

MCUXpresso SDK USB Stack

User's Guide



Chapter 1

Overview

This document provides the following:

- Detailed steps to compile the USB examples, download a binary image, and run the examples.
- Detailed steps to port the USB Stack to a new platform.
- Detailed steps to develop a new application based on the existing classes in the USB Stack.

Chapter 2

Build the USB examples in MCUXpresso SDK

This section describes how to compile the USB stack and examples, download a binary image, and run the examples.

2.1 Requirements for building USB examples

The TWR-K22F120M Tower System module or FRDM-K64F Freedom platform is used as an example in this document. The process for compiling, downloading, and running examples is similar on all other boards. For a detailed version of the toolchain software, see the *MCUXpresso SDK Release Notes* (document MCUXSDKRN).

2.1.1 Hardware

- TWR-K22F120M Tower System module and (optional) TWR-SER Tower System module and Elevator
- MCUXpresso SDK Boards
- J-Link debugger (optional)
- USB cables

2.1.2 Software

- MCUXpresso SDK release package
- IAR Embedded Workbench for ARM® Version 8.11.3
- Keil µVision5 Integrated Development Environment Version 5.23 , available for ARM®Cortex®-M4 devices
- Kinetis Design Studio IDE v3.2
- MCUXpresso IDE v10.1.0
- Makefiles support with GCC revision 6-2017-q2-update from ARM Embedded

NOTE

The Kinetis Design Studio does not support LPC parts.

2.2 USB Code structure

The USB code is located in the folder:

<install_dir>/middleware/usb

Build the USB examples in MCUXpresso SDK
Compiling or running the USB stack and examples

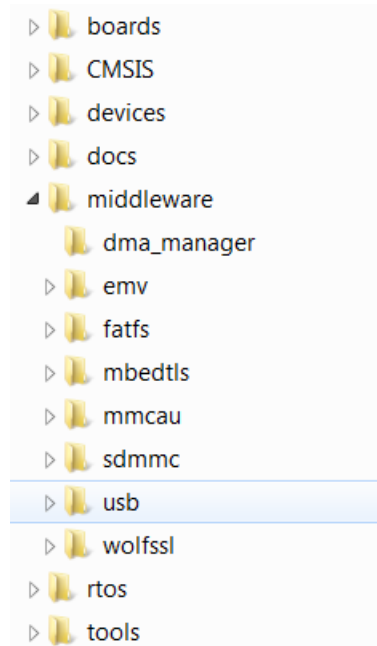


Figure 1. MCUXpresso SDK folder structure

The USB folder includes the source code for stack and examples. Note that the version number of the USB folder may vary.

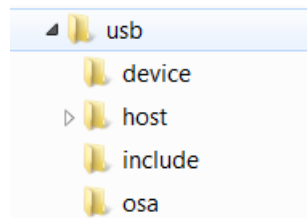


Figure 2. USB Folder Structure

The USB folder includes three subfolders:

- device
This subfolder includes the controller driver and common device driver for the USB device.
- include
This subfolder includes the definitions and structures for the USB stack.
- osa
This subfolder includes the adapter interfaces for various OSes.

NOTE

For different USB stack versions, the folder structure may be a little different. See the folder structure in the release package to get the exact folder structure.

2.3 Compiling or running the USB stack and examples

NOTE

The USB example maybe not support all compilers. The steps below just provide information on how to compile and run on all compilers. To know which compilers have support for the USB example, see the specific MCUXpresso SDK documentation.

2.3.1 Step-by-step guide for MCUXpresso IDE

1. Prepare a compressed release package , such as SDK_2.0_FRDM-K64F.zip.
2. Open MCUXpresso IDE and drag and drop the MCUXpresso SDK (zip file/folder) into the 'Installed SDKs'. The MCUXpresso SDK should install.

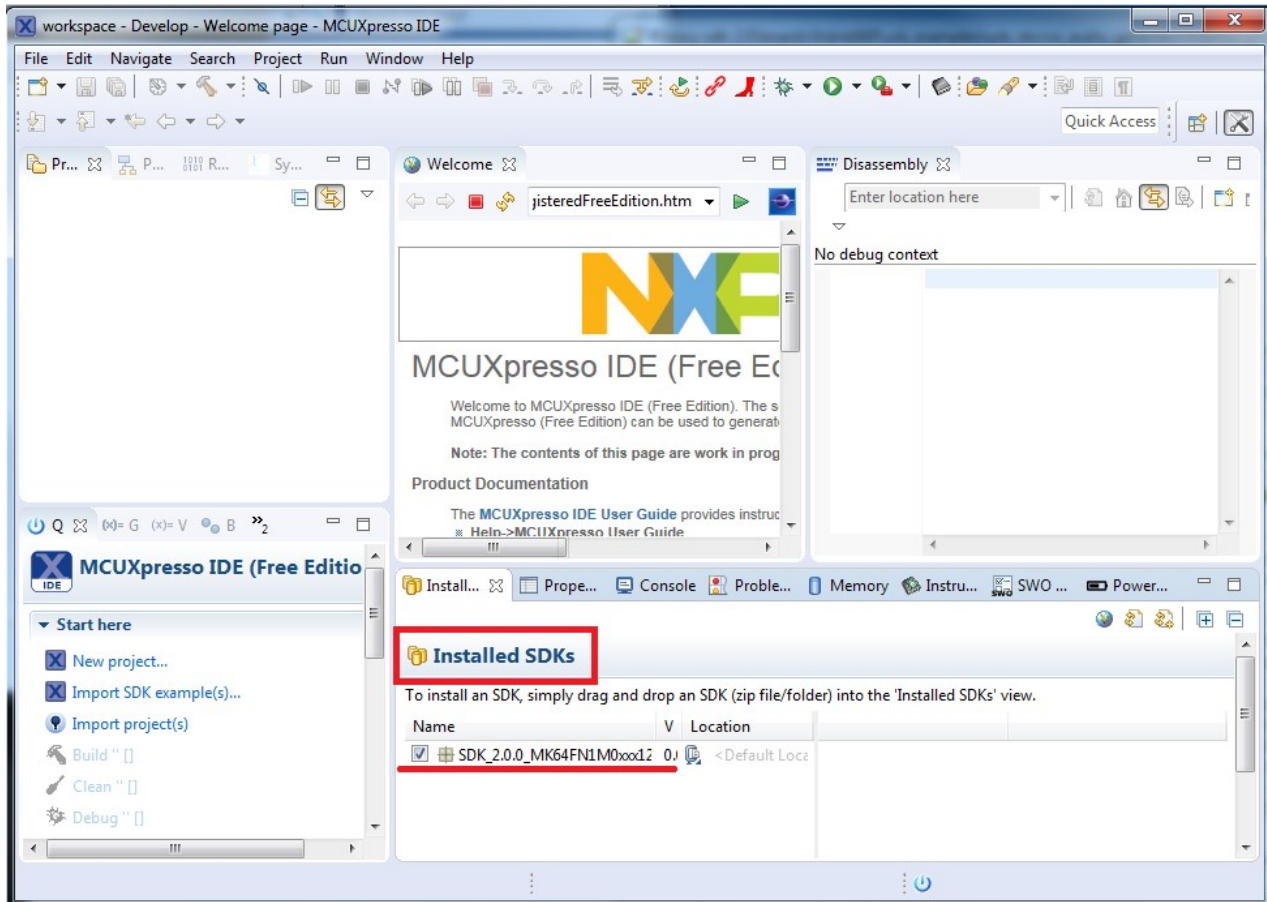


Figure 3. Installed SDK

3. To select an example, select the "Import SDK example(s) [To match the figure]" button. Click the "Next" button after selecting the available board.

Build the USB examples in MCUXpresso SDK
Compiling or running the USB stack and examples

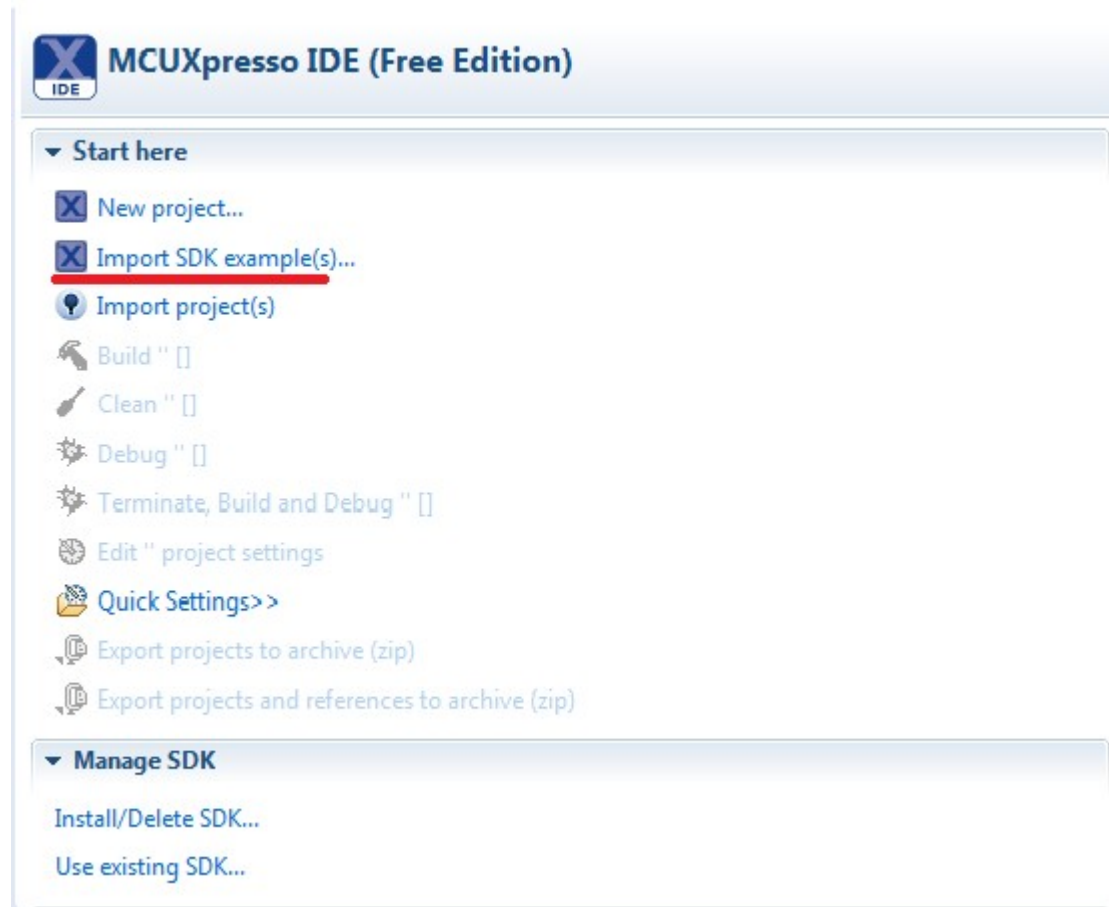


Figure 4. Import project button

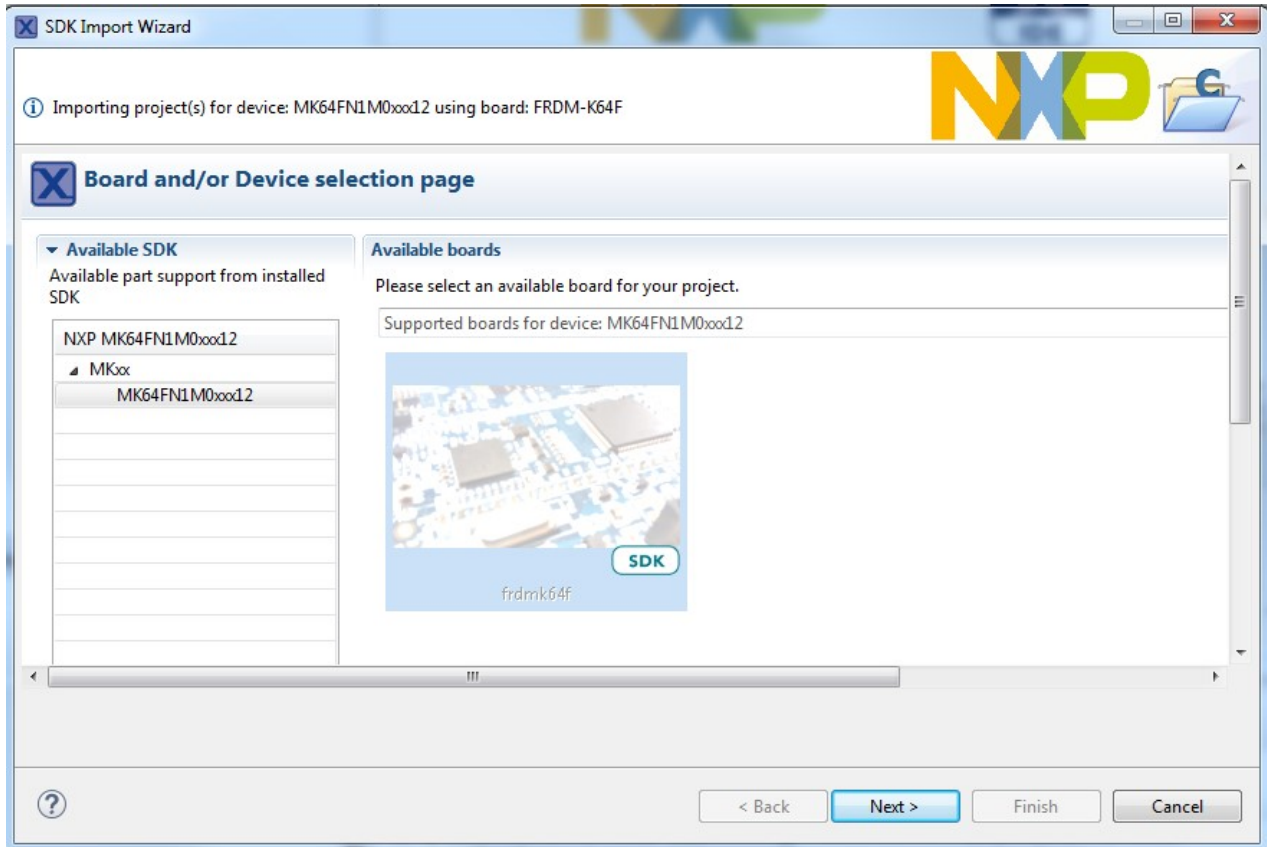


Figure 5. Select boards

4. To import one example, click the "Finish" button after selecting the available example.

Build the USB examples in MCUXpresso SDK
Compiling or running the USB stack and examples

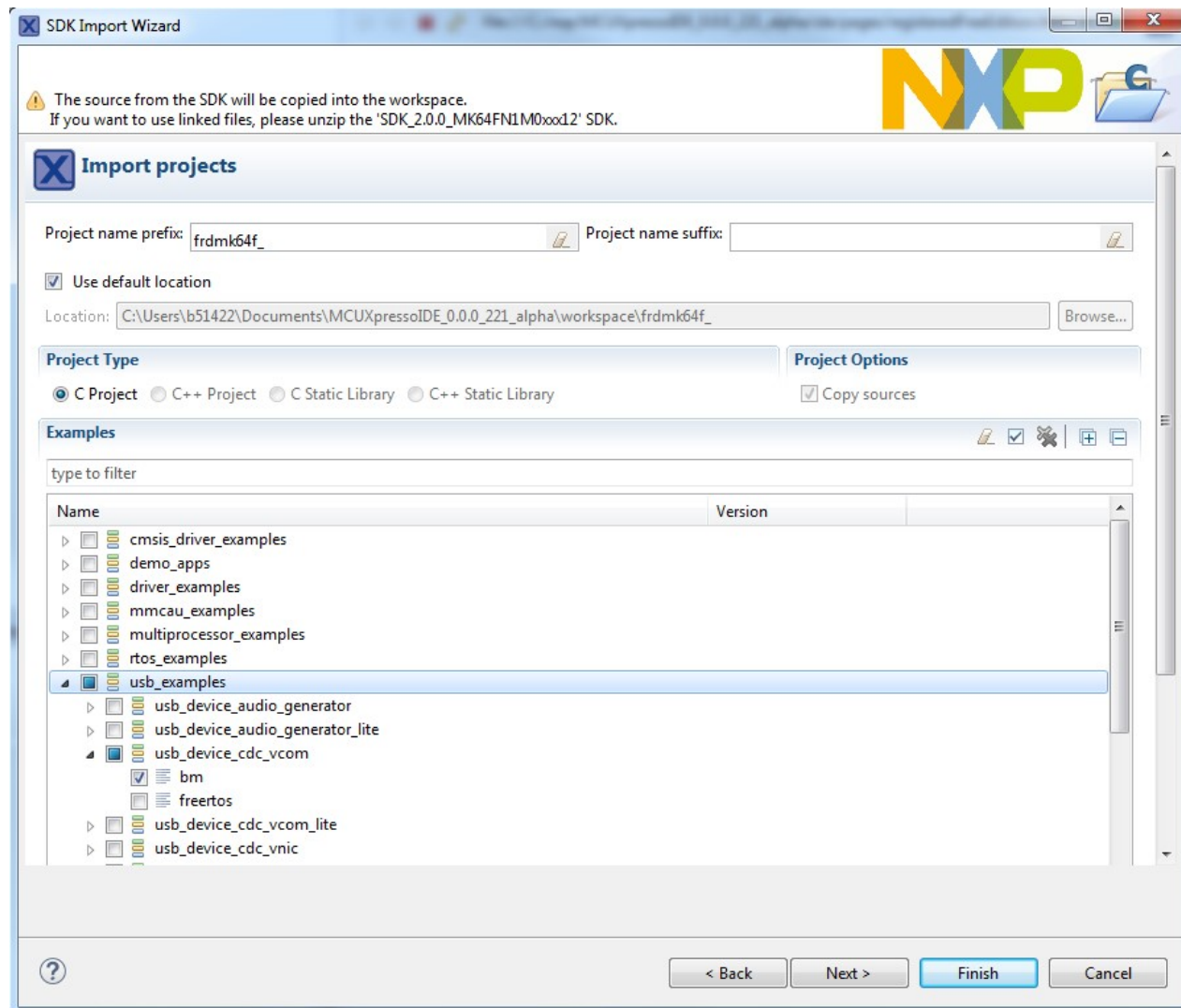


Figure 6. Import project

5. After importing, the window should look like the below figure.

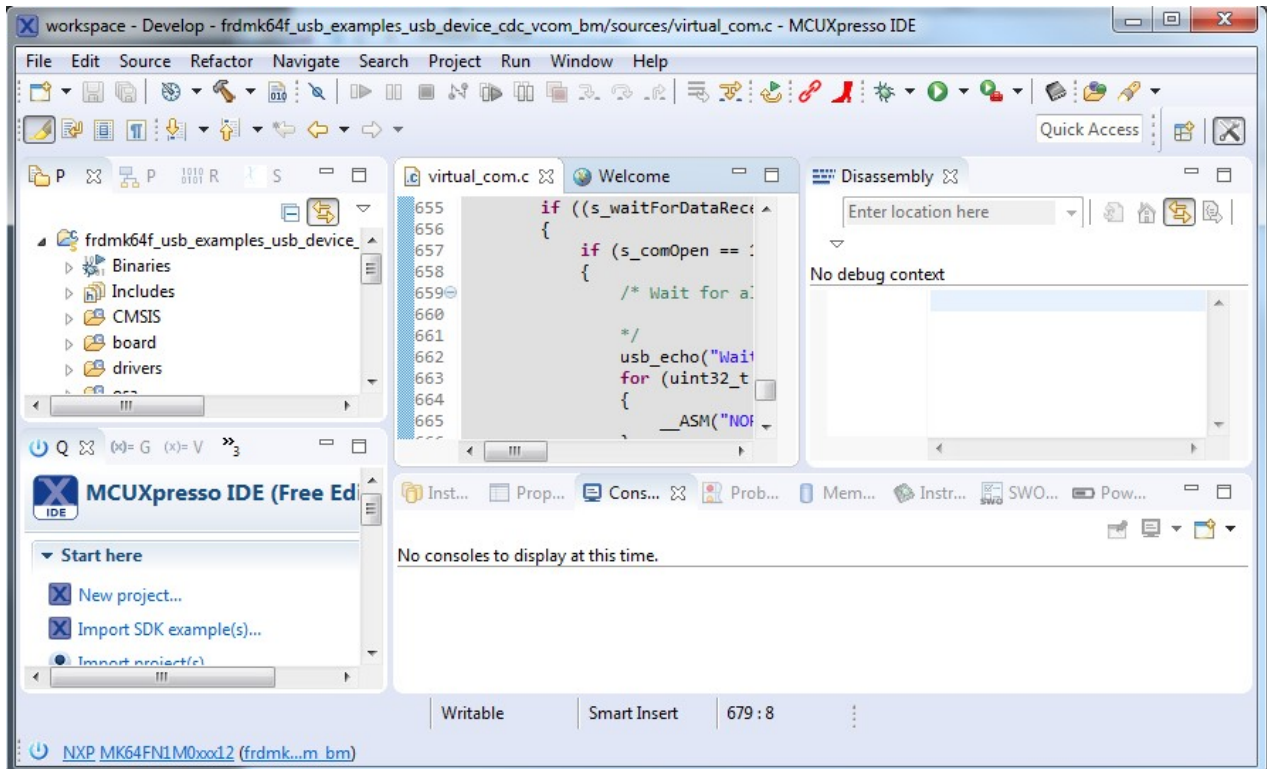


Figure 7. The USB projects workspace

6. Choose the appropriate build target, “Debug” or “Release”, by left-clicking the build configuration icon as show in the below figure.

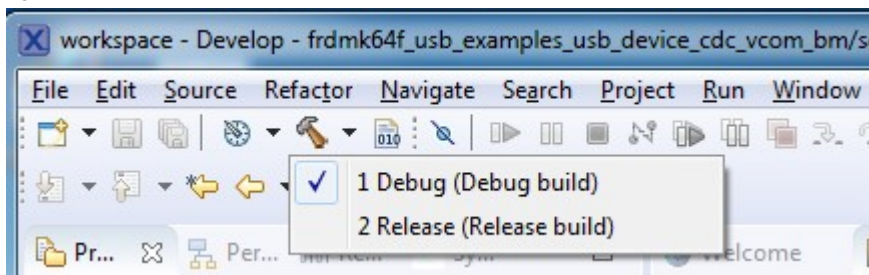


Figure 8. Manage build configuration button

7. If the project build does not begin after selecting the desired target, left-click the build icon to start the build.



Figure 9. Build project button

8. To check debugger configurations, click the down arrow next to the green debug button and select “Debug Configurations”

Build the USB examples in MCUXpresso SDK
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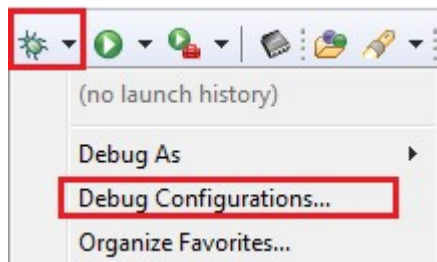


Figure 10. Configure debug button

9. After verifying the debugger configurations are correct, click the “Debug” button.

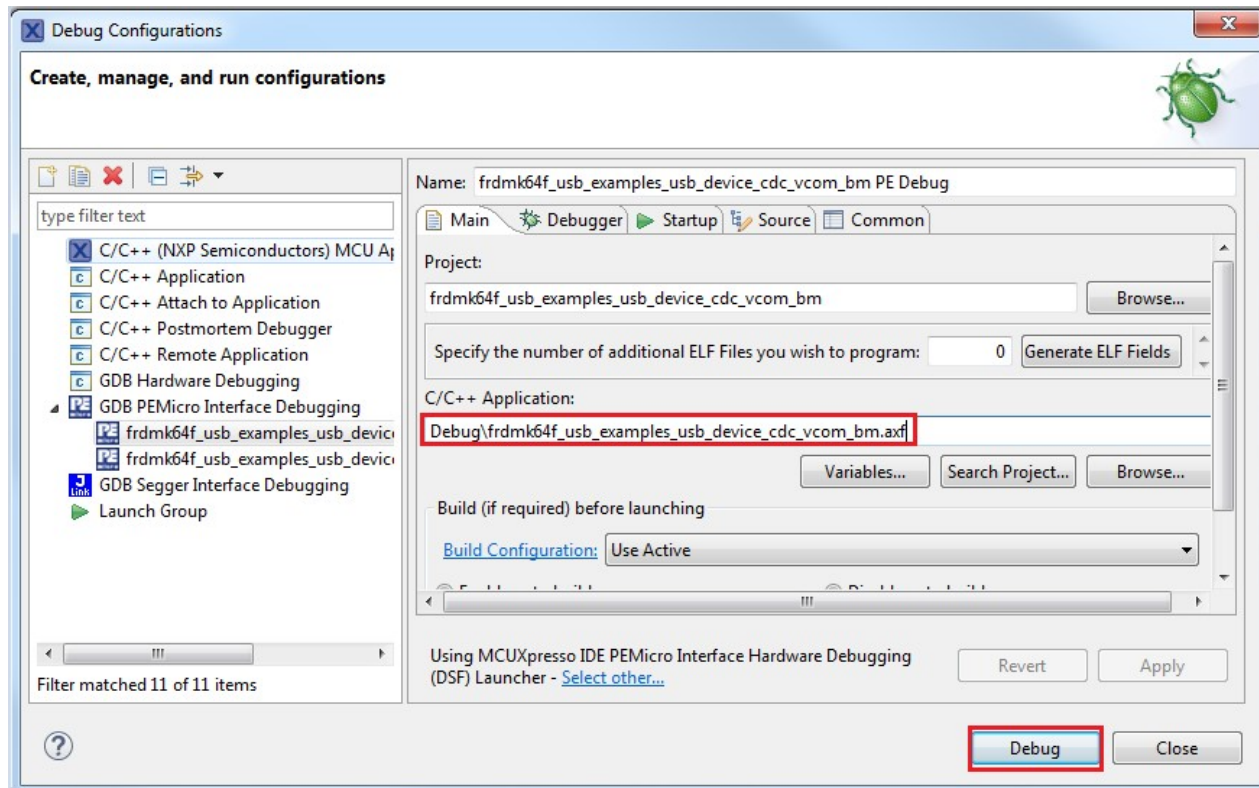


Figure 11. MCUXpresso IDE debug configurations

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

11. Run the code by clicking the “Resume” button to start the application:

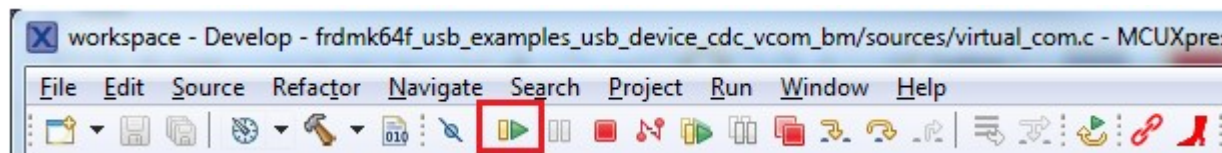


Figure 12. Resume button

12. See the example-specific document for more test information.

2.3.2 Step-by-step guide for IAR

This section shows how to use IAR. Open IAR as shown in this figure:

1. Open the workspace corresponding to different examples.

For example, the workspace file is located at: *<install_dir>/boards/twrk22f120m/usb_examples/usb_host_hid_mouse/bm/iar/host_hid_mouse_bm.eww*.

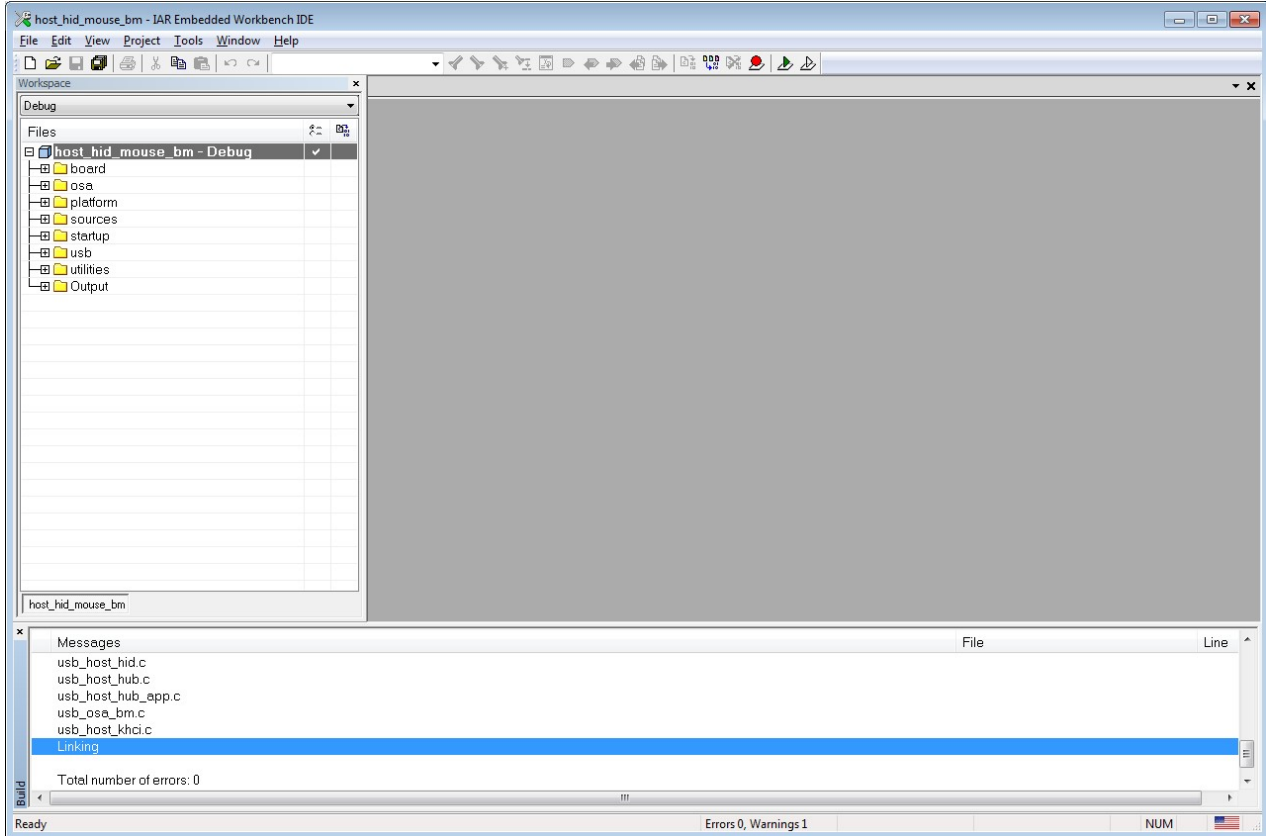


Figure 13. IAR workspace

2. Build the host_hid_mouse_bm example.
3. Connect the micro USB cable from a PC to the J25 of the TWR-K22F120M Tower System module to power on the board.
4. Click the “Download and Debug” button. Wait for the download to complete.
5. Click the “Go” button to run the example.
6. See the example-specific readme.pdf for more test information.

2.3.3 Step-by-step guide for Keil μ Vision5

This section shows how to use Keil μ Vision5. Open Keil μ Vision5 as shown in this figure:

1. Open the workspace corresponding to different examples.

For example, the workspace file is located in *<install_dir>/boards/twrk22f120m/usb_examples/usb_host_hid_mouse/bm/mdk/host_hid_mouse_bm.uvmpw*.

Build the USB examples in MCUXpresso SDK
Compiling or running the USB stack and examples

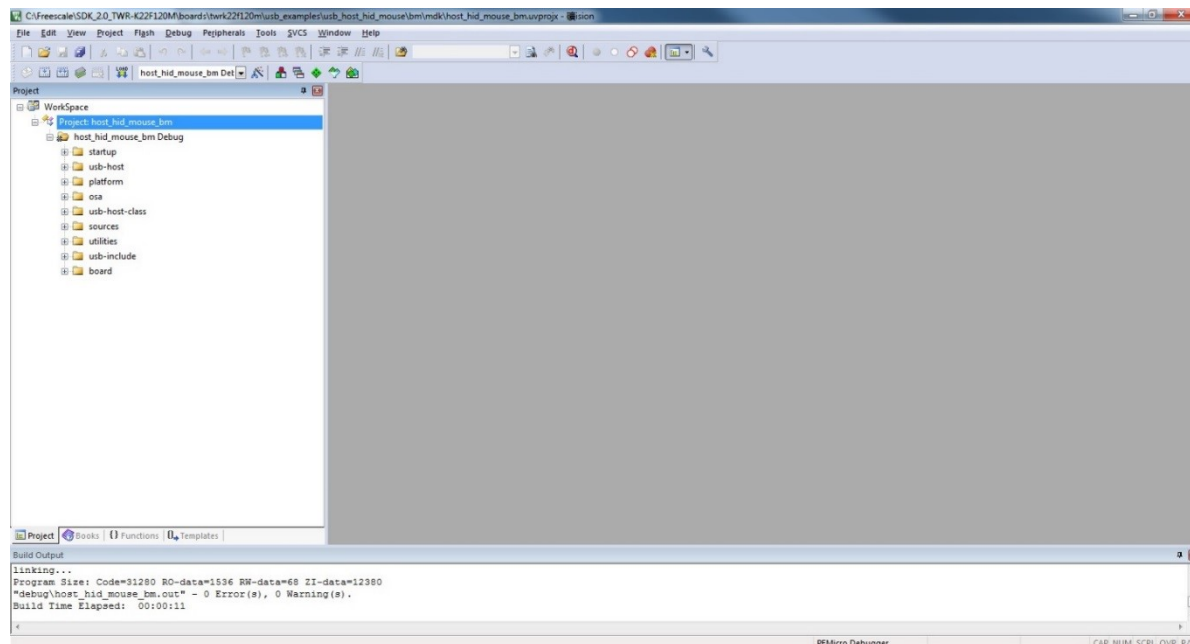


Figure 14. Keil uVision5 Workspace

2. Build the host_hid_mouse_bm example.
3. Click the “Start/Stop” debug session button. Wait for the download to complete.
4. Click the “Go” button to run the example.
5. See the example-specific readme.pdf for more test information.

2.3.4 Step-by-step guide for Kinetis Design Studio IDE

1. Unlike IAR or Keil, the Kinetis Design Studio does not have a workspace. Create a workspace and import Kinetis Design Studio USB examples.
2. Select “File” and “Import” from the KDS IDE Eclipse menu.
3. Expand the General folder and select “Existing Projects into Workspace”. Then, click the “Next” button.

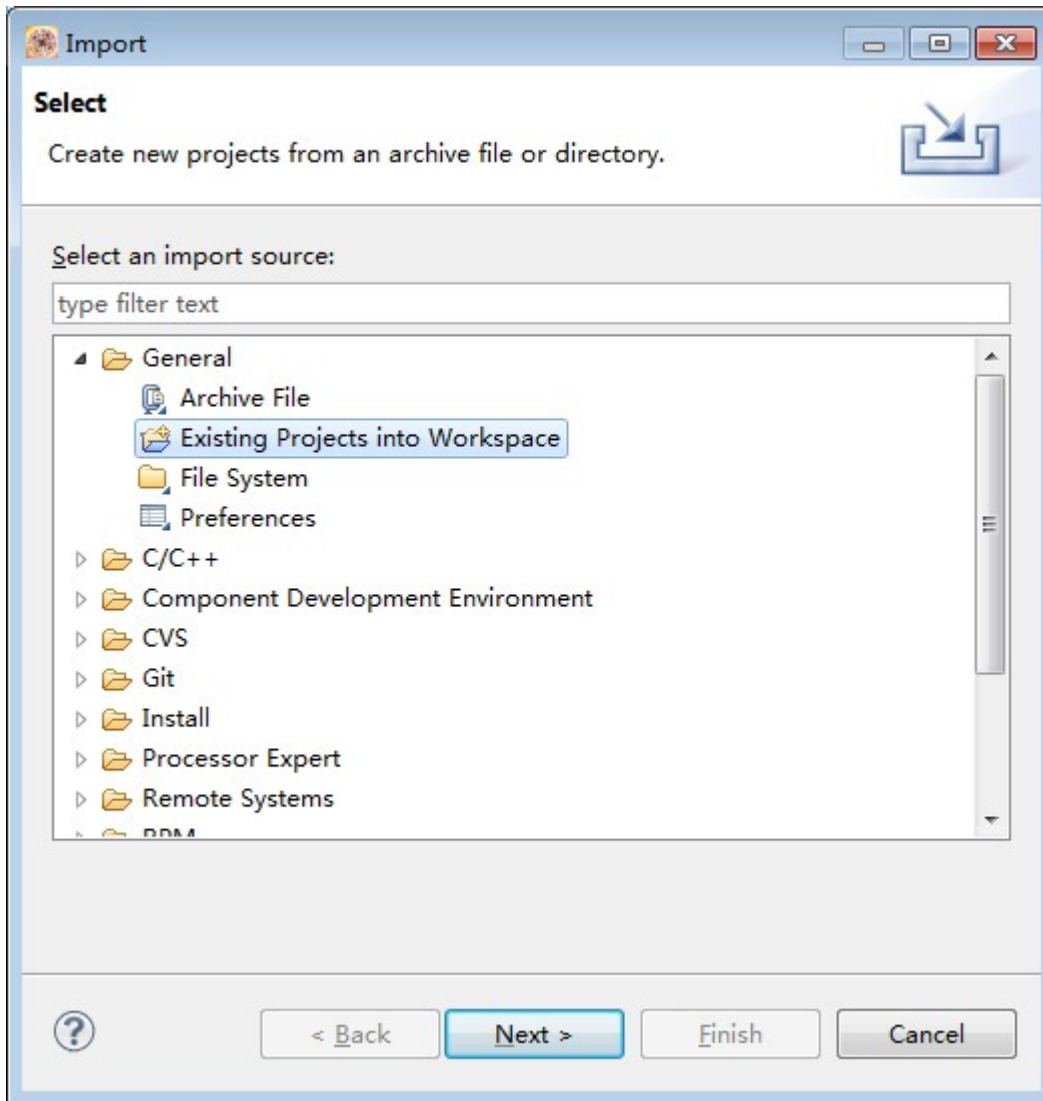


Figure 15. Selection of the correct import type in the KDS IDE

4. Point the KDS IDE to the *host_hid_mouse_bm* project in the K22, which is located in the *<install_dir>/boards/twrk22f120m/usb_examples/usb_host_hid_mouse/bm/kds*. The import projects directory selection window should resemble this figure.

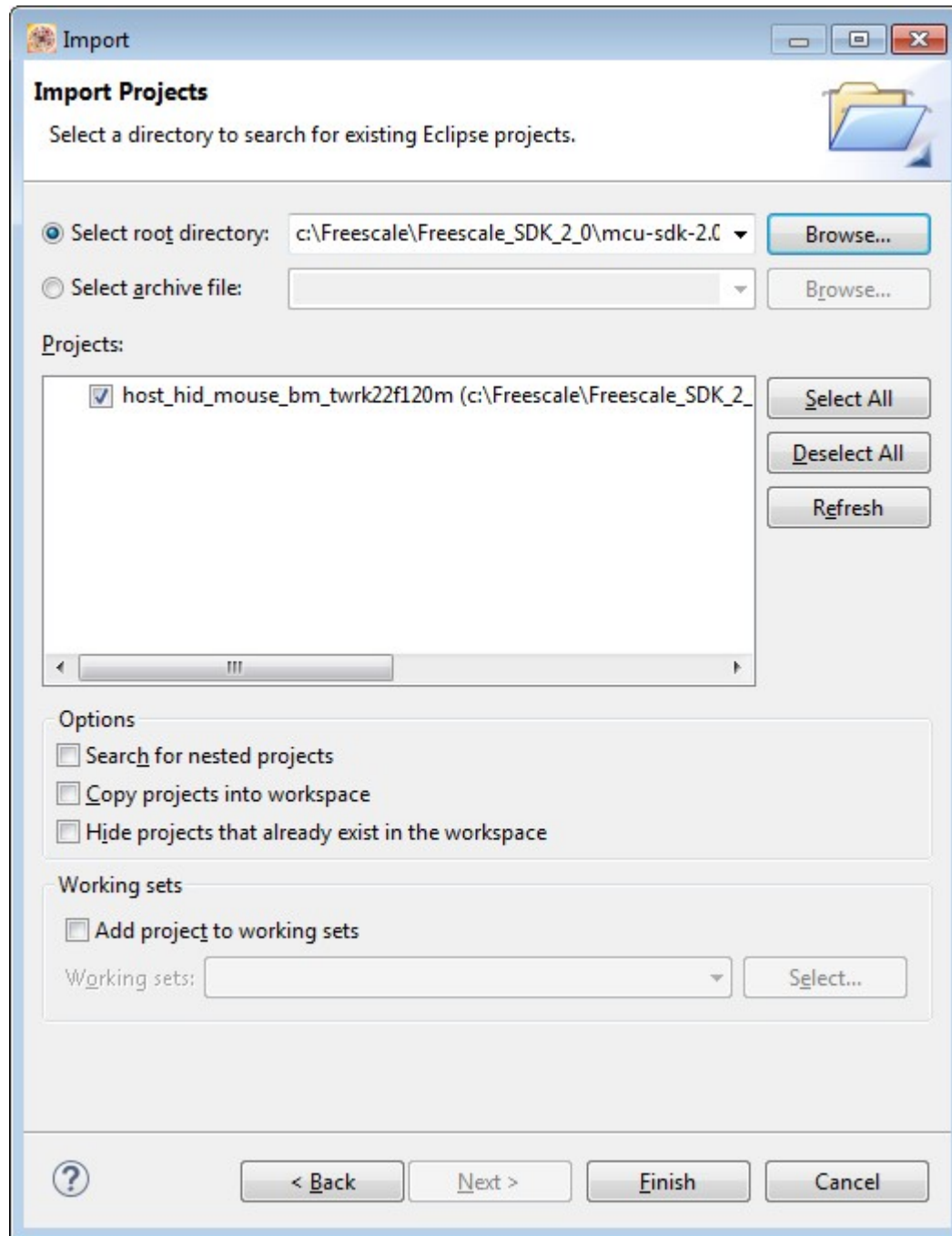


Figure 16. Selection of the K22 host_hid_mouse_bm project

5. After importing, the window should look like this.

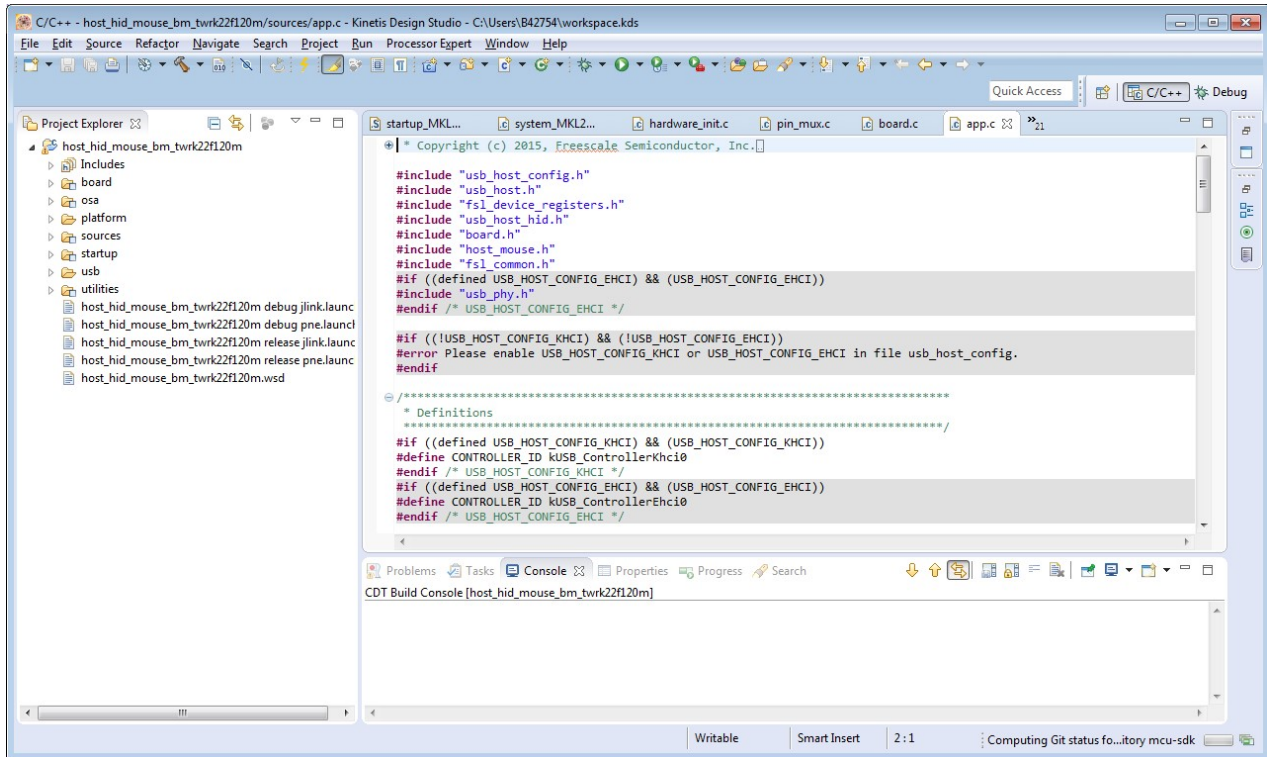


Figure 17. The USB projects workspace

6. Choose the appropriate build target: “Debug” or “Release” by left-clicking the arrow next to the hammer icon as shown here.

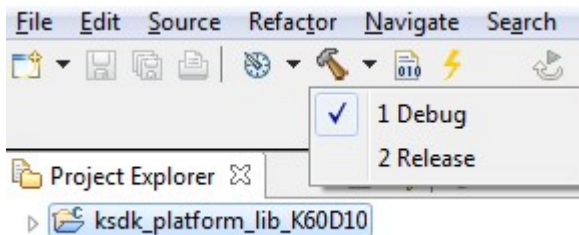


Figure 18. The hammer button

7. If the project build does not begin after selecting the desired target, left-click the hammer icon to start the build.
8. To check the debugger configurations, click the down arrow next to the green debug button and select “Debug Configurations”.



Figure 19. Debug configurations

9. After verifying that the debugger configurations are correct, click the “Debug” button.

Build the USB examples in MCUXpresso SDK
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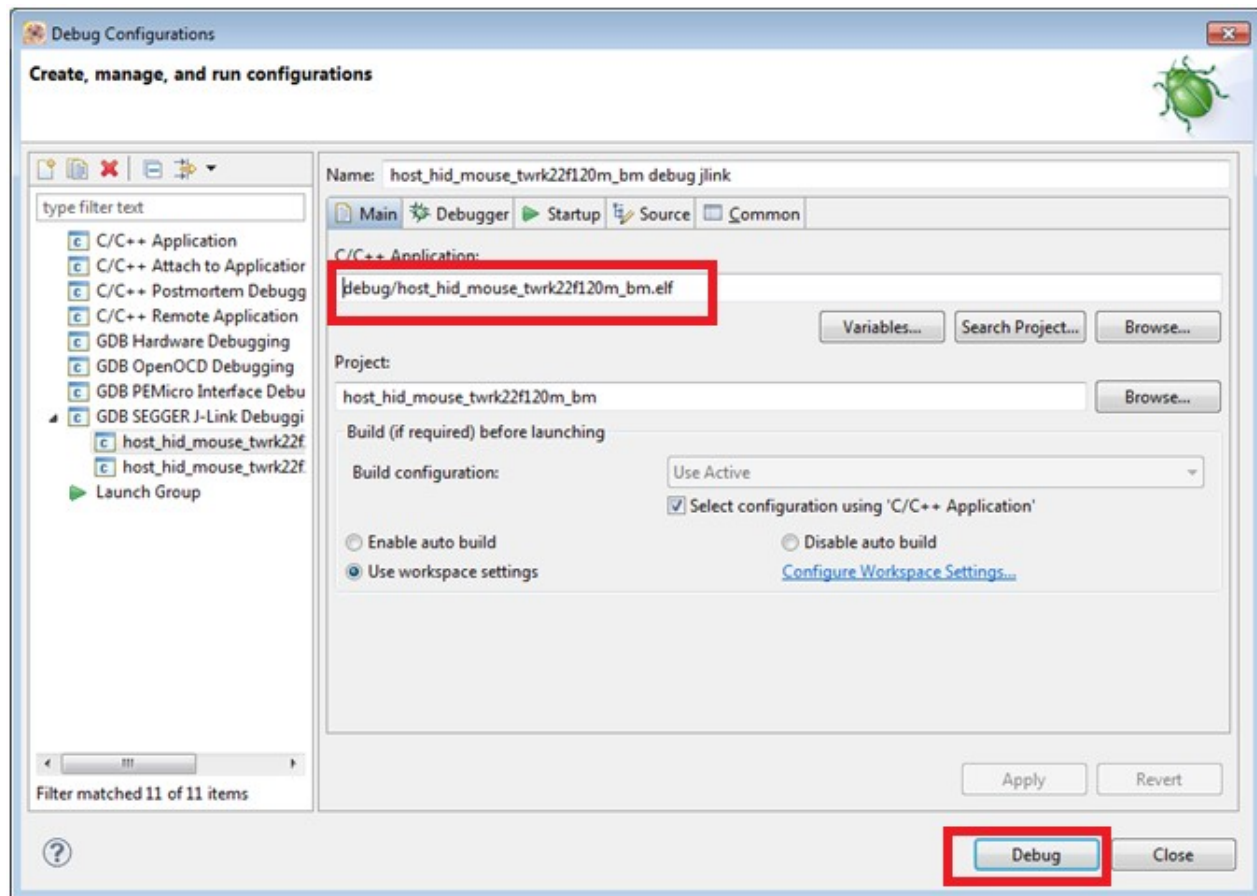


Figure 20. Kinetis Design Studio Debug configurations

10. The application is downloaded to the target and automatically run to main():
11. Run the code by clicking the “Resume” button to start the application:

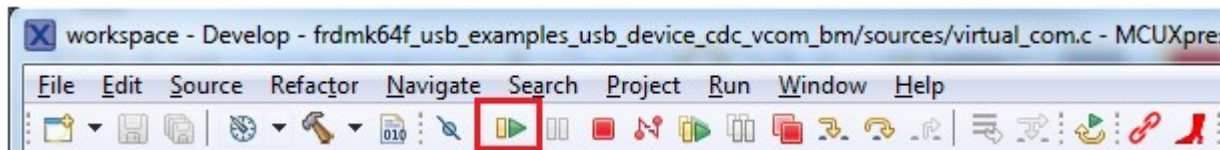


Figure 21. Resume button

12. See the example-specific document for more test information.

2.3.5 Step-by-step guide for ARM GCC

2.3.5.1 Setup tool chains

2.3.5.2 Install GCC ARM embedded tool chain

Download and install the installer from www.launchpad.net/gcc-arm-embedded.

2.3.5.3 Install MinGW

1. Download the latest mingw-get-setup.exe.

2. Install the GCC ARM Embedded toolchain. The recommended path is C:/MINGW. However, you may install to any location. Note that the installation path may not contain a space.
3. Ensure that the mingw32-base and msys-base are selected under Basic Setup.
4. Finally, click "Installation" and "Apply changes".

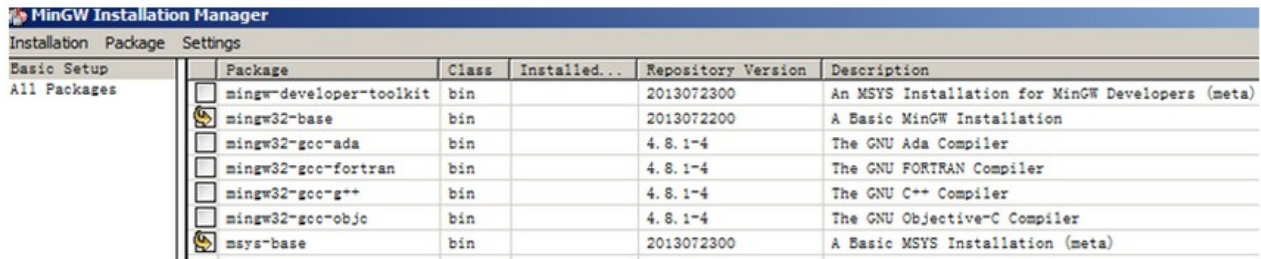


Figure 22. Setup MinGW and MSYS

5. Add paths C:/MINGW/msys/1.0/bin;C:/MINGW/bin to the system environment. Note that, if the GCC ARM Embedded tool chain was installed somewhere other than the recommended location, the system paths added should reflect this change. An example using the recommended installation locations are shown below.

NOTE

There is a high chance that, if the paths are not set correctly, the tool chain will not work properly.

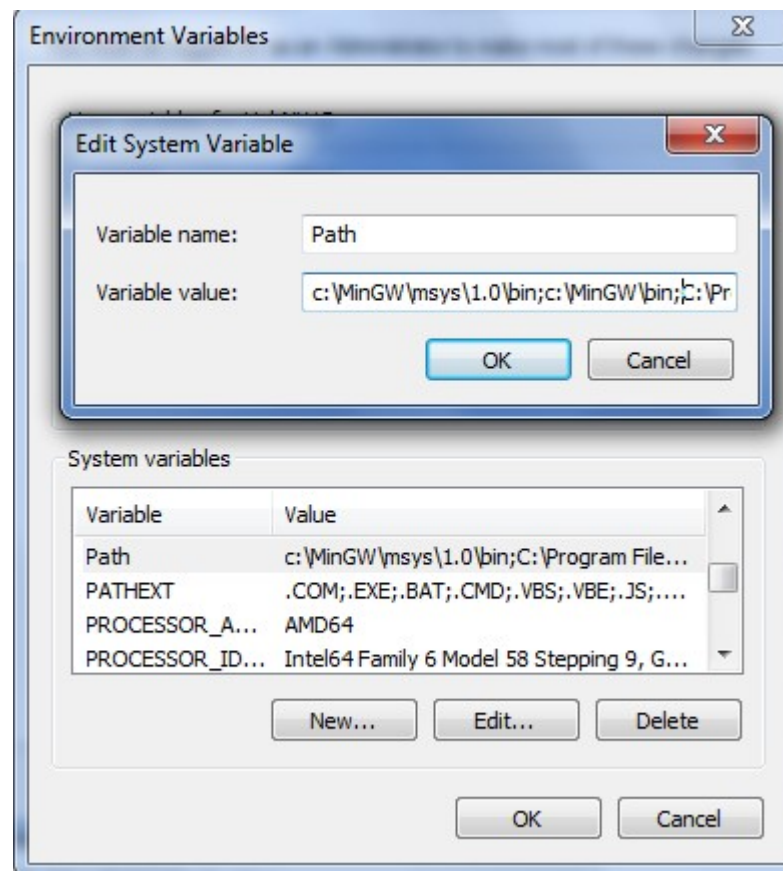


Figure 23. Add Path to systems environment

2.3.5.4 Add new system environment variable ARMGCC_DIR

Create a new system environment variable ARMGCC_DIR. The value of this variable should be the short name of the ARM GCC Embedded tool chain installation path.

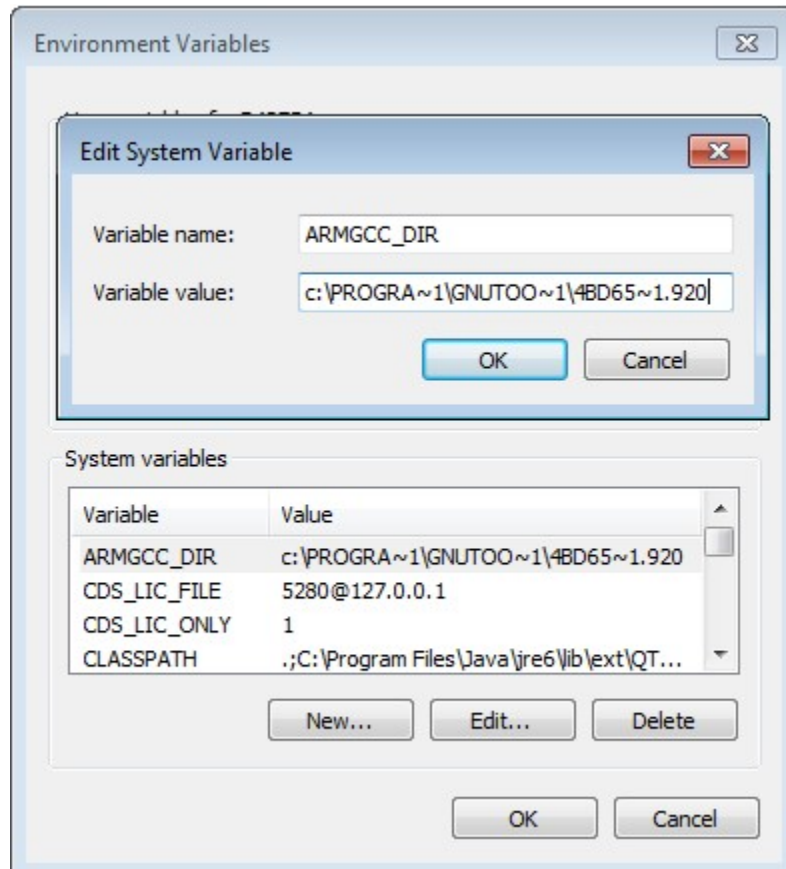


Figure 24. Add ARMGCC_DIR system variable

2.3.5.5 Install CMake

1. Download CMake 3.0.1 from www.cmake.org/cmake/resources/software.html.
2. Install Cmake 3.0.1 and ensure that the option "Add CMake to system PATH" is selected.

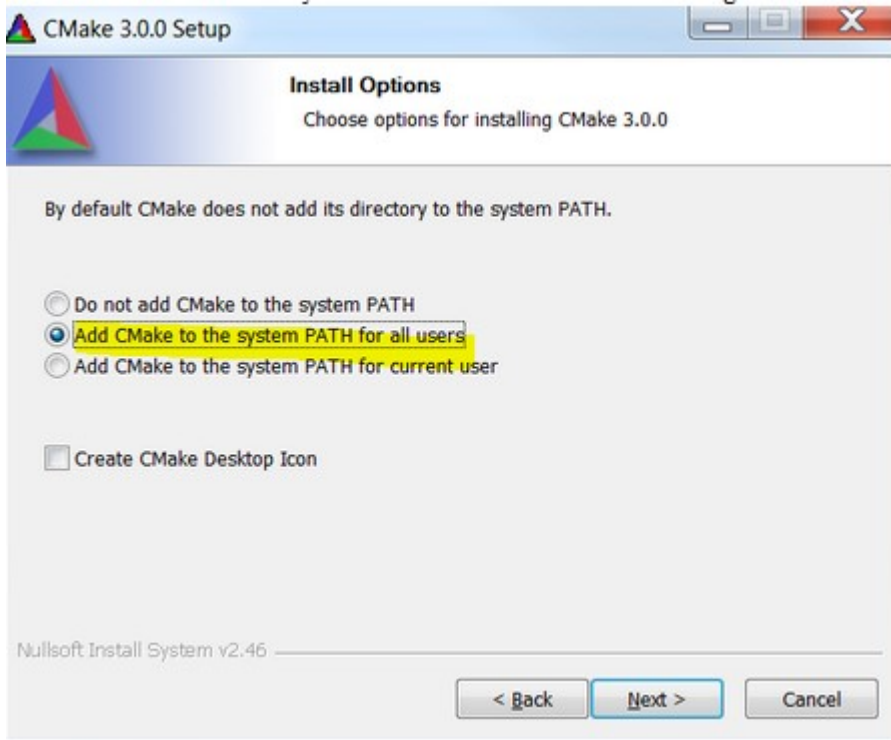


Figure 25. Install CMake

2.3.5.6 Build the USB demo

1. Change the directory to the project directory:
2. `<install_dir>/boards/twrk22f120m/usb_examples/usb_host_hid_mouse/bm/armgcc`. Run the `build_all.bat`. The build output is shown in this figure:

Build the USB examples in MCUXpresso SDK
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```
[ 77%] Building C object CMakeFiles/host_hid_mouse_bm.elf.dir/C:/Freescale/Freescale_SDK_2_0/mcu-sdk-2.0/platform/drivers/gpio/fsl_gpio.c.obj
[ 81%] Building C object CMakeFiles/host_hid_mouse_bm.elf.dir/C:/Freescale/Freescale_SDK_2_0/mcu-sdk-2.0/platform/drivers/common/fsl_common.c.obj
[ 85%] [ 88%] Building C object CMakeFiles/host_hid_mouse_bm.elf.dir/C:/Freescale/Freescale_SDK_2_0/mcu-sdk-2.0/examples/twrk22f120m/board.c.obj
Building C object CMakeFiles/host_hid_mouse_bm.elf.dir/C:/Freescale/Freescale_SDK_2_0/mcu-sdk-2.0/examples/twrk22f120m/lock_config.c.obj
[ 92%] [ 96%] Building C object CMakeFiles/host_hid_mouse_bm.elf.dir/C:/Freescale/Freescale_SDK_2_0/mcu-sdk-2.0/examples/twrk22f120m/usb/usb_host_hid_mouse/bm/hardware_init.c.obj
Building C object CMakeFiles/host_hid_mouse_bm.elf.dir/C:/Freescale/Freescale_SDK_2_0/mcu-sdk-2.0/examples/twrk22f120m/usb/usb_host_hid_mouse/bm/pin_mux.c.obj
[100%] Building C object CMakeFiles/host_hid_mouse_bm.elf.dir/C:/Freescale/Freescale_SDK_2_0/mcu-sdk-2.0/platform/drivers/smc/fsl_smc.c.obj
C:\Freescale\Freescale_SDK_2_0\mcu-sdk-2.0\platform\drivers\smc\fsl_smc.c: In function 'SMC_SetPowerModeStop':
C:\Freescale\Freescale_SDK_2_0\mcu-sdk-2.0\platform\drivers\smc\fsl_smc.c:83:23: warning: variable 'dummyRead' set but not used [-Wunused-but-set-variable]
    volatile uint32_t dummyRead;
                        ^
C:\Freescale\Freescale_SDK_2_0\mcu-sdk-2.0\platform\drivers\smc\fsl_smc.c: In function 'SMC_SetPowerModeU1ps':
C:\Freescale\Freescale_SDK_2_0\mcu-sdk-2.0\platform\drivers\smc\fsl_smc.c:168:23: warning: variable 'dummyRead' set but not used [-Wunused-but-set-variable]
    volatile uint32_t dummyRead;
                        ^
C:\Freescale\Freescale_SDK_2_0\mcu-sdk-2.0\platform\drivers\smc\fsl_smc.c: In function 'SMC_SetPowerModeL1s':
C:\Freescale\Freescale_SDK_2_0\mcu-sdk-2.0\platform\drivers\smc\fsl_smc.c:204:23: warning: variable 'dummyRead' set but not used [-Wunused-but-set-variable]
    volatile uint32_t dummyRead;
                        ^
C:\Freescale\Freescale_SDK_2_0\mcu-sdk-2.0\platform\drivers\smc\fsl_smc.c: In function 'SMC_SetPowerModeU1ls':
C:\Freescale\Freescale_SDK_2_0\mcu-sdk-2.0\platform\drivers\smc\fsl_smc.c:253:23: warning: variable 'dummyRead' set but not used [-Wunused-but-set-variable]
    volatile uint32_t dummyRead;
                        ^
Linking C executable release\host_hid_mouse_bm.elf
[100%] Built target host_hid_mouse_bm.elf
```

Figure 26. USB host demo built successfully

2.3.5.7 Run a demo application

This section describes steps to run a demo application using J-Link GDB Server application.

1. Connect the J-Link debug port to the SWD/JTAG connector of the board.
2. Open the J-Link GDB Server application and modify your connection settings as shown in this figure.

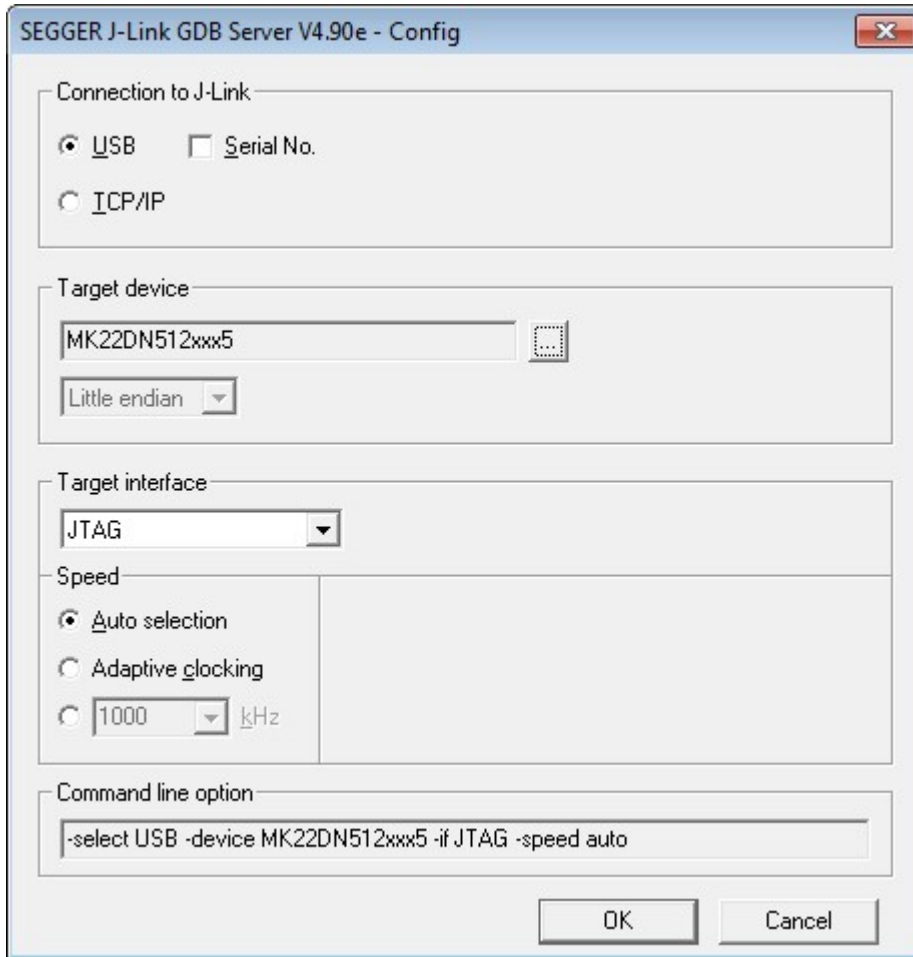


Figure 27. SEGGER J-Link GDB Server configuration

NOTE

The target device selection should be MK22FN512xxx12. The target interface should be SWD.

3. After connected, the screen should resemble this figure:

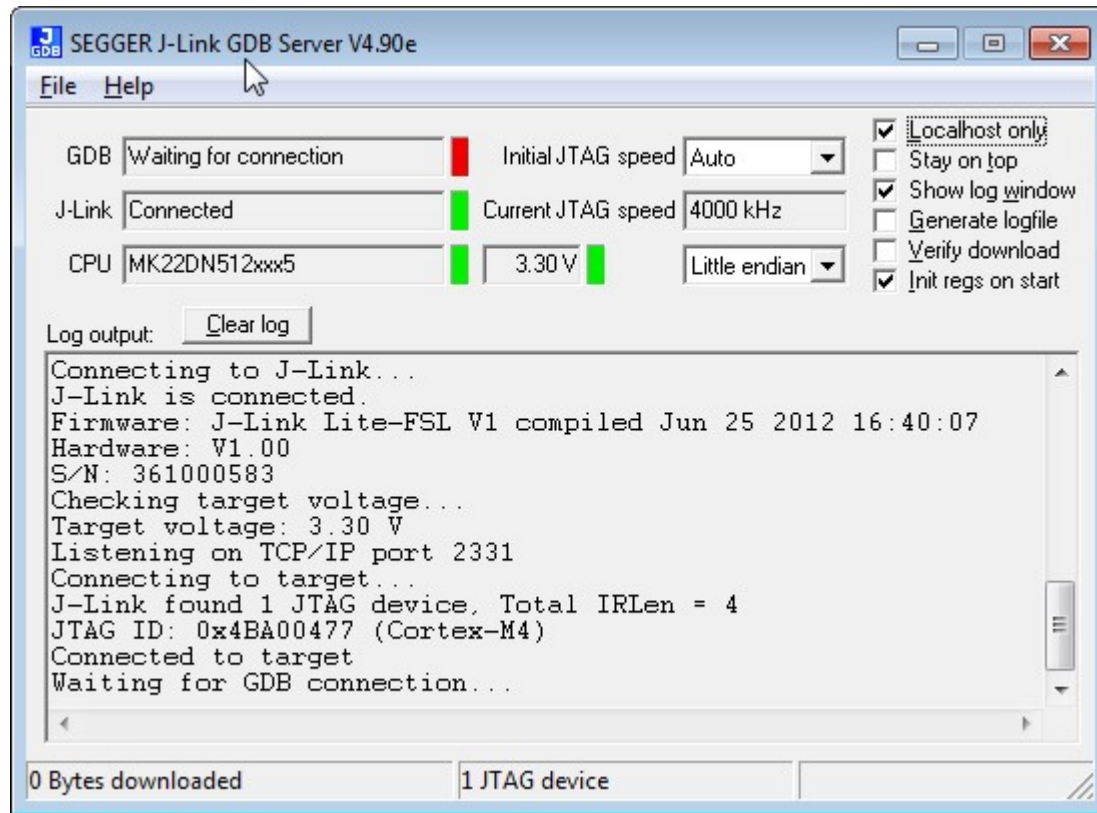


Figure 28. SEGGER J-Link GDB Server screen after successful connection

NOTE

The CPU selection should be CPU to: MK22FN512xxx12.

4. Open the ARM GCC command prompt and change the directory to the output directory of the desired demo. For this example, the directory is:
`<install_dir>/boards/twrk22f120m/usb_examples/usb_host_hid_mouse/bm/armgcc/debug.`
5. Run the command "arm-none-eabi-gdb.exe <DEMO_NAME>.elf". Run these commands:
 - "target remote localhost: 2331"
 - "monitor reset"
 - "monitor halt"
 - "load"
 - "monitor reset"
6. The application is downloaded and connected. Execute the "monitor go" command to start the demo application.
7. See the example-specific document for more test information.

2.4 USB stack configuration

2.4.1 Device configuration

A device configuration file is set up for each example, such as:

`<install_dir>/boards/twrk22f120m/usb_examples/usb_host_hid_mouse`

This file is used to either enable or disable the USB class driver and to configure the interface type (high-speed or full speed). The object number is configurable either to decrease the memory usage or to meet specific requirements.

If the device stack configuration is changed, rebuild the example projects. For each device, follow these steps.

If the board is a Tower or Freedom platform, enable the following macros:

Enable this macro for full speed.

`#define USB_DEVICE_CONFIG_KHCI (0U)`

Enable this macro if the board supports high-speed.

`#define USB_DEVICE_CONFIG_EHCI (0U)`

If board is part of the LPC series, enable the following macros:

Enable this macro for full speed.

`#define USB_DEVICE_CONFIG_LPCIP3511FS (0U)`

Enable this macro if the board supports high-speed.

`#define USB_DEVICE_CONFIG_LPCIP3511HS (0U)`

2.4.2 Host configuration

A host configuration file is set up for each example, such as:

`<install_dir>/boards/twrk22f120m/usb/usb_host_hid_mouse/bm/usb_host_config.h`

This file is used to either enable or disable the USB class driver. The object number is configurable either to decrease the memory usage or to meet specific requirements.

If the Host stack configuration is changed, rebuild the example projects.

For each Host, follow these steps.

If the board is a Tower for Freedom platform, enable the following macros:

Enable this macro for full speed.

`#define USB_HOST_CONFIG_KHCI (0U)`

Enable this macro if the board supports high-speed.

`#define USB_HOST_CONFIG_EHCI (0U)`

If board is part of the LPC series, enable the following macros:

Enable this macro for full speed.

`#define USB_HOST_CONFIG_OHCI (0U)`

Enable this macro if the board supports high-speed.

`#define USB_HOST_CONFIG_IP3516HS (0U)`

2.4.3 USB OSA Resource configuration

In the USB stack, some static resources for USB OSA, such as event and message, are defined. The user should update the configuration number if the resource is not enough.

For bare metal, the related macro is in `usb_osa_bm.c`.

Build the USB examples in MCUXpresso SDK
USB stack configuration

```
#define USB_OSA_BM_EVENT_COUNT (2U)
#define USB_OSA_BM_SEM_COUNT (1U)
#define USB_OSA_BM_MSGQ_COUNT (1U)
#define USB_OSA_BM_MSG_COUNT (8U)
#define USB_OSA_BM_MSG_SIZE (4U)
```

For FreeRTOS OS, if the configSUPPORT_STATIC_ALLOCATION macro is enabled, the related macro is in usb_osa_freertos.c.

```
#define USB_OSA_FREERTOS_EVENT_COUNT (2U)
#define USB_OSA_FREERTOS_SEM_COUNT (1U)
#define USB_OSA_FREERTOS_MUTEX_COUNT (3U)
#define USB_OSA_FREERTOS_MSGQ_COUNT (1U)
#define USB_OSA_FREERTOS_MSG_COUNT (8U)
#define USB_OSA_FREERTOS_MSG_SIZE (4U)
```

2.4.4 USB cache related MACROs definitions

There are few MACROs in the USB stack to define USB data attributes.

- USB_STACK_USE_DEDICATED_RAM
Configure USB stack to uses dedicated RAM or not, its values are as follow:
 1. USB_STACK_DEDICATED_RAM_TYPE_BDT_GLOBAL - it means USB device global variables (controller data and device stack data) are put into the USB dedicated RAM.
 2. USB_STACK_DEDICATED_RAM_TYPE_BDT - it means USB device controller global variables (BDT data) are put into the USB dedicated RAM.
 3. 0 - There is no USB dedicated RAM.
- USB_DEVICE_CONFIG_BUFFER_PROPERTY_CACHEABLE
Configure device stack cache enable or not, its values are as follow:
 - 0: disabled
 - 1: enable
- USB_HOST_CONFIG_BUFFER_PROPERTY_CACHEABLE
Configure host stack cache enable or not, its values are as follow:
 - 0: disable
 - 1: enable

Based on the above MACROs, the follow cache related MACROs are defined in the USB stack.

	USB_DEVICE_CONFIG_BUFFER_PROPERTY_CACHEABLE USB_HOST_CONFIG_BUFFER_PROPERTY_CACHEABLE	
USB_STACK_USE_DEDICATED_RA M's Value	1	0

Table continued from the previous page...

USB_STACK_DEDICATED_RAM_TY PE_BDT_GLOBAL	USB_GLOBAL	dedicated ram, stack use only	USB_GLOBAL	dedicated ram, stack use only
	USB_BDT	dedicated ram, stack use only	USB_BDT	dedicated ram, stack use only
	USB_CONTROLL ER_DATA	NonCachable, stack use only	USB_CONTROLL ER_DATA	dedicated ram, stack use only
	USB_DMA_NONI NIT_DATA_ALIG N(n)	cachable ram & alignment	USB_DMA_NONI NIT_DATA_ALIG N(n)	alignment
	USB_DMA_INIT_ DATA_ALIGN(n)	cachable ram & alignment	USB_DMA_INIT_ DATA_ALIGN(n)	alignment
USB_STACK_DEDICATED_RAM_TY PE_BDT	USB_GLOBAL	cachable ram & alignment, stack use only	USB_GLOBAL	Put in bss, stack use only
	USB_BDT	dedicated ram, stack use only	USB_BDT	dedicated ram, stack use only
	USB_CONTROLL ER_DATA	NonCachable, stack use only	USB_CONTROLL ER_DATA	NULL, stack use only
	USB_DMA_NONI NIT_DATA_ALIG N(n)	cachable ram & alignment	USB_DMA_NONI NIT_DATA_ALIG N(n)	alignment
	USB_DMA_INIT_ DATA_ALIGN(n)	cachable ram & alignment	USB_DMA_INIT_ DATA_ALIGN(n)	alignment
0	USB_GLOBAL	cachable ram & alignment, stack use only	USB_GLOBAL	Put in bss, stack use only
	USB_BDT	NonCachable, stack use only	USB_BDT	Put in bss, stack use only
	USB_CONTROLL ER_DATA	NonCachable, stack use only	USB_CONTROLL ER_DATA	NULL, stack use only
	USB_DMA_NONI NIT_DATA_ALIG N(n)	cachable ram & alignment	USB_DMA_NONI NIT_DATA_ALIG N(n)	alignment
	USB_DMA_INIT_ DATA_ALIGN(n)	cachable ram & alignment	USB_DMA_INIT_ DATA_ALIGN(n)	alignment

NOTE

“NULL” means that the MACRO is empty and has no influence.

There are four assistant MACROs:

USB_DATA_ALIGN_SIZE	Used in USB stack and application, define the default align size for USB data
USB_DATA_ALIGN_SIZE_MULTIPLE(n)	Used in USB stack and application, calculate the value that is multiple of data align size.
USB_DMA_DATA_NONCACHEABLE	Used in USB stack and application, put data in the noncacheable region if the cache is enable.
USB_GLOBAL_DEDICATED_RAM	Used in USB stack and application, put data in the dedicated ram if dedicated ram is enable.

Chapter 3

Porting to a new platform

To port the USB stack to a new platform in the MCUXpresso SDK, the SoC-related files, board-related files, and a linker file for a specified compiler are required.

Assume that the new platform's name is "xxxk22f120m" based on the MK22F51212 SoC.

3.1 SoC files

SoC source/header files are in the following directory, which are available by default from MCUXpresso SDK.

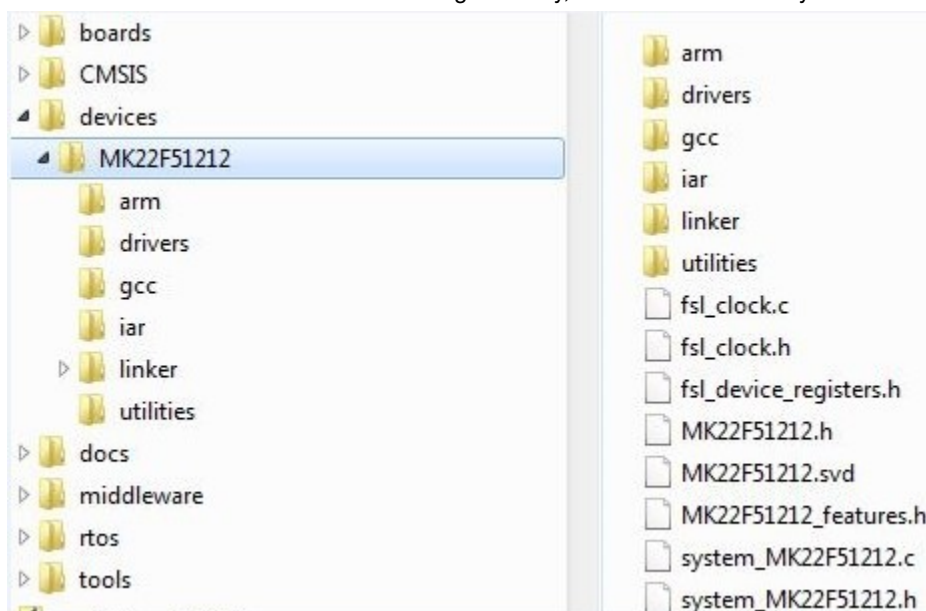


Figure 29. SoC header file directory

NOTE

Linker files for each toolchain are in the linker directory.

Different toolchains' SoC startup assembler files are in the arm, gcc, and iar directories.

3.2 Board files

The files for the board configuration and the clock configuration on a specific platform are needed to enable the USB stack.

The clock configuration files are as follows:

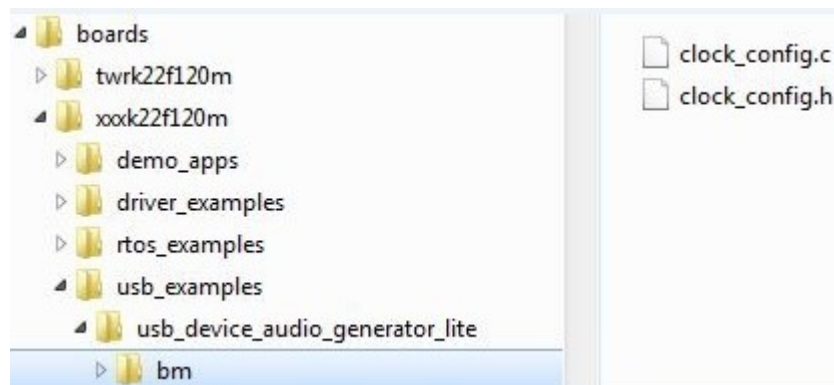


Figure 30. Clock configuration files

1. Create a folder “xxxk22f120m” under the examples directory.
2. Copy the clock_config.c and clock_config.h file from the similar platform. For example, the TWR-K22F120M Tower System module.
3. Ensure that BOARD_BootClockxxx is implemented in the clock_config.c file. For example, BOARD_BootClockRUN and BOARD_BootClockHSRUN. The user can change the function name. However, the BOARD_InitHardware must call the function. BOARD_InitHardware is introduced later.

The board clock initialization is based on the board crystal oscillator. Ensure that the following two MACROs are defined in the clock_config.h file:

```
#define BOARD_XTAL0_CLK_HZ    8000000U
#define BOARD_XTAL32K_CLK_HZ 32768U
```

The user can update the MACROs according to the board design. For example, if the XTAL0 crystal oscillator is 16000000U and the XTAL32K is 32768U, change the following MACROs as follows:

```
#define BOARD_XTAL0_CLK_HZ    16000000U
#define BOARD_XTAL32K_CLK_HZ 32768U
```

The board configuration files are as follows:

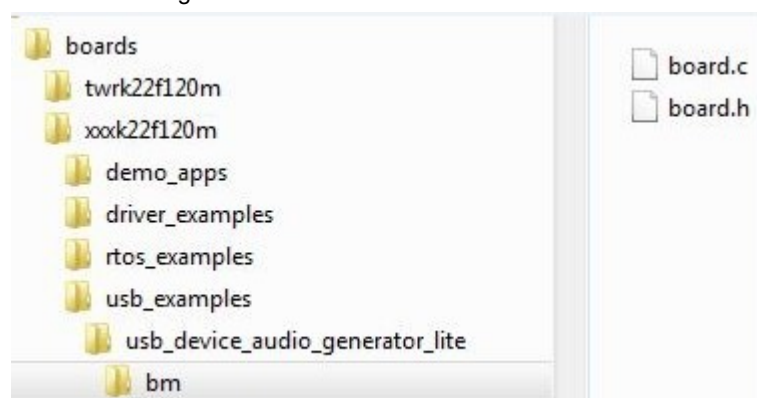


Figure 31. Board configuration files

4. Copy board.c and board.h from the similar platform. For example, the TWR-K22F120M platform. Ensure that the BOARD_InitDebugConsole is implemented in board.c file and that the BOARD_InitHardware calls the function. The BOARD_InitHardware function is introduced later.

Debug console-related MACROS are needed in the board.h file, as follows:

```
#define BOARD_DEBUG_UART_TYPE DEBUG_CONSOLE_DEVICE_TYPE_UART
#define BOARD_DEBUG_UART_BASEADDR (uint32_t) UART2
#define BOARD_DEBUG_UART_CLKSRC BUS_CLK
#define BOARD_DEBUG_UART_BAUDRATE 115200
```

Update the MACROS according to the board design. For example, the default UART instance on the board is LPUART1, the type of default UART instance on one specific platform is LPUART, and the LPUART clock source is the external clock. In this case, change the above MACROS as follows:

```
#define BOARD_DEBUG_UART_TYPE DEBUG_CONSOLE_DEVICE_TYPE_LPUART
#define BOARD_DEBUG_UART_BASEADDR (uint32_t) LPUART1
#define BOARD_DEBUG_UART_CLKSRC kCLOCK_Osc0ErClk
#define BOARD_DEBUG_UART_BAUDRATE 115200
```

Note that there are three kinds of UART instances provided in MCUXpresso SDK devices, UART, LPUART and LPSCI. The interfaces of the UART instance are different. To provide a uniform UART interface to an USB Host example in which the UART function is used, a UART instance wrapper is provided. The wrapper is implemented in the `usb_uart_drv.c`, `usb_lpuart_drv.c`, or `usb_lpsci_drv.c` file and has a common header file `usb_uart_drv.h`. For a different UART instance, use the corresponding UART instance wrapper file in the project.

3.3 Porting examples

3.3.1 Copy a new platform example

The platform USB examples directory is as follows:

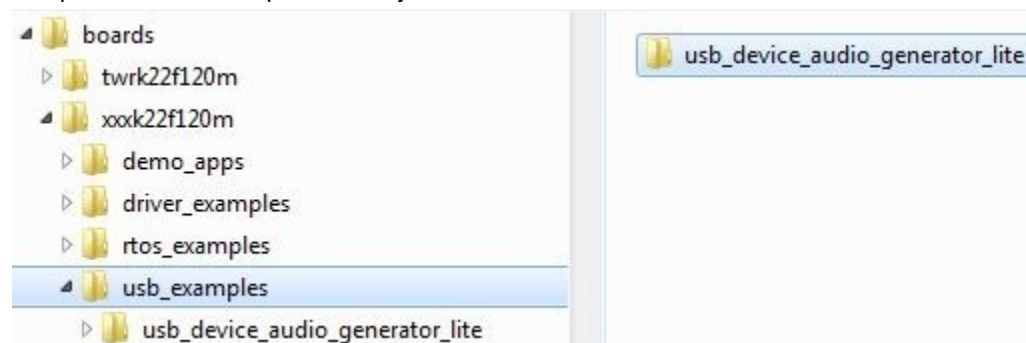


Figure 32. USB examples directory

Copy the existed example's whole directory from the similar platform, which ensures that all example source files and project files are copied.

For example:

Copy the `twrk22f120m/usb/usb_device_audio_generator_lite` to the `twrkxx/usb` location, which ensures that sources files and project files for `usb_device_audio_generator_lite` example are copied.

3.3.2 Porting the example

For different examples, different pins are used. As a result, the `pin_mux.c/h` files are needed to assign different pins to a specific functionality. Check the board schematic for correct pin settings.

Example-related port pin configurations are required in following files:

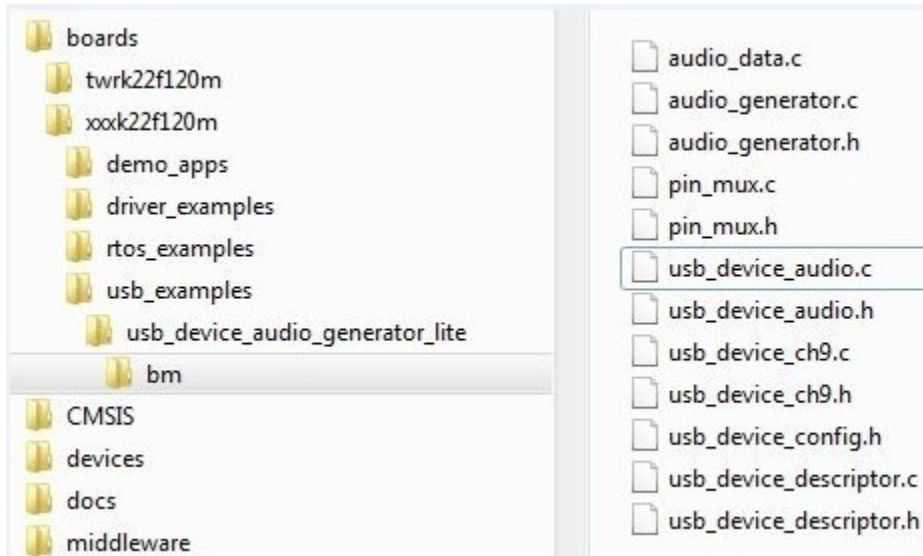


Figure 33. Example-related port pin configuration files

Ensure that the `BOARD_InitPins` function is implemented in the `pin_mux.c` file. In this function, the port clock and pin mux are initialized. Ensure that the `BOARD_InitHardware` calls the function. The `BOARD_InitHardware` function will be introduced later.

For example, on the TWR-K65F180M board, the VBUS of the USB Host is controlled by the `PORTD_8` as a GPIO. Therefore, the `PORTD` clock needs to be enabled first and then the `PORTD_8` configured to GPIO functionality. The debug console uses `UART2`. The TX/RX pins are `PORTE_16` and `PORTE_17`. As a result, the clock of `PORTE` needs to be enabled first and then the `PORTE_16` and `PORTE_17` configured to alternative 3.

This is example code for TWR-K65F180M:

```
void BOARD_InitPins(void)
{
    /* Initialize UART2 pins below */
    CLOCK_EnableClock(kCLOCK_PORTE);
    PORT_SetPinMux(PORTE, 16u, kPORT_MuxAlt3);
    PORT_SetPinMux(PORTE, 17u, kPORT_MuxAlt3);

    /* Initialize usb vbus pin */
    CLOCK_EnableClock(kCLOCK_PortD);
    PORT_SetPinMux(PORTD, 8u, kPORT_MuxAsGpio);
}
```

Check the specific board design to find out which port is used to control the USB VBUS and which port is used for debug console. For example, in the customer's board design, the `PORTC_15` is used to control the USB VBUS and `PORTD_1` and `PORTD_2` is used for debug console. This is the example code:

```
void BOARD_InitPins(void)
{
    /* Initialize UART2 pins below */
    CLOCK_EnableClock(kCLOCK_PortD);
    PORT_SetPinMux(PORTD, 1u, kPORT_MuxAlt3);
    PORT_SetPinMux(PORTD, 2u, kPORT_MuxAlt3);

    /* Initialize usb vbus pin */
    CLOCK_EnableClock(kCLOCK_PortC);
}
```

```
PORT_SetPinMux(PORTC, 15u, kPORT_MuxAsGpio);
}
```

The VBUS must output high. This is an example code for TWR-K65F180M:

```
void BOARD_InitHardware(void)
{
    gpio_pin_config_t pinConfig;
    BOARD_InitPins();
    BOARD_BootClockRUN();
    BOARD_InitDebugConsole();
    /* vbus gpio output high */
    pinConfig.pinDirection = kGPIO_DigitalOutput;
    pinConfig.outputLogic = 1U;
    GPIO_PinInit(PTD, 8U, &pinConfig);
}
```

The user can change the function as follows:

```
void BOARD_InitHardware(void)
{
    gpio_pin_config_t pinConfig;
    BOARD_InitPins();
    BOARD_BootClockxxx();
    BOARD_InitDebugConsole();
    /* vbus gpio output high */
    pinConfig.pinDirection = kGPIO_DigitalOutput;
    pinConfig.outputLogic = 1U;
    GPIO_PinInit(PTC, 15U, &pinConfig);
}
```

3.3.3 Modify the example project

USB example project files are kept in the example directory, as follows:

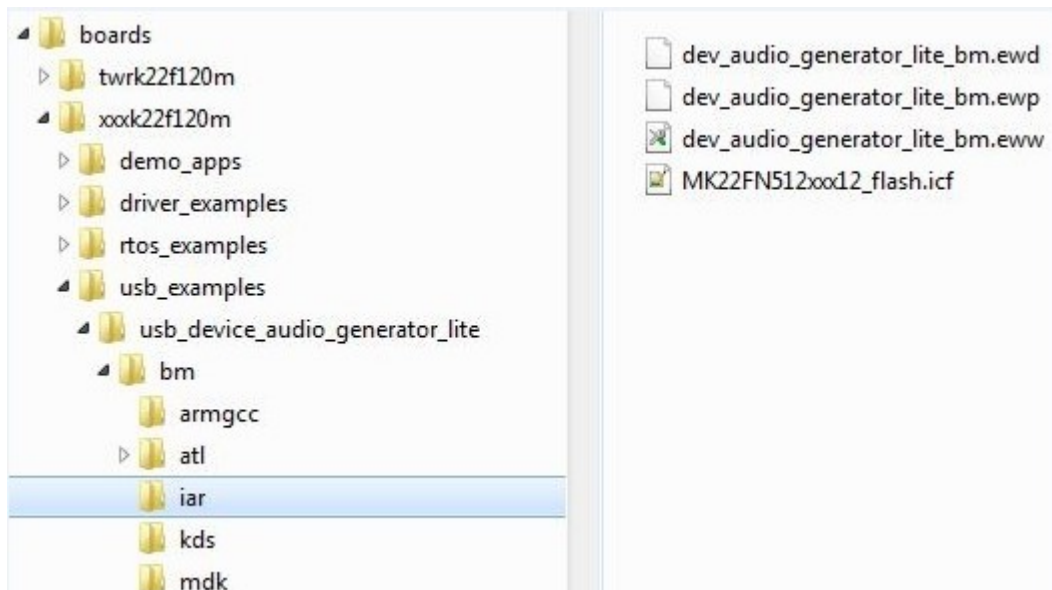


Figure 34. Modify the example project

1. Open the project and change the SoC.

NOTE

- a. Check the project SoC and update to the porting platform SoC.
- b. Update the SoC full name, platform name, and board type name macros if the SoC is updated.
For example, for TWR-K22F120M, update the CPU_MK22FN512VDC12, TWR_K22F120M, and TOWER macros.

2. Check the files in startup group, for example (IAR):

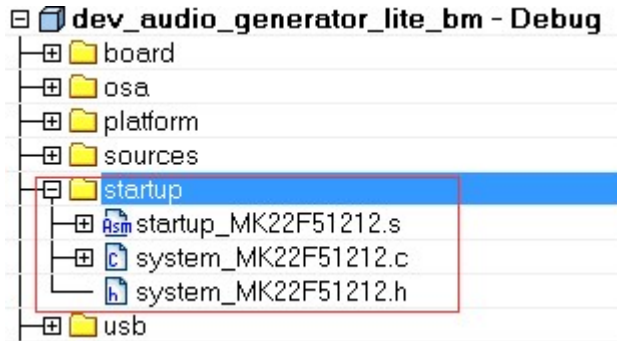


Figure 35. Check files in startup group

Ensure that the system_MK22F51212.c, system_MK22F51212.h, and strtup_MK22F51212.s are the porting SoC files. Also change the include path.

3. Check the files in the platform/clock group, for example (IAR):

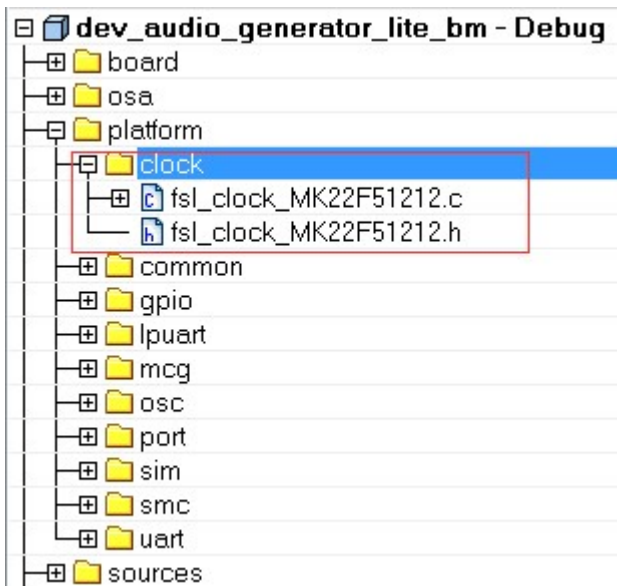


Figure 36. Check files in platform/clock group

Ensure that the fsl_clock_MK22F51212.c, and fsl_clock_MK22F51212.h are porting SoC files. Additionally, change the include path.

4. Change the files in board group, for example (IAR):

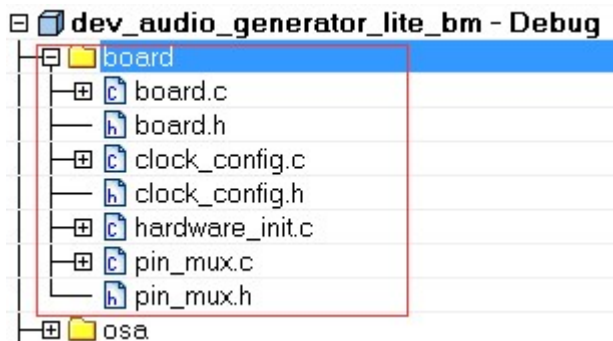


Figure 37. Change files in board group

Ensure that board.c, board.h, clock_config.c, and clock_config.h are porting platform files. Additionally, change the include path.

5. Check the files in the sources group, for example (IAR):

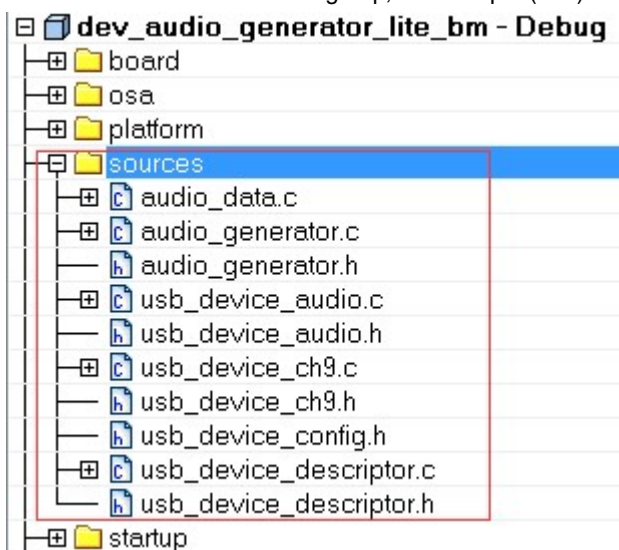


Figure 38. Check files in source group

The example application source files are copied when copying the example directory. Change the include path.

6. Change the linker file to the new platform. Ensure that the linker file is the porting SoC file.
7. Debug console may use UART, LPUART, or LPSCI according to the platform. As a result, the example project needs to contain UART, LPUART, or LPSCI driver files according to the platform.

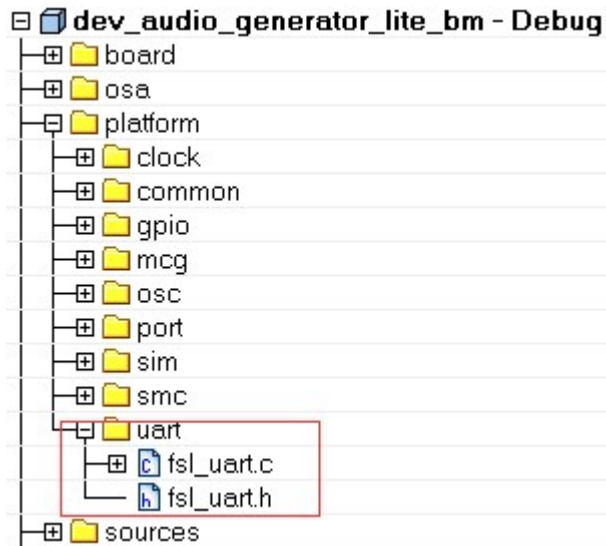


Figure 39. UART, LPUART, and LPSCI files

For example, for TWR-K22F120M all UART files are all in the project. In another example, TWR-K80F150M, all LPUART files are in the project.

3.3.4 USB host CDC example

The MCUXpresso SDK debug console can be based on The MCUXpresso SDK UART, LPUART, or LPSCI driver. Because different platforms may use different drivers, the CDC has a wrapper code. The files, which call the corresponding driver API according to the debug console use UART, LPUART, or LPSCI. The utility uses the BOARD_DEBUG_UART_TYPE to identify the UART type. To use a different UART instance, use the corresponding UART instance wrapper file.

The MCUXpresso SDK debug console only enables send. The Host CDC example needs the receive function. Therefore, configuration MACROS need to be defined in the board.h file. The debug console and the Host CDC share the same configuration. This is an example:

```
#define BOARD_DEBUG_UART_TYPE          DEBUG_CONSOLE_DEVICE_TYPE_UART
#define BOARD_DEBUG_UART_BASEADDR      (uint32_t)UART1
#define BOARD_DEBUG_UART_CLKSRC        kCLOCK_CoreSysClk
#define BOARD_DEBUG_UART_BAUDRATE      115200
```

Update MACROS according to board design. For example, the default UART instance on the board is LPUART1, the type of default UART instance on one specific platform is LPUART, and the LPUART clock source is the external clock. In this case, change the above MACROS as follows:

```
#define BOARD_DEBUG_UART_TYPE          DEBUG_CONSOLE_DEVICE_TYPE_LPUART
#define BOARD_DEBUG_UART_BASEADDR      (uint32_t) LPUART1
#define BOARD_DEBUG_UART_CLKSRC        kCLOCK_Osc0ErClk
#define BOARD_DEBUG_UART_BAUDRATE      115200
```

3.3.5 USB device MSC SD card example

USB device MSC SD card example needs SDHC driver support and SD card support. The example works only if the platform supports both SD card and the SDHC. To enable this example using the same code, the following MACROS are defined in the board.h file:

```
#define BOARD_SDHC_BASEADDR            SDHC
#define BOARD_SDHC_CLKSRC               kCLOCK_CoreSysClk
```

```
#define BOARD_SDHC_CD_GPIO_BASE      GPIOB
#define BOARD_SDHC_CD_GPIO_PIN      20U
#define BOARD_SDHC_CD_PORT_BASE      PORTB
#define BOARD_SDHC_CD_PORT_IRQ      PORTB_IRQn
#define BOARD_SDHC_CD_PORT_IRQ_HANDLER  PORTB_IRQHandler
```

Update the MACROs according to the board design. For example, the SD card detection GPIO on the board is PORTD_1. In this case, change the above MACROs as follows:

```
#define BOARD_SDHC_BASEADDR          SDHC
#define BOARD_SDHC_CLKSRC            kCLOCK_CoreSysClk
#define BOARD_SDHC_CD_GPIO_BASE      GPIOD
#define BOARD_SDHC_CD_GPIO_PIN      1U
#define BOARD_SDHC_CD_PORT_BASE      PORTD
#define BOARD_SDHC_CD_PORT_IRQ      PORTD_IRQn
#define BOARD_SDHC_CD_PORT_IRQ_HANDLER  PORTD_IRQHandler
```

3.3.6 USB device audio speaker example

USB device audio speaker example needs the I2C, SAI, and DMA driver support.

The instance of SAI (I2S) and I2C are defined in the app.h file in the example directory as follows:

```
#define DEMO_SAI I2S0
#define DEMO_I2C I2C0
#define DEMO_SAI_CLKSRC kCLOCK_CoreSysClk
```

Update the MACROs according to board design. For example, the I2S instance on the board is I2S2. In this case, change the above MACROs as follows:

```
#define DEMO_SAI I2S2
#define DEMO_I2C I2C2
#define DEMO_SAI_CLKSRC kCLOCK_CoreSysClk
```

3.3.7 USB device CCID Smart card example

The example is based on the EMVL1 stack, which works on the EMV protocol. As a result, the example can only be ported to the platform that supports both the EMVL1 stack and the EMV protocol.

Chapter 4

Developing a New USB Application

4.1 Developing a New USB Device Application

4.1.1 Application interfaces

The interface definition between the application and the classes includes the calls shown in the following table:

Table 1. Application and classes interface definition

API Call	Description
Class Initialization	This API is used to initialize the class.
Receive Data	This API is used by the application to receive data from the host system.
Send Data	This API is used by the application to send data to the host system.
USB descriptor-related callback	Handles the callback to get the descriptor.
USB Device call back function	Handles the callback by the class driver to inform the application about various USB bus events.
USB Class-specific call back function	Handles the specific callback of the class.

4.1.2 How to develop a new device application

Perform these steps to develop a new device application:

1. Create a new application directory under `<install_dir>/boards/<board>/usb_examples/usb_device_<class>_<application>` to locate the application source files and header files. For example, `<install_dir>/boards/<board>/usb_examples/usb_device_hid_test`.
2. Copy the following files from the similar existing applications to the application directory that is created in Step 1.

```
usb_device_descriptor.c
usb_device_descriptor.h
```

The `usb_device_descriptor.c` and `usb_device_descriptor.h` files contain the USB descriptors that are dependent on the application and the class driver.

3. Copy the `bm` directory from the similar existing application directory to the new application directory. Remove the unused project directory from the `bm` directory. Modify the project directory name to the new application project name. For example, to create `toolchain-IAR`, `board-frdmk64` class-`hid` related application, create the new application `hid_test` based on a similar existing application `hid_mouse`.

Change `<install_dir>/boards/<board>/usb_examples/usb_device_hid_mouse` to `<install_dir>/boards/<board>/usb_examples/usb_device_hid_test`

4. Modify the project file name to the new application project file name, for example, from `dev_hid_mouse_bm.ewp` to `dev_hid_test_bm.ewp`. Globally replace the existing name to the new project name by editing the project files. The `dev_hid_test_bm.ewp` file includes the new application project setting.

5. Create a new source file to implement the main application functions and callback functions. The name of this file is similar to the new application name, such as `mouse.c` and `keyboard.c`.

The following sections describe the steps to change application files created in the steps above to match the new application.

4.1.2.1 Changing the `usb_device_descriptor.c` file

This file contains the class driver interface. It also contains USB standard descriptors such as device descriptor, configuration descriptor, string descriptor, and the other class-specific descriptors that are provided to class driver when required.

The lists below show user-modifiable variable types for an already implemented class driver. The user should also modify the corresponding MACROS defined in the `usb_device_descriptor.h` file. See the *MCUXpresso SDK API Reference Manual* (document MCUXSDKAPIRM) for details.

- `usb_device_endpoint_struct_t`;
- `usb_device_endpoint_list_t`;
- `usb_device_interface_struct_t`;
- `usb_device_interfaces_struct_t`;
- `usb_device_interface_list_t`;
- `usb_device_class_struct_t`;
- `usb_device_class_config_struct_t`;
- `usb_device_class_config_list_struct_t`;

This diagram shows the relationship between these items:

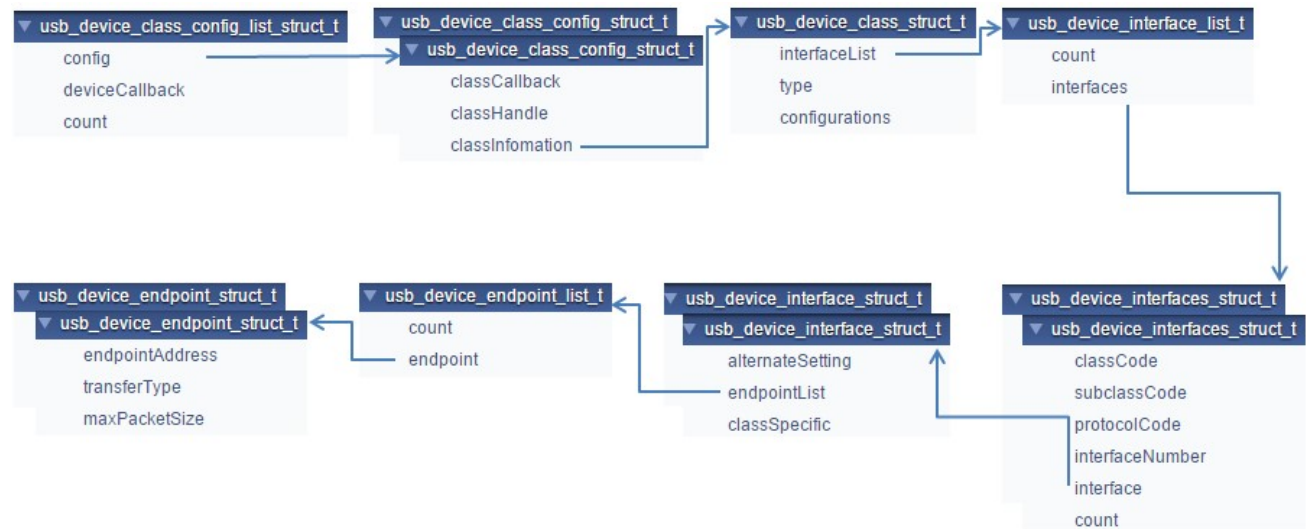


Figure 40. Relationship diagram

This is the sample code implementation of the endpoint descriptor for the HID class:

```

/* HID mouse endpoint information */
usb_device_endpoint_struct_t g_UsbDeviceHidMouseEndpoints[USB_HID_MOUSE_ENDPOINT_COUNT] =
{
    /* HID mouse interrupt IN pipe */
    {
        USB_HID_MOUSE_ENDPOINT_IN | (USB_IN << USB_DESCRIPTOR_ENDPOINT_ADDRESS_DIRECTION_SHIFT),
        USB_ENDPOINT_INTERRUPT,
        FS_HID_MOUSE_INTERRUPT_IN_PACKET_SIZE,
    },
};

```

The endpoint address, transfer type, and max packet size in this variable are defined in the `usb_device_descriptor.h` file. The user may change these value as required. For example, to implement a CDC class application:

```
/* Define endpoint for a communication class */
usb_device_endpoint_struct_t g_UsbDeviceCdcVcomCicEndpoints[USB_CDC_VCOM_ENDPOINT_CIC_COUNT] = {
    {
        USB_CDC_VCOM_INTERRUPT_IN_ENDPOINT | (USB_IN << 7U), USB_ENDPOINT_INTERRUPT,
        FS_CDC_VCOM_INTERRUPT_IN_PACKET_SIZE,
    },
};

/* HID mouse interface information */
usb_device_interface_struct_t g_UsbDeviceHidMouseInterface[] =
{
    {
        0U, /* The alternate setting for the interface */
        {
            USB_HID_MOUSE_ENDPOINT_COUNT, /* Endpoint count */
            g_UsbDeviceHidMouseEndpoints, /* Endpoints handle */
        },
    }
};
```

The endpoint count and alternate setting of the interface may differ in various applications. The user may change these values as required. For example, the interface structure of a CDC class application is as follows:

```
/* Define interface for communication class */
usb_device_interface_struct_t g_UsbDeviceCdcVcomCommunicationInterface[] = {{
    1U,
    {
        USB_CDC_VCOM_ENDPOINT_CIC_COUNT, g_UsbDeviceCdcVcomCicEndpoints,
    },
}};

usb_device_interfaces_struct_t g_UsbDeviceHidMouseInterfaces[USB_HID_MOUSE_INTERFACE_COUNT] =
{
    USB_HID_MOUSE_CLASS, /* HID mouse class code */
    USB_HID_MOUSE_SUBCLASS, /* HID mouse subclass code */
    USB_HID_MOUSE_PROTOCOL, /* HID mouse protocol code */
    USB_HID_MOUSE_INTERFACE_INDEX, /* The interface number of the HID mouse */
    g_UsbDeviceHidMouseInterface, /* Interfaces handle */
    sizeof(g_UsbDeviceHidMouseInterface) / sizeof(usb_device_interfaces_struct_t),
};
```

The class code, subclass code, and protocol code may differ in various classes. For example, the `usb_device_interfaces_struct` of a CDC class is as follows:

```
/* Define interfaces for the virtual com */
usb_device_interfaces_struct_t g_UsbDeviceCdcVcomInterfaces[USB_CDC_VCOM_INTERFACE_COUNT] = {
    {USB_CDC_VCOM_CIC_CLASS, USB_CDC_VCOM_CIC_SUBCLASS, USB_CDC_VCOM_CIC_PROTOCOL,
    USB_CDC_VCOM_COMM_INTERFACE_INDEX,
    g_UsbDeviceCdcVcomCommunicationInterface,
    sizeof(g_UsbDeviceCdcVcomCommunicationInterface) / sizeof(usb_device_interfaces_struct_t)},
    {USB_CDC_VCOM_DIC_CLASS, USB_CDC_VCOM_DIC_SUBCLASS, USB_CDC_VCOM_DIC_PROTOCOL,
    USB_CDC_VCOM_DATA_INTERFACE_INDEX,
    g_UsbDeviceCdcVcomDataInterface, sizeof(g_UsbDeviceCdcVcomDataInterface) /
    sizeof(usb_device_interfaces_struct_t)},
};

usb_device_interface_list_t g_UsbDeviceHidMouseInterfaceList[USB_DEVICE_CONFIGURATION_COUNT] =
```

```
{
    {
        USB_HID_MOUSE_INTERFACE_COUNT, /* The interface count of the HID mouse */
        g_UsbDeviceHidMouseInterfaces, /* The interfaces handle */
    },
};
```

The interface count may differ in various applications. For example, the `usb_device_interface_list` of a CDC class application is as follows:

```
/* Define configurations for virtual com */
usb_device_interface_list_t g_UsbDeviceCdcVcomInterfaceList[USB_DEVICE_CONFIGURATION_COUNT] = {
    {
        USB_CDC_VCOM_INTERFACE_COUNT, g_UsbDeviceCdcVcomInterfaces,
    },
};
usb_device_class_struct_t g_UsbDeviceHidMouseConfig =
{
    g_UsbDeviceHidMouseInterfaceList, /* The interface list of the HID mouse */
    kUSB_DeviceClassTypeHid,          /* The HID class type */
    USB_DEVICE_CONFIGURATION_COUNT,    /* The configuration count */
};
```

The interface list, class type and configuration count may differ in various applications. For example, the `usb_device_class_struct` of a CDC class application is as follows:

```
/* Define class information for virtual com */
usb_device_class_struct_t g_UsbDeviceCdcVcomConfig = {
    g_UsbDeviceCdcVcomInterfaceList, kUSB_DeviceClassTypeCdc, USB_DEVICE_CONFIGURATION_COUNT,
};
```

- `g_UsbDeviceDescriptor`

This variable contains the USB Device Descriptor.

Sample code implementation of the device descriptor for the HID class is given below:

```
uint8_t g_UsbDeviceDescriptor[USB_DESCRIPTOR_LENGTH_DEVICE] =
{
    USB_DESCRIPTOR_LENGTH_DEVICE, /* Size of this descriptor in bytes */
    USB_DESCRIPTOR_TYPE_DEVICE,    /* DEVICE Descriptor Type */
    USB_SHORT_GET_LOW(USB_DEVICE_SPECIFIC_BCD_VERSION),
    USB_SHORT_GET_HIGH(USB_DEVICE_SPECIFIC_BCD_VERSION), /* USB Specification Release Number in
                                                            Binary-Coded Decimal (i.e., 2.10 is 210H). */
    USB_DEVICE_CLASS,             /* Class code (assigned by the USB-IF). */
    USB_DEVICE_SUBCLASS,          /* Subclass code (assigned by the USB-IF). */
    USB_DEVICE_PROTOCOL,          /* Protocol code (assigned by the USB-IF). */
    USB_CONTROL_MAX_PACKET_SIZE,  /* Maximum packet size for endpoint zero
                                    (only 8, 16, 32, or 64 are valid) */
    0xA2U, 0x15U,                 /* Vendor ID (assigned by the USB-IF) */
    0x7CU, 0x00U,                 /* Product ID (assigned by the manufacturer) */
    USB_SHORT_GET_LOW(USB_DEVICE_DEMO_BCD_VERSION),
    USB_SHORT_GET_HIGH(USB_DEVICE_DEMO_BCD_VERSION), /* Device release number in binary-coded
                                                        decimal */
    0x01U,                        /* Index of string descriptor describing manufacturer */
    0x02U,                        /* Index of string descriptor describing product */
    0x00U,                        /* Index of string descriptor describing the
                                    device serial number */
    USB_DEVICE_CONFIGURATION_COUNT, /* Number of possible configurations */
};
```

The macros in the variable above are defined in the `usb_device_descriptor.h` file, such as the `USB_DEVICE_CLASS`, `USB_DEVICE_SUBCLASS`, and `USB_DEVICE_PROTOCOL`. Those values may need to be modified as required. The vendor ID and product ID can also be modified.

- `g_UsbDeviceConfigurationDescriptor`

This variable contains the USB Configuration Descriptor.

Sample code implementation of the configuration descriptor for the HID class is given below:

```
uint8_t g_UsbDeviceConfigurationDescriptor[USB_DESCRIPTOR_LENGTH_CONFIGURATION_ALL] =
{
    USB_DESCRIPTOR_LENGTH_CONFIGURE, /* Size of this descriptor in bytes */
    USB_DESCRIPTOR_TYPE_CONFIGURE,    /* CONFIGURATION Descriptor Type */
    USB_SHORT_GET_LOW(USB_DESCRIPTOR_LENGTH_CONFIGURATION_ALL),
    USB_SHORT_GET_HIGH(USB_DESCRIPTOR_LENGTH_CONFIGURATION_ALL), /* Total length of data returned
for this configuration. */
    USB_HID_MOUSE_INTERFACE_COUNT, /* Number of interfaces supported by this configuration */
    USB_HID_MOUSE_CONFIGURE_INDEX, /* Value to use as an argument to the
SetConfiguration() request to select this configuration */
    0x00U, /* Index of string descriptor describing this configuration */
    (USB_DESCRIPTOR_CONFIGURE_ATTRIBUTE_D7_MASK) |
    (USB_DEVICE_CONFIG_SELF_POWER << USB_DESCRIPTOR_CONFIGURE_ATTRIBUTE_SELF_POWERED_SHIFT) |
    (USB_DEVICE_CONFIG_REMOTE_WAKEUP << USB_DESCRIPTOR_CONFIGURE_ATTRIBUTE_REMOTE_WAKEUP_SHIFT),
    /* Configuration characteristics
D7: Reserved (set to one)
D6: Self-powered
D5: Remote Wakeup
D4...0: Reserved (reset to zero)
*/
    USB_DEVICE_MAX_POWER, /* Maximum power consumption of the USB
* device from the bus in this specific
* configuration when the device is fully
* operational. Expressed in 2 mA units
* (i.e., 50 = 100 mA).
*/
}
```

The macro `USB_DESCRIPTOR_LENGTH_CONFIGURATION_ALL`, which is defined in the `usb_device_descriptor.h`, needs to be modified to equal the size of this variable. The interface count and configuration index may differ in various applications. For example, this part of a CDC class application is as shown below:

```
/* Size of this descriptor in bytes */
USB_DESCRIPTOR_LENGTH_CONFIGURE,
/* CONFIGURATION Descriptor Type */
USB_DESCRIPTOR_TYPE_CONFIGURE,
/* Total length of data returned for this configuration. */
USB_SHORT_GET_LOW(USB_DESCRIPTOR_LENGTH_CONFIGURATION_ALL),
USB_SHORT_GET_HIGH(USB_DESCRIPTOR_LENGTH_CONFIGURATION_ALL),
/* Number of interfaces supported by this configuration */
USB_CDC_VCOM_INTERFACE_COUNT,
/* Value to use as an argument to the SetConfiguration() request to select this configuration */
USB_CDC_VCOM_CONFIGURE_INDEX,
/* Index of string descriptor describing this configuration */
0,
/* Configuration characteristics D7: Reserved (set to one) D6: Self-powered D5: Remote Wakeup
D4...0: Reserved
(reset to zero) */
(USB_DESCRIPTOR_CONFIGURE_ATTRIBUTE_D7_MASK) |
(USB_DEVICE_CONFIG_SELF_POWER << USB_DESCRIPTOR_CONFIGURE_ATTRIBUTE_SELF_POWERED_SHIFT) |
(USB_DEVICE_CONFIG_REMOTE_WAKEUP << USB_DESCRIPTOR_CONFIGURE_ATTRIBUTE_REMOTE_WAKEUP_SHIFT),
```



```

/* Maximum power consumption of the USB * device from the bus in this specific * configuration
when the device is
    fully * operational. Expressed in 2 mA units * (i.e., 50 = 100 mA). */
USB_DEVICE_MAX_POWER,

USB_DESCRIPTOR_LENGTH_INTERFACE, /* Size of this descriptor in bytes */
USB_DESCRIPTOR_TYPE_INTERFACE, /* INTERFACE Descriptor Type */
USB_HID_MOUSE_INTERFACE_INDEX, /* Number of this interface. */
0x00U, /* Value used to select this alternate setting
        for the interface identified in the prior field */
USB_HID_MOUSE_ENDPOINT_COUNT, /* Number of endpoints used by this
        interface (excluding endpoint zero). */
USB_HID_MOUSE_CLASS, /* Class code (assigned by the USB-IF). */
USB_HID_MOUSE_SUBCLASS, /* Subclass code (assigned by the USB-IF). */
USB_HID_MOUSE_PROTOCOL, /* Protocol code (assigned by the USB). */
0x00U, /* Index of string descriptor describing this interface */

```

The interface descriptor may differ from various applications. For example, the interface descriptor of a CDC class application would be as below.

```

/* Communication Interface Descriptor */
USB_DESCRIPTOR_LENGTH_INTERFACE, USB_DESCRIPTOR_TYPE_INTERFACE,
USB_CDC_VCOM_COMM_INTERFACE_INDEX, 0x00,
USB_CDC_VCOM_ENDPOINT_CIC_COUNT, USB_CDC_VCOM_CIC_CLASS, USB_CDC_VCOM_CIC_SUBCLASS,
USB_CDC_VCOM_CIC_PROTOCOL,
0x00, /* Interface Description String Index*/

USB_DESCRIPTOR_LENGTH_HID, /* Numeric expression that is the total size of the
        HID descriptor. */
USB_DESCRIPTOR_TYPE_HID, /* Constant name specifying type of HID
        descriptor. */
0x00U,
0x01U, /* Numeric expression identifying the HID Class
        Specification release. */
0x00U, /* Numeric expression identifying country code of
        The localized hardware */
0x01U, /* Numeric expression specifying the number of
        Class descriptors(at least one report descriptor) */
USB_DESCRIPTOR_TYPE_HID_REPORT, /* Constant name identifying type of class descriptor. */
USB_SHORT_GET_LOW(USB_DESCRIPTOR_LENGTH_HID_MOUSE_REPORT),
USB_SHORT_GET_HIGH(USB_DESCRIPTOR_LENGTH_HID_MOUSE_REPORT),
/* Numeric expression that is the total size of the
        Report descriptor. */

```

The class specific descriptor may differ from various applications. For example, the class specific descriptor of a CDC class application would be as below.

```

/* CDC Class-Specific descriptor */
USB_DESCRIPTOR_LENGTH_CDC_HEADER_FUNC, /* Size of this descriptor in bytes */
USB_DESCRIPTOR_TYPE_CDC_CS_INTERFACE, /* CS_INTERFACE Descriptor Type */
HEADER_FUNC_DESC, 0x10,
0x01, /* USB Class Definitions for Communications the Communication specification version 1.10 */

USB_DESCRIPTOR_LENGTH_CDC_CALL_MANAG, /* Size of this descriptor in bytes */
USB_DESCRIPTOR_TYPE_CDC_CS_INTERFACE, /* CS_INTERFACE Descriptor Type */
CALL_MANAGEMENT_FUNC_DESC,
0x01, /*Bit 0: Whether device handle call management itself 1, Bit 1: Whether device can send/
receive call
        management information over a Data Class Interface 0 */

```

```

    0x01, /* Indicates multiplexed commands are handled via data interface */
    USB_DESCRIPTOR_LENGTH_ENDPOINT, /* Size of this descriptor in bytes */
    USB_DESCRIPTOR_TYPE_ENDPOINT, /* ENDPOINT Descriptor Type */
    USB_HID_MOUSE_ENDPOINT_IN | (USB_IN << USB_DESCRIPTOR_ENDPOINT_ADDRESS_DIRECTION_SHIFT),
                                     /* The address of the endpoint on the USB device
                                     described by this descriptor. */
    USB_ENDPOINT_INTERRUPT, /* This field describes the endpoint's attributes */
    USB_SHORT_GET_LOW(FS_HID_MOUSE_INTERRUPT_IN_PACKET_SIZE),
    USB_SHORT_GET_HIGH(FS_HID_MOUSE_INTERRUPT_IN_PACKET_SIZE),
                                     /* Maximum packet size this endpoint is capable of
                                     sending or receiving when this configuration is
                                     is selected. */
    FS_HID_MOUSE_INTERRUPT_IN_INTERVAL, /* Interval for polling endpoint for data transfers. */

```

The endpoint descriptor may differ from various applications. For example, the endpoint descriptor of a CDC class application is as follows:

```

/*Notification Endpoint descriptor */
    USB_DESCRIPTOR_LENGTH_ENDPOINT, USB_DESCRIPTOR_TYPE_ENDPOINT,
    USB_CDC_VCOM_INTERRUPT_IN_ENDPOINT | (USB_IN << 7U),
    USB_ENDPOINT_INTERRUPT, USB_SHORT_GET_LOW(FS_CDC_VCOM_INTERRUPT_IN_PACKET_SIZE),
    USB_SHORT_GET_HIGH(FS_CDC_VCOM_INTERRUPT_IN_PACKET_SIZE), FS_CDC_VCOM_INTERRUPT_IN_INTERVAL,
}

```

- String Descriptors

Users can modify string descriptors to customize their product. String descriptors are written in the UNICODE format. An appropriate language identification number is specified in the USB_STR_0. Multiple language support can also be added.

- USB_DeviceGetDeviceDescriptor

This interface function is invoked by the application. This call is made when the application receives the kUSB_DeviceEventGetDeviceDescriptor event from the Host. Mandatory descriptors that an application is required to implement are as follows:

- Device Descriptor
- Configuration Descriptor
- Class-Specific Descriptors (For example, for HID class implementation, Report Descriptor, and HID Descriptor)

Apart from the mandatory descriptors, an application should also implement various string descriptors as specified by the Device Descriptor and other configuration descriptors.

Sample code for HID class application is given below:

```

/* Get device descriptor request */
usb_status_t USB_DeviceGetDeviceDescriptor(usb_device_handle handle,
                                           usb_device_get_device_descriptor_struct_t *deviceDescriptor)
{
    deviceDescriptor->buffer = g_UsbDeviceDescriptor;
    deviceDescriptor->length = USB_DESCRIPTOR_LENGTH_DEVICE;
    return kStatus_USB_Success;
}

```

The user may assign the appropriate variable of the device descriptor. For example, if the device descriptor variable name is g_UsbDeviceDescriptorUser, the sample code is as follows:

```

/* Get device descriptor request */
usb_status_t USB_DeviceGetDeviceDescriptor(usb_device_handle handle,
                                           usb_device_get_device_descriptor_struct_t *deviceDescriptor)
{

```

```

deviceDescriptor->buffer = g_UsbDeviceDescriptorUser;
deviceDescriptor->length = USB_DESCRIPTOR_LENGTH_DEVICE;
return kStatus_USB_Success;
}

```

- **USB_DeviceGetConfigurationDescriptor**

This interface function is invoked by the application. This call is made when the application receives the `kUSB_DeviceEventGetConfigurationDescriptor` event from the Host.

```

/* Get device configuration descriptor request */
usb_status_t USB_DeviceGetConfigurationDescriptor(
    usb_device_handle handle, usb_device_get_configuration_descriptor_struct_t
    *configurationDescriptor)
{
    if (USB_HID_MOUSE_CONFIGURE_INDEX > configurationDescriptor->configuration)
    {
        configurationDescriptor->buffer = g_UsbDeviceConfigurationDescriptor;
        configurationDescriptor->length = USB_DESCRIPTOR_LENGTH_CONFIGURATION_ALL;
        return kStatus_USB_Success;
    }
    return kStatus_USB_InvalidRequest;
}

```

The macro `HID_MOUSE_CONFIGURE_INDEX` may differ from various applications. For example, the implementation of a CDC class application would be as below.

```

usb_status_t USB_DeviceGetConfigurationDescriptor(
    usb_device_handle handle, usb_device_get_configuration_descriptor_struct_t
    *configurationDescriptor)
{
    if (USB_CDC_VCOM_CONFIGURE_INDEX > configurationDescriptor->configuration)
    {
        configurationDescriptor->buffer = g_UsbDeviceConfigurationDescriptor;
        configurationDescriptor->length = USB_DESCRIPTOR_LENGTH_CONFIGURATION_ALL;
        return kStatus_USB_Success;
    }
    return kStatus_USB_InvalidRequest;
}

```

- **USB_DeviceGetStringDescriptor**

This interface function is invoked by the application. This call is made when the application receives the `kUSB_DeviceEventGetStringDescriptor` event from the Host.

See the `usb_device_hid_mouse` example for sample code.

- **USB_DeviceGetHidReportDescriptor**

This interface function is invoked by the application. This call is made when the application receives the `kUSB_DeviceEventGetHidReportDescriptor` event from the Host.

See the `usb_device_hid_mouse` example for sample code.

- **USB_DeviceSetSpeed**

Because HS and FS descriptors are different, the device descriptors and configurations need to be updated to match the current speed. By default, the device descriptors and configurations are configured using FS parameters for EHCI, KHCI, and other controllers, such as LPC IP3511. When the EHCI is enabled, the application needs to call this function to update the device by using the current speed. The updated information includes the endpoint max packet size, endpoint interval, and so on.

4.1.2.2 Changing the `usb_device_descriptor.h` file

This file is mandatory for the application to implement. The `usb_device_descriptor.c` file includes this file for function prototype definitions. When the user modifies the `usb_device_descriptor.c`, MACROs in this file should also be modified.

4.1.2.3 Changing the application file

- Main application function

The main application function is provided by two functions: `USB_DeviceApplicationInit` and `APP_task(optional)`.

- The `USB_DeviceApplicationInit` enables the clock and the USB interrupt and also initialize the specific USB class. See the `usb_device_hid_mouse` example for the sample code.

- USB device call back function

The device callback function handles the USB device-specific requests. See the `usb_device_hid_mouse` example for the sample code.

- USB Class-specific call back function

The class callback function handles the USB class-specific requests. See the `usb_device_hid_mouse` example for the sample code.

4.2 Developing a New USB Host Application

4.2.1 Background

In the USB system, the host software controls the bus and talks to the target devices following the rules defined by the specification. A device is represented by a configuration that is a collection of one or more interfaces. Each interface comprises one or more endpoints. Each endpoint is represented as a logical pipe from the application software perspective.

The host application software registers a callback with the USB host stack, which notifies the application about the device attach/detach events and determines whether the device is supported or not. The following figure shows the enumeration and detachment flow.

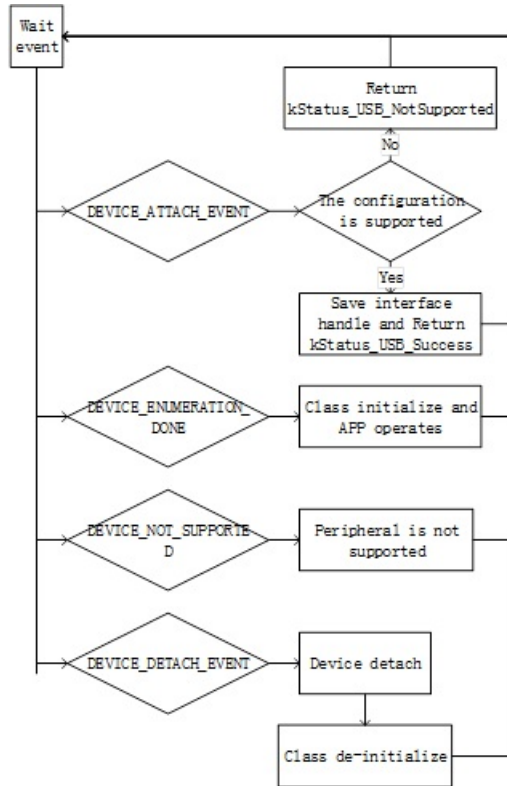


Figure 41. Enumeration and detachment flow

The USB host stack is a few lines of code executed before starting communication with the USB device. The examples on the USB stack are written with class driver APIs. Class drivers work with the host API as a supplement to the functionality. They make it easy to achieve the target functionality (see example sources for details) without dealing with the implementation of standard routines. The following code steps are taken inside a host application driver for any specific device.

4.2.2 How to develop a new host application

4.2.2.1 Creating a project

Perform the following steps to create a project.

- Create a new application directory under `<install_dir>/boards/<board>/usb_examples/usb_host_<class>_<application>` to locate the application source files and header files. For example, `<install_dir>/boards/<board>/usb_examples/usb_host_hid_mouse`.

- Copy the following files from the similar existing applications to the application directory that is created in step 1.

`app.c`

`usb_host_config.h`

The `app.c` file contains the common initialization code for USB host and the `usb_host_config.h` file contains the configuration MACROs for the USB host.

- Copy the `bm` directory from the similar existing application directory to the new application directory. Remove the unused project directory from the `bm` directory. Modify the project directory name to the new application project name. For example, to create toolchain-IAR, board-frdmk64 class-hid related application, create the new application `hid_test` based on a similar existing application `hid_mouse`.

Copy `<install_dir>/boards/frdmk64f/usb_examples/usb_host_hid_mouse/bm`

to `<install_dir>/boards/frdmk64f/usb_examples/usb_host_hid_test/bm`

- Modify the project file name to the new application project file name, for example, from `host_hid_mouse_bm.ewp` to `host_hid_test_bm.ewp`. Globally replace the existing name to the new project name by editing the project files. The `host_hid_test_bm.ewp` file includes the new application project setting.
- Create a new source file to implement the main application function, application task function, and the callback function. The name of this file is similar to the new application name, such as `host_mouse.c` and `host_keyboard.c`.

The following sections describe the steps to modify application files created in the steps above to match the new application.

4.2.2.2 Main application function flow

In the main application function, follow these steps:

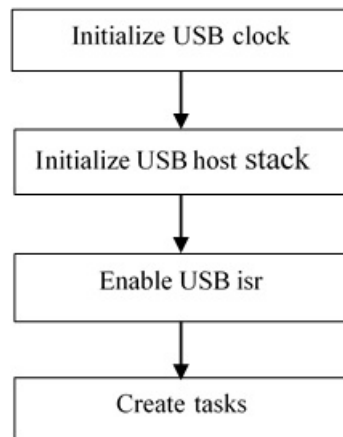


Figure 42. Main application function flow

- Initialize the USB clock.

Call the MCUXpresso SDK API to initialize the KHCI, or the EHCI USB clock.

- Initialize the host controller.

This allows the stack to initialize the necessary memory required to run the stack and register the callback function to the stack.

For example: `status = USB_HostInit(CONTROLLER_ID, &g_HostHandle, USB_HostEvent);`

- Enable the USB ISR.

Set the USB interrupt priority and enable the USB interrupt.

- Initialize the host stack task and application task.

For example (Bare metal):

```

while (1)
{
    #if (defined(USB_HOST_CONFIG_KHCI) && (USB_HOST_CONFIG_KHCI > 0U))
        USB_HostKhciTaskFunction(g_HostHandle);
    #endif /* USB_HOST_CONFIG_KHCI */
    #if (defined(USB_HOST_CONFIG_EHCI) && (USB_HOST_CONFIG_EHCI > 0U))
        USB_HostEhciTaskFunction(g_HostHandle);
    #endif /* USB_HOST_CONFIG_EHCI */
    USB_HostMsdkTask(&g_MsdCommandInstance);
}
  
```

Note that in this code, the `g_MsdCommandInstance` variable contains all states and pointers used by the application to control or operate the device. If implementing the application task as `USB_HostHidTestTask` and use `g_HidTestInstance` to maintain the application states, modify the code as follows:

```
while (1)
{
    #if (defined(USB_HOST_CONFIG_KHCI) && (USB_HOST_CONFIG_KHCI > 0U))
        USB_HostKhciTaskFunction(g_HostHandle);
    #endif /* USB_HOST_CONFIG_KHCI */
    #if (defined(USB_HOST_CONFIG_EHCI) && (USB_HOST_CONFIG_EHCI > 0U))
        USB_HostEhciTaskFunction(g_HostHandle);
    #endif /* USB_HOST_CONFIG_EHCI */
        USB_HostHidTestTask(&g_HidTestInstance);
}
```

4.2.2.3 Event callback function

In the `app.c` file, there is one `USB_HostEvent` function. By default, the function is registered to the host stack when calling the `USB_HostInit`. In the USB Host stack, customers do not have to write any enumeration code. When the device is connected to the host controller, the USB Host stack enumerates the device. The device attach/detach events are notified by this callback function.

Application needs to implement one or more functions to correspond to one class process. These application functions are called in the `USB_HostEvent`. The device's configuration handle and interface list are passed to the application through the function so that the application can determine whether the device is supported by this application.

There are four events in the callback: `kUSB_HostEventAttach`, `kUSB_HostEventNotSupported`, `kUSB_HostEventEnumerationDone`, and `kUSB_HostEventDetach`.

The events occur as follows:

- When one device is attached, host stack notifies `kUSB_HostEventAttach`.
- The application returns `kStatus_USB_Success` to notify the host stack that the device configuration is supported by this class application, or return the `kStatus_USB_NotSupported` to notify the host stack that the device configuration is not supported by this class application.
- The Host stack continues for enumeration if the device is supported by the application and notifies `kUSB_HostEventEnumerationDone` when the enumeration is done.
- The Host stack checks the next device's configuration if the current configuration is not supported by the application.
- When the Host stack checks all configurations and all are not supported by the application, it notifies the `kUSB_HostEventNotSupported`.
- When the device detaches, the Host stack notifies the `kUSB_HostEventDetach`.

This is the sample code for the HID mouse application. The `USB_HostHidMouseEvent` function should be called by the `USB_HostEvent`. In this code, the `g_HostHidMouse` variable contains all states and pointers used by the application to control or operate the device:

```
usb_status_t USB_HostHidMouseEvent
(
    usb_device_handle deviceHandle,
    usb_host_configuration_handle configurationHandle,
    uint32_t eventCode
)
{
    /* Process the same and supported device's configuration handle */
    static usb_host_configuration_handle s_ConfigHandle = NULL;
    usb_status_t status = kStatus_USB_Success;
```

```

uint8_t id;
usb_host_configuration_t *configuration;
uint8_t interfaceIndex;
usb_host_interface_t *interface;

switch (eventCode)
{
    case kUSB_HostEventAttach:
        /* judge whether is configurationHandle supported */
        configuration = (usb_host_configuration_t *)configurationHandle;
        for (interfaceIndex = 0; interfaceIndex < configuration->interfaceCount; +
+interfaceIndex)
        {
            interface = &configuration->interfaceList[interfaceIndex];
            id = interface->interfaceDesc->bInterfaceClass;
            if (id != USB_HOST_HID_CLASS_CODE)
            {
                continue;
            }
            id = interface->interfaceDesc->bInterfaceSubClass;
            if ((id != USB_HOST_HID_SUBCLASS_CODE_NONE) && (id !=
USB_HOST_HID_SUBCLASS_CODE_BOOT))
            {
                continue;
            }
            id = interface->interfaceDesc->bInterfaceProtocol;
            if (id != USB_HOST_HID_PROTOCOL_MOUSE)
            {
                continue;
            }
            else
            {
                /* the interface is supported by the application */
                g_HostHidMouse.deviceHandle = deviceHandle;
                g_HostHidMouse.interfaceHandle = interface;
                s_ConfigHandle = configurationHandle;
                return kStatus_USB_Success;
            }
        }
        status = kStatus_USB_NotSupported;
        break;
    case kUSB_HostEventNotSupported:
        break;
    case kUSB_HostEventEnumerationDone:
        if (s_ConfigHandle == configurationHandle)
        {
            if ((g_HostHidMouse.deviceHandle != NULL) && (g_HostHidMouse.interfaceHandle != NULL))
            {
                /* the device enumeration is done */
                if (g_HostHidMouse.deviceState == kStatus_DEV_Idle)
                {
                    g_HostHidMouse.deviceState = kStatus_DEV_Attached;
                }
                else
                {
                    usb_echo("not idle mouse instance\r\n");
                }
            }
        }
        break;

```



```

        case kUSB_HostEventDetach:
            if (s_ConfigHandle == configurationHandle)
            {
                /* the device is detached */
                s_ConfigHandle = NULL;
                if (g_HostHidMouse.deviceState != kStatus_DEV_Idle)
                {
                    g_HostHidMouse.deviceState = kStatus_DEV_Detached;
                }
            }
            break;
        default:
            break;
    }
    return status;
}

```

If implementing the callback as `USB_HostHidTestEvent`, use `g_HidTestInstance`, and support the device that the class code is `USB_HOST_HID_TEST_CLASS_CODE`, sub-class code is `USB_HOST_HID_TEST_SUBCLASS_CODE`, and the protocol is `USB_HOST_HID_TEST_PROTOCOL`. The code can be modified as follows:

```

usb_status_t USB_HostHidMouseEvent
(
    usb_device_handle deviceHandle,
    usb_host_configuration_handle configurationHandle,
    uint32_t eventCode
)
{
    /* Process the same and supported device's configuration handle */
    static usb_host_configuration_handle s_ConfigHandle = NULL;
    usb_status_t status = kStatus_USB_Success;
    uint8_t id;
    usb_host_configuration_t *configuration;
    uint8_t interfaceIndex;
    usb_host_interface_t *interface;

    switch (eventCode)
    {
        case kUSB_HostEventAttach:
            /* judge whether is configurationHandle supported */
            configuration = (usb_host_configuration_t *)configurationHandle;
            for (interfaceIndex = 0; interfaceIndex < configuration->interfaceCount; ++interfaceIndex)
            {
                interface = &configuration->interfaceList[interfaceIndex];
                id = interface->interfaceDesc->bInterfaceClass;
                if (id != USB_HOST_HID_TEST_CLASS_CODE)
                {
                    continue;
                }
                id = interface->interfaceDesc->bInterfaceSubClass;
                if (id != USB_HOST_HID_TEST_SUBCLASS_CODE)
                {
                    continue;
                }
                id = interface->interfaceDesc->bInterfaceProtocol;
                if (id != USB_HOST_HID_TEST_PROTOCOL)
                {
                    continue;
                }
            }
        }
    }
}

```

```

    }
    else
    {
        /* the interface is supported by the application */
        g_HidTestInstance.deviceHandle = deviceHandle;
        g_HidTestInstance.interfaceHandle = interface;
        s_ConfigHandle = configurationHandle;
        return kStatus_USB_Success;
    }
}

status = kStatus_USB_NotSupported;
break;
case kUSB_HostEventNotSupported:
    break;
case kUSB_HostEventEnumerationDone:
    if (s_ConfigHandle == configurationHandle)
    {
        if ((g_HidTestInstance.deviceHandle != NULL) && (g_HidTestInstance.interfaceHandle !=
= NULL))
        {
            /* the device enumeration is done */
            if (g_HidTestInstance.deviceState == kStatus_DEV_Idle)
            {
                g_HidTestInstance.deviceState = kStatus_DEV_Attached;
            }
            else
            {
                usb_echo("not idle mouse instance\r\n");
            }
        }
    }
    break;
case kUSB_HostEventDetach:
    if (s_ConfigHandle == configurationHandle)
    {
        /* the device is detached */
        s_ConfigHandle = NULL;
        if (g_HidTestInstance.deviceState != kStatus_DEV_Idle)
        {
            g_HidTestInstance.deviceState = kStatus_DEV_Detached;
        }
    }
    break;
default:
    break;
}
return status;
}

```

Note that the `kStatus_DEV_Attached`, `kStatus_DEV_Detached` MACROS are defined in the example.

4.2.2.4 Class initialization

When the supported device is attached, the device's class needs to be initialized.

For example, the HID mouse initialization flow is as follows:

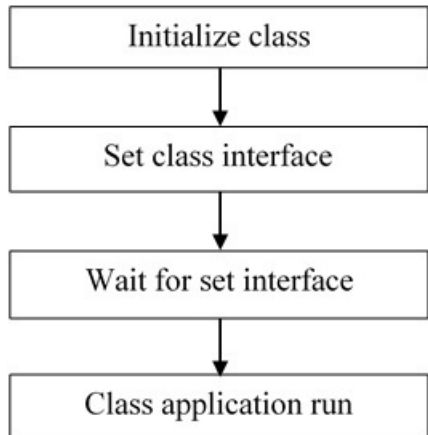


Figure 43. HID mouse initialization flow

- Call class initialization function to initialize the class instance.
- Call class set interface function to set the class interface
- When the set interface callback returns successfully, the application can run.

4.2.2.5 Sending/Receiving data to/from the device

The transfer flow is as follows:

1. Call the `USB_hostClassxxx` API to begin the transfer.
2. The transfer result is notified by the callback function that is passed as a parameter.
3. The HID mouse host uses the following code to receive data from the device:
`USB_HostHidRecv(classHandle, mouseBuffer, bufferLength, callbackFunction, callbackParameter);`

Chapter 5

USB Compliance tests

For the device, this is enabled on "dev_hid_mouse_bm" as an example.

```
enable USB_DEVICE_CONFIG_USB20_TEST_MODE (0U)
```

The macro is defined in `usb_device_config.h`. Use the TWR-K65F180M Tower System module as an example. The file path is

`<install_dir>/boards/twrk65f180m/usb_examples/usb_device_hid_mouse/bm/usb_device_config.h`.

For the host, this is enabled on "host_msd_fatfs_bm" as an example.

```
enable USB_HOST_CONFIG_COMPLIANCE_TEST (0U)
```

The macro is defined in the `usb_host_config.h` file.

For example, for the TWR-K65F180M Tower System module, the file path is

`<install_dir>/boards/twrk65f180m/usb_examples/usb_host_msd_fatfs/bm/usb_host_config.h`

Chapter 6

Revision history

This table summarizes revisions to this document since the release of the previous version.

Revision history		
Revision number	Date	Substantive changes
1	01/2016	KSDK 2.0.0 release
2	08/2016	Added LPC content for release
3	09/2016	Updated for KSDK 2.0.0 release 5
4	11/2016	Updated IAR version and USB code structure version, Section 2.4.1 and Section 2.4.2.
5	03/2017	Updated for MCUXpresso SDK
6	04/2017	Added note in Section 2.3
7	11/2017	MCUXpresso SDK 2.3.0 release

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