXpresso SDK (SDK) form a framework for development of software for NXP multicore devices.

The MCMGR component is located in the <MCUXpressoSDK_install_dir>/middleware/multicore/mcmgr directory.



The Multicore Manager provides the following major functions:

- Maintains information about all cores in system.
- Secondary/auxiliary core(s) startup and shutdown.
- Remote core monitoring and event handling.

For Further API documentation, please look at doxygen documentation at: <https://nxp-mcuxpresso.github.io/mcux-mcmgr/>

Usage of the MCMGR software component The main use case of MCMGR is the secondary/auxiliary core start. This functionality is performed by the public API function.

Example of MCMGR usage to start secondary core:

```
#include "mcmgr.h"

void main()
{
    /* Initialize MCMGR - low level multicore management library.
       Call this function as close to the reset entry as possible,
       (into the startup sequence) to allow CoreUp event triggering. */
    MCMGR_EarlyInit();

    /* Initialize MCMGR, install generic event handlers */
    MCMGR_Init();

    /* Boot secondary core application from the CORE1_BOOT_ADDRESS, pass "1" as startup data,
    ↪starting synchronously. */
    MCMGR_StartCore(kMCMGR_Core1, CORE1_BOOT_ADDRESS, 1, kMCMGR_Start_Synchronous);
    .
    .
    .
    /* Stop secondary core execution. */
    MCMGR_StopCore(kMCMGR_Core1);
}
```

Some platforms allow stopping and re-starting the secondary core application again, using the MCMGR_StopCore / MCMGR_StartCore API calls. It is necessary to ensure the initially loaded image is not corrupted before re-starting, especially if it deals with the RAM target. Cache coherence has to be considered/ensured as well.

Another important MCMGR feature is the ability for remote core monitoring and handling of events such as reset, exception, and application events. Application-specific callback functions for events are registered by the MCMGR_RegisterEvent() API. Triggering these events is done using the MCMGR_TriggerEvent() API. mcmgr_event_type_t enums all possible event types.

An example of MCMGR usage for remote core monitoring and event handling. Code for the primary side:

```
#include "mcmgr.h"

#define APP_RPMSG_READY_EVENT_DATA (1)
#define APP_NUMBER_OF_CORES (2)
#define APP_SECONDARY_CORE kMCMGR_Core1

/* Callback function registered via the MCMGR_RegisterEvent() and triggered by MCMGR_TriggerEvent()
↪called on the secondary core side */
void RPSGRemoteReadyEventHandler(mcmgr_core_t coreNum, uint16_t eventData, void *context)
{
    uint16_t *data = &((uint16_t *)context)[coreNum];

    *data = eventData;
}

void main()
{
    uint16_t RPSGRemoteReadyEventData[NUMBER_OF_CORES] = {0};

    /* Initialize MCMGR - low level multicore management library.
       Call this function as close to the reset entry as possible,
       (into the startup sequence) to allow CoreUp event triggering. */
    MCMGR_EarlyInit();
```

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```

/* Initialize MCMGR, install generic event handlers */
MCMGR_Init();

/* Register the application event before starting the secondary core */
MCMGR_RegisterEvent(kMCMGR_RemoteApplicationEvent, RPSMsgRemoteReadyEventHandler, (void_)
↳)RPSMsgRemoteReadyEventData);

/* Boot secondary core application from the CORE1_BOOT_ADDRESS, pass rpsmsg_lite_base address_
↳as startup data, starting synchronously. */
MCMGR_StartCore(APP_SECONDARY_CORE, CORE1_BOOT_ADDRESS, (uint32_t)rpsmsg_lite_
↳base, kMCMGR_Start_Synchronous);

/* Wait until the secondary core application signals the rpsmsg remote has been initialized and is ready to_
↳communicate. */
while(APP_RPSMSG_READY_EVENT_DATA != RPSMsgRemoteReadyEventData[APP_SECONDARY_
↳CORE]) {};
.
.
.
}

```

Code for the secondary side:

```

#include "mcmgr.h"

#define APP_RPSMSG_READY_EVENT_DATA (1)

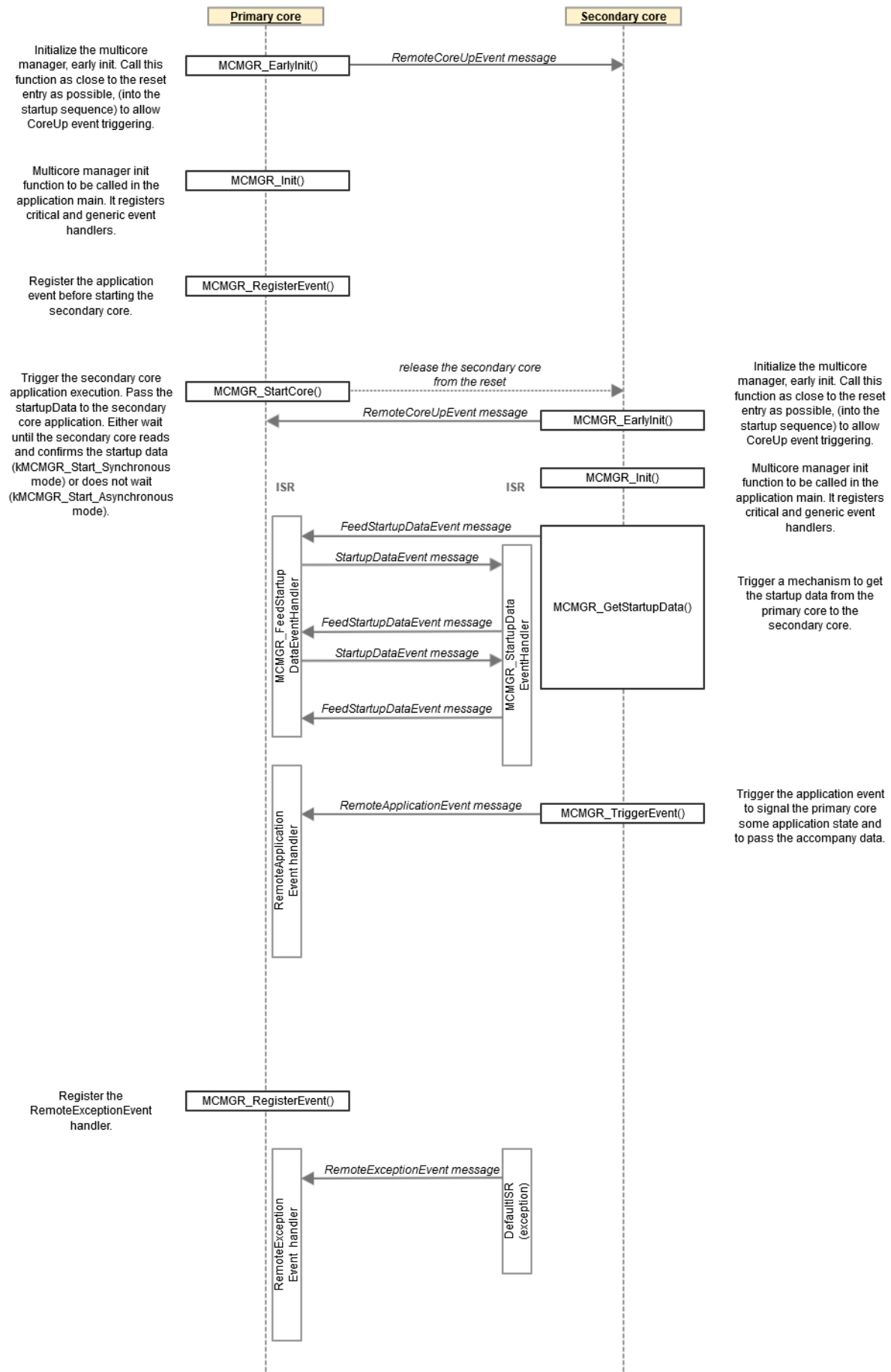
void main()
{
    /* Initialize MCMGR - low level multicore management library.
       Call this function as close to the reset entry as possible,
       (into the startup sequence) to allow CoreUp event triggering. */
    MCMGR_EarlyInit();

    /* Initialize MCMGR, install generic event handlers */
    MCMGR_Init();
    .
    .
    .

    /* Signal the to other core that we are ready by triggering the event and passing the APP_RPSMSG_
    ↳READY_EVENT_DATA */
    MCMGR_TriggerEvent(kMCMGR_Core0, kMCMGR_RemoteApplicationEvent, APP_RPSMSG_
    ↳READY_EVENT_DATA);
    .
    .
    .
}

```

MCMGR Data Exchange Diagram The following picture shows how the handshakes are supposed to work between the two cores in the MCMGR software.



Changelog Multicore Manager All notable changes to this project will be documented in this file.

The format is based on [Keep a Changelog](#), and this project adheres to [Semantic Versioning](#).

Unreleased

Added

Fixed

- Added CX flag into CMakeLists.txt to allow c++ build compatibility.

v5.0.0

Added

- Added MCMGR_BUSY_POLL_COUNT macro to prevent infinite polling loops in MCMGR operations.
- Implemented timeout mechanism for all polling loops in MCMGR code.
- Added support to handle more then two cores. Breaking API change by adding parameter `coreNum` specifying core number in functions bellow.
 - MCMGR_GetStartupData(uint32_t *startupData, mcmgr_core_t coreNum)
 - MCMGR_TriggerEvent(mcmgr_event_type_t type, uint16_t eventData, mcmgr_core_t coreNum)
 - MCMGR_TriggerEventForce(mcmgr_event_type_t type, uint16_t eventData, mcmgr_core_t coreNum)
 - typedef void (*mcmgr_event_callback_t)(uint16_t data, void *context, mcmgr_core_t coreNum);

When registering the event with function MCMGR_RegisterEvent() user now needs to provide `callbackData` pointer to array of elements per every core in system (see README.md for example). In case of systems with only two cores the `coreNum` in callback can be ignored as events can arrive only from one core. Please see Porting guide for more details: Porting-GuideTo_v5.md

- Updated all porting files to support new MCMGR API.
- Added new platform specific include file `mcmgr_platform.h`. It will contain common platform specific macros that can be then used in `mcmgr` and application. e.g. platform core count MCMGR_CORECOUNT 4.
- Move all header files to new `inc` directory.
- Added new platform-specific include files `inc/platform/<platform_name>/mcmgr_platform.h`.

Added

- Add MCXL20 porting layer and unit testing

v4.1.7

Fixed

- `mcmgr_stop_core_internal()` function now returns `kStatus_MCMGR_NotImplemented` status code instead of `kStatus_MCMGR_Success` when device does not support stop of secondary core. Ports affected: kw32w1, kw45b41, kw45b42, mcxw716, mcxw727.

[v4.1.6]

Added

- Multicore Manager moved to standalone repository.
- Add porting layers for imxrt700, mcmxw727, kw47b42.
- New `MCMGR_ProcessDeferredRxIsr()` API added.

[v4.1.5]

Added

- Add notification into `MCMGR_EarlyInit` and `mcmgr_early_init_internal` functions to avoid using uninitialized data in their implementations.

[v4.1.4]

Fixed

- Avoid calling tx isr callbacks when respective Messaging Unit Transmit Interrupt Enable flag is not set in the CR/TCR register.
- Messaging Unit RX and status registers are cleared after the initialization.

[v4.1.3]

Added

- Add porting layers for imxrt1180.

Fixed

- `mu_isr()` updated to avoid calling tx isr callbacks when respective Transmit Interrupt Enable flag is not set in the CR/TCR register.
- `mcmgr_mu_internal.c` code adaptation to new supported SoCs.

[v4.1.2]

Fixed

- Update `mcmgr_stop_core_internal()` implementations to set core state to `kMCMGR_ResetCoreState`.

[v4.1.0]

Fixed

- Code adjustments to address MISRA C-2012 Rules

[v4.0.3]

Fixed

- Documentation updated to describe handshaking in a graphic form.
- Minor code adjustments based on static analysis tool findings

[v4.0.2]

Fixed

- Align porting layers to the updated MCUXpressoSDK feature files.

[v4.0.1]

Fixed

- Code formatting, removed unused code

[v4.0.0]

Added

- Add new MCMGR_TriggerEventForce() API.

[v3.0.0]

Removed

- Removed MCMGR_LoadApp(), MCMGR_MapAddress() and MCMGR_SignalReady()

Modified

- Modified MCMGR_GetStartupData()

Added

- Added MCMGR_EarlyInit(), MCMGR_RegisterEvent() and MCMGR_TriggerEvent()
- Added the ability for remote core monitoring and event handling

[v2.0.1]

Fixed

- Updated to be Misra compliant.

[v2.0.0]

Added

- Support for lpcxpresso54114 board.

[v1.1.0]

Fixed

- Ported to KSDK 2.0.0.

[v1.0.0]

Added

- Initial release.

eRPC

MCUXpresso SDK : mcuxsdk-middleware-erpc

Overview This repository is for MCUXpresso SDK eRPC middleware delivery and it contains eRPC component officially provided in NXP MCUXpresso SDK. This repository is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository [mcuxsdk](#) for the complete delivery of MCUXpresso SDK to be able to build and run eRPC examples that are based on mcux-sdk-middleware-erpc component.

Documentation Overall details can be reviewed here: [MCUXpresso SDK Online Documentation](#)

Visit [eRPC - Documentation](#) to review details on the contents in this sub-repo.

Setup Instructions on how to install the MCUXpresso SDK provided from GitHub via west manifest [Getting Started with SDK - Detailed Installation Instructions](#)

Contribution We welcome and encourage the community to submit patches directly to the eRPC project placed on github. Contributing can be managed via pull-requests. Before a pull-request is created the code should be tested and properly formatted.

eRPC

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About

eRPC (Embedded RPC) is an open source Remote Procedure Call (RPC) system for multichip embedded systems and heterogeneous multicore SoCs.

Unlike other modern RPC systems, such as the excellent [Apache Thrift](#), eRPC distinguishes itself by being designed for tightly coupled systems, using plain C for remote functions, and having a small code size (<5kB). It is not intended for high performance distributed systems over a network.

eRPC does not force upon you any particular API style. It allows you to export existing C functions, without having to change their prototypes. (There are limits, of course.) And although the

internal infrastructure is written in C++, most users will be able to use only the simple C setup APIs shown in the examples below.

A code generator tool called `erpcgen` is included. It accepts input IDL files, having an `.erpc` extension, that have definitions of your data types and remote interfaces, and generates the shim code that handles serialization and invocation. `erpcgen` can generate either C/C++ or Python code.

Example `.erpc` file:

```
// Define a data type.
enum LEDName { kRed, kGreen, kBlue }

// An interface is a logical grouping of functions.
interface IO {
    // Simple function declaration with an empty reply.
    set_led(LEDName whichLed, bool onOrOff) -> void
}
```

Client side usage:

```
void example_client(void) {
    erpc_transport_t transport;
    erpc_mbf_t message_buffer_factory;
    erpc_client_t client_manager;

    /* Init eRPC client infrastructure */
    transport = erpc_transport_cmsis_uart_init(Driver_USART0);
    message_buffer_factory = erpc_mbf_dynamic_init();
    client_manager = erpc_client_init(transport, message_buffer_factory);

    /* init eRPC client IO service */
    initIO_client(client_manager);

    // Now we can call the remote function to turn on the green LED.
    set_led(kGreen, true);

    /* deinit objects */
    deinitIO_client();
    erpc_client_deinit(client_manager);
    erpc_mbf_dynamic_deinit(message_buffer_factory);
    erpc_transport_tcp_deinit(transport);
}
```

```
void example_client(void) {
    erpc_transport_t transport;
    erpc_mbf_t message_buffer_factory;
    erpc_client_t client_manager;

    /* Init eRPC client infrastructure */
    transport = erpc_transport_cmsis_uart_init(Driver_USART0);
    message_buffer_factory = erpc_mbf_dynamic_init();
    client_manager = erpc_client_init(transport, message_buffer_factory);

    /* scope for client service */
    {
        /* init eRPC client IO service */
        IO_client client(client_manager);

        // Now we can call the remote function to turn on the green LED.
        client.set_led(kGreen, true);
    }

    /* deinit objects */
```

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```

    erpc_client_deinit(client_manager);
    erpc_mbf_dynamic_deinit(message_buffer_factory);
    erpc_transport_tcp_deinit(transport);
}

```

Server side usage:

```

// Implement the remote function.
void set_led(LEDName whichLed, bool onOrOff) {
    // implementation goes here
}

void example_server(void) {
    erpc_transport_t transport;
    erpc_mbf_t message_buffer_factory;
    erpc_server_t server;
    erpc_service_t service = create_IO_service();

    /* Init eRPC server infrastructure */
    transport = erpc_transport_cmsis_uart_init(Driver_USART0);
    message_buffer_factory = erpc_mbf_dynamic_init();
    server = erpc_server_init(transport, message_buffer_factory);

    /* add custom service implementation to the server */
    erpc_add_service_to_server(server, service);

    // Run the server.
    erpc_server_run();

    /* deinit objects */
    destroy_IO_service(service);
    erpc_server_deinit(server);
    erpc_mbf_dynamic_deinit(message_buffer_factory);
    erpc_transport_tcp_deinit(transport);
}

```

```

// Implement the remote function.
class IO : public IO_interface
{
    /* eRPC call definition */
    void set_led(LEDName whichLed, bool onOrOff) override {
        // implementation goes here
    }
}

void example_server(void) {
    erpc_transport_t transport;
    erpc_mbf_t message_buffer_factory;
    erpc_server_t server;
    IO IOImpl;
    IO_service io(&IOImpl);

    /* Init eRPC server infrastructure */
    transport = erpc_transport_cmsis_uart_init(Driver_USART0);
    message_buffer_factory = erpc_mbf_dynamic_init();
    server = erpc_server_init(transport, message_buffer_factory);

    /* add custom service implementation to the server */
    erpc_add_service_to_server(server, &io);

    /* poll for requests */
}

```

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```
erpc_status_t err = server.run();

/* deinit objects */
erpc_server_deinit(server);
erpc_mbf_dynamic_deinit(message_buffer_factory);
erpc_transport_tcp_deinit(transport);
}
```

A number of transports are supported, and new transport classes are easy to write.

Supported transports can be found in *erpc/erpc_c/transport* folder. E.g:

- CMSIS UART
- NXP Kinetis SPI and DSPI
- POSIX and Windows serial port
- TCP/IP (mostly for testing)
- [NXP RPMsg-Lite / RPMsg TTY](#)
- SPIdev Linux
- USB CDC
- NXP Messaging Unit

eRPC is available with an unrestrictive BSD 3-clause license. See the [LICENSE file](#) for the full license text.

Releases [eRPC releases](#)

Edge releases Edge releases can be found on [eRPC CircleCI](#) webpage. Choose build of interest, then platform target and choose ARTIFACTS tab. Here you can find binary application from chosen build.

Documentation [Documentation](#) is in the wiki section.

[eRPC Infrastructure documentation](#)

Examples *Example IDL* is available in the *examples/* folder.

Plenty of eRPC multicore and multiprocessor examples can be also found in NXP MCUXpressoSDK packages. Visit <https://mcuxpresso.nxp.com> to configure, build and download these packages.

To get the board list with multicore support (eRPC included) use filtering based on Middleware and search for 'multicore' string. Once the selected package with the multicore middleware is downloaded, see

<MCUXpressoSDK_install_dir>/boards/<board_name>/multicore_examples for eRPC multicore examples (RPMsg_Lite or Messaging Unit transports used) or

<MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples for eRPC multiprocessor examples (UART or SPI transports used).

eRPC examples use the 'erpc_' name prefix.

Another way of getting NXP MCUXpressoSDK eRPC multicore and multiprocessor examples is using the [mcux-sdk](#) Github repo. Follow the description how to use the West tool to clone and

update the mcuxsdk repo in [readme Overview section](#). Once done the armgcc eRPC examples can be found in

mcuxsdk/examples/<board_name>/multicore_examples or in

mcuxsdk/examples/<board_name>/multiprocessor_examples folders.

You can use the evkmimxrt1170 as the board_name for instance. Similar to MCUXpressoSDK packages the eRPC examples use the 'erpc_' name prefix.

References This section provides links to interesting erpc-based projects, articles, blogs or guides:

- [erpc \(EmbeddedRPC\) getting started notes](#)
- [ERPC Linux Local Environment Construction and Use](#)
- [The New Wio Terminal eRPC Firmware](#)

Directories *doc* - Documentation.

doxygen - Configuration and support files for running Doxygen over the eRPC C++ infrastructure and erpcgen code.

erpc_c - Holds C/C++ infrastructure for eRPC. This is the code you will include in your application.

erpc_python - Holds Python version of the eRPC infrastructure.

erpcgen - Holds source code for erpcgen and makefiles or project files to build erpcgen on Windows, Linux, and OS X.

erpcsniffer - Holds source code for erpcsniffer application.

examples - Several example IDL files.

mk - Contains common makefiles for building eRPC components.

test - Client/server tests. These tests verify the entire communications path from client to server and back.

utilities - Holds utilities which bring additional benefit to eRPC apps developers.

Building and installing These build instructions apply to host PCs and embedded Linux. For bare metal or RTOS embedded environments, you should copy the *erpc_c* directory into your application sources.

CMake and KConfig build:

It builds a static library of the eRPC C/C++ infrastructure, the *erpcgen* executable, and optionally the unit tests and examples.

CMake is compatible with gcc and clang. On Windows local MingGW downloaded by *script* can be used.

Make build:

It builds a static library of the eRPC C/C++ infrastructure, the *erpcgen* executable, and optionally the unit tests.

The makefiles are compatible with gcc or clang on Linux, OS X, and Cygwin. A Windows build of *erpcgen* using Visual Studio is also available in the *erpcgen/VisualStudio_v14* directory. There is also an Xcode project file in the *erpcgen* directory, which can be used to build *erpcgen* for OS X.

Requirements erPC now support building **erpcgen**, **erpc_lib**, **tests** and **C examples** using CMake.

Requirements when using CMake:

- **CMake** (minimal version 3.20.0)
- Generator - **Make, Ninja, ...**
- **C/C++ compiler** - **GCC, CLANG, ...**
- **Bison** - <https://www.gnu.org/software/bison/>
- **Flex** - <https://github.com/westes/flex/>

Requirements when using Make:

- **Make**
- **C/C++ compiler - GCC, CLANG, ...**
- **Binson** - <https://www.gnu.org/software/bison/>
- **Flex** - <https://github.com/westes/flex/>

Windows Related steps to build **erpcgen** using **Visual Studio** are described in `erpcgen/VisualStudio_v14/readme_erpcgen.txt`.

To install MinGW, Bison, Flex locally on Windows:

```
./install_dependencies.ps1
* \ \ \

#### Linux

\ \ \ bash
./install_dependencies.sh
```

Mandatory for case, when build for different architecture is needed

- gcc-multilib, g++-multilib

Mac OS X

```
./install_dependencies.sh
```

Building

CMake and KConfig eRPC use CMake and KConfig to configurate and build eRPC related targets. KConfig can be edited by *prj.conf* or *menuconfig* when building.

Generate project, config and build. In *erpc/* execute:

```
cmake -B ./build # in erpc/build generate cmake project
cmake --build ./build --target menuconfig # Build menuconfig and configure erpcgen, erpc_lib, tests and examples
cmake --build ./build # Build all selected target from prj.conf/menuconfig
```

****CMake will use the system's default compilers and generator**

If you want to use Windows and locally installed MinGW, use *CMake preset* :


```
cmake --preset mingw64 # Generate project in ./build using mingw64's make and compilers
cmake --build ./build --target menuconfig # Build menuconfig and configure erpcgen, erpc_lib, tests and ↵
↵examples
cmake --build ./build # Build all selected target from prj.conf/menuconfig
```

Make To build the library and erpcgen, run from the repo root directory:

```
make
```

To install the library, erpcgen, and include files, run:

```
make install
```

You may need to sudo the make install.

By default this will install into /usr/local. If you want to install elsewhere, set the PREFIX environment variable. Example for installing into /opt:

```
make install PREFIX=/opt
```

List of top level Makefile targets:

- erpc: build the liberpc.a static library
- erpcgen: build the erpcgen tool
- erpcsniffer: build the sniffer tool
- test: build the unit tests under the *test* directory
- all: build all of the above
- install: install liberpc.a, erpcgen, and include files

eRPC code is validated with respect to the C++ 11 standard.

Installing for Python To install the Python infrastructure for eRPC see instructions in the *erpc python readme*.

Known issues and limitations

- Static allocations controlled by the ERPC_ALLOCATION_POLICY config macro are not fully supported yet, i.e. not all erpc objects can be allocated statically now. It deals with the ongoing process and the full static allocations support will be added in the future.

Code providing Repository on Github contains two main branches: **main** and **develop**. Code is developed on **develop** branch. Release version is created via merging **develop** branch into **main** branch.

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eRPC Getting Started

Overview This *Getting Started User Guide* shows software developers how to use Remote Procedure Calls (RPC) in embedded multicore microcontrollers (eRPC).

The eRPC documentation is located in the `<MCUXpressoSDK_install_dir>/middleware/multicore/erpc/doc` folder.

Create an eRPC application This section describes a generic way to create a client/server eRPC application:

1. **Design the eRPC application:** Decide which data types are sent between applications, and define functions that send/receive this data.
2. **Create the IDL file:** The IDL file contains information about data types and functions used in an eRPC application, and is written in the IDL language.
3. **Use the eRPC generator tool:** This tool takes an IDL file and generates the shim code for the client and the server-side applications.
4. **Create an eRPC application:**
 1. Create two projects, where one project is for the client side (primary core) and the other project is for the server side (secondary core).
 2. Add generated files for the client application to the client project, and add generated files for the server application to the server project.
 3. Add infrastructure files.
 4. Add user code for client and server applications.
 5. Set the client and server project options.
5. **Run the eRPC application:** Run both the server and the client applications. Make sure that the server has been run before the client request was sent.

A specific example follows in the next section.

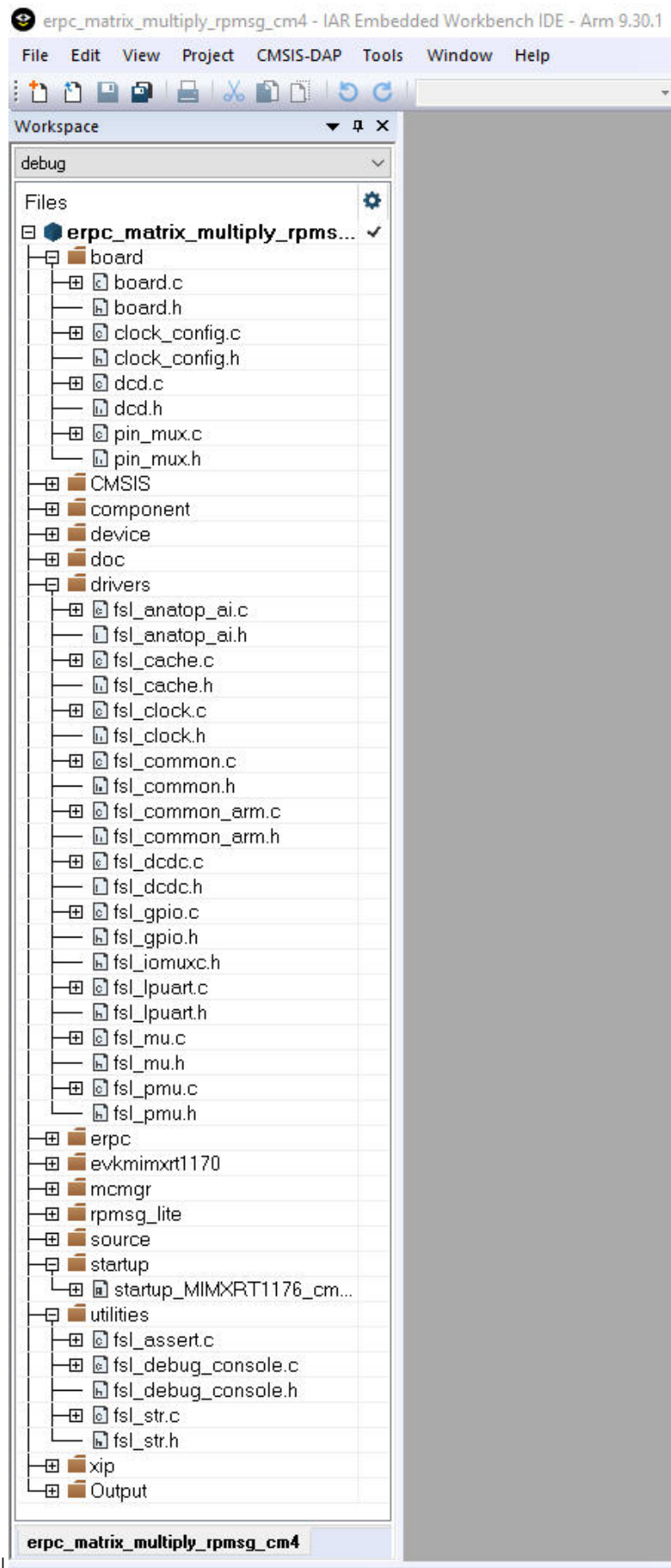
Multicore server application The “Matrix multiply” eRPC server project is located in the following folder:

`<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmmsg/cm4/iar`

The project files for the eRPC server have the `_cm4` suffix.

Server project basic source files The startup files, board-related settings, peripheral drivers, and utilities belong to the basic project source files and form the skeleton of all MCUXpresso SDK applications. These source files are located in:

- `<MCUXpressoSDK_install_dir>/devices/<device>`
- `<MCUXpressoSDK_install_dir>/boards/<board_name>/multicore_examples/<example_name>/`



|

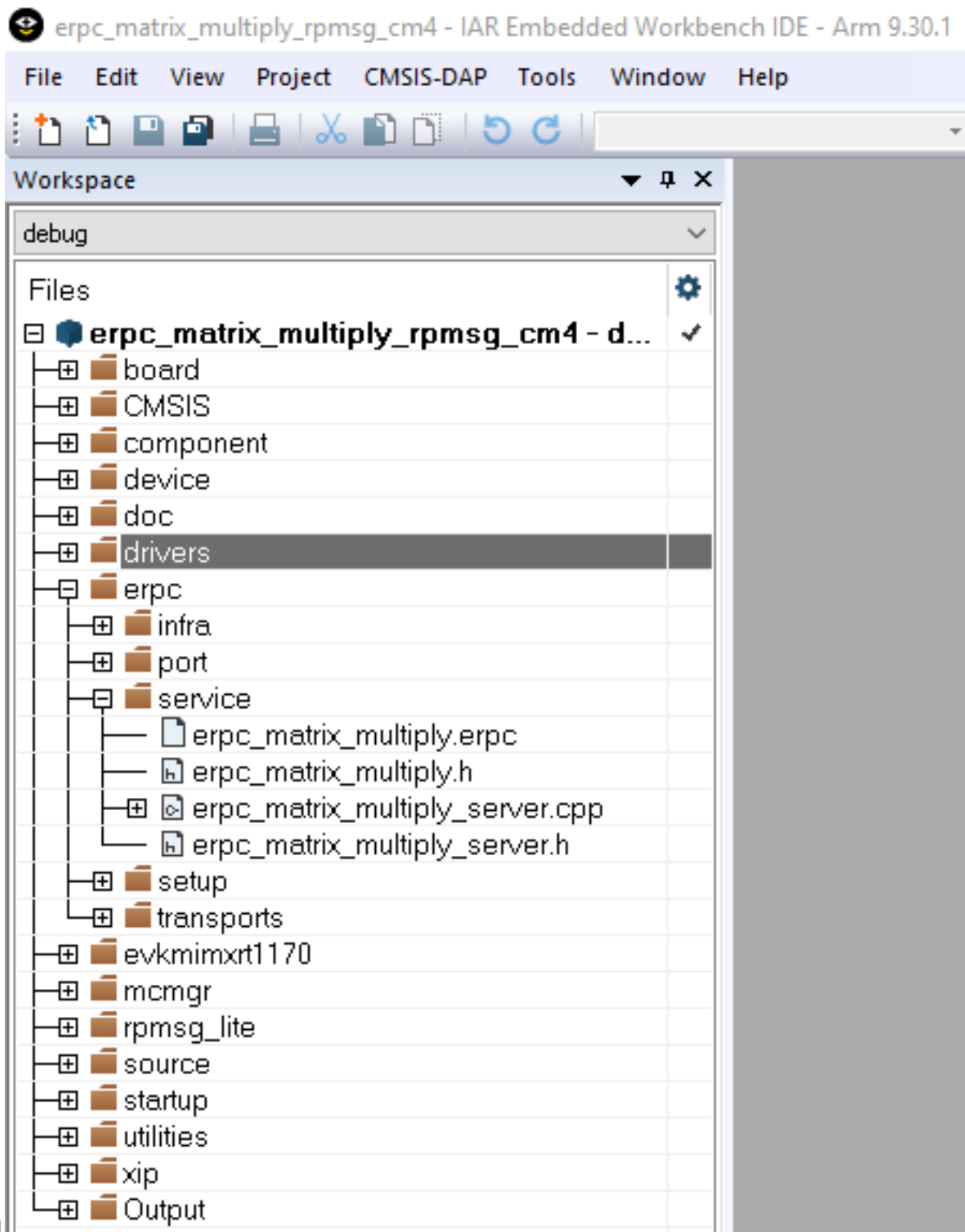
Parent topic: Multicore server application

Server related generated files The server-related generated files are:

- erpc__matric__multiply.h
- erpc__matrix__multiply__server.h
- erpc__matrix__multiply__server.cpp

The server-related generated files contain the shim code for functions and data types declared in the IDL file. These files also contain functions for the identification of client requested functions, data deserialization, calling requested function's implementations, and data serialization and return, if requested by the client. These shim code files can be found in the following folder:

<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/



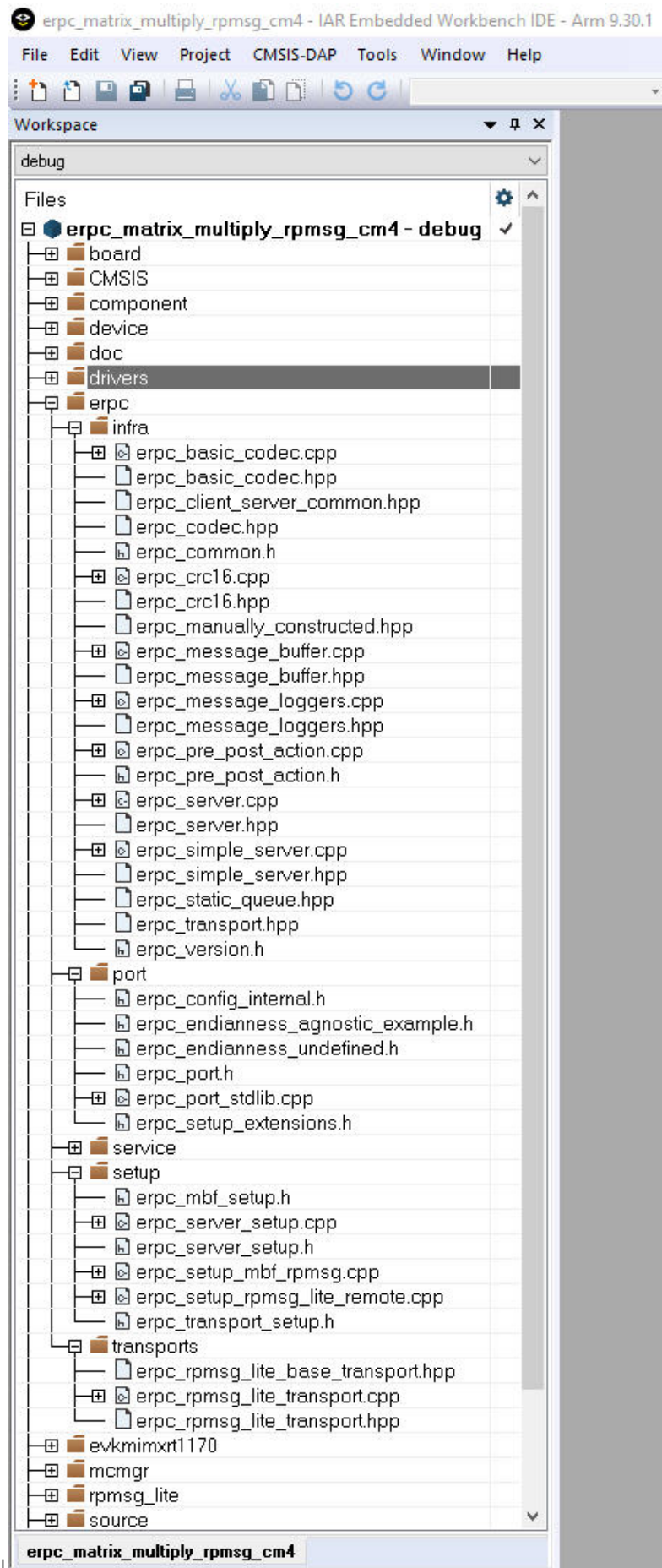
Parent topic: Multicore server application

Server infrastructure files The eRPC infrastructure files are located in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/erpc/erpc_c`

The **erpc_c** folder contains files for creating eRPC client and server applications in the C/C++ language. These files are distributed into subfolders.

- The **infra** subfolder contains C++ infrastructure code used to build server and client applications.
 - Four files, `erpc_server.hpp`, `erpc_server.cpp`, `erpc_simple_server.hpp`, and `erpc_simple_server.cpp`, are used for running the eRPC server on the server-side applications. The simple server is currently the only implementation of the server, and its role is to catch client requests, identify and call requested functions, and send data back when requested.
 - Three files (`erpc_codec.hpp`, `erpc_basic_codec.hpp`, and `erpc_basic_codec.cpp`) are used for codecs. Currently, the basic codec is the initial and only implementation of the codecs.
 - The `erpc_common.hpp` file is used for common eRPC definitions, typedefs, and enums.
 - The `erpc_manually_constructed.hpp` file is used for allocating static storage for the used objects.
 - Message buffer files are used for storing serialized data: `erpc_message_buffer.h` and `erpc_message_buffer.cpp`.
 - The `erpc_transport.h` file defines the abstract interface for transport layer.
- The **port** subfolder contains the eRPC porting layer to adapt to different environments.
 - `erpc_port.h` file contains definition of `erpc_malloc()` and `erpc_free()` functions.
 - `erpc_port_stdlib.cpp` file ensures adaptation to `stdlib`.
 - `erpc_config_internal.h` internal erpc configuration file.
- The **setup** subfolder contains a set of plain C APIs that wrap the C++ infrastructure, providing client and server init and deinit routines that greatly simplify eRPC usage in C-based projects. No knowledge of C++ is required to use these APIs.
 - The `erpc_server_setup.h` and `erpc_server_setup.cpp` files need to be added into the “Matrix multiply” example project to demonstrate the use of C-wrapped functions in this example.
 - The `erpc_transport_setup.h` and `erpc_setup_rpmsg_lite_remote.cpp` files need to be added into the project in order to allow the C-wrapped function for transport layer setup.
 - The `erpc_mbf_setup.h` and `erpc_setup_mbf_rpmsg.cpp` files need to be added into the project in order to allow message buffer factory usage.
- The **transports** subfolder contains transport classes for the different methods of communication supported by eRPC. Some transports are applicable only to host PCs, while others are applicable only to embedded or multicore systems. Most transports have corresponding client and server setup functions in the setup folder.
 - RPMsg-Lite is used as the transport layer for the communication between cores, `erpc_rpmsg_lite_base_transport.hpp`, `erpc_rpmsg_lite_transport.hpp`, and `erpc_rpmsg_lite_transport.cpp` files need to be added into the server project.



|

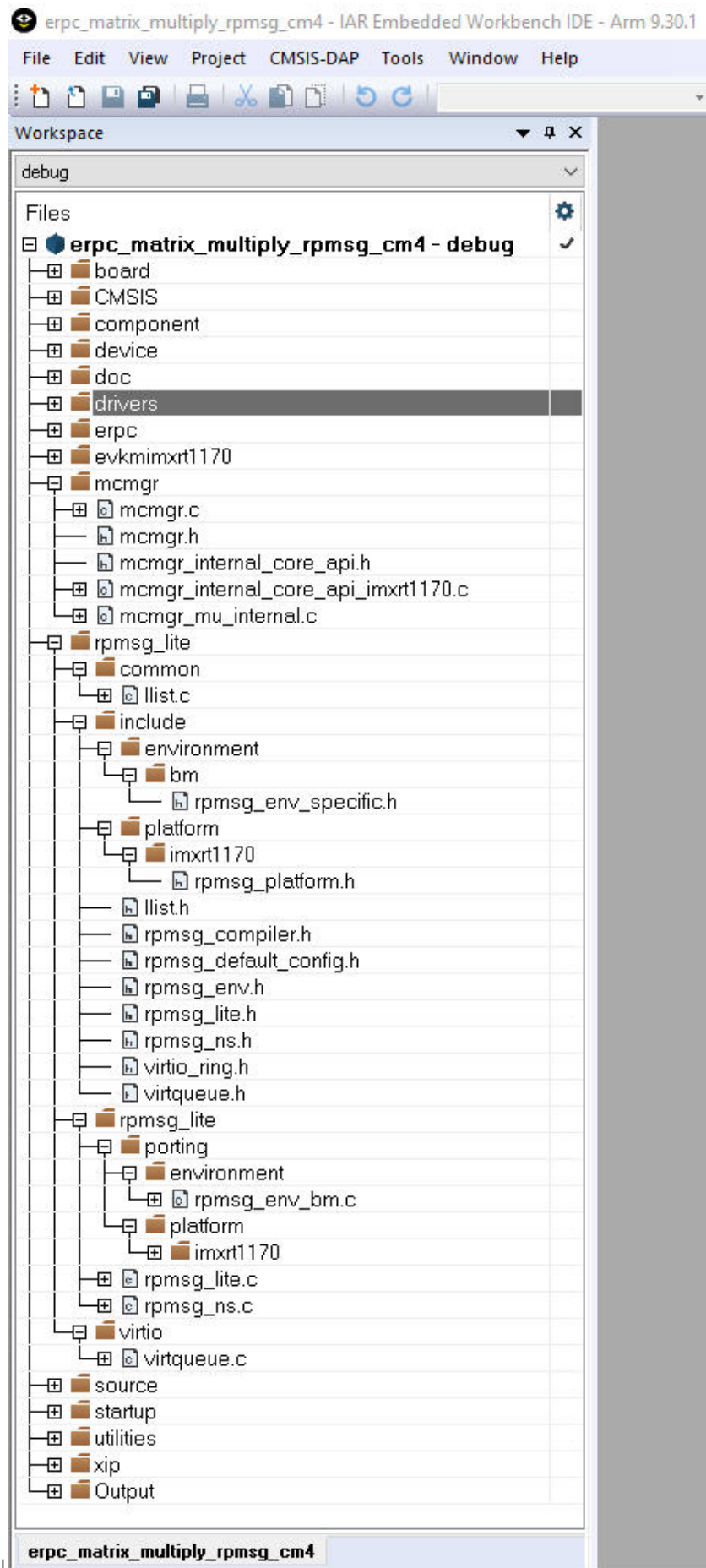
Parent topic: Multicore server application

Server multicore infrastructure files Because of the RPSMsg-Lite (transport layer), it is also necessary to include RPSMsg-Lite related files, which are in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/rpsmsg_lite/`

The multicore example applications also use the Multicore Manager software library to control the secondary core startup and shutdown. These source files are located in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/mcmgr/`



|

Parent topic: Multicore server application

Server user code The server's user code is stored in the `main_core1.c` file, located in the following folder:

`<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg/cm4`

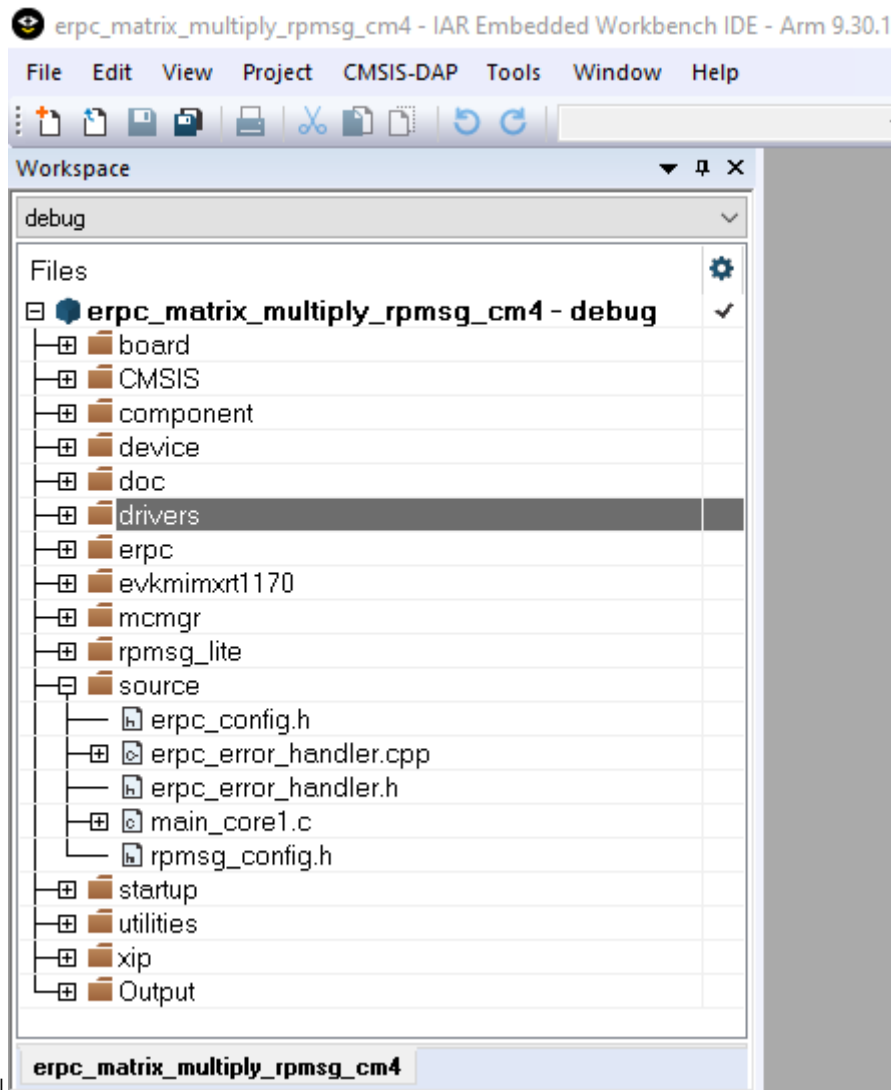
The `main_core1.c` file contains two functions:

- The **main()** function contains the code for the target board and eRPC server initialization. After the initialization, the matrix multiply service is added and the eRPC server waits for client's requests in the while loop.
- The **erpcMatrixMultiply()** function is the user implementation of the eRPC function defined in the IDL file.
- There is the possibility to write the application-specific eRPC error handler. The eRPC error handler of the matrix multiply application is implemented in the `erpc_error_handler.h` and `erpc_error_handler.cpp` files.

The eRPC-relevant code is captured in the following code snippet:

```
/* erpcMatrixMultiply function user implementation */
void erpcMatrixMultiply(const Matrix *matrix1, const Matrix *matrix2, Matrix *result_matrix)
{
    ...
}
int main()
{
    ...
    /* RPSMsg-Lite transport layer initialization */
    erpc_transport_t transport;
    transport = erpc_transport_rpmsg_lite_remote_init(src, dst, (void*)startupData,
    ERPC_TRANSPORT_RPMSG_LITE_LINK_ID, SignalReady, NULL);
    ...
    /* MessageBufferFactory initialization */
    erpc_mbf_t message_buffer_factory;
    message_buffer_factory = erpc_mbf_rpmsg_init(transport);
    ...
    /* eRPC server side initialization */
    erpc_server_t server;
    server = erpc_server_init(transport, message_buffer_factory);
    ...
    /* Adding the service to the server */
    erpc_service_t service = create_MatrixMultiplyService_service();
    erpc_add_service_to_server(server, service);
    ...
    while (1)
    {
        /* Process eRPC requests */
        erpc_status_t status = erpc_server_poll(server);
        /* handle error status */
        if (status != kErpcStatus_Success)
        {
            /* print error description */
            erpc_error_handler(status, 0);
            ...
        }
        ...
    }
}
```

Except for the application main file, there are configuration files for the RPMsg-Lite (rpmsg_config.h) and eRPC (erpc_config.h), located in the `<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg` folder.



Parent topic:Multicore server application

Parent topic:[Create an eRPC application](#)

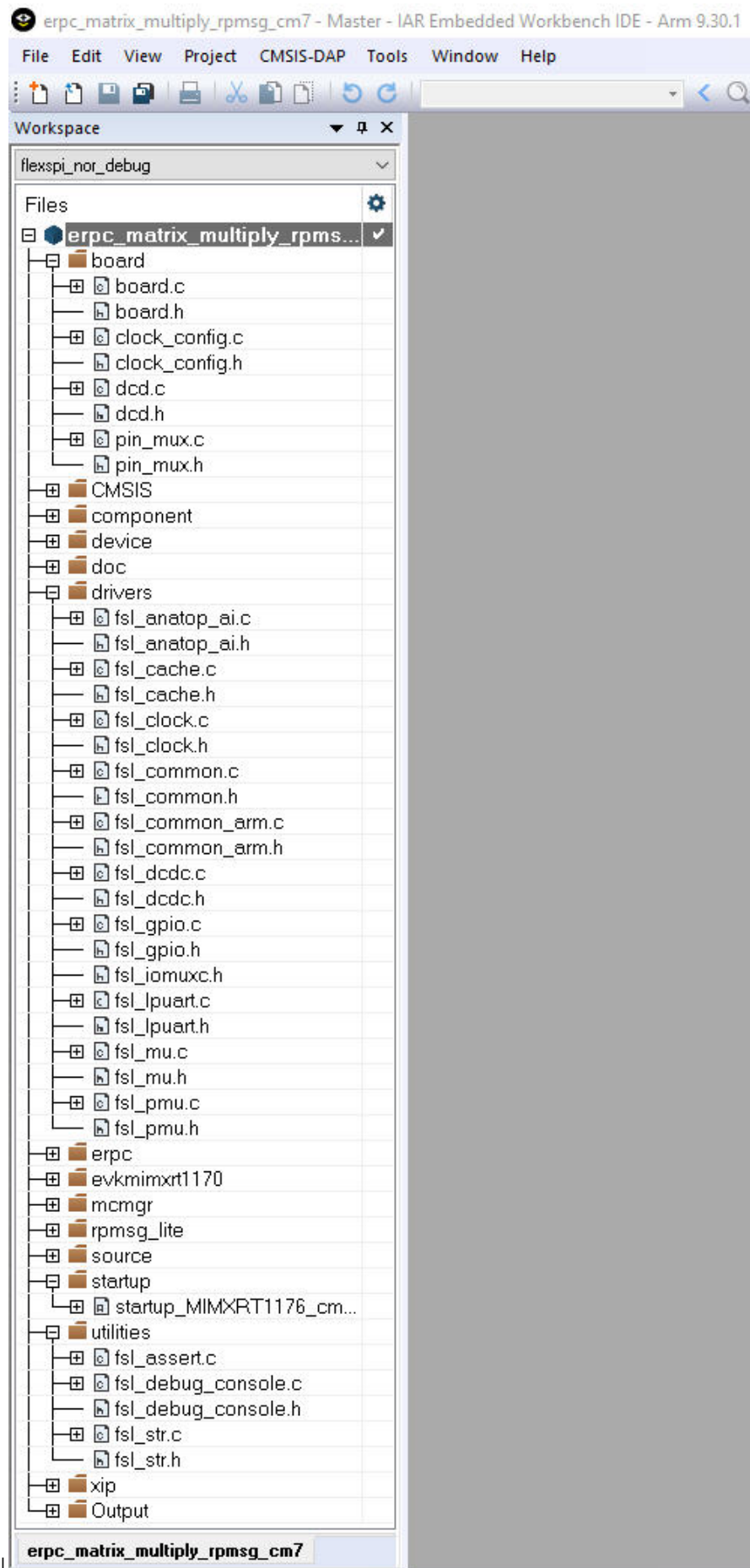
Multicore client application The “Matrix multiply” eRPC client project is located in the following folder:

`<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg/cm7/iar`

Project files for the eRPC client have the `_cm7` suffix.

Client project basic source files The startup files, board-related settings, peripheral drivers, and utilities belong to the basic project source files and form the skeleton of all MCUXpresso SDK applications. These source files are located in the following folders:

- `<MCUXpressoSDK_install_dir>/devices/<device>`
- `<MCUXpressoSDK_install_dir>/boards/<board_name>/multicore_examples/<example_name>/`



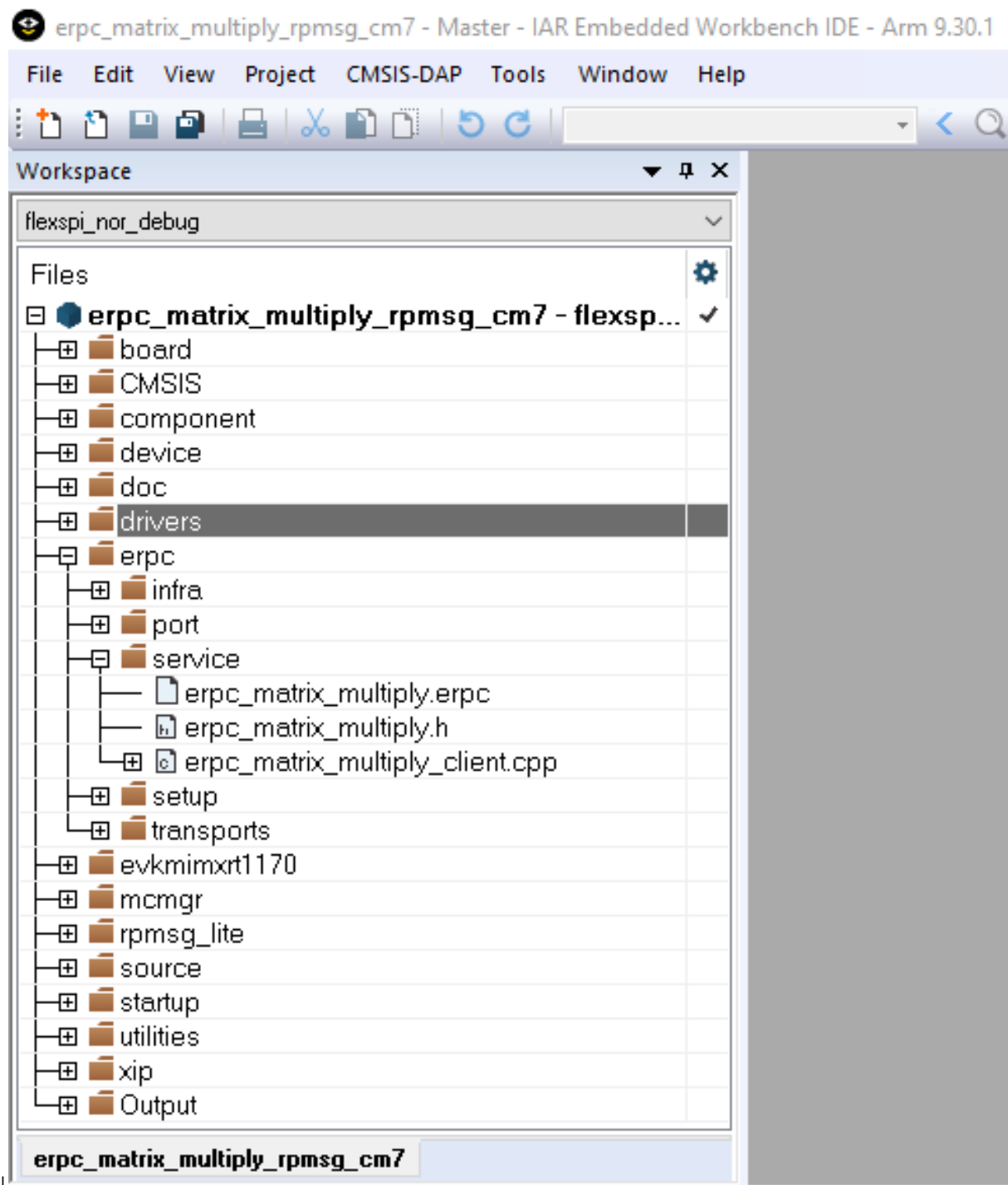
|

Parent topic: Multicore client application

Client-related generated files The client-related generated files are:

- `erpc__matric__multiply.h`
- `erpc__matrix__multiply__client.cpp`

These files contain the shim code for the functions and data types declared in the IDL file. These functions also call methods for codec initialization, data serialization, performing eRPC requests, and de-serializing outputs into expected data structures (if return values are expected). These shim code files can be found in the `<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/service/` folder.



Parent topic: Multicore client application

Client infrastructure files The eRPC infrastructure files are located in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/erpc/erpc_c`

The **erpc_c** folder contains files for creating eRPC client and server applications in the C/C++ language. These files are distributed into subfolders.

- The **infra** subfolder contains C++ infrastructure code used to build server and client applications.

- Two files, `erpc_client_manager.h` and `erpc_client_manager.cpp`, are used for managing the client-side application. The main purpose of the client files is to create, perform, and release eRPC requests.
- Three files (`erpc_codec.hpp`, `erpc_basic_codec.hpp`, and `erpc_basic_codec.cpp`) are used for codecs. Currently, the basic codec is the initial and only implementation of the codecs.
- `erpc_common.h` file is used for common eRPC definitions, typedefs, and enums.
- `erpc_manually_constructed.hpp` file is used for allocating static storage for the used objects.
- Message buffer files are used for storing serialized data: `erpc_message_buffer.hpp` and `erpc_message_buffer.cpp`.
- `erpc_transport.hpp` file defines the abstract interface for transport layer.

The **port** subfolder contains the eRPC porting layer to adapt to different environments.

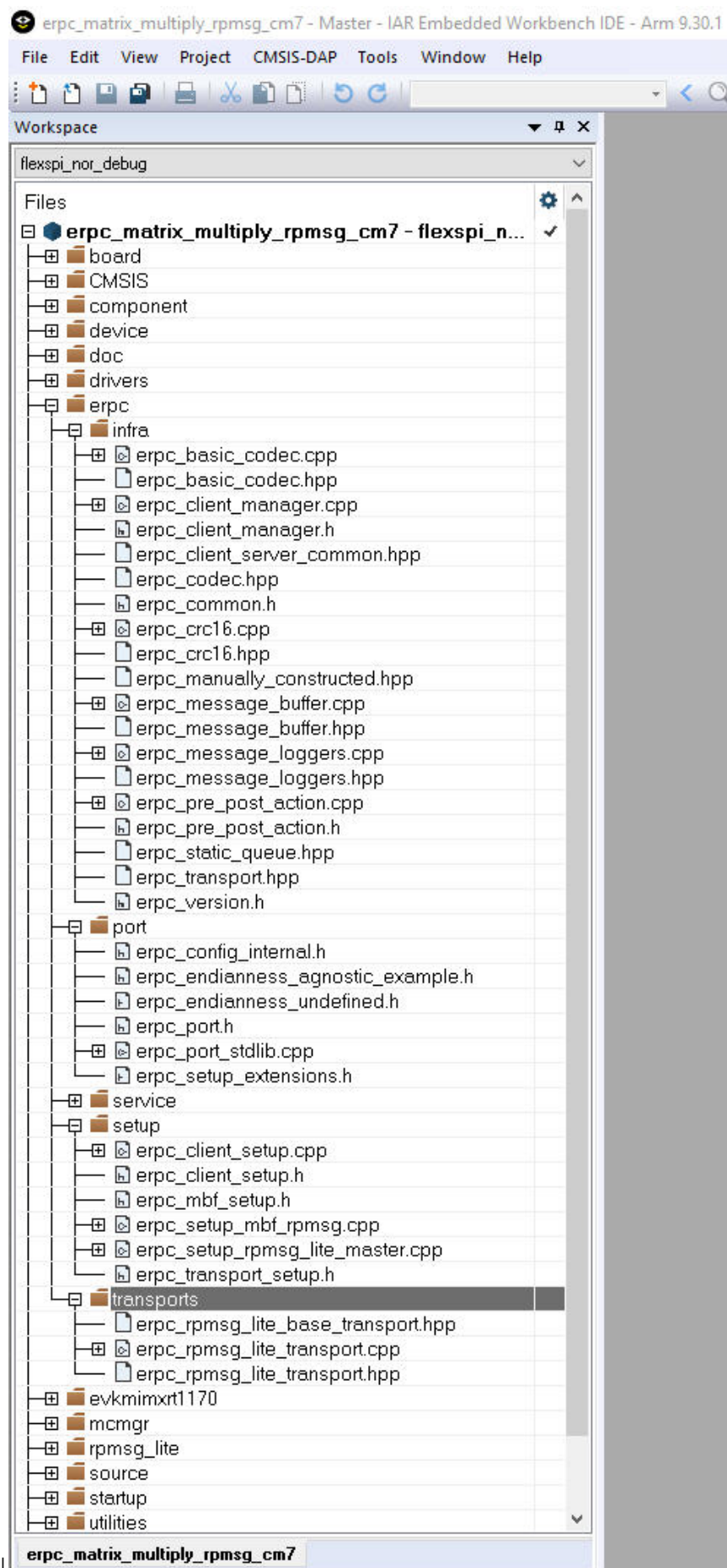
- `erpc_port.h` file contains definition of `erpc_malloc()` and `erpc_free()` functions.
- `erpc_port_stdlib.cpp` file ensures adaptation to `stdlib`.
- `erpc_config_internal.h` internal eRPC configuration file.

The **setup** subfolder contains a set of plain C APIs that wrap the C++ infrastructure, providing client and server init and deinit routines that greatly simplify eRPC usage in C-based projects. No knowledge of C++ is required to use these APIs.

- `erpc_client_setup.h` and `erpc_client_setup.cpp` files needs to be added into the “Matrix multiply” example project to demonstrate the use of C-wrapped functions in this example.
- `erpc_transport_setup.h` and `erpc_setup_rpmsg_lite_master.cpp` files needs to be added into the project in order to allow C-wrapped function for transport layer setup.
- `erpc_mbf_setup.h` and `erpc_setup_mbf_rpmsg.cpp` files needs to be added into the project in order to allow message buffer factory usage.

The **transports** subfolder contains transport classes for the different methods of communication supported by eRPC. Some transports are applicable only to host PCs, while others are applicable only to embedded or multicore systems. Most transports have corresponding client and server setup functions, in the setup folder.

- RPMsg-Lite is used as the transport layer for the communication between cores, `erpc_rpmsg_lite_base_transport.hpp`, `erpc_rpmsg_lite_transport.hpp`, and `erpc_rpmsg_lite_transport.cpp` files needs to be added into the client project.



|

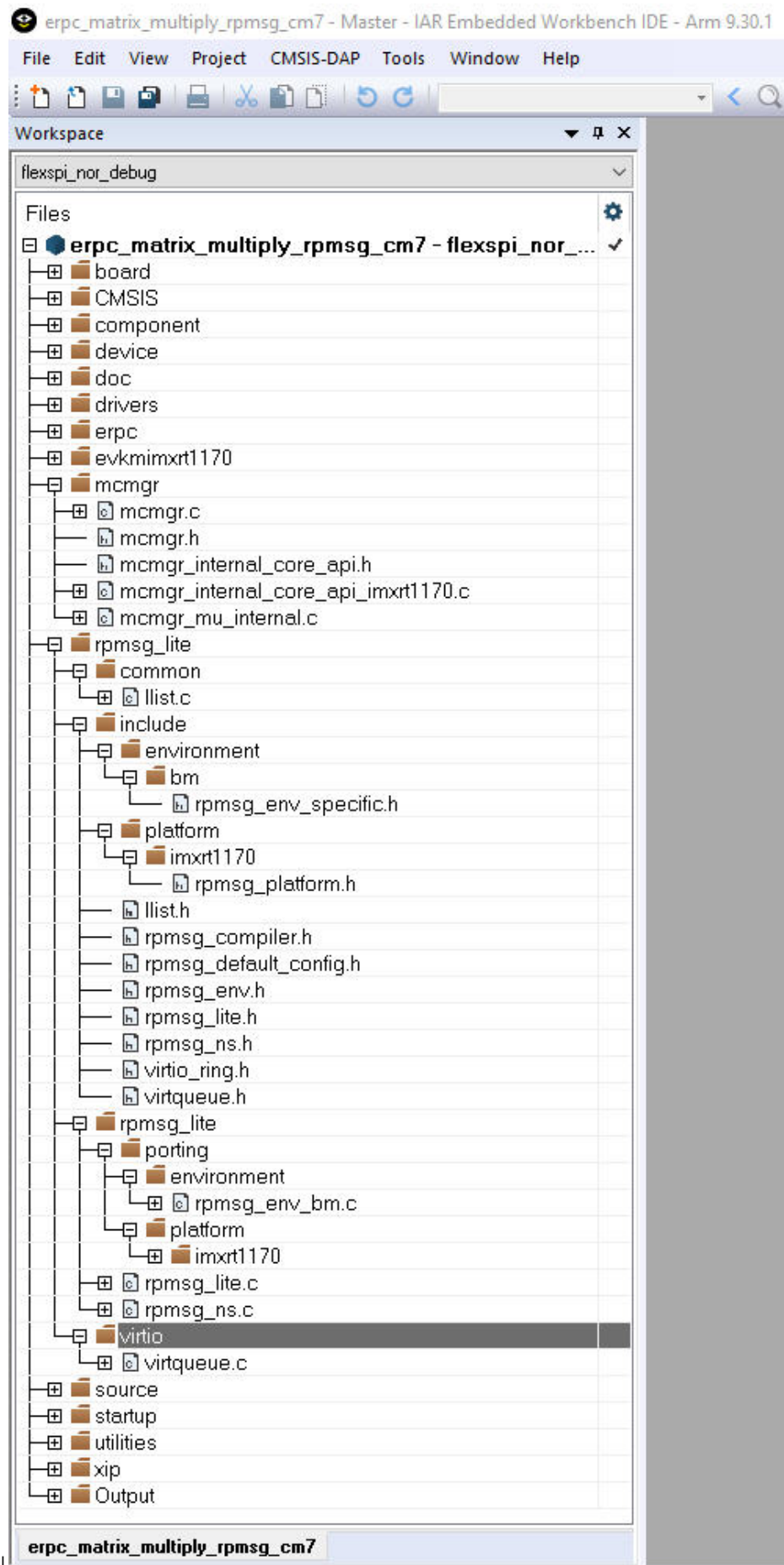
Parent topic: Multicore client application

Client multicore infrastructure files Because of the RPMsg-Lite (transport layer), it is also necessary to include RPMsg-Lite related files, which are in the following folder:

<MCUXpressoSDK_install_dir>/middleware/multicore/rpmsg_lite/

The multicore example applications also use the Multicore Manager software library to control the secondary core startup and shutdown. These source files are located in the following folder:

<MCUXpressoSDK_install_dir>/middleware/multicore/mcmgr/



Parent topic:Multicore client application

Client user code The client's user code is stored in the main_core0.c file, located in the following folder:

<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_example/erpc_matrix_multiply_rpmsg/cm7

The main_core0.c file contains the code for target board and eRPC initialization.

- After initialization, the secondary core is released from reset.
- When the secondary core is ready, the primary core initializes two matrix variables.
- The erpcMatrixMultiply eRPC function is called to issue the eRPC request and get the result.

It is possible to write the application-specific eRPC error handler. The eRPC error handler of the matrix multiply application is implemented in erpc_error_handler.h and erpc_error_handler.cpp files.

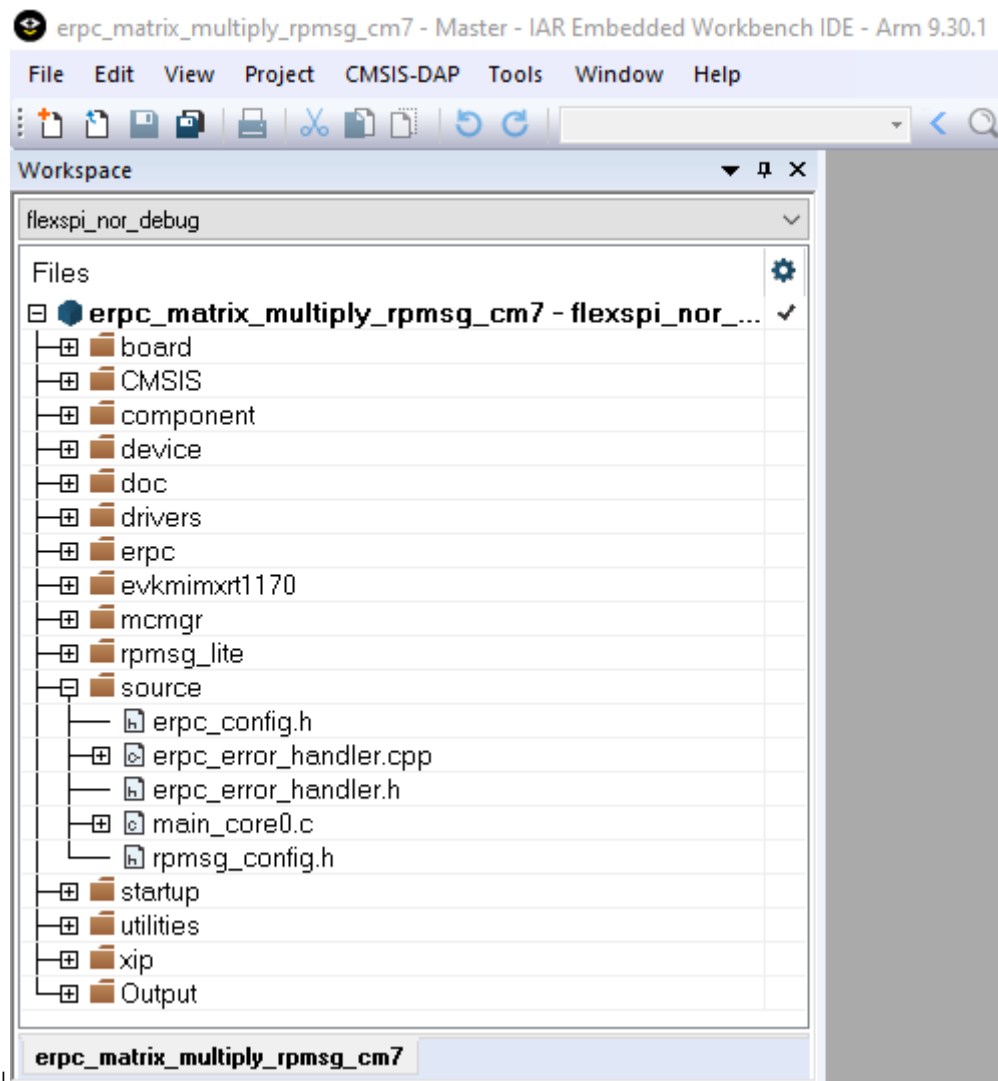
The matrix multiplication can be issued repeatedly, when pressing a software board button.

The eRPC-relevant code is captured in the following code snippet:

```
...
extern bool g_erpc_error_occurred;
...
/* Declare matrix arrays */
Matrix matrix1 = {0}, matrix2 = {0}, result_matrix = {0};
...
/* RPSMsg-Lite transport layer initialization */
erpc_transport_t transport;
transport = erpc_transport_rpmsg_lite_master_init(src, dst,
ERPC_TRANSPORT_RPMSG_LITE_LINK_ID);
...
/* MessageBufferFactory initialization */
erpc_mbf_t message_buffer_factory;
message_buffer_factory = erpc_mbf_rpmsg_init(transport);
...
/* eRPC client side initialization */
erpc_client_t client;
client = erpc_client_init(transport, message_buffer_factory);
...
/* Set default error handler */
erpc_client_set_error_handler(client, erpc_error_handler);
...
while (1)
{
    /* Invoke the erpcMatrixMultiply function */
    erpcMatrixMultiply(matrix1, matrix2, result_matrix);
    ...
    /* Check if some error occurred in eRPC */
    if (g_erpc_error_occurred)
    {
        /* Exit program loop */
        break;
    }
    ...
}
```

Except for the application main file, there are configuration files for the RPSMsg-Lite (rpmsg_config.h) and eRPC (erpc_config.h), located in the following folder:

<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg



Parent topic: Multicore client application

Parent topic: [Create an eRPC application](#)

Multiprocessor server application The “Matrix multiply” eRPC server project for multiprocessor applications is located in the `<MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_server_matrix_multiply_<transport_layer>` folder.

Most of the multiprocessor application setup is the same as for the multicore application. The multiprocessor server application requires server-related generated files (server shim code), server infrastructure files, and the server user code. There is no need for server multicore infrastructure files (MCMGR and RPMs-Lite). The RPMs-Lite transport layer is replaced either by SPI or UART transports. The following table shows the required transport-related files per each transport type.

SPI	<eRPC base directory>/erpc_c/setup/erpc_setup_(d)spi_slave.cpp
	<eRPC base directory>/erpc_c/transports/erpc_(d)spi_slave_transport.hpp
	<eRPC base directory>/erpc_c/transports/erpc_(d)spi_slave_transport.cpp
UART	<eRPC base directory>/erpc_c/setup/erpc_setup_uart_cmsis.cpp

<eRPC base directory>/erpc_c/transport/erpc_uart_cmsis_transport.hpp

<eRPC base directory>/erpc_c/transport/erpc_uart_cmsis_transport.cpp

|

Server user code The server's user code is stored in the main_server.c file, located in the <MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_server_matrix_multiply_<transport_layer>/ folder.

The eRPC-relevant code with UART as a transport is captured in the following code snippet:

```
/* erpcMatrixMultiply function user implementation */
void erpcMatrixMultiply(Matrix matrix1, Matrix matrix2, Matrix result_matrix)
{
    ...
}
int main()
{
    ...
    /* UART transport layer initialization, ERPC_DEMO_UART is the structure of CMSIS UART driver
    ↪operations */
    erpc_transport_t transport;
    transport = erpc_transport_cmsis_uart_init((void *)&ERPC_DEMO_UART);
    ...
    /* MessageBufferFactory initialization */
    erpc_mbf_t message_buffer_factory;
    message_buffer_factory = erpc_mbf_dynamic_init();
    ...
    /* eRPC server side initialization */
    erpc_server_t server;
    server = erpc_server_init(transport, message_buffer_factory);
    ...
    /* Adding the service to the server */
    erpc_service_t service = create_MatrixMultiplyService_service();
    erpc_add_service_to_server(server, service);
    ...
    while (1)
    {
        /* Process eRPC requests */
        erpc_status_t status = erpc_server_poll(server)
        /* handle error status */
        if (status != kErpcStatus_Success)
        {
            /* print error description */
            erpc_error_handler(status, 0);
            ...
        }
        ...
    }
}
```

Parent topic:Multiprocessor server application

Multiprocessor client application The “Matrix multiply” eRPC client project for multiprocessor applications is located in the <MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_client_matrix_multiply_<transport_layer>/iar/ folder.

Most of the multiprocessor application setup is the same as for the multicore application. The multiprocessor server application requires client-related generated files (server shim code),

client infrastructure files, and the client user code. There is no need for client multicore infrastructure files (MCMGR and RPSMsg-Lite). The RPSMsg-Lite transport layer is replaced either by SPI or UART transports. The following table shows the required transport-related files per each transport type.

SPI	<eRPC base directory>/erpc_c/setup/erpc_setup_(d)spi_master.cpp
<eRPC base directory>/erpc_c/transports/	erpc_(d)spi_master_transport.hpp
<eRPC base directory>/erpc_c/transports/	erpc_(d)spi_master_transport.cpp
UART	<eRPC base directory>/erpc_c/setup/erpc_setup_uart_cmsis.cpp
<eRPC base directory>/erpc_c/transports/	erpc_uart_cmsis_transport.hpp
<eRPC base directory>/erpc_c/transports/	erpc_uart_cmsis_transport.cpp

Client user code The client's user code is stored in the `main_client.c` file, located in the `<MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_client_matrix_multiply_<transport_layer>/` folder.

The eRPC-relevant code with UART as a transport is captured in the following code snippet:

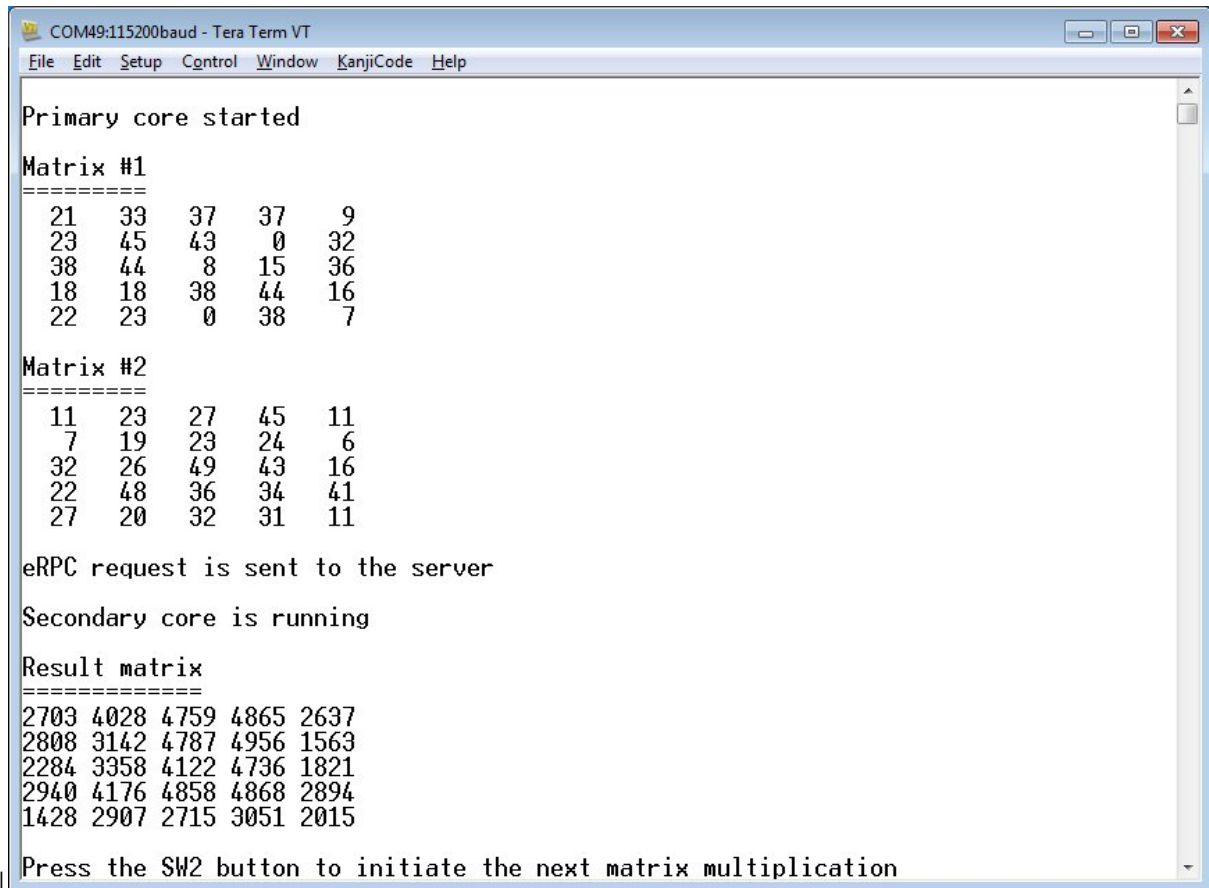
```
...
extern bool g_erpc_error_occurred;
...
/* Declare matrix arrays */
Matrix matrix1 = {0}, matrix2 = {0}, result_matrix = {0};
...
/* UART transport layer initialization, ERPC_DEMO_UART is the structure of CMSIS UART driver
↳operations */
erpc_transport_t transport;
transport = erpc_transport_cmsis_uart_init((void *)&ERPC_DEMO_UART);
...
/* MessageBufferFactory initialization */
erpc_mbf_t message_buffer_factory;
message_buffer_factory = erpc_mbf_dynamic_init();
...
/* eRPC client side initialization */
erpc_client_t client;
client = erpc_client_init(transport,message_buffer_factory);
...
/* Set default error handler */
erpc_client_set_error_handler(client, erpc_error_handler);
...
while (1)
{
    /* Invoke the erpcMatrixMultiply function */
    erpcMatrixMultiply(matrix1, matrix2, result_matrix);
    ...
    /* Check if some error occurred in eRPC */
    if (g_erpc_error_occurred)
    {
        /* Exit program loop */
        break;
    }
    ...
}
```

Parent topic:Multiprocessor client application

Parent topic:Multiprocessor server application

Parent topic:[Create an eRPC application](#)

Running the eRPC application Follow the instructions in *Getting Started with MCUXpresso SDK* (document MCUXSDKGSUG) (located in the <MCUXpressoSDK_install_dir>/docs folder), to load both the primary and the secondary core images into the on-chip memory, and then effectively debug the dual-core application. After the application is running, the serial console should look like:



```

COM49:115200baud - Tera Term VT
File Edit Setup Control Window KanjiCode Help

Primary core started

Matrix #1
=====
 21  33  37  37   9
 23  45  43   0  32
 38  44   8  15  36
 18  18  38  44  16
 22  23   0  38   7

Matrix #2
=====
 11  23  27  45  11
  7  19  23  24   6
 32  26  49  43  16
 22  48  36  34  41
 27  20  32  31  11

eRPC request is sent to the server

Secondary core is running

Result matrix
=====
2703 4028 4759 4865 2637
2808 3142 4787 4956 1563
2284 3358 4122 4736 1821
2940 4176 4858 4868 2894
1428 2907 2715 3051 2015

Press the SW2 button to initiate the next matrix multiplication

```

For multiprocessor applications that are running between PC and the target evaluation board or between two boards, follow the instructions in the accompanied example readme files that provide details about the proper board setup and the PC side setup (Python).

Parent topic:[Create an eRPC application](#)

Parent topic:[eRPC example](#)

eRPC example This section shows how to create an example eRPC application called “Matrix multiply”, which implements one eRPC function (matrix multiply) with two function parameters (two matrices). The client-side application calls this eRPC function, and the server side performs the multiplication of received matrices. The server side then returns the result.

For example, use the NXP MIMXRT1170-EVK board as the target dual-core platform, and the IAR Embedded Workbench for ARM (EWARM) as the target IDE for developing the eRPC example.

- The primary core (CM7) runs the eRPC client.
- The secondary core (CM4) runs the eRPC server.
- RPMsg-Lite (Remote Processor Messaging Lite) is used as the eRPC transport layer.

The “Matrix multiply” application can be also run in the multi-processor setup. In other words, the eRPC client running on one SoC communicates with the eRPC server that runs on another SoC, utilizing different transport channels. It is possible to run the board-to-PC example (PC as the eRPC server and a board as the eRPC client, and vice versa) and also the board-to-board example. These multiprocessor examples are prepared for selected boards only.

| Multicore application source and project files | `<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore/`
| Multiprocessor application source and project files | `<MCUXpressoSDK_install_dir>/boards/<board_name>/multi`
`<MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_server_matrix_multiply_<tr`
| | eRPC source files | `<MCUXpressoSDK_install_dir>/middleware/multicore/erpc/` | | RPLite
source files | `<MCUXpressoSDK_install_dir>/middleware/multicore/rplite/`

Designing the eRPC application The matrix multiply application is based on calling single eRPC function that takes 2 two-dimensional arrays as input and returns matrix multiplication results as another 2 two-dimensional array. The IDL file syntax supports arrays with the dimension length set by the number only (in the current eRPC implementation). Because of this, a variable is declared in the IDL dedicated to store information about matrix dimension length, and to allow easy maintenance of the user and server code.

For a simple use of the two-dimensional array, the alias name (new type definition) for this data type has been declared in the IDL. Declaring this alias name ensures that the same data type can be used across the client and server applications.

Parent topic: [eRPC example](#)

Creating the IDL file The created IDL file is located in the following folder:

`<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/`

The created IDL file contains the following code:

```
program erpc_matrix_multiply
/*! This const defines the matrix size. The value has to be the same as the
Matrix array dimension. Do not forget to re-generate the erpc code once the
matrix size is changed in the erpc file */
const int32 matrix_size = 5;
/*! This is the matrix array type. The dimension has to be the same as the
matrix size const. Do not forget to re-generate the erpc code once the
matrix size is changed in the erpc file */
type Matrix = int32[matrix_size][matrix_size];
interface MatrixMultiplyService {
erpcMatrixMultiply(in Matrix matrix1, in Matrix matrix2, out Matrix result_matrix) ->
void
}
```

Details:

- The IDL file starts with the program name (*erpc_matrix_multiply*), and this program name is used in the naming of all generated outputs.
- The declaration and definition of the constant variable named *matrix_size* follows next. The *matrix_size* variable is used for passing information about the length of matrix dimensions to the client/server user code.
- The alias name for the two-dimensional array type (*Matrix*) is declared.
- The interface group *MatrixMultiplyService* is located at the end of the IDL file. This interface group contains only one function declaration *erpcMatrixMultiply*.
- As shown above, the function’s declaration contains three parameters of *Matrix* type: *matrix1* and *matrix2* are input parameters, while *result_matrix* is the output parameter. Additionally, the returned data type is declared as *void*.

When writing the IDL file, the following order of items is recommended:

1. Program name at the top of the IDL file.
2. New data types and constants declarations.
3. Declarations of interfaces and functions at the end of the IDL file.

Parent topic: [eRPC example](#)

Using the eRPC generator tool | Windows OS | <MCUXpressoSDK_install_dir>/middleware/multicore/tools/erpcgen/Linux_x64
 | Linux OS | <MCUXpressoSDK_install_dir>/middleware/multicore/tools/erpcgen/Linux_x86
 <MCUXpressoSDK_install_dir>/middleware/multicore/tools/erpcgen/Linux_x86
 | | Mac OS | <MCUXpressoSDK_install_dir>/middleware/multicore/tools/erpcgen/Mac |

The files for the “Matrix multiply” example are pre-generated and already a part of the application projects. The following section describes how they have been created.

- The easiest way to create the shim code is to copy the erpcgen application to the same folder where the IDL file (*.erpc) is located; then run the following command:

```
erpcgen <IDL_file>.erpc
```

- In the “Matrix multiply” example, the command should look like:

```
erpcgen erpc_matrix_multiply.erpc
```

Additionally, another method to create the shim code is to execute the eRPC application using input commands:

- “-?”/”—help” – Shows supported commands.
- “-o <filePath>”/”—output<filePath>” – Sets the output directory.

For example,

```
<path_to_erpcgen>/erpcgen -o <path_to_output>  
<path_to_IDL>/<IDL_file_name>.erpc
```

For the “Matrix multiply” example, when the command is executed from the default erpcgen location, it looks like:

```
erpcgen -o
```

```
../../../../../boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/service  
../../../../../boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/service/erpc_matrix_mu
```

In both cases, the following four files are generated into the <MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/service folder:

- erpc_matrix_multiply.h
- erpc_matrix_multiply_client.cpp
- erpc_matrix_multiply_server.h
- erpc_matrix_multiply_server.cpp

For multiprocessor examples, the eRPC file and pre-generated files can be found in the <MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_common/erpc_matrix_multiply/service folder.

For Linux OS users:

- Do not forget to set the permissions for the eRPC generator application.
- Run the application as ./erpcgen... instead of as erpcgen

Parent topic: [eRPC example](#)

Create an eRPC application This section describes a generic way to create a client/server eRPC application:

1. **Design the eRPC application:** Decide which data types are sent between applications, and define functions that send/receive this data.
2. **Create the IDL file:** The IDL file contains information about data types and functions used in an eRPC application, and is written in the IDL language.
3. **Use the eRPC generator tool:** This tool takes an IDL file and generates the shim code for the client and the server-side applications.
4. **Create an eRPC application:**
 1. Create two projects, where one project is for the client side (primary core) and the other project is for the server side (secondary core).
 2. Add generated files for the client application to the client project, and add generated files for the server application to the server project.
 3. Add infrastructure files.
 4. Add user code for client and server applications.
 5. Set the client and server project options.
5. **Run the eRPC application:** Run both the server and the client applications. Make sure that the server has been run before the client request was sent.

A specific example follows in the next section.

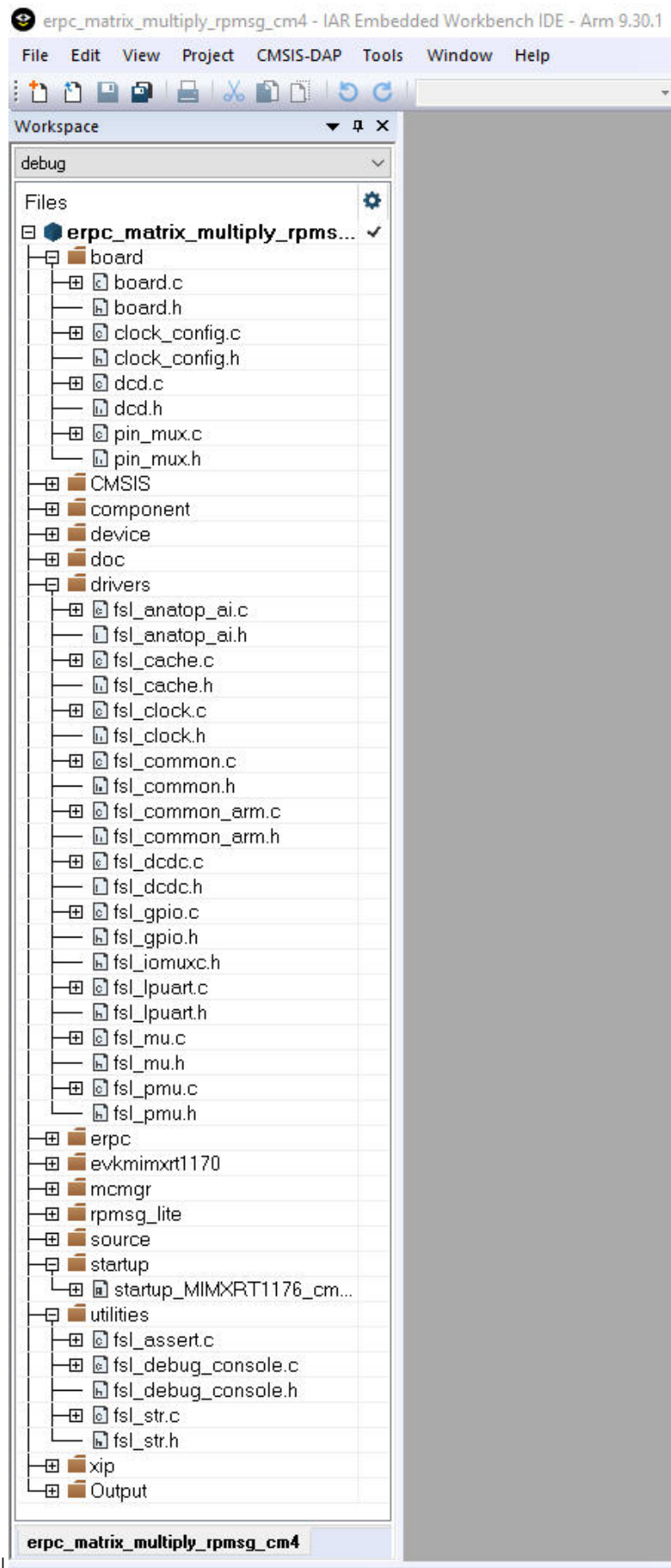
Multicore server application The “Matrix multiply” eRPC server project is located in the following folder:

`<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmmsg/cm4/iar`

The project files for the eRPC server have the `_cm4` suffix.

Server project basic source files The startup files, board-related settings, peripheral drivers, and utilities belong to the basic project source files and form the skeleton of all MCUXpresso SDK applications. These source files are located in:

- `<MCUXpressoSDK_install_dir>/devices/<device>`
- `<MCUXpressoSDK_install_dir>/boards/<board_name>/multicore_examples/<example_name>/`



|

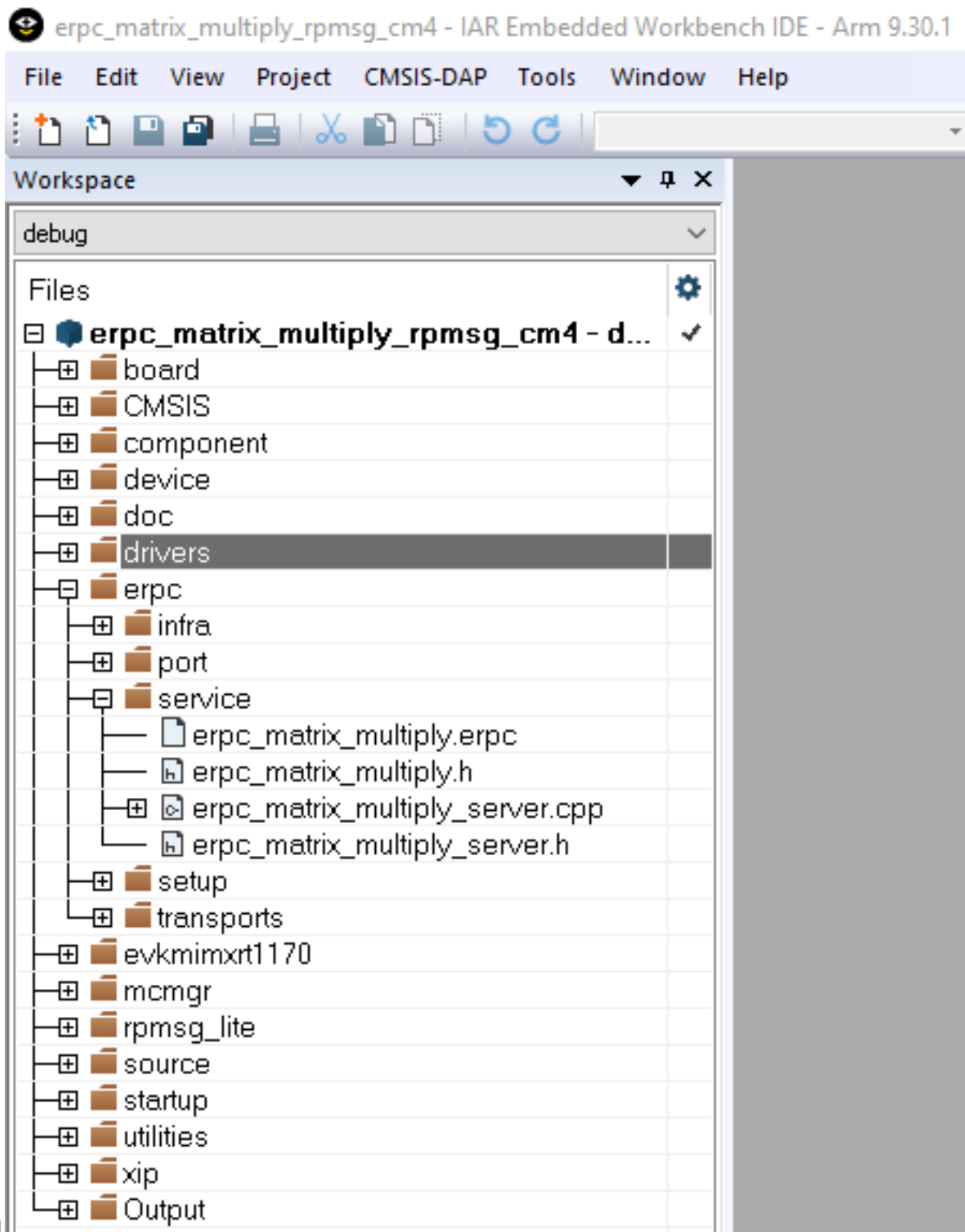
Parent topic:Multicore server application

Server related generated files The server-related generated files are:

- erpc__matric__multiply.h
- erpc__matrix__multiply__server.h
- erpc__matrix__multiply__server.cpp

The server-related generated files contain the shim code for functions and data types declared in the IDL file. These files also contain functions for the identification of client requested functions, data deserialization, calling requested function's implementations, and data serialization and return, if requested by the client. These shim code files can be found in the following folder:

<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/



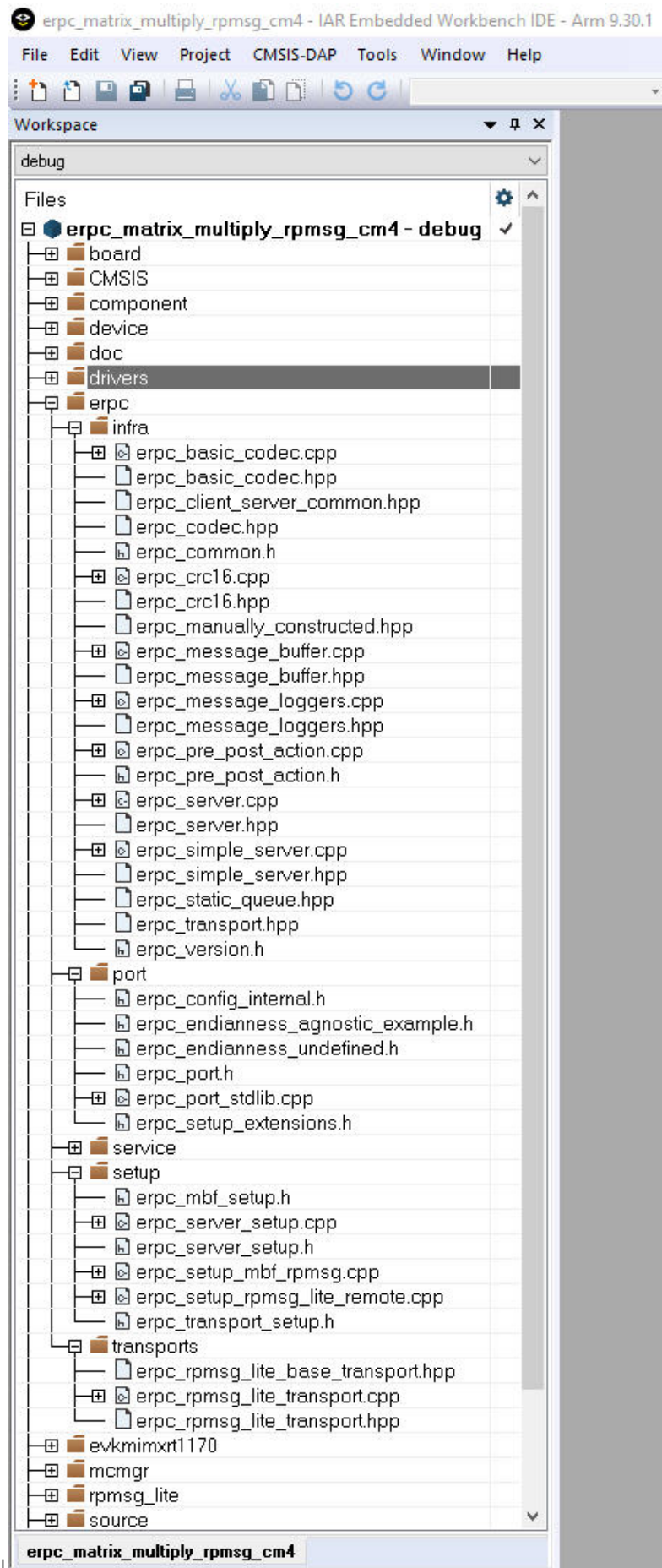
Parent topic: Multicore server application

Server infrastructure files The eRPC infrastructure files are located in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/erpc/erpc_c`

The **erpc_c** folder contains files for creating eRPC client and server applications in the C/C++ language. These files are distributed into subfolders.

- The **infra** subfolder contains C++ infrastructure code used to build server and client applications.
 - Four files, `erpc_server.hpp`, `erpc_server.cpp`, `erpc_simple_server.hpp`, and `erpc_simple_server.cpp`, are used for running the eRPC server on the server-side applications. The simple server is currently the only implementation of the server, and its role is to catch client requests, identify and call requested functions, and send data back when requested.
 - Three files (`erpc_codec.hpp`, `erpc_basic_codec.hpp`, and `erpc_basic_codec.cpp`) are used for codecs. Currently, the basic codec is the initial and only implementation of the codecs.
 - The `erpc_common.hpp` file is used for common eRPC definitions, typedefs, and enums.
 - The `erpc_manually_constructed.hpp` file is used for allocating static storage for the used objects.
 - Message buffer files are used for storing serialized data: `erpc_message_buffer.h` and `erpc_message_buffer.cpp`.
 - The `erpc_transport.h` file defines the abstract interface for transport layer.
- The **port** subfolder contains the eRPC porting layer to adapt to different environments.
 - `erpc_port.h` file contains definition of `erpc_malloc()` and `erpc_free()` functions.
 - `erpc_port_stdlib.cpp` file ensures adaptation to `stdlib`.
 - `erpc_config_internal.h` internal erpc configuration file.
- The **setup** subfolder contains a set of plain C APIs that wrap the C++ infrastructure, providing client and server init and deinit routines that greatly simplify eRPC usage in C-based projects. No knowledge of C++ is required to use these APIs.
 - The `erpc_server_setup.h` and `erpc_server_setup.cpp` files need to be added into the “Matrix multiply” example project to demonstrate the use of C-wrapped functions in this example.
 - The `erpc_transport_setup.h` and `erpc_setup_rpmsg_lite_remote.cpp` files need to be added into the project in order to allow the C-wrapped function for transport layer setup.
 - The `erpc_mbf_setup.h` and `erpc_setup_mbf_rpmsg.cpp` files need to be added into the project in order to allow message buffer factory usage.
- The **transports** subfolder contains transport classes for the different methods of communication supported by eRPC. Some transports are applicable only to host PCs, while others are applicable only to embedded or multicore systems. Most transports have corresponding client and server setup functions in the setup folder.
 - RPMsg-Lite is used as the transport layer for the communication between cores, `erpc_rpmsg_lite_base_transport.hpp`, `erpc_rpmsg_lite_transport.hpp`, and `erpc_rpmsg_lite_transport.cpp` files need to be added into the server project.



|

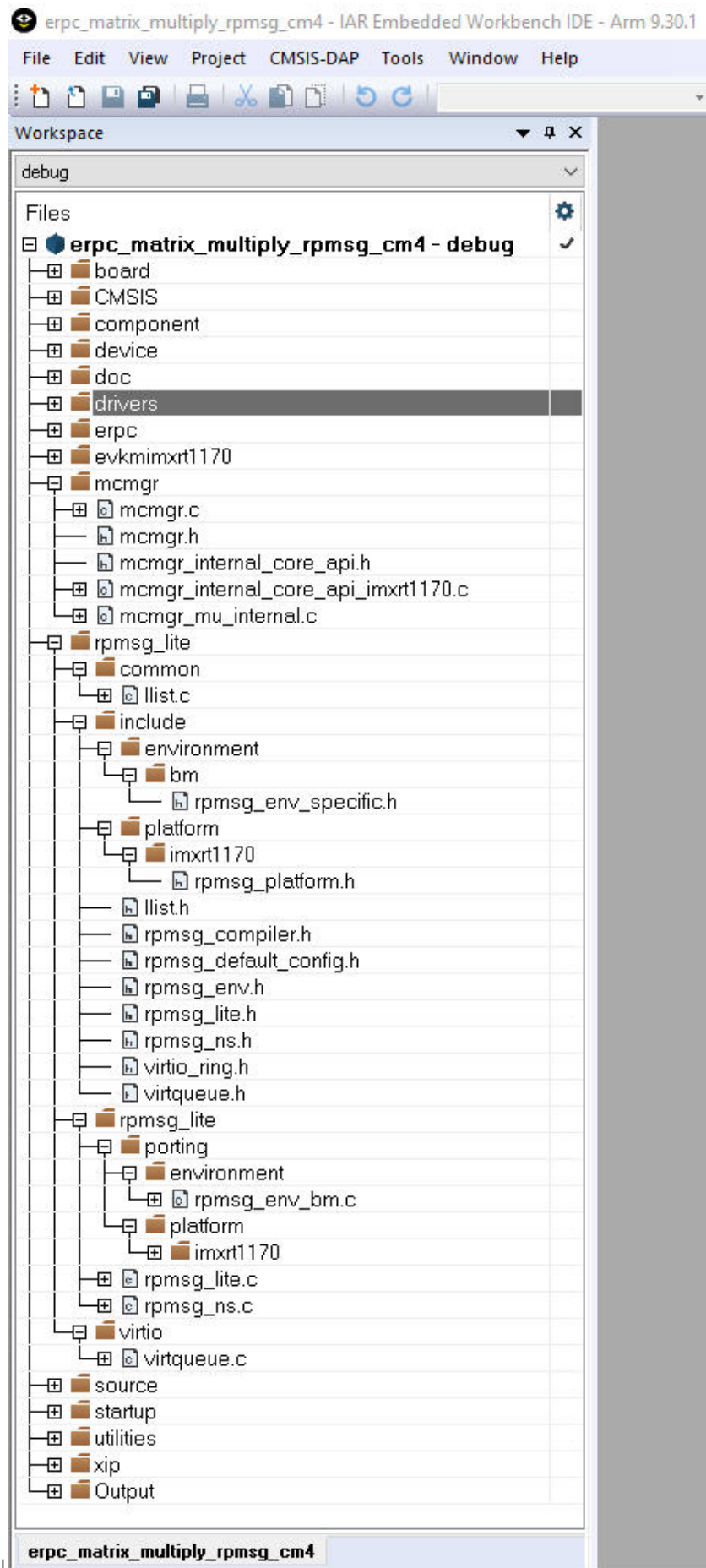
Parent topic:Multicore server application

Server multicore infrastructure files Because of the RPSMsg-Lite (transport layer), it is also necessary to include RPSMsg-Lite related files, which are in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/rpsmsg_lite/`

The multicore example applications also use the Multicore Manager software library to control the secondary core startup and shutdown. These source files are located in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/mcmgr/`



|

Parent topic:Multicore server application

Server user code The server's user code is stored in the `main_core1.c` file, located in the following folder:

`<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg/cm4`

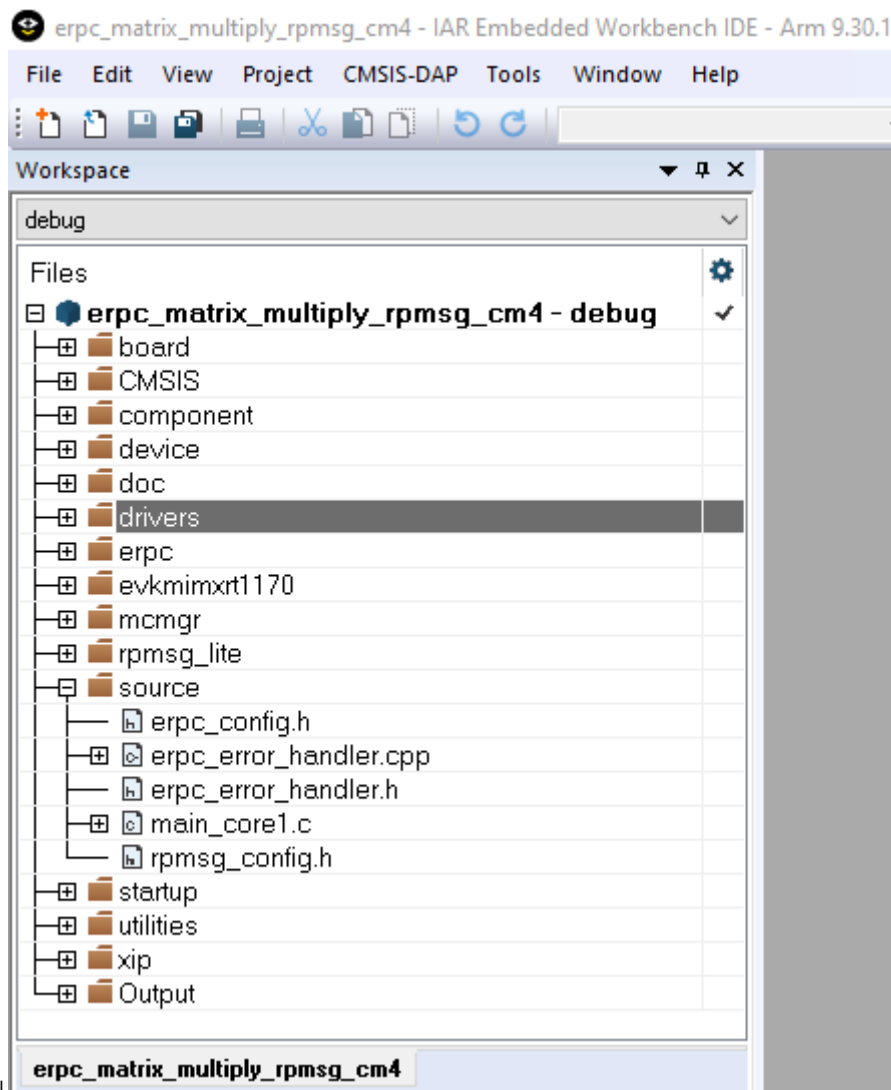
The `main_core1.c` file contains two functions:

- The **main()** function contains the code for the target board and eRPC server initialization. After the initialization, the matrix multiply service is added and the eRPC server waits for client's requests in the while loop.
- The **erpcMatrixMultiply()** function is the user implementation of the eRPC function defined in the IDL file.
- There is the possibility to write the application-specific eRPC error handler. The eRPC error handler of the matrix multiply application is implemented in the `erpc_error_handler.h` and `erpc_error_handler.cpp` files.

The eRPC-relevant code is captured in the following code snippet:

```
/* erpcMatrixMultiply function user implementation */
void erpcMatrixMultiply(const Matrix *matrix1, const Matrix *matrix2, Matrix *result_matrix)
{
    ...
}
int main()
{
    ...
    /* RPSMsg-Lite transport layer initialization */
    erpc_transport_t transport;
    transport = erpc_transport_rpmsg_lite_remote_init(src, dst, (void*)startupData,
    ERPC_TRANSPORT_RPMSG_LITE_LINK_ID, SignalReady, NULL);
    ...
    /* MessageBufferFactory initialization */
    erpc_mbf_t message_buffer_factory;
    message_buffer_factory = erpc_mbf_rpmsg_init(transport);
    ...
    /* eRPC server side initialization */
    erpc_server_t server;
    server = erpc_server_init(transport, message_buffer_factory);
    ...
    /* Adding the service to the server */
    erpc_service_t service = create_MatrixMultiplyService_service();
    erpc_add_service_to_server(server, service);
    ...
    while (1)
    {
        /* Process eRPC requests */
        erpc_status_t status = erpc_server_poll(server);
        /* handle error status */
        if (status != kErpcStatus_Success)
        {
            /* print error description */
            erpc_error_handler(status, 0);
            ...
        }
        ...
    }
}
```

Except for the application main file, there are configuration files for the RPMsg-Lite (rpmsg_config.h) and eRPC (erpc_config.h), located in the `<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg` folder.



Parent topic:Multicore server application

Parent topic:[Create an eRPC application](#)

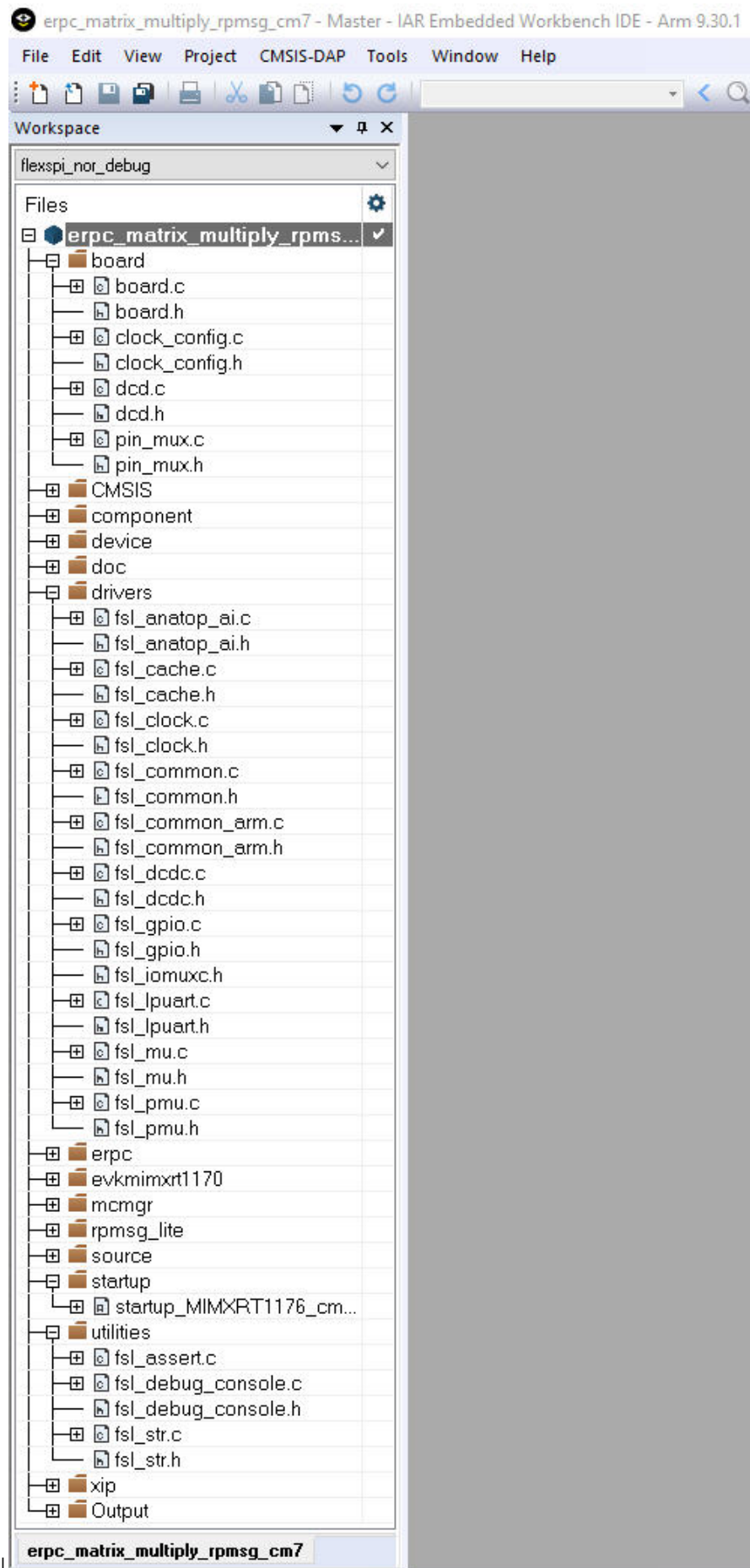
Multicore client application The “Matrix multiply” eRPC client project is located in the following folder:

`<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg/cm7/iar`

Project files for the eRPC client have the `_cm7` suffix.

Client project basic source files The startup files, board-related settings, peripheral drivers, and utilities belong to the basic project source files and form the skeleton of all MCUXpresso SDK applications. These source files are located in the following folders:

- `<MCUXpressoSDK_install_dir>/devices/<device>`
- `<MCUXpressoSDK_install_dir>/boards/<board_name>/multicore_examples/<example_name>/`



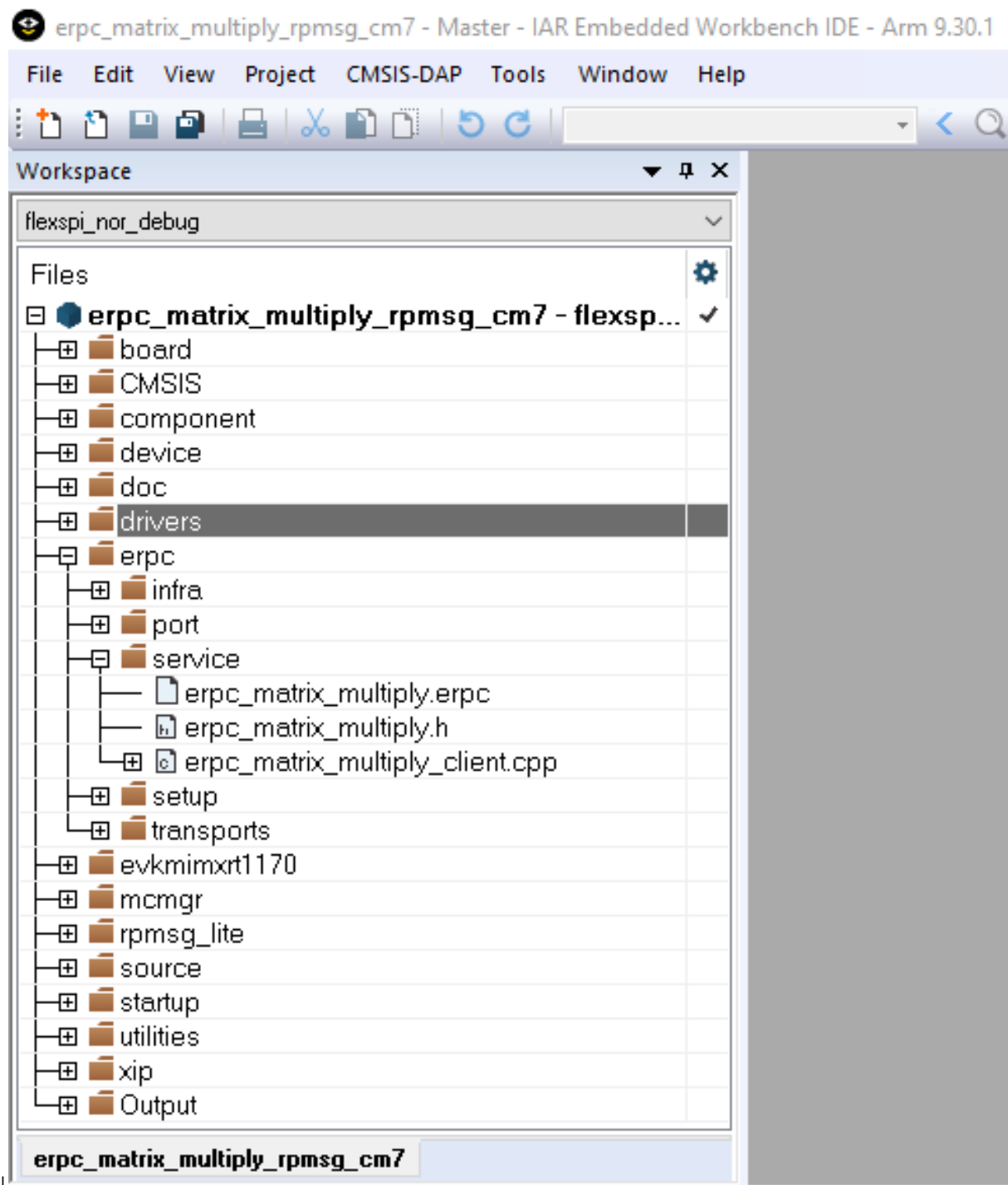
|

Parent topic:Multicore client application

Client-related generated files The client-related generated files are:

- erpc__matric__multiply.h
- erpc__matrix__multiply__client.cpp

These files contain the shim code for the functions and data types declared in the IDL file. These functions also call methods for codec initialization, data serialization, performing eRPC requests, and de-serializing outputs into expected data structures (if return values are expected). These shim code files can be found in the <MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/service/ folder.



Parent topic: Multicore client application

Client infrastructure files The eRPC infrastructure files are located in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/erpc/erpc_c`

The **erpc_c** folder contains files for creating eRPC client and server applications in the C/C++ language. These files are distributed into subfolders.

- The **infra** subfolder contains C++ infrastructure code used to build server and client applications.

- Two files, `erpc_client_manager.h` and `erpc_client_manager.cpp`, are used for managing the client-side application. The main purpose of the client files is to create, perform, and release eRPC requests.
- Three files (`erpc_codec.hpp`, `erpc_basic_codec.hpp`, and `erpc_basic_codec.cpp`) are used for codecs. Currently, the basic codec is the initial and only implementation of the codecs.
- `erpc_common.h` file is used for common eRPC definitions, typedefs, and enums.
- `erpc_manually_constructed.hpp` file is used for allocating static storage for the used objects.
- Message buffer files are used for storing serialized data: `erpc_message_buffer.hpp` and `erpc_message_buffer.cpp`.
- `erpc_transport.hpp` file defines the abstract interface for transport layer.

The **port** subfolder contains the eRPC porting layer to adapt to different environments.

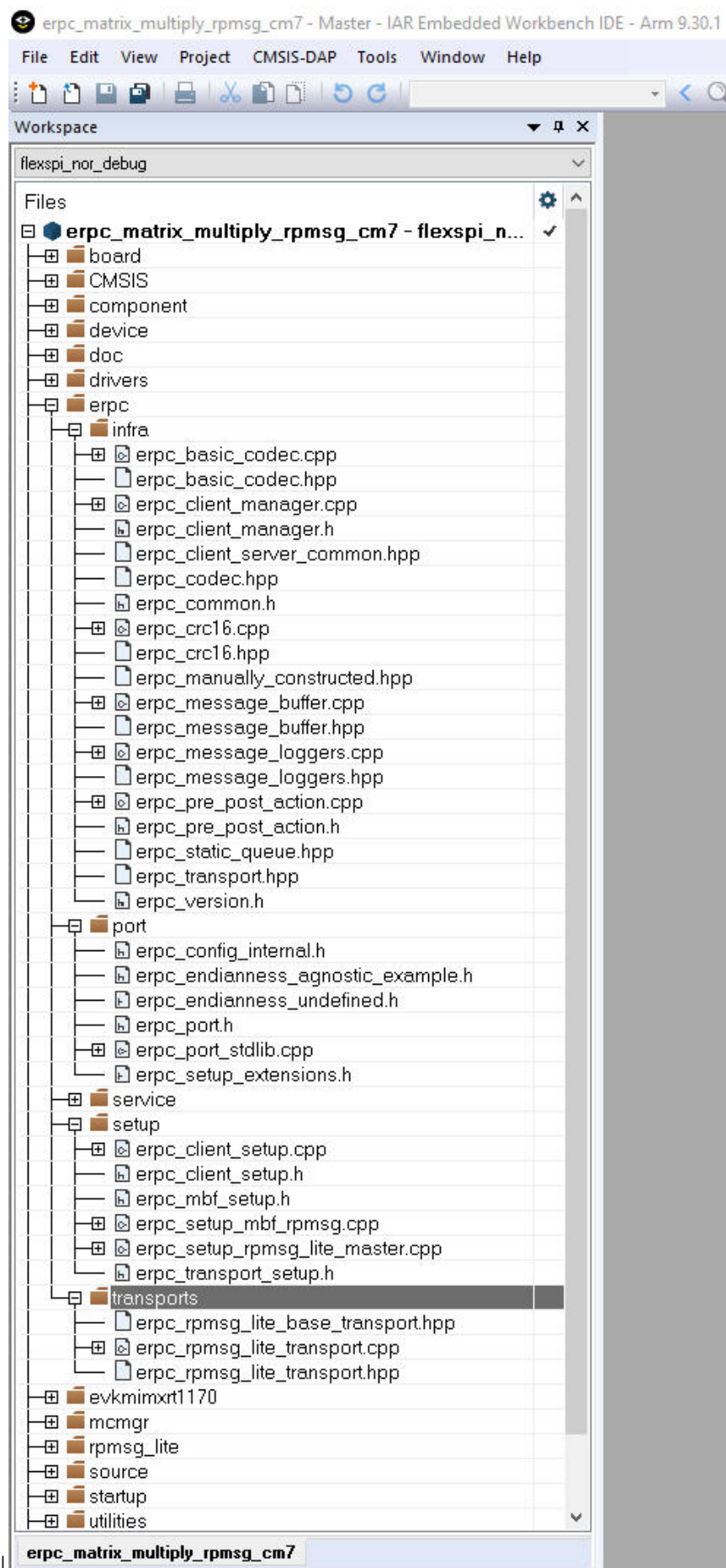
- `erpc_port.h` file contains definition of `erpc_malloc()` and `erpc_free()` functions.
- `erpc_port_stdlib.cpp` file ensures adaptation to `stdlib`.
- `erpc_config_internal.h` internal eRPC configuration file.

The **setup** subfolder contains a set of plain C APIs that wrap the C++ infrastructure, providing client and server init and deinit routines that greatly simplify eRPC usage in C-based projects. No knowledge of C++ is required to use these APIs.

- `erpc_client_setup.h` and `erpc_client_setup.cpp` files needs to be added into the “Matrix multiply” example project to demonstrate the use of C-wrapped functions in this example.
- `erpc_transport_setup.h` and `erpc_setup_rpmsg_lite_master.cpp` files needs to be added into the project in order to allow C-wrapped function for transport layer setup.
- `erpc_mbf_setup.h` and `erpc_setup_mbf_rpmsg.cpp` files needs to be added into the project in order to allow message buffer factory usage.

The **transports** subfolder contains transport classes for the different methods of communication supported by eRPC. Some transports are applicable only to host PCs, while others are applicable only to embedded or multicore systems. Most transports have corresponding client and server setup functions, in the setup folder.

- RPMsg-Lite is used as the transport layer for the communication between cores, `erpc_rpmsg_lite_base_transport.hpp`, `erpc_rpmsg_lite_transport.hpp`, and `erpc_rpmsg_lite_transport.cpp` files needs to be added into the client project.



|

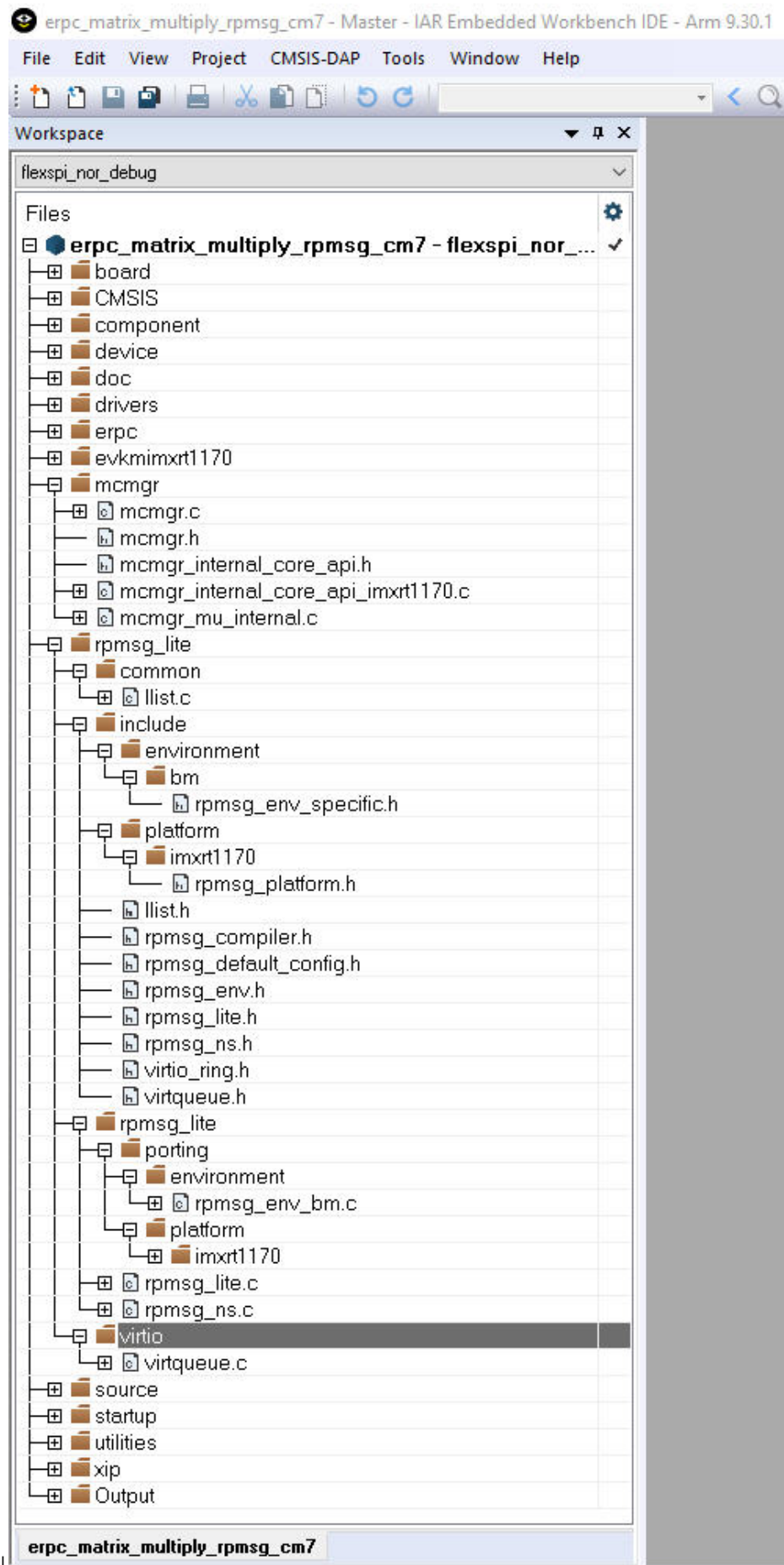
Parent topic: Multicore client application

Client multicore infrastructure files Because of the RPMsg-Lite (transport layer), it is also necessary to include RPMsg-Lite related files, which are in the following folder:

<MCUXpressoSDK_install_dir>/middleware/multicore/rpmsg_lite/

The multicore example applications also use the Multicore Manager software library to control the secondary core startup and shutdown. These source files are located in the following folder:

<MCUXpressoSDK_install_dir>/middleware/multicore/mcmgr/



Parent topic: Multicore client application

Client user code The client's user code is stored in the main_core0.c file, located in the following folder:

<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_example/erpc_matrix_multiply_rpmsg/cm7

The main_core0.c file contains the code for target board and eRPC initialization.

- After initialization, the secondary core is released from reset.
- When the secondary core is ready, the primary core initializes two matrix variables.
- The erpcMatrixMultiply eRPC function is called to issue the eRPC request and get the result.

It is possible to write the application-specific eRPC error handler. The eRPC error handler of the matrix multiply application is implemented in erpc_error_handler.h and erpc_error_handler.cpp files.

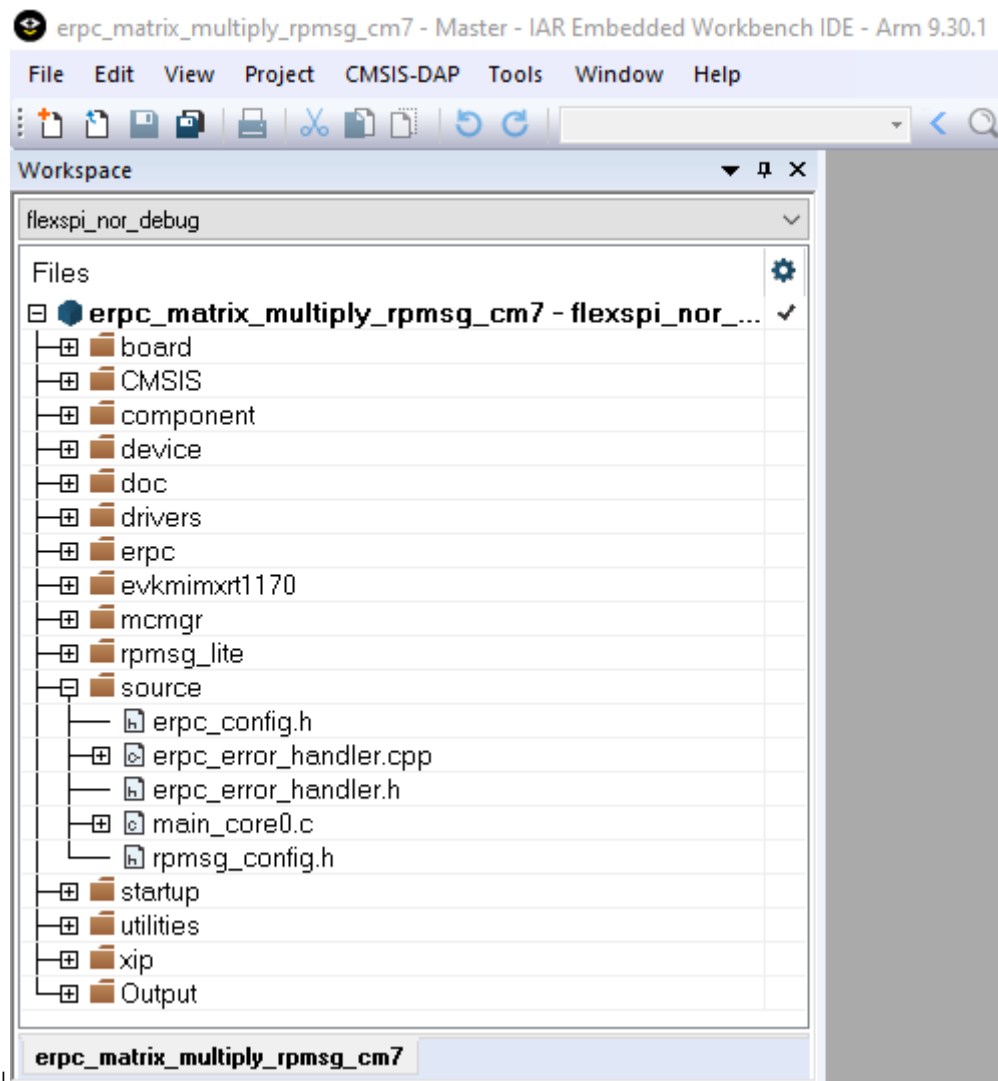
The matrix multiplication can be issued repeatedly, when pressing a software board button.

The eRPC-relevant code is captured in the following code snippet:

```
...
extern bool g_erpc_error_occurred;
...
/* Declare matrix arrays */
Matrix matrix1 = {0}, matrix2 = {0}, result_matrix = {0};
...
/* RPMsg-Lite transport layer initialization */
erpc_transport_t transport;
transport = erpc_transport_rpmsg_lite_master_init(src, dst,
ERPC_TRANSPORT_RPMSG_LITE_LINK_ID);
...
/* MessageBufferFactory initialization */
erpc_mbf_t message_buffer_factory;
message_buffer_factory = erpc_mbf_rpmsg_init(transport);
...
/* eRPC client side initialization */
erpc_client_t client;
client = erpc_client_init(transport, message_buffer_factory);
...
/* Set default error handler */
erpc_client_set_error_handler(client, erpc_error_handler);
...
while (1)
{
    /* Invoke the erpcMatrixMultiply function */
    erpcMatrixMultiply(matrix1, matrix2, result_matrix);
    ...
    /* Check if some error occurred in eRPC */
    if (g_erpc_error_occurred)
    {
        /* Exit program loop */
        break;
    }
    ...
}
```

Except for the application main file, there are configuration files for the RPMsg-Lite (rpmsg_config.h) and eRPC (erpc_config.h), located in the following folder:

<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg



Parent topic:Multicore client application

Parent topic:[Create an eRPC application](#)

Multiprocessor server application The “Matrix multiply” eRPC server project for multiprocessor applications is located in the `<MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_server_matrix_multiply_<transport_layer>` folder.

Most of the multiprocessor application setup is the same as for the multicore application. The multiprocessor server application requires server-related generated files (server shim code), server infrastructure files, and the server user code. There is no need for server multicore infrastructure files (MCMGR and RPMMsg-Lite). The RPMMsg-Lite transport layer is replaced either by SPI or UART transports. The following table shows the required transport-related files per each transport type.

SPI	<eRPC base directory>/erpc_c/setup/erpc_setup_(d)spi_slave.cpp
	<eRPC base directory>/erpc_c/transports/erpc_(d)spi_slave_transport.hpp
	<eRPC base directory>/erpc_c/transports/erpc_(d)spi_slave_transport.cpp
UART	<eRPC base directory>/erpc_c/setup/erpc_setup_uart_cmsis.cpp

<eRPC base directory>/erpc_c/transport/erpc_uart_cmsis_transport.hpp

<eRPC base directory>/erpc_c/transport/erpc_uart_cmsis_transport.cpp

|

Server user code The server's user code is stored in the main_server.c file, located in the <MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_server_matrix_multiply_<transport_layer>/ folder.

The eRPC-relevant code with UART as a transport is captured in the following code snippet:

```
/* erpcMatrixMultiply function user implementation */
void erpcMatrixMultiply(Matrix matrix1, Matrix matrix2, Matrix result_matrix)
{
    ...
}
int main()
{
    ...
    /* UART transport layer initialization, ERPC_DEMO_UART is the structure of CMSIS UART driver.
    ↪operations */
    erpc_transport_t transport;
    transport = erpc_transport_cmsis_uart_init((void *)&ERPC_DEMO_UART);
    ...
    /* MessageBufferFactory initialization */
    erpc_mbf_t message_buffer_factory;
    message_buffer_factory = erpc_mbf_dynamic_init();
    ...
    /* eRPC server side initialization */
    erpc_server_t server;
    server = erpc_server_init(transport, message_buffer_factory);
    ...
    /* Adding the service to the server */
    erpc_service_t service = create_MatrixMultiplyService_service();
    erpc_add_service_to_server(server, service);
    ...
    while (1)
    {
        /* Process eRPC requests */
        erpc_status_t status = erpc_server_poll(server)
        /* handle error status */
        if (status != kErpcStatus_Success)
        {
            /* print error description */
            erpc_error_handler(status, 0);
            ...
        }
        ...
    }
}
```

Parent topic:Multiprocessor server application

Multiprocessor client application The “Matrix multiply” eRPC client project for multiprocessor applications is located in the <MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_client_matrix_multiply_<transport_layer>/iar/ folder.

Most of the multiprocessor application setup is the same as for the multicore application. The multiprocessor server application requires client-related generated files (server shim code),

client infrastructure files, and the client user code. There is no need for client multicore infrastructure files (MCMGR and RPSMsg-Lite). The RPSMsg-Lite transport layer is replaced either by SPI or UART transports. The following table shows the required transport-related files per each transport type.

SPI	<eRPC base directory>/erpc_c/setup/erpc_setup_(d)spi_master.cpp
<eRPC base directory>/erpc_c/	transports/ erpc_(d)spi_master_transport.hpp
<eRPC base directory>/erpc_c/	transports/ erpc_(d)spi_master_transport.cpp
UART	<eRPC base directory>/erpc_c/setup/erpc_setup_uart_cmsis.cpp
<eRPC base directory>/erpc_c/	transports/erpc_uart_cmsis_transport.hpp
<eRPC base directory>/erpc_c/	transports/erpc_uart_cmsis_transport.cpp

Client user code The client's user code is stored in the `main_client.c` file, located in the `<MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_client_matrix_multiply_<transport_layer>/` folder.

The eRPC-relevant code with UART as a transport is captured in the following code snippet:

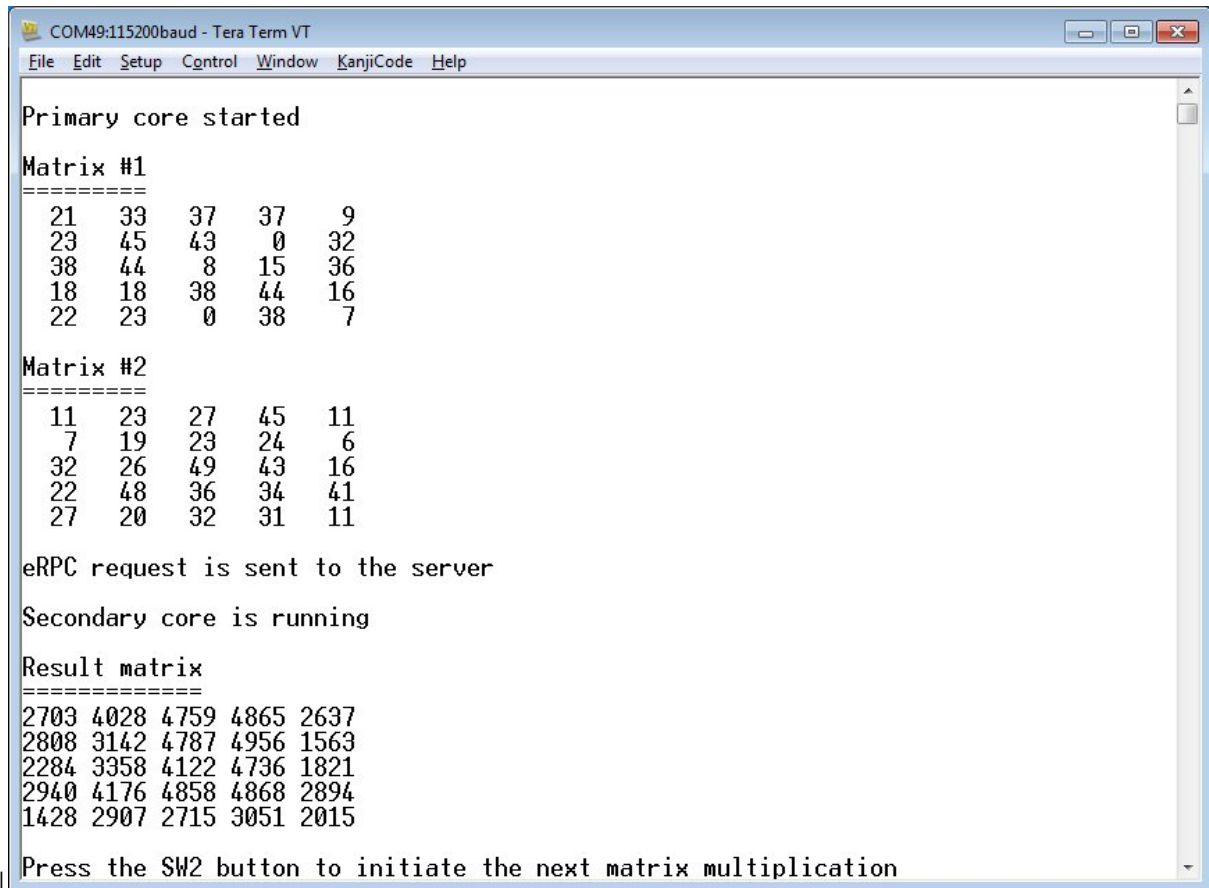
```
...
extern bool g_erpc_error_occurred;
...
/* Declare matrix arrays */
Matrix matrix1 = {0}, matrix2 = {0}, result_matrix = {0};
...
/* UART transport layer initialization, ERPC_DEMO_UART is the structure of CMSIS UART driver
↳operations */
erpc_transport_t transport;
transport = erpc_transport_cmsis_uart_init((void *)&ERPC_DEMO_UART);
...
/* MessageBufferFactory initialization */
erpc_mbf_t message_buffer_factory;
message_buffer_factory = erpc_mbf_dynamic_init();
...
/* eRPC client side initialization */
erpc_client_t client;
client = erpc_client_init(transport,message_buffer_factory);
...
/* Set default error handler */
erpc_client_set_error_handler(client, erpc_error_handler);
...
while (1)
{
    /* Invoke the erpcMatrixMultiply function */
    erpcMatrixMultiply(matrix1, matrix2, result_matrix);
    ...
    /* Check if some error occurred in eRPC */
    if (g_erpc_error_occurred)
    {
        /* Exit program loop */
        break;
    }
    ...
}
```

Parent topic:Multiprocessor client application

Parent topic:Multiprocessor server application

Parent topic:[Create an eRPC application](#)

Running the eRPC application Follow the instructions in *Getting Started with MCUXpresso SDK* (document MCUXSDKGSUG) (located in the <MCUXpressoSDK_install_dir>/docs folder), to load both the primary and the secondary core images into the on-chip memory, and then effectively debug the dual-core application. After the application is running, the serial console should look like:



```

COM49:115200baud - Tera Term VT
File Edit Setup Control Window KanjiCode Help

Primary core started

Matrix #1
=====
 21  33  37  37   9
 23  45  43   0  32
 38  44   8  15  36
 18  18  38  44  16
 22  23   0  38   7

Matrix #2
=====
 11  23  27  45  11
  7  19  23  24   6
 32  26  49  43  16
 22  48  36  34  41
 27  20  32  31  11

eRPC request is sent to the server

Secondary core is running

Result matrix
=====
2703 4028 4759 4865 2637
2808 3142 4787 4956 1563
2284 3358 4122 4736 1821
2940 4176 4858 4868 2894
1428 2907 2715 3051 2015

Press the SW2 button to initiate the next matrix multiplication

```

For multiprocessor applications that are running between PC and the target evaluation board or between two boards, follow the instructions in the accompanied example readme files that provide details about the proper board setup and the PC side setup (Python).

Parent topic:[Create an eRPC application](#)

Parent topic:[eRPC example](#)

Other uses for an eRPC implementation The eRPC implementation is generic, and its use is not limited to just embedded applications. When creating an eRPC application outside the embedded world, the same principles apply. For example, this manual can be used to create an eRPC application for a PC running the Linux operating system. Based on the used type of transport medium, existing transport layers can be used, or new transport layers can be implemented.

For more information and erpc updates see the github.com/EmbeddedRPC.

Note about the source code in the document Example code shown in this document has the following copyright and BSD-3-Clause license:

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2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
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Changelog eRPC All notable changes to this project will be documented in this file.

The format is based on [Keep a Changelog](#), and this project adheres to [Semantic Versioning](#).

Unreleased

Added

Fixed

- Python code of the eRPC infrastructure was updated to match the proper python code style, add type annotations and improve readability.

1.14.0

Added

- Added Cmake/Kconfig support.
- Made java code jdk11 compliant, GitHub PR #432.
- Added imxrt1186 support into mu transport layer.
- erpcgen: Added assert for listType before usage, GitHub PR #406.

Fixed

- eRPC: Sources reformatted.
- erpc: Fixed typo in semaphore get (mutex -> semaphore), and write it can fail in case of timeout, GitHub PR #446.
- erpc: Free the arbitrated client token from client manager, GitHub PR #444.

- erpc: Fixed Makefile, install the erpc_simple_server header, GitHub PR #447.
- erpc_python: Fixed possible AttributeError and OSError on calling TCPTransport.close(), GitHub PR #438.
- Examples and tests consolidated.

1.13.0

Added

- erpc: Add BSD-3 license to endianness agnostic files, GitHub PR #417.
- eRPC: Add new Zephyr-related transports (zephyr_uart, zephyr_mbox).
- eRPC: Add new Zephyr-related examples.

Fixed

- eRPC,erpcgen: Fixing/improving markdown files, GitHub PR #395.
- eRPC: Fix Python client TCPTransports not being able to close, GitHub PR #390.
- eRPC,erpcgen: Align switch brackets, GitHub PR #396.
- erpc: Fix zephyr uart transport, GitHub PR #410.
- erpc: UART ZEPHYR Transport stop to work after a few transactions when using USB-CDC resolved, GitHub PR #420.

Removed

- eRPC,erpcgen: Remove cstbool library, GitHub PR #403.

1.12.0

Added

- eRPC: Add dynamic/static option for transport init, GitHub PR #361.
- eRPC,erpcgen: Winsock2 support, GitHub PR #365.
- eRPC,erpcgen: Feature/support multiple clients, GitHub PR #271.
- eRPC,erpcgen: Feature/buffer head - Framed transport header data stored in Message-Buffer, GitHub PR #378.
- eRPC,erpcgen: Add experimental Java support.

Fixed

- eRPC: Fix receive error value for spidev, GitHub PR #363.
- eRPC: UartTransport::init adaptation to changed driver.
- eRPC: Fix typo in assert, GitHub PR #371.
- eRPC,erpcgen: Move enums to enum classes, GitHub PR #379.
- eRPC: Fixed rpmsg tty transport to work with serial transport, GitHub PR #373.

1.11.0

Fixed

- eRPC: Makefiles update, GitHub PR #301.
- eRPC: Resolving warnings in Python, GitHub PR #325.
- eRPC: Python3.8 is not ready for usage of typing.Any type, GitHub PR #325.
- eRPC: Improved codec function to use reference instead of address, GitHub PR #324.
- eRPC: Fix NULL check for pending client creation, GitHub PR #341.
- eRPC: Replace sprintf with snprintf, GitHub PR #343.
- eRPC: Use MU_SendMsg blocking call in MU transport.
- eRPC: New LPSPI and LPI2C transport layers.
- eRPC: Freeing static objects, GitHub PR #353.
- eRPC: Fixed casting in deinit functions, GitHub PR #354.
- eRPC: Align LIBUSB_SIO.GetNumPorts API use with libusb_sio python module v. 2.1.11.
- erpcgen: Renamed temp variable to more generic one, GitHub PR #321.
- erpcgen: Add check that string read is not more than max length, GitHub PR #328.
- erpcgen: Move to g++ in pytest, GitHub PR #335.
- erpcgen: Use build=release for make, GitHub PR #334.
- erpcgen: Removed boost dependency, GitHub PR #346.
- erpcgen: Mingw support, GitHub PR #344.
- erpcgen: VS build update, GitHub PR #347.
- erpcgen: Modified name for common types macro scope, GitHub PR #337.
- erpcgen: Fixed memcpy for template, GitHub PR #352.
- eRPC,erpcgen: Change default build target to release + adding artefacts, GitHub PR #334.
- eRPC,erpcgen: Remove redundant includes, GitHub PR #338.
- eRPC,erpcgen: Many minor code improvements, GitHub PR #323.

1.10.0

Fixed

- eRPC: MU transport layer switched to blocking MU_SendMsg() API use.

1.10.0

Added

- eRPC: Add TCP_NODELAY option to python, GitHub PR #298.

Fixed

- eRPC: MUPTransport adaptation to new supported SoCs.
- eRPC: Simplifying CI with installing dependencies using shell script, GitHub PR #267.
- eRPC: Using event for waiting for sock connection in TCP python server, formatting python code, C specific includes, GitHub PR #269.
- eRPC: Endianness agnostic update, GitHub PR #276.
- eRPC: Assertion added for functions which are returning status on freeing memory, GitHub PR #277.
- eRPC: Fixed closing arbitrator server in unit tests, GitHub PR #293.
- eRPC: Makefile updated to reflect the correct header names, GitHub PR #295.
- eRPC: Compare value length to used length() in reading data from message buffer, GitHub PR #297.
- eRPC: Replace EXPECT_TRUE with EXPECT_EQ in unit tests, GitHub PR #318.
- eRPC: Adapt rpmsg_lite based transports to changed rpmsg_lite_wait_for_link_up() API parameters.
- eRPC, erpcgen: Better distinguish which file can and cannot be linked by C linker, GitHub PR #266.
- eRPC, erpcgen: Stop checking if pointer is NULL before sending it to the erpc_free function, GitHub PR #275.
- eRPC, erpcgen: Changed api to count with more interfaces, GitHub PR #304.
- erpcgen: Check before reading from heap the buffer boundaries, GitHub PR #287.
- erpcgen: Several fixes for tests and CI, GitHub PR #289.
- erpcgen: Refactoring erpcgen code, GitHub PR #302.
- erpcgen: Fixed assigning const value to enum, GitHub PR #309.
- erpcgen: Enable runTesttest_enumErrorCode_allDirection, serialize enums as int32 instead of uint32.

1.9.1

Fixed

- eRPC: Construct the USB CDC transport, rather than a client, GitHub PR #220.
- eRPC: Fix premature import of package, causing failure when attempting installation of Python library in a clean environment, GitHub PR #38, #226.
- eRPC: Improve python detection in make, GitHub PR #225.
- eRPC: Fix several warnings with deprecated call in pytest, GitHub PR #227.
- eRPC: Fix freeing union members when only default need be freed, GitHub PR #228.
- eRPC: Fix making test under Linux, GitHub PR #229.
- eRPC: Assert costumizing, GitHub PR #148.
- eRPC: Fix corrupt clientList bug in TransportArbitrator, GitHub PR #199.
- eRPC: Fix build issue when invoking g++ with -Wno-error=free-nonheap-object, GitHub PR #233.
- eRPC: Fix inout cases, GitHub PR #237.

- eRPC: Remove ERPC_PRE_POST_ACTION dependency on return type, GitHub PR #238.
- eRPC: Adding NULL to ptr when codec function failed, fixing memcpy when fail is present during deserialization, GitHub PR #253.
- eRPC: MessageBuffer usage improvement, GitHub PR #258.
- eRPC: Get rid of serial and enum34 dependency (enum34 is in python3 since 3.4 (from 2014)), GitHub PR #247.
- eRPC: Several MISRA violations addressed.
- eRPC: Fix timeout for Freertos semaphore, GitHub PR #251.
- eRPC: Use of `rpmsg_lite_wait_for_link_up()` in `rpmsg_lite` based transports, GitHub PR #223.
- eRPC: Fix codec nullptr dereferencing, GitHub PR #264.
- erpcgen: Fix two syntax errors in erpcgen Python output related to non-encapsulated unions, improved test for union, GitHub PR #206, #224.
- erpcgen: Fix serialization of list/binary types, GitHub PR #240.
- erpcgen: Fix empty list parsing, GitHub PR #72.
- erpcgen: Fix templates for malloc errors, GitHub PR #110.
- erpcgen: Get rid of encapsulated union declarations in global scale, improve enum usage in unions, GitHub PR #249, #250.
- erpcgen: Fix compile error: `UniqueIdChecker.cpp:156:104: 'sort' was not declared`, GitHub PR #265.

1.9.0

Added

- eRPC: Allow used LIBUSBSIO device index being specified from the Python command line argument.

Fixed

- eRPC: Improving template usage, GitHub PR #153.
- eRPC: `run_clang_format.py` cleanup, GitHub PR #177.
- eRPC: Build TCP transport setup code into `liberpc`, GitHub PR #179.
- eRPC: Fix multiple definitions of `g_client` error, GitHub PR #180.
- eRPC: Fix `memset` past end of buffer in `erpc_setup_mbf_static.cpp`, GitHub PR #184.
- eRPC: Fix deprecated error with newer `pytest` version, GitHub PR #203.
- eRPC, erpcgen: Static allocation support and usage of `rpmsg` static FreeRTOSs related API, GitHub PR #168, #169.
- erpcgen: Remove redundant module imports in erpcgen, GitHub PR #196.

1.8.1

Added

- eRPC: New `i2c_slave_transport` transport introduced.

Fixed

- eRPC: Fix misra erpc c, GitHub PR #158.
- eRPC: Allow conditional compilation of message_loggers and pre_post_action.
- eRPC: (D)SPI slave transports updated to avoid busy loops in rtos environments.
- erpcgen: Re-implement EnumMember::hasValue(), GitHub PR #159.
- erpcgen: Fixing several misra issues in shim code, erpcgen and unit tests updated, GitHub PR #156.
- erpcgen: Fix bison file, GitHub PR #156.

1.8.0

Added

- eRPC: Support win32 thread, GitHub PR #108.
- eRPC: Add mbed support for malloc() and free(), GitHub PR #92.
- eRPC: Introduced pre and post callbacks for eRPC call, GitHub PR #131.
- eRPC: Introduced new USB CDC transport.
- eRPC: Introduced new Linux spidev-based transport.
- eRPC: Added formatting extension for VSC, GitHub PR #134.
- erpcgen: Introduce ustring type for unsigned char and force cast to char*, GitHub PR #125.

Fixed

- eRPC: Update makefile.
- eRPC: Fixed warnings and error with using MessageLoggers, GitHub PR #127.
- eRPC: Extend error msg for python server service handle function, GitHub PR #132.
- eRPC: Update CMSIS UART transport layer to avoid busy loops in rtos environments, introduce semaphores.
- eRPC: SPI transport update to allow usage without handshaking GPIO.
- eRPC: Native _WIN32 erpc serial transport and threading.
- eRPC: Arbitrator deadlock fix, TCP transport updated, TCP setup functions introduced, GitHub PR #121.
- eRPC: Update of matrix_multiply.py example: Add -serial and -baud argument, GitHub PR #137.
- eRPC: Update of .clang-format, GitHub PR #140.
- eRPC: Update of erpc_framed_transport.cpp: return error if received message has zero length, GitHub PR #141.
- eRPC, erpcgen: Fixed error messages produced by -Wall -Wextra -Wshadow -pedantic-errors compiler flags, GitHub PR #136, #139.
- eRPC, erpcgen: Core re-formatted using Clang version 10.
- erpcgen: Enable deallocation in server shim code when callback/function pointer used as out parameter in IDL.
- erpcgen: Removed '\$' character from generated symbol name in '_\$union' suffix, GitHub PR #103.

- erpcgen: Resolved mismatch between C++ and Python for callback index type, GitHub PR #111.
- erpcgen: Python generator improvements, GitHub PR #100, #118.
- erpcgen: Fixed error messages produced by -Wall -Wextra -Wshadow -pedantic-errors compiler flags, GitHub PR #136.

1.7.4

Added

- eRPC: Support MU transport unit testing.
- eRPC: Adding mbed os support.

Fixed

- eRPC: Unit test code updated to handle service add and remove operations.
- eRPC: Several MISRA issues in rpmsg-based transports addressed.
- eRPC: Fixed Linux/TCP acceptance tests in release target.
- eRPC: Minor documentation updates, code formatting.
- erpcgen: Whitespace removed from C common header template.

1.7.3

Fixed

- eRPC: Improved the test_callbacks logic to be more understandable and to allow requested callback execution on the server side.
- eRPC: TransportArbitrator::prepareClientReceive modified to avoid incorrect return value type.
- eRPC: The ClientManager and the ArbitratedClientManager updated to avoid performing client requests when the previous serialization phase fails.
- erpcgen: Generate the shim code for destroy of statically allocated services.

1.7.2

Added

- eRPC: Add missing doxygen comments for transports.

Fixed

- eRPC: Improved support of const types.
- eRPC: Fixed Mac build.
- eRPC: Fixed serializing python list.
- eRPC: Documentation update.

1.7.1

Fixed

- eRPC: Fixed semaphore in static message buffer factory.
- erpcgen: Fixed MU received error flag.
- erpcgen: Fixed tcp transport.

1.7.0

Added

- eRPC: List names are based on their types. Names are more deterministic.
- eRPC: Service objects are as a default created as global static objects.
- eRPC: Added missing doxygen comments.
- eRPC: Added support for 64bit numbers.
- eRPC: Added support of program language specific annotations.

Fixed

- eRPC: Improved code size of generated code.
- eRPC: Generating crc value is optional.
- eRPC: Fixed CMSIS Uart driver. Removed dependency on KSDK.
- eRPC: Forbid users use reserved words.
- eRPC: Removed outByref for function parameters.
- eRPC: Optimized code style of callback functions.

1.6.0

Added

- eRPC: Added @nullable support for scalar types.

Fixed

- eRPC: Improved code size of generated code.
- eRPC: Improved eRPC nested calls.
- eRPC: Improved eRPC list length variable serialization.

1.5.0

Added

- eRPC: Added support for unions type non-wrapped by structure.
- eRPC: Added callbacks support.
- eRPC: Added support @external annotation for functions.
- eRPC: Added support @name annotation.
- eRPC: Added Messaging Unit transport layer.
- eRPC: Added RPMSG Lite RTOS TTY transport layer.
- eRPC: Added version verification and IDL version verification between eRPC code and eRPC generated shim code.
- eRPC: Added support of shared memory pointer.
- eRPC: Added annotation to forbid generating const keyword for function parameters.
- eRPC: Added python matrix multiply example.
- eRPC: Added nested call support.
- eRPC: Added struct member “byref” option support.
- eRPC: Added support of forward declarations of structures
- eRPC: Added Python RPMsg Multiendpoint kernel module support
- eRPC: Added eRPC sniffer tool

1.4.0

Added

- eRPC: New RPMsg-Lite Zero Copy (RPMsgZC) transport layer.

Fixed

- eRPC: win_flex_bison.zip for windows updated.
- eRPC: Use one codec (instead of inCodec outCodec).

[1.3.0]

Added

- eRPC: New annotation types introduced (@length, @max_length, ...).
- eRPC: Support for running both erpc client and erpc server on one side.
- eRPC: New transport layers for (LP)UART, (D)SPI.
- eRPC: Error handling support.

[1.2.0]

Added

- eRPC source directory organization changed.
- Many eRPC improvements.

[1.1.0]

Added

- Multicore SDK 1.1.0 ported to KSDK 2.0.0.

[1.0.0]

Added

- Initial Release

3.7 Multimedia

3.7.1 Xtensa Audio Framework (XAF)

Xtensa Audio Framework (XAF) Examples

Overview The Xtensa Audio Framework (XAF) is designed to accelerate the development of audio processing applications for the HiFi family of DSP cores. The multicore version of XAF described in these examples is designed to work with subsystems having single or multiple DSPs, enabling sophisticated audio processing capabilities in embedded systems.

Each demo showcases a dual-core architecture:

- cm33/ - The ARM application for the Cortex-M33 core, which provides the user interface and system control
- dsp/ - The DSP application that performs audio processing using the XAF middleware library

When an application is started, a shell interface is displayed on the terminal that executes from the ARM core. Users can control the application through shell commands, which are relayed via RMsg-Lite IPC to the DSP core where they are processed and responses are returned. This architecture demonstrates efficient partitioning of workloads - with user interface and control tasks handled by the ARM core while computationally intensive audio processing is offloaded to the specialized DSP core.

For more information about XAF and detailed documentation on the API and available components, please refer to the Cadence XAF documentation ([/middleware/cadence/multicore-xaf/xa_af_hostless/doc](/middleware/cadence/multicore-xaf/xa_af_hostless/doc)).

Availability Note Important: These XAF examples are not included in the standard MCUXpresso SDK repository. They are available as part of the MCUXpresso SDK Builder package on the NXP website. To access these examples, please visit [MCUXpresso SDK Builder](#) and create a customized SDK package that includes the XAF examples for your target platform.

Included Examples

XAF Playback Example The `dsp_xaf_playback` application demonstrates audio file decoding and playback capabilities using the DSP core and Xtensa Audio Framework, supporting various audio codecs while handling operations through a shell interface on the ARM core that communicates with DSP processing.

XAF Record Example The `dsp_xaf_record` example captures audio from digital microphones (DMIC), processes it on the DSP core using voice enhancement algorithms, performs voice recognition (VIT), and outputs the detected wake words and voice commands to the console, enabling hands-free voice control applications.

XAF USB Example The XAF USB example demonstrates DSP-powered USB audio processing in two configurations: USB speaker and USB microphone. The application uses shell commands to switch between modes, with the ARM core handling USB communication while the DSP processes audio.

XAF Playback Example

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Overview The `dsp_xaf_playback` application demonstrates audio processing using the DSP core, the Xtensa Audio Framework (XAF) middleware library, and selected Xtensa audio codecs.

As shown in the table below, the application is supported on several development boards and each development board may have certain limitations, some development boards may also require hardware modifications or allow the use of an audio expansion board. Therefore, please check the supported features and [Hardware modifications](#) or [Example configuration](#) sections before running the demo.

Limitations:

- **MP3 encoder, G.711, G.722, BSAC, DAB+, DAB/MP2, DRM:** Provided only as linked libraries but are not enabled in the example.

Functionality The application includes the following main components:

1. **ARM Core (CM33)** - Handles user interface, SD card operations, and communicates with the DSP core
2. **DSP Core** - Processes audio data using the Xtensa Audio Framework (XAF)

The typical audio processing pipeline includes:

- File source component (reads from SD card)
- Decoder component (decodes compressed audio)
- Renderer component (outputs to audio hardware)

When the file playback command is issued, the ARM core reads the file from SD card and sends data to the DSP, which processes it and outputs to the audio hardware.

Hardware Requirements

- Development board (one of the following):
 - EVK-MIMXRT595 board
 - EVK-MIMXRT685 board
 - MIMXRT685-AUD-EVK board
 - MIMXRT700-EVK board
- Micro USB cable
- JTAG/SWD debugger
- Headphones with 3.5 mm stereo jack
- Personal Computer
- SD card with audio files (for file playback feature)

Hardware Modifications Some development boards need some hardware modifications to run the application.

- *EVK-MIMXRT595:*

To enable the example audio using WM8904 codec, connect pins as follows:

- JP7-1 <--> JP8-2

Note: The I3C Pin configuration in pin_mux.c is verified for default 1.8V, for 3.3V, need to manually configure slew rate to slow mode for I3C-SCL/SDA.

- *EVK-MIMXRT685:*

To enable the example audio using WM8904 codec, connect pins as follows:

- JP7-1 <--> JP8-2

- *MIMXRT685-AUD-EVK:*

- Set the hardware jumpers (Tower system/base module) to default settings.
- Set hardware jumpers JP2 2<-->3, JP44 1<-->2 and JP45 1<-->2.

- *MIMXRT700-EVK:*

Set the hardware jumpers to default settings.

Preparation

1. Connect headphones to Audio HP / Line-Out connector (J4).
 - EVK-MIMXRT595 - J4
 - EVK-MIMXRT685 - J4
 - MIMXRT685-AUD-EVK - J4, J50, J51, J52
 - MIMXRT700-EVK - J29
2. Connect a micro USB cable between the PC host and the debug USB port on the development board.
 - EVK-MIMXRT595 - J40
 - EVK-MIMXRT685 - J5
 - MIMXRT685-AUD-EVK - J5
 - MIMXRT700-EVK - J54

3. Open a serial terminal with the following settings:
 - 115200 baud rate
 - 8 data bits
 - No parity
 - One stop bit
 - No flow control
4. Download the program for CM33 core to the target board.
5. Launch the debugger in your IDE to begin running the demo.
6. If building release configuration, start the xt-ocd daemon and download the program for DSP core to the target board. If building debug configuration, launch the Xtensa IDE or xt-gdb debugger to begin running the demo.

Notes:

- DSP image can only be debugged using J-Link debugger. See the document ‘Getting Started with Xplorer’ for your particular board for more information.

Example Configuration The example can be configured by user. Before configuration, please check the [table](#) to see if the feature is supported on the development board.

- **MIMXRT700-EVK Decoder Configuration:**

RT700 has limited RAM on Cortex-M33 core 1 which limits the available decoders. Only SBC decoder is enabled by default. In order to enable a different decoder/encoder, it is necessary to define the appropriate define on project level. Use one of the following define from the list of the supported decoders on the HiFi1 core:

- XA_AAC_DECODER
- XA_MP3_DECODER
- XA_SBC_DECODER
- XA_VORBIS_DECODER
- XA_OPUS_DECODER

Running the Demo The ARM application will power and clock the DSP, so it must be loaded prior to loading the DSP application. The DSP application can be built by the following tools: Xtensa Xplorer or Xtensa C Compiler. Application for Cortex-M33 can be built by the other toolchains listed in MCUXpresso SDK Release Notes.

The release configurations of the demo will combine both applications into one ARM image. With this, the ARM core will load and start the DSP application on startup. Pre-compiled DSP binary images are provided under dsp/binary/ directory. If you make changes to the DSP application in release configuration, rebuild ARM application after building the DSP application. If you plan to use MCUXpresso IDE for cm33 you will have to make sure that the preprocessor symbol `DSP_IMAGE_COPY_TO_RAM`, found in IDE project settings, is defined to the value 1 when building release configuration.

The debug configurations will build two separate applications that need to be loaded independently. DSP application can be built by the following tools: Xtensa Xplorer or Xtensa C Compiler. Required tool versions can be found in MCUXpresso SDK Release Notes for the board. Application for cm33 can be built by the other toolchains listed there. If you plan to use MCUXpresso IDE for cm33 you will have to make sure that the preprocessor symbol `DSP_IMAGE_COPY_TO_RAM`, found in IDE project settings, is defined to the value 0 when building debug configuration. The ARM application will power and clock the DSP, so it must be loaded prior to loading the DSP application.

In order to debug both the Cortex-M33 and DSP side of the application, please follow the instructions:

1. It is necessary to run the Cortex-M33 side first and stop the application before the DSP_Start function
2. Run the xt-ocd daemon with proper settings
3. Download and debug the DSP application

In order to get TRACE debug output from the XAF it is necessary to define XF_TRACE 1 in the project settings. It is possible to save the TRACE output into RAM using DUMP_TRACE_TO_BUF 1 define on project level. Please see the initialization of the TRACE function in the xaf_main_dsp.c file. For more details see XAF documentation.

When the demo runs successfully, the terminal will display the following output (example from MIMXRT700-EVK):

```
*****
DSP audio framework demo start
*****

[CM33_Main] Configure codec

[DSP_Main] Cadence Xtensa Audio Framework
[DSP_Main] Library Name   : Audio Framework (Hostless)
[DSP_Main] Library Version : 3.5
[DSP_Main] API Version    : 3.2

[DSP_Main] start
[DSP_Main] established RPMsg link
[CM33_Main] DSP image copied to DSP TCM
[CM33_Main][APP_SDCARD_Task] start
[CM33_Main][APP_DSP_IPC_Task] start
[CM33_Main][APP_Shell_Task] start

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```

Type help to see the command list. Similar description will be displayed on serial console (*If multi-channel playback mode is enabled, the description is slightly different. Available encoders/decoders may differ - refer to the [table](#)*):

```
"help": List all the registered commands

"exit": Exit program

"version": Query DSP for component versions

"file": Perform audio file decode and playback from SD card
USAGE: file [list|stop|<audio_file>]
list       List audio files on SD card available for playback
<audio_file> Select file from SD card and start playback

"decoder": Perform decode on DSP and play to speaker.
USAGE: decoder [aac|mp3|opus|sbc|vorbis_ogg|vorbis_raw]
aac:       Decode aac data
mp3:       Decode mp3 data
opus:      Decode opus data
sbc:       Decode sbc data
vorbis_ogg: Decode OGG VORBIS data
vorbis_raw: Decode raw VORBIS data

"encoder": Encode PCM data on DSP and compare with reference data.
```

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USAGE: encoder [opus|sbc]
 opus: Encode pcm data using opus encoder
 sbc: Encode pcm data using sbc encoder

"src" Perform sample rate conversion on DSP

"gain": Perform PCM gain adjustment on DSP

Xtensa IDE log when command is playing a file (mp3/aac/vorbis/...):

```
File playback start, initial buffer size: 16384
[DSP Codec] Audio Device Ready
[DSP Codec] Decoder component started
[DSP Codec] Setting decode playback format:
  Decoder   : mp3_dec
  Sample rate: 16000
  Bit Width  : 16
  Channels   : 2
[DSP Codec] Renderer component started
[DSP Codec] Connected XA_DECODER -> XA_RENDERER
[DSP_ProcessThread] start
[DSP_BufferThread] start
```

Xtensa IDE log when decoder command starts playback successfully:

```
[DSP_Main] Input buffer addr: 0x20020000, buffer size: 94276
[DSP Codec] Audio Device Ready
[DSP Codec] Decoder created
[DSP Codec] Decoder component started
[DSP Codec] Renderer component created
[DSP Codec] Connected XA_DECODER -> XA_RENDERER
[DSP_ProcessThread] start
[DSP_ProcessThread] Execution complete - exiting
[DSP_ProcessThread] exiting
[DSP Codec] Audio device closed

[CM33 CMD] [APP_DSP_IPC_Task] response from DSP, cmd: 0, error: 0
[CM33 CMD] Decode complete
```

MIMXRT685-AUD-EVK Multi-channel Support: The MIMXRT685-AUD-EVK board supports multi-channel audio. When selecting audio files for playback, you can specify the number of channels:

```
...
file [list|stop|<audio_file> [<nchannel>]]
<nchannel>   Select the number of channels (2 or 8 can be selected).
NOTE: Selected audio file must meet the following parameters:
      - Sample rate: 96 kHz
      - Width:       32 bit
...
```

Xtensa IDE log when command is playing a PCM file:

```
...
[DSP_FILE_REN] Audio Device Ready
[DSP_FILE_REN] post-proc/pcm_gain component started
[DSP_FILE_REN] post-proc/client_proxy component started
[DSP_FILE_REN] Connected post-proc/pcm_gain -> post-proc/client_proxy
[DSP_FILE_REN] renderer component started
```

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```
[DSP_FILE_REN] Connected post-proc/client_proxy -> renderer
[DSP_BufferThread] start
[DSP_ProcessThread] start
[DSP_CleanupThread] start3
```

```

### Known Issues

1. The “file stop” command doesn’t stop the playback for some small files (with low sample rate).
2. MIMXRT700-EVK: Has limited RAM on Cortex-M33 core 1 which limits the available decoders.

### XAF Record Example

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**Overview** The dsp\_xaf\_record application demonstrates audio processing using the DSP core, the Xtensa Audio Framework (XAF) middleware library, with a focus on audio recording, processing and voice recognition (VIT - Voice Intelligent Technology, Voice seeker).

As shown in the table below, the application is supported on several development boards and each development board may have certain limitations, some development boards may also require hardware modifications or allow to use of an audio expansion board. Therefore, please check the supported features and [Hardware modifications](#) or [Example configuration](#) sections before running the demo.

**Functionality** The application includes the following main components:

1. **ARM Core (CM33)** - Handles user interface and communicates with the DSP core
2. **DSP Core** - Processes audio data using the Xtensa Audio Framework (XAF)

The typical audio processing pipeline includes:

- Audio source component - DMIC audio
- VIT and Voice seeker component (perform voice recognition)
- Renderer component (playback on codec)

The application demonstrates recording from digital microphones (DMIC), processing the audio with voice enhancement algorithms, performing voice recognition, and prints back in console detected WakeWord and list of commands.

## Hardware Requirements

- Development board (one of the following):
  - EVK-MIMXRT595 board
  - EVK-MIMXRT685 board
  - MIMXRT685-AUD-EVK board (optionally with 8CH-DMIC expansion board - rev B required)
  - MIMXRT700-EVK board
- Micro USB cable
- JTAG/SWD debugger
- Headphones with 3.5 mm stereo jack
- Personal Computer

**Hardware Modifications** Some development boards need some hardware modifications to run the application.

- *EVK-MIMXRT595:*

To enable the example audio using WM8904 codec, connect pins as follows:

- JP7-1 <--> JP8-2

Note: The I3C Pin configuration in pin\_mux.c is verified for default 1.8V, for 3.3V, need to manually configure slew rate to slow mode for I3C-SCL/SDA.

- *EVK-MIMXRT685:*

To enable the example audio using WM8904 codec, connect pins as follows:

- JP7-1 <--> JP8-2

- *MIMXRT685-AUD-EVK*

1. Set the hardware jumpers (Tower system/base module) to default settings.
2. Set hardware jumpers JP2 2<-->3, JP44 1<-->2 and JP45 1<-->2.

*For 8CH-DMIC expansion board (optional):*

1. Connect the 8CH-DMIC expansion board to the MIMXRT685-AUD-EVK board to the DMIC connector (J31). For safety reasons, the expansion board must be connected when the power supply is disconnected.
2. Set the hardware jumpers on the 8-DMIC expansion board to 2MIC, 3MICA, 3MICC config (Short: J6, J9, J10).
3. Set the hardware jumpers JP44 2<-->3 and JP45 2<-->3 on the MIMXRT685-AUD-EVK board for on-board DMIC bypass.

- *MIMXRT700-EVK:*

Set the hardware jumpers to default settings.

## Preparation

1. Connect headphones to Audio HP / Line-Out connector.
  - EVK-MIMXRT595 - J4
  - EVK-MIMXRT685 - J4
  - MIMXRT685-AUD-EVK - J4, J50 for third channel when using 3 microphones



- MIMXRT700-EVK - J29
2. Connect a micro USB cable between the PC host and the debug USB port on the development board.
    - EVK-MIMXRT595 - J40
    - EVK-MIMXRT685 - J5
    - MIMXRT685-AUD-EVK - J5
    - MIMXRT700-EVK - J54
  3. Open a serial terminal with the following settings:
    - 115200 baud rate
    - 8 data bits
    - No parity
    - One stop bit
    - No flow control
  4. Download the program for CM33 core to the target board.
  5. Launch the debugger in your IDE to begin running the demo.
  6. If building release configuration, start the xt-ocd daemon and download the program for DSP core to the target board. If building debug configuration, launch the Xtensa IDE or xt-gdb debugger to begin running the demo.

Notes:

- DSP image can only be debugged using J-Link debugger. See the document ‘Getting Started with Xplorer’ for your particular board for more information.

**Example Configuration** The example can be configured by user. Before configuration, please check the [table](#) to see if the feature is supported on the development board.

- **MIMXRT685-AUD-EVK 8CH-DMIC expansion board settings:**

Select how many microphones should be used

- Set the BOARD\_DMIC\_NUM preprocessor macro to 1,2, 3 (default) or 4 in the project for the CM33 core.
- When the 8CH-DMIC expansion board is used, the DMIC\_BOARD\_CONNECTED macro must be set to 1 (default) in the project for the DSP core.
- Important: When you set the value to 2, 3 or 4 you have to connect the 8CH-DMIC expansion board and set the DMIC\_BOARD\_CONNECTED macro to 1. Don’t forget set the hardware jumpers JP44 2-3 and JP45 2-3.

**Running the Demo** The ARM application will power and clock the DSP, so it must be loaded prior to loading the DSP application. The DSP application can be built by the following tools: Xtensa Xplorer or Xtensa C Compiler. Application for Cortex-M33 can be built by the other toolchains listed in MCUXpresso SDK Release Notes.

The release configurations of the demo will combine both applications into one ARM image. With this, the ARM core will load and start the DSP application on startup. Pre-compiled DSP binary images are provided under dsp/binary/ directory. If you make changes to the DSP application in release configuration, rebuild ARM application after building the DSP application. If you plan to use MCUXpresso IDE for cm33 you will have to make sure that the preprocessor symbol DSP\_IMAGE\_COPY\_TO\_RAM, found in IDE project settings, is defined to the value 1 when building release configuration.

The debug configurations will build two separate applications that need to be loaded independently. DSP application can be built by the following tools: Xtensa Xplorer or Xtensa C Compiler. Required tool versions can be found in MCUXpresso SDK Release Notes for the board. Application for cm33 can be built by the other toolchains listed there. If you plan to use MCUXpresso IDE for cm33 you will have to make sure that the preprocessor symbol `DSP_IMAGE_COPY_TO_RAM`, found in IDE project settings, is defined to the value 0 when building debug configuration. The ARM application will power and clock the DSP, so it must be loaded prior to loading the DSP application.

In order to debug both the Cortex-M33 and DSP side of the application, please follow the instructions:

1. It is necessary to run the Cortex-M33 side first and stop the application before the `DSP_Start` function
2. Run the `xt-ocd` daemon with proper settings
3. Download and debug the DSP application

In order to get TRACE debug output from the XAF it is necessary to define `XF_TRACE 1` in the project settings. It is possible to save the TRACE output into RAM using `DUMP_TRACE_TO_BUF 1` define on project level. Please see the initialization of the TRACE function in the `xaf_main_dsp.c` file. For more details see XAF documentation.

**Running on CM33** When the demo runs successfully, the CM33 terminal will display the following output (example from MIMXRT700-EVK):

```

DSP audio framework demo start

[CM33 Main] Configure codec

[DSP_Main] Cadence Xtensa Audio Framework
[DSP_Main] Library Name : Audio Framework (Hostless)
[DSP_Main] Library Version : 3.5
[DSP_Main] API Version : 3.2

[DSP_Main] start
[DSP_Main] established RPMsg link
[CM33 Main] DSP image copied to DSP TCM
[CM33 Main][APP_DSP_IPC_Task] start
[CM33 Main][APP_Shell_Task] start

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>>
```

Type `help` to see the command list. Similar description will be displayed on serial console (example from MIMXRT700-EVK):

```
"help": List all the registered commands

"exit": Exit program

"version": Query DSP for component versions

"record_dmic": Record DMIC audio , perform voice recognition (VIT) and playback on codec
USAGE: record_dmic [language]
For voice recognition say supported WakeWord and in 3s frame supported command.
If selected model contains strings, then WakeWord and list of commands will be printed in console.
NOTE: this command does not return to the shell
```

After running the “record\_dmic en” command, similar output will be printed

```
[CM33 CMD] Setting VIT language to en
[DSP_Main] Number of channels 1, sampling rate 16000, PCM width 32
[CM33 CMD] [APP_DSP_IPC_Task] response from DSP, cmd: 13, error: 0
[DSP Record] Audio Device Ready
[CM33 CMD] DSP DMIC Recording started
[CM33 CMD] To see VIT functionality say wakeword and command
[DSP VIT] VIT Model info
[DSP VIT] VIT Model Release = 0x40a00
[DSP VIT] Language supported : English
[DSP VIT] Number of WakeWords supported : 2
[DSP VIT] Number of Commands supported : 12
[DSP VIT] VIT_Model integrating WakeWord and Voice Commands strings : YES
[DSP VIT] WakeWords supported :
[DSP VIT] 'HEY NXP'
[DSP VIT] 'HEY TV'
[DSP VIT] Voice commands supported :
[DSP VIT] 'MUTE'
[DSP VIT] 'NEXT'
[DSP VIT] 'SKIP'
[DSP VIT] 'PAIR DEVICE'
[DSP VIT] 'PAUSE'
[DSP VIT] 'STOP'
[DSP VIT] 'POWER OFF'
[DSP VIT] 'POWER ON'
[DSP VIT] 'PLAY MUSIC'
[DSP VIT] 'PLAY GAME'
[DSP VIT] 'WATCH CARTOON'
[DSP VIT] 'WATCH MOVIE'
[DSP Record] connected CAPTURER -> GAIN_0
[DSP Record] connected XA_GAIN_0 -> XA_VIT_PRE_PROC_0
[DSP Record] connected XA_VIT_PRE_PROC_0 -> XA_RENDERER_0
[DSP VIT] - WakeWord detected 1 HEY NXP
[DSP VIT] - Voice Command detected 6 STOP
```

Xtensa IDE log of successful start of command:

```
Number of channels 2, sampling rate 16000, PCM width 16
Audio Device Ready
connected CAPTURER -> GAIN_0
connected CAPTURER -> XA_VIT_PRE_PROC_0
connected XA_VIT_PRE_PROC_0 -> XA_RENDERER_0
```

**Running on DSP** Debug configuration: When the demo runs successfully, the terminal will display the following:

```
Cadence Xtensa Audio Framework
Library Name : Audio Framework (Hostless)
Library Version : 3.2
API Version : 3.0

[DSP_Main] start
[DSP_Main] established RPMMsg link
Number of channels 2, sampling rate 16000, PCM width 16

Audio Device Ready
VoiceSeekerLight lib initialized!
===== VoiceSeekerLight Configuration =====
version = 0.6.0
num mics = 2
```

(continues on next page)

(continued from previous page)

```

max num mics = 4
mic0 = (35, 0, 0)
mic1 = (-35, 0, 0)
mic2 = (0, -35, 0)
num_spks = 0
max num spks = 2
samplerate = 16000
framesize_in = 32
framesize_out = 480
create_aec = 0
create_doa = 0
buffer_length_sec = 1.5
aec_filter_length_ms = 0
===== VoiceSeekerLight Memory Allocation =====
VoiceSeekerLib allocated 80592 persistent bytes
VoiceSeekerLib allocated 3840 scratch bytes
===== VoiceSeekerLight Memory Usage
↔ =====
=====
Total = 72400 bytes

connected CAPTURER -> GAIN_0
connected XA_GAIN_0 -> XA_VOICE_SEEKER_0
connected XA_VOICE_SEEKER_0 -> XA_VIT_PRE_PROC_0
connected XA_VIT_PRE_PROC_0 -> XA_RENDERER_0

```

**Known Issues** There are limited features in release SRAM target because of memory limitations. To enable/disable components, set appropriate preprocessor define in project settings to 0/1 (e.g. XA\_VIT\_PRE\_PROC etc.). Debug and flash targets have full functionality enabled.

## XAF USB Example

### Table of Content

- [Overview](#)
- [Functionality](#)
- [Hardware Requirements](#)
- [Hardware Modifications](#)
- [Preparation](#)
- [Running the Demo](#)
- [Known Issues](#)

**Overview** The dsp\_xaf\_usb\_demo application demonstrates audio processing using the DSP core, the Xtensa Audio Framework (XAF) middleware library.

As shown in the table below, the application is supported on several development boards and each development board may have certain limitations, some development boards may also require hardware modifications or allow to use of an audio expansion board. Therefore, please check the supported features and [Hardware modifications](#) section before running the demo.

**Functionality** The application includes the following main components:

1. **ARM Core (CM33)** - Handles user interface, and communicates with the DSP core

## 2. **DSP Core** - Processes audio data using the Xtensa Audio Framework (XAF)

The XAF USB example demonstrates DSP-powered USB audio processing in two configurations: USB speaker and USB microphone. The application uses shell commands to switch between modes, with the ARM core handling USB communication while the DSP processes audio.

- **USB Speaker Mode (USB2.0 □ Line out):** Receives audio from a USB host, processes it on the DSP, and outputs through the headphone jack, making the device function as a USB speaker for your computer.
- **USB Microphone Mode (DMIC □ USB2.0):** Captures audio from the onboard digital microphones, processes it on the DSP, and streams it to a USB host as a standard audio input device.

### Hardware Requirements

- Development board (one of the following):
  - EVK-MIMXRT595 board
  - EVK-MIMXRT685 board
  - MIMXRT685-AUD-EVK board
  - MIMXRT700-EVK board
- 2x Micro USB cable
- JTAG/SWD debugger
- Headphones with 3.5 mm stereo jack
- Personal Computer

**Hardware Modifications** Some development boards need some hardware modifications to run the application.

- *EVK-MIMXRT595:*

To enable the example audio using WM8904 codec, connect pins as follows:

- JP7-1 <--> JP8-2

Note: The I3C Pin configuration in pin\_mux.c is verified for default 1.8V, for 3.3V, need to manually configure slew rate to slow mode for I3C-SCL/SDA.

- *EVK-MIMXRT685:*

To enable the example audio using WM8904 codec, connect pins as follows:

- JP7-1 <--> JP8-2

- *MIMXRT685-AUD-EVK*

- Set the hardware jumpers (Tower system/base module) to default settings.
- Set hardware jumpers JP2 2<-->3, JP44 1<-->2 and JP45 1<-->2.

- *MIMXRT700-EVK:*

Set the hardware jumpers to default settings.

### Preparation

#### 1. Connect headphones to Audio HP / Line-Out connector.

- EVK-MIMXRT595 - J4
- EVK-MIMXRT685 - J4

- MIMXRT685-AUD-EVK - J4
  - MIMXRT700-EVK - J29
2. Connect the first micro USB cable between the PC host and the debug USB port on the development board.
    - EVK-MIMXRT595 - J40
    - EVK-MIMXRT685 - J5
    - MIMXRT685-AUD-EVK - J5
    - MIMXRT700-EVK - J54
  3. Connect the second micro USB cable between the PC host and the USB port on the development board.
    - EVK-MIMXRT595 - J38
    - EVK-MIMXRT685 - J7
    - MIMXRT685-AUD-EVK - J7
    - MIMXRT700-EVK - J40
  4. Open a serial terminal with the following settings:
    - 115200 baud rate
    - 8 data bits
    - No parity
    - One stop bit
    - No flow control
  5. Download the program for CM33 core to the target board.
  6. Launch the debugger in your IDE to begin running the demo.
  7. If building release configuration, start the xt-ocd daemon and download the program for DSP core to the target board. If building debug configuration, launch the Xtensa IDE or xt-gdb debugger to begin running the demo.

Notes:

- DSP image can only be debugged using J-Link debugger. See the document ‘Getting Started with Xplorer’ for your particular board for more information.

**Running the Demo** The ARM application will power and clock the DSP, so it must be loaded prior to loading the DSP application. The DSP application can be built by the following tools: Xtensa Xplorer or Xtensa C Compiler. Application for Cortex-M33 can be built by the other toolchains listed in MCUXpresso SDK Release Notes.

The release configurations of the demo will combine both applications into one ARM image. With this, the ARM core will load and start the DSP application on startup. Pre-compiled DSP binary images are provided under dsp/binary/ directory. If you make changes to the DSP application in release configuration, rebuild ARM application after building the DSP application. If you plan to use MCUXpresso IDE for cm33 you will have to make sure that the preprocessor symbol `DSP_IMAGE_COPY_TO_RAM`, found in IDE project settings, is defined to the value 1 when building release configuration.

The debug configurations will build two separate applications that need to be loaded independently. DSP application can be built by the following tools: Xtensa Xplorer or Xtensa C Compiler. Required tool versions can be found in MCUXpresso SDK Release Notes for the board. Application for cm33 can be built by the other toolchains listed there. If you plan to use MCUXpresso IDE for cm33 you will have to make sure that the preprocessor symbol `DSP_IMAGE_COPY_TO_RAM`,

found in IDE project settings, is defined to the value 0 when building debug configuration. The ARM application will power and clock the DSP, so it must be loaded prior to loading the DSP application.

In order to debug both the Cortex-M33 and DSP side of the application, please follow the instructions:

1. It is necessary to run the Cortex-M33 side first and stop the application before the DSP\_Start function
2. Run the xt-ocd daemon with proper settings
3. Download and debug the DSP application

In order to get TRACE debug output from the XAF it is necessary to define XF\_TRACE 1 in the project settings. It is possible to save the TRACE output into RAM using DUMP\_TRACE\_TO\_BUF 1 define on project level. Please see the initialization of the TRACE function in the xaf\_main\_dsp.c file. For more details see XAF documentation.

**Running on CM33** When the demo runs successfully, the CM33 terminal will display the following output (example from MIMXRT700-EVK):

```

DSP audio framework demo start

[CM33 Main] Configure codec

[DSP_Main] Cadence Xtensa Audio Framework
[DSP_Main] Library Name : Audio Framework (Hostless)
[DSP_Main] Library Version : 3.5
[DSP_Main] API Version : 3.2

[DSP_Main] start
[DSP_Main] established RPMsg link
[CM33 Main] DSP image copied to DSP TCM
[CM33 Main][APP_DSP_IPC_Task] start
[CM33 Main][APP_Shell_Task] start

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>>
```

Type help to see the command list. Similar description will be displayed on serial console (example from MIMXRT700-EVK):

```
"help": List all the registered commands

"exit": Exit program

"version": Query DSP for component versions

"usb_speaker": Perform usb speaker device and playback on DSP
 USAGE: usb_speaker [start|stop]
 start Start usb speaker device and playback on DSP
 stop Stop usb speaker device and playback on DSP

"usb_mic": Record DMIC audio and playback on usb microphone audio device
 USAGE: usb_mic [start|stop]
 start Start record and playback on usb microphone audio device
 stop Stop record and playback on usb microphone audio device
```

When `usb_speaker` command starts playback successfully, the terminal will display following output:

```
[APP_DSP_IPC_Task] response from DSP, cmd: 21, error: 0
DSP USB playback start
>>
```

Xtensa IDE log when command is playing a file:

```
USB speaker start, initial buffer size: 960
[DSP_USB_SPEAKER] Audio Device Ready
[DSP_USB_SPEAKER] post-proc/pcm_gain component started
[DSP_USB_SPEAKER] post-proc/client_proxy component started
[DSP_USB_SPEAKER] Connected post-proc/pcm_gain -> post-proc/client_proxy
[DSP_USB_SPEAKER] renderer component started
[DSP_USB_SPEAKER] Connected post-proc/client_proxy -> renderer
[DSP_ProcessThread] start
[DSP_BufferThread] start
[DSP_CleanupThread] start
```

The USB device on your host will be enumerated as XAF USB DEMO.

Xtensa IDE will not show any additional log entry.

**Running the demo DSP** Debug configuration: When the demo runs successfully, the terminal will display the following:

```
Cadence Xtensa Audio Framework
Library Name : Audio Framework (Hostless)
Library Version : 2.6p1
API Version : 2.0

[DSP_Main] start
[DSP_Main] established RPMMsg link
```

### Known Issues

- When starting the “usb\_speaker” after the “usb\_mic” command, the sound output may be distorted. Please power cycle the board.

## 3.8 Wireless

### 3.8.1 NXP Wireless Framework and Stacks

#### Wi-Fi, Bluetooth, 802.15.4

##### Application notes

- [Link AN12918-Wi-Fi-Tx-Power-Table-and-Channel-Scan-Management-for-i.MX-RT-SDK.pdf](#)
- [Link TN00066-WFA-Derivative-Certification-Process.pdf](#)

##### User manuals

- [Link UM11441-Getting-Started-with-NXP-based-Wireless-Modules-and-i.MX-RT-Platforms.pdf](#)
- [UM11442-NXP-Wi-Fi-and-Bluetooth-Demo-Applications-for-i.MX-RT-Platforms.pdf](#)



- [Link UM11443-NXP-Wi-Fi-and-Bluetooth-Debug-Feature-Configuration-Guide-for-i.MX-RT-Platforms.pdf](#)
- [Link UM11567-WFA-Certification-Guide-for-NXP-based-Wireless-Modules-on-i.MX-RT-Platform-Running-RTOS.pdf](#)

## Release notes

### Wireless SoC features and release notes for FreeRTOS

**About this document** This document provides information about the supported features, release versions, fixed and/or known issues, performance of the Wi-Fi, Bluetooth/802.15.4 radios, including the coexistence.

The SDK release version 25.06.00 has been tested for the wireless SoCs listed in Supported products.

### Supported products

- 88W8987
- IW416
- IW611<sup>1</sup>
- IW612<sup>2</sup>
- AW611<sup>3</sup>
- RW610
- RW612

**Parent topic:** [About this document](#)

## Features

### Wi-Fi radio

#### Client mode

| Features                  | Sub features                                               |
|---------------------------|------------------------------------------------------------|
| 802.11n - High throughput | 2.4 GHz band operation supported channel bandwidth: 20 MHz |
| 802.11n - High throughput | 2.4 GHz band supported channel bandwidth: 40 MHz           |
| 802.11n - High throughput | 5 GHz band supported channel bandwidth: 20 MHz             |
| 802.11n - High throughput | 5 GHz band supported channel bandwidth: 40 MHz             |
| 802.11n - High throughput | Short/long guard interval (400 ns/800 ns)                  |
| 802.11n - High throughput | Data rates up to 72 Mbit/s (MCS 0 to MCS 7)                |
| 802.11n - High throughput | Data rates up to 150 Mbit/s (MCS 0 to MCS 7)               |

<sup>1</sup> The support of IW611 is enabled in i.MX RT1170 EVKB and i.MX RT1060 EVKC.

<sup>2</sup> The support of IW612 is enabled in i.MX RT1170 EVKB and i.MX RT1060 EVKC.

<sup>3</sup> AW611 module support is available only in i.MX RT1180 EVKA

Table 1 – continued from p

| Features                        | Sub features                                                |
|---------------------------------|-------------------------------------------------------------|
| 802.11n - High throughput       | 1 spatial stream (1x1)                                      |
| 802.11n - High throughput       | HT protection mechanisms                                    |
| 802.11n - High throughput       | Aggregated MAC protocol data unit (AMPDU) TX and RX sup     |
| 802.11n - High throughput       | Aggregated MAC service data unit (AMSDU) 4k TX and RX su    |
| 802.11n - High throughput       | TX MCS rate adaptation (BGN)                                |
| 802.11n - High throughput       | RX low density parity check (LDPC) 1x1 20 MHz and 40 MHz    |
| 802.11n - High throughput       | HT Beamformee (explicit)                                    |
| 802.11ac - Very high throughput | 2.4 GHz band supported channel bandwidth: 20MHz             |
| 802.11ac - Very high throughput | 5 GHz band supported channel bandwidth: 20 MHz              |
| 802.11ac - Very high throughput | 5 GHz band supported channel bandwidth: 40 MHz              |
| 802.11ac - Very high throughput | 5 GHz band supported channel bandwidth: 80 MHz              |
| 802.11ac - Very high throughput | Data rates up to 86.7 Mbps (MCS0 to MCS 8)                  |
| 802.11ac - Very high throughput | Data rates up to 433.3 Mbps (MCS 0 to MCS 9) - 1x1          |
| 802.11ac - Very high throughput | MU-MIMO Beamformee (Explicit and Implicit)                  |
| 802.11ac - Very high throughput | RTS/CTS with BW signaling                                   |
| 802.11ac - Very high throughput | Operation mode notification                                 |
| 802.11ac - Very high throughput | Backward compatibility with non-VHT devices                 |
| 802.11ac - Very high throughput | TX VHT MCS rate adaptation                                  |
| 802.11ac - Very high throughput | Low density parity check (LDPC)                             |
| 802.11ax - High efficiency      | 2.4 GHz band supported channel bandwidth: 20MHz             |
| 802.11ax - High efficiency      | 5 GHz band supported channel bandwidth: 20 MHz              |
| 802.11ax - High efficiency      | 5 GHz band supported channel bandwidth: 40 MHz              |
| 802.11ax - High efficiency      | 5 GHz band supported channel bandwidths: 80 MHz             |
| 802.11ax - High efficiency      | OFDMA (UL/DL, 106 RU)                                       |
| 802.11ax - High efficiency      | OFDMA (UL/DL, 484 RU)                                       |
| 802.11ax - High efficiency      | 1024 QAM                                                    |
| 802.11ax - High efficiency      | Target wake time (TWT)                                      |
| 802.11ax - High efficiency      | 256 QAM modulation – MCS8 and MCS9                          |
| 802.11ax - High efficiency      | 1024 QAM modulation – MCS10 and MCS11, 2.4 GHz              |
| 802.11ax - High efficiency      | 1024 QAM modulation – MCS10 and MCS11, 5 GHz                |
| 802.11ax - High efficiency      | DCM                                                         |
| 802.11ax - High efficiency      | DCM                                                         |
| 802.11ax - High efficiency      | ER (extended range)                                         |
| 802.11ax - High efficiency      | SU Beamforming                                              |
| 802.11ax - High efficiency      | OMI (operating mode indication)                             |
| 802.11a/b/g features            | 802.11b/g data rates up to 54 Mbit/s                        |
| 802.11a/b/g features            | 802.11a data rates up to 54 Mbit/s                          |
| 802.11a/b/g features            | TX rate adaptation (BG)                                     |
| 802.11a/b/g features            | Fragmentation/defragmentation                               |
| 802.11a/b/g features            | ERP protection, slot time, preamble                         |
| 802.11d                         | 802.11d - Regulatory domain/operating class/country info    |
| 802.11e QoS                     | EDCA [enhanced distributed channel access] / WMM (wirele    |
| 802.11i security                | OpenSource WPA Supplicant Support                           |
| 802.11i security                | WPA2-PSK AES   WPA Supplicant                               |
| 802.11i security                | WPA3-SAE (Simultaneous Authentication of Equals)   WPA      |
| 802.11i security                | WPA2+WPA3 PSK Mixed Mode (WPA3 Transition Mode)   W         |
| 802.11i security                | Wi-Fi Enhanced Open - OWE (Opportunistic Wireless Encry     |
| 802.11i security                | 802.1x EAP Authentication Methods   WPA Supplicant          |
| 802.11i security                | WPA2-Enterprise Mixed Mode   WPA Supplicant                 |
| 802.11i security                | WPA3-Enterprise (Suite-B)   National Security Algorithm (CS |
| 802.11i security                | 802.11w - PMF (Protected Management Frames)   WPA Supp      |
| 802.11i security                | Embedded Supplicant Support                                 |
| 802.11i security                | WPA2-PSK AES   Embedded Supplicant                          |
| 802.11i security                | WPA+WPA2 PSK Mixed Mode   Embedded Supplicant               |
| 802.11i security                | WPA3-SAE (Simultaneous Authentication of Equals)   Embe     |

Table 1 – continued from p

| Features                                    | Sub features                                                       |
|---------------------------------------------|--------------------------------------------------------------------|
| 802.11i security                            | 802.11w - PMF (Protected Management Frames)   Embedded             |
| 802.11i security                            | Wi-Fi Roaming                                                      |
| 802.11i security                            | WPA3 Enterprise                                                    |
| Power save mode                             | Deep sleep                                                         |
| Power save mode                             | IEEE power save                                                    |
| Power save mode                             | Host sleep/WoWLAN (inband)                                         |
| Power save mode                             | Host sleep/WoWLAN (outband)                                        |
| Power save mode                             | U-APSD                                                             |
| 802.11w - PMF (protected management frames) | PMF require and capable                                            |
| 802.11w - PMF (protected management frames) | Unicast management frames - Encryption/decryption - using          |
| 802.11w - PMF (protected management frames) | Broadcast management frames - Encryption/decryption - us           |
| 802.11w - PMF (protected management frames) | SA query request/response                                          |
| 802.11w - PMF (protected management frames) | PMF support using embedded supplicant                              |
| DPP functionality                           | Wi-Fi easy connect <sup>[^3]</sup>                                 |
| General features                            | Embedded supplicant                                                |
| General features                            | Host sleep packet filtering                                        |
| General features                            | Host-based supplicant                                              |
| General features                            | Embedded MLME                                                      |
| General features                            | EDMAC - EU adaptivity support (ETSI certification)                 |
| General features                            | External coexistence                                               |
| General features                            | IPv6 NS offload                                                    |
| General features                            | FIPS                                                               |
| General features                            | TKIP <sup>[^1]</sup>                                               |
| General features                            | RF test mode                                                       |
| General features                            | 802.11k                                                            |
| General features                            | 802.11v                                                            |
| General features                            | DFS radar detection in peripheral mode (follow AP) <sup>[^5]</sup> |
| General features                            | Embedded roaming based on RSSI threshold beacon loss               |
| General features                            | ARP offload                                                        |
| General features                            | Cloud keep alive                                                   |
| General features                            | UNII-4 channel support                                             |
| General features                            | ClockSync using TSF                                                |
| General features                            | Auto reconnect                                                     |
| General features                            | CSI (channel state information)                                    |
| General features                            | Independent reset (in-band) <sup>[^3]</sup>                        |
| General features                            | Independent reset (out-band) <sup>[^3]</sup>                       |
| General features                            | Wi-Fi agile multiband                                              |
| General features                            | Network co-processor (NCP) mode                                    |
| General features                            | 802.11mc - WLS (Wi-Fi location service)                            |
| General features                            | 802.11az                                                           |

**Parent topic:**Wi-Fi radio

<sup>[^1]</sup> As per Wi-Fi specification, connecting in TKIP security in non 802.11n mode is allowed.

<sup>[^2]</sup> Support available in host-base supplicant.

<sup>[^3]</sup> Feature not enabled by default in the SDK. Refer to [Feature enable and memory impact](#) for the macro to enable the feature and the impact on the memory when enabling the feature.

<sup>[^4]</sup> Read more about NCP feature in [References](#). <sup>[^5]</sup> To enable the feature, CONFIG\_ECSA = 1 must be defined in wifi\_config.h (does not apply to RW610 and RW612).

**AP mode**

| Features                                    | Sub features                                                           |
|---------------------------------------------|------------------------------------------------------------------------|
| 802.11n - High throughput                   | 2.4 GHz band operation supported channel bandwidth: 20 MHz             |
| 802.11n - High throughput                   | 2.4 GHz band supported channel bandwidth: 40 MHz                       |
| 802.11n - High throughput                   | 5 GHz band supported channel bandwidth: 20 MHz                         |
| 802.11n - High throughput                   | 5 GHz band supported channel bandwidth: 40 MHz                         |
| 802.11n - High throughput                   | Short/long guard interval (400 ns/800 ns)                              |
| 802.11n - High throughput                   | Data rates up to 72 Mbit/s (MCS 0 to MCS 7)                            |
| 802.11n - High throughput                   | Data rates up to 150 Mbit/s (MCS 0 to MCS 7)                           |
| 802.11n - High throughput                   | 1 spatial stream (1x1)                                                 |
| 802.11n - High throughput                   | HT protection mechanisms                                               |
| 802.11n - High throughput                   | Aggregated MAC protocol data unit (AMPDU) Rx support                   |
| 802.11n - High throughput                   | Aggregated MAC service data unit (AMSDU) -4k RX support                |
| 802.11n - High throughput                   | Max client support (up to 8 devices)                                   |
| 802.11n - High throughput                   | TX MCS rate adaptation (BGN)                                           |
| 802.11n - High throughput                   | RX low density parity check (LDPC)                                     |
| 802.11ac – Very high throughput             | 5 GHz band supported channel bandwidth: 20 MHz                         |
| 802.11ac – Very high throughput             | 5 GHz band supported channel bandwidth: 40 MHz                         |
| 802.11ac – Very high throughput             | 5 GHz band supported channel bandwidth: 80MHz                          |
| 802.11ac – Very high throughput             | Short/long guard interval (400ns/800ns)                                |
| 802.11ac – Very high throughput             | Data rates up to 86.7 Mbps (MCS0 to MCS 8)                             |
| 802.11ac – Very high throughput             | Data rates up to 433.3 Mbps (MCS 0 to MCS 9)                           |
| 802.11ac – Very high throughput             | Single user- Aggregated MAC protocol data unit (SU-AMPDU)              |
| 802.11ac – Very high throughput             | RTS/CTS with BW signaling                                              |
| 802.11ac – Very high throughput             | Backward compatibility with non-VHT devices                            |
| 802.11ac – Very high throughput             | TX VHT MCS rate adaptation                                             |
| 802.11ac – Very high throughput             | MU-MIMO Beamformee (explicit and implicit)                             |
| 802.11ac – Very high throughput             | Operation mode notification                                            |
| 802.11ax – High efficiency                  | 2.4 GHz band operation (20 MHz channel bandwidth)                      |
| 802.11ax – High efficiency                  | 2.4 GHz band operation (40 MHz channel bandwidth)                      |
| 802.11ax – High efficiency                  | 5 GHz band operation (20MHz channel bandwidth)                         |
| 802.11ax – High efficiency                  | 5 GHz band operation (40MHz channel bandwidth)                         |
| 802.11ax – High efficiency                  | 5 GHz band operation (80 MHz channel bandwidth)                        |
| 802.11d                                     | 802.11d - Regulatory domain/operating class/country info               |
| 802.11e -QoS                                | EDCA [enhanced distributed channel access] / WMM (wireless multimedia) |
| 802.11i security                            | Hostapd Support                                                        |
| 802.11i security                            | WPA2-PSK AES   hostapd                                                 |
| 802.11i security                            | WPA3-SAE (Simultaneous Authentication of Equals)   Hostapd             |
| 802.11i security                            | WPA2+WPA3 PSK Mixed Mode (WPA3 Transition Mode)   Hostapd              |
| 802.11i security                            | Wi-Fi Enhanced Open - OWE (Opportunistic Wireless Encryption)          |
| 802.11i security                            | 802.1x EAP Authentication Methods   Hostapd                            |
| 802.11i security                            | WPA2-Enterprise Mixed Mode   Hostapd                                   |
| 802.11i security                            | WPA3-Enterprise (Suite-B)   National Security Algorithm (CS)           |
| 802.11i security                            | 802.11w - PMF (Protected Management Frames)   Hostapd                  |
| 802.11i security                            | Embedded Authenticator                                                 |
| 802.11i security                            | WPA2-PSK AES   Embedded Supplicant                                     |
| 802.11i security                            | WPA+WPA2 PSK Mixed Mode   Embedded Supplicant                          |
| 802.11i security                            | WPA3-SAE (Simultaneous Authentication of Equals)   Embedded Supplicant |
| 802.11i security                            | 802.11w - PMF (Protected Management Frames)   Embedded Supplicant      |
| 802.11y                                     | Extended channel switch announcement (ECSA)                            |
| 802.11w - protected management frames (PMF) | PMF require and capable                                                |
| 802.11w - protected management frames (PMF) | Unicast management frames -Encryption/decryption - using PMF           |
| 802.11w - protected management frames (PMF) | Broadcast management frames -encryption/decryption - using PMF         |
| 802.11w - protected management frames (PMF) | SA query request/response                                              |
| General features                            | Embedded authenticator                                                 |
| General features                            | Embedded MLME                                                          |
| General features                            | EU adaptivity support                                                  |

Table 2 – continued from previ

| Features         | Sub features                                    |
|------------------|-------------------------------------------------|
| General features | Automatic channel selection (ACS)               |
| General features | External coexistence (software interface)       |
| General features | Independent reset (in-band) <sup>[^1]</sup>     |
| General features | Network co-processor (NCP) mode <sup>[^2]</sup> |
| General features | Vendor specific IE (custom IE)                  |
| General features | Hidden SSID (broadcast SSID disabled)           |
| General features | MAC address filter                              |
| General features | Multiple external STA support                   |

**Parent topic:**Wi-Fi radio

<sup>[^1]</sup> Feature not enabled by default in the SDK. Refer to [Feature enable and memory impact](#) for the macro to enable the feature and the impact on the memory. <sup>[^2]</sup> Read more about NCP feature in [References](#).

#### AP-STA mode

| Features                                     | Sub features                               | 88W89 | IW41 | IW611/IV | RW610/R | IW61 | AW611 |
|----------------------------------------------|--------------------------------------------|-------|------|----------|---------|------|-------|
| Simultaneous AP-STA operation (same channel) | AP-STA functionality                       | Y     | Y    | Y        | Y       | Y    | Y     |
| SAD                                          | Software antenna diversity <sup>[^1]</sup> | Y     | Y    | Y        | Y       | Y    | Y     |

**Parent topic:**Wi-Fi radio

<sup>[^1]</sup> Feature not enabled by default in the SDK. Refer to [Feature enable and memory impact](#) for the macro to enable the feature and the impact on the memory when enabling the feature.

**Parent topic:**[Features](#)

#### Wi-Fi Generic features

| Features | Sub features                                 | 88W89 | IW41 | IW611/IW | RW610/RW | IW61 | AW611 |
|----------|----------------------------------------------|-------|------|----------|----------|------|-------|
| Generic  | Firmware download (parallel) <sup>[^1]</sup> | Y     | Y    | Y        | N        | N    | Y     |
| Generic  | Secure boot                                  | N     | N    | Y        | Y        | Y    | Y     |
| Generic  | Kconfig memory optimizer                     | Y     | Y    | Y        | Y        | Y    | Y     |
| Generic  | Firmware Compression <sup>[^2]</sup>         | N     | Y    | N        | N        | N    | N     |
| Generic  | u-AP intra-BSS                               | Y     | N    | Y        | Y        | Y    | Y     |
| Generic  | Net Monitor Mode                             | N     | N    | N        | Y        | Y    | N     |
| Generic  | Net Monitor Mode with packet transmission    | N     | N    | N        | Y        | Y    | N     |
| Generic  | In-Channel Net Monitor mode                  | N     | N    | N        | N        | N    | N     |

**Parent topic:**Wi-Fi radio

<sup>[^1]</sup> Feature not enabled by default in the SDK. Refer to [Feature enable and memory impact](#) for the macro to enable the feature and the impact on the memory when enabling the feature. <sup>[^2]</sup> The feature is used to compress the Wi-Fi Bluetooth firmware and optimize the flashing of the host

**Wi-Fi direct/P2P**

| Features                                    | Sub fea-<br>tures | 88W8987 | IW416 <sup>[1]</sup> | IW611/IW61 | RW610/RW61 | IW610 <sup>[1]</sup> | AW611 <sup>[3]</sup> |
|---------------------------------------------|-------------------|---------|----------------------|------------|------------|----------------------|----------------------|
| P2P basic func-<br>tionality <sup>[1]</sup> | P2P<br>Auto<br>GO | Y       | Y                    | Y          | Y          | Y                    | Y                    |
| P2P basic func-<br>tionality <sup>[1]</sup> | P2P GO            | Y       | Y                    | Y          | Y          | Y                    | Y                    |
| P2P basic func-<br>tionality <sup>[1]</sup> | P2P GC            | Y       | Y                    | Y          | Y          | Y                    | Y                    |

**Parent topic:**Wi-Fi radio

<sup>[1]</sup> Feature not enabled by default in the SDK. Refer to [Feature enable and memory impact](#) for the macro to enable the feature and the impact on the memory when enabling the feature. <sup>[2]</sup> This is an experimental software release for this feature for IW416. <sup>[3]</sup> Contact your support representative to use this feature for.

**Bluetooth radio**

## Bluetooth classic

| Feature                         |      | Sub feature                                                                  | 88W8 | IW4' | IW611/ | RW610/ | IW6' | AW611 |
|---------------------------------|------|------------------------------------------------------------------------------|------|------|--------|--------|------|-------|
| General features                | fea- | Bluetooth Class 1.5 and Class 2 support                                      | Y    | Y    | Y      | N      | N    | Y     |
| General features                | fea- | Scatternet support                                                           | Y    | Y    | Y      | N      | N    | Y     |
| General features                | fea- | Maximum of seven simultaneous ACL connections – Central links                | Y    | Y    | Y      | N      | N    | Y     |
| General features                | fea- | Automatic packet type selection                                              | Y    | Y    | Y      | N      | N    | Y     |
| General features                | fea- | Bluetooth - 2.1 to 5.0 specification support                                 | Y    | Y    | Y      | N      | N    | Y     |
| General features                | fea- | Low power sniff                                                              | Y    | Y    | Y      | N      | N    | Y     |
| General features                | fea- | Deep sleep using out-of-band                                                 | Y    | Y    | N      | N      | N    | N     |
| General features                | fea- | Wake on Bluetooth (SoC to host)                                              | Y    | Y    | Y      | N      | N    | Y     |
| General features                | fea- | Independent reset (in-band) <sup>[^1]</sup>                                  | Y    | Y    | Y      | Y      | N    | Y     |
| General features                | fea- | Independent reset (out-band) <sup>[^1]</sup>                                 | Y    | Y    | N      | N      | N    | N     |
| General features                | fea- | Firmware download (parallel) <sup>[^1]</sup>                                 | Y    | Y    | N      | N      | N    | N     |
| General features                | fea- | RF test mode                                                                 | Y    | Y    | Y      | N      | N    | Y     |
| Bluetooth packet type supported | type | ACL (DM1, DH1, DM3, DH3, DM5, DH5, 2-DH1, 2-DH3, 2-DH5, 3-DH1, 3-DH3, 3-DH5) | Y    | Y    | Y      | N      | N    | Y     |
| Bluetooth packet type supported | type | SCO (HV1, HV3)                                                               | Y    | Y    | Y      | N      | N    | Y     |
| Bluetooth packet type supported | type | eSCO (EV3, EV4, EV5, 2EV3, 3EV3, 2EV5, 3EV5)                                 | Y    | Y    | Y      | N      | N    | Y     |
| Bluetooth profiles supported    | sup- | A2DP source/sink                                                             | Y    | Y    | Y      | N      | N    | Y     |
| Bluetooth profiles supported    | sup- | AVRCP target/controller                                                      | Y    | Y    | Y      | N      | N    | Y     |
| Bluetooth profiles supported    | sup- | HFP Dev/AG                                                                   | Y    | Y    | Y      | N      | N    | Y     |
| Bluetooth profiles supported    | sup- | OPP server/client                                                            | Y    | Y    | Y      | N      | N    | Y     |
| Bluetooth profiles supported    | sup- | SPP server/client                                                            | Y    | Y    | Y      | N      | N    | Y     |
| Bluetooth profiles supported    | sup- | HID target/device                                                            | Y    | Y    | Y      | N      | N    | Y     |
| Bluetooth audio features        | au-  | PCM NBS central/peripheral                                                   | Y    | Y    | Y      | N      | N    | Y     |
| Bluetooth audio features        | au-  | PCM WBS central/peripheral                                                   | Y    | Y    | Y      | N      | N    | Y     |

**Parent topic:**Bluetooth radio

**[^1]** Experimental feature intended for evaluation/early development only and not production. Incomplete mandatory certification.

### Bluetooth LE

| Features                            | Sub features                                       |
|-------------------------------------|----------------------------------------------------|
| Generic features                    | Maximum 16 Bluetooth LE connections (central role) |
| Generic features                    | Deep sleep using out-of-band                       |
| Generic features                    | Wake on Bluetooth LE (SoC to Host)                 |
| Generic features                    | RF Test mode                                       |
| Bluetooth profile support           | Bluetooth LE GATT                                  |
| Bluetooth profile support           | Bluetooth LE HID over GATT                         |
| Bluetooth profile support           | Bluetooth LE GAP                                   |
| Bluetooth LE 4.0 support            | Low Energy physical layer                          |
| Bluetooth LE 4.0 support            | Low Energy link layer                              |
| Bluetooth LE 4.0 support            | Enhancements to HCI for Low Energy                 |
| Bluetooth LE 4.0 support            | Low energy direct test mode                        |
| Bluetooth 4.1 support               | Low duty cycle directed advertising                |
| Bluetooth 4.1 support               | Bluetooth LE dual mode topology                    |
| Bluetooth 4.1 support               | Bluetooth LE privacy v1.1                          |
| Bluetooth 4.1 support               | Bluetooth LE link layer topology                   |
| Bluetooth 4.2 support               | Bluetooth LE secure connection                     |
| Bluetooth 4.2 support               | Bluetooth LE link layer privacy v1.2               |
| Bluetooth 4.2 support               | Bluetooth LE data length extension                 |
| Bluetooth 4.2 support               | Link layer extended scanner filter policies        |
| Bluetooth 5.0 support               | Bluetooth LE 2 Mbps support                        |
| Bluetooth 5.0 support               | High duty cycle directed advertising               |
| Bluetooth 5.0 support               | Low Energy advertising extension                   |
| Bluetooth 5.0 support               | Low Energy long range                              |
| Bluetooth 5.0 support               | Low Energy periodic advertisement                  |
| Bluetooth 5.2 support               | Low Energy power control                           |
| Bluetooth LE audio support[^1] [^2] | Isochronous channel                                |
| Bluetooth LE audio support[^1] [^2] | Broadcast LE Audio BIS source                      |
| Bluetooth LE audio support[^1] [^2] | Broadcast LE Audio BIS sink                        |
| Bluetooth LE audio support[^1] [^2] | Broadcast LE Audio BIG Validation                  |
| Bluetooth LE audio support[^1] [^2] | Broadcast LE Audio Phy: 1M/2M/ coded               |
| Bluetooth LE audio support[^1] [^2] | Broadcast LE Audio framed mode                     |
| Bluetooth LE audio support[^1] [^2] | Broadcast LE Audio unframed mode                   |
| Bluetooth LE audio support[^1] [^2] | Broadcast LE Audio sequential packing              |
| Bluetooth LE audio support[^1] [^2] | Broadcast LE Audio: Mono and Stereo                |
| Bluetooth LE audio support[^1] [^2] | Broadcast LE Audio BIS encrypted audio             |
| Bluetooth LE audio support[^1] [^2] | Broadcast LE Audio BIS unencrypted audio           |
| Bluetooth LE audio support[^1] [^2] | Unicast LE Audio CIS source                        |
| Bluetooth LE audio support[^1] [^2] | Unicast LE Audio CIS sink                          |
| Bluetooth LE audio support[^1] [^2] | Unicast LE Audio CIG validation                    |
| Bluetooth LE audio support[^1] [^2] | Unicast LE Audio CIS synchronization               |
| Bluetooth LE audio support[^1] [^2] | Unicast LE Audio Phy: 1M/2M/ coded                 |
| Bluetooth LE audio support[^1] [^2] | Unicast LE Audio framed mode                       |
| Bluetooth LE audio support[^1] [^2] | Unicast LE Audio unframed mode                     |
| Bluetooth LE audio support[^1] [^2] | Unicast LE Audio sequential packing                |
| Bluetooth LE audio support[^1] [^2] | Unicast LE Audio: mono and stereo                  |
| Bluetooth LE audio support[^1] [^2] | Unicast LE Audio CIS encrypted audio               |
| Bluetooth LE audio support[^1] [^2] | Unicast LE Audio CIS unencrypted audio             |
| Bluetooth LE audio support[^1] [^2] | Unicast LE Audio TX/RX and bidirectional traffic   |



Table 3 – continued from prev

| Features                                                   | Sub features                                             |
|------------------------------------------------------------|----------------------------------------------------------|
| Bluetooth LE audio support <sup>[^1]</sup> <sup>[^2]</sup> | ISO interval for LE Audio: 7.5ms 10ms 20ms 30ms          |
| Bluetooth LE audio support <sup>[^1]</sup> <sup>[^2]</sup> | Sampling frequency for LE Audio: 8kHz 16kHz 24kHz, 32kHz |
| Bluetooth LE audio support <sup>[^1]</sup> <sup>[^2]</sup> | LE Audio Auracast use cases: Auracast streaming 2 BISes  |
| Bluetooth LE audio support <sup>[^1]</sup> <sup>[^2]</sup> | LE Audio Unicast use cases: Unicast streaming 2 CISes    |
| Bluetooth LE audio support <sup>[^1]</sup> <sup>[^2]</sup> | LE Audio Unicast Use cases: Unicast streaming 4 CISes    |
| Bluetooth LE audio support <sup>[^1]</sup> <sup>[^2]</sup> | A2DP + Auracast/Unicast Bridge use cases – CIS/BIS       |
| BCA TDM Coexistence mode (shared antenna)                  | STA + Bluetooth coexistence                              |
| BCA TDM Coexistence mode (shared antenna)                  | STA + Bluetooth LE coexistence                           |
| BCA TDM Coexistence mode (shared antenna)                  | STA + Bluetooth + Bluetooth LE coexistence               |
| BCA TDM Coexistence mode (shared antenna)                  | AP + Bluetooth coexistence                               |
| BCA TDM Coexistence mode (shared antenna)                  | AP + Bluetooth LE coexistence                            |
| BCA TDM Coexistence mode (shared antenna)                  | AP + Bluetooth + Bluetooth LE coexistence                |
| BCA TDM coexistence mode (separate antenna)                | STA + Bluetooth coexistence                              |
| BCA TDM coexistence mode (separate antenna)                | STA + Bluetooth LE coexistence                           |
| BCA TDM coexistence mode (separate antenna)                | STA + Bluetooth + Bluetooth LE coexistence               |
| BCA TDM coexistence mode (separate antenna)                | AP + Bluetooth coexistence                               |
| BCA TDM coexistence mode (separate antenna)                | AP + Bluetooth LE coexistence                            |
| BCA TDM coexistence mode (separate antenna)                | AP + Bluetooth + Bluetooth LE coexistence                |

**Note:** Details of the tested Bluetooth LE Audio use cases:

- Number of streams:
  - 1-CIG | upto 4-CIS with 1 LE ACL (for 4-CIS: execute only mono UCs, SDU Int: 10ms)
  - 1-CIG | upto 4-CIS with 4 separate LE ACL (for 4-CIS: SDU Size= Max 100 Oct, PHY=2M, RTN=1, SDU Int: 10ms only) (execute only mono UCs for 4-CIS)
  - 1-BIG | upto 4-BIS (for 4-BIS: execute only mono UCs, SDU Int: 10ms only)
- PHY: 2M and 1M
- Audio mode: mono (for 1 to 4 streams) and stereo (for 1 stream)
- Packing: sequential and interleaved
- Bit rate: maximum 96kbps
  - For 1-CIG with upto 3-CIS: maximum bit rate 96kbps
  - For 1-CIG with 4-CIS: maximum bit rate 80kbps
  - For 1-BIG with 4-BIS: maximum bit rate 80kbps
  - For 2-CIG cases: maximum bit rate 80kbps
- Mode: unframed mode
- 48\_5 and 48\_6 mono and stereo configurations are not supported.

Details of the tested Bluetooth coexistence (Bluetooth + Bluetooth LE Audio) use cases:

- Bluetooth + Bluetooth LE Audio
- A2DP + Bluetooth LE Audio bridging support
- A2DP sink link (central) -> LEA 2-CIS (SDU Int: 10ms only | A2DP only with SBC Codec | PHY: 2M)

**Parent topic:**Bluetooth radio

<sup>[^1]</sup> Experimental feature intended for evaluation/early development only and not production. Incomplete mandatory certification.

<sup>[^2]</sup> LE audio feature is supported for standalone scenarios only and not for BR/EDR and Wi-Fi coexistence scenarios such as LE audio + BR/EDR link or LE audio + Wi-Fi link. From the

perspective of NXP Edgefast Bluetooth host stack, LE audio feature can be disabled by the CONFIG\_BT\_AUDIO macro without impact on any other features. LE audio feature can be tested by the user, using their own supported host stack.

Parent topic:[Features](#)

#### 802.15.4 radio

| Features        | Sub features                                         | IW612 | IW610 | RW612 |
|-----------------|------------------------------------------------------|-------|-------|-------|
| General tures   | fea- Spinel over SPI                                 | Y     | N     | N     |
| General tures   | fea- OpenThread RCP Mode implementing Thread1.3      | Y     | N     | N     |
| General tures   | fea- 802.15.4-2015 MAC/PHY as required by Thread 1.3 | Y     | Y     | Y     |
| General tures   | fea- OpenThread Border Router (OTBR) v1.1            | Y     | Y     | Y     |
| General tures   | fea- Direct/indirect transmission with/without ACK   | Y     | Y     | Y     |
| General tures   | fea- 802.15.4 CSL parent feature implementation      | Y     | Y     | Y     |
| General tures   | fea- Enhanced Frame Pending                          | Y     | Y     | Y     |
| General tures   | fea- Enhanced keep alive                             | Y     | Y     | Y     |
| General tures   | fea- Router                                          | Y     | Y     | Y     |
| General tures   | fea- Leader                                          | Y     | Y     | Y     |
| General tures   | fea- Router Eligible End Device (REED)               | Y     | Y     | Y     |
| General tures   | fea- End Device (FED, MED)                           | Y     | Y     | Y     |
| Zigbee features | Coordinator                                          | N     | N     | Y     |
| Zigbee features | Router                                               | N     | N     | Y     |
| Zigbee features | End Device (RX ON)                                   | N     | N     | Y     |
| Zigbee features | R23                                                  | N     | N     | Y     |
| Zigbee features | OTA Client                                           | N     | N     | Y     |
| Zigbee features | OTA server                                           | N     | N     | Y     |
| Matter features | Matter over Wi-Fi                                    | Y     | N     | N     |
| Matter features | Matter over Thread                                   | Y     | N     | Y     |

Parent topic:[Features](#)

#### Coexistence

**Wi-Fi and Bluetooth/802.15.4 coexistence**

| Features                                                                                                         | Sub features                                  | IW6' | IW6' | RW612 |
|------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|------|------|-------|
| BCA_TDM separate antenna <sup>[^1]</sup> (lower and higher isolation) 1x1 Wi-Fi, (Bluetooth and 802.15.4 shared) | STA + Bluetooth                               | Y    | N    | N     |
| BCA_TDM separate antenna <sup>[^1]</sup> (lower and higher isolation) 1x1 Wi-Fi, (Bluetooth and 802.15.4 shared) | Mobile AP + Bluetooth                         | Y    | N    | N     |
| BCA_TDM separate antenna <sup>[^1]</sup> (lower and higher isolation) 1x1 Wi-Fi, (Bluetooth and 802.15.4 shared) | Bluetooth LE + Wi-Fi                          | Y    | Y    | Y     |
| BCA_TDM separate antenna <sup>[^1]</sup> (lower and higher isolation) 1x1 Wi-Fi, (Bluetooth and 802.15.4 shared) | Bluetooth + Bluetooth LE + Wi-Fi              | Y    | N    | N     |
| BCA_TDM separate antenna <sup>[^1]</sup> (lower and higher isolation) 1x1 Wi-Fi, (Bluetooth and 802.15.4 shared) | OpenThread + Bluetooth                        | Y    | N    | N     |
| BCA_TDM separate antenna <sup>[^1]</sup> (lower and higher isolation) 1x1 Wi-Fi, (Bluetooth and 802.15.4 shared) | OpenThread + Bluetooth LE <sup>[^2]</sup>     | Y    | Y    | Y     |
| BCA_TDM separate antenna <sup>[^1]</sup> (lower and higher isolation) 1x1 Wi-Fi, (Bluetooth and 802.15.4 shared) | OpenThread + Bluetooth + Bluetooth LE         | Y    | N    | N     |
| BCA_TDM separate antenna <sup>[^1]</sup> (lower and higher isolation) 1x1 Wi-Fi, (Bluetooth and 802.15.4 shared) | OpenThread + Wi-Fi                            | Y    | Y    | Y     |
| BCA_TDM separate antenna <sup>[^1]</sup> (lower and higher isolation) 1x1 Wi-Fi, (Bluetooth and 802.15.4 shared) | Bluetooth + OpenThread + Wi-Fi                | Y    | N    | N     |
| BCA_TDM separate antenna <sup>[^1]</sup> (lower and higher isolation) 1x1 Wi-Fi, (Bluetooth and 802.15.4 shared) | Bluetooth LE + OpenThread + Wi-Fi             | Y    | Y    | Y     |
| BCA_TDM separate antenna <sup>[^1]</sup> (lower and higher isolation) 1x1 Wi-Fi, (Bluetooth and 802.15.4 shared) | Bluetooth + Bluetooth LE + OpenThread + Wi-Fi | Y    | N    | N     |
| BCA_TDM separate antenna <sup>[^1]</sup> (lower and higher isolation) 1x1 Wi-Fi, (Bluetooth and 802.15.4 shared) | Single antenna configuration                  | Y    | Y    | Y     |
| BCA_TDM separate antenna <sup>[^1]</sup> (lower and higher isolation) 1x1 Wi-Fi, (Bluetooth and 802.15.4 shared) | External Coexistence PTA                      | N    | Y    | Y     |

**Parent topic:**Coexistence

<sup>[^1]</sup> Experimental feature intended for evaluation/early development only and not production. Incomplete mandatory certification.

<sup>[^2]</sup> The narrow-band radio can be configured to support Bluetooth LE, 802.15.4, and to time-slice between Bluetooth LE and 802.15.4.

**Parent topic:**[Features](#)**Feature enable and memory impact**

| Features                                 | Macros to enable the feature                                                                                                                                                                  | Memory impact                          |
|------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|
| CSI                                      | CONFIG_CSI                                                                                                                                                                                    | Flash<br>- 60K,<br>RAM -<br>4K         |
| DPP                                      | CONFIG_WPA_SUPP_DPP                                                                                                                                                                           | Flash -<br>240K,<br>RAM -<br>12K       |
| Independent reset                        | CONFIG_WIFI_IND_DNLDCONFIG_WIFI_IND_RESET                                                                                                                                                     | Minimal                                |
| Parallel firmware download<br>Wi-Fi      | CONFIG_WIFI_IND_DNLD                                                                                                                                                                          | Minimal                                |
| Parallel firmware download<br>Bluetooth  | CONFIG_BT_IND_DNLD                                                                                                                                                                            | Minimal                                |
| WPA3 enterprise                          | CONFIG_WPA_SUPP_CRYPTO_ENTERPRISE [Macros specific to EAP-methods included] CONFIG_EAP_TLS CONFIG_EAP_PEAP CONFIG_EAP_TTLS CONFIG_EAP_FAST CONFIG_EAP_SIM CONFIG_EAP_AKA CONFIG_EAP_AKA_PRIME | Flash -<br>165K,<br>RAM -<br>18K       |
| WPA2 enterprise                          | CONFIG_WPA_SUPP_CRYPTO_ENTERPRISE [Macros specific to EAP-methods included] CONFIG_EAP_TLS CONFIG_EAP_PEAP CONFIG_EAP_TTLS CONFIG_EAP_FAST CONFIG_EAP_SIM CONFIG_EAP_AKA CONFIG_EAP_AKA_PRIME | Flash -<br>165K,<br>RAM -<br>18K       |
| Host sleep                               | CONFIG_HOST_SLEEP                                                                                                                                                                             | Minimal                                |
| WMM                                      | CONFIG_WMM <sup>[^1]</sup>                                                                                                                                                                    | Flash<br>- 10K,<br>RAM -<br>57K        |
| 802.11mc                                 | CONFIG_11MC CONFIG_CSI CONFIG_WLS_CSI_PROC <sup>[^2]</sup> CONFIG_11AZ                                                                                                                        | Flash:<br>52.78KB,<br>RAM :<br>121.1KB |
| 802.11az                                 | CONFIG_11MC CONFIG_CSI <sup>[2]</sup> CONFIG_WLS_CSI_PROC <sup>[^2]</sup> CONFIG_11AZ                                                                                                         | Flash:<br>52.78KB,<br>RAM :<br>121.1KB |
| Non-blocking firmware download mechanism | CONFIG_FW_DNLD_ASYNC                                                                                                                                                                          | —                                      |
| Antenna diversity                        | CONFIG_WLAN_CALDATA_2ANT_DIVERSITY                                                                                                                                                            | -                                      |
| P2P                                      | CONFIG_WPA_SUPP_P2P                                                                                                                                                                           | -                                      |

**Note:**

- For Wi-Fi, the macros are set with the value “0” by default in the file `wifi_config_default.h` located in `<SDK_PATH>/middleware/wifi_nxp/incl/` directory.

To enable the features, set the value of the macros to “1\*” in the file `wifi_config.h` located in `*<SDK_Wi-Fi_Example_PATH>/directory***.***`

- Bluetooth

To enable the features, set the value of the macros to “1” in the file `app_bluetooth_config.h` located in `<SDK_Bluetooth_Example_PATH>/` directory.

**Kconfig memory optimizer** The MCUXpresso SDK provides options to reduce the host memory usage with build-time configuration parameters referred to as Kconfig memory optimizer. The configuration parameters are used to reduce the use of the flash memory and SRAM.

This section explains how to enable the host memory saving configurations within the Wi-Fi drivers of NXP wireless devices.

Memory impact of i.MX RT1060 EVKC + IW416 module (Murata 1XK):

- Maximum Flash usage: 889 KB
- Maximum SRAM usage: 418.77 KB

To reduce the use of the flash and SRAM, change the settings of the Kconfig macros listed in table in the file `wifi_config.h` located in `<path-to-SDK_Wi-Fi_Example>` directory.

| Kconfig macros                                        | Feature disabled                                                                                                                                                                                                                                                      |
|-------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CON-<br>FIG_WIFI_SL]                                  | CONFIG_ROAMING CONFIG_11R                                                                                                                                                                                                                                             |
| CON-<br>FIG_WIFI_SL]                                  | CONFIG_CLOUD_KEEP_ALIVE CONFIG_WIFI_EU_CRYPTO CON-<br>FIG_TX_AMPDU_PROT_MODE CONFIG_WNM_PS CONFIG_TURBO_MODE<br>CONFIG_AUTO_RECONNECT CONFIG_DRIVER_OWE CONFIG_OWE<br>CONFIG_WIFI_FORCE_RTS CONFIG_WIFI_FRAG_THRESHOLD CON-<br>FIG_COMBO_SCAN CONFIG_SCAN_CHANNEL_GAP |
| CON-<br>FIG_WIFI_SL]                                  | CONFIG_UAP_STA_MAC_ADDR_FILTER CONFIG_WIFI_MAX_CLIENTS_CNT                                                                                                                                                                                                            |
| CON-<br>FIG_FREERTC                                   | If the macro is enabled, the heap memory usage is reduced by 10 KB (from 70 KB to 60 KB).                                                                                                                                                                             |
| CON-<br>FIG_LWIP_LC                                   | Curtails LWIP stack parameters, reduces data throughput, disables data net-<br>stats                                                                                                                                                                                  |
| Non-<br>blocking<br>firmware<br>download<br>mechanism | CONFIG_FW_DNLD_ASYNC                                                                                                                                                                                                                                                  |

**Parent topic:** [Feature enable and memory impact](#)

[^1] The macro is not used for IW416.

[^2] Prerequisite macros for 802.11mc and 802.11az features

## 88W8987 release notes

### Package information

- SDK version: 25.06.00

**Parent topic:** [88W8987 release notes](#)

### Version information

- Wireless SoC: 88W8987
- Wi-Fi and Bluetooth/Bluetooth LE firmware version: 16.92.21.p151.7
  - 16 - Major revision
  - 91 - Feature pack
  - 21 - Release version
  - p151.7 - Patch number

**Parent topic:**[88W8987 release notes](#)

### Host platform

- All i.MX RT platforms running FreeRTOS.
- Host interfaces
  - Wi-Fi over SDIO (SDIO 2.0 support, SDIO clock frequency: 50 MHz)
  - Bluetooth/Bluetooth LE over UART
- Test tools
  - iPerf (version 2.1.9)

**Parent topic:**[88W8987 release notes](#)

**Wi-Fi and Bluetooth certification** The Wi-Fi and Bluetooth certification is obtained with the following combinations.

### WFA certifications

- STA | 802.11n
- STA | 802.11ac
- STA | PMF
- STA | FFD
- STA | SVD
- STA | WPA3 SAE (R3)
- STA | QTT

Refer to 6.

**Note:** This release supports STAUT only certifications.

**Parent topic:**Wi-Fi and Bluetooth certification

**Bluetooth controller certification** QDID: refer to 4.

**Parent topic:**Wi-Fi and Bluetooth certification

**Parent topic:**[88W8987 release notes](#)

### Wi-Fi throughput

### Throughput test setup

- Environment: Shield Room - Over the Air
- External Access Point: ASUS AX88U
- DUT: W8987 Murata (Module: **1ZM M.2**) with EVK-MIMXRT1060 EVKC platform
- DUT Power Source: External power supply
- External Client: Apple MacBook Air
- Channel: 6 | 36
- Wi-Fi application: wifi\_wpa\_supPLICant
- Compiler used to build application: armgcc
- Compiler Version: gcc-arm-none-eabi-13.2
- iPerf commands used in test:

#### TCP TX

```
iperf -c <remote_ip> -t 60
```

#### TCP RX

```
iperf -s
```

#### UDP TX

```
iperf -c <remote_ip> -t 60 -u -B <local_ip> -b 120
```

**Note:** The default rate is 100 Mbps.

#### UDP RX

```
iperf -s -u -B <local_ip>
```

**Note:** Read more about the throughput test setup and topology in 2.

**Parent topic:** Wi-Fi throughput

### STA throughput External APs: ASUS AX88U

#### STA mode throughput - BGN Mode | 2.4 GHz Band | 20 MHz

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 46           | 51           | 60           | 60           |
| WPA2-AES     | 45           | 42           | 60           | 54           |
| WPA3-SAE     | 46           | 41           | 60           | 54           |

#### STA mode throughput - BGN Mode | 2.4 GHz Band | 40 MHz

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 62           | 83           | 121          | 124          |
| WPA2-AES     | 61           | 82           | 120          | 126          |
| WPA3-SAE     | 60           | 82           | 120          | 126          |

#### STA mode throughput - AN Mode | 5 GHz Band | 20 MHz

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 43           | 52           | 60           | 64           |
| WPA2-AES     | 43           | 52           | 61           | 64           |
| WPA3-SAE     | 43           | 52           | 60           | 65           |

**STA mode throughput - AN Mode | 5 GHz Band | 40 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 64           | 87           | 126          | 125          |
| WPA2-AES     | 63           | 85           | 125          | 120          |
| WPA3-SAE     | 63           | 80           | 125          | 123          |

**STA mode throughput - AC Mode | 5 GHz Band | 20 MHz (VHT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 48           | 60           | 73           | 78           |
| WPA2-AES     | 47           | 60           | 73           | 77           |
| WPA3-SAE     | 47           | 60           | 73           | 77           |

**STA mode throughput - AC Mode | 5 GHz Band | 40 MHz (VHT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 68           | 96           | 161          | 157          |
| WPA2-AES     | 69           | 92           | 160          | 155          |
| WPA3-SAE     | 70           | 94           | 160          | 155          |

**STA mode throughput - AC Mode | 5 GHz Band | 80 MHz (VHT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 78           | 99           | 125          | 203          |
| WPA2-AES     | 78           | 98           | 126          | 197          |
| WPA3-SAE     | 82           | 98           | 125          | 197          |

**Parent topic:**Wi-Fi throughput

**Mobile AP throughput** External client: Apple Macbook Air

**Mobile AP Mode Throughput - BGN Mode | 2.4 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 43           | 51           | 56           | 62           |
| WPA2-AES     | 42           | 50           | 54           | 61           |
| WPA3-SAE     | 40           | 50           | 65           | 62           |



**Mobile AP Mode Throughput - BGN Mode | 2.4 GHz Band | 40 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 66           | 81           | 107          | 121          |
| WPA2-AES     | 65           | 80           | 107          | 120          |
| WPA3-SAE     | 65           | 80           | 108          | 120          |

**Mobile AP Mode Throughput - AN Mode | 5 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 44           | 52           | 60           | 61           |
| WPA2-AES     | 44           | 51           | 60           | 61           |
| WPA3-SAE     | 44           | 51           | 60           | 61           |

**Mobile AP Mode Throughput - AN Mode | 5 GHz Band | 40 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 70           | 89           | 126          | 103          |
| WPA2-AES     | 70           | 87           | 124          | 102          |
| WPA3-SAE     | 70           | 88           | 125          | 103          |

**Mobile AP Mode Throughput - AC Mode | 5 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 49           | 60           | 73           | 76           |
| WPA2-AES     | 48           | 59           | 73           | 76           |
| WPA3-SAE     | 48           | 60           | 73           | 76           |

**Mobile AP Mode Throughput - AC Mode | 5 GHz Band | 40 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 77           | 106          | 161          | 102          |
| WPA2-AES     | 77           | 104          | 160          | 102          |
| WPA3-SAE     | 77           | 104          | 160          | 111          |

**Mobile AP Mode Throughput - AC Mode | 5 GHz Band | 80 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 93           | 114          | 125          | 206          |
| WPA2-AES     | 92           | 111          | 125          | 191          |
| WPA3-SAE     | 92           | 111          | 125          | 173          |

Parent topic:Wi-Fi throughput

Parent topic:[88W8987 release notes](#)

**EU conformance tests**

- EU Adaptivity test - EN 300 328 v2.1.1 (for 2.4 GHz)
- EU Adaptivity test - EN 301 893 v2.1.1 (for 5 GHz)

**Parent topic:**[88W8987 release notes](#)**Bug fixes and/or feature enhancements****Firmware version: From 16.91.21.p64.1 to 16.91.21.p82**

| Compo-<br>po-<br>nent | Description                                                                                                                                                                                                       |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Wi-Fi                 | WPA3-R3 enabled APUT beacons does not have RSNXE when configured in H2E mode-Associated event is received even when connecting using wrong password WFA APUT Low iperf TCP/UDP Tx throughput with Realtek station |

**Parent topic:**Bug fixes and/or feature enhancements**Firmware version: From 16.91.21.p82 to 16.91.21.p91.6**

| Compo-<br>nent | Description                                                                                         |
|----------------|-----------------------------------------------------------------------------------------------------|
| Wi-Fi          | In wrong password scenario, After updating new password the phone is not able to connect with DUTAP |

**Parent topic:**Bug fixes and/or feature enhancements**Firmware version: From 16.91.21.p91.6 to 16.91.21.p124**

| Compo-<br>nent | Description                                                                                                       |
|----------------|-------------------------------------------------------------------------------------------------------------------|
| Wi-Fi          | Cloud keep alive packets not seen after DUT enters host sleep. DUT is sending QOS null packets even in host sleep |

**Parent topic:**Bug fixes and/or feature enhancements**Firmware version: From 16.91.21.p124 to 16.91.21.p133**

| Compo-<br>nent | Description                                                                                                              |
|----------------|--------------------------------------------------------------------------------------------------------------------------|
| Wi-Fi          | Samsung S24 Ultra and Google Pixel 7 mobiles having Android 14 are not able connect to the DUTAP with WPA3 SAE security. |

**Parent topic:**Bug fixes and/or feature enhancements

**Firmware version: From 16.91.21.p133 to 16.91.21.p142.5**  
**{#firmware\_version\_from\_16\_91\_21\_p133\_to\_16\_91\_21\_p142\_5}**

| Component | Description                                                                        |
|-----------|------------------------------------------------------------------------------------|
| Wi-Fi     | Fails to encrypt and decrypt data with ccmp 128 and 256 using CLI crypto commands. |

**Parent topic:**Bug fixes and/or feature enhancements

**Firmware version: From 16.91.21.p142.5 to 16.91.21.p149.2**  
**{#firmware\_version\_from\_16\_91\_21\_p142\_5\_to\_16\_91\_21\_p149\_2}**

| Component | Description                                                        |
|-----------|--------------------------------------------------------------------|
| Wi-Fi     | DUTSTA does not associate to hidden SSID beaconing in DFS channel. |

**Parent topic:**Bug fixes and/or feature enhancements

**Firmware version: From 16.91.21.p149.2 to 16.92.21.p151.7**  
**{#firmware\_version\_from\_16\_91\_21\_p149\_2\_to\_16\_92\_21\_p151\_7}**

| Component | Description                                                                      |
|-----------|----------------------------------------------------------------------------------|
| Wi-Fi     | Getting low TCP/UDP TP in DUT-AP 11ac-vht80 mode after hard-reset or wlan-reset. |

**Parent topic:**Bug fixes and/or feature enhancements

**Parent topic:**[88W8987 release notes](#)

#### Known issues

| Component | Description |
|-----------|-------------|
| -         | NA          |

**Parent topic:**[88W8987 release notes](#)

## IW416 release notes

### Package information

- SDK version: 25.06.00

**Parent topic:**[IW416 release notes](#)

### Version information

- Wireless SoC: IW416
- Wi-Fi and Bluetooth/Bluetooth LE firmware version: 16.92.21.p151.7
  - 16 - Major revision

- 92 - Feature pack
- 21 - Release version
- p151.7 - Patch number

**Parent topic:** [IW416 release notes](#)

### Host platform

- All i.MX RT platforms running FreeRTOS.
- Host interfaces
  - Wi-Fi over SDIO (SDIO 2.0 Support, SDIO clock frequency: 50 MHz)
  - Bluetooth/Bluetooth LE over UART
- Test tools
  - iPerf (version 2.1.9)

**Parent topic:** [IW416 release notes](#)

**Wi-Fi and Bluetooth certification** The Wi-Fi and Bluetooth certification is obtained with the following combinations.

### WFA certifications

- STA | 802.11n
- STA | PMF
- STA | FFD
- STA | SVD
- STA | WPA3 SAE (R3)
- STA | QTT

Refer to 6.

**Note:** This release supports STAUT only certifications.

**Parent topic:** Wi-Fi and Bluetooth certification

**Bluetooth controller certification** QDID: refer to 4.

**Note:** QDID upgrade to Bluetooth Core Specification Version 5.4 is in progress.

**Parent topic:** Wi-Fi and Bluetooth certification

**Parent topic:** [IW416 release notes](#)

### Wi-Fi throughput

### Throughput test setup

- Environment: Shield Room - Over the Air
- Access Point: Asus AX88u
- DUT: IW416 Murata (Module: 1XK M.2) with EVK-MIMXRT1060 EVKC platform
- DUT Power Source: External power supply
- Client: Apple MacBook Air
- Channel: 6 | 36
- Wi-Fi application: wifi\_wpa\_supplicant
- Compiler used to build application: armgcc
- Compiler Version: gcc-arm-none-eabi-13.2
- iPerf commands used in test:

#### TCP TX

```
iperf -c <remote_ip> -t 60
```

#### TCP RX

```
iperf -s
```

#### UDP TX

```
iperf -c <remote_ip> -t 60 -u -B <local_ip> -b 120
```

**Note:** The default rate is 100 Mbps.

#### UDP RX

```
iperf -s -u -B <local_ip>
```

**Note:** Read more about the throughput test setup and topology in 2.

**Parent topic:** Wi-Fi throughput

### STA throughput External AP: Asus AX88u

#### STA mode throughput - BGN Mode | 2.4 GHz Band | 20 MHz

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 39           | 38           | 59           | 58           |
| WPA2-AES     | 38           | 36           | 57           | 58           |
| WPA3-SAE     | 41           | 35           | 57           | 57           |

#### STA mode throughput - BGN Mode | 2.4 GHz Band | 40 MHz

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 58           | 58           | 93           | 91           |
| WPA2-AES     | 56           | 49           | 94           | 74           |
| WPA3-SAE     | 54           | 57           | 94           | 73           |

#### STA mode throughput - AN Mode | 5 GHz Band | 20 MHz (HT)

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 40           | 45           | 61           | 58           |
| WPA2-AES     | 40           | 43           | 61           | 57           |
| WPA3-SAE     | 40           | 44           | 61           | 57           |

**STA mode throughput - AN Mode | 5 GHz Band | 40 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 60           | 66           | 94           | 100          |
| WPA2-AES     | 58           | 61           | 94           | 98           |
| WPA3-SAE     | 59           | 61           | 94           | 98           |

**Parent topic:**Wi-Fi throughput

**Mobile AP throughput** External client: Apple MacBook Air**Mobile AP mode throughput - BGN Mode | 2.4 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 40           | 43           | 59           | 57           |
| WPA2-AES     | 40           | 42           | 59           | 57           |
| WPA3-SAE     | 39           | 42           | 59           | 57           |

**Mobile AP mode throughput - BGN Mode | 2.4 GHz Band | 40 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 62           | 74           | 121          | 118          |
| WPA2-AES     | 60           | 64           | 116          | 91           |
| WPA3-SAE     | 60           | 65           | 116          | 91           |

**Mobile AP mode throughput - AN Mode | 5 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 50           | 42           | 45           | 62           |
| WPA2-AES     | 42           | 45           | 53           | 62           |
| WPA3-SAE     | 42           | 62           | 53           | 45           |

**Mobile AP mode throughput - AN Mode | 5 GHz Band | 40 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 66           | 76           | 126          | 96           |
| WPA2-AES     | 63           | 68           | 121          | 95           |
| WPA3-SAE     | 63           | 67           | 121          | 95           |

**Parent topic:**Wi-Fi throughput

**Parent topic:**[IW416 release notes](#)

#### EU conformance tests

- EU Adaptivity test - EN 300 328 v2.1.1 (for 2.4 GHz)
- EU Adaptivity test - EN 301 893 v2.1.1 (for 5 GHz)

**Parent topic:**[IW416 release notes](#)

#### Bug fixes and/or feature enhancements

##### Firmware version: From 16.91.21.p64.1 to 16.91.21.p82

| Component | Description                                                                  |
|-----------|------------------------------------------------------------------------------|
| Wi-Fi     | WPA3-R3 enabled APUT beacons does not have RSNXE when configured in H2E mode |

**Parent topic:**Bug fixes and/or feature enhancements

##### Firmware version: From 16.91.21.p82 to 16.91.21.p91.6

| Component | Description |
|-----------|-------------|
| Wi-Fi     | NA          |

**Parent topic:**Bug fixes and/or feature enhancements

##### Firmware version: From 16.91.21.p91.6 to 16.91.21.p124

| Component | Description                                                                                                       |
|-----------|-------------------------------------------------------------------------------------------------------------------|
| Wi-Fi     | Cloud keep alive packets not seen after DUT enters host sleep. DUT is sending QOS null packets even in host sleep |

**Parent topic:**Bug fixes and/or feature enhancements

##### Firmware version: From 16.91.21.p124 to 16.91.21.p133

| Component | Description |
|-----------|-------------|
| Wi-Fi     | NA          |

**Parent topic:**Bug fixes and/or feature enhancements

**Firmware version: From 16.91.21.p133 to 16.91.21.p133.2**  
**{#firmware\_version\_from\_16\_91\_21\_p133\_to\_16\_91\_21\_p133\_2}**

| Com-<br>ponent | Description                                                                                                                         |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------|
| Wi-Fi          | DUT STA getting rebooted after 15~20 iterations of 11R-Command based roaming0xa4 command timeout after several hours of stress test |

**Parent topic:**Bug fixes and/or feature enhancements

**Firmware version: From 16.91.21.p133.2 to 16.91.21.p142.5**  
**{#firmware\_version\_from\_16\_91\_21\_p133\_2\_to\_16\_91\_21\_p142\_5}**

| Component | Description                                                               |
|-----------|---------------------------------------------------------------------------|
| Wi-Fi     | DUT fails to reconnect after the configured auto-reconnect time interval. |
| Coex      | During HFP call, TX side noise is observed with coex CLI                  |

**Parent topic:**Bug fixes and/or feature enhancements

**Firmware version: From 16.91.21.p142.5 to 16.91.21.p149.4**  
**{#firmware\_version\_from\_16\_91\_21\_p142\_5\_to\_16\_91\_21\_p149\_4}**

| Component | Description |
|-----------|-------------|
| -         | NA          |

**Parent topic:**Bug fixes and/or feature enhancements

**Firmware version: From 16.91.21.p149.4 to 16.92.21.p151.7**  
**{#firmware\_version\_from\_16\_91\_21\_p149\_4\_to\_16\_92\_21\_p151\_7}**

| Com-<br>ponent | Description                                                                                                              |
|----------------|--------------------------------------------------------------------------------------------------------------------------|
| Wi-Fi          | Samsung S24 Ultra and Google Pixel 7 mobiles having Android 14 are not able connect to the DUTAP with WPA3 SAE security. |

**Parent topic:**Bug fixes and/or feature enhancements

**Parent topic:**[IW416 release notes](#)

### Known issues

| Compo-<br>nent | Description                                                                       |
|----------------|-----------------------------------------------------------------------------------|
| Coex           | Wi-Fi connection in 2.4GHz is not stable, observed deauthentication within 10sec. |

**Parent topic:**[IW416 release notes](#)

**IW611/IW612 release notes** **Note:** The IW611/IW612 support is enabled in i.MX RT1170 EVKB and i.MX RT1060 EVKC.



### Package information

- SDK version: 25.06.00

**Parent topic:** [IW611/IW612 release notes](#)

### Version information

- Wireless SoC: IW611/IW612
- Wi-Fi and Bluetooth/Bluetooth LE firmware version: 18.99.3.p25.11
  - 18 - Major revision
  - 99 - Feature pack
  - 3 - Release version
  - p25.11 - Patch number

**Parent topic:** [IW611/IW612 release notes](#)

### Host platform

- i.MX RT1170 EVKB and i.MX RT1060 EVKC Platforms running FreeRTOS
- Host interfaces
  - Wi-Fi over SDIO (SDIO 2.0 support, SDIO clock frequency: 50 MHz)
  - Bluetooth/Bluetooth LE over UART
  - 802.15.4 over SPI (IW612 only)
- Test tools
  - iPerf (version 2.1.9)

**Parent topic:** [IW611/IW612 release notes](#)

**Wi-Fi and Bluetooth certification** The Wi-Fi and Bluetooth certification is obtained with the following combinations.

### WFA certifications

- STA | 802.11n
- STA | PMF
- STA | FFD
- STA | SVD
- STA | WPA3 SAE (R3)
- STA | 802.11ac
- STA | 802.11ax
- STA | QTT

Refer to 6.

**Note:** This release supports STAUT only certifications.

**Parent topic:** Wi-Fi and Bluetooth certification

**Bluetooth controller certification** QDID: refer to 4.

**Note:** QDID upgrade to Bluetooth Core Specification Version 5.4 is in progress.

**Parent topic:** Wi-Fi and Bluetooth certification

**Parent topic:** [IW611/IW612 release notes](#)

## Wi-Fi throughput

### Throughput test setup

- Environment: Shield Room - Over the Air
- Access Point: Asus AX88u
- DUT: IW612 Murata (Module: 2EL M.2) with EVK-MIMXRT1060 EVKC platform
- DUT Power Source: External power supply
- Client: Apple MacBook Air
- Channel: 6 | 36
- Wi-Fi application: wifi\_wpa\_supplicant
- Compiler used to build application: armgcc
- Compiler Version gcc-arm-none-eabi-13.2
- iPerf commands used in test:

#### TCP TX

```
iperf -c <remote_ip> -t 60
```

#### TCP RX

```
iperf -s
```

#### UDP TX

```
iperf -c <remote_ip> -t 60 -u -B <local_ip> -b 120
```

**Note:** The default rate is 100 Mbps.

#### UDP RX

```
iperf -s -u -B <local_ip>
```

**Note:** Read more about the throughput test setup and topology in 2

The throughput numbers are captured with default configurations using *wifi\_wpa\_supplicant* sample application.

**Parent topic:** Wi-Fi throughput

### iPerf host configuration and impact on throughput [{#iperf\\_host\\_configuration\\_and\\_impact\\_on\\_throughput}](#)

To get the highest throughput, the throughput values shown in STA throughput and Mobile AP throughput are measured with the maximum values of the default host configuration macros. STA and AP throughput captured with the minimum values of the host configuration macros shows the throughput numbers obtained when using the minimum values of the host configuration macros. The macro values are defined in *lwipopts.h* file.

The table below lists the minimum and maximum values of the host configuration macros.

**Values of the host configuration macros**

| Parameter                 | Maximum value | Minimum value |
|---------------------------|---------------|---------------|
| TCPIP_MBOX_SIZE           | 96            | 32            |
| DEFAULT_RAW_RECVMBOX_SIZE | 32            | 12            |
| DEFAULT_UDP_RECVMBOX_SIZE | 64            | 12            |
| DEFAULT_TCP_RECVMBOX_SIZE | 64            | 12            |
| TCP_MSS                   | 1460          | 536           |
| TCP_SND_BUF               | 24 * TCP_MSS  | 2 * TCP_MSS   |
| MEM_SIZE                  | 319160        | 41,080        |
| TCP_WND                   | 15 * TCP_MSS  | 10 * TCP_MSS  |
| MEMP_NUM_PBUF             | 20            | 10            |
| MEMP_NUM_TCP_SEG          | 96            | 12            |
| MEMP_NUM_TCPIP_MSG_INPKT  | 80            | 16            |
| MEMP_NUM_TCPIP_MSG_API    | 80            | 8             |
| MEMP_NUM_NETBUF           | 32            | 16            |

**STA and AP throughput captured with the minimum values of the host configuration macros****STA mode throughput - HE Mode | 5 GHz Band | 80 MHz**

| Protocol      | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|---------------|--------------|--------------|--------------|--------------|
| Direction     | TX           | RX           | TX           | RX           |
| Open Security | 7            | 18           | 111          | 124          |
| WPA2-AES      | 7            | 18           | 110          | 124          |
| WPA3-SAE      | 6            | 18           | 110          | 124          |

**Mobile AP mode throughput - HE Mode | 5 GHz Band | 80 MHz**

| Protocol      | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|---------------|--------------|--------------|--------------|--------------|
| Direction     | TX           | RX           | TX           | RX           |
| Open Security | 2            | 19           | 93           | 127          |
| WPA2-AES      | 2            | 19           | 105          | 126          |
| WPA3-SAE      | 2            | 19           | 104          | 132          |

**Parent topic:**iPerf host configuration and impact on throughput**Parent topic:**Wi-Fi throughput**STA throughput** External AP: Asus AX88u**STA mode throughput - BGN Mode | 2.4 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 43           | 47           | 45           | 60           |
| WPA2-AES     | 43           | 46           | 48           | 59           |
| WPA3-SAE     | 47           | 49           | 63           | 63           |

**STA mode throughput - BGN Mode | 2.4 GHz Band | 40 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 68           | 82           | 131          | 131          |
| WPA2-AES     | 72           | 82           | 130          | 129          |
| WPA3-SAE     | 68           | 81           | 129          | 130          |

**STA mode throughput - AN Mode | 5 GHz Band | 20 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 45           | 51           | 63           | 65           |
| WPA2-AES     | 45           | 51           | 63           | 65           |
| WPA3-SAE     | 45           | 51           | 63           | 65           |

**STA mode throughput - AN Mode | 5 GHz Band | 40 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 67           | 83           | 129          | 134          |
| WPA2-AES     | 66           | 83           | 129          | 133          |
| WPA3-SAE     | 65           | 83           | 129          | 133          |

**STA mode throughput - VHT Mode | 2.4 GHz Band | 20 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 49           | 53           | 72           | 71           |
| WPA2-AES     | 48           | 52           | 73           | 70           |
| WPA3-SAE     | 52           | 56           | 75           | 75           |

**STA mode throughput - VHT Mode | 2.4 GHz Band | 40 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 74           | 88           | 172          | 172          |
| WPA2-AES     | 75           | 92           | 171          | 169          |
| WPA3-SAE     | 77           | 92           | 172          | 171          |

**STA mode throughput - VHT Mode | 5 GHz Band | 20 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 50           | 58           | 76           | 78           |
| WPA2-AES     | 49           | 57           | 76           | 77           |
| WPA3-SAE     | 49           | 57           | 76           | 77           |

**STA mode throughput - VHT Mode | 5 GHz Band | 40 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 74           | 93           | 175          | 177          |
| WPA2-AES     | 74           | 93           | 174          | 174          |
| WPA3-SAE     | 73           | 93           | 173          | 175          |

**STA mode throughput - VHT Mode | 5 GHz Band | 80 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 88           | 94           | 221          | 196          |
| WPA2-AES     | 87           | 95           | 219          | 194          |
| WPA3-SAE     | 89           | 95           | 219          | 195          |

**STA mode throughput - HE Mode | 2.4 GHz Band | 20 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 60           | 60           | 98           | 115          |
| WPA2-AES     | 62           | 61           | 94           | 113          |
| WPA3-SAE     | 61           | 59           | 97           | 108          |

**STA mode throughput - HE Mode | 2.4 GHz Band | 40 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 77           | 71           | 215          | 190          |
| WPA2-AES     | 77           | 72           | 212          | 187          |
| WPA3-SAE     | 76           | 72           | 152          | 189          |

**STA mode throughput - HE Mode | 5 GHz Band | 20 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 63           | 65           | 127          | 128          |
| WPA2-AES     | 63           | 67           | 125          | 128          |
| WPA3-SAE     | 63           | 67           | 125          | 126          |

**STA mode throughput - HE Mode | 5 GHz Band | 40 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 79           | 64           | 212          | 199          |
| WPA2-AES     | 78           | 68           | 218          | 199          |
| WPA3-SAE     | 79           | 68           | 217          | 198          |

**STA mode throughput - HE Mode | 5 GHz Band | 80 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 88           | 70           | 219          | 192          |
| WPA2-AES     | 87           | 72           | 219          | 193          |
| WPA3-SAE     | 91           | 72           | 220          | 194          |

**Parent topic:**Wi-Fi throughput

**Mobile AP throughput** External client: Apple MacBook Air

**Mobile AP mode throughput - BGN Mode | 2.4 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 40           | 52           | 61           | 62           |
| WPA2-AES     | 40           | 51           | 61           | 62           |
| WPA3-SAE     | 40           | 51           | 61           | 62           |

**Mobile AP mode throughput - BGN Mode | 2.4 GHz Band | 40 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 63           | 83           | 116          | 130          |
| WPA2-AES     | 67           | 82           | 115          | 131          |
| WPA3-SAE     | 60           | 81           | 115          | 132          |

**Mobile AP mode throughput - AN Mode | 5 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 39           | 49           | 60           | 62           |
| WPA2-AES     | 39           | 49           | 60           | 62           |
| WPA3-SAE     | 41           | 51           | 63           | 62           |

**Mobile AP mode throughput - AN Mode | 5 GHz Band | 40 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 66           | 89           | 128          | 133          |
| WPA2-AES     | 64           | 87           | 128          | 133          |
| WPA3-SAE     | 62           | 86           | 128          | 133          |

**Mobile AP mode throughput - VHT Mode | 2.4 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 44           | 60           | 74           | 75           |
| WPA2-AES     | 43           | 59           | 74           | 75           |
| WPA3-SAE     | 43           | 59           | 74           | 75           |

**Mobile AP mode throughput - VHT Mode | 2.4 GHz Band | 40 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 64           | 53           | 112          | 75           |
| WPA2-AES     | 65           | 51           | 111          | 75           |
| WPA3-SAE     | 62           | 51           | 112          | 75           |

**Mobile AP mode throughput - VHT Mode | 5 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 45           | 60           | 76           | 76           |
| WPA2-AES     | 44           | 59           | 76           | 76           |
| WPA3-SAE     | 44           | 59           | 76           | 76           |

**Mobile AP mode throughput - VHT Mode | 5 GHz Band | 40 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 73           | 100          | 155          | 178          |
| WPA2-AES     | 72           | 99           | 152          | 176          |
| WPA3-SAE     | 72           | 99           | 152          | 176          |

**Mobile AP mode throughput - VHT Mode | 5 GHz Band | 80 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 80           | 86           | 211          | 189          |
| WPA2-AES     | 84           | 87           | 223          | 188          |
| WPA3-SAE     | 83           | 94           | 224          | 192          |

**Mobile AP mode throughput - HE Mode | 2.4 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 53           | 66           | 85           | 123          |
| WPA2-AES     | 52           | 65           | 83           | 122          |
| WPA3-SAE     | 52           | 65           | 83           | 120          |

**Mobile AP mode throughput - HE Mode | 2.4 GHz Band | 40 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 75           | 102          | 124          | 166          |
| WPA2-AES     | 74           | 100          | 121          | 148          |
| WPA3-SAE     | 73           | 101          | 121          | 154          |

**Mobile AP mode throughput - HE Mode | 5 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 54           | 68           | 84           | 124          |
| WPA2-AES     | 53           | 66           | 83           | 122          |
| WPA3-SAE     | 54           | 66           | 83           | 123          |

**Mobile AP mode throughput - HE Mode | 5 GHz Band | 40 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 76           | 107          | 155          | 193          |
| WPA2-AES     | 75           | 105          | 152          | 192          |
| WPA3-SAE     | 76           | 106          | 151          | 191          |

**Mobile AP mode throughput - HE Mode | 5 GHz Band | 80 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 86           | 118          | 220          | 187          |
| WPA2-AES     | 86           | 119          | 221          | 185          |
| WPA3-SAE     | 86           | 116          | 220          | 188          |

**Parent topic:**Wi-Fi throughput

**Parent topic:**[IW611/IW612 release notes](#)

**EU conformance tests**

- EU Adaptivity test - EN 300 328 v2.1.1 (for 2.4 GHz)
- EU Adaptivity test - EN 301 893 v2.1.1 (for 5 GHz)

**Parent topic:**[IW611/IW612 release notes](#)

**Bug fixes and/or feature enhancements****Firmware version: 18.99.2.p7.19**

| Component | Description |
|-----------|-------------|
| -         | NA          |

**Parent topic:**Bug fixes and/or feature enhancements

**Firmware version: 18.99.2.p7.19 to 18.99.2.p49.9**

| Component | Description |
|-----------|-------------|
| -         | NA          |

**Parent topic:**Bug fixes and/or feature enhancements



**Firmware version: 18.99.2.p49.9 to 18.99.2.p155**

| Component | Description                                                                                                                                                                   |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bluetooth | Audio lost occurs due to periodic adv sync lost, during 2 BIS 44.1kHz unencrypted streams with 1M PHY configuration.BIS sync loss may occur in long audio streaming sessions. |

**Parent topic:**Bug fixes and/or feature enhancements

**Firmware version: 18.99.2.p155 to 18.99.2.p66.30**

| Component | Description                                                                                                                                                                                                                                                                                                                 |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Wi-Fi     | 802.11R Fast BSS roaming works only with hostapd and does not work with standard APs (supporting 11R)                                                                                                                                                                                                                       |
| Bluetooth | DUT is not able to sustain a connection with the remote device that does extended advertisement with coded PHY configuration. When 2 CIS streams are active, after the first device disconnects followed by the second device disconnecting, the second peripheral device hangs.Audio Play/Pause does not work in BIS case. |

**Parent topic:**Bug fixes and/or feature enhancements

**Firmware version: 18.99.2.p66.30 to 18.99.3.p10.5**

| Component | Description                                                                                                                                                                                                                                                                                              |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Wi-Fi     | STAUT not sending Neighbor Advertisement packet after receiving Neighbor Solicitation packet from Ex-AP.Antenna selection time exceeds configured evaluation time                                                                                                                                        |
| Bluetooth | When DUT works as CIS source and CIS Offset is 612us, high packet drops observed which affects the audio streaming.For BIS Source Use Cases, Periodic Interval and ISO Interval should be multiple of each other value.In 1-CIS and 2-CIS, Continuous Audio Glitches are observed with 96 kbps bit rate. |

**Parent topic:**Bug fixes and/or feature enhancements

**Firmware version: 18.99.3.p10.5 to 18.99.3.p17.9**  
**{#firmware\_version\_18\_99\_3\_p10\_5\_to\_18\_99\_3\_p17\_9}**

| Component | Description                                                                                                                                                                                                                                                                                                                                                                                                     |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Wi-Fi     | After performing independent reset (out-of-band mode), the STAUT fails to connect to the external AP via wlan-connect command, observed command timeout 0x107 error.                                                                                                                                                                                                                                            |
| Bluetooth | Audio glitches observed with Google Pixel 7 Pro streaming audio after CIS is established with DUT.During Call Gateway (CG) / Call Terminal (CT) Use Case, the firmware periodically sends NULL PDU, which results in frequent Audio Glitch on both CG and CT sides.Heavy audio glitches observed with CIS SRC Google Pixel 7 ProContinuous audio glitches observed in 1 CIS and 2 CIS for 48_3 and 48_4 config. |

**Parent topic:**Bug fixes and/or feature enhancements

**Firmware version: 18.99.3.p17.9 to 18.99.3.p21.154**  
**{#firmware\_version\_18\_99\_3\_p17\_9\_to\_18\_99\_3\_p21\_154}**

| Component | Description                                                                                         |
|-----------|-----------------------------------------------------------------------------------------------------|
| Wi-Fi     | STAUT fail to ping AP backend machine when connected with DFS channel and DUTSTA went in bad state. |
| Bluetooth | CIS Sink frequently fails to acknowledge CIS Source TX PDU.                                         |

**Parent topic:**Bug fixes and/or feature enhancements

**Firmware version: 18.99.3.p21.154 to 18.99.3.p23.16**  
**{#firmware\_version\_18\_99\_3\_p21\_154\_to\_18\_99\_3\_p23\_16}**

| Component | Description |
|-----------|-------------|
| -         | NA          |

**Parent topic:**Bug fixes and/or feature enhancements

**Firmware version: 18.99.3.p23.16 to 18.99.3.p25.11**  
**{#firmware\_version\_18\_99\_3\_p23\_16\_to\_18\_99\_3\_p25\_11}**

| Component | Description                                                 |
|-----------|-------------------------------------------------------------|
| Bluetooth | Packet lost observed in CIS case, which causes audio noise. |

**Parent topic:**Bug fixes and/or feature enhancements

**Parent topic:**[IW611/IW612 release notes](#)

### Known issues

| Component | Description                                                                                                                                                                                                                                                                                                                                                                                                      |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bluetooth | Sequential Removal of CIS Handles as per current Controller implementation i.e CIS Disconnection sequence should be in sequence => CIS - 4,3,2,1While 4-CIS streaming, audio glitches observed on all CIS SINK with Samsung Galaxy budsWhile 4-CIS streaming, disconnection with connection timeout observed on first CIS SINK with Samsung Galaxy budsOnly two streams (CIS/BIS) with one channel is supported. |

**Parent topic:**[IW611/IW612 release notes](#)

**RW610/RW612 release notes**

### Package information

- SDK version: 25.06.00

**Parent topic:**[RW610/RW612 release notes](#)

### Version information

- Wi-Fi firmware version: 18.99.6.p40
  - rw61x\_sb\_wifi\_a2.bin for A2
  - 18 - Major revision
  - 99 - Feature pack
  - 6 - Release version
  - p40 - Patch number
- Bluetooth LE firmware version: 18.25.6.p40
  - rw61x\_sb\_ble\_a2.bin for A2
  - 18 - Major revision
  - 25 - Feature pack
  - 6 - Release version
  - p40 - Patch number
- 802.15.4 and Bluetooth LE (up to core 4.1) firmware version: 18.34.6.p40
  - rw61x\_sb\_ble\_15d4\_combo\_a2.bin for A2
  - 18 - Major revision
  - 34 - Feature pack
  - 6 - Release version
  - p40 - Patch number

**Parent topic:**[RW610/RW612 release notes](#)

### Host platform

- RW610/RW612 platform running FreeRTOS
- Test tools
  - iPerf (version 2.1.9)

**Parent topic:**[RW610/RW612 release notes](#)

**Wireless certification** The Wi-Fi and Bluetooth certification is obtained with the following combinations.

### WFA certifications

- STA | 802.11n
- STA | PMF
- STA | FFD
- STA | SVD
- STA | WPA3 SAE (R3)
- STA | 802.11ac
- STA | 802.11ax
- STA | QTT

Refer to 1.

**Note:** This release supports STAUT only certifications.

**Parent topic:** Wireless certification

**Bluetooth LE controller certification** QDID: Refer to 4.

**Parent topic:** Wireless certification

**Thread** Thread group: refer to 7.

Product Name: NXP RW612 Wireless MCU with Integrated Tri-Radio

Thread version: V1.3.0

CID #: 13A109

**Parent topic:** Wireless certification

**Matter** RW612 certification: refer to 8.

Certificate ID: CSA23C36MAT41746-24

Device type: Root Node, Thermostat

Transport: Matter over Wi-Fi

RW610 certification: refer to 9.

Certificate ID: CSA23C43MAT41753-50

Device type: Root Node, Thermostat

Transport: Matter over Wi-Fi and Matter over Thread

**Parent topic:** Wireless certification

**Parent topic:** [RW610/RW612 release notes](#)

## Wi-Fi throughput

### Throughput test setup

- Environment: Shield Room - Over the Air
- Access Point: Asus AX88u
- DUT: RW610/RW612
- External Client: Intel AX210
- Channel: 6 | 36
- Wi-Fi application: wifi\_cli
- Compiler used to build application: armgcc
- Compiler version gcc-arm-none-eabi-13.2
- iPerf commands used in test:

TCP TX

```
iperf -c <remote_ip> -t 60
```

TCP RX

```
iperf -s
```

#### UDP TX

```
iperf -c <remote_ip> -t 60 -u -B <local_ip> -b 120
```

**Note:** The default rate is 100 Mbps.

#### UDP RX

```
iperf -s -u -B <local_ip>
```

**Note:** Read more about the throughput test setup and topology in 3.

**Parent topic:** Wi-Fi throughput

### STA throughput External AP: Asus AX88u

#### STA mode throughput - BGN Mode | 2.4 GHz Band | 20 MHz

| Protocol     | TCP (Mbit/s) |    | UDP (Mbit/s) |    |
|--------------|--------------|----|--------------|----|
| Direction    | TX           | RX | TX           | RX |
| OpenSecurity | 38           | 38 | 62           | 62 |
| WPA2-AES     | 37           | 37 | 61           | 63 |
| WPA3-SAE     | 37           | 37 | 60           | 61 |

#### STA mode throughput - AN Mode | 5 GHz Band | 20 MHz

| Protocol     | TCP (Mbit/s) |    | UDP (Mbit/s) |    |
|--------------|--------------|----|--------------|----|
| Direction    | TX           | RX | TX           | RX |
| OpenSecurity | 39           | 39 | 64           | 64 |
| WPA2-AES     | 37           | 38 | 62           | 64 |
| WPA3-SAE     | 39           | 38 | 62           | 64 |

#### STA mode throughput - VHT Mode | 2.4 GHz Band | 20 MHz (HT)

| Protocol     | TCP (Mbit/s) |    | UDP (Mbit/s) |    |
|--------------|--------------|----|--------------|----|
| Direction    | TX           | RX | TX           | RX |
| OpenSecurity | 41           | 41 | 75           | 74 |
| WPA2-AES     | 41           | 41 | 73           | 74 |
| WPA3-SAE     | 40           | 41 | 72           | 73 |

#### STA mode throughput - VHT Mode | 5 GHz Band | 20 MHz

| Protocol     | TCP (Mbit/s) |    | UDP (Mbit/s) |    |
|--------------|--------------|----|--------------|----|
| Direction    | TX           | RX | TX           | RX |
| OpenSecurity | 42           | 42 | 76           | 76 |
| WPA2-AES     | 42           | 41 | 75           | 75 |
| WPA3-SAE     | 42           | 41 | 75           | 74 |

#### STA mode throughput - HE Mode | 2.4 GHz Band | 20 MHz

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 44           | 45           | 97           | 99           |
| WPA2-AES     | 43           | 44           | 96           | 98           |
| WPA3-SAE     | 42           | 44           | 97           | 98           |

**STA mode throughput - HE Mode | 5 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 47           | 47           | 100          | 103          |
| WPA2-AES     | 45           | 46           | 100          | 101          |
| WPA3-SAE     | 47           | 46           | 100          | 101          |

**Parent topic:**Wi-Fi throughput

**Mobile AP throughput** External client: Apple MacBook Air**Mobile AP throughput - BGN Mode | 2.4 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 39           | 39           | 62           | 62           |
| WPA2-AES     | 39           | 39           | 61           | 61           |
| WPA3-SAE     | 38           | 39           | 61           | 61           |

**Mobile AP throughput - AN Mode | 5 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 40           | 40           | 63           | 63           |
| WPA2-AES     | 39           | 39           | 62           | 61           |
| WPA3-SAE     | 39           | 39           | 62           | 61           |

**Mobile AP throughput - VHT Mode | 2.4 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 43           | 43           | 73           | 73           |
| WPA2-AES     | 43           | 42           | 72           | 72           |
| WPA3-SAE     | 43           | 42           | 73           | 72           |

**Mobile AP throughput - VHT Mode | 5 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 44           | 44           | 74           | 74           |
| WPA2-AES     | 43           | 43           | 74           | 74           |
| WPA3-SAE     | 43           | 43           | 74           | 74           |

**Mobile AP throughput - HE Mode | 2.4 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 48           | 48           | 95           | 96           |
| WPA2-AES     | 47           | 47           | 98           | 95           |
| WPA3-SAE     | 47           | 47           | 97           | 95           |

**Mobile AP throughput - HE Mode | 5 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 49           | 49           | 96           | 97           |
| WPA2-AES     | 48           | 48           | 101          | 97           |
| WPA3-SAE     | 48           | 48           | 101          | 97           |

**Parent topic:**Wi-Fi throughput**Parent topic:**[RW610/RW612 release notes](#)**Bug fixes and/or feature enhancements**

**Firmware version: 18.99.6.p34 to 18.99.6.p40**  
**{#firmware\_version\_18\_99\_6\_p34\_to\_18\_99\_6\_p40}**

| Com-<br>ponent | Description                                                                                                                    |
|----------------|--------------------------------------------------------------------------------------------------------------------------------|
| Zigbee         | Zigbee Coordinator and Router are disconnected during BLE connection pairing and bonding with a mobile app for the first time. |

**Parent topic:**Bug fixes and/or feature enhancements**Parent topic:**[RW610/RW612 release notes](#)**Known issues**

| Component    | Description |
|--------------|-------------|
| Wi-Fi        | —           |
| Bluetooth LE | —           |
| Zigbee       | -           |

**Parent topic:**[RW610/RW612 release notes](#)**IW610 release notes****Package information**

- SDK version: 25.06.00

**Parent topic:**[IW610 release notes](#)

### Version information

- Wireless SoC: IW610
- Wi-Fi and Bluetooth/Bluetooth LE firmware version: 18.99.5.p66
  - 18 - Major revision
  - 99 - Feature pack
  - 5 - Release version
  - p66 - Patch number

**Parent topic:**[IW610 release notes](#)

### Host platform

- IW610 platform running FreeRTOS
- Test tools
  - iPerf (version 2.1.9)

**Parent topic:**[IW610 release notes](#)

**Wi-Fi and Bluetooth certification** The Wi-Fi and Bluetooth certification is obtained with the following combinations.

### WFA certifications

- STA | 802.11n
- STA | PMF
- STA | FFD
- STA | SVD
- STA | WPA3 SAE (R3)
- STA | 802.11ac
- STA | 802.11ax
- STA | QTT

Refer to 6.

**Note:** This release supports STAUT only certifications.

**Parent topic:**Wi-Fi and Bluetooth certification

**Bluetooth controller certification** QDID: Refer to 4.

**Note:** QDID upgrade to Bluetooth Core Specification Version 5.4 is in progress.

**Parent topic:**Wi-Fi and Bluetooth certification

**Parent topic:**[IW610 release notes](#)

### Wi-Fi throughput



### Throughput test setup

- Environment: Shield Room - Over the Air
- Access Point: Asus AX88u
- DUT: IW610
- External Client: Intel AX210
- Channel: 6 | 36
- Wi-Fi application: wifi\_cli
- Compiler used to build application: armgcc
- Compiler version gcc-arm-none-eabi-13.2
- iPerf commands used in test:

#### TCP TX

```
iperf -c <remote_ip> -t 60
```

#### TCP RX

```
iperf -s
```

#### UDP TX

```
iperf -c <remote_ip> -t 60 -u -B <local_ip> -b 120
```

**Note:** The default rate is 100 Mbps.

#### UDP RX

```
iperf -s -u -B <local_ip>
```

**Note:** Read more about the throughput test setup and topology in 3.

**Parent topic:** Wi-Fi throughput

### STA throughput External AP: Asus AX88u

#### STA mode throughput - BGN Mode | 2.4 GHz Band | 20 MHz

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 40           | 42           | 63           | 61           |
| WPA2-AES     | 40           | 47           | 60           | 62           |
| WPA3-SAE     | 40           | 39           | 60           | 62           |

#### STA mode throughput - AN Mode | 5 GHz Band | 20 MHz

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 42           | 49           | 64           | 64           |
| WPA2-AES     | 41           | 48           | 62           | 63           |
| WPA3-SAE     | 41           | 48           | 62           | 63           |

#### STA mode throughput - VHT Mode | 2.4 GHz Band | 20 MHz (HT)

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 45           | 54           | 75           | 74           |
| WPA2-AES     | 45           | 53           | 73           | 73           |
| WPA3-SAE     | 44           | 53           | 73           | 72           |

**STA mode throughput - VHT Mode | 5 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 46           | 48           | 77           | 70           |
| WPA2-AES     | 45           | 47           | 74           | 68           |
| WPA3-SAE     | 46           | 47           | 74           | 68           |

**STA mode throughput - HE Mode | 2.4 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 51           | 62           | 98           | 98           |
| WPA2-AES     | 50           | 60           | 96           | 91           |
| WPA3-SAE     | 51           | 60           | 96           | 91           |

**STA mode throughput - HE Mode | 5 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 53           | 60           | 101          | 94           |
| WPA2-AES     | 53           | 58           | 99           | 93           |
| WPA3-SAE     | 52           | 58           | 99           | 93           |

**Parent topic:**Wi-Fi throughput

**Mobile AP throughput** External client: Apple MacBook Air

**Mobile AP throughput - BGN Mode | 2.4 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 39           | 39           | 63           | 62           |
| WPA2-AES     | 39           | 38           | 60           | 60           |
| WPA3-SAE     | 39           | 38           | 60           | 60           |

**Mobile AP throughput - AN Mode | 5 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 40           | 39           | 64           | 62           |
| WPA2-AES     | 39           | 39           | 61           | 61           |
| WPA3-SAE     | 39           | 38           | 61           | 61           |

**Mobile AP throughput - VHT Mode | 2.4 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 43           | 43           | 74           | 73           |
| WPA2-AES     | 42           | 42           | 73           | 71           |
| WPA3-SAE     | 42           | 42           | 74           | 72           |

**Mobile AP throughput - VHT Mode | 5 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 43           | 43           | 75           | 73           |
| WPA2-AES     | 43           | 42           | 74           | 72           |
| WPA3-SAE     | 43           | 43           | 74           | 72           |

**Mobile AP throughput - HE Mode | 2.4 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 46           | 46           | 95           | 94           |
| WPA2-AES     | 45           | 45           | 96           | 91           |
| WPA3-SAE     | 45           | 45           | 96           | 91           |

**Mobile AP throughput - HE Mode | 5 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 47           | 47           | 96           | 94           |
| WPA2-AES     | 46           | 46           | 98           | 91           |
| WPA3-SAE     | 46           | 46           | 99           | 91           |

**Parent topic:**Wi-Fi throughput**Parent topic:**[IW610 release notes](#)**Known issues**

| Component    | Description |
|--------------|-------------|
| Wi-Fi        | —           |
| Bluetooth LE | —           |

**Parent topic:**[IW610 release notes](#)**AW611 release notes** **Note:** The AW611 support is enabled in i.MX RT1180 EVKA.**Package information**

- SDK version: 25.06.00

**Parent topic:**[AW611 release notes](#)

### Version information

- Wireless SoC: AW611
- Wi-Fi and Bluetooth/Bluetooth LE firmware version: 18.99.3.p25.11
  - 18 - Major revision
  - 99 - Feature pack
  - 3 - Release version
  - p25.11 - Patch number

**Parent topic:**[AW611 release notes](#)

### Host platform

- i.MX RT1180 EVKA Platform running FreeRTOS
- Host interfaces
  - Wi-Fi over SDIO (SDIO 2.0 Support, SDIO clock frequency: 50 MHz)
  - Bluetooth/Bluetooth LE over UART
- Test tools
  - iPerf (version 2.1.9)

**Parent topic:**[AW611 release notes](#)

**Wi-Fi and Bluetooth certification** The Wi-Fi and Bluetooth certification is obtained with the following combinations.

### WFA certifications

- STA | 802.11n
- STA | PMF
- STA | FFD
- STA | SVD
- STA | WPA3 SAE (R3)
- STA | 802.11ac
- STA | 802.11ax
- STA | QTT

Refer to 6.

**Note:** This release supports STAUT only certifications.

**Parent topic:**Wi-Fi and Bluetooth certification

**Bluetooth controller certification** QDID: Refer to 4.

**Note:** QDID upgrade to Bluetooth Core Specification Version 5.4 is in progress.

**Parent topic:**Wi-Fi and Bluetooth certification

**Parent topic:**[AW611 release notes](#)

## Wi-Fi throughput

### Throughput test setup

- Environment: Shield Room - Over the Air
- Access Point: Asus AX88u
- DUT: AW611 uBlox (Module: U-BLOX\_Jody\_W5 M.2) with EVK-MIMXRT1180 EVKA platform
- DUT Power Source: External power supply
- Client: Apple MacBook Air
- Channel: 6 | 36
- Wi-Fi application: wifi\_wpa\_supplicant
- Compiler used to build application: armgcc
- Compiler Version: gcc-arm-none-eabi-13.2
- iPerf commands used in test:

#### TCP TX

```
iperf -c <remote_ip> -t 60
```

#### TCP RX

```
iperf -s
```

#### UDP TX

```
iperf -c <remote_ip> -t 60 -u -B <local_ip> -b 120
```

**Note:** The default rate is 100 Mbps.

#### UDP RX

```
iperf -s -u -B <local_ip>
```

**Note:** Read more about the throughput test setup and topology in 2.

The throughput numbers are captured with default configurations using *wifi\_wpa\_supplicant* sample application.

**Parent topic:**Wi-Fi throughput

### STA throughput External AP: Asus AX88u

#### STA mode throughput - BGN Mode | 2.4 GHz Band | 20 MHz

| Protocol     | TCP (Mbit/s) |    | UDP (Mbit/s) |    |
|--------------|--------------|----|--------------|----|
| Direction    | TX           | RX | TX           | RX |
| OpenSecurity | 43           | 47 | 45           | 60 |
| WPA2-AES     | 43           | 46 | 48           | 59 |
| WPA3-SAE     | 47           | 49 | 63           | 63 |

#### STA mode throughput - BGN Mode | 2.4 GHz Band | 40 MHz

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 68           | 82           | 131          | 131          |
| WPA2-AES     | 72           | 82           | 130          | 129          |
| WPA3-SAE     | 68           | 81           | 129          | 130          |

**STA mode throughput - AN Mode | 5 GHz Band | 20 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 45           | 51           | 63           | 65           |
| WPA2-AES     | 45           | 51           | 63           | 65           |
| WPA3-SAE     | 45           | 51           | 63           | 65           |

**STA mode throughput - AN Mode | 5 GHz Band | 40 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 67           | 83           | 129          | 134          |
| WPA2-AES     | 66           | 83           | 129          | 133          |
| WPA3-SAE     | 65           | 83           | 129          | 133          |

**STA mode throughput - VHT Mode | 2.4 GHz Band | 20 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 49           | 53           | 72           | 71           |
| WPA2-AES     | 48           | 52           | 73           | 70           |
| WPA3-SAE     | 52           | 56           | 75           | 75           |

**STA mode throughput - VHT Mode | 2.4 GHz Band | 40 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 74           | 88           | 172          | 172          |
| WPA2-AES     | 75           | 92           | 171          | 169          |
| WPA3-SAE     | 77           | 92           | 172          | 171          |

**STA mode throughput - VHT Mode | 5 GHz Band | 20 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 50           | 58           | 76           | 78           |
| WPA2-AES     | 49           | 57           | 76           | 77           |
| WPA3-SAE     | 49           | 57           | 76           | 77           |

**STA mode throughput - VHT Mode | 5 GHz Band | 40 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 74           | 93           | 175          | 177          |
| WPA2-AES     | 74           | 93           | 174          | 174          |
| WPA3-SAE     | 73           | 93           | 173          | 175          |

**STA mode throughput - VHT Mode | 5 GHz Band | 80 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 88           | 94           | 221          | 196          |
| WPA2-AES     | 87           | 95           | 219          | 194          |
| WPA3-SAE     | 89           | 95           | 219          | 195          |

**STA mode throughput - HE Mode | 2.4 GHz Band | 20 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 60           | 60           | 98           | 115          |
| WPA2-AES     | 62           | 61           | 94           | 113          |
| WPA3-SAE     | 61           | 59           | 97           | 108          |

**STA mode throughput - HE Mode | 2.4 GHz Band | 40 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 77           | 71           | 215          | 190          |
| WPA2-AES     | 77           | 72           | 212          | 187          |
| WPA3-SAE     | 76           | 72           | 152          | 189          |

**STA mode throughput - HE Mode | 5 GHz Band | 20 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 63           | 65           | 127          | 128          |
| WPA2-AES     | 63           | 67           | 125          | 128          |
| WPA3-SAE     | 63           | 67           | 125          | 126          |

**STA mode throughput - HE Mode | 5 GHz Band | 40 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 79           | 64           | 212          | 199          |
| WPA2-AES     | 78           | 68           | 218          | 199          |
| WPA3-SAE     | 79           | 68           | 217          | 198          |

**STA mode throughput - HE Mode | 5 GHz Band | 80 MHz (HT)**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 88           | 70           | 219          | 192          |
| WPA2-AES     | 87           | 72           | 219          | 193          |
| WPA3-SAE     | 91           | 72           | 220          | 194          |

**Parent topic:**Wi-Fi throughput

**Mobile AP throughput** External client: Apple MacBook Air

**Mobile AP mode throughput - BGN Mode | 2.4 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 40           | 52           | 61           | 62           |
| WPA2-AES     | 40           | 51           | 61           | 62           |
| WPA3-SAE     | 40           | 51           | 61           | 62           |

**Mobile AP mode throughput - BGN Mode | 2.4 GHz Band | 40 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 63           | 83           | 116          | 130          |
| WPA2-AES     | 67           | 82           | 115          | 131          |
| WPA3-SAE     | 60           | 81           | 115          | 132          |

**Mobile AP mode throughput - AN Mode | 5 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 39           | 49           | 60           | 62           |
| WPA2-AES     | 39           | 49           | 60           | 62           |
| WPA3-SAE     | 41           | 51           | 63           | 62           |

**Mobile AP mode throughput - AN Mode | 5 GHz Band | 40 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 66           | 89           | 128          | 133          |
| WPA2-AES     | 64           | 87           | 128          | 133          |
| WPA3-SAE     | 62           | 86           | 128          | 133          |

**Mobile AP mode throughput - VHT Mode | 2.4 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 44           | 60           | 74           | 75           |
| WPA2-AES     | 43           | 59           | 74           | 75           |
| WPA3-SAE     | 43           | 59           | 74           | 75           |



**Mobile AP mode throughput - VHT Mode | 2.4 GHz Band | 40 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 64           | 53           | 112          | 75           |
| WPA2-AES     | 65           | 51           | 111          | 75           |
| WPA3-SAE     | 62           | 51           | 112          | 75           |

**Mobile AP mode throughput - VHT Mode | 5 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 45           | 60           | 76           | 76           |
| WPA2-AES     | 44           | 59           | 76           | 76           |
| WPA3-SAE     | 44           | 59           | 76           | 76           |

**Mobile AP mode throughput - VHT Mode | 5 GHz Band | 40 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 73           | 100          | 155          | 178          |
| WPA2-AES     | 72           | 99           | 152          | 176          |
| WPA3-SAE     | 72           | 99           | 152          | 176          |

**Mobile AP mode throughput - VHT Mode | 5 GHz Band | 80 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 80           | 86           | 211          | 189          |
| WPA2-AES     | 84           | 87           | 223          | 188          |
| WPA3-SAE     | 83           | 94           | 224          | 192          |

**Mobile AP mode throughput - HE Mode | 2.4 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 53           | 66           | 85           | 123          |
| WPA2-AES     | 52           | 65           | 83           | 122          |
| WPA3-SAE     | 52           | 65           | 83           | 120          |

**Mobile AP mode throughput - HE Mode | 2.4 GHz Band | 40 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 75           | 102          | 124          | 166          |
| WPA2-AES     | 74           | 100          | 121          | 148          |
| WPA3-SAE     | 73           | 101          | 121          | 154          |

**Mobile AP mode throughput - HE Mode | 5 GHz Band | 20 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 54           | 68           | 84           | 124          |
| WPA2-AES     | 53           | 66           | 83           | 122          |
| WPA3-SAE     | 54           | 66           | 83           | 123          |

**Mobile AP mode throughput - HE Mode | 5 GHz Band | 40 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 76           | 107          | 155          | 193          |
| WPA2-AES     | 75           | 105          | 152          | 192          |
| WPA3-SAE     | 76           | 106          | 151          | 191          |

**Mobile AP mode throughput - HE Mode | 5 GHz Band | 80 MHz**

| Protocol     | TCP (Mbit/s) | TCP (Mbit/s) | UDP (Mbit/s) | UDP (Mbit/s) |
|--------------|--------------|--------------|--------------|--------------|
| Direction    | TX           | RX           | TX           | RX           |
| OpenSecurity | 86           | 118          | 220          | 187          |
| WPA2-AES     | 86           | 119          | 221          | 185          |
| WPA3-SAE     | 86           | 116          | 220          | 188          |

**Parent topic:**Wi-Fi throughput**Parent topic:**[AW611 release notes](#)**EU conformance tests**

- EU Adaptivity test - EN 300 328 v2.1.1 (for 2.4 GHz)
- EU Adaptivity test - EN 301 893 v2.1.1 (for 5 GHz)

**Parent topic:**[AW611 release notes](#)**Bug fixes and/or feature enhancements {#bug\_fixes\_and\_or\_feature\_enhancements\_04}**

**Firmware version: 18.99.3.p10.5 to 18.99.3.p17.9**  
**{#firmware\_version\_18\_99\_3\_p10\_5\_to\_18\_99\_3\_p17\_9\_0}**

| Com po-<br>nent | Description                                                                                                                                                                                                                                                                                                                                                                                                     |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Wi-Fi           | After performing independent reset (out-of-band mode), the STAUT fails to connect to the external AP via wlan-connect command, observed command timeout 0x107 error.                                                                                                                                                                                                                                            |
| Blue tooth      | Audio glitches observed with Google Pixel 7 Pro streaming audio after CIS is established with DUT.During Call Gateway (CG) / Call Terminal (CT) Use Case, the firmware periodically sends NULL PDU, which results in frequent Audio Glitch on both CG and CT sides.Heavy audio glitches observed with CIS SRC Google Pixel 7 ProContinuous audio glitches observed in 1 CIS and 2 CIS for 48_3 and 48_4 config. |

**Parent topic:**Bug fixes and/or feature enhancements

**Firmware version: 18.99.3.p17.9 to 18.99.3.p21.154**  
**{#firmware\_version\_18\_99\_3\_p17\_9\_to\_18\_99\_3\_p21\_154\_0}**

| Component  | Description                                                                                         |
|------------|-----------------------------------------------------------------------------------------------------|
| Wi-Fi      | STAUT fail to ping AP backend machine when connected with DFS channel and DUTSTA went in bad state. |
| Blue-tooth | CIS Sink frequently fails to acknowledge CIS Source TX PDU.                                         |

**Parent topic:**Bug fixes and/or feature enhancements

**Parent topic:**[AW611 release notes](#)

### Known issues

| Component  | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Blue tooth | Packet lost would be observed in CIS case which causes audio noise.Sequential Removal of CIS Handles as per current Controller implementation i.e CIS Disconnection sequence should be in sequence => CIS - 4,3,2,1While 4-CIS streaming, audio glitches observed on all CIS SINK with Samsung Galaxy budsWhile 4-CIS streaming, disconnection with connection timeout observed on first CIS SINK with Samsung Galaxy budsOnly two streams (CIS/BIS) with one channel is supported. |

**Parent topic:**[AW611 release notes](#)

### Abbreviations

| Abbreviation | Definition                          |
|--------------|-------------------------------------|
| A2DP         | Advanced audio distribution profile |
| AMPDU        | Aggregated MAC protocol data unit   |
| AMSDU        | Aggregated MAC service data unit    |
| AP           | Access point                        |
| BW           | Bandwidth                           |
| CCMP         | Counter mode CBC-MAC protocol       |
| CSI          | Channel state information           |
| CTS          | Clear To Send                       |
| DL           | Down link                           |
| EDCA         | Enhanced distributed channel access |
| ER           | Extended range                      |
| ERP          | Extended rate physical              |
| GATT         | Generic attribute profile           |
| HFP          | Hands free profile                  |
| HID          | Human interface device              |
| HT           | High throughput                     |
| LDPC         | Low density parity check            |
| MCS          | Modulation and coding scheme        |
| MLME         | Mac layer management entity         |
| OMI          | Operating mode indication           |
| PMF          | Protected management frames         |
| RTS          | Request to send                     |

continues on next page

Table 4 – continued from previous page

| Abbreviation | Definition                            |
|--------------|---------------------------------------|
| SAE          | Simultaneous authentication of equals |
| STA          | Station                               |
| TWT          | Target wake time                      |
| UL           | Up link                               |
| VHT          | Very high throughput                  |
| WEP          | Wired equivalent private              |
| WFD          | Wi-Fi direct                          |
| WMM          | Wireless multi-media                  |
| WPA          | Wi-Fi protected access                |
| WPS          | Wi-Fi protected setup                 |
| WSC          | Wi-Fi Simple Configuration            |

## References

1. Application note - AN13681 – Wi-Fi Alliance (WFA) Derivative Certification Process (available in the SDK package)
2. User manual – UM11442 - NXP Wi-Fi and Bluetooth Demo Applications User Guide for i.MX RT Platforms (available in the SDK package)
3. User manual – UM11799 - NXP Wi-Fi and Bluetooth Demo Applications User Guide for RW61x (available in the SDK package)
4. Certification – Bluetooth controller - QDID ([link](#))
5. User manual - UM12133 - NXP NCP Application Guide for RW612 with MCU Host
6. Technical note - TN00066 – Wi-Fi Alliance (WFA) Derivative Certification Process (available in the SDK package)
7. Web page – Thread certified products ([link](#))
8. Web page – Connectivity standard alliance (csa) – NXP RW612 Tri-Radio Wireless MCU Development Platform ([link](#))
9. Web page – Connectivity standard alliance (csa) – NXP RW610 Wireless MCU Development Platform ([link](#))

# Chapter 4

## RTOS

### 4.1 FreeRTOS

#### 4.1.1 FreeRTOS kernel

Open source RTOS kernel for small devices.

**FreeRTOS kernel for MCUXpresso SDK Readme**

**FreeRTOS kernel for MCUXpresso SDK**

**Overview** The purpose of this document is to describes the [FreeRTOS kernel repo](#) integration into the [NXP MCUXpresso Software Development Kit: mcuxsdk](#). MCUXpresso SDK provides a comprehensive development solutions designed to optimize, ease, and help accelerate embedded system development of applications based on MCUs from NXP. This project involves the FreeRTOS kernel repo fork with:

- cmake and Kconfig support to allow the configuration and build in MCUXpresso SDK ecosystem
- FreeRTOS OS additions, such as [FreeRTOS driver wrappers](#), RTOS ready FatFs file system, and the implementation of FreeRTOS tickless mode

The history of changes in FreeRTOS kernel repo for MCUXpresso SDK are summarized in [CHANGELOG\\_mcuxsdk.md](#) file.

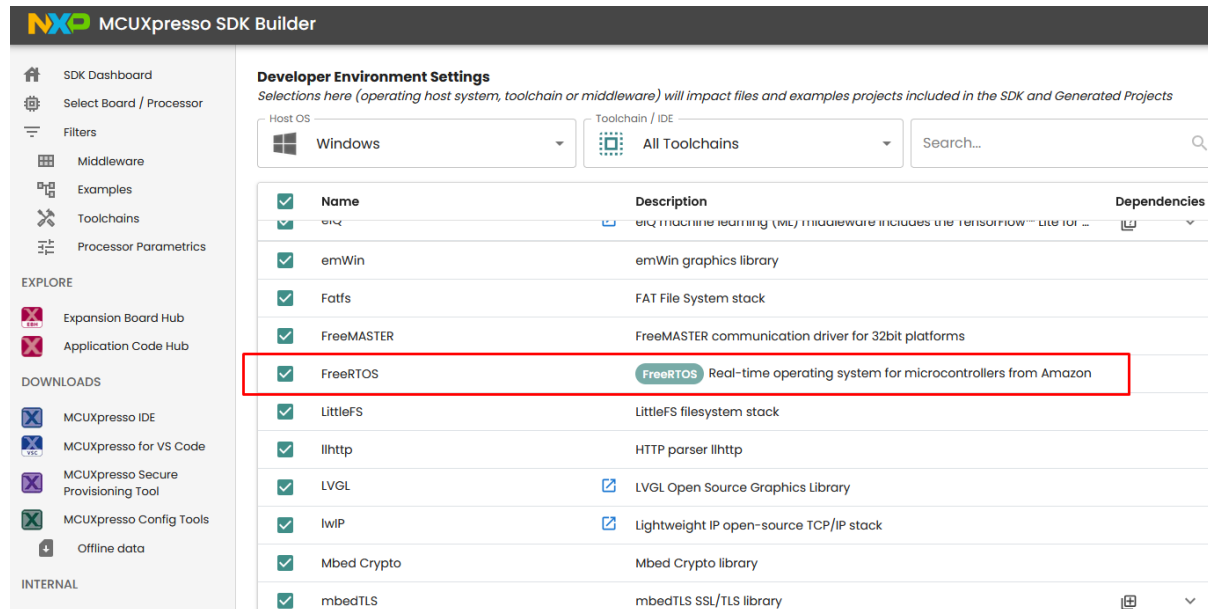
The MCUXpresso SDK framework also contains a set of FreeRTOS examples which show basic FreeRTOS OS features. This makes it easy to start a new FreeRTOS project or begin experimenting with FreeRTOS OS. Selected drivers and middleware are RTOS ready with related FreeRTOS adaptation layer.

**FreeRTOS example applications** The FreeRTOS examples are written to demonstrate basic FreeRTOS features and the interaction between peripheral drivers and the RTOS.

**List of examples** The list of freertos\_examples, their description and availability for individual supported MCUXpresso SDK development boards can be obtained here: [https://mcuxpresso.nxp.com/mcuxsdk/latest/html/examples/freertos\\_examples/index.html](https://mcuxpresso.nxp.com/mcuxsdk/latest/html/examples/freertos_examples/index.html)

**Location of examples** The FreeRTOS examples are located in [mcuxsdk-examples](#) repository, see the `freertos_examples` folder.

Once using MCUXpresso SDK zip packages created via the [MCUXpresso SDK Builder](#) the FreeRTOS kernel library and associated `freertos_examples` are added into final zip package once FreeRTOS components is selected on the Developer Environment Settings page:



The FreeRTOS examples in MCUXpresso SDK zip packages are located in `<MCUXpressoSDK_install_dir>/boards/<board_name>/freertos_examples/` subfolders.

**Building a FreeRTOS example application** For information how to use the cmake and Kconfig based build and configuration system and how to build `freertos_examples` visit: [MCUXpresso SDK documentation for Build And Configuration MCUXpresso SDK Getting Start Guide](#)

Tip: To list all FreeRTOS example projects and targets that can be built via the west build command, use this `west list_project` command in `mcuxsdk` workspace:

```
west list_project -p examples/freertos_examples
```

**FreeRTOS aware debugger plugin** NXP provides FreeRTOS task aware debugger for GDB. The plugin is compatible with Eclipse-based (MCUXpressoIDE) and is available after the installation.

| Task List (FreeRTOS) |           |             |            |          |              |                          |               |
|----------------------|-----------|-------------|------------|----------|--------------|--------------------------|---------------|
| TCB#                 | Task Name | Task Handle | Task State | Priority | Stack Usage  | Event Object             | Runtime       |
| 1                    | task_one  | 0x1fffecc8  | Blocked    | 1 (1)    | 0 B / 880 B  | MyCountingSemaphore (Rx) | 0x0 (0.0%)    |
| 2                    | task_two  | 0x1ffff130  | Blocked    | 2 (2)    | 0 B / 888 B  | MyCountingSemaphore (Rx) | 0x1 (0.1%)    |
| 3                    | IDLE      | 0x1ffff330  | Running    | 0 (0)    | 0 B / 296 B  |                          | 0x3e5 (99.6%) |
| 4                    | Tmr Svc   | 0x1ffff6b8  | Blocked    | 17 (17)  | 28 B / 672 B | TmrQ (Rx)                | 0x3 (0.3%)    |

## FreeRTOS kernel for MCUXpresso SDK ChangeLog

**Changelog FreeRTOS kernel for MCUXpresso SDK** All notable changes to this project will be documented in this file.

The format is based on [Keep a Changelog](#), and this project adheres to [Semantic Versioning](#).

**[Unreleased]****Added**

- Kconfig added CONFIG\_FREERTOS\_USE\_CUSTOM\_CONFIG\_FRAGMENT config to optionally include custom FreeRTOSConfig fragment include file FreeRTOSConfig\_frag.h. File must be provided by application.
- Added missing Kconfig option for configUSE\_PICOLIBC\_TLS.
- Add correct header files to build when configUSE\_NEWLIB\_REENTRANT and configUSE\_PICOLIBC\_TLS is selected in config.

**[11.1.0\_rev0]**

- update amazon freertos version

**[11.0.1\_rev0]**

- update amazon freertos version

**[10.5.1\_rev0]**

- update amazon freertos version

**[10.4.3\_rev1]**

- Apply CM33 security fix from 10.4.3-LTS-Patch-2. See rtos\freertos\freertos\_kernel\History.txt
- Apply CM33 security fix from 10.4.3-LTS-Patch-1. See rtos\freertos\freertos\_kernel\History.txt

**[10.4.3\_rev0]**

- update amazon freertos version.

**[10.4.3\_rev0]**

- update amazon freertos version.

**[9.0.0\_rev3]**

- New features:
  - Tickless idle mode support for Cortex-A7. Add fsl\_tickless\_epit.c and fsl\_tickless\_generic.h in portable/IAR/ARM\_CA9 folder.
  - Enabled float context saving in IAR for Cortex-A7. Added configUSE\_TASK\_FPU\_SUPPORT macros. Modified port.c and portmacro.h in portable/IAR/ARM\_CA9 folder.
- Other changes:
  - Transformed ARM\_CM core specific tickless low power support into generic form under freertos/Source/portable/low\_power\_tickless/.

### [9.0.0\_rev2]

- New features:
  - Enabled MCUXpresso thread aware debugging. Add `freertos_tasks_c_additions.h` and `configINCLUDE_FREERTOS_TASK_C_ADDITIONS_H` and `configFREERTOS_MEMORY_SCHEME` macros.

### [9.0.0\_rev1]

- New features:
  - Enabled `-flto` optimization in GCC by adding `attribute((used))` for `vTaskSwitchContext`.
  - Enabled KDS Task Aware Debugger. Apply FreeRTOS patch to enable `configRECORD_STACK_HIGH_ADDRESS` macro. Modified files are `task.c` and `FreeRTOS.h`.

### [9.0.0\_rev0]

- New features:
  - Example `freertos_sem_static`.
  - Static allocation support RTOS driver wrappers.
- Other changes:
  - Tickless idle rework. Support for different timers is in separated files (`fsl_tickless_systick.c`, `fsl_tickless_lptmr.c`).
  - Removed configuration option `configSYSTICK_USE_LOW_POWER_TIMER`. Low power timer is now selected by linking of appropriate file `fsl_tickless_lptmr.c`.
  - Removed `configOVERRIDE_DEFAULT_TICK_CONFIGURATION` in RVDS port. Use of `attribute((weak))` is the preferred solution. Not same as `_weak`!

### [8.2.3]

- New features:
  - Tickless idle mode support.
  - Added template application for Kinetis Expert (KEx) tool (`template_application`).
- Other changes:
  - Folder structure reduction. Keep only Kinetis related parts.

## FreeRTOS kernel Readme

**MCUXpresso SDK: FreeRTOS kernel** This repository is a fork of FreeRTOS kernel (<https://github.com/FreeRTOS/FreeRTOS-Kernel>)(11.1.0). Modifications have been made to adapt to NXP MCUXpresso SDK. `CMakeLists.txt` and `Kconfig` added to enable FreeRTOS kernel repo sources build in MCUXpresso SDK. It is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository `mcuxsdk-manifests`(<https://github.com/nxp-mcuxpresso/mcuxsdk-manifests>) for the complete delivery of MCUXpresso SDK.

For more information about the FreeRTOS kernel repo adoption see [README\\_mcuxsdk.md: FreeRTOS kernel for MCUXpresso SDK](#) document.





**Getting started** This repository contains FreeRTOS kernel source/header files and kernel ports only. This repository is referenced as a submodule in [FreeRTOS/FreeRTOS](#) repository, which contains pre-configured demo application projects under [FreeRTOS/Demo](#) directory.

The easiest way to use FreeRTOS is to start with one of the pre-configured demo application projects. That way you will have the correct FreeRTOS source files included, and the correct include paths configured. Once a demo application is building and executing you can remove the demo application files, and start to add in your own application source files. See the [FreeRTOS Kernel Quick Start Guide](#) for detailed instructions and other useful links.

Additionally, for FreeRTOS kernel feature information refer to the [Developer Documentation](#), and [API Reference](#).

Also for contributing and creating a Pull Request please refer to *the instructions here*.

**Getting help** If you have any questions or need assistance troubleshooting your FreeRTOS project, we have an active community that can help on the [FreeRTOS Community Support Forum](#).

## To consume FreeRTOS-Kernel

**Consume with CMake** If using CMake, it is recommended to use this repository using FetchContent. Add the following into your project's main or a subdirectory's CMakeLists.txt:

- Define the source and version/tag you want to use:

```
FetchContent_Declare(freertos_kernel
 GIT_REPOSITORY https://github.com/FreeRTOS/FreeRTOS-Kernel.git
 GIT_TAG main #Note: Best practice to use specific git-hash or tagged version
)
```

In case you prefer to add it as a git submodule, do:

```
git submodule add https://github.com/FreeRTOS/FreeRTOS-Kernel.git <path of the submodule>
git submodule update --init
```

- Add a freertos\_config library (typically an INTERFACE library) The following assumes the directory structure:

– include/FreeRTOSConfig.h

```
add_library(freertos_config INTERFACE)

target_include_directories(freertos_config SYSTEM
 INTERFACE
 include
)

target_compile_definitions(freertos_config
 INTERFACE
 projCOVERAGE_TEST=0
)
```

In case you installed FreeRTOS-Kernel as a submodule, you will have to add it as a subdirectory:

```
add_subdirectory(${FREERTOS_PATH})
```

- Configure the FreeRTOS-Kernel and make it available
  - this particular example supports a native and cross-compiled build option.

```
set(FREERTOS_HEAP "4" CACHE STRING "" FORCE)
Select the native compile PORT
set(FREERTOS_PORT "GCC_POSIX" CACHE STRING "" FORCE)
Select the cross-compile PORT
if (CMAKE_CROSSCOMPILING)
 set(FREERTOS_PORT "GCC_ARM_CA9" CACHE STRING "" FORCE)
endif()

FetchContent_MakeAvailable(freertos_kernel)
```

- In case of cross compilation, you should also add the following to `freertos_config`:

```
target_compile_definitions(freertos_config INTERFACE ${definitions})
target_compile_options(freertos_config INTERFACE ${options})
```

### Consuming stand-alone - Cloning this repository

To clone using HTTPS:

```
git clone https://github.com/FreeRTOS/FreeRTOS-Kernel.git
```

Using SSH:

```
git clone git@github.com:FreeRTOS/FreeRTOS-Kernel.git
```

### Repository structure

- The root of this repository contains the three files that are common to every port - `list.c`, `queue.c` and `tasks.c`. The kernel is contained within these three files. `croutine.c` implements the optional co-routine functionality - which is normally only used on very memory limited systems.
- The `./portable` directory contains the files that are specific to a particular microcontroller and/or compiler. See the readme file in the `./portable` directory for more information.
- The `./include` directory contains the real time kernel header files.
- The `./template_configuration` directory contains a sample `FreeRTOSConfig.h` to help jumpstart a new project. See the *FreeRTOSConfig.h* file for instructions.

**Code Formatting** FreeRTOS files are formatted using the “`uncrustify`” tool. The configuration file used by `uncrustify` can be found in the [FreeRTOS/CI-CD-GitHub-Actions's uncrustify.cfg](#) file.

**Line Endings** File checked into the FreeRTOS-Kernel repository use unix-style LF line endings for the best compatibility with git.

For optimal compatibility with Microsoft Windows tools, it is best to enable the git `autocrlf` feature. You can enable this setting for the current repository using the following command:

```
git config core.autocrlf true
```

**Git History Optimizations** Some commits in this repository perform large refactors which touch many lines and lead to unwanted behavior when using the `git blame` command. You can configure git to ignore the list of large refactor commits in this repository with the following command:

```
git config blame.ignoreRevsFile .git-blame-ignore-revs
```

**Spelling and Formatting** We recommend using [Visual Studio Code](#), commonly referred to as VSCode, when working on the FreeRTOS-Kernel. The FreeRTOS-Kernel also uses [cSpell](#) as part of its spelling check. The config file for which can be found at [cspell.config.yaml](#). There is additionally a [cSpell plugin for VSCode](#) that can be used as well. `.cSpellWords.txt` contains words that are not traditionally found in an English dictionary. It is used by the spellchecker to verify the various jargon, variable names, and other odd words used in the FreeRTOS code base are correct. If your pull request fails to pass the spelling and you believe this is a mistake, then add the word to `.cSpellWords.txt`. When adding a word please then sort the list, which can be done by running the bash command: `sort -u .cSpellWords.txt -o .cSpellWords.txt`. Note that only the FreeRTOS-Kernel Source Files, *include*, *portable/MemMang*, and *portable/Common* files are checked for proper spelling, and formatting at this time.

### 4.1.2 FreeRTOS drivers

This is set of NXP provided FreeRTOS reentrant bus drivers.

### 4.1.3 backoffalgorithm

Algorithm for calculating exponential backoff with jitter for network retry attempts.

#### Readme

**MCUXpresso SDK: backoffAlgorithm Library** This repository is a fork of backoffAlgorithm library (<https://github.com/FreeRTOS/backoffalgorithm>)(1.3.0). Modifications have been made to adapt to NXP MCUXpresso SDK. `CMakeLists.txt` and `Kconfig` added to enable backoffAlgorithm repo sources build in MCUXpresso SDK. It is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository `mcuxsdk-manifests`(<https://github.com/nxp-mcuxpresso/mcuxsdk-manifests>) for the complete delivery of MCUXpresso SDK.

**backoffAlgorithm Library** This repository contains the backoffAlgorithm library, a utility library to calculate backoff period using an exponential backoff with jitter algorithm for retrying network operations (like failed network connection with server). This library uses the “Full Jitter” strategy for the exponential backoff with jitter algorithm. More information about the algorithm can be seen in the [Exponential Backoff and Jitter](#) AWS blog.

The backoffAlgorithm library is distributed under the *MIT Open Source License*.

Exponential backoff with jitter is typically used when retrying a failed network connection or operation request with the server. An exponential backoff with jitter helps to mitigate failed network operations with servers, that are caused due to network congestion or high request load on the server, by spreading out retry requests across multiple devices attempting network operations. Besides, in an environment with poor connectivity, a client can get disconnected at any time. A backoff strategy helps the client to conserve battery by not repeatedly attempting reconnections when they are unlikely to succeed.

See memory requirements for this library [here](#).

**backoffAlgorithm v1.3.0 source code is part of the FreeRTOS 202210.00 LTS release.**

**backoffAlgorithm v1.0.0 source code is part of the FreeRTOS 202012.00 LTS release.**

**Reference example** The example below shows how to use the backoffAlgorithm library on a POSIX platform to retry a DNS resolution query for amazon.com.

```
#include "backoff_algorithm.h"
#include <stdlib.h>
#include <string.h>
#include <netdb.h>
#include <unistd.h>
#include <time.h>

/* The maximum number of retries for the example code. */
#define RETRY_MAX_ATTEMPTS (5U)

/* The maximum back-off delay (in milliseconds) for between retries in the example. */
#define RETRY_MAX_BACKOFF_DELAY_MS (5000U)

/* The base back-off delay (in milliseconds) for retry configuration in the example. */
#define RETRY_BACKOFF_BASE_MS (500U)

int main()
{
 /* Variables used in this example. */
 BackoffAlgorithmStatus_t retryStatus = BackoffAlgorithmSuccess;
 BackoffAlgorithmContext_t retryParams;
 char serverAddress[] = "amazon.com";
 uint16_t nextRetryBackoff = 0;

 int32_t dnsStatus = -1;
 struct addrinfo hints;
 struct addrinfo ** pListHead = NULL;
 struct timespec tp;

 /* Add hints to retrieve only TCP sockets in getaddrinfo. */
 (void) memset(&hints, 0, sizeof(hints));

 /* Address family of either IPv4 or IPv6. */
 hints.ai_family = AF_UNSPEC;
 /* TCP Socket. */
 hints.ai_socktype = (int32_t) SOCK_STREAM;
 hints.ai_protocol = IPPROTO_TCP;

 /* Initialize reconnect attempts and interval. */
 BackoffAlgorithm_InitializeParams(&retryParams,
 RETRY_BACKOFF_BASE_MS,
 RETRY_MAX_BACKOFF_DELAY_MS,
 RETRY_MAX_ATTEMPTS);

 /* Seed the pseudo random number generator used in this example (with call to
 * rand() function provided by ISO C standard library) for use in backoff period
 * calculation when retrying failed DNS resolution. */

 /* Get current time to seed pseudo random number generator. */
 (void) clock_gettime(CLOCK_REALTIME, &tp);
 /* Seed pseudo random number generator with seconds. */
 srand(tp.tv_sec);

 do
 {
 /* Perform a DNS lookup on the given host name. */
 dnsStatus = getaddrinfo(serverAddress, NULL, &hints, pListHead);
 }
```

(continues on next page)

(continued from previous page)

```

/* Retry if DNS resolution query failed. */
if(dnsStatus != 0)
{
 /* Generate a random number and get back-off value (in milliseconds) for the next retry.
 * Note: It is recommended to use a random number generator that is seeded with
 * device-specific entropy source so that backoff calculation across devices is different
 * and possibility of network collision between devices attempting retries can be avoided.
 *
 * For the simplicity of this code example, the pseudo random number generator, rand()
 * function is used. */
 retryStatus = BackoffAlgorithm_GetNextBackoff(&retryParams, rand(), &nextRetryBackoff);

 /* Wait for the calculated backoff period before the next retry attempt of querying DNS.
 * As usleep() takes nanoseconds as the parameter, we multiply the backoff period by 1000. */
 (void) usleep(nextRetryBackoff * 1000U);
}
} while((dnsStatus != 0) && (retryStatus != BackoffAlgorithmRetriesExhausted));

return dnsStatus;
}

```

**Building the library** A compiler that supports **C90 or later** such as *gcc* is required to build the library.

Additionally, the library uses a header file introduced in ISO C99, *stdint.h*. For compilers that do not provide this header file, the *source/include* directory contains *stdint.readme*, which can be renamed to *stdint.h* to build the backoffAlgorithm library.

For instance, if the example above is copied to a file named *example.c*, *gcc* can be used like so:

```
gcc -I source/include example.c source/backoff_algorithm.c -o example
./example
```

*gcc* can also produce an output file to be linked:

```
gcc -I source/include -c source/backoff_algorithm.c
```

## Building unit tests

**Checkout Unity Submodule** By default, the submodules in this repository are configured with `update=none` in *.gitmodules*, to avoid increasing clone time and disk space usage of other repositories (like [amazon-freertos](#) that submodules this repository).

To build unit tests, the submodule dependency of Unity is required. Use the following command to clone the submodule:

```
git submodule update --checkout --init --recursive test/unit-test/Unity
```

## Platform Prerequisites

- For running unit tests
  - C89 or later compiler like *gcc*
  - CMake 3.13.0 or later
- For running the coverage target, *gcov* is additionally required.

### Steps to build Unit Tests

1. Go to the root directory of this repository. (Make sure that the **Unity** submodule is cloned as described [above](#).)
2. Create build directory: `mkdir build && cd build`
3. Run `cmake` while inside build directory: `cmake -S ../test`
4. Run this command to build the library and unit tests: `make all`
5. The generated test executables will be present in `build/bin/tests` folder.
6. Run `ctest` to execute all tests and view the test run summary.

**Contributing** See *CONTRIBUTING.md* for information on contributing.

### 4.1.4 corehttp

C language HTTP client library designed for embedded platforms.

#### MCUXpresso SDK: coreHTTP Client Library

This repository is a fork of coreHTTP Client library (<https://github.com/FreeRTOS/corehttp>)(3.0.0). Modifications have been made to adapt to NXP MCUXpresso SDK. CMakeLists.txt and Kconfig added to enable coreHTTP Client repo sources build in MCUXpresso SDK. It is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository mcuxsdk-manifests(<https://github.com/nxp-mcuxpresso/mcuxsdk-manifests>) for the complete delivery of MCUXpresso SDK.

#### coreHTTP Client Library

This repository contains a C language HTTP client library designed for embedded platforms. It has no dependencies on any additional libraries other than the standard C library, [llhttp](#), and a customer-implemented transport interface. This library is distributed under the *MIT Open Source License*.

This library has gone through code quality checks including verification that no function has a [GNU Complexity](#) score over 8. This library has also undergone both static code analysis from [Coverity static analysis](#), and validation of memory safety and data structure invariance through the [CBMC automated reasoning tool](#).

See memory requirements for this library [here](#).

**coreHTTP v3.0.0 source code is part of the FreeRTOS 202210.00 LTS release.**

**coreHTTP v2.0.0 source code is part of the FreeRTOS 202012.00 LTS release.**

**coreHTTP Config File** The HTTP client library exposes configuration macros that are required for building the library. A list of all the configurations and their default values are defined in *core\_http\_config\_defaults.h*. To provide custom values for the configuration macros, a custom config file named *core\_http\_config.h* can be provided by the user application to the library.

By default, a *core\_http\_config.h* custom config is required to build the library. To disable this requirement and build the library with default configuration values, provide `HTTP_DO_NOT_USE_CUSTOM_CONFIG` as a compile time preprocessor macro.

**The HTTP client library can be built by either:**

- Defining a `core_http_config.h` file in the application, and adding it to the include directories for the library build. **OR**
- Defining the `HTTP_DO_NOT_USE_CUSTOM_CONFIG` preprocessor macro for the library build.

**Building the Library** The `httpFilePaths.cmake` file contains the information of all source files and header include paths required to build the HTTP client library.

As mentioned in the *previous section*, either a custom config file (i.e. `core_http_config.h`) OR `HTTP_DO_NOT_USE_CUSTOM_CONFIG` macro needs to be provided to build the HTTP client library.

For a CMake example of building the HTTP library with the `httpFilePaths.cmake` file, refer to the `coverity_analysis` library target in `test/CMakeLists.txt` file.

## Building Unit Tests

### Platform Prerequisites

- For running unit tests, the following are required:
  - **C90 compiler** like `gcc`
  - **CMake 3.13.0 or later**
  - **Ruby 2.0.0 or later** is required for this repository's [CMock test framework](#).
- For running the coverage target, the following are required:
  - `gcov`
  - `lcov`

### Steps to build Unit Tests

1. Go to the root directory of this repository.
2. Run the `cmake` command: `cmake -S test -B build -DBUILD_CLONE_SUBMODULES=ON`
3. Run this command to build the library and unit tests: `make -C build all`
4. The generated test executables will be present in `build/bin/tests` folder.
5. Run `cd build && ctest` to execute all tests and view the test run summary.

**CBMC** To learn more about CBMC and proofs specifically, review the training material [here](#).

The `test/cbmc/proofs` directory contains CBMC proofs.

In order to run these proofs you will need to install CBMC and other tools by following the instructions [here](#).

**Reference examples** The AWS IoT Device SDK for Embedded C repository contains demos of using the HTTP client library [here](#) on a POSIX platform. These can be used as reference examples for the library API.

## Documentation



**Existing Documentation** For pre-generated documentation, please see the documentation linked in the locations below:

| Location                                                       |
|----------------------------------------------------------------|
| <a href="#">AWS IoT Device SDK for Embedded C FreeRTOS.org</a> |

Note that the latest included version of coreHTTP may differ across repositories.

**Generating Documentation** The Doxygen references were created using Doxygen version 1.9.2. To generate the Doxygen pages, please run the following command from the root of this repository:

```
doxygen docs/doxygen/config.doxyfile
```

**Contributing** See *CONTRIBUTING.md* for information on contributing.

## 4.1.5 corejson

JSON parser.

### Readme

**MCUXpresso SDK: coreJSON Library** This repository is a fork of coreJSON library (<https://github.com/FreeRTOS/corejson>)(3.2.0). Modifications have been made to adapt to NXP MCUXpresso SDK. CMakeLists.txt and Kconfig added to enable coreJSON repo sources build in MCUXpresso SDK. It is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository mcuxsdk-manifests(<https://github.com/nxp-mcuxpresso/mcuxsdk-manifests>) for the complete delivery of MCUXpresso SDK.

**coreJSON Library** This repository contains the coreJSON library, a parser that strictly enforces the ECMA-404 JSON standard and is suitable for low memory footprint embedded devices. The coreJSON library is distributed under the *MIT Open Source License*.

This library has gone through code quality checks including verification that no function has a [GNU Complexity](#) score over 8, and checks against deviations from mandatory rules in the [MISRA coding standard](#). Deviations from the MISRA C:2012 guidelines are documented under *MISRA Deviations*. This library has also undergone both static code analysis from [Coverity static analysis](#), and validation of memory safety through the [CBMC automated reasoning tool](#).

See memory requirements for this library [here](#).

**coreJSON v3.2.0 source code is part of the FreeRTOS 202210.00 LTS release.**

**coreJSON v3.0.0 source code is part of the FreeRTOS 202012.00 LTS release.**

### Reference example



```

#include <stdio.h>
#include "core_json.h"

int main()
{
 // Variables used in this example.
 JSONStatus_t result;
 char buffer[] = "{\"foo\":\"abc\", \"bar\":{\"foo\":\"xyz\"}}";
 size_t bufferLength = sizeof(buffer) - 1;
 char queryKey[] = "bar.foo";
 size_t queryKeyLength = sizeof(queryKey) - 1;
 char * value;
 size_t valueLength;

 // Calling JSON_Validate() is not necessary if the document is guaranteed to be valid.
 result = JSON_Validate(buffer, bufferLength);

 if(result == JSONSuccess)
 {
 result = JSON_Search(buffer, bufferLength, queryKey, queryKeyLength,
 &value, &valueLength);
 }

 if(result == JSONSuccess)
 {
 // The pointer "value" will point to a location in the "buffer".
 char save = value[valueLength];
 // After saving the character, set it to a null byte for printing.
 value[valueLength] = '\0';
 // "Found: bar.foo -> xyz" will be printed.
 printf("Found: %s -> %s\n", queryKey, value);
 // Restore the original character.
 value[valueLength] = save;
 }

 return 0;
}

```

A search may descend through nested objects when the queryKey contains matching key strings joined by a separator, .. In the example above, bar has the value { "foo": "xyz" }. Therefore, a search for query key bar.foo would output xyz.

**Building coreJSON** A compiler that supports **C90 or later** such as *gcc* is required to build the library.

Additionally, the library uses 2 header files introduced in ISO C99, *stdbool.h* and *stdint.h*. For compilers that do not provide this header file, the *source/include* directory contains *stdbool.readme* and *stdint.readme*, which can be renamed to *stdbool.h* and *stdint.h* respectively.

For instance, if the example above is copied to a file named *example.c*, *gcc* can be used like so:

```
gcc -I source/include example.c source/core_json.c -o example
./example
```

*gcc* can also produce an output file to be linked:

```
gcc -I source/include -c source/core_json.c
```

## Documentation

**Existing documentation** For pre-generated documentation, please see the documentation linked in the locations below:

| Location                                                       |
|----------------------------------------------------------------|
| <a href="#">AWS IoT Device SDK for Embedded C FreeRTOS.org</a> |

Note that the latest included version of the coreJSON library may differ across repositories.

**Generating documentation** The Doxygen references were created using Doxygen version 1.9.2. To generate the Doxygen pages, please run the following command from the root of this repository:

```
doxygen docs/doxygen/config.doxyfile
```

## Building unit tests

**Checkout Unity Submodule** By default, the submodules in this repository are configured with `update=none` in `.gitmodules`, to avoid increasing clone time and disk space usage of other repositories (like [amazon-freertos](#) that submodules this repository).

To build unit tests, the submodule dependency of Unity is required. Use the following command to clone the submodule:

```
git submodule update --checkout --init --recursive test/unit-test/Unity
```

## Platform Prerequisites

- For running unit tests
  - C90 compiler like gcc
  - CMake 3.13.0 or later
  - Ruby 2.0.0 or later is additionally required for the Unity test framework (that we use).
- For running the coverage target, gcov is additionally required.

## Steps to build Unit Tests

1. Go to the root directory of this repository. (Make sure that the **Unity** submodule is cloned as described [above](#).)
2. Create build directory: `mkdir build && cd build`
3. Run `cmake` while inside build directory: `cmake -S ../test`
4. Run this command to build the library and unit tests: `make all`
5. The generated test executables will be present in `build/bin/tests` folder.
6. Run `ctest` to execute all tests and view the test run summary.

**CBMC** To learn more about CBMC and proofs specifically, review the training material [here](#).

The `test/cbmc/proofs` directory contains CBMC proofs.

In order to run these proofs you will need to install CBMC and other tools by following the instructions [here](#).

**Contributing** See *CONTRIBUTING.md* for information on contributing.

### 4.1.6 coremqtt

MQTT publish/subscribe messaging library.

#### MCUXpresso SDK: coreMQTT Library

This repository is a fork of coreMQTT library (<https://github.com/FreeRTOS/coremqtt>)(2.1.1). Modifications have been made to adapt to NXP MCUXpresso SDK. CMakeLists.txt and Kconfig added to enable coreMQTT repo sources build in MCUXpresso SDK. It is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository mcuxsdk-manifests(<https://github.com/nxp-mcuxpresso/mcuxsdk-manifests>) for the complete delivery of MCUXpresso SDK.

#### coreMQTT Client Library

This repository contains the coreMQTT library that has been optimized for a low memory footprint. The coreMQTT library is compliant with the [MQTT 3.1.1](#) standard. It has no dependencies on any additional libraries other than the standard C library, a customer-implemented network transport interface, and *optionally* a user-implemented platform time function. This library is distributed under the *MIT Open Source License*.

This library has gone through code quality checks including verification that no function has a [GNU Complexity](#) score over 8, and checks against deviations from mandatory rules in the [MISRA coding standard](#). Deviations from the MISRA C:2012 guidelines are documented under *MISRA Deviations*. This library has also undergone both static code analysis from [Coverity static analysis](#), and validation of memory safety through the [CBMC automated reasoning tool](#).

See memory requirements for this library [here](#).

**coreMQTT v2.1.1 source code is part of the FreeRTOS 20210.01 LTS release.**

**MQTT Config File** The MQTT client library exposes build configuration macros that are required for building the library. A list of all the configurations and their default values are defined in *core\_mqtt\_config\_defaults.h*. To provide custom values for the configuration macros, a custom config file named *core\_mqtt\_config.h* can be provided by the application to the library.

By default, a *core\_mqtt\_config.h* custom config is required to build the library. To disable this requirement and build the library with default configuration values, provide `MQTT_DO_NOT_USE_CUSTOM_CONFIG` as a compile time preprocessor macro.

**Thus, the MQTT library can be built by either:**

- Defining a *core\_mqtt\_config.h* file in the application, and adding it to the include directories list of the library
- OR**
- Defining the `MQTT_DO_NOT_USE_CUSTOM_CONFIG` preprocessor macro for the library build.

**Sending metrics to AWS IoT** When establishing a connection with AWS IoT, users can optionally report the Operating System, Hardware Platform and MQTT client version information of their device to AWS. This information can help AWS IoT provide faster issue resolution and technical support. If users want to report this information, they can send a specially formatted string (see below) in the username field of the MQTT CONNECT packet.

#### Format

The format of the username string with metrics is:

```
<Actual_Username>?SDK=<OS_Name>&Version=<OS_Version>&Platform=<Hardware_Platform>&MQTTLib=<MQTT_Library_name>@<MQTT_Library_version>
```

#### Where

- <Actual\_Username> is the actual username used for authentication, if username and password are used for authentication. When username and password based authentication is not used, this is an empty value.
- <OS\_Name> is the Operating System the application is running on (e.g. FreeRTOS)
- <OS\_Version> is the version number of the Operating System (e.g. V10.4.3)
- <Hardware\_Platform> is the Hardware Platform the application is running on (e.g. WinSim)
- <MQTT\_Library\_name> is the MQTT Client library being used (e.g. coreMQTT)
- <MQTT\_Library\_version> is the version of the MQTT Client library being used (e.g. 1.0.2)

#### Example

- Actual\_Username = "iotuser", OS\_Name = FreeRTOS, OS\_Version = V10.4.3, Hardware\_Platform\_Name = WinSim, MQTT\_Library\_Name = coremqtt, MQTT\_Library\_version = 2.1.1. If username is not used, then "iotuser" can be removed.

```
/* Username string:
 * iotuser?SDK=FreeRTOS&Version=v10.4.3&Platform=WinSim&MQTTLib=coremqtt@2.1.1
 */

#define OS_NAME "FreeRTOS"
#define OS_VERSION "V10.4.3"
#define HARDWARE_PLATFORM_NAME "WinSim"
#define MQTT_LIB "coremqtt@2.1.1"

#define USERNAME_STRING "iotuser?SDK=" OS_NAME "&Version=" OS_VERSION "&Platform=" HARDWARE_PLATFORM_NAME "&MQTTLib=" MQTT_LIB
#define USERNAME_STRING_LENGTH ((uint16_t) (sizeof(USERNAME_STRING) - 1))

MQTTConnectInfo_t connectInfo;
connectInfo.userName = USERNAME_STRING;
connectInfo.userNameLength = USERNAME_STRING_LENGTH;
mqttStatus = MQTT_Connect(pMqttContext, &connectInfo, NULL, CONNACK_RECV_TIMEOUT_MS,
↳ pSessionPresent);
```

**Upgrading to v2.0.0 and above** With coreMQTT versions >=v2.0.0, there are breaking changes. Please refer to the *coreMQTT version >=v2.0.0 Migration Guide*.

**Building the Library** The *mqttFilePaths.cmake* file contains the information of all source files and the header include path required to build the MQTT library.

Additionally, the MQTT library requires two header files that are not part of the ISO C90 standard library, *stdbool.h* and *stdint.h*. For compilers that do not provide these header files, the

*source/include* directory contains the files *stdbool.readme* and *stdint.readme*, which can be renamed to *stdbool.h* and *stdint.h*, respectively, to provide the type definitions required by MQTT.

As mentioned in the previous section, either a custom config file (i.e. *core\_mqtt\_config.h*) OR *MQTT\_DO\_NOT\_USE\_CUSTOM\_CONFIG* macro needs to be provided to build the MQTT library.

For a CMake example of building the MQTT library with the *mqttFilePaths.cmake* file, refer to the *coverity\_analysis* library target in *test/CMakeLists.txt* file.

## Building Unit Tests

**Checkout CMock Submodule** By default, the submodules in this repository are configured with *update=none* in *.gitmodules* to avoid increasing clone time and disk space usage of other repositories (like [amazon-freertos](#) that submodules this repository).

To build unit tests, the submodule dependency of CMock is required. Use the following command to clone the submodule:

```
git submodule update --checkout --init --recursive test/unit-test/CMock
```

## Platform Prerequisites

- Docker

or the following:

- For running unit tests
  - **C90 compiler** like gcc
  - **CMake 3.13.0 or later**
  - **Ruby 2.0.0 or later** is additionally required for the CMock test framework (that we use).
- For running the coverage target, **gcov** and **lcov** are additionally required.

## Steps to build Unit Tests

1. If using docker, launch the container:
  1. `docker build -t coremqtt .`
  2. `docker run -it -v "$PWD":/workspaces/coreMQTT -w /workspaces/coreMQTT coremqtt`
2. Go to the root directory of this repository. (Make sure that the **CMock** submodule is cloned as described [above](#))
3. Run the *cmake* command: `cmake -S test -B build`
4. Run this command to build the library and unit tests: `make -C build all`
5. The generated test executables will be present in *build/bin/tests* folder.
6. Run `cd build && ctest` to execute all tests and view the test run summary.

**CBMC** To learn more about CBMC and proofs specifically, review the training material [here](#).

The *test/cbmc/proofs* directory contains CBMC proofs.

In order to run these proofs you will need to install CBMC and other tools by following the instructions [here](#).

**Reference examples** Please refer to the demos of the MQTT client library in the following locations for reference examples on POSIX and FreeRTOS platforms:

| Platform | Location                                            | Transport Interface Implementation                 |
|----------|-----------------------------------------------------|----------------------------------------------------|
| POSIX    | <a href="#">AWS IoT Device SDK for Embedded C</a>   | POSIX sockets for TCP/IP and OpenSSL for TLS stack |
| FreeRTOS | <a href="#">FreeRTOS/FreeRTOS</a>                   | FreeRTOS+TCP for TCP/IP and mbedTLS for TLS stack  |
| FreeRTOS | <a href="#">FreeRTOS AWS Reference Integrations</a> | Based on Secure Sockets Abstraction                |

## Documentation

**Existing Documentation** For pre-generated documentation, please see the documentation linked in the locations below:

| Location                                          |
|---------------------------------------------------|
| <a href="#">AWS IoT Device SDK for Embedded C</a> |
| <a href="#">FreeRTOS.org</a>                      |

Note that the latest included version of coreMQTT may differ across repositories.

**Generating Documentation** The Doxygen references were created using Doxygen version 1.9.2. To generate the Doxygen pages, please run the following command from the root of this repository:

```
doxygen docs/doxygen/config.doxyfile
```

**Contributing** See *CONTRIBUTING.md* for information on contributing.

### 4.1.7 coremqtt-agent

The coreMQTT Agent library is a high level API that adds thread safety to the coreMQTT library.

#### Readme

**MCUXpresso SDK: coreMQTT Agent Library** This repository is a fork of coreMQTT Agent library (<https://github.com/FreeRTOS/coremqtt-agent>)(1.2.0). Modifications have been made to adapt to NXP MCUXpresso SDK. CMakeLists.txt and Kconfig added to enable coreMQTT Agent repo sources build in MCUXpresso SDK. It is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository mcuxsdk-manifests(<https://github.com/nxp-mcuxpresso/mcuxsdk-manifests>) for the complete delivery of MCUXpresso SDK.

**coreMQTT Agent Library** The coreMQTT Agent library is a high level API that adds thread safety to the [coreMQTT](#) library. The library provides thread safe equivalents to the coreMQTT's APIs, greatly simplifying its use in multi-threaded environments. The coreMQTT Agent library manages the MQTT connection by serializing the access to the coreMQTT library and reducing implementation overhead (e.g., removing the need for the application to repeatedly call to MQTT\_ProcessLoop). This allows your multi-threaded applications to share the same MQTT connection, and enables you to design an embedded application without having to worry about coreMQTT thread safety.

This library has gone through code quality checks including verification that no function has a [GNU Complexity](#) score over 8, and checks against deviations from mandatory rules in the [MISRA coding standard](#). Deviations from the MISRA C:2012 guidelines are documented under *MISRA Deviations*. This library has also undergone both static code analysis from [Coverity static analysis](#), and validation of memory safety through the [CBMC automated reasoning tool](#).

See memory requirements for this library [here](#).

**Cloning this repository** This repo uses [Git Submodules](#) to bring in dependent components.

To clone using HTTPS:

```
git clone https://github.com/FreeRTOS/coreMQTT-Agent.git --recurse-submodules
```

Using SSH:

```
git clone git@github.com:FreeRTOS/coreMQTT-Agent.git --recurse-submodules
```

If you have downloaded the repo without using the `--recurse-submodules` argument, you need to run:

```
git submodule update --init --recursive
```

**coreMQTT Agent Library Configurations** The MQTT Agent library uses the same `core_mqtt_config.h` configuration file as coreMQTT, with the addition of configuration constants listed at the top of `core_mqtt_agent.h` and `core_mqtt_agent_command_functions.h`. Documentation for these configurations can be found [here](#).

To provide values for these configuration values, they must be either:

- Defined in `core_mqtt_config.h` used by coreMQTT **OR**
- Passed as compile time preprocessor macros

**Porting the coreMQTT Agent Library** In order to use the MQTT Agent library on a platform, you need to supply thread safe functions for the agent's *messaging interface*.

**Messaging Interface** Each of the following functions must be thread safe.



| Function Pointer          | Description                                                                                                                                                                                                                                                                   |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MQTTAgentMessageSend_t    | A function that sends commands (as MQTTAgentCommand_t * pointers) to be received by MQTTAgent_CommandLoop. This can be implemented by pushing to a thread safe queue.                                                                                                         |
| MQTTAgentMessageRecv_t    | A function used by MQTTAgent_CommandLoop to receive MQTTAgentCommand_t * pointers that were sent by API functions. This can be implemented by receiving from a thread safe queue.                                                                                             |
| MQTTAgentCommandGet_t     | A function that returns a pointer to an allocated MQTTAgentCommand_t structure, which is used to hold information and arguments for a command to be executed in MQTTAgent_CommandLoop(). If using dynamic memory, this can be implemented using malloc().                     |
| MQTTAgentCommandRelease_t | A function called to indicate that a command structure that had been allocated with the MQTTAgentCommandGet_t function pointer will no longer be used by the agent, so it may be freed or marked as not in use. If using dynamic memory, this can be implemented with free(). |

Reference implementations for the interface functions can be found in the [reference examples](#) below.

## Additional Considerations

**Static Memory** If only static allocation is used, then the MQTTAgentCommandGet\_t and MQTTAgentCommandRelease\_t could instead be implemented with a pool of MQTTAgentCommand\_t structures, with a queue or semaphore used to control access and provide thread safety. The below [reference examples](#) use static memory with a command pool.

**Subscription Management** The MQTT Agent does not track subscriptions for MQTT topics. The receipt of any incoming PUBLISH packet will result in the invocation of a single MQTTAgentIncomingPublishCallback\_t callback, which is passed to MQTTAgent\_Init() for initialization. If it is desired for different handlers to be invoked for different incoming topics, then the publish callback will have to manage subscriptions and fan out messages. A platform independent subscription manager example is implemented in the [reference examples](#) below.

**Building the Library** You can build the MQTT Agent source files that are in the *source* directory, and add *source/include* to your compiler's include path. Additionally, the MQTT Agent library requires the coreMQTT library, whose files follow the same *source/* and *source/include* pattern as the agent library; its build instructions can be found [here](#).

If using CMake, the *mqttAgentFilePaths.cmake* file contains the above information of the source files and the header include path from this repository. The same information is found for coreMQTT from *mqttFilePaths.cmake* in the *coreMQTT submodule*.

For a CMake example of building the MQTT Agent library with the *mqttAgentFilePaths.cmake* file, refer to the *coverity\_analysis* library target in *test/CMakeLists.txt* file.

## Building Unit Tests



**Checkout CMock Submodule** To build unit tests, the submodule dependency of CMock is required. Use the following command to clone the submodule:

```
git submodule update --checkout --init --recursive test/unit-test/CMock
```

### Unit Test Platform Prerequisites

- For running unit tests
  - **C90 compiler** like gcc
  - **CMake 3.13.0 or later**
  - **Ruby 2.0.0 or later** is additionally required for the CMock test framework (that we use).
- For running the coverage target, **gcov** and **lcov** are additionally required.

### Steps to build Unit Tests

1. Go to the root directory of this repository. (Make sure that the **CMock** submodule is cloned as described [above](#))
2. Run the *cmake* command: `cmake -S test -B build`
3. Run this command to build the library and unit tests: `make -C build all`
4. The generated test executables will be present in `build/bin/tests` folder.
5. Run `cd build && ctest` to execute all tests and view the test run summary.

**CBMC** To learn more about CBMC and proofs specifically, review the training material [here](#).

The `test/cbmc/proofs` directory contains CBMC proofs.

In order to run these proofs you will need to install CBMC and other tools by following the instructions [here](#).

**Reference examples** Please refer to the demos of the MQTT Agent library in the following locations for reference examples on FreeRTOS platforms:

| Location                             |
|--------------------------------------|
| <a href="#">coreMQTT Agent Demos</a> |
| <a href="#">FreeRTOS/FreeRTOS</a>    |

**Documentation** The MQTT Agent API documentation can be found [here](#).

**Generating documentation** The Doxygen references were created using Doxygen version 1.9.2. To generate the Doxygen pages yourself, please run the following command from the root of this repository:

```
doxygen docs/doxygen/config.doxyfile
```

**Getting help** You can use your Github login to get support from both the FreeRTOS community and directly from the primary FreeRTOS developers on our [active support forum](#). You can find a list of [frequently asked questions](#) [here](#).

**Contributing** See *CONTRIBUTING.md* for information on contributing.

**License** This library is licensed under the MIT License. See the *LICENSE* file.

### 4.1.8 corepkcs11

PKCS #11 key management library.

#### Readme

**MCUXpresso SDK: corePKCS11 Library** This repository is a fork of PKCS #11 key management library (<https://github.com/FreeRTOS/corePKCS11/tree/v3.5.0>)(v3.5.0). Modifications have been made to adapt to NXP MCUXpresso SDK. CMakeLists.txt and Kconfig added to enable corepkcs11 repo sources build in MCUXpresso SDK. It is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository mcuxsdk-manifests(<https://github.com/nxp-mcuxpresso/mcuxsdk-manifests>) for the complete delivery of MCUXpresso SDK.

**corePKCS11 Library** PKCS #11 is a standardized and widely used API for manipulating common cryptographic objects. It is important because the functions it specifies allow application software to use, create, modify, and delete cryptographic objects, without ever exposing those objects to the application's memory. For example, FreeRTOS AWS reference integrations use a small subset of the PKCS #11 API to, among other things, access the secret (private) key necessary to create a network connection that is authenticated and secured by the [Transport Layer Security \(TLS\)](#) protocol – without the application ever ‘seeing’ the key.

The Cryptoki or PKCS #11 standard defines a platform-independent API to manage and use cryptographic tokens. The name, “PKCS #11”, is used interchangeably to refer to the API itself and the standard which defines it.

This repository contains a software based mock implementation of the PKCS #11 interface (API) that uses the cryptographic functionality provided by Mbed TLS. Using a software mock enables rapid development and flexibility, but it is expected that the mock be replaced by an implementation specific to your chosen secure key storage in production devices.

Only a subset of the PKCS #11 standard is implemented, with a focus on operations involving asymmetric keys, random number generation, and hashing.

The targeted use cases include certificate and key management for TLS authentication and code-sign signature verification, on small embedded devices.

corePKCS11 is implemented on PKCS #11 v2.4.0, the full PKCS #11 standard can be found on the [oasis website](#).

This library has gone through code quality checks including verification that no function has a [GNU Complexity](#) score over 8, and checks against deviations from mandatory rules in the [MISRA coding standard](#). Deviations from the MISRA C:2012 guidelines are documented under *MISRA Deviations*. This library has also undergone both static code analysis from [Coverity static analysis](#) and validation of memory safety through the [CBMC automated reasoning tool](#).

See memory requirements for this library [here](#).

**corePKCS11 v3.5.0 source code is part of the FreeRTOS 202210.00 LTS release.**

**corePKCS11 v3.0.0 source code is part of the FreeRTOS 202012.00 LTS release.**

**Purpose** Generally vendors for secure cryptoprocessors such as Trusted Platform Module (TPM), Hardware Security Module (HSM), Secure Element, or any other type of secure hardware enclave, distribute a PKCS #11 implementation with the hardware. The purpose of the corePKCS11 software only mock library is therefore to provide a non hardware specific PKCS #11 implementation that allows for rapid prototyping and development before switching to a cryptoprocessor specific PKCS #11 implementation in production devices.

Since the PKCS #11 interface is defined as part of the PKCS #11 [specification](#) replacing this library with another implementation should require little porting effort, as the interface will not change. The system tests distributed in this repository can be leveraged to verify the behavior of a different implementation is similar to corePKCS11.

**corePKCS11 Configuration** The corePKCS11 library exposes preprocessor macros which must be defined prior to building the library. A list of all the configurations and their default values are defined in the doxygen documentation for this library.

### Build Prerequisites

**Library Usage** For building the library the following are required:

- **A C99 compiler**
- **mbedcrypto** library from [mbedtls](#) version 2.x or 3.x.
- **pkcs11 API header(s)** available from [OASIS](#) or [OpenSC](#)

Optionally, variables from the `pkcsFilePaths.cmake` file may be referenced if your project uses `cmake`.

**Integration and Unit Tests** In order to run the integration and unit test suites the following are dependencies are necessary:

- **C Compiler**
- **CMake 3.13.0 or later**
- **Ruby 2.0.0 or later** required by CMock.
- **Python 3** required for configuring mbedtls.
- **git** required for fetching dependencies.
- **GNU Make** or **Ninja**

The *mbedtls*, *CMock*, and *Unity* libraries are downloaded and built automatically using the `cmake` `FetchContent` feature.

**Coverage Measurement and Instrumentation** The following software is required to run the coverage target:

- Linux, MacOS, or another POSIX-like environment.
- A recent version of **GCC** or **Clang** with support for gcov-like coverage instrumentation.
- **gcov** binary corresponding to your chosen compiler
- **lcov** from the [Linux Test Project](#)
- **perl** needed to run the `lcov` utility.

Coverage builds are validated on recent versions of Ubuntu Linux.

## Running the Integration and Unit Tests

1. Navigate to the root directory of this repository in your shell.
2. Run **cmake** to construct a build tree: `cmake -S test -B build`
  - You may specify your preferred build tool by appending `-G'Unix Makefiles'` or `-GNinja` to the command above.
  - You may append `-DUNIT_TESTS=0` or `-DSYSTEM_TESTS=0` to disable Unit Tests or Integration Tests respectively.
3. Build the test binaries: `cmake --build ./build --target all`
4. Run `ctest --test-dir ./build` or `cmake --build ./build --target test` to run the tests without capturing coverage.
5. Run `cmake --build ./build --target coverage` to run the tests and capture coverage data.

**CBMC** To learn more about CBMC and proofs specifically, review the training material [here](#).

The `test/cbmc/proofs` directory contains CBMC proofs.

In order to run these proofs you will need to install CBMC and other tools by following the instructions [here](#).

**Reference examples** The FreeRTOS-Labs repository contains demos using the PKCS #11 library [here](#) using FreeRTOS on the Windows simulator platform. These can be used as reference examples for the library API.

**Porting Guide** Documentation for porting corePKCS11 to a new platform can be found on the AWS [docs](#) web page.

corePKCS11 is not meant to be ported to projects that have a TPM, HSM, or other hardware for offloading crypto-processing. This library is specifically meant to be used for development and prototyping.

**Related Example Implementations** These projects implement the PKCS #11 interface on real hardware and have similar behavior to corePKCS11. It is preferred to use these, over corePKCS11, as they allow for offloading Cryptography to separate hardware.

- ARM's [Platform Security Architecture](#).
- Microchip's [cryptoauthlib](#).
- Infineon's [Optiga Trust X](#).

## Documentation

**Existing Documentation** For pre-generated documentation, please see the documentation linked in the locations below:

| Location                                                       |
|----------------------------------------------------------------|
| <a href="#">AWS IoT Device SDK for Embedded C FreeRTOS.org</a> |

Note that the latest included version of corePKCS11 may differ across repositories.

**Generating Documentation** The Doxygen references were created using Doxygen version 1.9.2. To generate the Doxygen pages, please run the following command from the root of this repository:

```
doxygen docs/doxygen/config.doxyfile
```

**Security** See *CONTRIBUTING* for more information.

**License** This library is licensed under the MIT-0 License. See the LICENSE file.

### 4.1.9 freertos-plus-tcp

Open source RTOS FreeRTOS Plus TCP.

#### Readme

**MCUXpresso SDK: FreeRTOS-Plus-TCP Library** This repository is a fork of FreeRTOS-Plus-TCP library (<https://github.com/FreeRTOS/freertos-plus-tcp>)(4.0.0). Modifications have been made to adapt to NXP MCUXpresso SDK. CMakeLists.txt and Kconfig added to enable FreeRTOS-Plus-TCP repo sources build in MCUXpresso SDK. It is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository mcuxsdk-manifests(<https://github.com/nxp-mcuxpresso/mcuxsdk-manifests>) for the complete delivery of MCUXpresso SDK.

**Introduction** This branch contains unified IPv4 and IPv6 functionalities. Refer to the Getting started Guide (found [here](#)) for more details.

**FreeRTOS-Plus-TCP Library** FreeRTOS-Plus-TCP is a lightweight TCP/IP stack for FreeRTOS. It provides a familiar Berkeley sockets interface, making it as simple to use and learn as possible. FreeRTOS-Plus-TCP's features and RAM footprint are fully scalable, making FreeRTOS-Plus-TCP equally applicable to smaller lower throughput microcontrollers as well as larger higher throughput microprocessors.

This library has undergone static code analysis and checks for compliance with the [MISRA coding standard](#). Any deviations from the MISRA C:2012 guidelines are documented under [MISRA Deviations](#). The library is validated for memory safety and data structure invariance through the [CBMC automated reasoning tool](#) for the functions that parse data originating from the network. The library is also protocol tested using Maxwell protocol tester for both IPv4 and IPv6.

**Getting started** The easiest way to use the 4.0.0 version of FreeRTOS-Plus-TCP is to refer the Getting started Guide (found [here](#)) Another way is to start with the pre-configured demo application project (found in [this directory](#)). That way you will have the correct FreeRTOS source files included, and the correct include paths configured. Once a demo application is building and executing you can remove the demo application files, and start to add in your own application source files. See the [FreeRTOS Kernel Quick Start Guide](#) for detailed instructions and other useful links.

Additionally, for FreeRTOS-Plus-TCP source code organization refer to the [Documentation](#), and [API Reference](#).

**Getting help** If you have any questions or need assistance troubleshooting your FreeRTOS project, we have an active community that can help on the [FreeRTOS Community Support Forum](#). Please also refer to [FAQ](#) for frequently asked questions.

Also see the [Submitting a bugs/feature request](#) section of CONTRIBUTING.md for more details.

**Note:** All the remaining sections are generic and applies to all the versions from V3.0.0 onwards.

**Upgrading to V3.0.0 and V3.1.0** In version 3.0.0 or 3.1.0, the folder structure of FreeRTOS-Plus-TCP has changed and the files have been broken down into smaller logically separated modules. This change makes the code more modular and conducive to unit-tests. FreeRTOS-Plus-TCP V3.0.0 improves the robustness, security, and modularity of the library. Version 3.0.0 adds comprehensive unit test coverage for all lines and branches of code and has undergone protocol testing, and penetration testing by AWS Security to reduce the exposure to security vulnerabilities. Additionally, the source files have been moved to a `source` directory. This change requires modification of any existing project(s) to include the modified source files and directories. There are examples on how to use the new files and directory structure. For an example based on the Xilinx Zynq-7000, use the code in this [branch](#) and follow these [instructions](#) to build and run the demo.

**FreeRTOS-Plus-TCP V3.1.0 source code(.c .h) is part of the FreeRTOS 202210.00 LTS release.**

**Generating pre V3.0.0 folder structure for backward compatibility:** If you wish to continue using a version earlier than V3.0.0 i.e. continue to use your existing source code organization, a script is provided to generate the folder structure similar to [this](#).

**Note:** After running the script, while the `.c` files will have same names as the pre V3.0.0 source, the files in the `include` directory will have different names and the number of files will differ as well. This should, however, not pose any problems to most projects as projects generally include all files in a given directory.

Running the script to generate pre V3.0.0 folder structure: For running the script, you will need Python version > 3.7. You can download/install it from [here](#).

Once python is downloaded and installed, you can verify the version from your terminal/command window by typing `python --version`.

To run the script, you should switch to the FreeRTOS-Plus-TCP directory that was created using the *Cloning this repository* step above. And then run `python <Path/to/the/script>/GenerateOriginalFiles.py`.

## To consume FreeRTOS+TCP

**Consume with CMake** If using CMake, it is recommended to use this repository using FetchContent. Add the following into your project's main or a subdirectory's CMakeLists.txt:

- Define the source and version/tag you want to use:

```
FetchContent_Declare(freertos_plus_tcp
 GIT_REPOSITORY https://github.com/FreeRTOS/FreeRTOS-Plus-TCP.git
 GIT_TAG master #Note: Best practice to use specific git-hash or tagged version
 GIT_SUBMODULES "" # Don't grab any submodules since not latest
)
```

- Configure the FreeRTOS-Kernel and make it available
  - this particular example supports a native and cross-compiled build option.

```

set(FREERTOS_PLUS_FAT_DEV_SUPPORT OFF CACHE BOOL "" FORCE)
Select the native compile PORT
set(FREERTOS_PLUS_FAT_PORT "POSIX" CACHE STRING "" FORCE)
Select the cross-compile PORT
if (CMAKE_CROSSCOMPILING)
 # Eg. Zynq 2019_3 version of port
 set(FREERTOS_PLUS_FAT_PORT "ZYNQ_2019_3" CACHE STRING "" FORCE)
endif()

FetchContent_MakeAvailable(freertos_plus_tcp)

```

**Consuming stand-alone** This repository uses [Git Submodules](#) to bring in dependent components.

Note: If you download the ZIP file provided by GitHub UI, you will not get the contents of the submodules. (The ZIP file is also not a valid Git repository)

To clone using HTTPS:

```

git clone https://github.com/FreeRTOS/FreeRTOS-Plus-TCP.git ./FreeRTOS-Plus-TCP
cd ./FreeRTOS-Plus-TCP
git submodule update --checkout --init --recursive tools/CMock test/FreeRTOS-Kernel

```

Using SSH:

```

git clone git@github.com:FreeRTOS/FreeRTOS-Plus-TCP.git ./FreeRTOS-Plus-TCP
cd ./FreeRTOS-Plus-TCP
git submodule update --checkout --init --recursive tools/CMock test/FreeRTOS-Kernel

```

**Porting** The porting guide is available on [this page](#).

**Repository structure** This repository contains the FreeRTOS-Plus-TCP repository and a number of supplementary libraries for testing/PR Checks. Below is the breakdown of what each directory contains:

- tools
  - This directory contains the tools and related files (CMock/uncrustify) required to run tests/checks on the TCP source code.
- tests
  - This directory contains all the tests (unit tests and CBMC) and the dependencies ([FreeRTOS-Kernel/Litani-port](#)) the tests require.
- source/portable
  - This directory contains the portable files required to compile the FreeRTOS-Plus-TCP source code for different hardware/compilers.
- source/include
  - The include directory has all the ‘core’ header files of FreeRTOS-Plus-TCP source.
- source
  - This directory contains all the [.c] source files.

**Note** At this time it is recommended to use `BufferAllocation_2.c` in which case it is essential to use the `heap_4.c` memory allocation scheme. See [memory management](#).



**Kernel sources** The FreeRTOS Kernel Source is in [FreeRTOS/FreeRTOS-Kernel repository](#), and it is consumed by testing/PR checks as a submodule in this repository.

The version of the FreeRTOS Kernel Source in use could be accessed at `./test/FreeRTOS-Kernel` directory.

**CBMC** The `test/cbmc/proofs` directory contains CBMC proofs.

To learn more about CBMC and proofs specifically, review the training material [here](#).

In order to run these proofs you will need to install CBMC and other tools by following the instructions [here](#).