AN12238
i.MX RT Flashloader Use Case

Rev. 2 — February 4, 2021

Application Note

Contents

1 Introduction

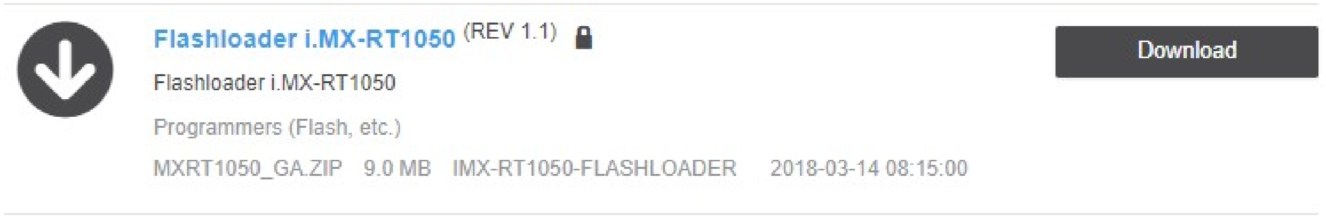
The i.MX RT Flashloader is a stand-alone, complete software utility for developing and manufacturing of the i.MX RT series MCUs. It includes both the Flashloader binary running in the MCU RAM and the PC-host tools to communicate with the Flashloader binary. It enables quick and easy programming of the internal OCOTP (eFuse) and external NOR/NAND/HyperFlash devices. The host-side command line and GUI tools are available to communicate with the Flashloader binary via the supported peripherals (USB-HID or UART).

The Flashloader used for the example in this document is Flashloader_RT1050_1.1. The hardware platform is the MIMXRT1050-EVKB board.

2 i.MX RT1050 Flashloader

2.1 Obtaining the i.MX RT1050 Flashloader

NXP provides the Flashloader package on the official website. Download the Flashloader package for the i.MX RT1050 MCU and the MIMXRT1050-EVK board from i.MX RT1050 Evaluation Kit.


Flashloader i.MX-RT1050 (REV 1.1)

Flashloader i.MX-RT1050

Programmers (Flash, etc.)

MXRT1050_GA.ZIP 9.0 MB IMX-RT1050-FLASHLOADER 2018-03-14 08:15:00

Figure 1. Downloading the i.MX RT1050 Flashloader

NOTE

There are different Flashloader packages for different MCU platforms and they cannot be used interchangeably. Make sure to download the correct Flashloader package for the specific MCU platform. For the download sites, see Obtain Flashloader packages.

2.2 Flashloader package

All the files and tools in the Flashloader package work together to achieve these functionalities:

1. Communicate with the MCU BootROM and download the Flashloader image.
2. Create a bootable image (SB file).

3. Program the MCU internal OCOTP (eFuse) to define the boot mode, MAC address, security mode, and so on.
4. Program the bootable image (SB file) into the MCU external flash (Nor/NAND/HyperFlash/SD).

This is the directory structure of the Flashloader package after it is unzipped:

```
└──Flashloader_RT1050_1.1
    │  LA_OPT_Base_License.htm
    │  SW_Content_Register_Kinetis_Bootloader.txt
    ├──doc
    ├──example_images
    ├──Flashloader
    └──Tools
        ├──bd_file
        ├──blhost
        ├──elftosb
        ├──Mfgtools-rel
        └──sdphost
```

Table 1 shows detailed information about the Flashloader directories and files.

Table 1. Flashloader directories and files

LA_OPT_Base_License.htm	NXP Software License Agreement
SW_Content_Register_Kinetis_Bootloader .txt	Flashloader release information and software content
doc	The *doc* directory includes all the documents: • *i.MX MCU Manufacturing User's Guide.pdf* • *MXRT1050 Flashloader v1.1.0 Release Notes.pdf* • *Kinetis blhost User's Guide.pdf* • *Kinetis SDPHost User's Guide.pdf* • *MCUX Flashloader Reference Manual.pdf*
example_images	The *example_images* directory includes example executable images. They can be used by the Flashloader tools to verify the basic process on the MIMXRT1050-EVK board.
Flashloader	The *Flashloader* directory includes the released Flashloader executable image. It can be downloaded into the target device and implements the supported features.

Table continues on the next page...

Table 1. Flashloader directories and files (continued)

Tools\bd_file\	The *Tools\bd_file* directory includes the example BD files for the i.MX RT1050 platform. The BD file is the "Boot Description" file. It is used by the elftosb tool to control the sequence of the bootloader commands present in the final bootable output file.
Tools\blhost\	The *Tools\blhost* directory includes the blhost tool for the Windows®/MAC/Linux OS host systems. The `blhost` application is a command-line utility used by the host computer to initiate the communication and inject commands to the Flashloader running on the target device. It can communicate directly with the Flashloader over the host computer UART (Serial Port) or USB connections and then implement the programming of the internal eFuse and the external flash device.
Tools\elftosb\	The *Tools\elftosb* directory includes the elftosb tool for the Windows/Linux OS host systems. The elftosb tool creates a binary output file that contains the user application image and a series of bootloader commands. The output is the Secure Binary (SB) file.
Tools\Mfgtools-rel\	The *Tools\Mfgtools-rel* directory includes the GUI Mfgtool and the configuration files. The Mfgtool is a GUI application for downloading and programming of application images into external flash devices.
Tools\sdphost\	The *Tools\sdphost* directory includes the sdphost tool for the Windows/MAC/Linux OS host systems. The sdphost tool provides a command line interface for sending Serial Download Protocol (SDP) commands from the PC host to NXP i.MX devices in the serial download mode. The sdphost tool is very useful in the factory programming/manufacturing process. It can be invoked from other applications and is a very useful tool for testing of automation software, development and test setups, or manufacturing environments.

3 i.MX RT1050 OCOTP and external flash

The key features of the Flashloader are the OCOTP (eFuse) operation and external flash programming. The following subsections provide a simple introduction to the Flashloader and OCOTP. For more details, see *i.MX RT1050 Processor Reference Manual* (document IMXRT1050RM).

3.1 OCOTP (eFuse)

The OCOTP (On-Chip One-Time Programmable) memory, also named eFuse, is a special memory module in the chip. Any eFuse bit in the field can be programmed from 0 to 1 just once (fused), but the read operation has no limitations. The memory space contains the whole chip configuration. Here are some key configurations:

- Boot mode
- MAC address
- FlexRAM setting

For the eFuse programming examples using the Flashloader, see Program OCOTP (eFuse).

The eFuse memory space is not assigned to the system 4G address space, so the normal address Read/Write cannot be used to access the eFuse registers. A specific process is needed to Read/Write the eFuse registers and for the Flashloader to support this feature.

The OTP memory footprint in Figure 2 shows the registers grouped by the lock region.

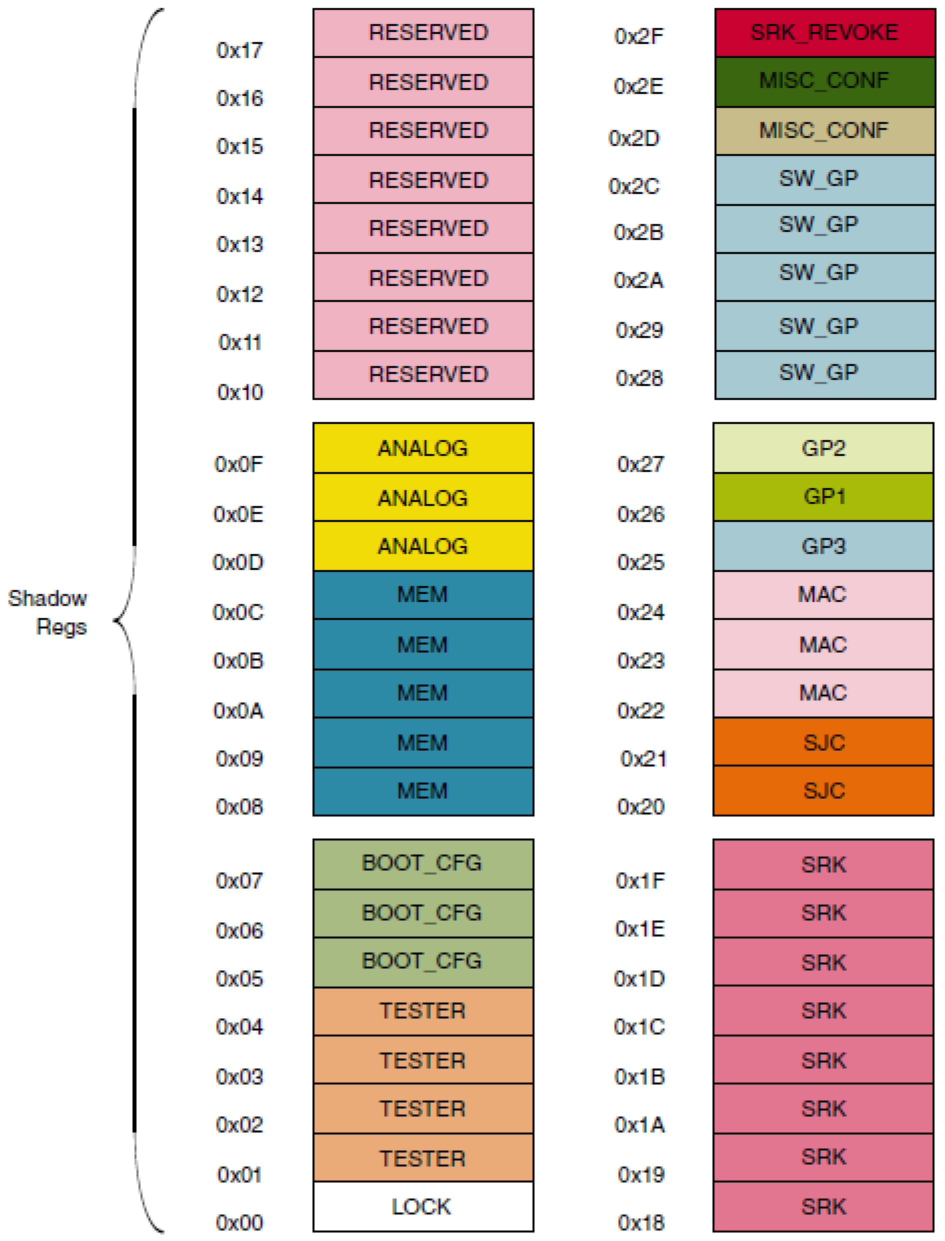


Figure 2. OTP memory footprint

3.2 External flash

The i.MX RT1050 device provides various external flash memory interfaces:

- 8/16-bit SLC NAND FLASH with the ECC handled by software
- SD/eMMC
- HyperFlash
- Parallel NOR FLASH with XIP support
- Single/dual-channel quad SPI FLASH with XIP support

The external flash can be used to store the application image and make the i.MX RT1050 boot from the flash image. The Flashloader includes various flash-programming algorithms to support the flash image programming in the development and manufacture phases.

3.2.1 Bootable image

For the i.MX RT1050 device, the application image must be stored in the external flash device. It is different for MCUs that have an internal parallel NOR flash. The internal parallel NOR flash space is assigned to the system 4 G memory space and can be accessed directly by address. The core can fetch the boot image binary directly and run the eXecute-In-Place (XIP).

After the chip power reset, the BootROM in the i.MX RT1050 always runs first. It checks the boot mode and helps the core to boot from a specific external flash device.

For various flash interfaces and boot modes, the BootROM must get some additional information from the application image in the external flash device. By combining the additional necessary information with the application image, you get the final programmable bootable image.

The additional necessary information are:

- Flash Configuration Block (FCB):
  - Optional (used for serial/parallel NOR FLASH).
  - Offset: 0x0000.
  - Description: The structure of the external flash interface definition.
- Image Vector Table (IVT):
  - Required.
  - Offset: 0x0400 (non-XIP flash)/0x1000 (XIP flash).
  - Description: The structure includes the address information of the application binary, DCD, BD, and CSF.
- Boot Data (BD):
  - Required.
  - Offset: 0x0420 (non-XIP)/0x1020 (XIP).
  - Description: The structure includes the start address and size of the SB image.
- Device Configuration Data (DCD):
  - Optional.
  - Offset: Defined in the IVT.
  - Description: Currently used to configure the SDRAM (SEMC interface).
- Application binary:
  - Required.
  - Offset: 0x2000 (Typical).
  - Description: The pure application binary.
- Command Sequence File (CSF):
  - Optional.
  - Offset: Defined in the IVT.
  - Description: Used by the High-Assurance Boot (HAB).
- KeyBlob:
  - Optional.
  - Offset: Defined in the IVT.

— Description: Secure boot key information.

The `elftosb` tool in the Flashloader can be used to create the bootable image. The Flashloader also provides some BD example files. Figure 3 shows the bootable image layout and the function of each block.

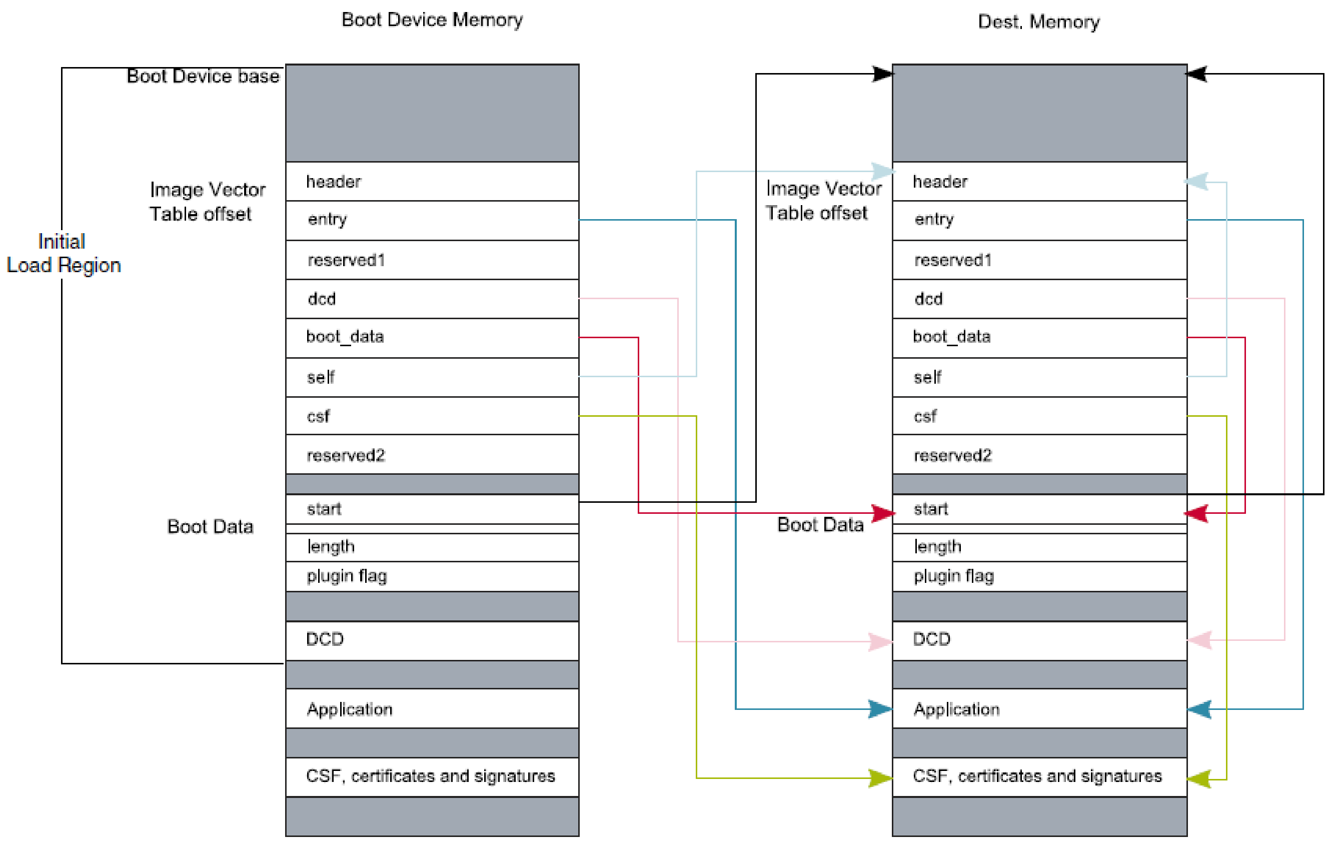


Figure 3. Bootable image layout

3.2.2 Booting from external flash

With BootROM, the i.MX RT1050 can boot from various external flash devices in the XIP (NOR-only) or NON-XIP modes. Based on the IVT and BD information in the Bootable image, the BootROM starts up the application binary directly (XIP) or copies the bootable image to the RAM and starts up the application binary (NON-XIP).

Figure 4 shows the process of the NON-XIP boot.

- Stage 1: Bootable image is in the external flash.
- Stage 2: BootROM loads the starting 4 KB of data from the bootable image to the internal SRAM (OCRAM). It includes the IVT and BD information and will be used for the application image loading.
- Stage 3: BootROM transfers the starting 4 KB of data from the internal SRAM (OCRAM) to the destination address space of the bootable image.
- Stage 4: BootROM continues loading the rest of the bootable image from the external flash to the destination address space and starts up the application binary.

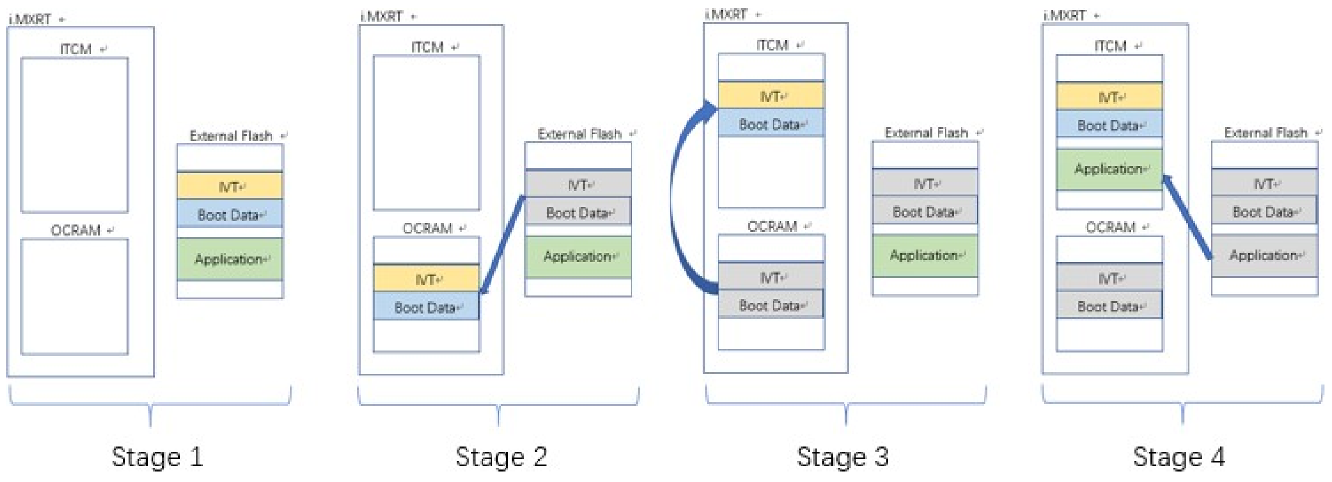


Figure 4. NON-XIP boot

In stage 2, if the BootROM finds the destination address equal to the external flash address, it will skip the remaining stages and start up the application binary directly in the flash address space. It is XIP boot.

4 i.MX RT1050 Flashloader use cases

This chapter describes the Flashloader usage case by case and provides the command lines and simple descriptions.

4.1 Target platform environment

All the Flashloader use cases are demonstrated using the MIMXRT1050 EVK target platform, as shown in Figure 5.

For the Flashloader usage, set the configurations as follows:

- Set the **Boot Mode Switch (SW7)** to **0001b** for the serial downloader mode.
- BootROM/Flashloader supports both the **OpenSDA/UART** and **USB-HID** ports as the communication interfaces with the PC host.
- Set the correct **Power Supply Switch (J1)** based on the communication interfaces used:
  - — OpenSDA/UART - J1-5&J1-6
  - — USB-HID - J1-3&J1-4

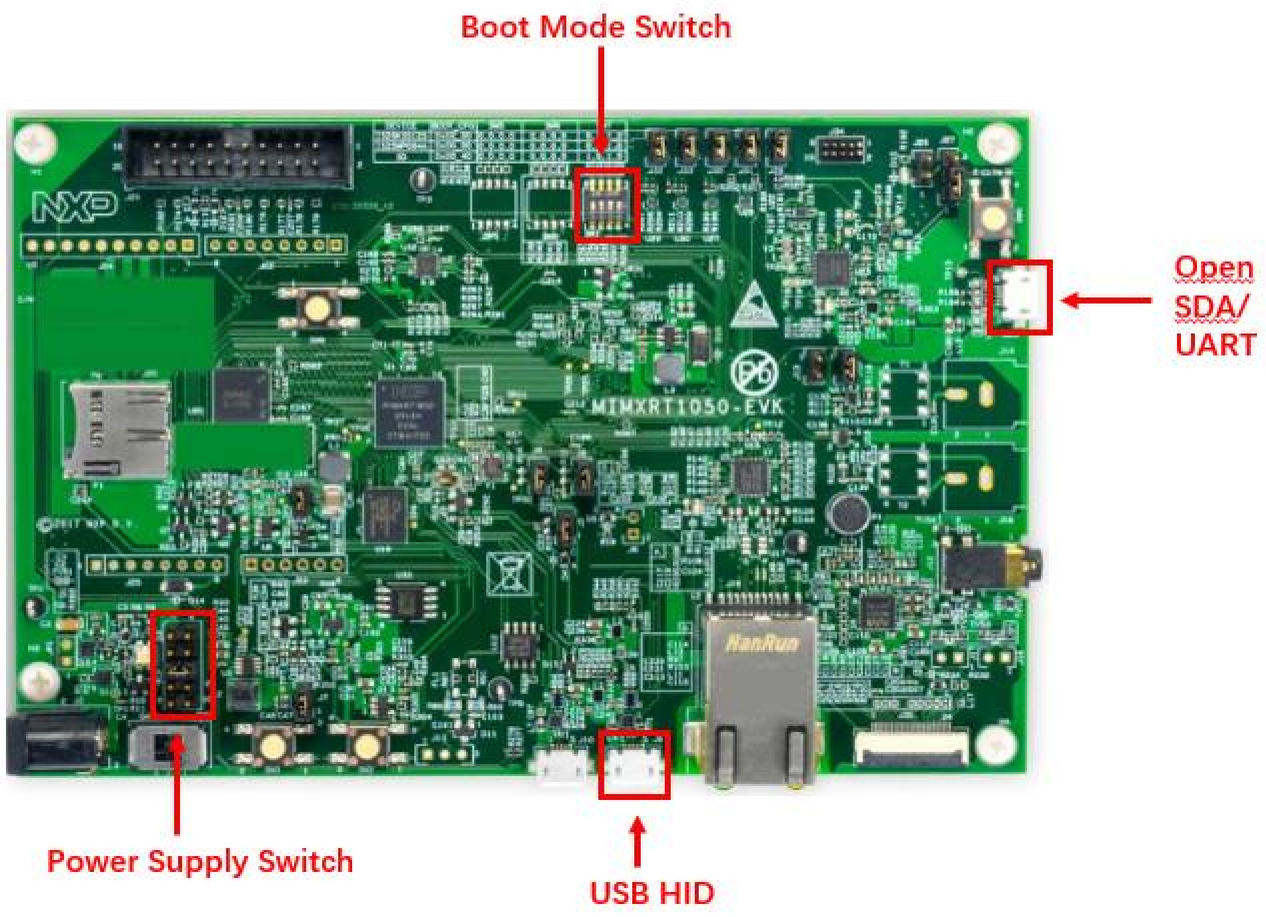
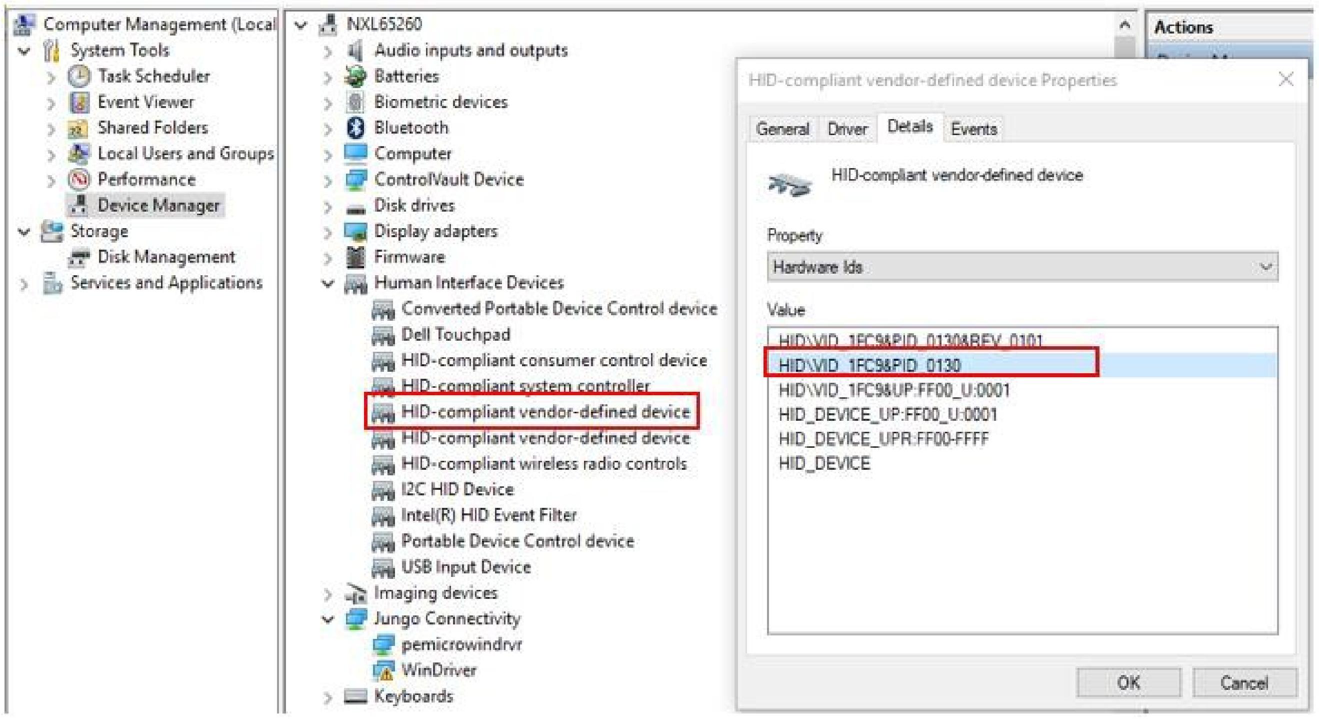


Figure 5. MIMXRT1050 EVK

When you set the USB-HID as the communication interface with the host PC (Windows OS), the USB-HID device (as shown in Figure 6) appears in the Windows OS Device Manager.



HID-compliant vendor-defined device

Property: Hardware Ids

Value:

```
HID\VID_1FC9&PID_0130&REV_0101
HID\VID_1FC9&PID_0130
HID\VID_1FC9&UP:FF00_U:0001
HID_DEVICE_UP:FF00_U:0001
HID_DEVICE_UPR:FF00-FFFF
HID_DEVICE
```

Figure 6. MIMXRT1050 EVK board USB-HID device

When you set the UART as the communication interface with the host PC (Windows OS), the COM device (as shown in Figure 7) appears in the Windows OS Device Manager.

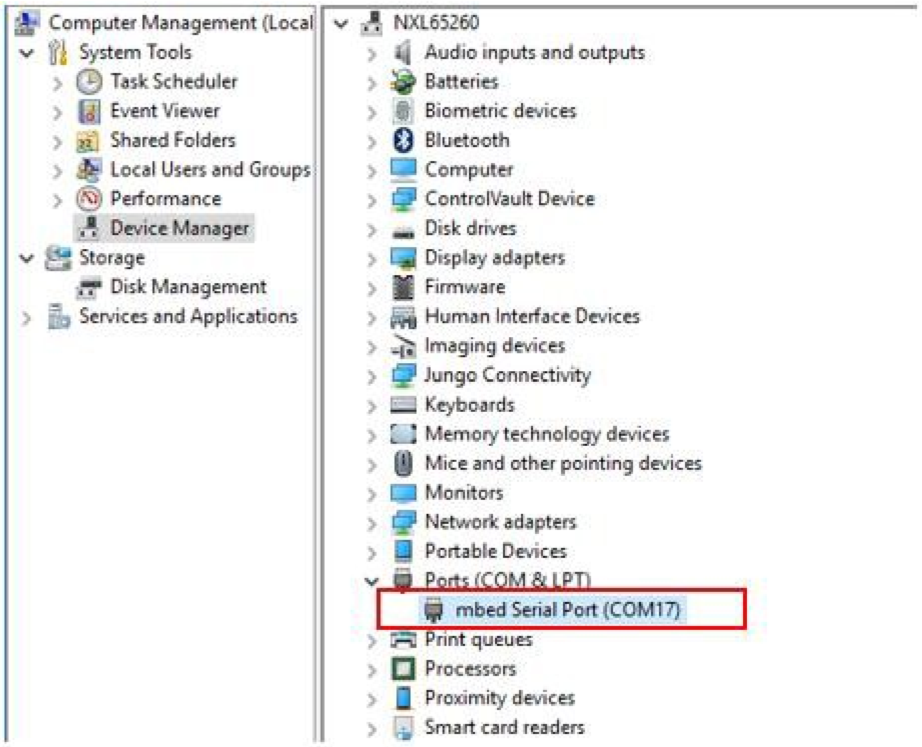


Figure 7. MIMXRT1050 EVK board UART device

NOTE

The ROM detects the communication over the USB-HID or UART ports and the unused port will be disabled. The board must be reset to change the communication port used to communicate with the host PC.

4.2 Serial Downloader mode

The BootROM provides the Serial Downloader feature via the UART or USB-HID interfaces, based on the Serial Downloader Protocol. The main purpose of the Serial Download Protocol is to download bootable images (Flashloader) from the PC (SDPHost tool) to the device's internal RAM memory and execute the bootable images in the RAM space. There is a set of commands to read and write a memory/register unit, get the status of the last command, jump, and execute the image from the provided address.

4.2.1 SDPHost downloads Flashloader image

The BootROM solidified into the i.MX RT chip does not support programming the flash device and the eFuse register. For the two targets, the Flashloader image is downloaded to the i.MX RT internal RAM using SDPHost (communicates with the running BootROM) and takes over the device from the BootROM (by the jump-address command of SDPHost). Then it implements the program process (communicates with the `blhost` tool).

In addition, the SDPHost jump-address command can start up the image just with the IVT header. Therefore, the *ivt_flashloader.bin* image should be used here.

1. Set the MIMXRT1050 EVK board to the Serial Downloader mode and connect the UART/USB-HID interface to the host PC.
2. Open the Windows OS Command Prompt and change the directory to *Flashloader_i.MXRT1050_GA\Flashloader_RT1050_1.1\Tools\sdphost\win*.
3. Verify that the SPDHost tool communicates with the BootROM of MIMXRT1050-EVK.
   - Using UART interface:

     ```
     >sdphost.exe -p COM17 -- error-status
     Status (HAB mode) = 1450735702 (0x56787856) HAB disabled.
     Reponse Status = 4042322160 (0xf0f0f0f0) HAB Success.
     ```

   - Using USB-HID interface:

     ```
     >sdphost.exe -u 0x1fc9,0x0130 -- error-status
     Status (HAB mode) = 1450735702 (0x56787856) HAB disabled.
     Reponse Status = 4042322160 (0xf0f0f0f0) HAB Success.
     ```

   NOTE

   -p COM17 and **-u 0x1fc9,0x0130** are used to indicate the COM and USB-HID port. The value of **COM17** and **0x1fc9,0x0130** can be obtained in Target platform environment. For the USB-HID interface, the PID and VID values can also be omitted in the command. The following cases only show the commands using the USB-HID interface.

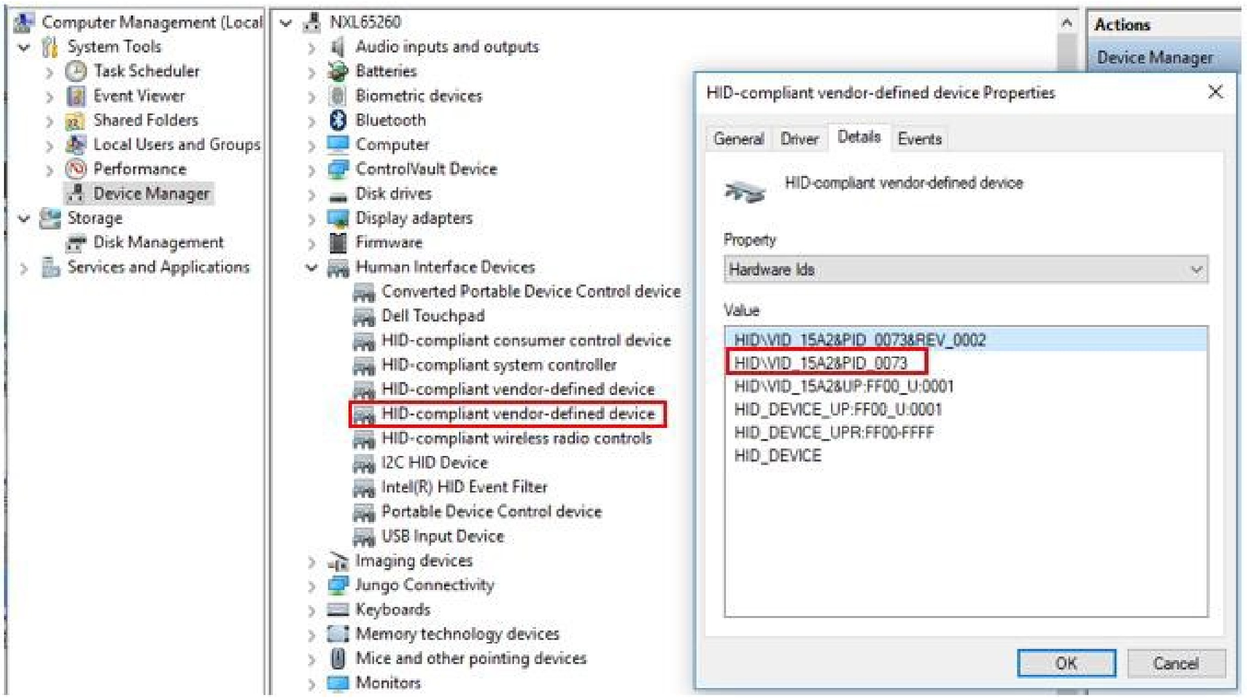
4. Download the IVT Flashloader image onto the MIMXRT1050-EVK board.

   ```
   >sdphost.exe -u 0x1fc9,0x0130 -- write-file 0x20000000 "..\..\Mfgtools-rel\Profiles\MXRT105X\OS
   Firmware\ivt_flashloader.bin"
   Preparing to send 90039 (0x15fb7) bytes to the target.
   (1/1)1%Status (HAB mode) = 1450735702 (0x56787856) HAB disabled.
   Reponse Status = 2290649224 (0x88888888) Write File complete.
   ```

5. Start up the Flashloader image.

   ```
   >sdphost.exe -u 0x1fc9,0x0130 -- jump-address 0x20000400
   Status (HAB mode) = 1450735702 (0x56787856) HAB disabled.
   ```

The USB-HID is re-enumerated by the running Flashloader image. The communication through the USB-HID changes from the BootROM to the Flashloader running in the internal RAM.


Computer Management (Local
System Tools
Task Scheduler
Event Viewer
Shared Folders
Local Users and Groups
Performance
Device Manager
Storage
Disk Management
Services and Applications
NXL65260
Audio inputs and outputs
Batteries
Biometric devices
Bluetooth
Computer
ControlVault Device
Disk drives
Display adapters
Firmware
Human Interface Devices
Converted Portable Device Control device
Dell Touchpad
HID-compliant consumer control device
HID-compliant system controller
HID-compliant vendor-defined device
HID-compliant vendor-defined device
HID-compliant wireless radio controls
I2C HID Device
Intel(R) HID Event Filter
Portable Device Control device
USB Input Device
Imaging devices
Jungo Connectivity
Keyboards
Memory technology devices
Mice and other pointing devices
Monitors
Actions
Device Manager
HID-compliant vendor-defined device Properties
General
Driver
Details
Events
HID-compliant vendor-defined device
Property
Hardware Ids
Value
OK
Cancel

HID\VID_15A2&PID_0073&REV_0002
HID\VID_15A2&PID_0073
HID\VID_15A2&UP:FF00_U:0001
HID_DEVICE_UP:FF00_U:0001
HID_DEVICE_UPR:FF00-FFFF
HID_DEVICE

Figure 8. Re-enumerated USB-HID device

6. Verify the communication with a running Flashloader using the `blhost` tool.

```
# change the directory to
"Flashloader_i.MXRT1050_GA\Flashloader_RT1050_1.1\Tools\blhost\win"
>blhost.exe -u -- get-property 1
Inject command 'get-property'
Response status = 0 (0x0) Success.
Response word 1 = 1258422528 (0x4b020100)
Current Version = K2.1.0
```

4.3 Program OCOTP (eFuse)

1. Download and start up the Flashloader image, as shown in SDPHost downloads Flashloader image.
2. Verify that the `blhost` tool communicates with the Flashloader running on the MIMXRT1050-EVK board.

```
# change the directory to
"Flashloader_i.MXRT1050_GA\Flashloader_RT1050_1.1\Tools\blhost\win"
>blhost.exe -u 0x15a2,0x0073 -- get-property 1
Inject command 'get-property'
Response status = 0 (0x0) Success.
Response word 1 = 1258422528 (0x4b020100)
Current Version = K2.1.0
```

3. Show the `blhost` help information about the eFuse operations commands.

```
>blhost.exe -?
......
Command:
```

```
……
    efuse-program-once <addr> <data>
                                 Program one word of OCOTP Field
                                 <addr> is ADDR of OTP word, not the shadowed memory address.
                                 <data> is hex digits without prefix '0x' efuse-read-once <addr>
                                 Read one word of OCOTP Field <addr> is ADDR of OTP word, not
the shadowed memory address.
```

4. Program the eFuse register `SRK_REVOKE` as an example.
   - `SRK_REVOKE` eFuse OCOTP index: 0x2F.
   - `SRK_REVOKE` eFuse shadow register address: 0x401F46F0.
   - Program the `SRK_REVOKE` eFuse LSB to: 0x5A.
   - Program the `SRK_REVOKE` eFuse MSB to: 0xFE.
   - Verify the `SRK_REVOKE` eFuse via a shadow register.

```
>blhost.exe -u 0x15a2,0x0073 -- efuse-program-once 0x2F 0000005A
Inject command 'efuse-program-once'
Successful generic response to command 'efuse-program-once'
Response status = 0 (0x0) Success.

>blhost.exe -u 0x15a2,0x0073 -- efuse-program-once 0x2F FE000000
Inject command 'efuse-program-once'
Successful generic response to command 'efuse-program-once'
Response status = 0 (0x0) Success.

>blhost.exe -u 0x15a2,0x0073 -- efuse-read-once 0x2F
Inject command 'efuse-read-once'
Response status = 0 (0x0) Success.
Response word 1 = 4 (0x4)
```

5. Verify the shadow register of the `SRK_REVOKE` eFuse.

```
>blhost.exe -u 0x15a2,0x0073 -- read-memory 0x401F46F0 4
Inject command 'read-memory'
Successful response to command 'read-memory' 5a 00 00 fe (1/1)100% Completed!
Successful generic response to command 'read-memory'
Response status = 0 (0x0) Success.
Response word 1 = 4 (0x4)
Read 4 of 4 bytes.
```

6. Some key points.
   - The eFuse bits can only be programmed from **0** to **1**. The OCOTP ignores the writes changing from **1** to **0**. For one eFuse register, the `efuse-program-once` command can be implemented for a specific bit field in multiple steps.
   - The `efuse-program-once` command includes the eFuse register reload command by default. The latest eFuse register value can be obtained from a shadow register after the `efuse-program-once` command.

4.3.1 Program boot mode eFuse to SD boot

- BOOT_CFG eFuse OCOTP index: 0x05.
- BOOT_CFG eFuse OCOTP index: 0x06.
- BOOT_CFG (0x05) eFuse shadow register address: 0x401F4450.
- BOOT_CFG (0x06) eFuse shadow register address: 0x401F4460.
- Program the BOOT_CFG (0x06) eFuse to: 0x00000010.

- Program the BOOT_CFG (0x05) eFuse to: 0x00000040.
- Verify the eFuse registers via shadow registers.

First, implement Step 1 to Step 3 in Program OCOTP (eFuse).

```
>blhost.exe -u -- efuse-program-once 0x06 00000010
>blhost.exe -u -- efuse-program-once 0x05 00000040
>blhost.exe -u -- efuse-read-once 0x06
>blhost.exe -u -- efuse-read-once 0x05
>blhost.exe -u -- read-memory 0x401F4460 4
>blhost.exe -u -- read-memory 0x401F4450 4
```

4.3.2 Program FlexRAM eFuse

- MISC_CFG eFuse OCOTP index: 0x2D.
- MISC_CFG (0x2D) eFuse shadow register address: 0x401F46D0.
- Select the group 0011: DTCM 128 KB, ITCM 32 KB, ORAM 352 KB.
- Program the MISC_CFG (0x2D) eFuse to: 0x00030000.
- Verify the eFuse registers via shadow registers.

Table 2 shows the i.MX RT1050 FlexRAM RAM bank partition.

Table 2. i.MX RT1050 FlexRAM banks

Parameter	DTCM	ITCM	ORAM
0000	128 KB	128 KB	256 KB
0001	128 KB	64 KB	320 KB
0010	128 KB	256 KB	128 KB
0011	**128 KB**	**32 KB**	**352 KB**
0100	64 KB	128 KB	320 KB
0101	64 KB	64 KB	384 KB
0110	64 KB	256 KB	192 KB
0111	0 KB	448 KB	64 KB
1000	256 KB	128 KB	128 KB
1001	256 KB	64 KB	192 KB
1010	192 KB	256 KB	64 KB
1011	448 KB	0 KB	64 KB
1100	0 KB	128 KB	384 KB
1101	32 KB	32 KB	448 KB

Table continues on the next page...

Table 2. i.MX RT1050 FlexRAM banks (continued)

Parameter	DTCM	ITCM	ORAM
1110	0 KB	256 KB	256 KB
1111	0 KB	0 KB	512 KB

First, implement Step 1 to Step 3 in Program OCOTP (eFuse).

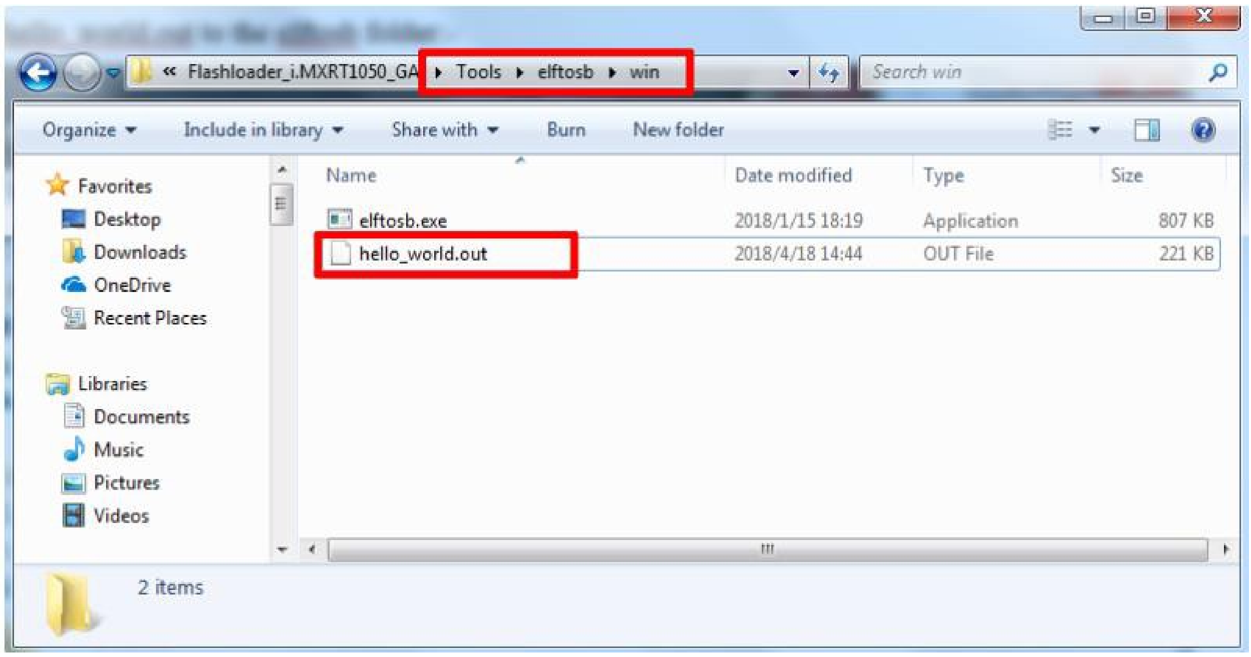
```
>blhost.exe -u -- efuse-program-once 0x2D 00030000
>blhost.exe -u -- efuse-read-once 0x2D
>blhost.exe -u -- read-memory 0x401F46D0 4
```

4.4 Building the bootable image

The elftosb tool creates a binary output file that contains the application image along with a series of Flashloader commands. The output file is known as an SB file. These files have a *.sb* extension. The tool uses an input command file to control a sequence of Flashloader commands present in the output file. This command file is called a BD file.

The XIP *hello_world* project for the QSPI NOR flash is used to demonstrate the process of creating a bootable image.

1. Build the XIP *hello_world.out* file with XIP_BOOT_HEADER_ENABLE=0 and XIP_BOOT_HEADER_DCD_ENABLE=0.
2. Copy *hello_world.out* to the *elftosb/win* directory.



Name	Date modified	Type	Size
elftosb.exe	2018/1/15 18:19	Application	807 KB
hello_world.out	2018/4/18 14:44	OUT File	221 KB

Figure 9. Copying *hello_world.out* to *elftosb*

3. Open the Windows OS Command Prompt and change the directory to *Flashloader_i.MXRT1050_GA\Flashloader_RT1050_1.1\Tools\elftosb\win*.

```
>elftosb.exe -f imx -V -c ..\..\bd_file\imx10xx\imx-flexspinor-normal-unsigned.bd -o
ivt_flexspi_nor_hello_world.bin hello_world.out
```

There are two bootable images with the IVT information after the above command:

- *ivt_flexspi_nor_hello_world.bin*

  The region from 0 to *ivt_offset* is filled with padding bytes (all 0x00).

- *ivt_flexspi_nor_hello_world_nopadding.bin*

  No padding bytes before `ivt_offset`.

  The later one (*nopadding.bin*) is used to generate the SB file for the QSPI NOR flash.

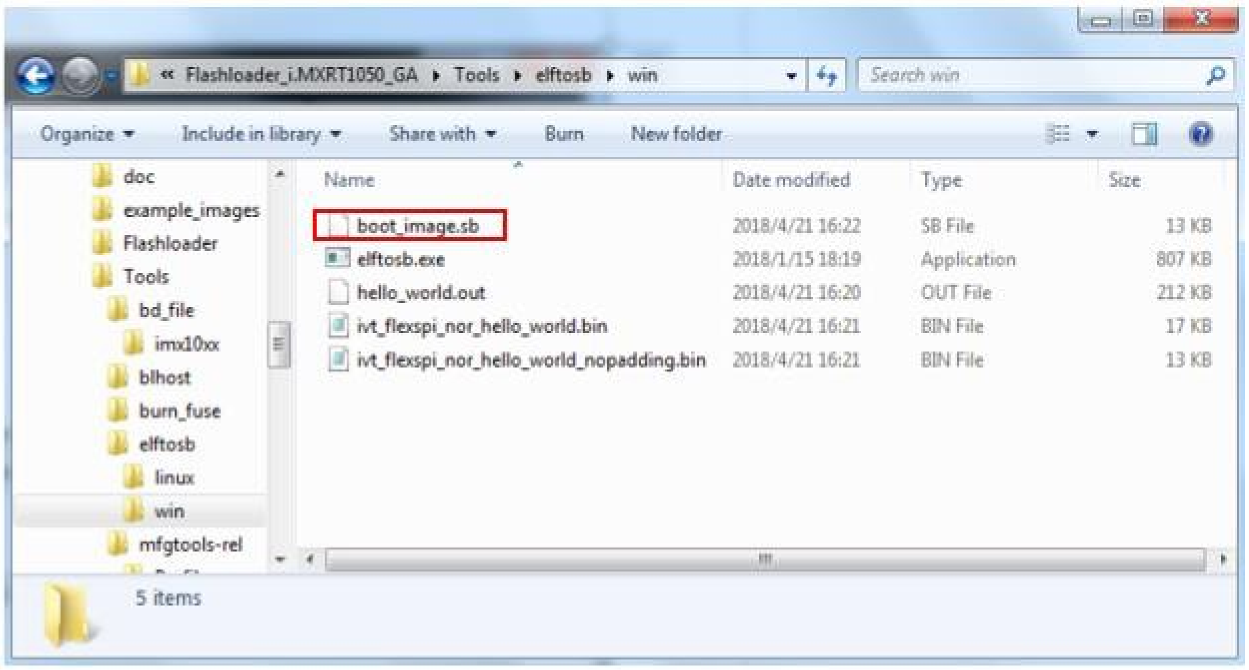
  NOTE

  The command may crash if the input file (*.out*) includes the boot header sections. Make sure the macros XIP_BOOT_HEADER_ENABLE=0 and XIP_BOOT_HEADER_DCD_ENABLE=0 are set when building the *.out* file.

4. Create the final SB image.

```
>elftosb.exe -f kinetis -V -c ..\..\bd_file\imx10xx\program_flexspinor_image_qspinor.bd -o
boot_image.sb ivt_flexspi_nor_hello_world_nopadding.bin
```

The *boot_image.sb* file is now in the *elftosb\win* directory.



Name	Date modified	Type	Size
boot_image.sb	2018/4/21 16:22	SB File	13 KB
elftosb.exe	2018/1/15 18:19	Application	807 KB
hello_world.out	2018/4/21 16:20	OUT File	212 KB
ivt_flexspi_nor_hello_world.bin	2018/4/21 16:21	BIN File	17 KB
ivt_flexspi_nor_hello_world_nopadding.bin	2018/4/21 16:21	BIN File	13 KB

Figure 10. Creating *boot_image.sb*

4.5 Programming external flash device

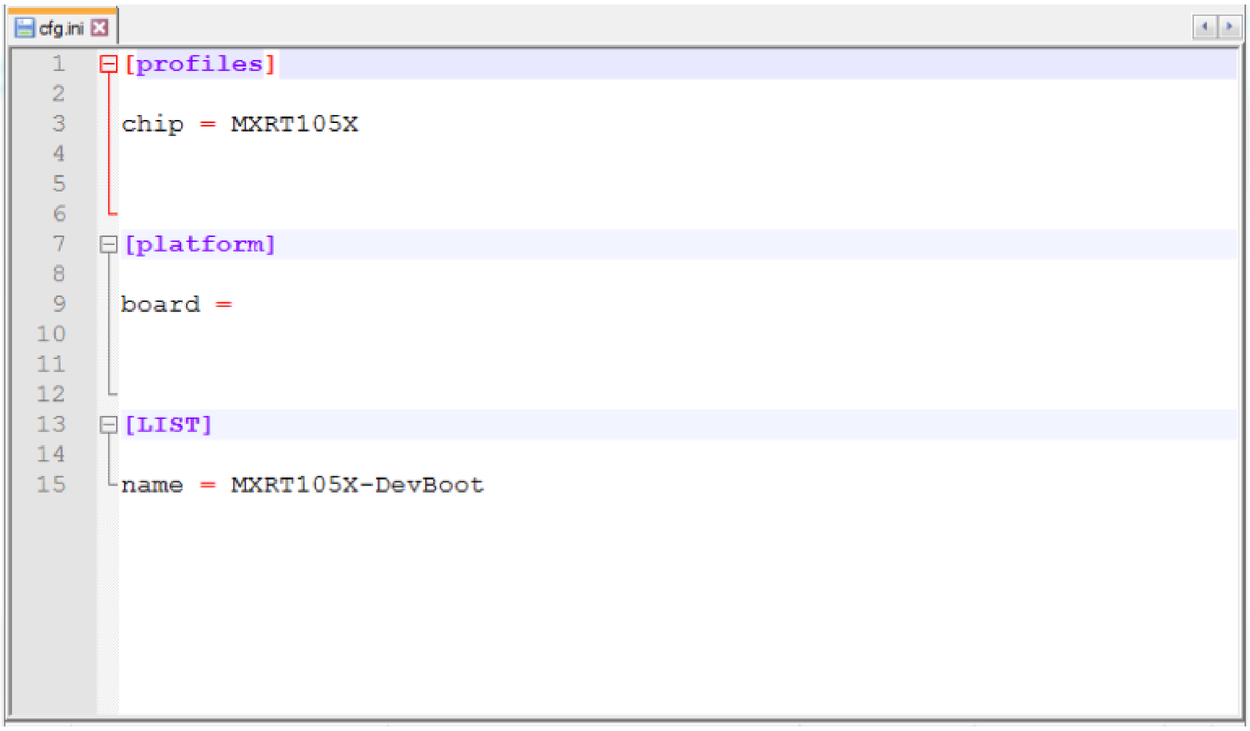
For the flash programming, the Flashloader provides an easy-to-use GUI programming tool (Mfgtool).

4.5.1 Mfgtool

The `Mfgtool` is a GUI tool that helps to program the external flash. It integrates the functionalities of the `SDPHost` and `blhost` tools and can detect an i.MX MCU BootROM connected to the PC host.

These steps show how to program the SB image from Building the bootable image using the `Mfgtool`.

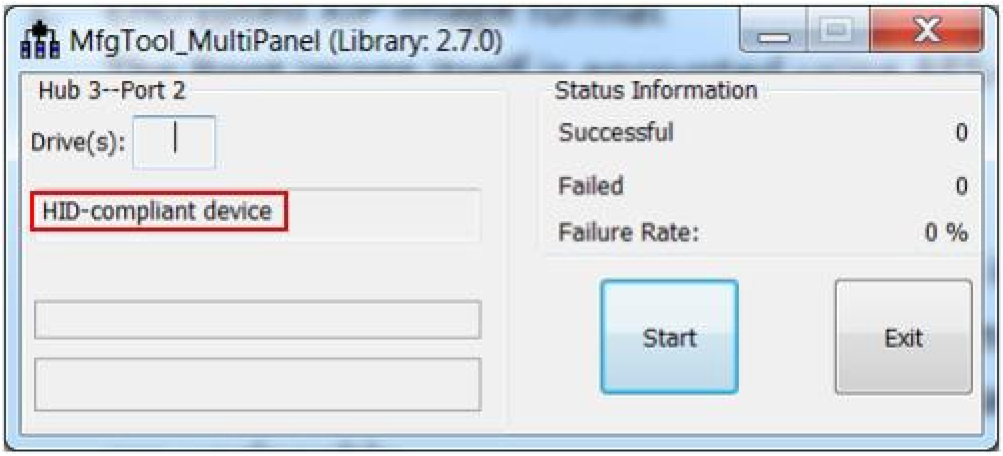
1. Copy the *boot_image.sb* file to the *<Mfgtool_root_dir>\Profiles\MXRT105X\OS* Firmware folder.
2. Change the **name** under **[List]** to **MXRT105x-DevBoot** in the *cfg.ini* file in the *<Mfgtool_root_dir>* directory.



```
[profiles]

chip = MXRT105X



[platform]

board =



[LIST]

name = MXRT105X-DevBoot
```

Figure 11. Setting the name of the LIST item

3. Set the MIMXRT1050-EVK board to the **Serial Downloader** mode and connect the USB-HID interface to the host PC.
4. Open the **Mfgtool** and connect to the MIMXRT1050-EVK board.



MfgTool_MultiPanel (Library: 2.7.0)

Hub 3--Port 2

Drive(s):

HID-compliant device

Status Information

Successful	0
Failed	0
Failure Rate:	0 %

Figure 12. Connect with MIMXRT1050 EVK

5. Program the bootable image. Click the **Start** button to trigger a programming sequence and wait for it to complete, as shown in Figure 13. To exit Mfgtool, click the **Stop** and **Exit** buttons.

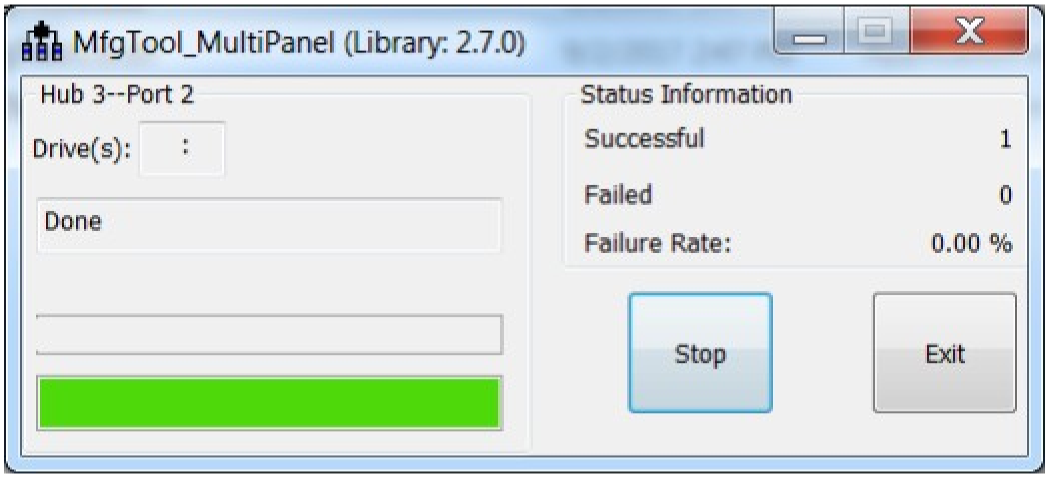


Figure 13. Programing the flash successfully

6. Switch the MIMXRT1050-EVK board to a correct boot mode for the programmed SB image and verify the application.

For more information about building the bootable image and programming the external flash, see *How to Enable Boot from Octal SPI Flash and SD Card* (document AN12107) and *How to Enable Boot from QSPI Flash* (document AN12108).

4.5.2 blhost

The `blhost` application is a command-line utility used on the host computer to initiate communication and issue commands to the MCU bootloader (Flashloader). The application only sends one command per invocation. It can communicate directly with the Flashloader over the host computer UART (Serial Port) or USB connections and then implement the programming of the external flash device. It is also available under the **Downloads** tab at MCUBOOT.

Example programming SB file via USB connection.

```
>blhost.exe -u -- receive-sb-file boot_image.sb
Inject command 'receive-sb-file'
Preparing to send 22208 (0x56c0) bytes to the target.
Successful generic response to command 'receive-sb-file'
(1/1)100% Completed!
Successful generic response to command 'receive-sb-file'
Response status = 0 (0x0) Success.
Wrote 22208 of 22208 bytes.
```

The `blhost` can also support to program the binary (not SB file) step by step.

1. The config parameter should be stored in RAM, which will be used in configuring the FlexSPI in next step. The config parameter is selected according to the FLASH type. Different NOR flash need different config parameters to enable and program. For more information, see FlexSPI configuration options and memory ID.

   ```
   >blhost.exe -u -- fill-memory 0x2000 0x4 0xC0000006
   ```

2. Use the config parameter stored in RAM in previous step to config the FlexSPI. Then, you can read, erase, and program the flash. The value `0x9` in the command line indicates the memory ID. For more information, see FlexSPI configuration options and memory ID.

   ```
   >blhost.exe -u -- configure-memory 0x9 0x2000
   ```

3. Program the raw binary using `-- flash-erase-region` and `-- write-memory` commands, or program the formatted image using `-- flash-image` by memory ID.

```
>blhost.exe -u -- flash-image hello_world.hex erase 0x9
```

5 i.MX RT10xx Flashloader

This chapter provide more Flashloader information of other RT10xx platforms.

5.1 Obtain Flashloader packages

- i.MX RT1010

  There is no standalone Flashloader package for i.MX RT1010. Please obtain the SDK including the `mcu-boot` middleware and find the Flashloader elements in *<SDK ROOT>\middleware\mcu-boot*.

- i.MX RT1015

  There is no standalone Flashloader package for i.MX RT1015. Please obtain the SDK including the `mcu-boot` middleware and find the Flashloader elements in *<SDK ROOT>\middleware\mcu-boot*.

- i.MX RT1020

  Please find the Flashloader package on i.MX RT1020 Crossover MCU with Arm® Cortex®-M7 core

- i.MX RT1050

  Please find the Flashloader package on i.MX RT1050 Crossover MCU with Arm® Cortex®-M7 core

- i.MX RT1060

  Please find the Flashloader package on i.MX RT1060 Crossover MCU with Arm® Cortex®-M7 core

NOTE

For RT1020, RT1050 and RT1060, the latest SDKs also include Flashloader elements in *<SDK ROOT>\middleware\mcu-boot* if selecting the `mcu-boot` module in SDK builder page. But the older version of SDK may not have the `mcu-boot` module.

5.2 Serial downloader

The *sdphost.exe* can also be found in the SDK:

<SDK ROOT>\middleware\mcu-boot\bin\Tools\sdphost\win\sdphost.exe

And the USB VID/PID for different i.MX RT10xx platform can be found in the list:

Device	VID	PID
RT1010	0x1FC9	0x0145
RT1015	0x1FC9	0x0130
RT1020	0x1FC9	0x0130
RT1050	0x1FC9	0x0130
RT1060	0x1FC9	0x0135

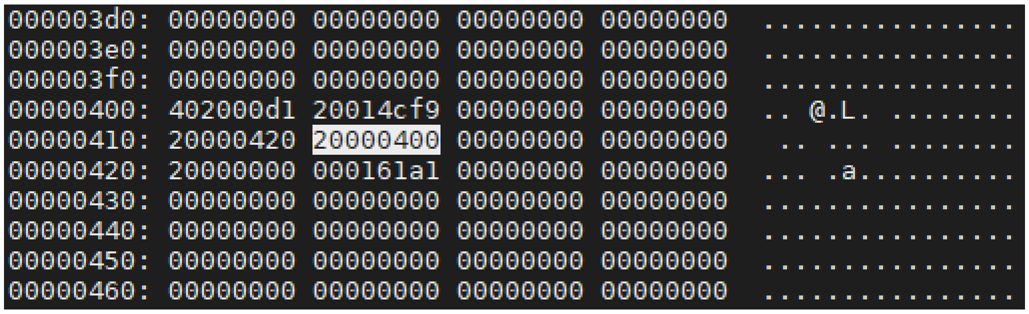
Likewise, the *ivt_flashloader.bin* binary can also be found in the SDK:

<SDK ROOT>\middleware\mcu-boot\bin\Tools\mfgtools-rel\Profiles\<Device Family>\OS Firmware\ivt_flashloader.bin

ivt_flashloader.bin load address and jump address can be derived by decoding the `ivt` header of the *ivt_flashloader.bin* file from the SDK. The `ivt` header is typically located at offset `0x000` or `0x400` and the first word is `0x402000d1`. The jump address is at offset `0x14` from the start of the `ivt` header. The load address for the `spdhost` write-file command is the jump address minus any padding in the binary file before `ivt` header (`0x000` or `0x400`). The jump address is the address that needs to be used for the `spdhost` jump-address command.

shows an example from i.MX RT1060 *ivt_flashloader.bin* binary.

- `ivt` first word `0x402000d1` is at `0x00000400`.
- The jump address is `0x20000400` at `ivt` head offset `0x14`.
- The load address is `0x20000400 - 0x00000400 = 0x20000000`.



```
000003d0: 00000000 00000000 00000000 00000000  ................
000003e0: 00000000 00000000 00000000 00000000  ................
000003f0: 00000000 00000000 00000000 00000000  ................
00000400: 402000d1 20014cf9 00000000 00000000  .. @.L. ........
00000410: 20000420 20000400 00000000 00000000   .. ... ........
00000420: 20000000 000161a1 00000000 00000000  ... .a..........
00000430: 00000000 00000000 00000000 00000000  ................
00000440: 00000000 00000000 00000000 00000000  ................
00000450: 00000000 00000000 00000000 00000000  ................
00000460: 00000000 00000000 00000000 00000000  ................
```

Figure 14. Example from i.MX RT1060 ivt_flashloader.bin binary

And the load address/jump address for different i.MX RT10xx platform can be found in the list:

Device	Load Addr	Jump Addr
RT1010	0x20205800	0x20205800
RT1015	0x20208000	0x20208000
RT1020	0x20208000	0x20208400
RT1050	0x20000000	0x20000400
RT1060	0x20000000	0x20000400

Example loading flashloader from SDK for RT1010:

```
>sdphost.exe -u 0x1fc9,0x0145 -V -- write-file 0x20205800 "<path to flashloader>\ivt_flashloader.bin"
>sdphost.exe -u 0x1fc9,0x0145 -V -- jump-address 0x20205800
```

RT1010 example of complete steps are:

1. Power down RT1010 and switch to Serial Downloader Boot mode:

   ```
   BOOT_MODE[1:0]=01
   ```

2. Power up RT1010 and connect USB cable.
3. Load flashloader binary into RAM and launch it using `sdphost`.

   ```
   >sdphost.exe -u 0x1fc9,0x0145 -V -- write-file 0x20205800 ".\ivt_flashloader.bin"
   >sdphost.exe -u 0x1fc9,0x0145 -V -- jump-address 0x20205800
   ```

4. Set FlexSPI configuration options. Configure FlexSPI and program image to flash with `blhost`.

```
>blhost.exe -u 0x15a2,0x0073 -- fill-memory 0x2000 4 0xC0000007
>blhost.exe -u 0x15a2,0x0073 -- configure-memory 9 0x2000
>blhost.exe -u 0x15a2,0x0073 -- flash-image .\imxrt1010_evk-firmware.hex erase 9
```

5. Power down RT1010 and switch to Internal Boot mode.

```
BOOT_MODE[1:0]=10
```

6. Power on RT1010.

6 Conclusion

This application note describes the background knowledge of the Flashloader and the use cases of the Flashloader. For more information, see these documents:

- *i.MX MCU Manufacturing User's Guide.pdf*
- *Kinetis blhost User's Guide.pdf*
- *Kinetis SDPHost User's Guide.pdf*
- *MCUX Flashloader Reference Manual.pdf*

7 Revision history

Table 3. Revision history

Revision number	Date	Substantive changes
0	08/2018	Initial release.
1	09/2018	Fixed errors in Program FlexRAM eFuse.
2	02/2021	Added blhost, and FlexSPI configuration options and memory ID.

A FlexSPI configuration options and memory ID

The source code for the flashloader is provided as an example in the SDK:

<SDK ROOT>\boards\<Board Name>\bootloader_examples\flashloader

The FlexSPI configuration options used by the `blhost` configure-memory command get passed to and are defined by the `flexspi_nor_get_config` function in *<SDK ROOT>\middleware\mcu-boot\targets\<Device Family>\src\flexspi_nor_flash_<Device Family>.c*.

The structure for `serial_nor_config_option_t` is specified in *<SDK ROOT>\middleware\mcu-boot\src\drivers\flexspi_nor\flexspi_nor_flash.h* along with some enumerations for the option tag and device types.

```
/*
 * Serial NOR Configuration Option
 */
typedef struct _serial_nor_config_option
{
    union
    {
        struct
        {
            uint32_t max_freq : 4;          //!< Maximum supported Frequency
            uint32_t misc_mode : 4;         //!< miscellaneous mode
            uint32_t quad_mode_setting : 4; //!< Quad mode setting
            uint32_t cmd_pads : 4;          //!< Command pads
            uint32_t query_pads : 4;        //!< SFDP read pads
            uint32_t device_type : 4;       //!< Device type
            uint32_t option_size : 4;       //!< Option size, in terms of uint32_t, size =
(option_size + 1) * 4
            uint32_t tag : 4;               //!< Tag, must be 0x0E
        } B;
        uint32_t U;
    } option0;

    union
    {
        struct
        {
            uint32_t dummy_cycles : 8;     //!< Dummy cycles before read
            uint32_t status_override : 8;  //!< Override status register value during device mode
configuration
            uint32_t pinmux_group : 4;     //!< The pinmux group selection
            uint32_t dqs_pinmux_group : 4; //!< The DQS Pinmux Group Selection
            uint32_t drive_strength : 4;   //!< The Drive Strength of FlexSPI Pads
            uint32_t flash_connection : 4; //!< Flash connection option: 0 - Single Flash connected
to port A, 1 -
            //! Parallel mode, 2 - Single Flash connected to Port B
        } B;
        uint32_t U;
    } option1;

} serial_nor_config_option_t;

enum
{
    kSerialNorCfgOption_Tag = 0x0c,
    kSerialNorCfgOption_DeviceType_ReadSFDP_SDR = 0,
    kSerialNorCfgOption_DeviceType_ReadSFDP_DDR = 1,
    kSerialNorCfgOption_DeviceType_HyperFLASH1V8 = 2,
    kSerialNorCfgOption_DeviceType_HyperFLASH3V0 = 3,
    kSerialNorCfgOption_DeviceType_MacronixOctalDDR = 4,
    kSerialNorCfgOption_DeviceType_MacronixOctalSDR = 5,
    kSerialNorCfgOption_DeviceType_MicronOctalDDR = 6,
    kSerialNorCfgOption_DeviceType_MicronOctalSDR = 7,
    kSerialNorCfgOption_DeviceType_AdestoOctalDDR = 8,
    kSerialNorCfgOption_DeviceType_AdestoOctalSDR = 9,
};
```

In most cases, you should be able to use `0xC000000n`, where `n` is the serial clock frequency from the list of `kFlexSpiSerialClk_xxx` values in *<SDK ROOT>\middleware\mcu-boot\targets\<Device Family>\src\target_config.h*.

```
//! @brief FlexSPI supported speed defintions
enum
{
    kFlexSpiSerialClk_30MHz = 1,
    kFlexSpiSerialClk_50MHz = 2,
    kFlexSpiSerialClk_60MHz = 3,
    kFlexSpiSerialClk_75MHz = 4,
    kFlexSpiSerialClk_80MHz = 5,
    kFlexSpiSerialClk_100MHz = 6,
    kFlexSpiSerialClk_133MHz = 7,
    kFlexSpiSerialClk_166MHz = 8,
    kFlexSpiSerialClk_200MHz = 9,
};
```

Table 4 shows the memory ID definitions for `-- configure-memory` command.

Table 4. Memory ID definitions for -- configure-memory command

Internal memory	Device internal memory space
0	Internal memory (Default selected mmory)
16 (0 × 10)	Execute-only region on internal flash (only used for flash-erase-all)
Mapped external memory	The memories that are remapped to internal space, and must be accessed by internal addresses. (IDs in this group are only used for flash-erase-all and configure-memory, and ignored by write-memory, read-memory, flash-erase-region and flash-image (use default 0))
1	QuadSPI memory
8	SEMC NOR memory
9	FlexSPI NOR memory
10 (0xa)	SPIFI NOR memory
Unmapped external memory	Memories which cannot be remapped to internal spance, and only can be accessed by memories' addresses. (Must be spencified for all commends with <memoryID> argument)
256 (0 × 100)	SEMC NAND memory
257 (0 × 101)	SPI NAND memory
272 (0 × 110)	SPI NOR/EEPROM memory
273 (0 × 111)	I2C NOR/EEPROM memory
288 (0 × 120)	uSDHC SD memory
289 (0 × 121)	uSDHC MMC memory

Date of release: February 4, 2021
Document identifier: AN12238