Renesas Synergy™ Platform

Customizable Flashloader Solution for Synergy MCUs

R11AN0073EU0112
Rev.1.12
Dec 28, 2018

Introduction

This application project describes how to integrate and use the Renesas Flashloader module to update the application software running on a Renesas Synergy™ microcontroller. The ability to update the application software in the field is critical to successfully pushing feature improvements and bug fixes to an embedded system.

The Flashloader solution contains three separate application pieces:

- The bootloader is a complete, self-contained image that runs on the Synergy microcontroller and performs the application update.
- The downloader is a collection of functions linked to your application image that is separate from the bootloader image. The downloader receives the new application by communicating with an external host, device, or network. Once the application is validated, the bootloader performs the update.
- Depending on the communication interface, a software application running on a host such as a PC will facilitate the firmware update process.

The example Flashloader solution demonstrated in this application project leverages the Synergy Software Package (SSP) in addition to Express Logic's ThreadX® real-time operating system (RTOS) and the X-Ware USBX™ stack. The Flashloader application was developed within e^2 studio and IAR Embedded Workbench® for Renesas Synergy™ using the SSP Flashloader Framework that is included in the associated project files.

Target Device

The application project works with the Synergy MCU Family. Examples are shown for the S7G2 Synergy MCU Group on a Synergy Development Kit, DK-S7G2 Version 3.1. Appendices provide information about other Synergy MCU Groups.

Minimum PC Recommendation

- Microsoft® Windows® 7
- Intel® Core™ family processor running at 2.0 GHz or higher (or equivalent processor)
- 8 GB memory
- At least 2 GB of free space on hard disk or SSD
- USB 2.0
- Connection to the Internet

Installed Software

- Synergy Tool, e^2 studio v5.4.0.023 or IAR EW for Synergy version 7.71.3
- SSP v1.3.x
- Flashloader_pack_1.3.0.exe
- Python 2.7 for Windows
- Python 2.7 modcrc
- pyserial 3.2.1 library (https://github.com/pyserial/pyserial/releases)
- **r_fl_mot_convert.py** and **r_fl_serial_flashloader.py** (included with this project)
- Microsoft Visual Studio (Free version) (only required if the Flashloader Utility GUI will be modified)
- Microsoft.Net Framework 4.x

Notes:

1. If you do not have one of these software applications you should install it before continuing.
2. ***This version of Flashloader is supported for SSP v1.3.x release only.***

Recommended Reading

SSP User's Manual introductory chapters
SSP Datasheet v1.3.0 or later
Importing a Renesas Synergy Project (r11an0023eu0117-synergy-ssp-import-guide.pdf)

Note: If you are not familiar with the above documents you should review them before continuing.

Provided Software Projects:

- Bootloader
- Downloader
- Flashloader PC Utility

Purpose

This application note takes you through integrating an example Flashloader solution into your project. In addition, you learn how major components and software can be customized and configured for your project. You can use the example solution to understand Flashloader fundamentals and as a starting point for a production Flashloader solution. Every product will have slightly different requirements pertaining to the communication interface and how the application image is validated. The provided example is flexible and can be modified to fit nearly any application requirement.

Intended Audience

The intended audience are users that understand the Renesas Synergy™ Platform's fundamentals and are interested in developing an application that can be updated in the field through a Flashloader solution.

Prerequisites

As the user of this application note, you are assumed to have some experience with the Renesas e^2 studio integrated solution development environment (ISDE) and the SSP. For example, before performing the procedure in this application note, you should follow the procedure in the board's Quick Start Guide to build and run the Blinky project.

By doing so, you will become familiar with e^2 studio and the SSP, and ensure that the debug connection to your board is functioning properly.

In addition, you can use the *SSP User Manual* (available as part of the SSP download) to get complete information on the SSP architecture, modules, and starting development with SSP.

Contents

1. Overview 4
2. Running the Custom Flashloader Solution Example 5
2.1 Preparation 5
2.2 Build, download and debug 5
2.3 Running Flashloader 8
3. Bootloader Memory Layout 11
4. Downloader Memory Layout 13
5. Non-Blocking Bootloader Application Stack Configuration 14
6. Bootloader Linker Script 19
7. Non-Blocking Bootloader Application Design and Implementation Overview 21
8. Blocking Bootloader Application Software Stack Configuration 25
9. Blocking Bootloader Application Design and Implementation Overview 28
10. Non-Blocking Downloader Application Software Stack Overview 31
11. Blocking Downloader Application Software Stack Overview 34
12. Non-Blocking Downloader Application Design and Implementation Overview 37
13. Downloader Linker Script 39
14. Converting User Applications to BCH Files using the Python Converter Script 40
14.1 Convert User Application to BCH files manually 40
14.2 Convert User Application to BCH files manually 42

14.3 Verify BCH image 42
15. Flashloader Utility Python Script 44
16. Flashloader Utility GUI 46
17. Going Further 49
18. Troubleshooting 50
Appendix A Configuring the DK-S7G2 Development Kit for USB CDC 51
Appendix B Configuring the DK-S7G2 Development Kit for UART 52
Appendix C Configuring the SK-S7G2 Development Kit for USB CDC 54
Appendix D Configuring the SK-S7G2 Development Kit for UART 55
Appendix E Configuring the PK-S5D9 Development Kit for USB CDC 56
Appendix F Configuring the PK-S5D9 Development Kit for UART 57
Appendix G Installing USB CDC drivers in Windows 7/8 and Windows 10 57
Revision History 62

1. Overview

Flashloaders are one of the most common application components in embedded systems and probably the most neglected. The flashloader discussed in this application project is software that a developer would develop and customize to run on their system. This flashloader should not be confused with the factory flashloader application built into a microcontroller's ROM and designed to update the internal flash system. In some circumstances, the factory flashloader is all that is required to update firmware in the field. However, in many cases you will want to customize the firmware update process. This is where the flashloader discussed here comes into play. There are many solutions for how a flashloader can be architected, but the most flexible and scalable solution is to break the flashloader up into two primary components; the bootloader and the downloader.

The downloader is software within the developer's application code that can detect that a new application is ready to be downloaded to the device through a communication interface. The downloader stores and validates the new application but it typically does not update the current application image. Instead, the downloader notifies the bootloader that there is an image available for updating.

The downloader can be architected so that it behaves in a blocking or a non-blocking manner. A blocking downloader will prevent the primary application code from executing while the new firmware is downloaded and updated. The non-blocking downloader will allow the application to execute normally while the new image is downloaded, usually to an external memory device. Once the downloader has stored the new image to either internal flash memory or external memory such as an SD card, the system can be restarted so that the bootloader can update the firmware.

The bootloader software exists in a separate memory space from the user application code and downloader. It facilitates the firmware update process. The bootloader verifies the available image and contains all the necessary algorithms and intelligence to process the image, erase internal flash, program the new application and then verify it. When the application has been successfully written, the bootloader then jumps to the applications reset vector and begin executing the updated firmware. The following figure is a flowchart showing an example of the flashloader solution's behavior.

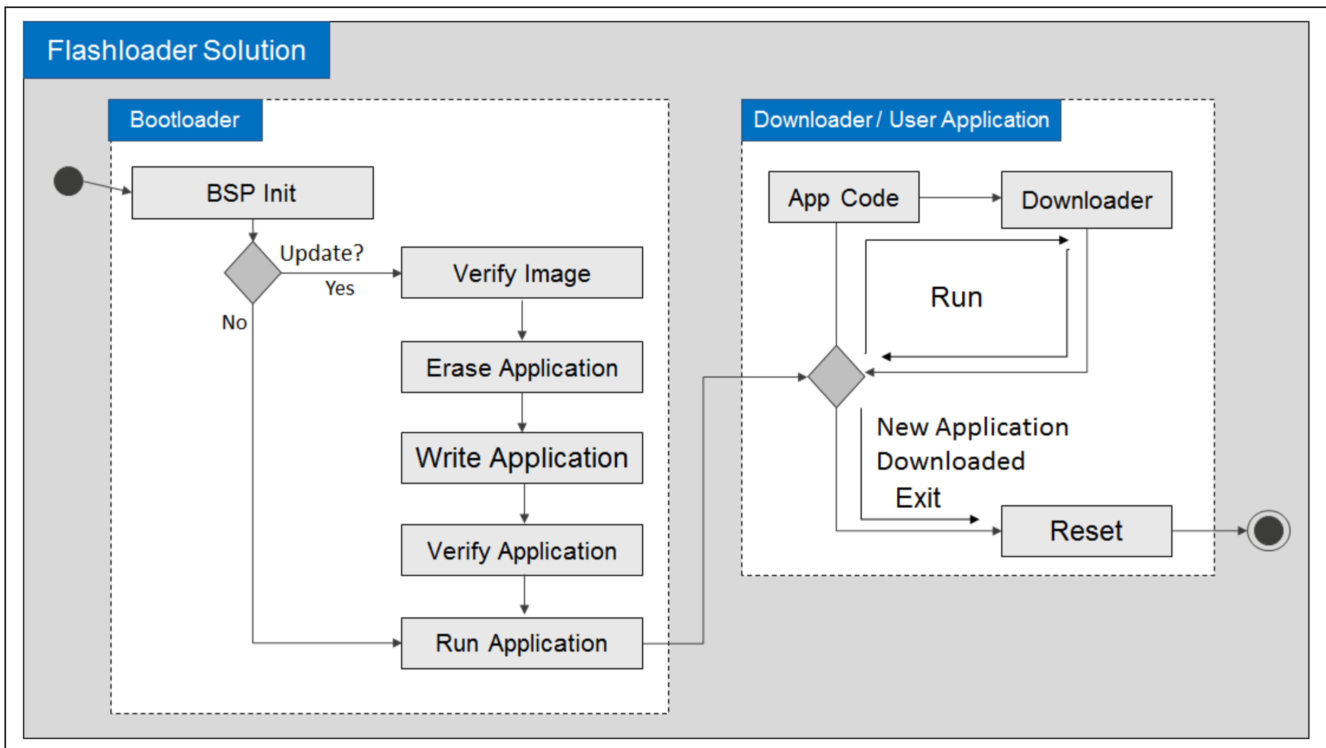


Figure 1 Flashloader solution's behavior

2. Running the Custom Flashloader Solution Example

The easiest way to get up to speed on the Flashloader solution is to import and walk through the example project to understand the various stacks, code and settings required to get the Flashloader solution working. Once a developer understands the Flashloader Framework, it becomes easier to recreate the stacks in your own project, or export the stacks and import them into a project.

2.1 Preparation

- Start setup by making sure that all the required applications listed at the beginning of the application project are installed and you have downloaded the Flashloader application project.
- Run the installer **Flashloader_pack_1.3.0.exe** so that you have the required SSP flashloader pack installed in e^2 studio or SSC.
- If you are interested in the USB CDC flashloader, be sure to examine the flashloader application package. Within the flashloader directory, there is a Windows USB driver that allows the downloader application to show up as a standard serial communication port.
- Make sure that you download the Python 2.7 pyserial-3.3 library and install it. The library can be downloaded from https://pypi.python.org/pypi/pyserial/3.3. Alternatively, you can download pyserial using pip by running the following command from the python27 folder:
  `python -m pip install pyserial`
- The **python modcrc library** also needs to be downloaded from https://pypi.python.org/pypi/crcmod/1.7. These libraries allow the flashloader utility to communicate over a communication link and generate CRC's for the communication packets.
- To proceed with running the example, the development kit needs to be configured based on the communication protocol and the development kit selected. Review the appendices for the development kit and communication protocol setup details. Walk through the appendix setup now.

2.2 Build, download and debug

The following steps can then be used to build, download and debug the Flashloader:

1. Follow Synergy *SSP Import Guide* to import and build the desired flashloader solution. Example solutions include:
   - USB CDC Non-blocking
   - USB CDC Blocking
   - UART Non-blocking
   - UART Blocking
2. Each of these 4 examples includes two projects that must be imported into the workspace and built:
   - The bootloader project
   - The downloader project

Note: Don't forget to generate the code before building the projects.

3. The workspace should appear like the following figure.

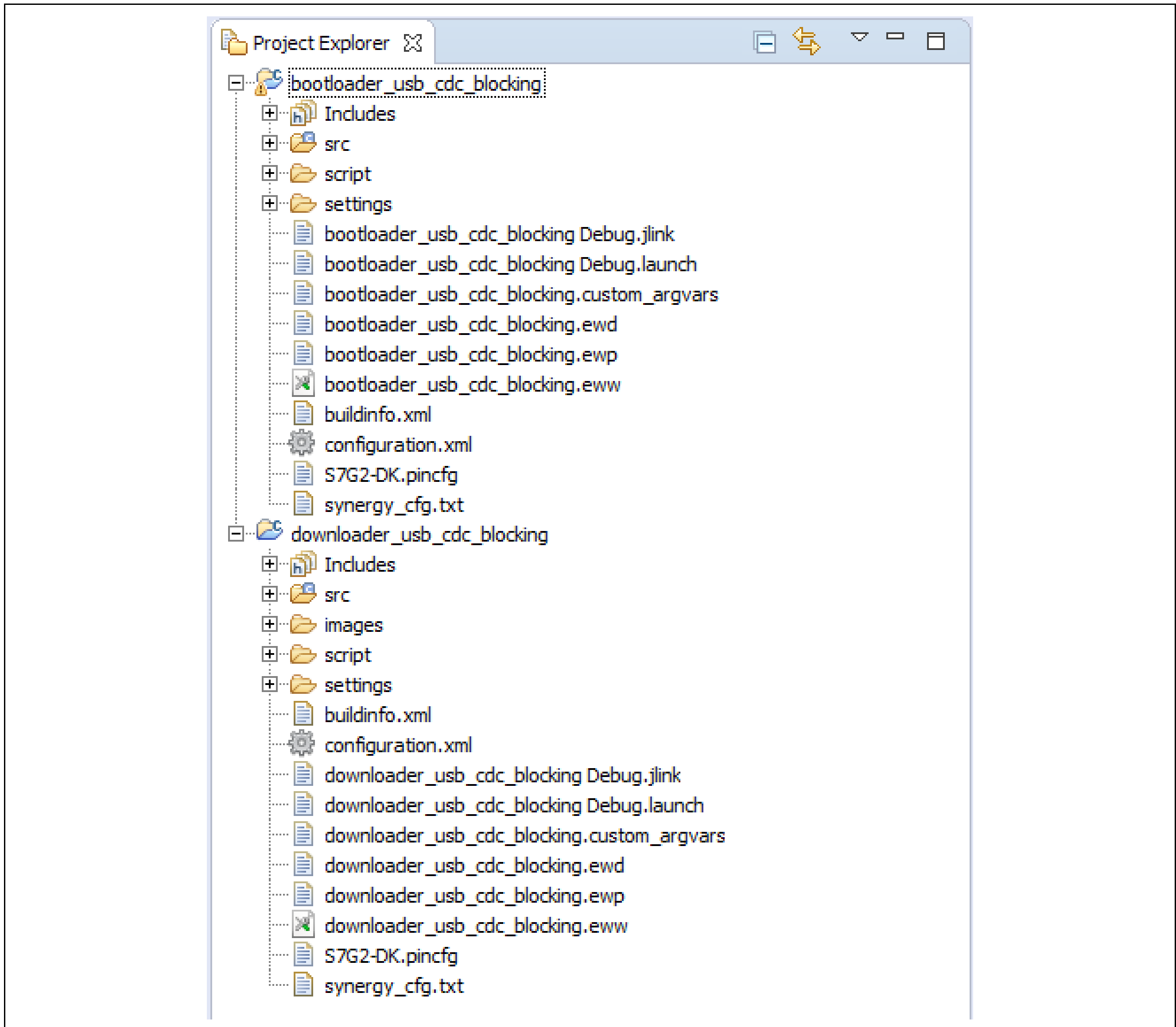


Figure 2 Imported project workspace

4. Open the downloader projects **Debug Configuration** options.

Navigate to the **Renesas GDB Hardware Debugging** setting and select the **Downloader_Debug** entry as shown in the following figure. Navigate to the **Startup** tab. There is a section for **Load Image and Symbols**. Verify that the path to load the bootloader image is included and correct. If the **Startup** tab has a warning next to it, verify that the path to the elf files for the bootloader and downloader are correct by clicking on each and pressing edit.

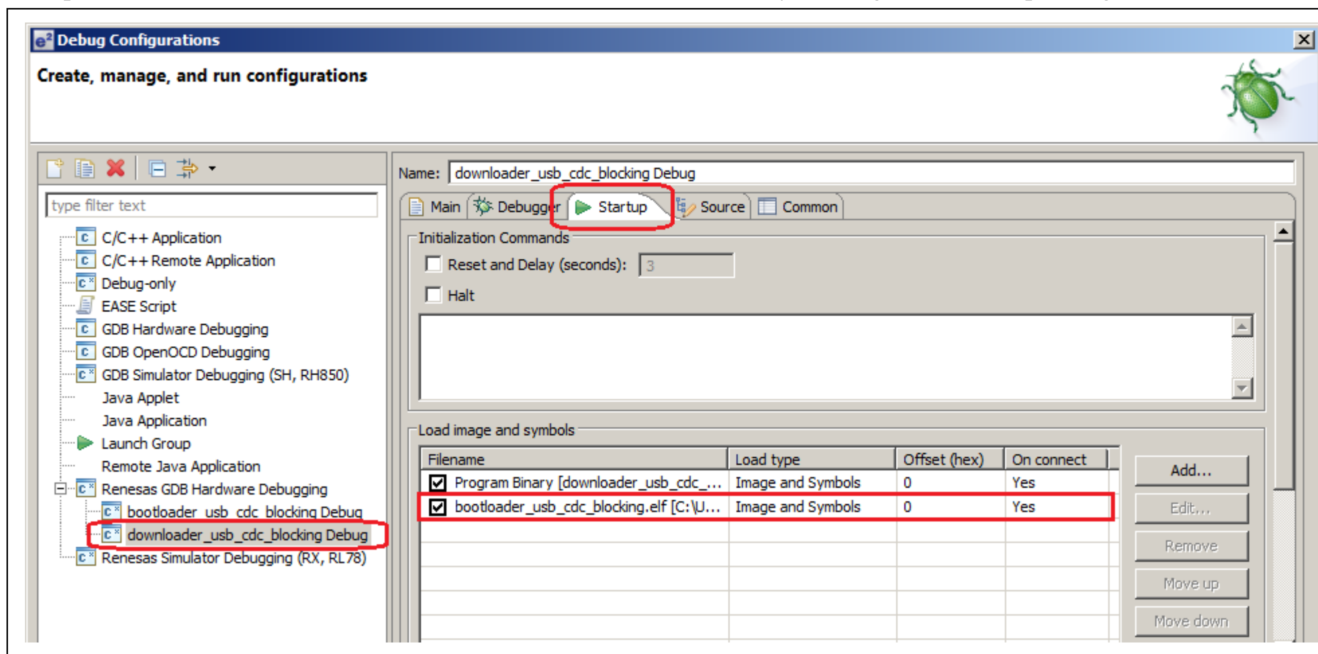


Figure 3 Updating the Downloaders Debug Configuration

Note: The bootloader application code will be programmed into the microcontroller with the downloader code. DO NOT DOWNLOAD AND DEBUG THE BOOTLOADER APPLICATION BY ITSELF. All the bootloader symbols are included to enable developers to step through the entire process and debug any issues.

Verify that the commands shown in the following figure are still configured at the bottom of the **Startup** tab.

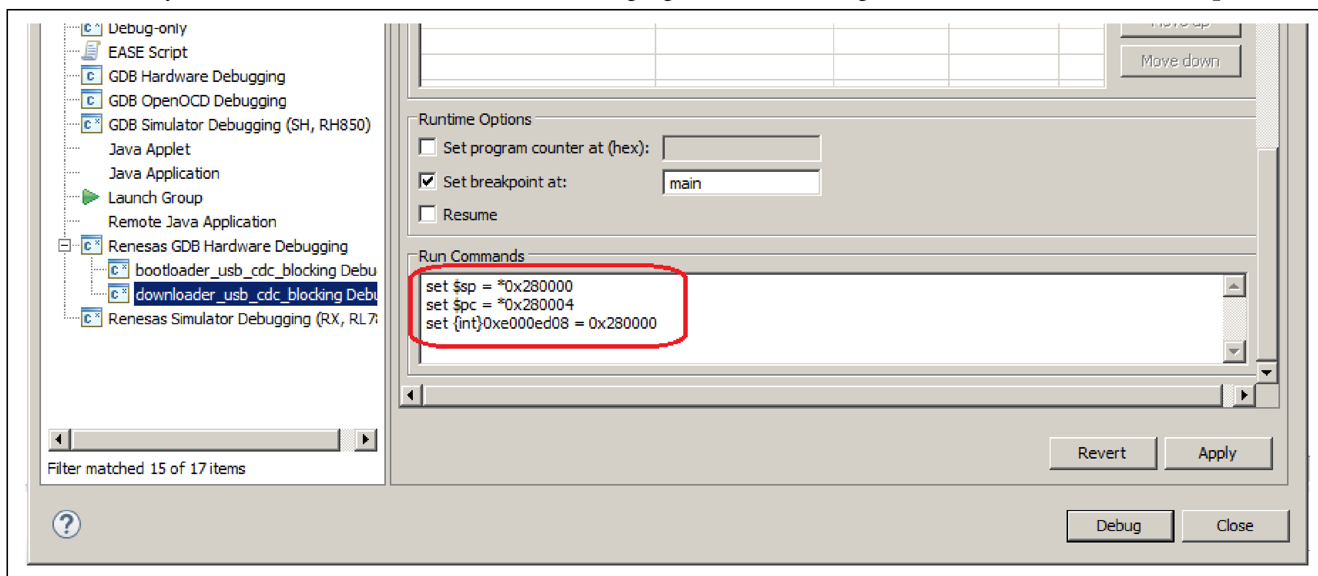


Figure 4 Adding run commands to bypass the User Application Image

Note: The run commands are setting the stack pointer, program counter and the VTOR register. During the first execution, the bootloader will be skipped over and the downloader code will be executed directly.

Note: For users who create their own images, should set Run Commands based on the Slot they are flashing the initial Downloader to. Starting address for Slot 0 is 0x100000 and Slot 1 is 0x280000. Replace 0x10 with 0x28 in the run commands showed in picture above to flash and run Downloader from slot 1.

At this point, a developer can click apply and then Debug to program the chip and start debugging the application. Once the application is programmed the execution will break at the Reset_Handler.

Note: Do not press the restart button at this time as doing so will skip those commands in the debug configuration and cause the bootloader to run and not the downloader application.

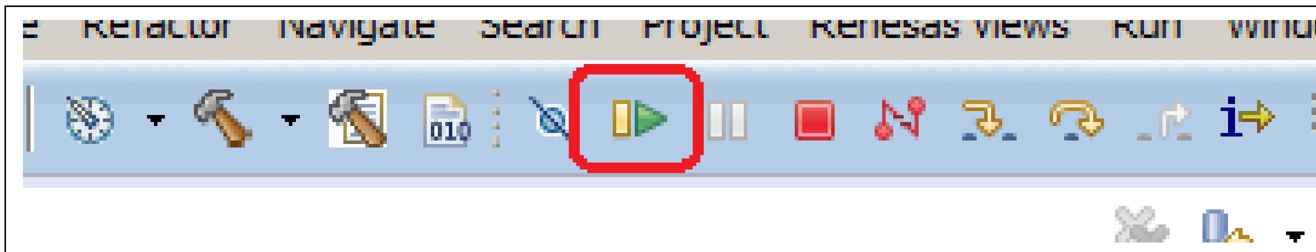


Figure 5 Resume button

Press the Resume button to run the application. The LED(s) should start blinking at a frequency of 1 Hz.

2.3 Running Flashloader

The flashloader solution is now executing. Now it is just a matter of communicating with the flashloader so that it can download a new application. Whether you are planning to use the Python script updater or the Flashloader Utility GUI, you will need to examine which communication port the downloader application will appear on. A developer needs to use a communication port whether they are using USB CDC or using UART through a USB to UART converter.

1. Open the Windows Device Manager and expand the **Ports** tab as shown in the following figure.

   Identify the communication port that will be used to communicate with the development board. If this is the first time running the project and if the USB CDC protocol was selected, the board USB drivers may not be found and the device will show up as **Unknown device**. See Appendix G Installing USB CDC drivers in Windows 7/8 and Windows 10 for details on how to install a Windows driver.

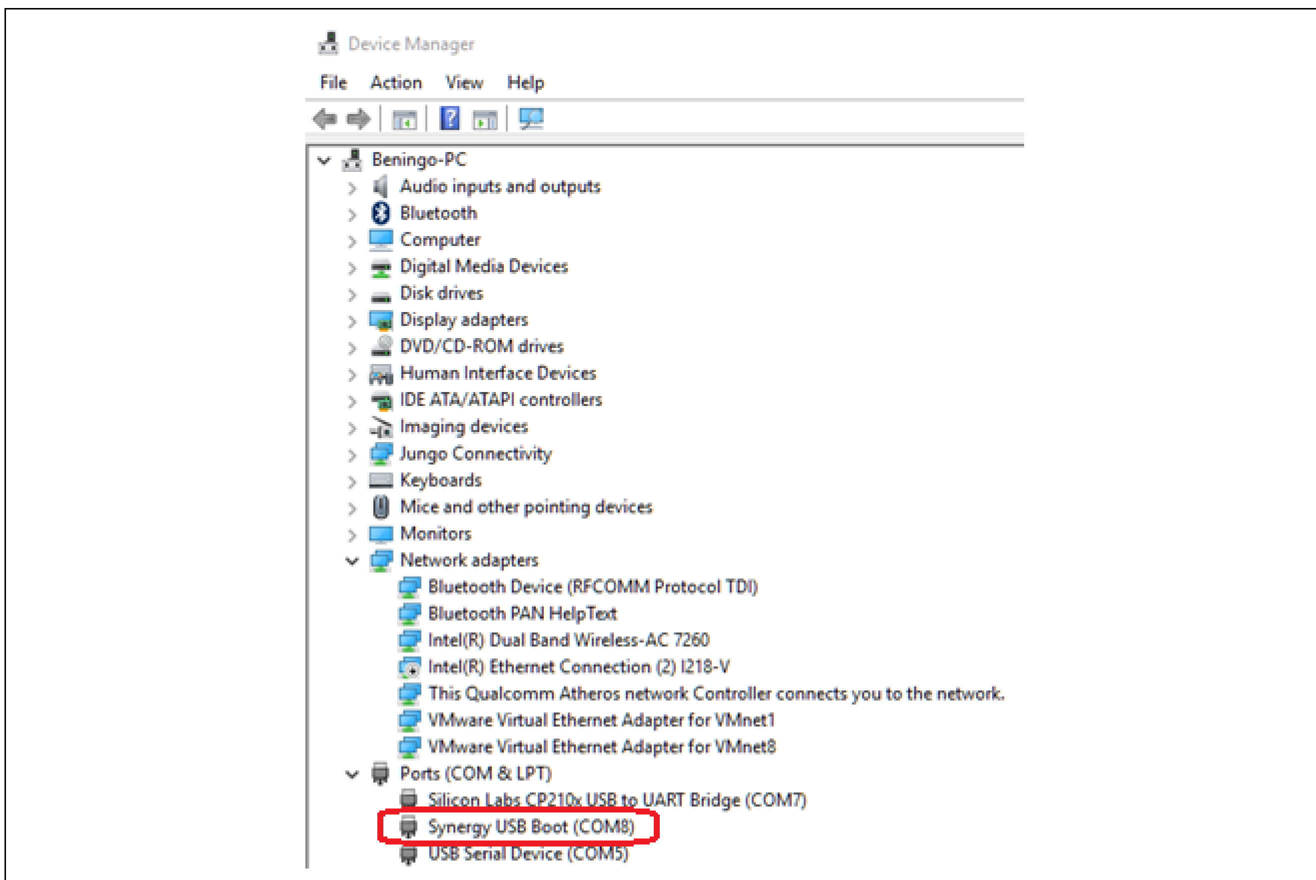


Figure 6 Identify the USB Communication Port Number

2. Start the Renesas Synergy Flashloader Utility
3. In the **File** menu, select **Options**. As shown in the following figure, use **Browse…** to set the path to the Python 2.7 executable.

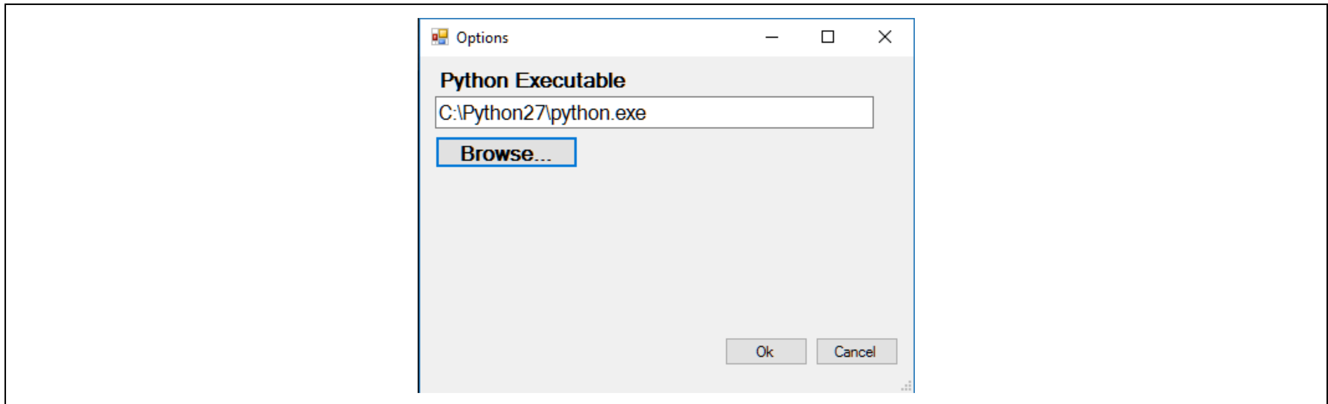


Figure 7 Setting the Flashloader Utility Python path

1. In the **S-Rec to BCH Conversion Options** shown in the following figure, select the **Output Filename** using the **Browse…** button.

   The pre-built images are located in the downloader images folders. For example, the images for the USB CDC Blocking Flashloader is located in: Flashloader\Flashloader_Examples\USB CDC\blocking\downloader\images

   For non-blocking flashloaders, the options are:

   - eLED_Blink_Fast.bch
   - aLED_Blink_Slow.bch

   For the blocking flashloader, the options are:

   - LED_Blink_Fast_Slot0_v5.bch
   - LED_Blink_Slow_Slot1_v6.bch
   - LED_Blink_Fast_Slot0_v7.bch
   - LED_Blink_Slow_Slot1_v8.bch

   Use `LED_Blink_Fast.bch` if you are using the non-blocking flashloader. Select `LED_Blink_Fast_Slot0_v5.bch` for the blocking flashloader. This file is the image that will be transmitted to the development board.

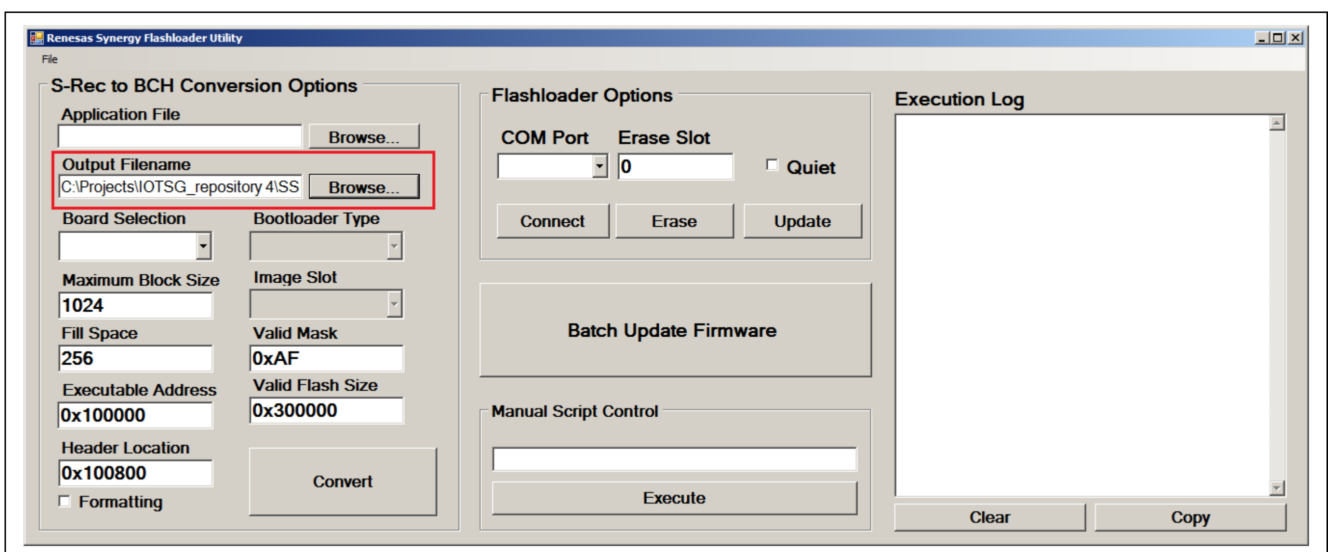


Figure 8 Selecting the BCH file to load

4. In the **Flashloader Options**, select the **COM Port** from the dropdown (COM8 in this example) and then select **Connect**.

   The **Execution Log** shows whether the connection was successful. If the connection is successful, you should see something like the following figure in the execution log. Connecting to the device reveals information about the application that is currently stored in the device, such as the version number.

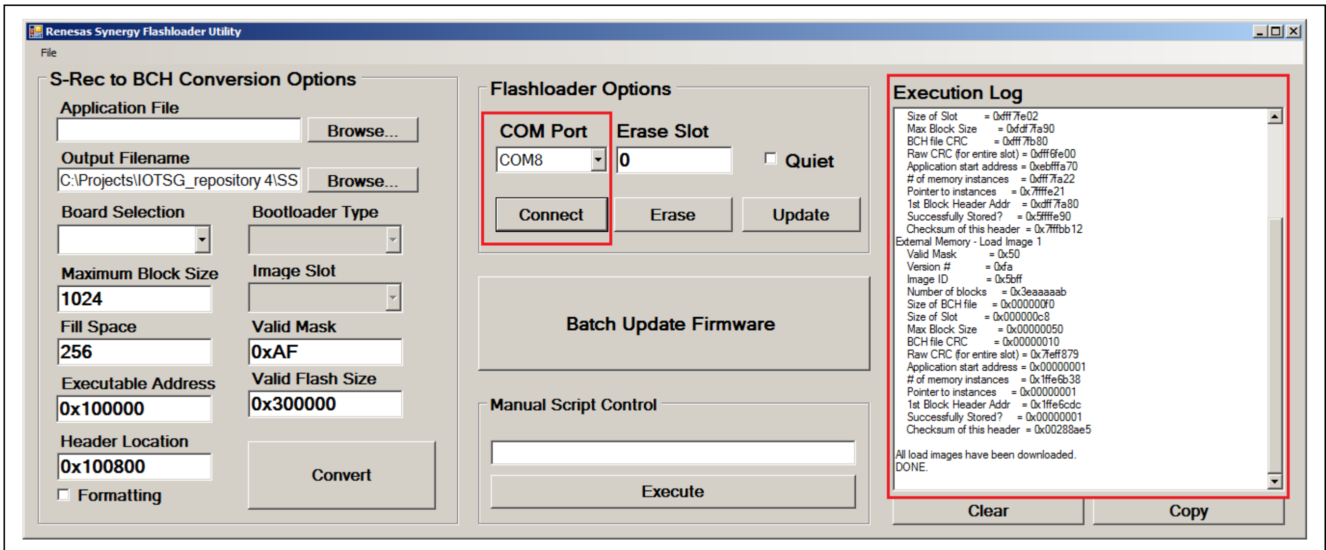


Figure 9 Connect to the communication port

5. Once the device has responded, select the **Erase** button.
   The device now erases the application images that are currently stored on the device at the specified location. The output should appear like the following figure. If a device supports multiple image locations, the erased block text box could be used to specify the location that should be erased. For example, if you are working with the non-blocking flashloader, erase the block that is not currently executing the application. The default application is running in application slot 1.

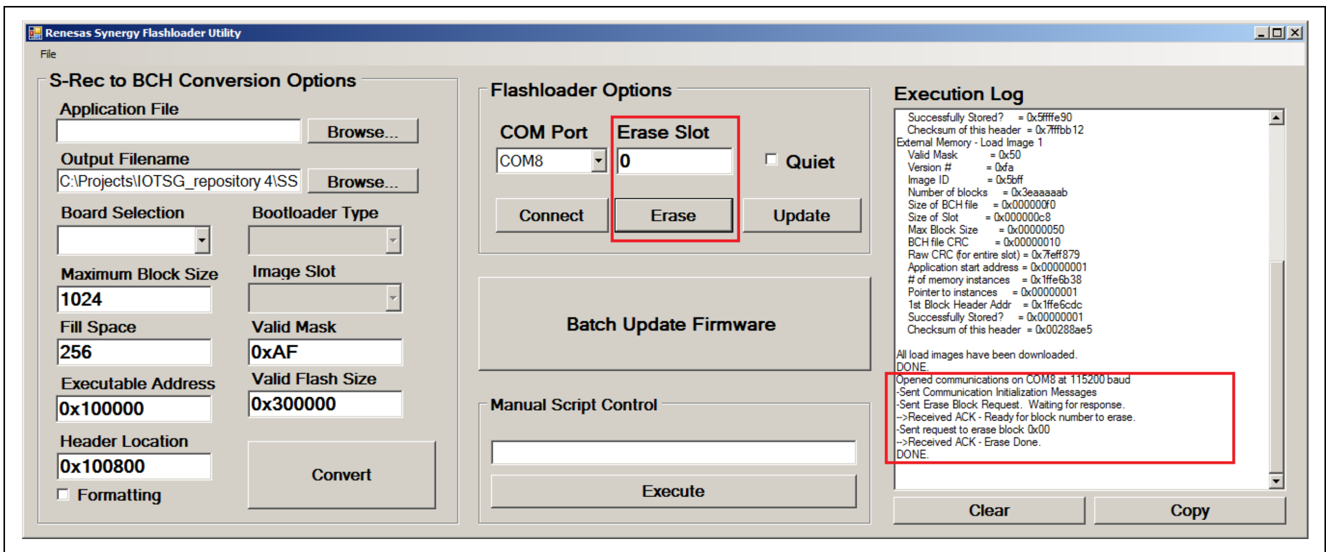


Figure 10 Erase the stored program images

6. Select press the **Update** button.
   The execution log will begin to fill with information related to transferring application records to the downloader. The output will look something like the following figure. This is the selected BCH file being transmitted to the downloader application that is running on the development kit.

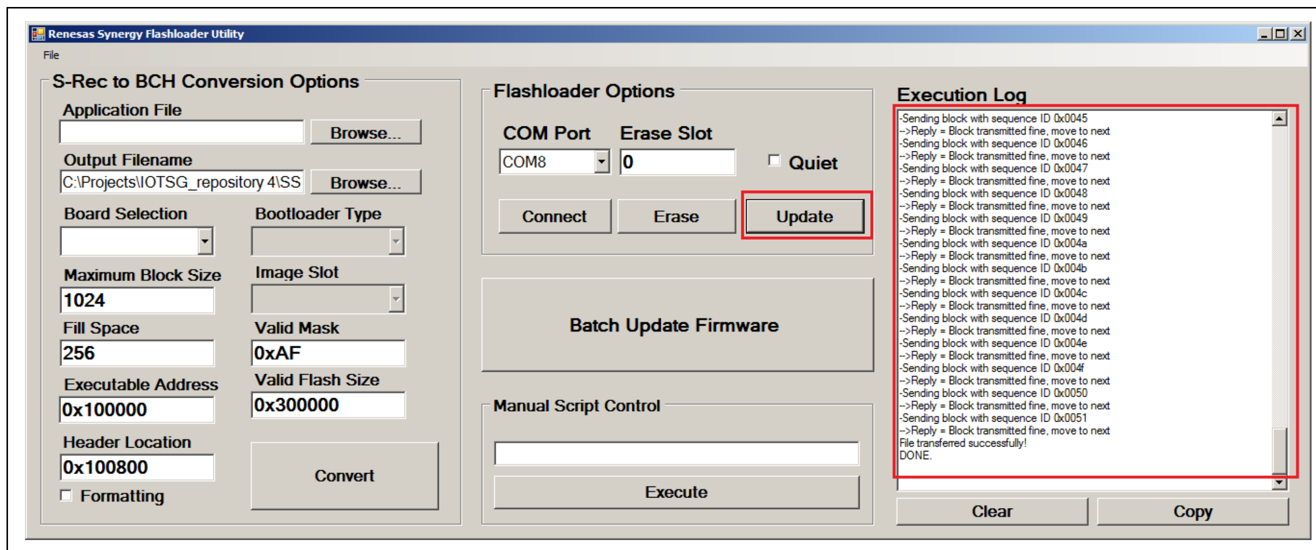


Figure 11 Updating the Downloader Application

7. When the records have been transferred, the device will now restart and load the new application.
   It may take a few minutes depending on the application size before the system wakes back up and the new application is running. The LED(s) will start blinking at 5 Hz when the new application has been successfully loaded.

You have completed the entire flashloader update process. You can now go back through steps 4-7 and load the next application (**LED_Blink_Slow_Slot1_v6.bch**) into the development board. Just make sure that if you are using the blocking flashloader, erase the opposite slot (slot 1) that was just programmed and select an image (BCH file) for that slot that has an equal or higher version number. The rest of this application project will now dig into the details on how to configure and integrate the flashloader along with information on how to use the various scripts and utilities associated with the flashloader solution.

3. Bootloader Memory Layout

Developing a flashloader solution requires having two separate applications being stored in flash memory simultaneously on the microcontroller. To do this, the flash memory space needs to be broken up into two separate regions; one where the bootloader will reside and one where the application/downloader resides. There are two separate projects, each need to configure their linker script so that the two applications can communicate but not go into each other's memory regions. Since there are two applications, there will be two separate vector tables that will need to be tracked and managed.

The bootloader application is located at the memory start address location 0x00000000, which is the microcontroller's reset vector. This means that when the microcontroller boots, the bootloader is the first application to execute on start-up. There are several reasons for having the bootloader run first that include:

- Initializing the microcontroller to a known state
- Verifying the application image is valid and programmed (there could have been a failed update)
- Checking whether a new application is present and should be written to memory
- Providing a safe system state for when something goes wrong with the application

The following figure shows how the flash space is split into a bootloader section and a user application area. The bootloader memory contains two software framework (sf) components; one for accesses to the internal flash on the microcontroller where the new image will be written and a second optional component for reading the downloaded application image from external memory. The external memory instance is only required when the bootloader is configured for the non-blocking application mode where the new image will be stored in the memory, external to the microcontroller. It shows how the flash space is split into a bootloader section and the user application area. The bootloader memory contains two software framework (sf) components; one for accesses to the internal flash on the

microcontroller where the new image will be written and a second optional component for reading the downloaded application image from the external memory.

Beyond these two main components, there are also two data regions that are used to communicate information between the bootloader application and the user/downloader application. The first data region stores a record for where the internal flash application images are stored. There can be up to two different areas in memory where the application code is stored. This allows for a developer to store the new updated firmware along with the previous version if something goes wrong and the firmware must be rolled back. The internal application record is required for the flashloader solution to function.

The second region contains information for where the new image that needs to be written to flash currently resides. The second region is optional because it is used to store a custom binary file format that is stored on the external memory devices. Solutions that write the new application image directly to internal flash do not require this extra storage record.

Note: The flashloader solution example currently does not support rolling back the firmware to an earlier version but a developer that has gone through this application project and understands the flashloader solution should be able to add a feature without too much effort.

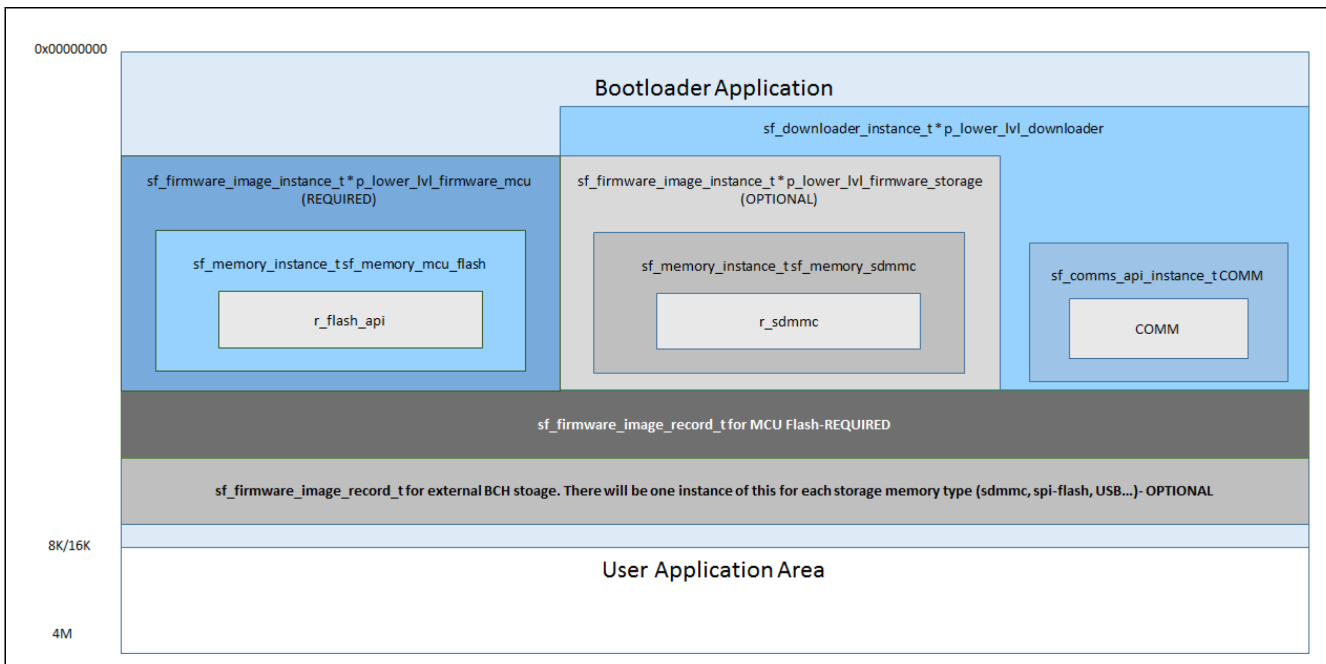


Figure 12 Flashloader Memory Map

Note: The **sf_comms_api_instance_t** supports multiple communication types. COMM is used in the diagram to show a generic interface. COMM would be replaced by the real interface such as **r_sci** for UART or USBX for a USB CDC solution.

4. Downloader Memory Layout

The downloader application contains not just the code necessary to download a new application image to the device but also contains the product's user application code. For this reason, the downloader will take up most of the remaining flash space on the device. The downloader start location in memory is configurable by the developer and mostly dependent on the device memory layout and the bootloader size. The downloader memory space must not overlap the bootloaders. On most microcontrollers, there are minimum flash erase sizes that need to be considered when locating the downloader code.

There are two things that a developer should immediately notice. First, the application image is received through the selected communication interface. The downloader software stack is set up so that it doesn't care about the communication interface. A developer could just as easily set up a UART, Ethernet, or even I2C interface. Second, the downloader for the non-blocking solution stores the application image to an SD card. An important consideration is that when an application image is stored in external memory, the binary application image is stored in its entirety with CRCs and everything. The image is stored in a custom file format known as a BCH file that we will talk about later in the application project. The blocking downloader solution doesn't store the BCH file because it writes directly into a flash location on the microcontroller.

A non-blocking downloader uses the second memory record location to determine where it will store the new application image. That record also tells the bootloader application where it needs to look for the new application that will then be processed and written to internal flash. Looking back at Figure 12 and comparing it to Figure 13, you will notice that both memory layouts are aware that the record locations exist in the memory. You need to make sure that the linker scripts for both the bootloader and downloader applications are looking at the same location in the memory to compare them.

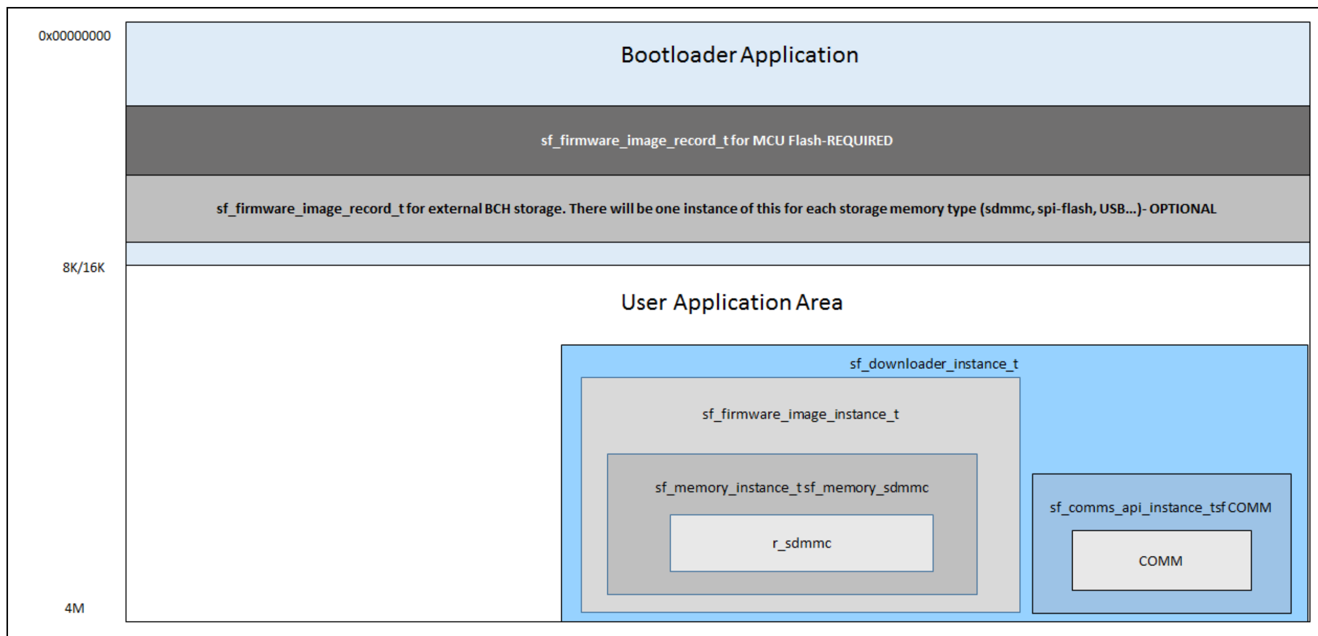


Figure 13 Non-blocking Flashloader Application Memory Layout

5. Non-Blocking Bootloader Application Stack Configuration

After running the flashloader project for the first time, many developers will want to dig into the flashloader framework and understand the different settings and capabilities that are available. This section will highlight the settings that you will want to understand within the bootloader application code.

1. Start by opening the bootloader project, the Synergy **configuration.xml** file and navigating to the **Threads** tab.
   It should look like the bootloader stack shown in the following figure. For the non-blocking bootloader, both the internal and external firmware image frameworks will be populated. The reason is that the internal framework is required to save the new image to flash and the external memory will be used to store the image so that the application code can continue to run while the image is downloaded.

Note: Microcontroller flash controllers have limitations when it comes to running an application from the flash space and trying to write to flash simultaneously.

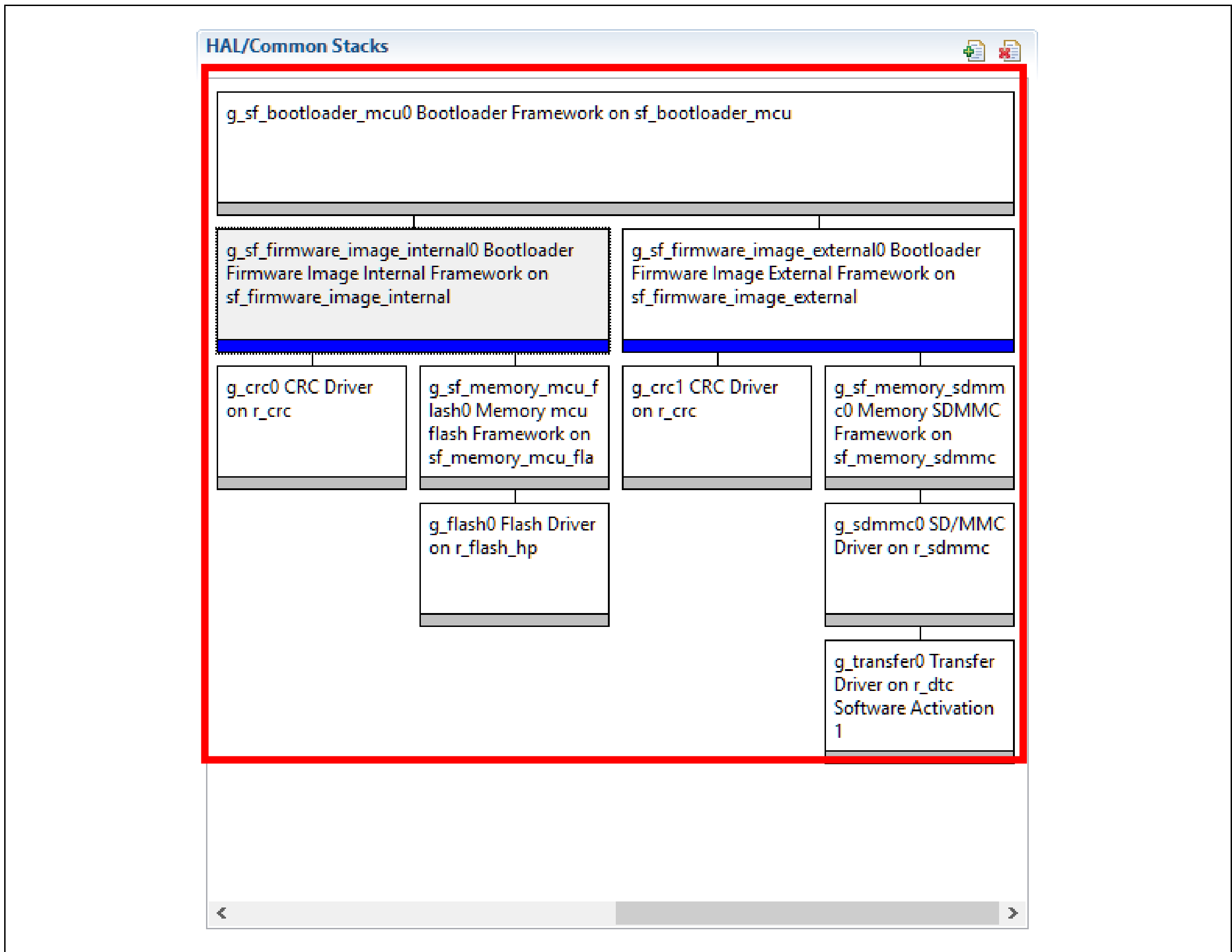


Figure 14 Bootloader Framework Stack

1. The first framework to examine should be the **g_sf_firmware_image_internal0** framework shown in Figure 16. Click on the framework and examine the properties.

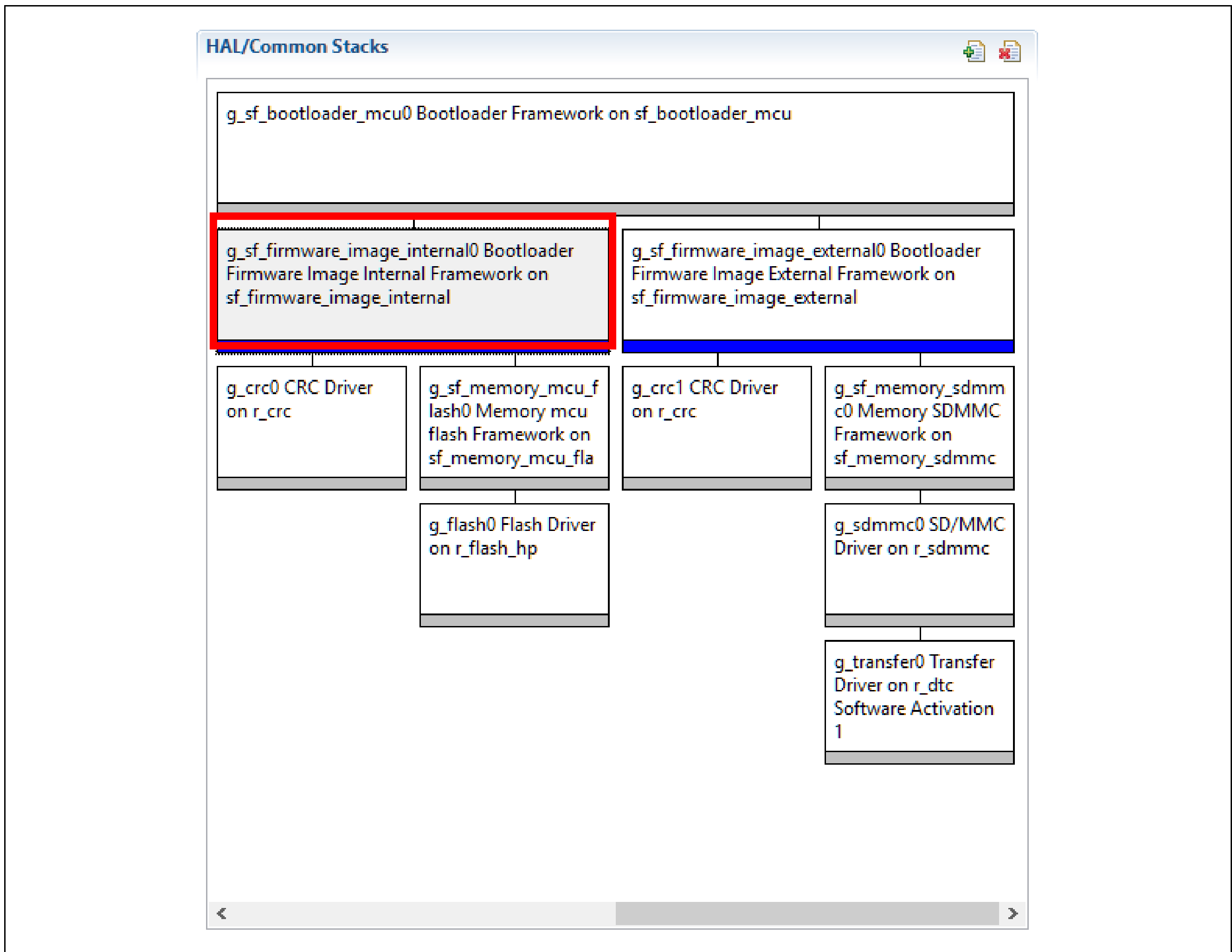


Figure 15 Bootloader Firmware Image Internal Framework

2. The following figure shows important properties that developers will want to configure for their own applications.

Property	Value
◢ Common	
Parameter Checking	Default (BSP)
◢ Module g_sf_firmware_image_internal0 Bootloader Firmware Image Internal Framework on sf_firm	
Name	g_sf_firmware_image_internal0
Enter the starting address of the first flash area	0x100000
Enter the size of the first flash area	0x300000
Number of slots supported (1 or 2 slots supported)	1
Callback	NULL

Figure 16 g_sf_firmware_image_internal0 Configuration

In the property, **Enter the starting address of the first flash area**, enter the memory address where the User Application Area and the downloader begins in internal flash. The address location 0x0 is not an appropriate location because the bootloader resides in this memory location. You can select any location for the application to start based on your requirements and how you decide to split up the flash memory map. In this example, the S7G2 Group MCU on the SK-S7G2 board has 4 MB of flash available. The application is stored at the 1 MB location (0x100000 hex). Keep in mind that flash size varies based on the specific MCU selected from the S7G2 Group.

In the property, **Enter the size of the first flash area**; specify how large the memory location is that the User Application Area has available to it. This example allocates the remaining 3 MB memory space for the application.
In the property, **Number of slots supported** determines whether the memory space specified will be used to store one single application image or whether it will be broken up into two application areas. The value 2 will split the flash area size in half and allow you to store multiple images on the internal flash. This can be used to keep a backup image in the event something goes wrong with a firmware update.

3. The remaining modules in the Bootloader Firmware Image Internal Framework do not contain developer configurable properties.
   You will want to review the Flash Driver. There are two different flash types that are used with Synergy microcontrollers; high performance (hp) and low power (lp). The S1 and S3 microcontrollers use low-power flash since they are targeted towards low-power applications. The S5 and S7 use the high-performance flash since they target applications that are more computationally intensive. Make sure that your application is using the correct flash type as shown in the following figure.

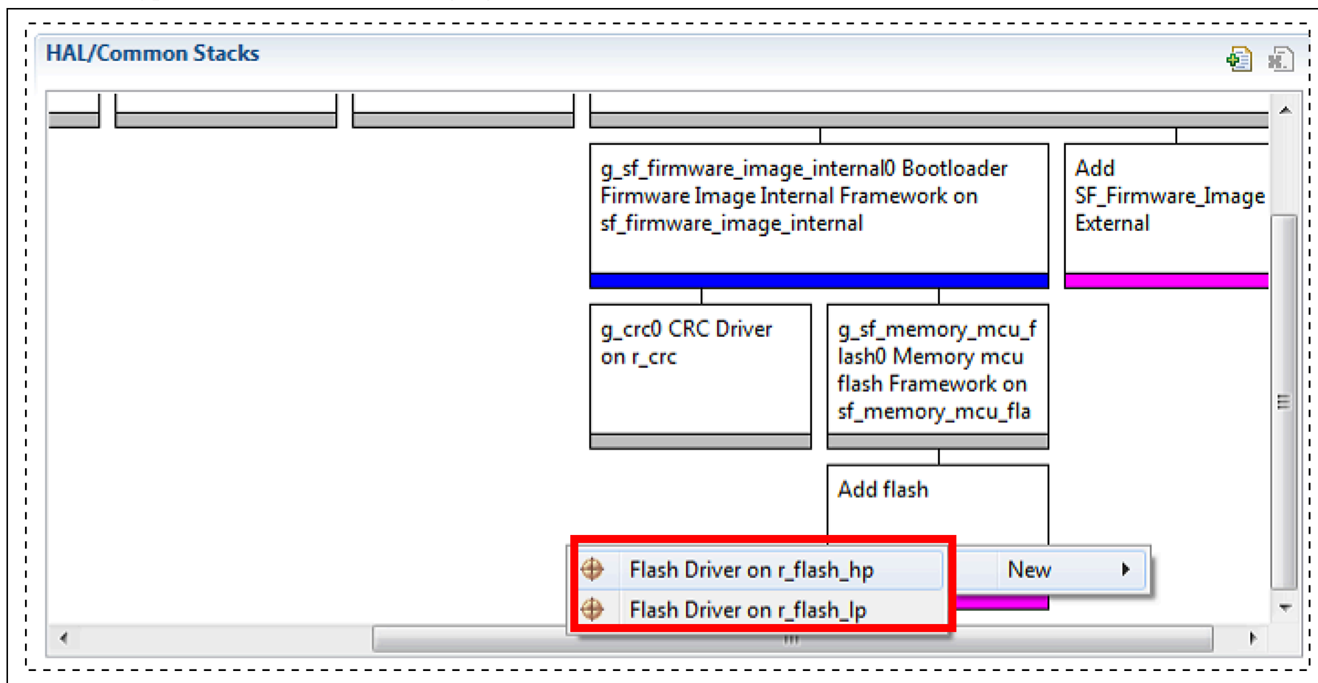


Figure 17 Add the flash driver instance

4. Click on the `g_flash0` component and examine the properties.
   As shown in the following figure, find the **Code Flash Enable Programming** property. This property is used to enabled or disable internal flash writing. For the bootloader, this property should be **enabled**.

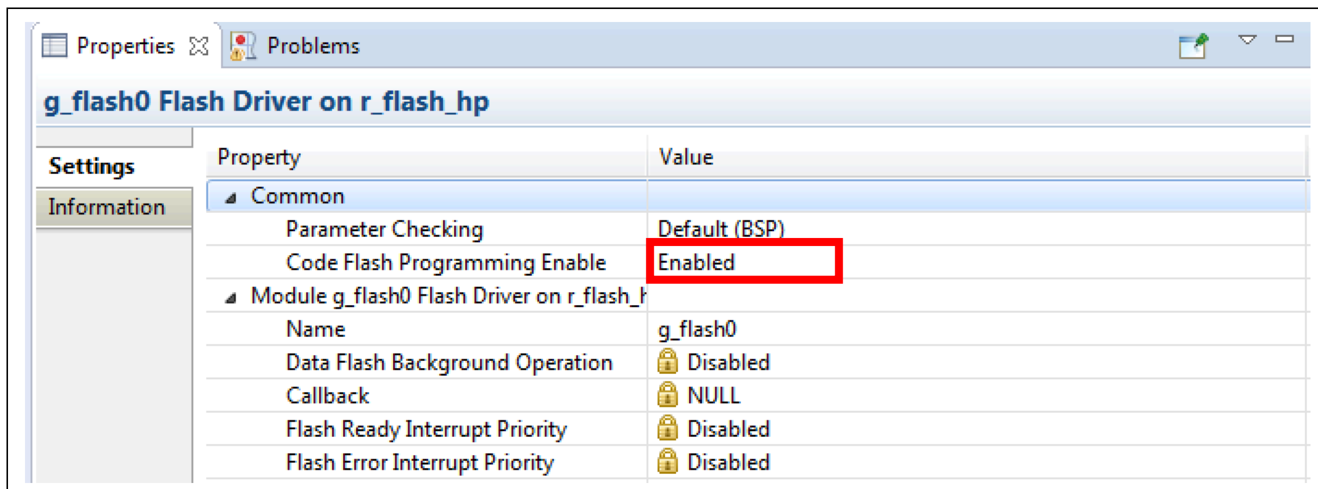


Figure 18 Enable the Code Flash Programming Property

5. Click the **Bootloader Firmware Image External Framework** stack as shown in the following figure.
   Notice that the internal and external memory frameworks look very similar in that they both contain a CRC stack and a framework for accessing memory. The external memory framework is designed to interface to an SD card while the internal is for internal flash space.

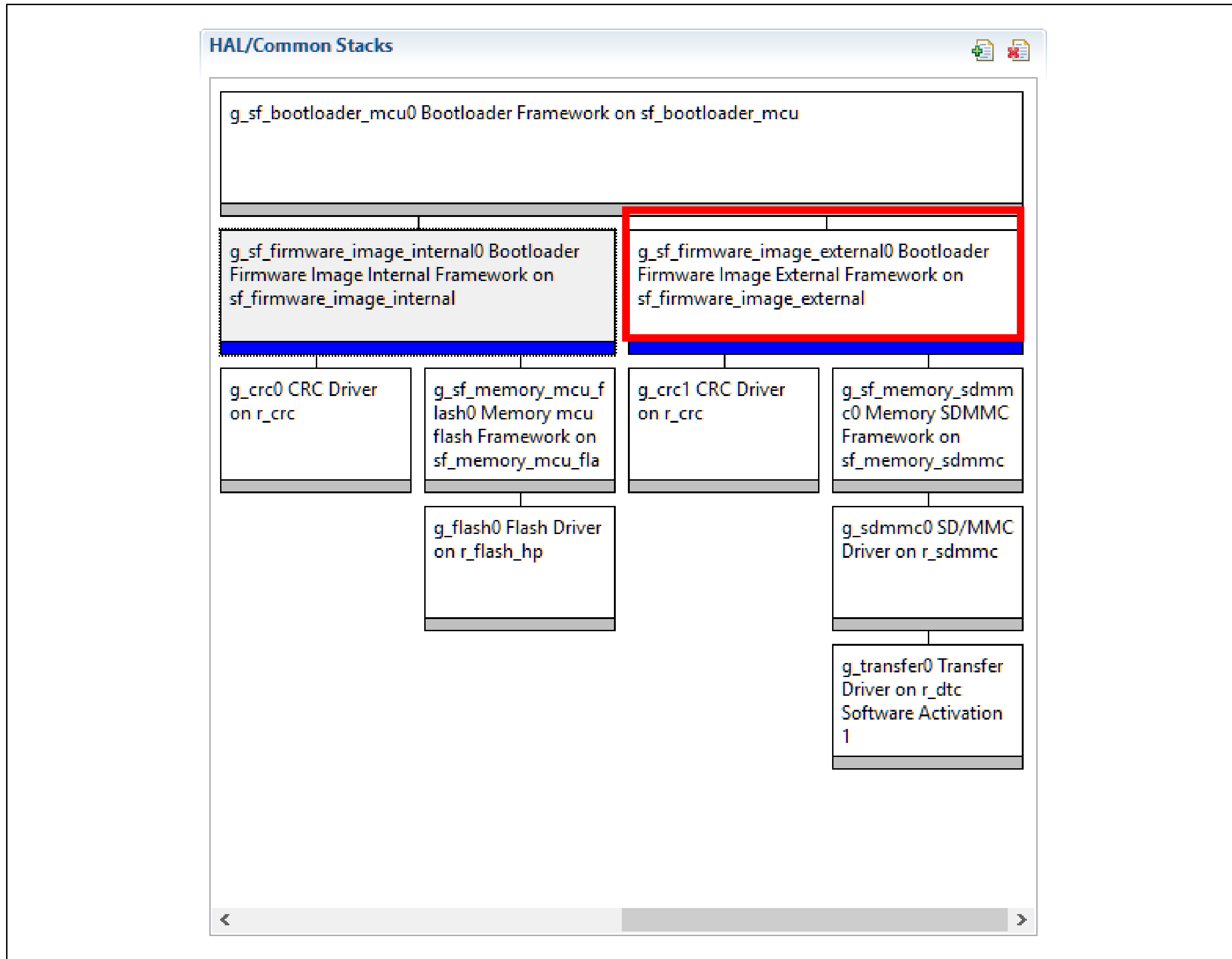


Figure 19 External Image Stack

6. The **Bootloader Firmware Image External Framework** properties will be displayed like the following figure.

Property	Value
◢ Common	
Parameter Checking	Default (BSP)
◢ Module g_sf_firmware_image_external0 Bootloader Firmware Image External Framework on sf_firm	
Name	g_sf_firmware_image_external0
Enter the starting address of the memory storage area	0
Enter the size of the memory storage area	0x400000
Number of slots supported (1 to 4 slots supported)	1
Address/Pointer to Firmware Image Records (Not applicable for a Bootloader Project)	NULL
Callback	NULL
Maximum size of a BCH block in bytes	1024

Figure 20 Configuring External Image Framework

There are three parameters that you need to consider when configuring the external SDMMC memory.

First, the parameter **Enter the starting address of the memory storage area** specifies the memory address within the SD card where the application image is stored. The application data is stored directly onto the SD card and does **NOT** use a file system. You can store images anywhere on a SD card but the logical place to begin storing images are at address location 0x0.

The parameter **Enter the size of the memory storage area** is the size on the SD card that will be used to store the BCH image. You should size this to be the maximum application size plus the BCH file overhead from CRCs. In this example, the microcontroller has 4 MB of flash available but only 3 MB is used for your application. Sizing the memory storage location to the 4 MB provides sufficient overhead to store a 3 MB image plus the BCH file overhead.

Finally, since the updated images are being stored to an SD card first, multiple images can be stored to the card. For this example, the number of image slots is set to just one even though the bootloader framework supports storing up to four images on the external memory device.

7. The **g_sf_memory_sdmmc0** framework does not have any properties that can be modified. The **g_sdmmc0 SD/MMC Driver** on **r_sdmmc**, however, does have parameters related to the SD card that need to be configured. Start by clicking on the **g_sdmmc0** stack and reviewing the properties. The generally recommended settings can be found in the following figure.

Property	Value
◢ Common	
Parameter Checking Enable	Default (BSP)
◢ Module g_sdmmc0 SD/MMC Driver on r_sdmmc	
Name	g_sdmmc0
Channel	0
Media Type	Card
Bus Width	4 Bits
Block Size	512
Callback	NULL
Access Interrupt Priority	Priority 2
Card Interrupt Priority	Priority 2
DMA Request Interrupt Priority	Priority 2

Figure 21 Configuring g_sdmmc0 Driver

Note: On the DK-S7G2 board, the SD card is located on Channel 0. The SD card is connected using four data lines that correspond to a property setting of **4 Bits**. In this example, the **Media Type** property is **Card** that corresponds to using a SD card rather than the embedded memory. Interrupt priorities should be carefully considered based on the application behavior and needs. For this example, that contains only the bootloader, we set a high priority for the SD card communication by setting the interrupt priorities to Priority 2.

8. Another property that you may want to note is the **Transfer Driver**.

   You have two different choices, the **r_dmac** and the **r_dtc**. The **r_dmac**, direct memory access controller, contains registers and a limited number of channels that can be used to move data around the microcontroller without the CPU's intervention. Since the channels are limited in number, the **r_dtc** can be used and still perform a transfer without the CPU's intervention, but the details will be stored in SRAM instead of within hardware registers. This means you can create nearly an unlimited number of **r_dtc** transfers within our application. There may be a nearly non-existent performance hit to use the **r_dtc** when compared to the **r_dmac** due to the need to access SRAM versus over a hardware register. The following figure shows how you would select the transfer driver.

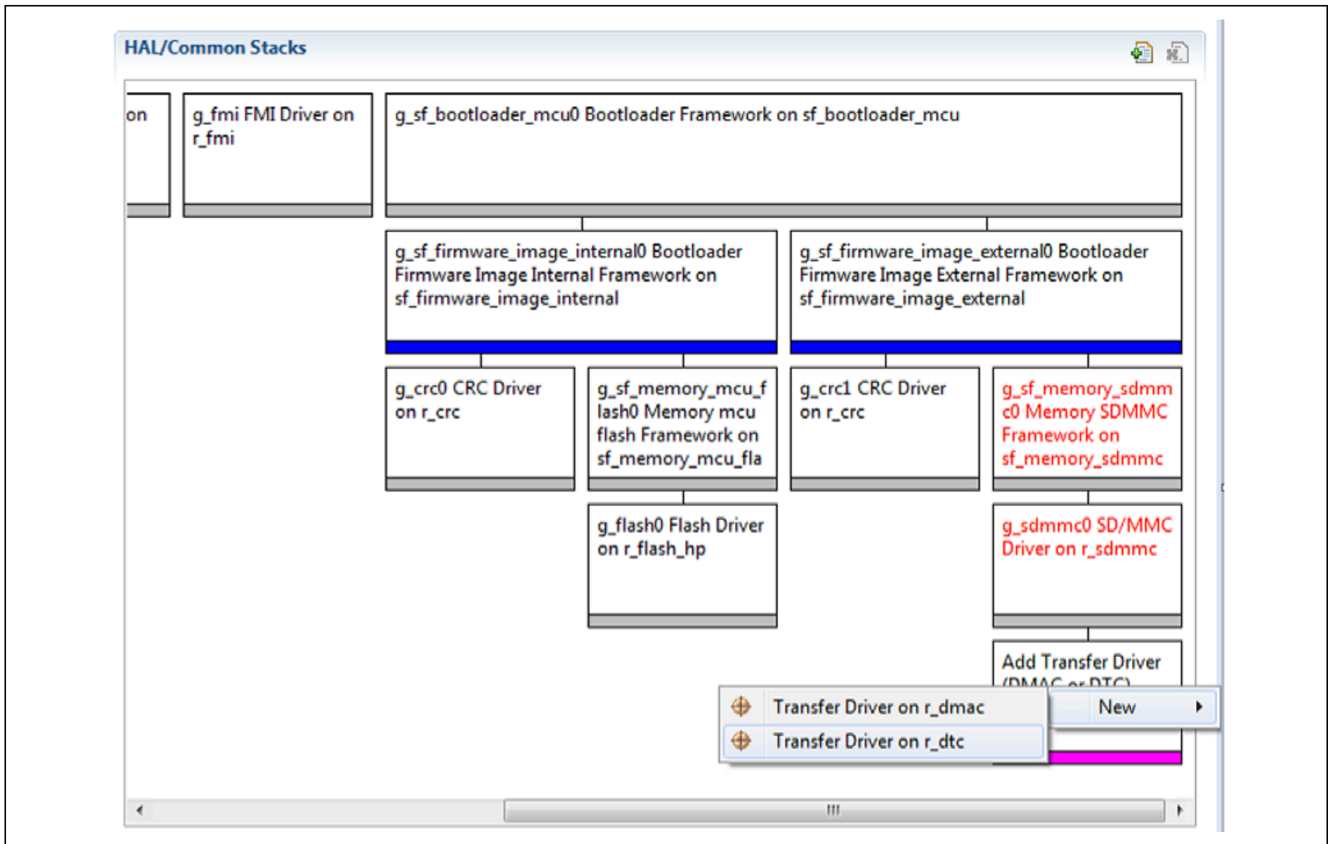


Figure 22 Adding Transfer Driver

Those are the major configuration properties that you need to pay close attention to in the bootloader framework. You still may need to adjust their linker file and add in application code that utilizes the bootloader framework.

6. Bootloader Linker Script

The linker script for the bootloader is the same for both the non-blocking and the blocking varieties. The linker partitions the memory map up into different regions and even defines the information type that will be stored in those regions. Eventually there will be two different applications, the bootloader and the downloader (your application) that need to share the same physical memory. Both applications by default will want to store their application code starting at memory location zero. Obviously, this is not acceptable and the linker scripts will need to be modified to ensure that both applications can exist within memory without trying to creep into the others memory region. In addition to providing separate memory locations for both applications, these applications need to communicate with each other somehow so that the application images can be found in memory.

1. In the project explorer, expand the Bootloader project. Under the scripts folder, open the ***.ld** file associated with the project. For example, if the processor is a S7G2, the linker will be **S7G2.ld**. The script is rather large but there are two areas that we are interested in. First, you should see something like the following figure. For the bootloader, you can theoretically leave these memory values as is. To prevent the bootloader from becoming too large and trying to store itself in the downloader (your application) flash space, you may want to limit the flash space length allocated to the bootloader.

```
S7G2.ld

/*
                  Linker File for S7G2 MCU
*/

/* Linker script to configure memory regions. */
MEMORY
{
  FLASH (rx)         : ORIGIN = 0x00000000, LENGTH = 0x0400000  /*   4M */
  RAM (rwx)          : ORIGIN = 0x1FFE0000, LENGTH = 0x00A0000  /* 640K */
  DATA_FLASH (rx)    : ORIGIN = 0x40100000, LENGTH = 0x0010000  /*  64K */
  QSPI_FLASH (rx)    : ORIGIN = 0x60000000, LENGTH = 0x4000000  /*  64M, Change in QSPI section below also */
  SDRAM (rwx)        : ORIGIN = 0x90000000, LENGTH = 0x2000000  /*  32M */
}
```

Figure 23 Linker Script Memory Allocation

Note: Figure 23 shows the entire memory map being available to the bootloader but the value highlighted in red could be changed to the maximum bootloader size. An example might be to allocate 32 KB of flash space which would change the length from 0x400000 to 0x8000. Then, if the bootloader size grows behind the expected memory region, it will no longer fit and you will receive a linker error. The linker error will serve as a reminder to properly size both the bootloader and downloader memory regions.

2. Scroll down to where the memory sections begin at approximately line 58. After the ROM registers, create a memory region where the bootloader can store information. See the following figure for the code. This region is where the bootloader will store its records.

```
58  SECTIONS
59  {
60      .text :
61      {
62          __ROM_Start = .;
63
64          /* Even though the vector table is not 256 entries (1KB) long, we still allocate that much
65           * space because ROM registers are at address 0x400 and there is very little space
66           * in between. */
67          KEEP(*(.vectors))
68          KEEP(*(SORT_BY_NAME(.vector.*)))
69          __Vectors_End = .;
70          __Vectors_Size = __Vectors_End - __Vectors;
71          __end__ = .;
72
73          /* ROM Registers start at address 0x00000400 */
74          . = __ROM_Start + 0x400;
75          KEEP(*(.rom_registers*))
76
77          /* Reserving 0x100 bytes of space for ROM registers. */
78          . = __ROM_Start + 0x500;
79
80          /* bootloader_record(s) at address 0x500 (1280B) */
81          KEEP(*(.bootloader_record*))
82
83          /* Vector information array. */
84          __Vector_Info_Start = .;
85          KEEP(*(SORT_BY_NAME(.vector_info.*)))
86          __Vector_Info_End = .;
87          __Vector_Info_Size = __Vector_Info_End - __Vector_Info_Start;
```

Figure 24 Creating the Bootloader Record Section

3. Whenever a change is made to the linker, select **Project** > **Clean** in the top menu.

   Make sure that the project is selected and the **Build automatically** checkbox is checked. Press **OK**. The object files are removed and recompiled and the new linker settings should take effect. Since the code that is compiled did not change, simply doing a build causes the compiler to believe that nothing has changed and the linker would not be invoked. Any linker script changes should always be accompanied with a project clean and build.

   The linker script has now been reviewed. The bootloader is now set up. No further steps are necessary to make the bootloader function. The next step in the bootloader solution is to create the downloader (your application) that will download the new application image to the external memory.

7. Non-Blocking Bootloader Application Design and Implementation Overview

The bootloader framework is designed to allow a developer to implement their bootloader with any requirements that may be part of their product in a flexible and scalable manner. Before you implement the bootloader, Renesas strongly recommends that you draw out your bootloader design before writing a single line of code. An example, baseline bootloader can be found in the following figure. Review this diagram and walk through the bootloader code to see the implemented behavior.

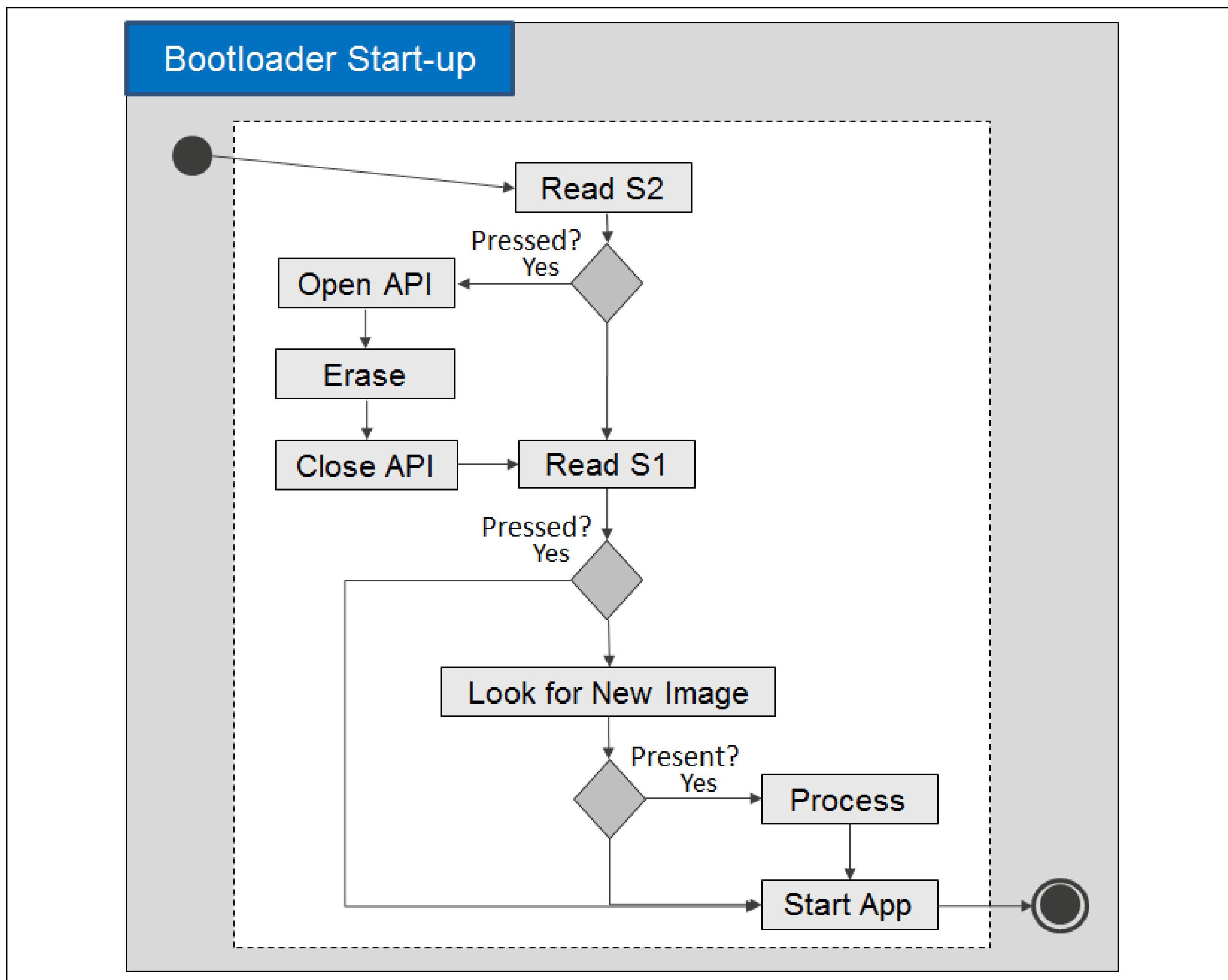


Figure 25 Non-blocking bootloader program design

1. The bootloader application start-up code first checks to see if any buttons are pressed before checking if a new application exists.

   If switch S2 is pressed at start-up, the application stored on the microcontroller's internal flash will be erased. The **hal_entry** module can be setup to check S2 and erase the application by adding the code in like in the following figure to the **hal_entry** function. At first glance, the code might seem a bit complicated. A closer look will reveal that it is nothing more than calling the internal flash open, **imageErase**, and **close** API functions.

Note: For debugging purposes, the S1 and S2 capabilities can be very useful. Features like this can get a production system into trouble by you accidentally pressing the wrong button. For production, you will want to make sure that these features are removed from the build.

```
    ioport_level_t level;

    g_ioport.p_api->pinRead(IOPORT_PORT_00_PIN_10, &level);

    /** Erase MCU flash if S2 is pressed. */
    if (IOPORT_LEVEL_LOW == level)
    {
        /** TEMP: erase flash */
        ssp_err_t ssp_err;
        sf_firmware_image_erase_cfg_t erase_cfg = { .slot_number = 0 };
        ssp_err = g_sf_bootloader_mcu0.p_cfg->p_lower_lvl_firmware_mcu->p_api->open(g_sf_bootloader_mcu0.p_cfg->p_lower_lvl_firmware_mcu->p_ctrl,
                                                                                   g_sf_bootloader_mcu0.p_cfg->p_lower_lvl_firmware_mcu->p_cfg);

        if (SSP_SUCCESS != ssp_err) { __BKPT(0); }

        ssp_err = g_sf_bootloader_mcu0.p_cfg->p_lower_lvl_firmware_mcu->p_api->imageErase(g_sf_bootloader_mcu0.p_cfg->p_lower_lvl_firmware_mcu->p_ctrl,
                                                                                         &erase_cfg);

        if (SSP_SUCCESS != ssp_err) { __BKPT(0); }

        ssp_err = g_sf_bootloader_mcu0.p_cfg->p_lower_lvl_firmware_mcu->p_api->close(g_sf_bootloader_mcu0.p_cfg->p_lower_lvl_firmware_mcu->p_ctrl);

        if (SSP_SUCCESS != ssp_err) { __BKPT(0); }
    }
```

Figure 26 S2 Switch Check to Erase Flash Application

2. The bootloader must make a critical decision; jump to the application image or search for a new application image to copy into the flash. To handle this decision, a function in the **hal_entry** module called **my_entry** is used to decide what function to perform. The **my_entry** function takes pointers to the bootloader control and configuration structures in addition to a Boolean value to tell the function whether it should check for a new image or just jump to the application image. Before jumping to the application image, the bootloader verifies the application image CRC to ensure that the application is valid.
3. Holding S1 during the power-on sequence will tell the bootloader to skip the check for a new application image and cause it instead to jump to the current application image.

```
    g_ioport.p_api->pinRead(IOPORT_PORT_00_PIN_06, &level);

    /** Try to jump to app if S1 is pressed. */
    if (IOPORT_LEVEL_LOW == level)
    {
        my_entry(g_sf_bootloader_mcu0.p_ctrl, g_sf_bootloader_mcu0.p_cfg, false);
    }
```

Figure 27 S1 Switch Check for Jump to Application

4. If a button has not been pressed, the **my_entry** function still needs to be called to perform the bootloader functionality. The code for this check can be seen in the following figure.

```
    while(1)
    {
        /** Look for new image. */
        my_entry(g_sf_bootloader_mcu0.p_ctrl, g_sf_bootloader_mcu0.p_cfg, true);
    }
```

Figure 28 Main Bootloader Loop

5. The function **my_entry** makes the decision to check for a new application or jump to the application code. For the application jump to occur, the **sf_firmware_mcu_flash** interface still needs to be initialized and used. This is done by making a call to its **open** API. When the interface is opened, the **appStart** API can be called to initiate the jump to the application. Since the **appStart** API causes a jump to the application code, the bootloader has essentially ended the execution until the next time the system restarts. To follow good programming practices and to account for something going wrong such as a bad jump, there should still be a call to the **close** API. The following figure shows the implementation details for the code segment that handles jumping to the application.

```
if(check_for_new_images == false)
{
    /** Since we are not checking for new images, only initialize the sf_firmware_mcu_flash interface*/
    //ssp_err = g_sf_bootloader_mcu0.p_api->open(p_ctrl, p_cfg, false);
    ssp_err = g_sf_bootloader_mcu0.p_api->open(p_ctrl, &my_cfg);

    if (ssp_err != SSP_SUCCESS)
    {
        //break;
    }

    /** Jump to the app */
    ssp_err = g_sf_bootloader_mcu0.p_api->appStart(p_ctrl);

    if (ssp_err != SSP_SUCCESS)
    {
       // break;
    }

    ssp_err = g_sf_bootloader_mcu0.p_api->close(p_ctrl);

    return SSP_SUCCESS;
}
```

Figure 29 Jump to Application

Note: There are empty error handlers following each call to the SSP API's that check whether the call was successful (equal to SSP_SUCCESS). If there is an error, ssp_err will hold a different value and in a production system the developer will need to decide how to handle these errors. For now, they are left as error handling stubs to remind us we need to think through the possible error conditions and how they should be handled.

6. If you want to check for new application images, you need to add code to determine whether a new image exists on the external memory card.

   To do this, you must first call the **open** API call for the **g_sf**_bootloader_**mcu0** stack. After the framework has been opened, the **newImageCheck** API can be called with the **update_info** variable passed in as a pointer. The return value from calling **newImageCheck** will determine if a new image is present and ready to be written to flash. The following figure shows the code that should be added to **my_entry**.

```
/** Since we are checking for new images (or if the partial open failed), initialize all available interfaces */
//ssp_err = g_sf_bootloader_mcu0.p_api->open(p_ctrl, p_cfg, true);
ssp_err = g_sf_bootloader_mcu0.p_api->open(p_ctrl, &my_cfg);
if (ssp_err != SSP_SUCCESS)
{
   // break;
}

/** Check to see if there is a newer image available */
ssp_err = g_sf_bootloader_mcu0.p_api->newImageCheck(p_ctrl, &update_info);
```

Figure 30 Initialize and Check for a New Application Image

7. If the image exists, then the application update can continue.

   The first thing that the bootloader needs to do is erase the current application image. The image can be erased by setting the application slot image that is going to be erased and then calling the **imageErase** API as shown in the following figure.

8. Once the image has been erased successfully, the **flashUpdate** API can be called. The **flashUpdate** expects a pointer to the bootloader control structure and a pointer to the new image that will be copied into flash.

   The **flashUpdate** function performs all the bootloader copy functions on its own without any additional information from you.

9. When the application update is complete, check the return data to determine whether the update was successful.

   If the update was not successful, you can do many things, such as trying again, entering a safe system state, notifying the user, or resetting the microcontroller. In this example, we just leave a placeholder with the commented example for resetting the system.

10. In most cases, the firmware update will be successful. When the update is successful, the bootloader should jump into the application code by calling the **appStart** API function.

```
/** If the check was successful and a valid slot with a newer image was re"turned, then update the MCU flash with this new image*/
if ((ssp_err == SSP_SUCCESS) || (ssp_err == SSP_ERR_NO_FLASH_IMAGES))
{

    sf_firmware_image_erase_cfg_t erase_cfg = { .slot_number = 0 };
    ssp_err = g_sf_bootloader_mcu0.p_cfg->p_lower_lvl_firmware_mcu->p_api->imageErase(g_sf_bootloader_mcu0.p_cfg->p_lower_lvl_firmware_mcu->p_ctrl,
                                                                                      &erase_cfg);

    if (SSP_SUCCESS != ssp_err) { __BKPT(0); }

    ssp_err = g_sf_bootloader_mcu0.p_api->flashUpdate(p_ctrl, &update_info);

    /** If the update did not succeed, then reset the MCU*/
    if ((ssp_err != SSP_SUCCESS) && (ssp_err != SSP_ERR_IMAGE_ALREADY_EXISTS))
    {
        //g_sf_bootloader_mcu0.p_api->reset(p_ctrl);
    }
    else
    {
        /** If the update was successful, jump to the app*/
        ssp_err = g_sf_bootloader_mcu0.p_api->appStart(p_ctrl);
        /** If the jump failed, then reset the MCUS */
        if (ssp_err != SSP_SUCCESS)
        {
            //g_sf_bootloader_mcu0.p_api->reset(p_ctrl);
        }
    }
}
```

Figure 31 Find New Image and Update

11. If a new image does not exist, you should call the **appStart** API to start the current application and once again close the interface. The code to do this is like that used before and can be found in the following figure.

```
    else
    {
        /** If the check for new image was not successful, jump to the existing app*/
        ssp_err = g_sf_bootloader_mcu0.p_api->appStart(p_ctrl);
#if 0
        /** If the jump failed, then reset the MCU */
        if (ssp_err != SSP_SUCCESS)
        {
            g_sf_bootloader_mcu0.p_api->reset(p_ctrl);
        }
#endif
    }

    ssp_err = g_sf_bootloader_mcu0.p_api->close(p_ctrl);

    return ssp_err;
```

Figure 32 No New Application Image, Load Current Application

Note: A robust bootloader will not just assume that the jump to the application will be successful. Something could go wrong and if the jump fails, you should have a back-up plan for how the system will recover itself. Figure 31 shows an example that is conditionally compiled on how the bootloader may check if the jump was successful. If we can perform this check the jump failed and the **ssp_err** will not hold, **SSP_SUCCESS**. The application can then call the **reset** API to force the system to reset and try again or take any measure that the you deem necessary to recover from the error.

8. Blocking Bootloader Application Software Stack Configuration

After running the flashloader project for the first time, you may want to dig into the flashloader framework and understand the different settings and capabilities that are available. This section will highlight the settings that you will want to understand within the bootloader application code.

1. Start by opening the bootloader project Synergy **configuration.xml** file and navigating to the **Threads** tab. The bootloader stack will look like the following figure. For the blocking bootloader, only the internal firmware image framework will be populated. The reason is that the internal framework is required to save the new image to flash and the image is already stored on internal flash rather than external memory such as a SD card.

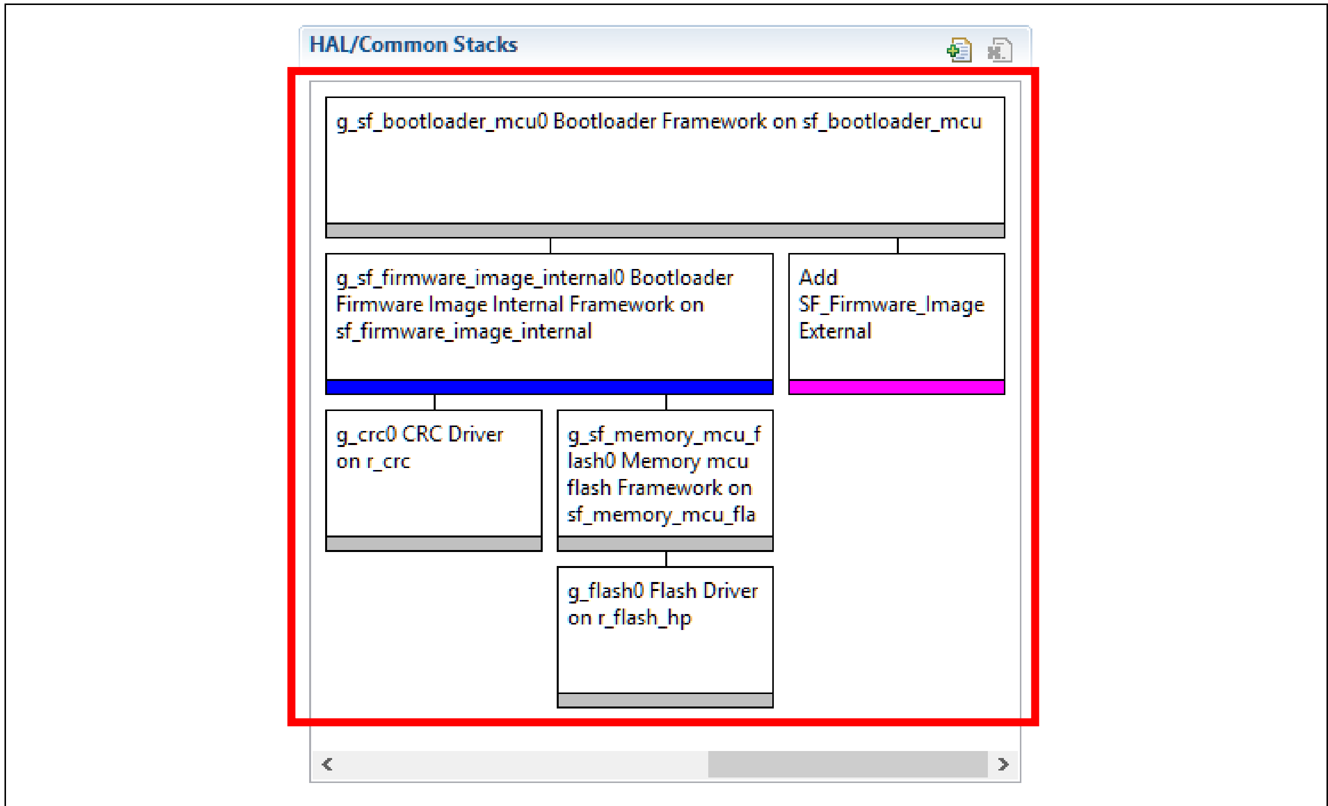


Figure 33 Adding the g_sf_bootloader_mcu stack

2. Click on the **g_sf_firmware_image_internal0** and select the **Properties** tab shown in the following figure. These are the same options that are available in the non-blocking bootloader internal memory framework. For the non-blocking bootloader, the options are set slightly differently like in the following figure. Notice that in this case there are two slots selected. One slot will be for the current application code and the second will be for the new application image.

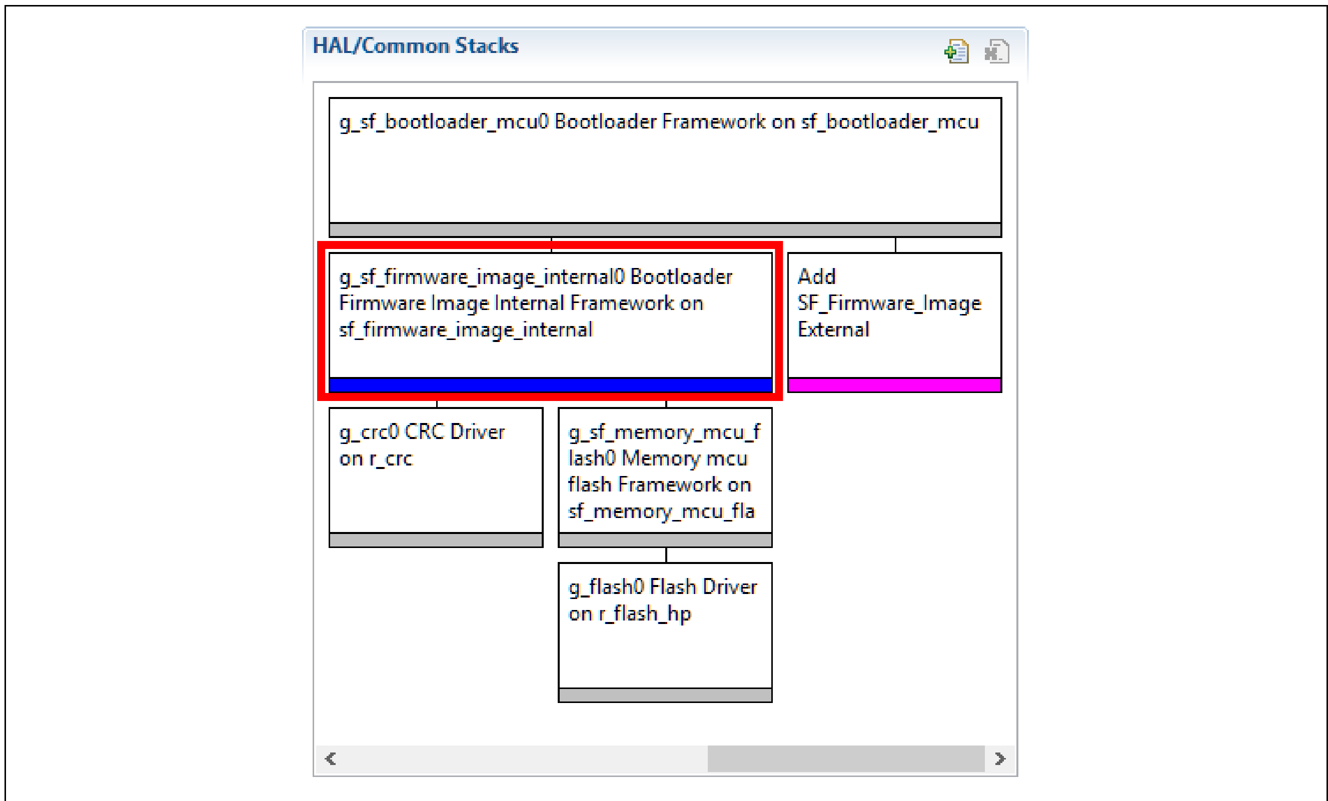


Figure 34 Blocking Bootloader Framework Stack

Property	Value
◢ Common	
Parameter Checking	Default (BSP)
◢ Module g_sf_firmware_image_internal0 Bootloader Firmware Image	
Name	g_sf_firmware_image_internal0
Enter the starting address of the first flash area	0x100000
Enter the size of the first flash area	0x300000
Number of slots supported (1 or 2 slots supported)	2
Callback	NULL

Figure 35 g_sf_firmware_image_internal0 Configuration

In the property **Enter the starting address of the first flash area**, enter the memory address where the User Application Area begins. The address location 0x0 is not an appropriate location because the bootloader resides in this memory location. You can select any location for the application to start at based on your requirements and how you decide to split up the flash memory map. In this example, the S7G2 Group MCU on the DK-S7G2 board has 4 MB of flash available and the application will be stored at the 1 MB location which in hex is 0x100000. Keep in mind that flash size will vary based on the selected specific MCU selected.

In the property **Enter the size of the first flash area**, specify how large the memory location is that the User Application Area has available to it. In this example, allocate the remaining 3 MB memory space for the application.

For a blocking bootloader where the application will be store internally in flash, there should be two flash locations: one for the current program and one for the new application that will be stored.

3. The remaining modules in the **Bootloader Firmware Image Internal Framework** do not contain developer configurable properties. However, you will want to review the Flash Driver. There are two different flash types that are used with Synergy microcontrollers; high performance (hp) and low power (lp). The S1 and S3 microcontrollers use the low-power flash since they are targeted towards low-power applications. The S5 and S7

use the high-performance flash since they target applications that are more computationally intensive. Make sure that your application is using the correct flash type as shown like in the following figure.

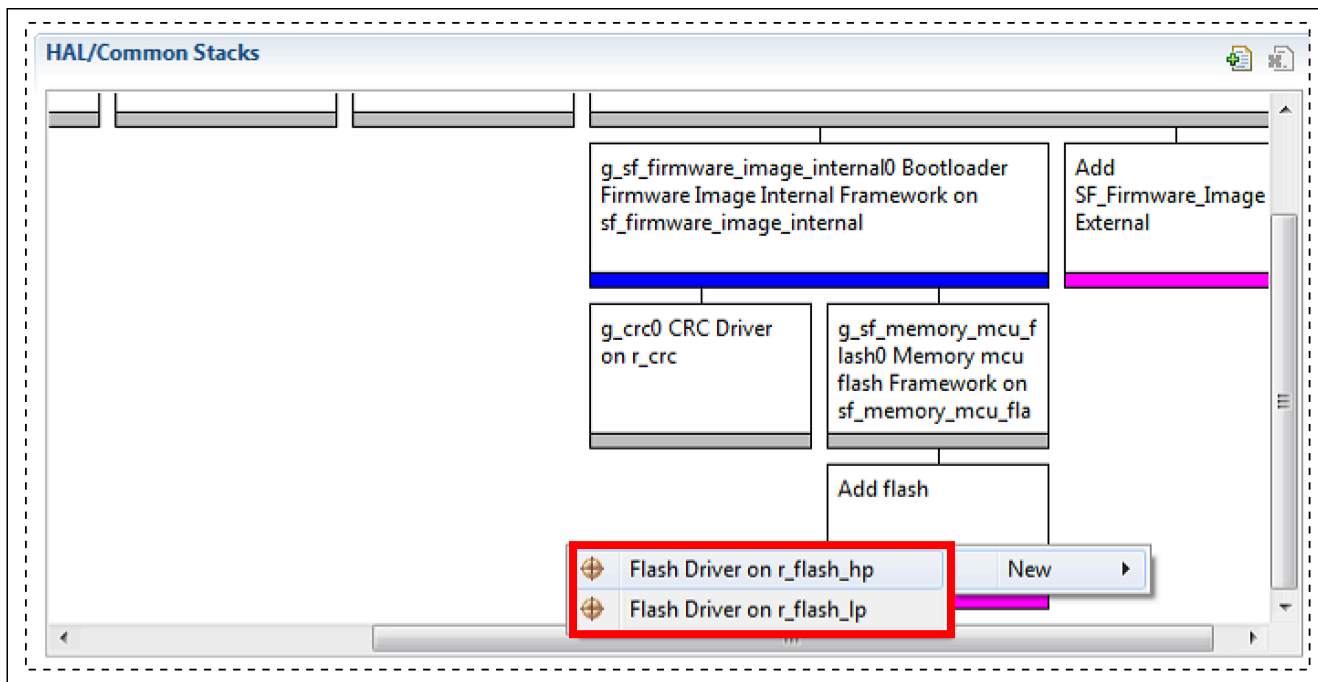


Figure 36 Add the flash driver instance

4. Click on the **g_flash0** component and examine the properties like the following figure and find the **Code Flash Enable Programming** property. This property is used to enabled or disable internal flash writing. For the bootloader, this property should be **enabled**.

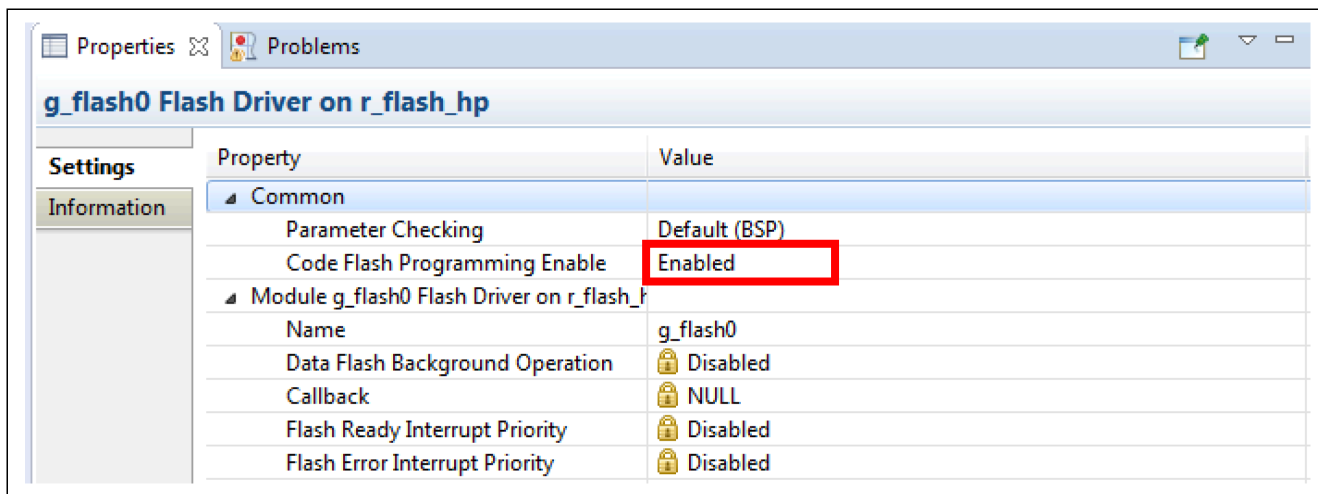


Figure 37 Enable the Code Flash Programming Property

These are the major properties to manage the setup of the blocking bootloader.

9. Blocking Bootloader Application Design and Implementation Overview

The bootloader framework is designed to allow you to implement their bootloader with any requirements that may be part of their product in a flexible and scalable manner. Before you implement the bootloader, Renesas strongly recommends that you draw out your bootloader design before writing a single line of code. An example, baseline bootloader can be found in the following figure. Review this diagram to understand the bootloader behavior and then move on to the next step to write the bootloader software.

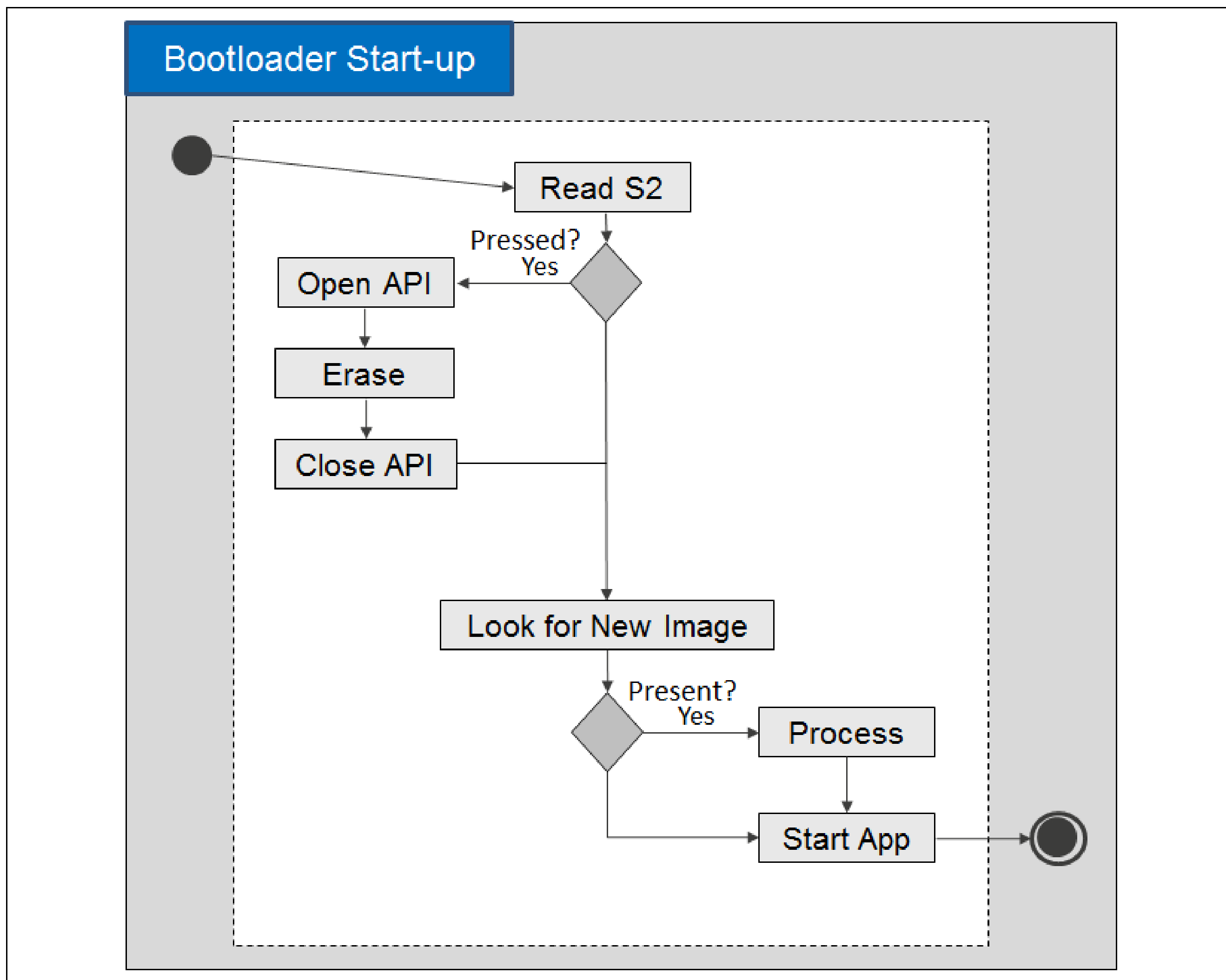


Figure 38 Blocking Bootloader Program Design

Note: When there are multiple internal flash memory slots, it probably isn't a good idea to allow a button press to erase the internal memory. While the activity diagram does show the ability to erase the internal flash in the code that is developed, we will conditionally compile it out but provide it as a debugging tool for developers.

Note: Blinking LEDs in the bootloader to show that the system is processing and still doing something can be extremely useful. We will add code to control LED's that are being absorbed by the check for image and process blocks.

1. In the project explorer, expand the project. Under the **src** folder, open the **hal_entry.c** module.
2. The bootloader application start-up code first checks to see if any buttons are pressed before checking to see if a new application exists.

   If switch S2 is pressed at start-up, the application stored on the microcontroller's internal flash will be erased. At first glance, the code might seem a bit complicated. A closer look will reveal that it is nothing more than calling the internal flash **open, imageErase**, and **close** API functions.

```
ioport_level_t level;

g_ioport.p_api->pinRead(IOPORT_PORT_00_PIN_10, &level);

/** Erase MCU flash if S2 is pressed. */
if (IOPORT_LEVEL_LOW == level)
{
    /** TEMP: erase flash */
    ssp_err_t ssp_err;
    sf_firmware_image_erase_cfg_t erase_cfg = { .slot_number = 0 };
    ssp_err = g_sf_bootloader_mcu0.p_cfg->p_lower_lvl_firmware_mcu->p_api->open(g_sf_bootloader_mcu0.p_cfg->p_lower_lvl_firmware_mcu->p_ctrl,
                                                                               g_sf_bootloader_mcu0.p_cfg->p_lower_lvl_firmware_mcu->p_cfg);

    if (SSP_SUCCESS != ssp_err) { __BKPT(0); }

    ssp_err = g_sf_bootloader_mcu0.p_cfg->p_lower_lvl_firmware_mcu->p_api->imageErase(g_sf_bootloader_mcu0.p_cfg->p_lower_lvl_firmware_mcu->p_ctrl,
                                                                                     &erase_cfg);

    if (SSP_SUCCESS != ssp_err) { __BKPT(0); }

    ssp_err = g_sf_bootloader_mcu0.p_cfg->p_lower_lvl_firmware_mcu->p_api->close(g_sf_bootloader_mcu0.p_cfg->p_lower_lvl_firmware_mcu->p_ctrl);

    if (SSP_SUCCESS != ssp_err) { __BKPT(0); }
}
```

Figure 39 S2 Switch Check to Erase Flash Application

3. The bootloader must make a critical decision; jump to the application image or search for a new application image to copy into flash.

   The **my_entry** function takes pointers to the bootloader control and configuration structures in addition to a Boolean value to tell the function whether it should check for a new image or just jump to the application image. Before jumping to the application image, the bootloader verifies the application image CRC to ensure that the application is valid.
4. In the following figure, the main loop for the bootloader simply makes a call to the **my_entry** function and passes it the bootloader control and configuration parameters.

```
while(1)
{
    /** Look for new image. */
    my_entry(g_sf_bootloader_mcu0.p_ctrl, g_sf_bootloader_mcu0.p_cfg, true);
}
```

Figure 40 Main Bootloader Loop

5. You typically want the bootloader to perform all its checks in the minimal amount of time to keep the system boot up time to a minimum.

Since in most cases the application is not updating firmware on start-up, the first feature that should be implemented inside **my_entry** is the check for jumping directly to the application. In this case, the code checks the parameter **check_for_new_images** and if it is false, the application should go directly to the application. When the interface is open, the **appStart** API can be called to initiate the jump to the application. Since the **appStart** API causes a jump to the application code, the bootloader has essentially ended execution until the next time the system restarts. To follow good programming practices and to account for something going wrong like a bad jump, there should still be a call to the **close** API. The following figure shows the implementation details for the code segment that handles jumping to the application.

```
if(check_for_new_images == false)
{
    /** Since we are not checking for new images, only initialize the sf_firmware_mcu_flash interface*/
    //ssp_err = g_sf_bootloader_mcu0.p_api->open(p_ctrl, p_cfg, false);
    ssp_err = g_sf_bootloader_mcu0.p_api->open(p_ctrl, &my_cfg);

    if (ssp_err != SSP_SUCCESS)
    {
        //break;
    }

    /** Jump to the app */
    ssp_err = g_sf_bootloader_mcu0.p_api->appStart(p_ctrl);

    if (ssp_err != SSP_SUCCESS)
    {
       // break;
    }

    ssp_err = g_sf_bootloader_mcu0.p_api->close(p_ctrl);

    return SSP_SUCCESS;
}
```

Figure 41 Jump to Application

Note: There are empty error handlers following each call to the SSP APIs that check whether the call was successful (equal to `SSP_SUCCESS`). If there is an error, `ssp_err` will hold a different value. In a production system, you will need to decide how to handle these errors. For now, they are left as error handling stubs to remind us we need to think through the possible error conditions and how they should be handled.

6. The bootloader is verifying that the application was written successfully to the flash and has not been damaged. Erasing and updating for the blocking bootloader is performed by the downloader. If there was a failure and the system is now stuck in the bootloader, you will be notified by blinking LEDs.

The blocking bootloader application overview is now complete. If you have not yet reviewed the bootloader script section, now would be a good time before moving on to the downloader section.

10. Non-Blocking Downloader Application Software Stack Overview

The downloader application is responsible for fetching the new application image and storing it to some external storage device, such as the SDMMC card. That image could be coming over any number of possible interfaces. This section will provide an overview for the configuration parameters for a common downloader stack. Specific interface setups such as USB and UART can be found in the Appendices of this document.

1. Start by opening the downloader's Synergy **configuration.xml** file and navigating to the **Threads** tab.

   Within this tab, there will be a downloader thread. Click on that thread to view the downloader framework stack. An example that uses USB CDC can be seen in the following figure.

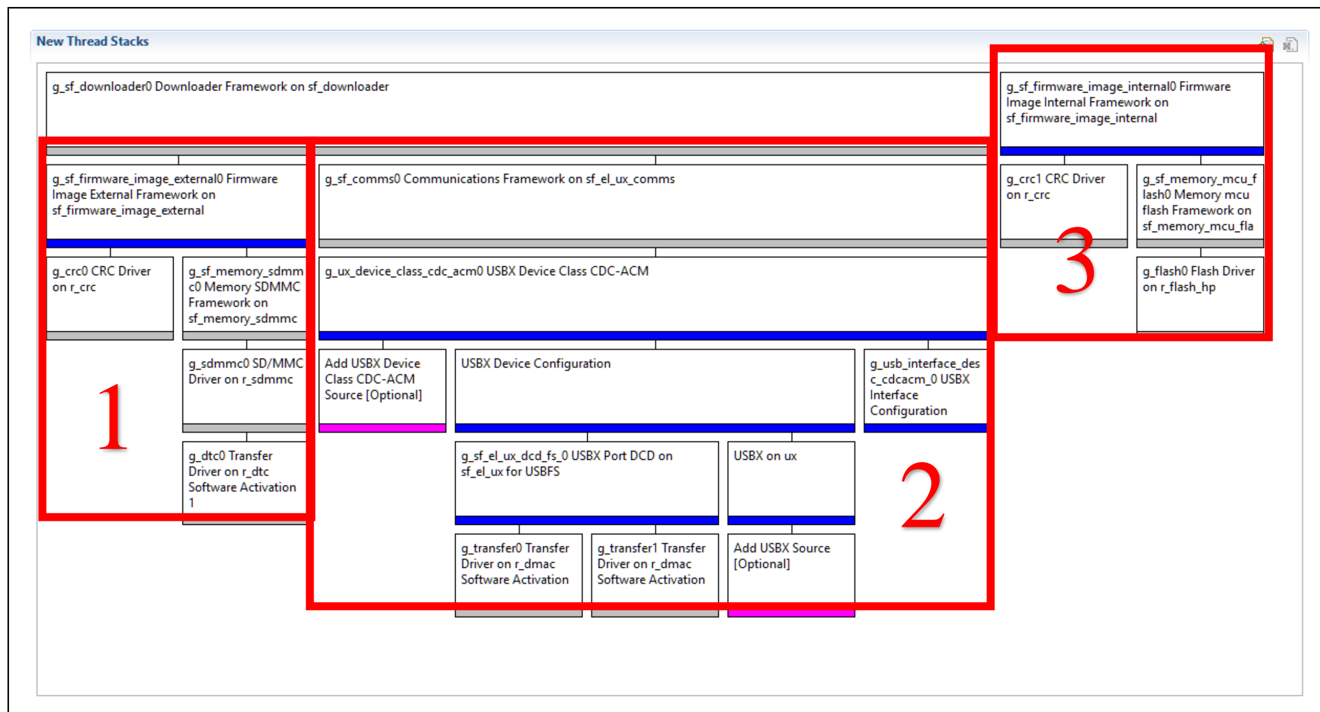


Figure 42 Downloader Example Stack using USB CDC

1. Section 1 and 3 in the above figure will have common configuration properties that will be similar from one application to the next.

   Section 1 manages the external memory where the new image will be stored. Section 2 is communication interface specific. Section 2 options and setup are described in the appendices for the specific interface. It is just the communication channel that the downloader uses to retrieve the new application image. Section 3 manages the internal memory records that are set up to communicate between the bootloader application and the downloader application.

2. The **g_sf_downloader0** does not have many properties that need to be configured.

   The one property that is critical to a functioning downloader is the callback function. A developer needs to configure a callback function that is called when a downloader event occurs within the application. The callback can be seen in in the following figure.

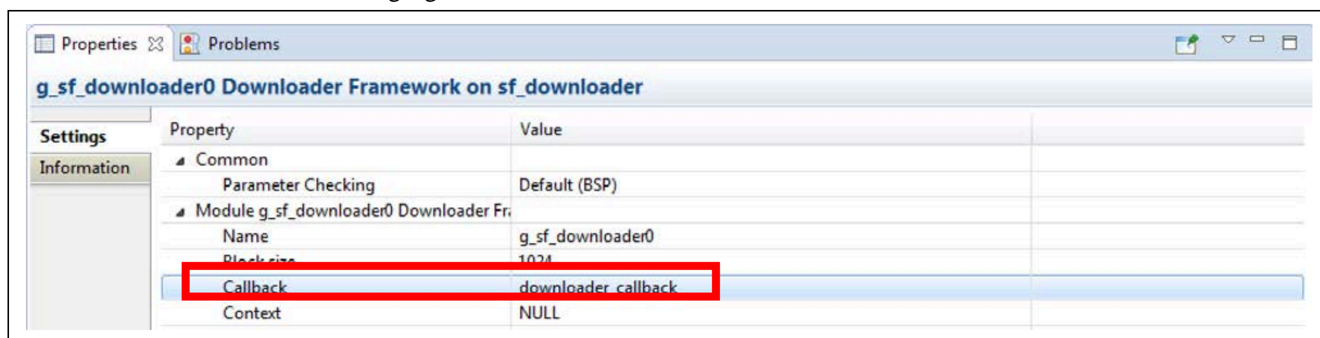


Figure 43 Downloader Framework Callback Configuration

3. You have different choices within the downloader framework for the image type and image location.

   For example, if you wanted to store the image in the internal flash, you could use the **Firmware Image Internal Framework** on **sf_firmware_image_internal**. The difference between Firmware Image and Bootloader Firmware is that the Bootloader Image creates bootloader records that load into the microcontroller ROM while the Firmware Image will not create those records. External images will store the entire BCH image with the CRCs, so the bootloader can verify the application has not become corrupted. Internal images strip out the extra headers and CRCs that are in the BCH and write the application to internal memory.

4. Click on the **Firmware Image External Framework** module shown in Figure 44.

   The settings in Figure 45 need to match the same settings that are stored in the bootloader application. Notice that there is a slight difference from the bootloader. The **Address to Firmware Records** property is now populated. Note that it matches the memory location that was configured in the bootloader linker file for where the firmware image records would be stored.

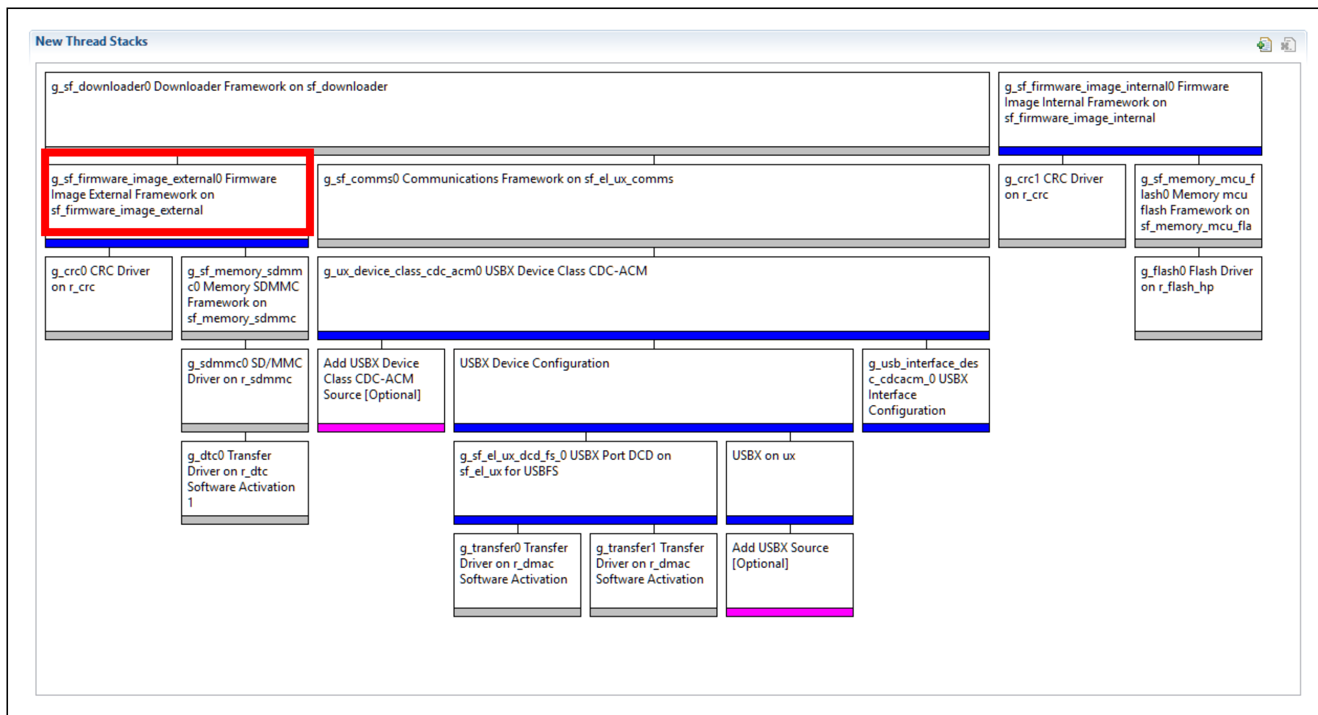


Figure 44 External Memory Properties

Properties | Problems

g_sf_firmware_image_external0 Firmware Image External Framework on sf_firmware_image_external

Settings | Information

Property	Value
▲ Common	
Parameter Checking	Default (BSP)
▲ Module g_sf_firmware_image_external0 Firmware Image External Framework on sf_firmware_image_external	
Name	g_sf_firmware_image_external0
Enter the starting address of the memory storage area	0
Enter the size of the memory storage area	0x400000
Number of slots supported (1 to 4 slots supported)	1
Address/Pointer to Firmware Image Records (Not applicable for a Bootloader Project)	0x500
Callback	NULL
Maximum size of a BCH block in bytes	1024

Figure 45 sf_firmware_image_external Configuration

Note: Remember that the starting address is the location on the SD card where the image information will be stored. The SD card could be much larger than 0x400000 but since this is the maximum flash size on the microcontroller, there is no point in allocating more space than this. Recall that the location in flash that we

modified the bootloader linker for image records was located at address 0x500. The downloader needs this information so the Address/Pointer to Firmware Image Records property is now allocated with 0x500.

5. The downloader is going to have to write an application record to the internal flash storage.

   The Firmware Image Internal Framework is used to write the record into internal memory. The application header information is added to **src/synergy_gen/common_data.c**. To see an example for the application header, open the **common_data.c** file and locate the variable `g_sf_firmware_image_internal0_image_file_header`.

6. Click on the **Firmware Image Internal Framework** module and examine its properties in the following figure.

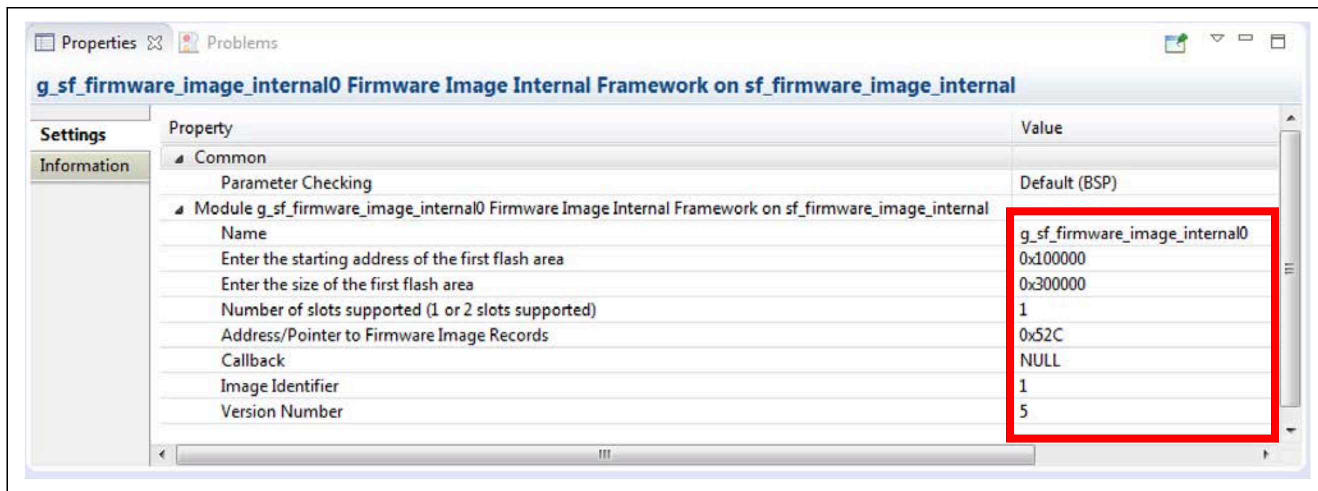


Figure 46 Configuration Settings for the Internal Firmware Image Stack

The bootloader has the application space from 0x000000 through 0x0FFFFF. The location that the current user application exists in starts at 0x100000 and has a length of 0x300000. This bootloader is only using a single image slot as an example. Once again, set up the location for the Firmware Image records. The Image Identifier is related to a product class. For example, a garage door opener would have an Image Identifier of 1 while a sprinkler system might have a value of 2. It is used to verify the application goes to this product. The version number is used for incremental firmware changes. The value should be updated with each version. The bootloader can roll back to a previous version or update to a new version but will NOT update the application if the Version Number matches the current application version.

7. Just as before with the bootloader, the Flash Driver on **r_flash_hp** may need to be adjusted to match whether the microcontroller uses high performance or low power flash.

Those are the major modules and configuration values that you will need to know to integrate the downloader into their own application code.

11. Blocking Downloader Application Software Stack Overview

The blocking downloader is like the non-blocking bootloader. The difference is that there is no longer a need to use an external and internal memory framework. Using only the internal memory framework is all that is required. An example blocking downloader stack can be seen in the following figure. Section 1 is the internal memory framework that will be common to every blocking downloader application. Section 2, is the communication stack that is used to fetch a new application image. This stack will change depending on whether the developer is using USB CDC, UART, I2C, Ethernet, and so on. In this section, we will examine the configuration properties associated with the blocking bootloaders internal memory framework. Configuration parameters for the communication channel can be found in the appendices and by reviewing the module guides associated with the communication stack of interest.

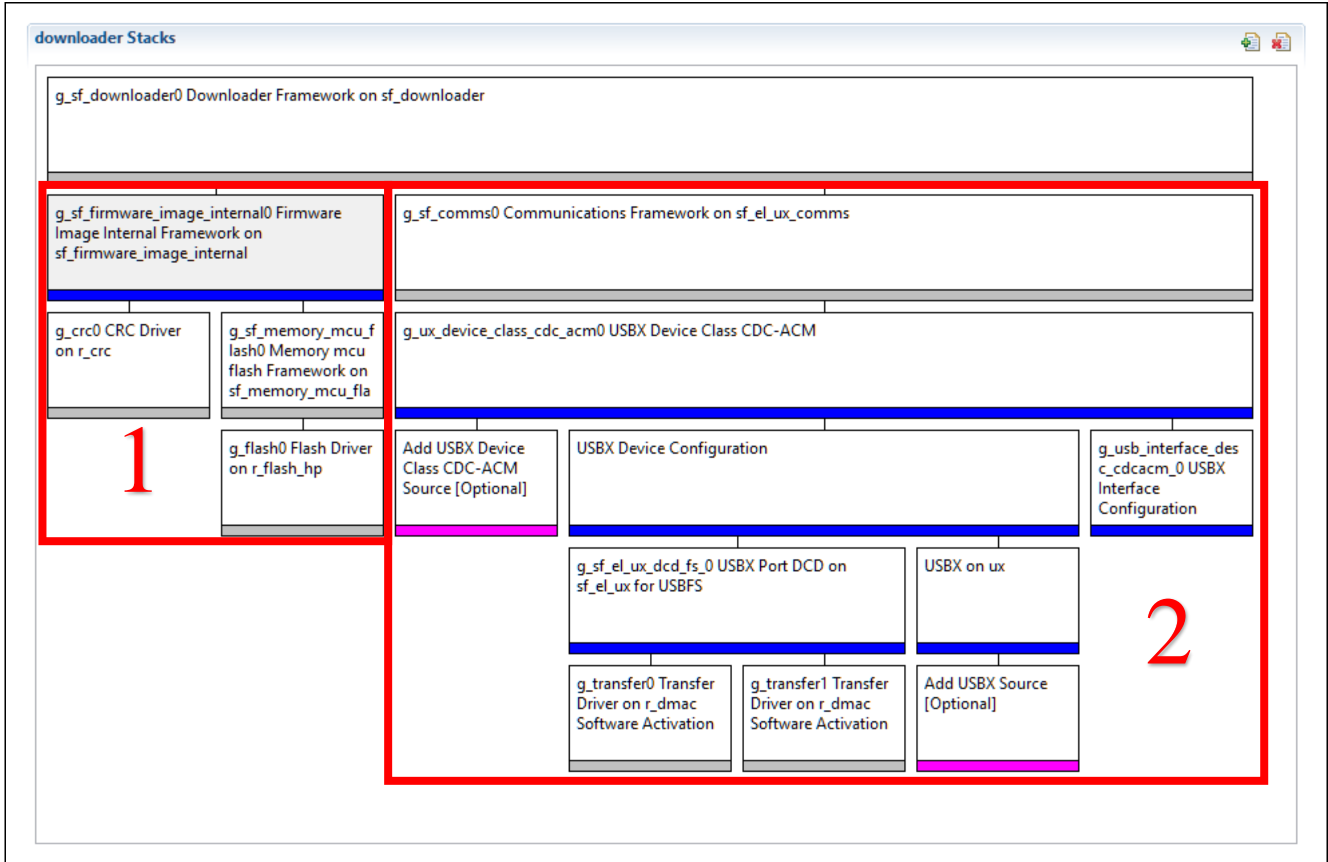


Figure 47 Blocking Downloader USB CDC Example Stack Overview

1. Start by opening the downloader's **configuration.xml** file and navigate to the **Threads** tab and click on the downloader framework module.
2. The **g_sf_downloader0** does not have many properties that need to be configured.

   The one property that is critical to a functioning downloader is the callback function. You need to configure a callback function that is called when a downloader event occurs within the application. The callback can be seen in the following figure.

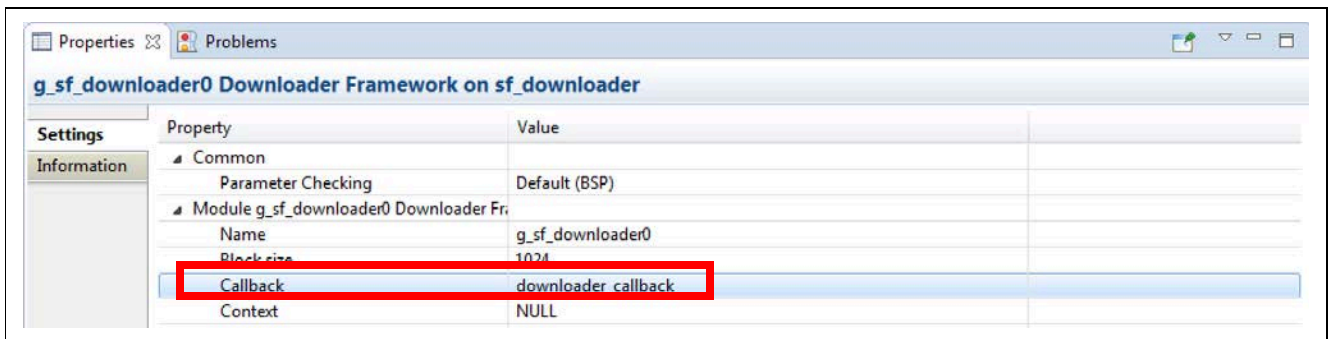


Figure 48 Downloader Framework Callback Configuration

3. Developers have different choices within the downloader framework for the image type and image location.

   For example, if a developer wanted to store the image in the internal flash, they could use **Firmware Image Internal Framework** on **sf_firmware_image_internal**. The difference between Firmware Image and Bootloader Firmware is that the Bootloader Image will create bootloader records that load into the microcontroller ROM while the Firmware Image will not create those records. External images will store the entire BCH image with the CRCs so that the bootloader can verify the application hasn't become corrupted. Internal images strip out the extra headers and CRCs that are in the BCH and write the application to internal memory.

4. Click on the **Firmware Image Internal Framework** module shown in Figure 49.

   The settings in Figure 50 need to match the same settings that are stored in the bootloader application. Notice that there is a slight difference from the bootloader. The **Address to Firmware Records** property is now populated. Note that it matches the memory location that was configured in the bootloader linker file where firmware image records would be stored.

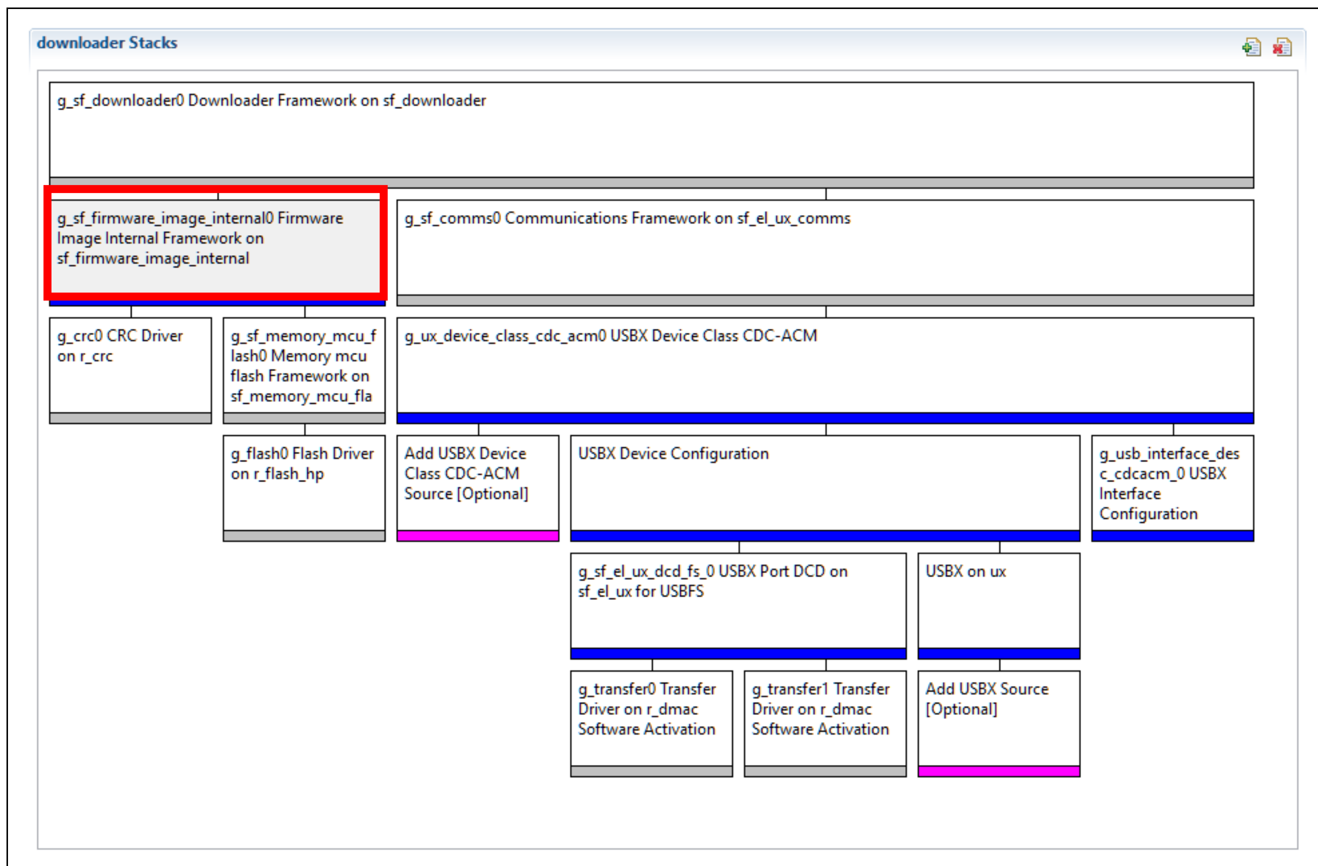


Figure 49 Internal Memory Framework Module

Property	Value
◢ Common	
Parameter Checking	Default (BSP)
◢ Module g_sf_firmware_image_internal0 Firmware Image Internal Fran	
Name	g_sf_firmware_image_internal0
Enter the starting address of the first flash area	0x100000
Enter the size of the first flash area	0x300000
Number of slots supported (1 or 2 slots supported)	2
Address/Pointer to Firmware Image Records	0x500
Callback	NULL
Image Identifier	1
Version Number	7

Figure 50 sf_firmware_image_internal Configuration

Note: Remember that the starting address is the location in internal memory where the application section will begin. In this case, it is 0x100000 with 0x300000 bytes available to write applications. The number of slots needs to match the bootloader that was set to two. Recall that the location in flash that we modified the bootloader linker for image records was located at address 0x500. The downloader needs this information so the **Address/Pointer to Firmware Image Records** property is now allocated with 0x500. The image identifier is used to specify a firmware product. The version number is the software version number. This value should be updated as the software changes.

8. Just as before with the bootloader, the **Flash Driver** on **r_flash_hp** may need to be adjusted to match whether the microcontroller uses high-performance or low-power flash.

9. The blocking downloader has one additional difference that developers might overlook.

   The blocking downloader must write the new application into an internal memory location. To do this, you must make sure that the downloader has the **Code Flash Programming Enable** property set to **enabled** in the flash driver module as shown in the following figure. Not enabling flash writing results in the new application not being written to flash and might throw run-time errors indicating that the flash is not writable.

Property	Value
◢ Common	
Parameter Checking	Default (BSP)
Code Flash Programming Enable	Enabled
◢ Module g_flash1 Flash Driver on r_flash_hp	
Name	g_flash1
Data Flash Background Operation	Disabled
Callback	NULL
Flash Ready Interrupt Priority	Disabled
Flash Error Interrupt Priority	Disabled

Figure 51 Enabling Code Flash Programming

These are the properties that a developer needs to be aware of and has control over in the downloader stack. To learn more about the communication stacks, see the appendices and the module guide for the communication stack that is of interest.

12. Non-Blocking Downloader Application Design and Implementation Overview

The downloader framework is designed to allow you to implement your flashloader solution with any requirements that may be part of their product in a flexible and scalable manner. The downloader framework handles many details in the background and requires only a few lines of code to be fully functional. This section will walk you through how to open the downloader API and setup the callback event that processes communication events.

1. From the Project Explorer, navigate to the **src** directory and open the **downloader_thread_entry.c** source file.
2. In the function **downloader_thread_entry,** the downloader framework is initialized by first making a call to the `open()` API and passing in the control and configuration structures as shown in the following figure.

```
void downloader_thread_entry(void)
{
    ssp_err_t err;

    err = g_sf_downloader0.p_api->open(g_sf_downloader0.p_ctrl, g_sf_downloader0.p_cfg);

    if (SSP_SUCCESS != err) { __BKPT(0); }

    /* TODO: add your own code here */
    while (1)
    {
        tx_thread_sleep (1);
    }
}
```

Figure 52 Opening the Downloader Framework

Note: Whenever a call is made to an SSP Framework component, a recommended best practice is to check the return value to make sure that the call was successful.

3. With the Downloader Framework open, the downloader thread should periodically process the control structure to perform any framework functionality that may be pending. This is done by making a call to the downloaders **process** API as shown in the following figure.

```
void downloader_thread_entry(void)
{
    ssp_err_t err;

    err = g_sf_downloader0.p_api->open(g_sf_downloader0.p_ctrl, g_sf_downloader0.p_cfg);

    if (SSP_SUCCESS != err) { __BKPT(0); }

    /* TODO: add your own code here */
    while (1)
    {
        tx_thread_sleep (1);

        err = g_sf_downloader0.p_api->process(g_sf_downloader0.p_ctrl);

        if (SSP_SUCCESS != err) { __BKPT(0); }
    }
}
```

Figure 53 Downloader Processing

Note: If the downloader framework returns an error, the application forces a breakpoint for the developer to debug the issue. A production solution may decide to handle this in an alternative manner that won't stop the embedded system from operating. Error handling strategies will vary from one development team to the next.

4. The final piece that needs to be added to the downloader thread source code is the **downloader_callback**.

The callback handles events that occur in the downloader framework. In this example, the only event that is interesting is when the downloader receives an entire image, stores it to external memory, and is ready for a reset to occur so that the bootloader can process the image and update the internal application. The following figure shows this callback.

```
void downloader_callback(sf_downloader_callback_args_t * p_args)
{
    if (SF_DOWNLOADER_EVENT_LOAD_IMAGE == p_args->event)
    {
        g_sf_downloader0.p_api->reset(g_sf_downloader0.p_ctrl);
    }
}
```

Figure 54 Adding the downloader_callback

5. The Downloader that is designed for blocking may also include code to erase the individual memory slots. The code listed in the following figure indicates how SW1 and SW2 can be used to erase different memory locations.

Note: This code is disabled out-of-box. It can be enabled by enabling ifdef wrapper around it.

```
ioport_level_t level_sw1;
ioport_level_t level_sw2;
g_ioport.p_api->pinRead(IOPORT_PORT_00_PIN_06, &level_sw1);
g_ioport.p_api->pinRead(IOPORT_PORT_00_PIN_10, &level_sw2);

/** Erase MCU flash if S2 is pressed. */
if (IOPORT_LEVEL_LOW == level_sw1)
{
    /** TEMP: erase flash */
    ssp_err_t ssp_err;
    sf_firmware_image_erase_cfg_t erase_cfg;

    /** If SW2 is pressed then erase slot 1, otherwise slot 0. */
    if (IOPORT_LEVEL_LOW == level_sw2)
    {
        erase_cfg.slot_number = 1;
    }
    else
    {
        erase_cfg.slot_number = 0;
    }

    ssp_err = g_sf_firmware_image_internal0.p_api->imageErase(g_sf_firmware_image_internal0.p_ctrl, &erase_cfg);

    if (SSP_SUCCESS != ssp_err) { __BKPT(0); }

    ssp_err = g_sf_firmware_image_internal0.p_api->close(g_sf_firmware_image_internal0.p_ctrl);

    if (SSP_SUCCESS != ssp_err) { __BKPT(0); }
}
```

Figure 55 Adding Button Functionality for Erasing Application Spaces

This is everything that you need to know to use the downloader framework.

13. Downloader Linker Script

Just like with the bootloader application, the downloader linker needs to be updated to exist within a separate flash memory region and to be able to store image record information. These changes are going to be like the changes made to the bootloader linker script but will be complimentary and not identical.

1. In the project explorer, expand the Downloader project.

   Under the scripts folder, open ***.ld**, where in this example, the file will be **S7G2.ld**. The script is rather large but there are two areas of interest. First, you should see something like in the following figure. For the downloader, the starting flash **ORIGIN** should match the end memory location for the bootloader, in this case 0x100000. The bootloader resides at memory location 0x000000 that would cause a conflict if we left the location set to 0x000000.
2. The **LENGTH** should be sized based on the available flash and whether the entire memory location will be used for a single application or whether multiple applications will be stored.

   For example, for a blocking downloader, the memory space available for the downloader is 0x300000 bytes, divided in half is 0x180000. This will give two locations in the memory that you can use.

```
5    /* Linker script to configure memory regions. */
6    MEMORY
7    {
8      FLASH (rx)          : ORIGIN = 0x00100000, LENGTH = 0x0180000  /*   4M */
9      RAM (rwx)           : ORIGIN = 0x1FFE0000, LENGTH = 0x00A0000  /* 640K */
10     DATA_FLASH (rx)     : ORIGIN = 0x40100000, LENGTH = 0x0010000  /*  64K */
11     QSPI_FLASH (rx)     : ORIGIN = 0x60000000, LENGTH = 0x4000000  /*  64M, Change in QSPI section below also */
12     SDRAM (rwx)         : ORIGIN = 0x90000000, LENGTH = 0x2000000  /*  32M */
13   }
```

Figure 56 Linker Script Memory Allocation for Slot 1

3. If a blocking bootloader is being used, there will be two different linker files.

   The first is for slot 1 and the second for slot 2. Each linker file is slightly different because the start location for the application needs to be different. Examine the following figure. This is the linker for the second application whose origin memory location is 0x00280000.

```
5    /* Linker script to configure memory regions. */
6    MEMORY
7    {
8      FLASH (rx)          : ORIGIN = 0x00280000, LENGTH = 0x0180000  /*   4M */
9      RAM (rwx)           : ORIGIN = 0x1FFE0000, LENGTH = 0x00A0000  /* 640K */
10     DATA_FLASH (rx)     : ORIGIN = 0x40100000, LENGTH = 0x0010000  /*  64K */
11     QSPI_FLASH (rx)     : ORIGIN = 0x60000000, LENGTH = 0x4000000  /*  64M, Change in QSPI section below also */
12     SDRAM (rwx)         : ORIGIN = 0x90000000, LENGTH = 0x2000000  /*  32M */
13   }
```

Figure 57 Linker Script Memory Allocation for Slot 2

4. Scroll down to where the memory sections begin at approximately line 90. After **Lock_Lookup_Size,** we want to create a memory region where the downloader can store information. See the following figure for the code.

```
89          __Lock_Lookup_End = .;
90          __Lock_Lookup_Size = __Lock_Lookup_End - __Lock_Lookup_Start;
91
92          /* Flash Loader App Header at 0x800. This offset is fixed in sf_firmware_image.h and in XML */
93          . = __ROM_Start + 0x800;
94          KEEP(*(.sf_firmware_image_file_header*))
95
96          *(.text*)
```

Figure 58 Creating the Bootloader Record Section

5. When updating the application, you will need to compile the application based on the application slot that the program will be running in.

   If the application will run in slot 1, build and link using the slot 1 linker file. If the application will run in slot 0, build and link using the slot 0 linker file.

6. In the top menu, select **Project > Clean**.

Make sure that the project is selected and the **build automatically** checkbox is checked. Press **OK**. The object files are removed. Recompile and the new linker settings should now take effect. Since the code that is compiled did not change, simply doing a build will cause the compiler to believe that nothing has changed and the linker would not be invoked. Any linker script changes should always be accompanied with a **project clean** and **build**.
The application projects include the linker file(s) by default but you may want to customize the linker slightly for your own applications.

14. Converting User Applications to BCH Files using the Python Converter Script

The compiler toolchains will generate an **.elf** and an **.srec** file when the program is successfully compiled and linked. The flashloader framework uses a custom file format created by Renesas known as the BCH. The BCH file is designed with headers and CRCs to ensure that the application image is successfully transferred to the embedded system without errors and provides a more robust transfer mechanism. In this section, we will examine the Python converter script that will convert a s-record into a BCH file.

There are two ways to convert the s-record. First you can use the `r_fl_mot_converter.py` script manually. Second, you can use the flashloader utility that provides a GUI front end to interact with the Python script. The GUI is described in a later section.

14.1 Convert User Application to BCH files manually

1. The s-record files cannot be directly downloaded to the flashloader solution. They must first be converted to BCH records. The downloader and bootloader can process those files. The conversion is performed using the Renesas `r_fl_mot_converter.py` Python script. To use the Python script:
   A. Download Python 2.7 and install it on the development machine.
   B. Download the **crcmod** library for Python 2.7 from the following website: https://pypi.python.org/pypi/crcmod
   C. The **crcmod.msi** can be installed from any directory. When asked where to install the library:
      a. Select the local hard drive option
      b. Provide the Python installation directory such as **C:\Python27**
2. Once the tools have been installed, navigate to the directory containing the `r_fl_mot_converter.py` script. Start by typing `python r_fl_mot_converter.py` without any options. You will see the parameter list with descriptions as seen in the below figure.

Note: Python should be in the path but if it isn't, Python can be executed in the command line using the path to the executable such as `C:\Python27\python.exe r_fl_mot_convert.py`.

```
FlashLoader S-Record Converter

Options:
  -h, --help            show this help message and exit
  -i FILE, --input=FILE
                        The path to the file you want to convert.
  -o OUTPUT, --output=OUTPUT
                        Name of the output file.
  -m MAXBLOCKSIZE, --maximum_block_size=MAXBLOCKSIZE
                        Set max size in bytes for Block [default=1024]
  -f FILLSPACE, --fill_space=FILLSPACE
                        Max bytes between 2 records to fill with 0xFF's and
                        join data [default=256]
  -e EXECUTABLE_ADDRESS, --executable_address=EXECUTABLE_ADDRESS
                        Flash location for application
  -l HEADERLOC, --location=HEADERLOC
                        Flash location for application load file header
                        [default=0x00008400]
  --formatting          Displays information on how the binary file is
                        structured.
  -v VALIDMASK, --valid_mask=VALIDMASK
                        Set the value you used for the valid mask
                        [default=0xAF]
  -s VALIDFLASHSIZE, --slot_size=VALIDFLASHSIZE
                        Set the desired flash size to calculate the checksum
                        over. The default is to use the compiler defined
                        value. [default=0]
```

Figure 59 S-Rec to BCH Converter Script Options

3. The next step is to identify the options that are needed to run the converter script.

   The following example lays out the recommended information that should be provided for a conversion. Start by determining the parameters for the **Downloader_blinky1.srec** file. The bold text in the following statements can be used to build and compile the command line.

   A. **–i** specifies the input file and for this example is **Downloader_blink1.srec**. Keep in mind that unless the s-record has been copied to the same directory as the converter script, the full path will need to be provided so that the file can be found.

   B. **–o** is the output filename for the converted file. You can technically name the file anything you want but for the example we will name it **Downloader_blink1.bch**.

   C. **–m** is the maximum block size that has a default value of **1024**. This value should be an integer multiple of the external memory page size that is going to be programmed.

   D. **–f** tells the converter that if there is a gap between two records, the data should be filled with 0xFF. The default value for this behavior is **256**.

   E. **–e** allows you to specify where in memory the application will be located. For example, we have been providing the bootloader with 1 MB of flash space (more than is required) and the application has had the last 3 MB of memory. This option is used to tell the converter where the application section begins so that the application can be appropriately addressed. An example value for this application is **0x100000**.

   F. **–l** tells the converter where the header information is going to be placed in memory. If you recall back to when the Downloader linker script was updated, we added the header information to `ROM_START` + 0x800. Since the application starts at 0x100000, we set this value to **0x100800**.

   G. **–s** tells the converter the desired flash range that should be used when calculating the checksum that is placed on the application space. A standard practice is to checksum the entire application program space including the space that is NOT the application code but is empty unprogrammed memory. In this case, the example value that we have used through-out the application project is **0x300000**.

4. You can now take the values that were in bold in the previous step and run the command line script with the options that result in converting the **Downloader_blink1.srec** into **Download_blink1.bch** as shown in the following figure.

```
C:\bch_script\bch_creator_script>c:\Python27\python.exe r_fl_mot_converter.py -i Downloader_CDC_blin
k1.srec -o Downloader_CDC_blink1.bch -m 1024 -f 256 -e 0x100000 -l 0x100800 -s 0x300000

S-Record file converted successfully.
Output file is Downloader_CDC_blink1.bch
Size of entire Load Image is 67130 bytes
Downloader_CDC_blink1.srec checksum_fw_image: 000052b8
```

Figure 60 Convert Downloader_blinky1.srec to Downloader_blink1.bch

Note: The output will notify the developer if the conversion was successful or not. In addition, it provides the entire load image size and the checksum value for the image which can come in handy when debugging.

   You have to copy the files with the extension **.srec** that you would like to convert to a **.bch** into the folder that contains the file **r_fl_mot_converter.py**.

5. Converting the second test image uses the same steps as we walked through above. The difference is that the input and output options change but the rest remain the same. An example can be seen in the figure below.

```
C:\bch_script\bch_creator_script>c:\Python27\python.exe r_fl_mot_converter.py -i Downloader_CDC_blin
k2.srec -o Downloader_CDC_blink2.bch -m 1024 -f 256 -e 0x100000 -l 0x100800 -s 0x300000

S-Record file converted successfully.
Output file is Downloader_CDC_blink2.bch
Size of entire Load Image is 67130 bytes
Downloader_CDC_blink2.srec checksum_fw_image: 000052b8
```

Figure 61 Convert Downloader_blinky2.srec to Downloader_blink2.bch

At this point, the **.bch** file is ready and can be sent to the downloader application.

If you are compiling code for a blocking bootloader you will need to modify the linker scripts. The blocking bootloaders contain two separate linker scripts as can be seen in the following figure.

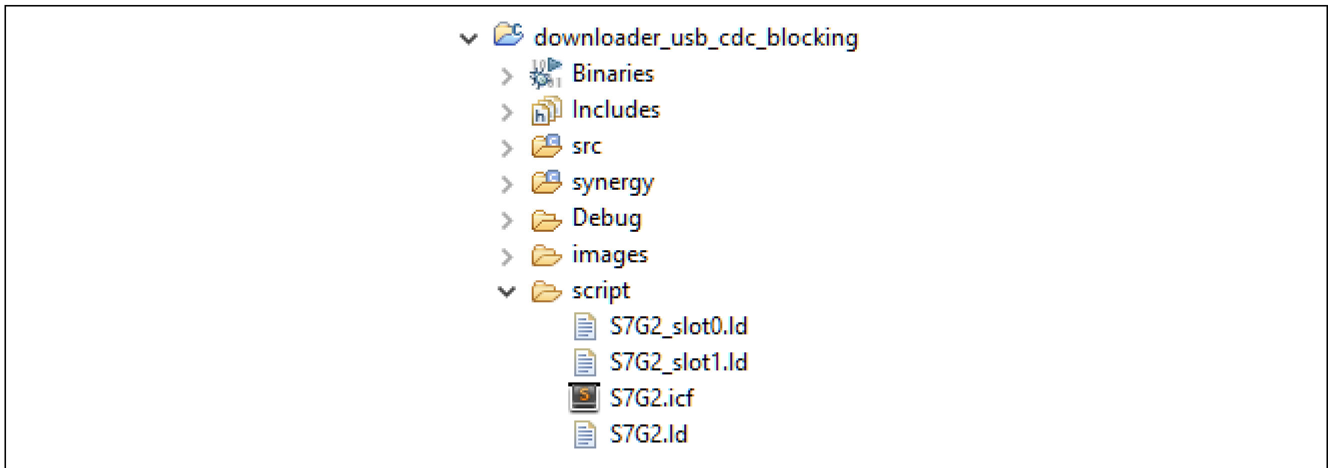


Figure 62 Blocking Downloader Application Multiple Linker Scripts

To compile an application for **slot0** or **slot1**, copy the linker contents from the desired slot location and paste it into the primary linker script. Make sure that you perform a **clean** before recompiling. Without the **clean**, the toolchain will not recognize that the linker changed and not change the location for the application.

14.2 Convert User Application to BCH files manually

You can also convert User Application files to BCH files using **Flashloader_windows_utility.exe**. For step-by-step representation you can check Section 16.

14.3 Verify BCH image

Sometimes you may find that you want to verify the BCH image once it has been created. You can download Hexedit from http://www.hexedit.com/ and use the instructions below to install the BCH file format and view the files. Install HexEdit:

1. Copy and paste the BCH.xml file included with this project package to `C:\Users\<your user name>\AppData\Roaming\ECSoftware\HexEdit`
2. Open a BCH file from within HexEdit.
3. Select **Template > Design Mode**. This will turn off design mode.
4. Select **Template > Split Window**
5. In the dropdown, or from **Template > Open Other**, select **BCH**
6. The different data locations and header information can now be easily browsed by the developer as shown in the following figure.

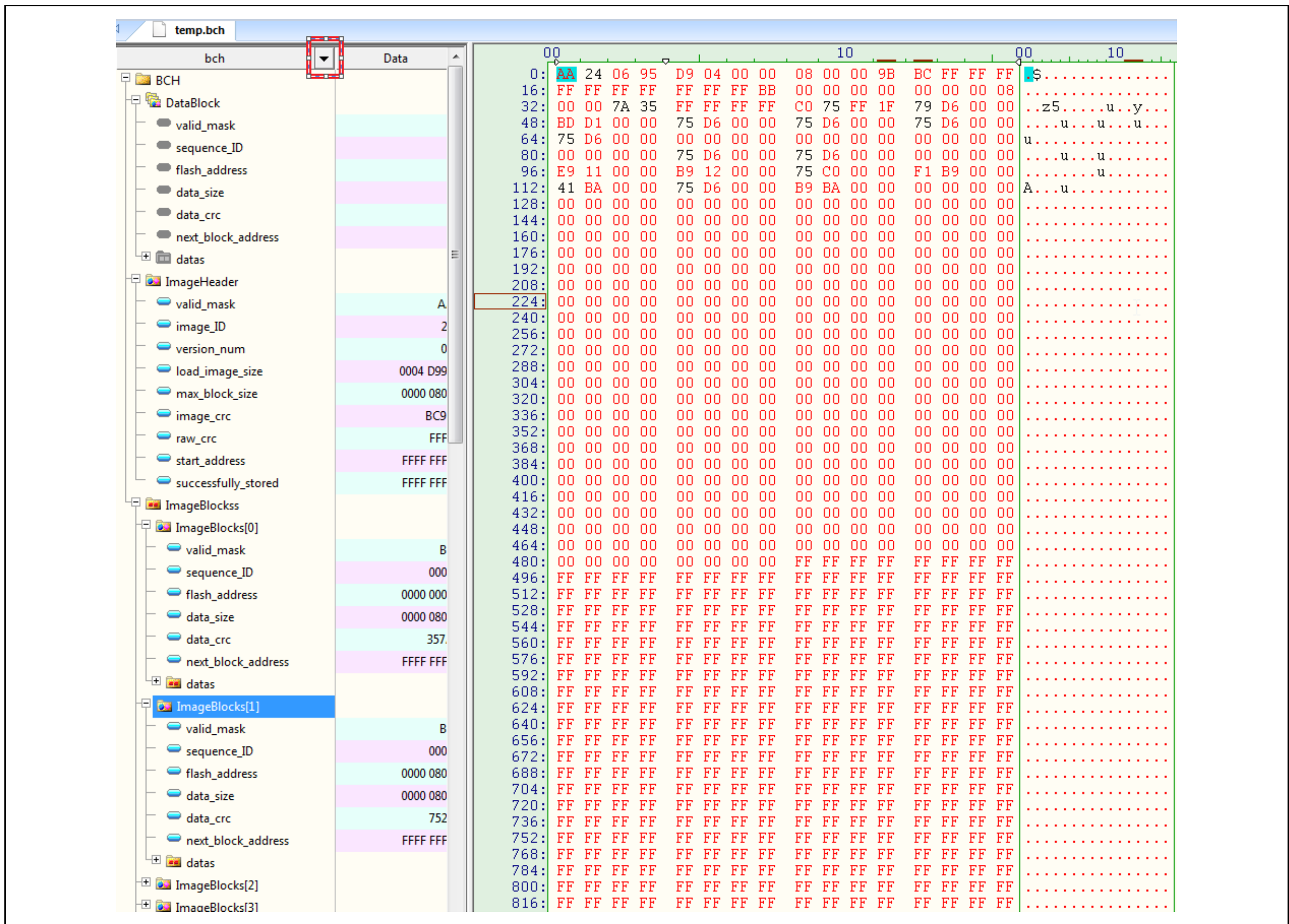


Figure 63 BCH File Review using HexEdit

15. Flashloader Utility Python Script

The flashloader utility python script can be used manually to communicate with the downloader application. Alternatively, you can use the flashloader utility GUI that will act as a front end for the Python script. This section explores the process and capability for using the script.

1. In the Project Explorer, navigate to the Debug directory, expand it, and locate the `r_fl_serial_flash_loader.py` script. Right click on the script and click on the command prompt. A new command prompt window should now open.
2. Just like with the S-Record to BCH converter script, you will want to know what commands are possible using the flashloader tool. Run the script with no options to see what options are available. The result is shown in in the following figure.

```
Usage: r_fl_serial_flash_loader.py [options]

FlashLoader Uploader - Upload new load image to MCU over Asynchronous Serial

Options:
  -h, --help            show this help message and exit
  -f FILE, --file=FILE  The path to the file you want to upload.
  -p Port#, --port=Port#
                        The port number to use for communications
  -c command, --command=command
                        The command you want to execute [info, load, erase]
  -q, --quiet           If specified, messages will be suppressed.
  -b BLOCK, --block=BLOCK
                        The load block you want to erase
```

Figure 64 Options available through the Flashloader Python script

3. The next step is to review these options and understand what exactly they mean.
   A. **–f** is used when loading a new program to specify the BCH file name. It is only used with the load command.
   B. **–p** specifies the communication port number that the device occupies. The value entered here is the communication port number minus one. For example, if the device is on COM23 then 22 will be entered.
   C. **–c** sends a command. The commands are info, erase and load. Before starting any update, the info command should be sent first to verify communication and the current system state.
   D. **–b** specifies the block memory location during an erase command. For a system with a single application slot, the value 0 is used. If switching between different application slots, use 0 for slot 1 and 1 for slot 2.
4. If the device enumerated on COM23, the following command would be used to get the system information:

```
python r_fl_serial_flash_loader.py –p 22
```

The result would be something like the following figure.

```
C:\Users\Jacob Beningo\e2_studio\workspace\2016_10_25_downloader\Debug>python r_fl_serial_flash_loader.py
 -p 22 -c info
Opened communications on COM23 at 115200 baud
-Sent Communication Initialization Messages
-Sent Information Request.  Waiting for response.
-->Repsonse Good - Now receive 52 bytes
-->Received Headers. Decoding and printing...
Current Running Image Info:
    Valid Mask              = 0xaf
    Version #               = 0x07
    Image ID                = 0x0001
    Number of blocks        = 0x00000063
    Size of BCH file        = 0x00018b3d
    Size of Slot            = 0x00300000
    Max Block Size          = 0x00000400
    BCH file CRC            = 0x0000e346
    Raw CRC (for entire slot) = 0x0000b06c
    Application start address = 0x00100000
    # of memory instances     = 0x00000000
    Pointer to instances      = 0x00000000
    1st Block Header Addr     = 0x00000200
    Successfully Stored?      = 0x00000001
    Checksum of this header   = 0x0000acd6

All load images have been downloaded.
DONE.
```

Figure 65 Result from issuing the info command

Note: The first time flash memory is programmed through the debug interface the bootloader and application records have not have been written to. The returned values may be all 0's.

5. Next, to load a new application, you will want to erase the application that is currently stored. This can be done by issuing the erase command using:

```
python r_fl_serial_flash_loader.py -p 22 -c erase -b 0
```

The expected output can be seen in the following figure.

Note: It may take a few minutes for the erase operation to complete. You might notice that your debugging session suddenly halts. This is normal. The application that was being debugged has just been erased from flash. After the erase process if the info command is issued again, the result will be all 0's, showing that there is no application image on the device.

```
C:\Users\Jacob Beningo\e2_studio\workspace\2016_10_25_downloader\Debug>python r_fl_serial_flash_loader.py
 -p 22 -c erase -b 0
Opened communications on COM23 at 115200 baud
-Sent Communication Initialization Messages
-Sent Erase Block Request.  Waiting for response.
-->Received ACK - Ready for block number to erase.
-Sent request to erase block 0x00
-->Received ACK - Erase Done.
DONE.
```

Figure 66 Result from issuing the erase command

6. Finally, you can issue the command to update the application code. In this example, the application name is going to be one of the BCH files that were created. For example:

```
python r_fl_serial_flash_loader.py -p 22 -c load -f Blink2.BCH
```

Once the command is issued, there is a data exchange between the host and the flashloader.

```
-Sending block with sequence ID 0x005a
-->Reply = Block transmitted fine, move to next
-Sending block with sequence ID 0x005b
-->Reply = Block transmitted fine, move to next
-Sending block with sequence ID 0x005c
-->Reply = Block transmitted fine, move to next
-Sending block with sequence ID 0x005d
-->Reply = Block transmitted fine, move to next
-Sending block with sequence ID 0x005e
-->Reply = Block transmitted fine, move to next
-Sending block with sequence ID 0x005f
-->Reply = Block transmitted fine, move to next
-Sending block with sequence ID 0x0060
-->Reply = Block transmitted fine, move to next
-Sending block with sequence ID 0x0061
-->Reply = Block transmitted fine, move to next
-Sending block with sequence ID 0x0062
-->Reply = Block transmitted fine, move to next
File transferred successfully!
DONE.
```

Figure 67 Result from issuing the load command

7. Wait patiently. Once the image has been downloaded, the system restarts and enters the bootloader. The bootloader verifies the image and writes it to flash. It may take a few minutes to write to the internal flash. Earlier it was mentioned that it can be helpful to have the bootloader code blink some LEDs and provide status information. As you wait patiently this information helps to let you know that the update is progressing smoothly and has not halted or crashed.

8. Eventually, you hear the USB device enumerate and see the LED blink pattern change. The new application has been loaded successfully and the info command can be issued to check the firmware version.

16. Flashloader Utility GUI

The easiest way to convert an s-record into a BCH file and then transfer it to the flashloader is through the Flashloader Utility. The Flashloader Utility is a GUI written in C# that is designed to make configuring the Python scripts easier through a user interface rather than a command line.

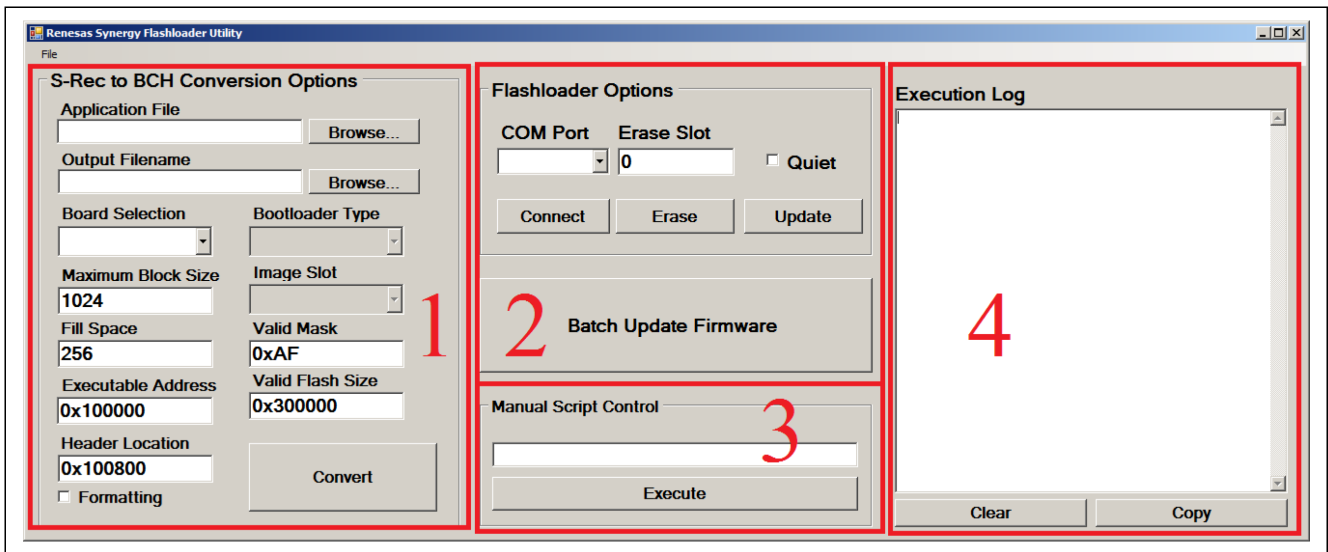


Figure 68 Flashloader Utility

The Flashloader Utility is broken up into four primary sections:

1. Section 1 is used to convert your application files to BCH files. It contains all the parameters necessary to load an s-record, specify the BCH and configure the BCH file parameters such as block size and flash size. Once these parameters have all been configured, the **Convert** button will generate the BCH file.
2. Section 2 contains the interface for loading the new BCH file onto the target device. If a conversion from s-record to BCH was not necessary, you could use the **Browse…** button next to the **Output Filename** to select the desired BCH file to load. Section 2 allows you to select the communication port, which memory slot you want to erase, and also step through the update process.

   The typical update process will require connecting to the target, erasing the previous application, and then updating it with the new application code. To streamline this process, there is also a batch update that runs through the process to connect, erase, and update with a single button press.
3. Section 3 will be rarely used. This section allows you to execute the Python scripts directly through the textbox. Custom parameters can be executed along with additional fine-tuning. The Flashloader Utility does expose all features within the Python scripts.
4. Section 4 provides you with a real-time log. When connecting to a device, you will see that the connection is taking place and also what the device is reporting. The log can be copied and saved to a file for later analysis or cleared if there are too many messages.

Before the Flashloader Utility can be run for the first time, you need to tell the utility where the Python 2.7 executable resides. This can be done by selecting **File > Options**. The dialog box from the following figure is displayed. Simply browse to find the correct location and then select **Ok**.

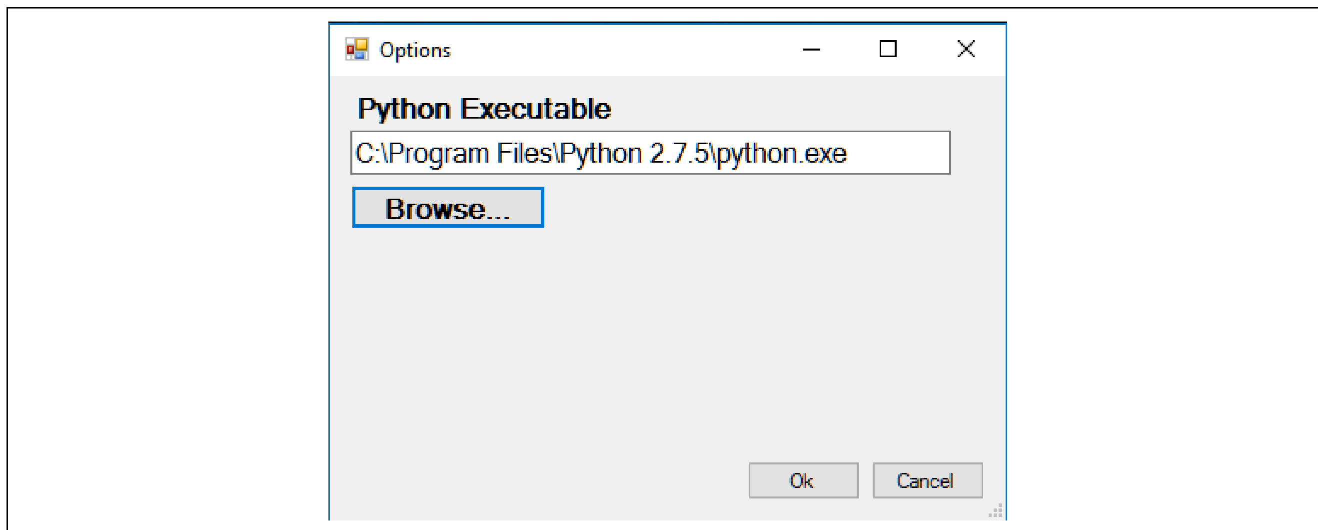


Figure 69 Python Executable Settings

There are two important aspects to using the GUI Utility with a blocking flashloader that you need to be aware of. First, Section 1 needs to be modified depending on whether the application was compiled to run in slot 0 or slot 1 application locations. There are three different parameters that need to be adjusted:

- The executable address should match the starting location for slot 0 or slot 1 depending on your choice.
- The header location will be different for slot 1 and slot 2. You need to scale the location based on the executable address.
- Valid flash size is half the fully available flash. The reason is that with two application slots, the memory needs to be cut in half. This value stays the same though whether slot 0 or slot 1 is used.

This can sound a bit confusing so let's look at an example that uses the S7G2 that is included on the SK-S7G2 or DK-S7G2 boards. Let's say that there are two application versions: one that runs in slot 0 and one that runs in slot 1. The first application will runs from slot 0 where memory starts at 0x100000. The second application runs from slot 1 and starts at 0x280000. The first application s-record would be converted to a file using the settings shown in the following figure.

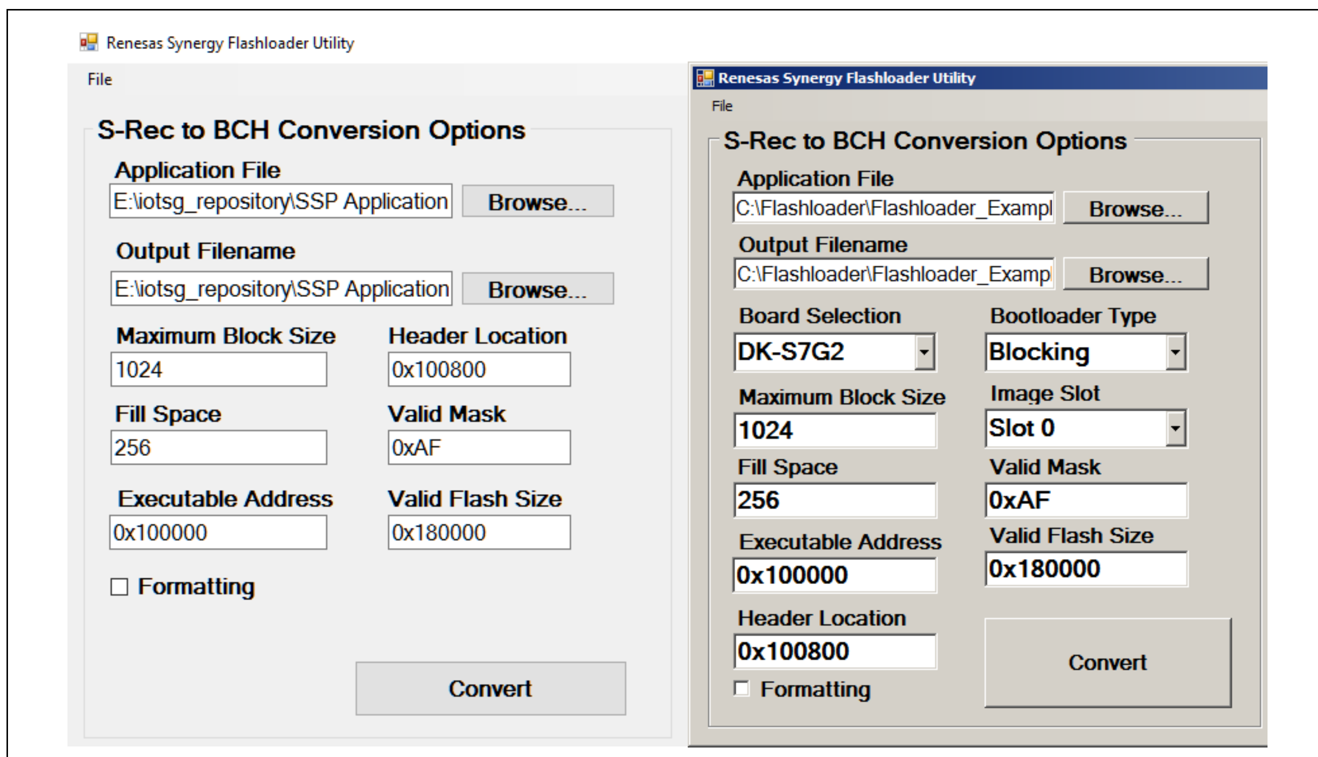


Figure 70 Application Slot 0 S-Record to BCH Conversion Settings

The application that runs in the Slot 1 location needs to be offset from the Slot 0 location (with settings that match the linker file for Slot 1). In this case, Slot 1 memory starts at 0x180000 so the executable address and header location are offset to match that value as shown in shown in the following figure.

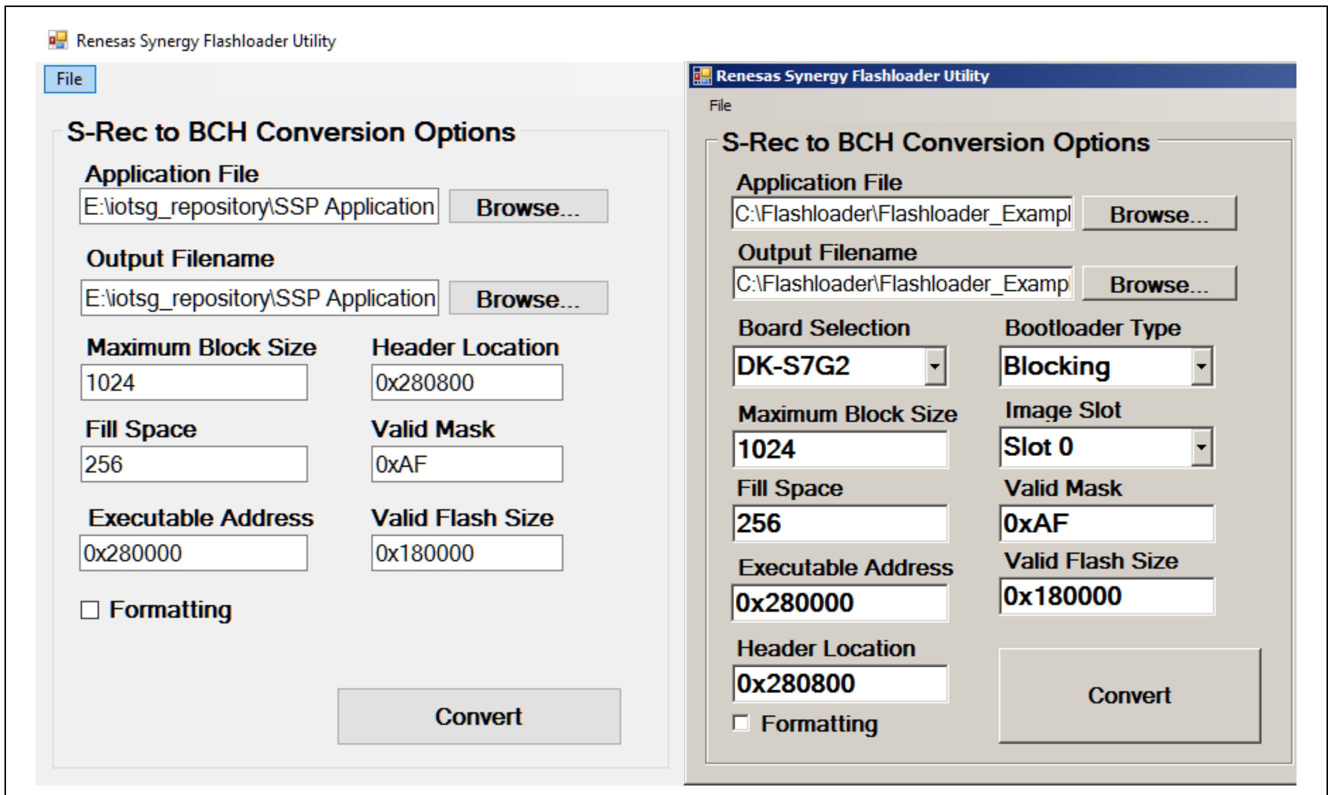


Figure 71 Application Slot 1 S-Record to BCH Conversion Settings

Second, you will want to make sure that you erase the block associated with the slot location you are planning to store a new image in. Attempting to erase a slot that is currently executing code will give an error stating that the block could not be erased. Loading new applications on a blocking implementation will require loading code into Slot 0 on the first update, Slot 1 on the second update and then Slot 0 again for the third and so on.

17. Going Further

Different applications are going to require different robustness and error handling methods. There are many ways that the flashloader solution can be augmented and adapted for an application. Here are a few ideas about how you might take this application project and build on it.

- Integrate the BCH conversion script into the build process so that the BCH file is automatically created at build time.
- Automate the serial flashloader script to perform the update process in sequence on its own without human interaction.
- Identify potential high-level errors for the bootloader and downloader and develop a procedure to recover the bootloader if something goes wrong.
- Use the errors that were identified to create error codes that can be blinked or communicated in some form so that the system doesn't fail silently.
- Optimize the flash space used by the bootloader. In this application project, we selected the bootloader size to be 0x100000 bytes for convenience. The actual bootloader is much smaller than this. To maximize the space available for your applications the bootloader space should be minimized.
- Port the bootloader from the development kit to target hardware. You can use the Custom BSP Creator tool to create a custom board that sets the correct pin-outs, clocks and initialization code. The bootloader project can then be modified to use the new BSP.
- Add code to the bootloader the blinks of a different LED pattern or flashes a LED at a different blink rate to indicate to you that the bootloader is running and busy.

18. Troubleshooting

Setting up a flashloader is not a trivial endeavor. Slight differences in the way a development kit is setup or even the host machine can be the difference between successfully running the demonstration application or not. This section contains advice for how to troubleshoot your setup if you encounter issues running the flashloader application.

My downloader project runs for approximately 10 seconds and then hits a breakpoint with a SSP_INTERNAL_ERR.

There are many reasons that the application could time out. Check the following:

- Verify that an SD card is inserted in the development kit if using a non-blocking bootloader.
- Verify that the SD card dip switches are set on the development kit if using a non-blocking bootloader.
- If using USB CDC, make sure that the Synergy driver is being used. It is included in the application example package.

My blocking bootloader application image does not appear to take. The flashloader goes through the process but I don’t see a change.

There are two items to check if the application appears to not take:

- Verify that the new application image version number, located in the Synergy Configuration in the **Firmware Image Internal Framework** on **sf_firmware_internal** module is larger than the current image version. The framework will install new images and performs an image version check.
- The application image slot location may not be correct. Verify that the image was compiled for the correct slot location in memory.

When converting my s-record, I receive a message stating that the header location is not correct.

The main reason for this error is that the linker file header location is not matching BCH converter utility location. The following steps can be followed to resolve the issue:

- Review the linker file and verify the location for the header image. The header image is typically located 0x800 after the applications starting location. For example, if the starting memory location is 0x100000, then the image header will be located at 0x100800. If the application starts at 0x280000, then the header will be located at 0x280800.

Appendix A Configuring the DK-S7G2 Development Kit for USB CDC

Renesas has made it very easy to get up and running with the DK-S7G2 development kit. This section outlines the board setup.

1. If you will be running the non-blocking flashloader example, make sure that an SD card has been inserted into the SD Card slot. Failure to insert a card will result in an SSP_ERROR_INTERNAL message when running the downloader application. The SD card can be seen properly inserted in Figure 72. Note that the blocking flashloader example does not require external memory storage since the new image is stored internally on the MCU flash.

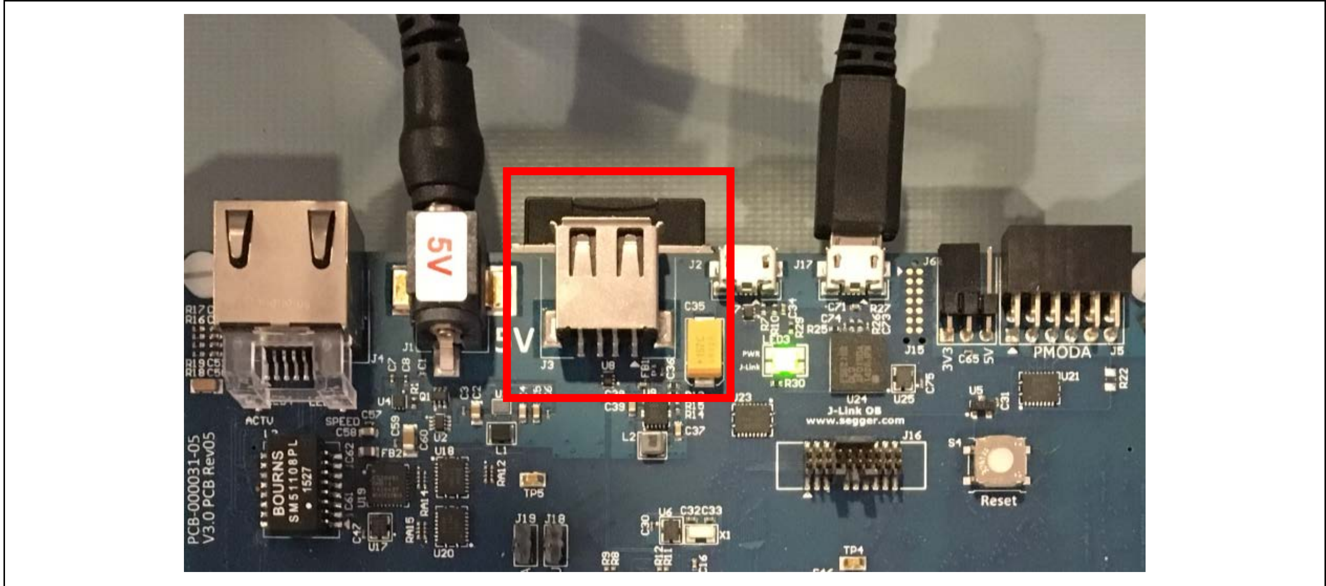


Figure 72 SD Card Insertion

Review the jumpers on S5. Make sure the following switches are in the on position:

- JTAG Enable (JTAG)
- PBs
- DRAM

See Figure 73 for other switch positions.

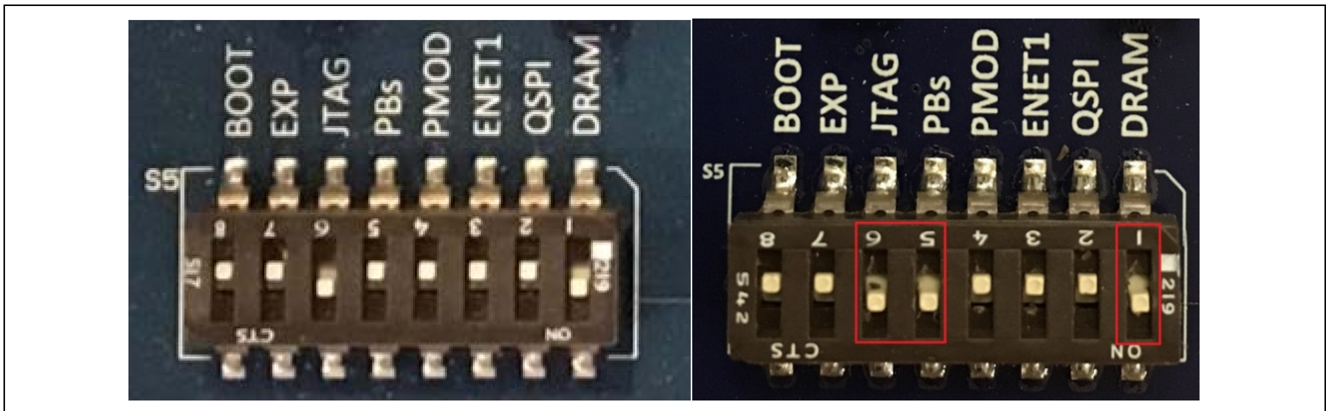


Figure 73 S5 Switch Positions

2. Review the jumpers on S101. Make sure that only the following switches are in the on position:

- SD
- RS

See Figure 74 for other switch positions.

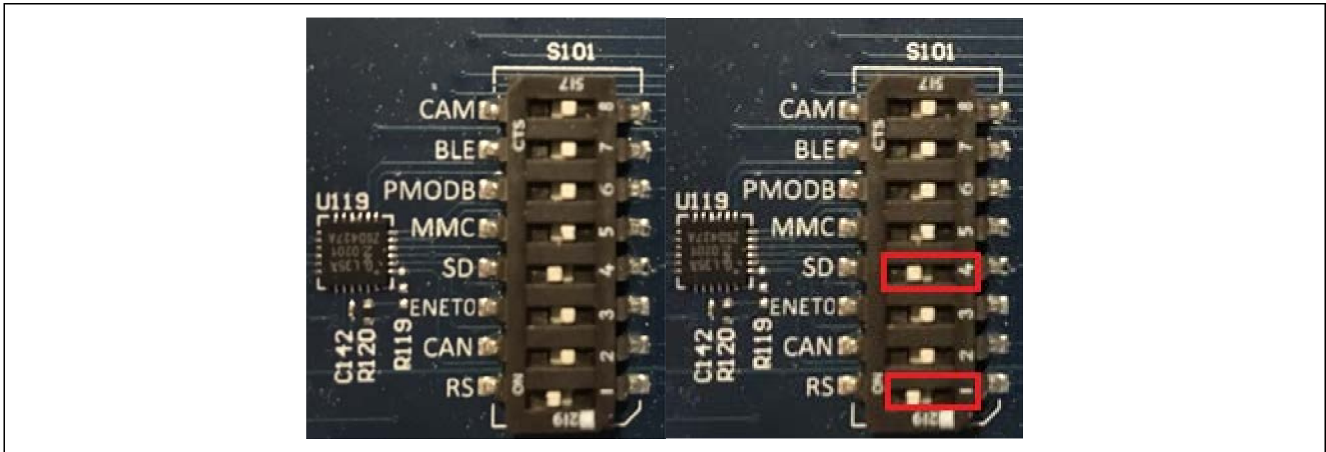


Figure 74 S101 Switch Positions

Appendix B Configuring the DK-S7G2 Development Kit for UART

Renesas has made it very easy to get up and running with the DK-S7G2 development kit. This section outlines the board setup.

1. If you will be running the non-blocking flashloader example, make sure that an SD card has been inserted into the SD Card slot.

Note: Failure to insert a card results in an SSP_ERROR_INTERNAL message when you run the downloader application. The SD card can be seen properly inserted in Figure 75. Note that the blocking flashloader example does not require external memory storage since the new image is stored internally on the MCU flash.

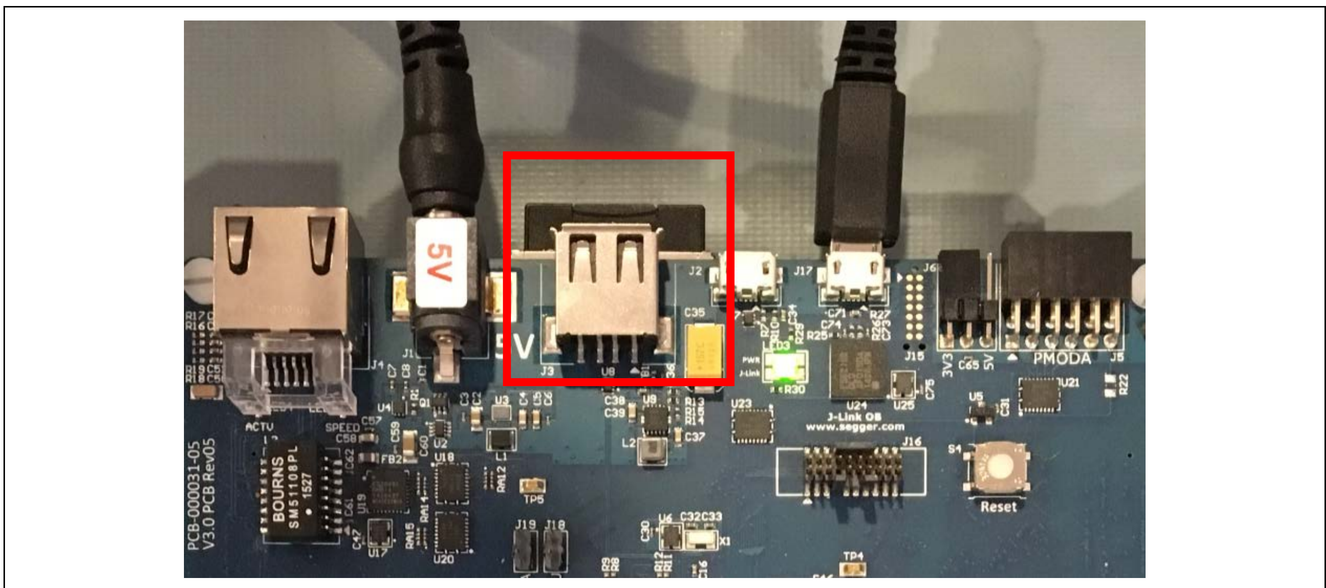


Figure 75 SD Card Insertion

2. Review the jumpers included in S5. Make sure the following switches are in the on position:

- JTAG Enable (JTAG)
- DRAM
- PBs

See Figure 76 for other S5 switch position settings.

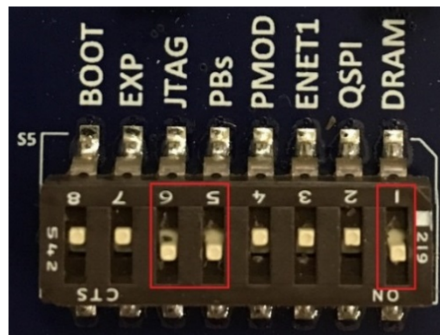


Figure 76 S5 Switch Positions

3. Review the jumpers included on S101. Make sure the following switches are in the on position:
   - SD
   - RS

See Figure 77 for other S101 switch position settings.

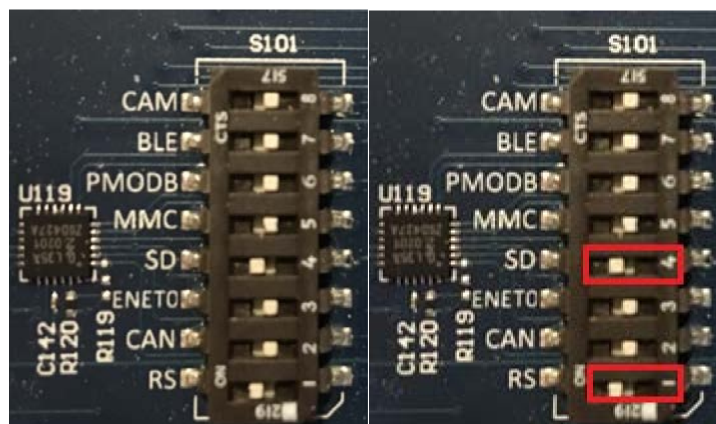


Figure 77 S101 Switch Positions

4. Review the jumpers to include on S102. Make sure the following switches are in the on position:

- 232

See Figure 78 for other S102 switch position settings.

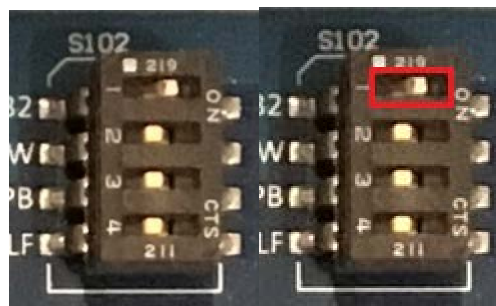


Figure 78 S102 Positions

5. Connect a Serial-to-USB converter to connector J112.
   The J112 following pin-outs are used:

   A. A is the microcontrollers receive pin
   B. Y is the microcontrollers transmit pin
   C. Make sure a ground is also included

Connection can also be established using the J10 connector.

A. 11 is the microcontrollers receive pin

B. 12 is the microcontrollers transmit pin.

C. Connect to any Ground pin on the board

The full setup can be found in Figure 79.

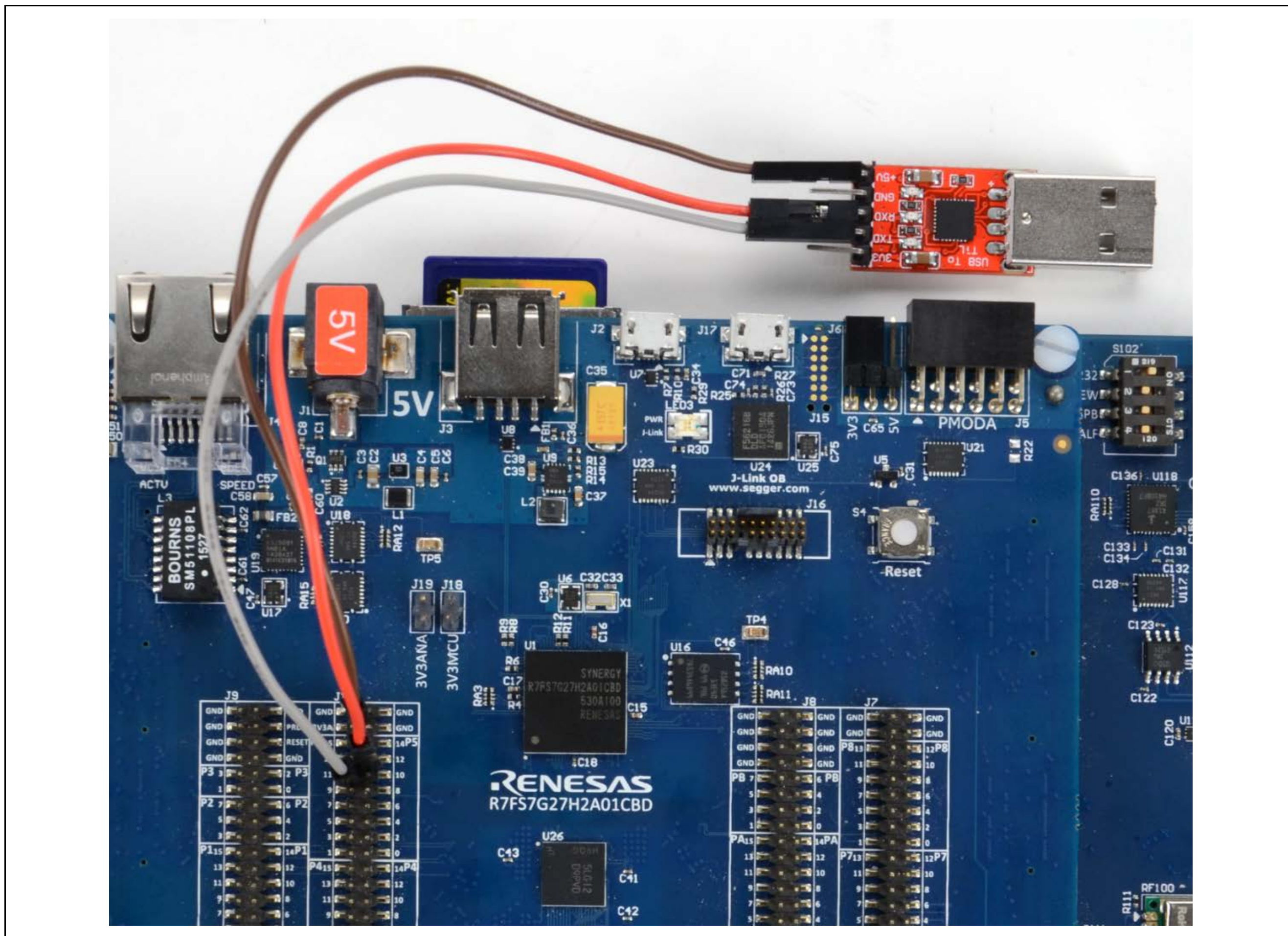


Figure 79 Serial to USB Converter Setup

The development kit and the project pins should now be configured properly to run the flashloader solution. If you haven't already done so, make sure that you perform a save and a build all.

Appendix C Configuring the SK-S7G2 Development Kit for USB CDC

Renesas has made it very easy to get up and running with the SK-S7G2 development kit. This section outlines the board setup. Note that the SK-S7G2 does not include a SD card slot. For this reason, only the blocking flashloader example setup is shown.

1. Connect a USB mini cable to the DEBUG_USB connector J19. This connector powers the development kit — no external power is required.
2. Connect a USB mini cable to connector J5. This connector is the microcontroller USB device port. The final setup can be seen in Figure 80.

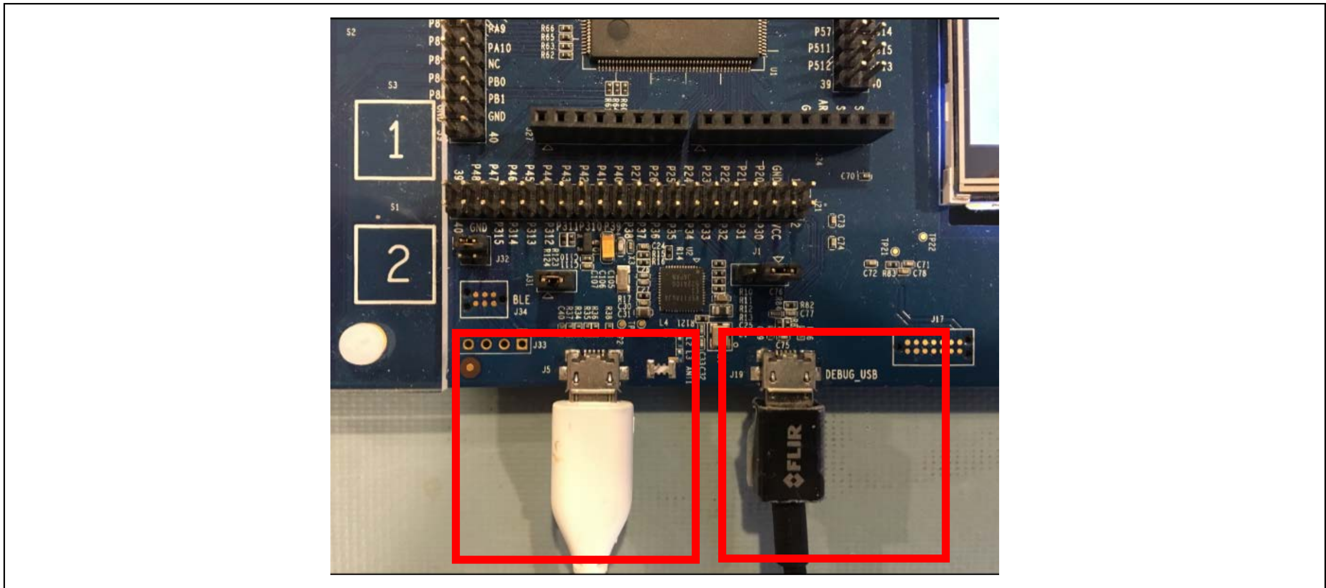


Figure 80 USB Connection Setup

The development kit and the project pins should now be configured properly to run the flashloader solution. If you have not already done so, make sure that you perform a save and a build all.

Appendix D Configuring the SK-S7G2 Development Kit for UART

Renesas has made it very easy to get up and running with the SK-S7G2 development kit. This section outlines the board setup. Note that the SK-S7G2 does not have a SD card holder and only the blocking flashloader application can be used on the board.

1. Connect a Serial to USB adapter to SCI-2 on J22.
   A. P512 (MCU TXD) connects to the converter RX
   B. P511 (MCU RXD) connects to the converter TX
   C. Make sure to connect a ground for the converter (pin 3 on J22 is a good example).

Figure 81 shows the complete setup.

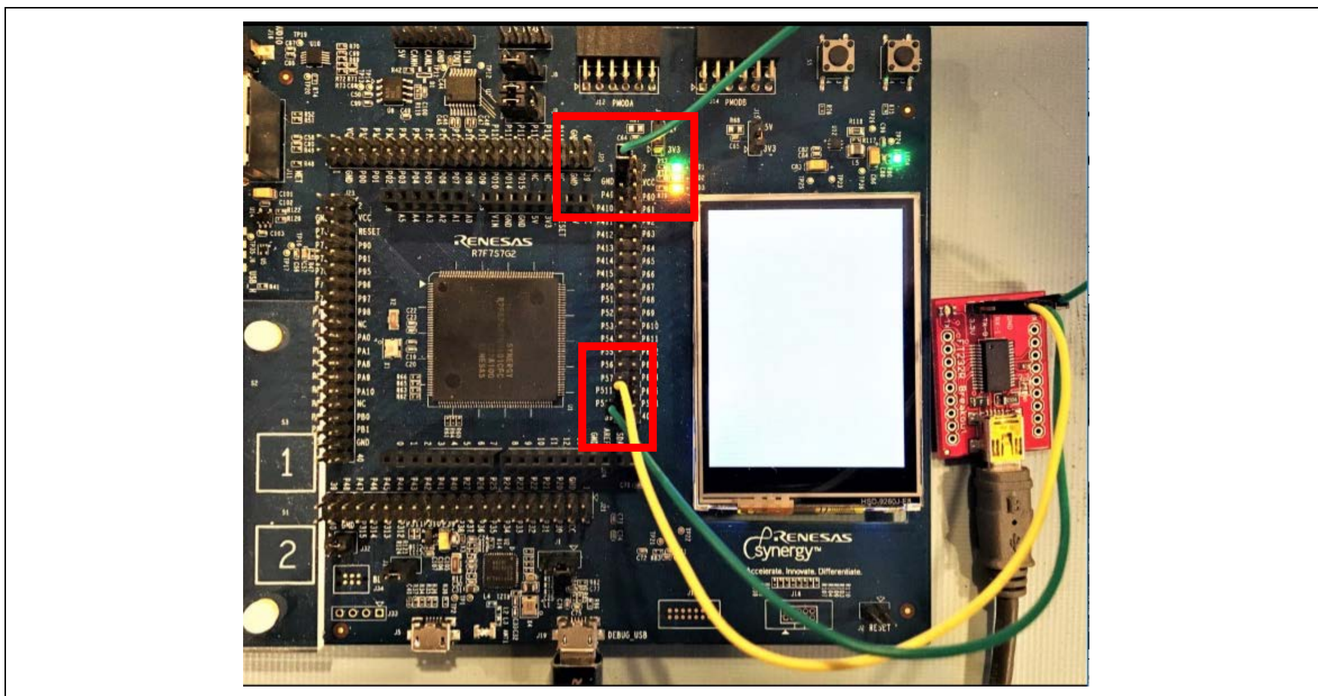


Figure 81 Serial to USB Converter Setup

The development kit and the project pins should now be configured properly to run the flashloader solution. If you have not already done so, make sure that you perform a save and a build all.

Appendix E Configuring the PK-S5D9 Development Kit for USB CDC

Renesas has made it very easy to get up and running with the PK-S5D9 development kit. This section outlines the board setup. Note that the PK-S5D9 does not include a SD card slot. For this reason, only the blocking flashloader example setup is shown.

1. Connect a USB mini cable to the DEBUG_USB connector J19. This connector powers the development kit — no external power is required.
2. Connect a USB mini cable to connector J5. This connector is the microcontroller USB device port. The final setup can be seen in Figure 82.

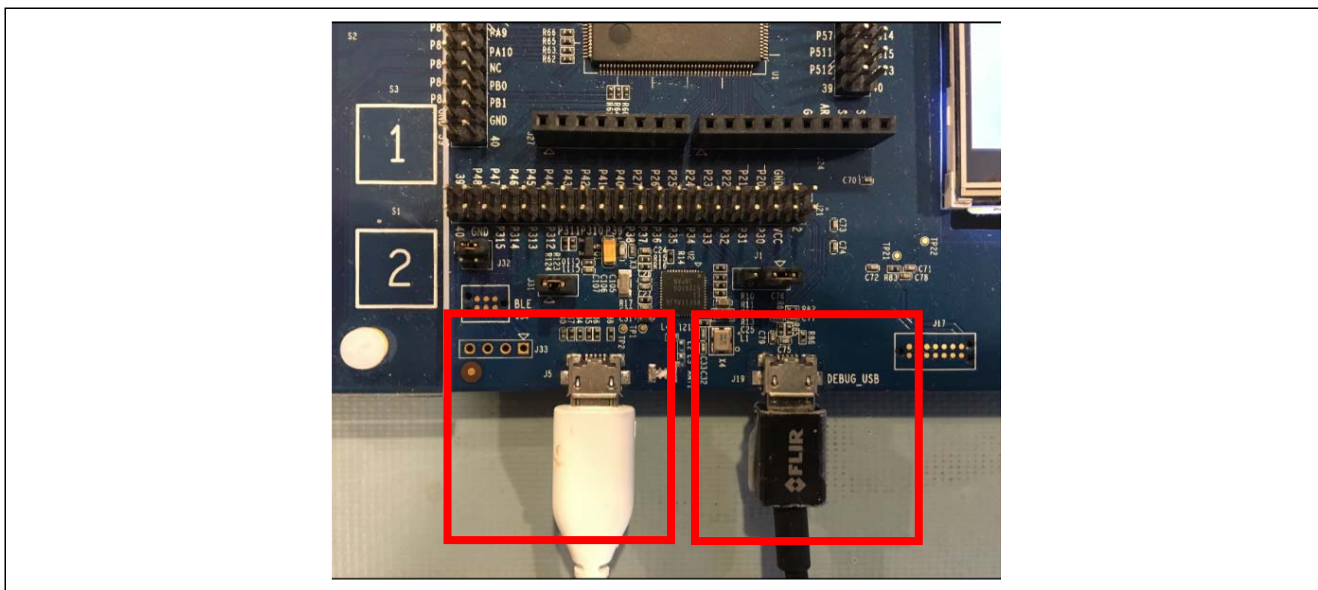


Figure 82 USB Connection Setup

The development kit and the project pins should now be configured properly to run the flashloader solution. If you haven't already done so, make sure that you perform a save and a build all.

Appendix F Configuring the PK-S5D9 Development Kit for UART

Renesas has made it very easy to get up and running with the PK-S5D9 development kit. This section outlines the board setup. Note that the PK-S5D9 does not have a SD card holder and only the blocking flashloader application can be used on the board.

1. Connect a Serial to USB adapter to SCI-2 on J21.
   A. P31 (MCU RXD) connects to the converter TX
   B. P32 (MCU TXD) connects to the converter RX
   C. Make sure to connect a ground for the converter (Pin 3 on J21 is a good example).

Figure 83 shows the complete setup.

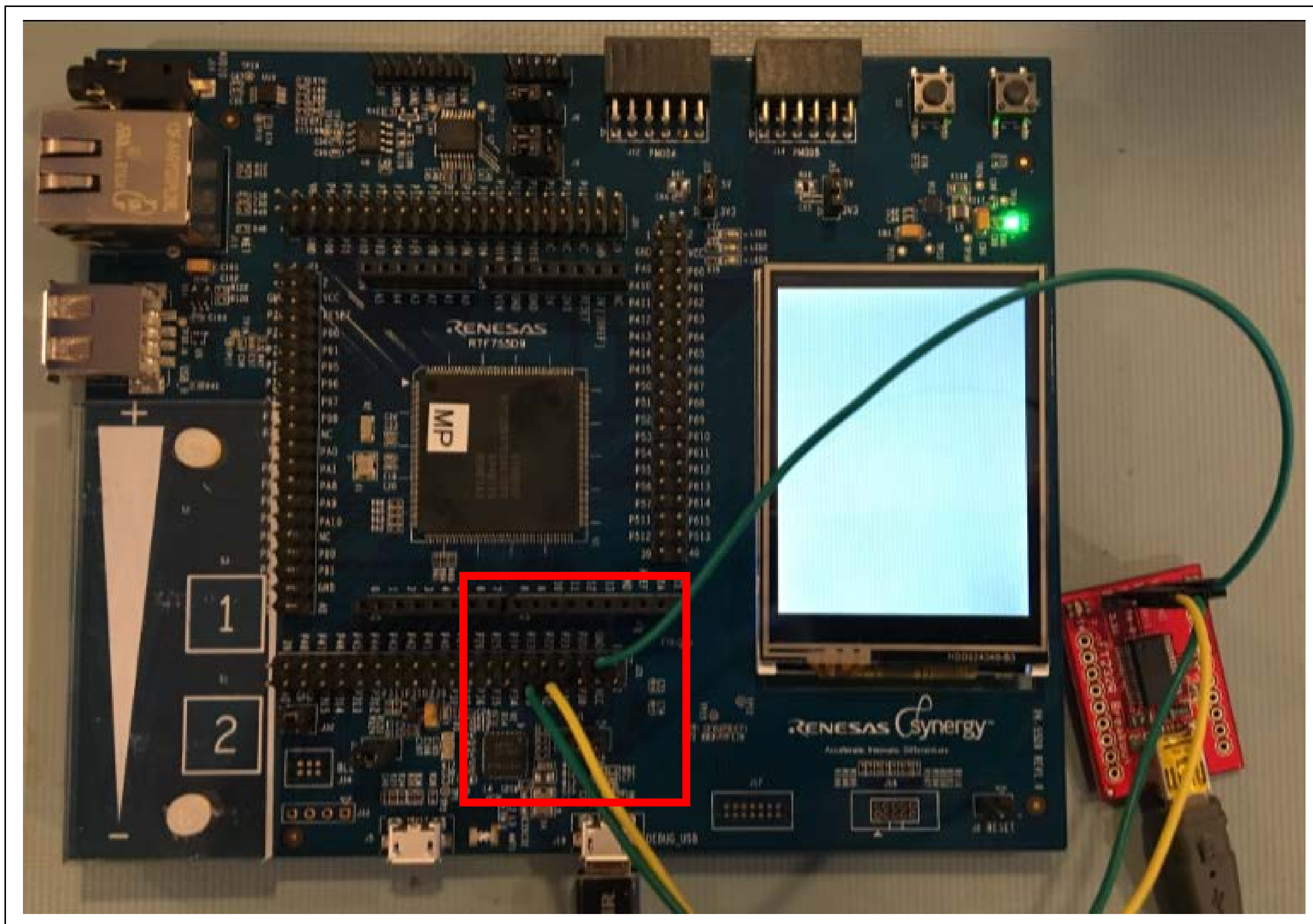


Figure 83 Serial to USB Converter Setup

The development kit and the project pins should now be configured properly to run the flashloader solution. If you have not already done so, make sure you perform a save and a build all.

Appendix G Installing USB CDC drivers in Windows 7/8 and Windows 10

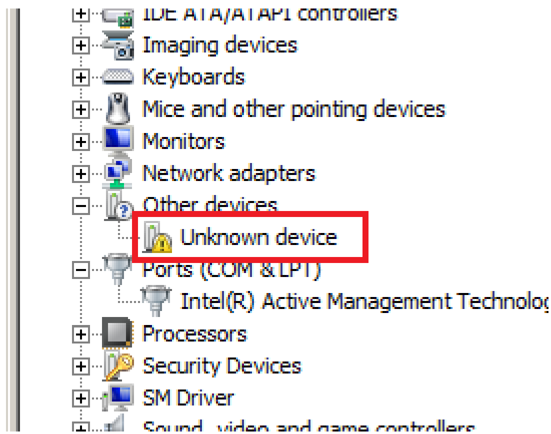
The Flashloader examples that use the USB interface use the USB CDC device class to communicate with the host.

With Windows 10 there is no need for a special driver as this version of Windows automatically installs its own internal USB CDC driver.

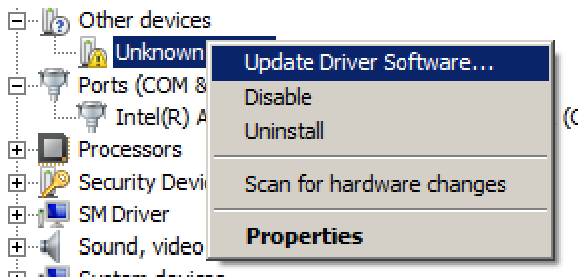
When your host is Windows 7 or Windows 8 you need to install a driver so that the board can communicate with the Python scripts running in Windows.

The flashloader download package includes these drivers in the folder
`Flashloader_Windows_Utility\Windows USB serial driver`

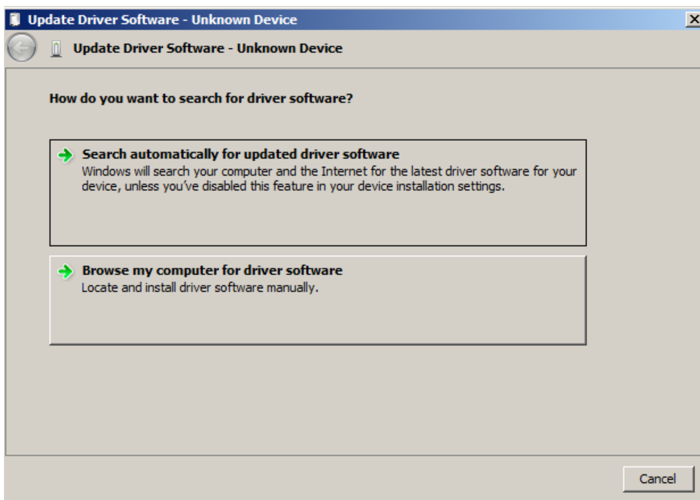
1. Connect the board running one of the USB examples to a Windows system using a USB cable
2. The USB device shows up in the Windows device manager as an 'Unknown device'.



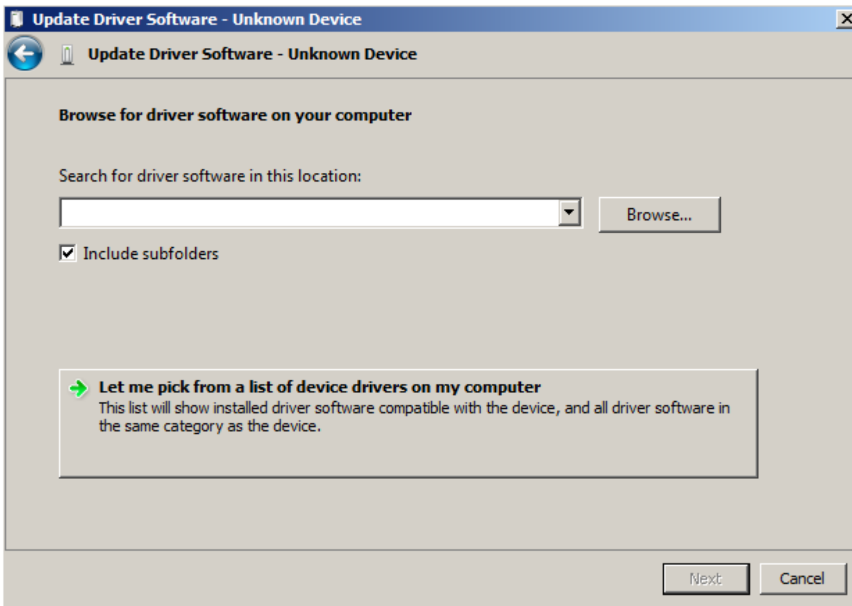
3. To install the drivers in Windows, right click on this device and select **Update Driver Software…**



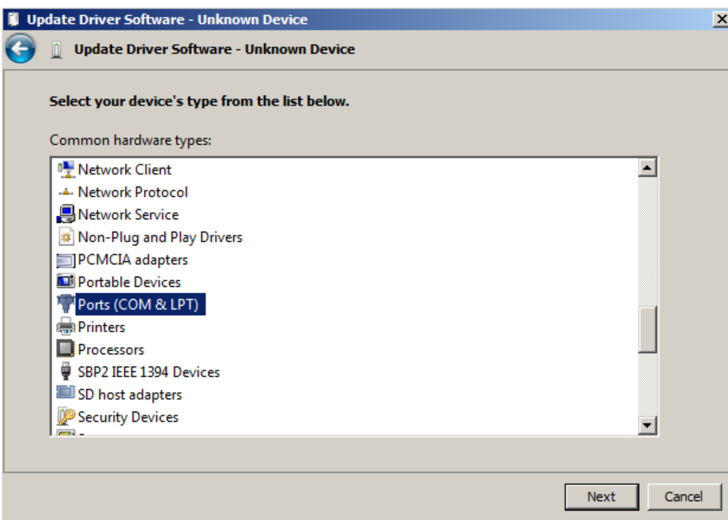
4. Select **Browse my computer for driver software**.



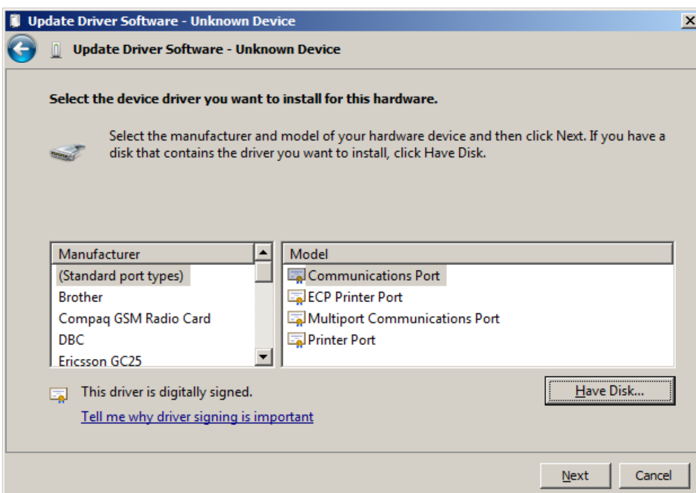
5. Select **Let me pick from a list of device drivers on my computer**.



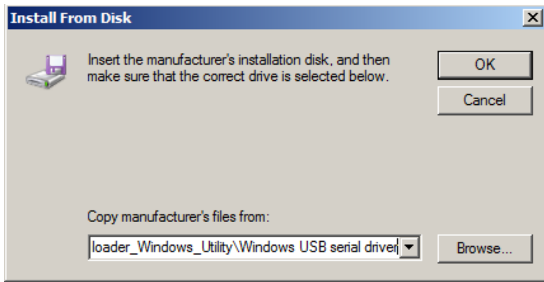
6. Select **Ports (COM & LPT)**.



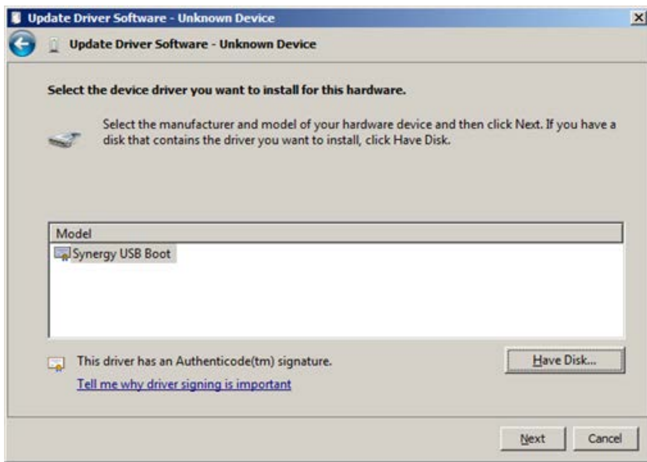
7. Click on **Have Disk…**.



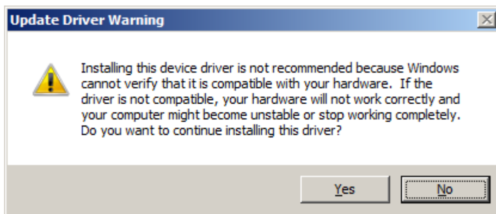
8. Browse to the folder the folder holding the Windows driver and click **OK**.



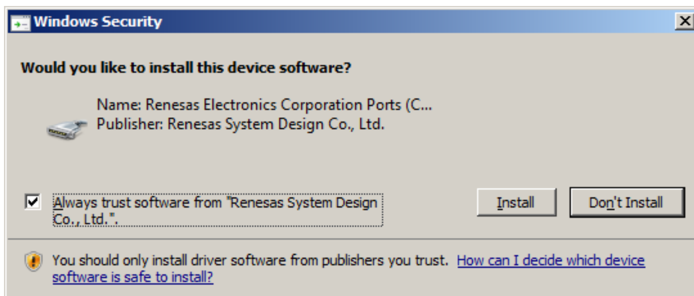
9. You should see the following dialog box. Click **Next**



10. If you see the following message, click **Yes**.



11. Check the option box and click **Install**.



The driver is now installed.

Website and Support

Visit the following vanity URLs to learn about key elements of the Synergy Platform, download components and related documentation, and get support.

Synergy Software www.renesas.com/synergy/software
- Synergy Software Package www.renesas.com/synergy/ssp
- Software add-ons www.renesas.com/synergy/addons
- Software glossary www.renesas.com/synergy/softwareglossary
- Development tools www.renesas.com/synergy/tools

Synergy Hardware www.renesas.com/synergy/hardware
- Microcontrollers www.renesas.com/synergy/mcus
- MCU glossary www.renesas.com/synergy/mcuglossary
- Parametric search www.renesas.com/synergy/parametric
- Kits www.renesas.com/synergy/kits

Synergy Solutions Gallery www.renesas.com/synergy/solutionsgallery
- Partner projects www.renesas.com/synergy/partnerprojects
- Application projects www.renesas.com/synergy/applicationprojects

Self-service support resources:
- Documentation www.renesas.com/synergy/docs
- Knowledgebase www.renesas.com/synergy/knowledgebase
- Forums www.renesas.com/synergy/forum
- Training www.renesas.com/synergy/training
- Videos www.renesas.com/synergy/videos
- Chat and web ticket www.renesas.com/synergy/resourcelibrary

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	May 9, 2017	—	Initial version
1.10	Nov 17, 2017	—	Fixed the package installer, added support for SSP v1.3.0, updated the Windows utility, and made minor changes throughout.
1.11	Apr 19, 2018	1, 5	Corrected Flashloader_pack_1.3.0.exe filename.
1.12	Dec 28, 2018	1	Installed Software updated.

All trademarks and registered trademarks are the property of their respective owners.

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
5. Renesas Electronics products are classified according to the following two quality grades: “Standard” and “High Quality”. The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.
   "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.
   "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.
   Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.
6. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, “General Notes for Handling and Using Semiconductor Devices” in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
7. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
9. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
10. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
11. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note 1) “Renesas Electronics” as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.

(Note 2) “Renesas Electronics product(s)” means any product developed or manufactured by or for Renesas Electronics.

(Rev.4.0-1 November 2017)

SALES OFFICES Renesas Electronics Corporation http://www.renesas.com

Refer to "http://www.renesas.com/" for the latest and detailed information.

Renesas Electronics Corporation
TOYOSU FORESIA, 3-2-24 Toyosu, Koto-ku, Tokyo 135-0061, Japan

Renesas Electronics America Inc.
1001 Murphy Ranch Road, Milpitas, CA 95035, U.S.A.
Tel: +1-408-432-8888, Fax: +1-408-434-5351

Renesas Electronics Canada Limited
9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3
Tel: +1-905-237-2004

Renesas Electronics Europe Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-651-700

Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.
Room 1709 Quantum Plaza, No.27 ZhichunLu, Haidian District, Beijing, 100191 P. R. China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, 200333 P. R. China
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

Renesas Electronics Hong Kong Limited
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2265-6688, Fax: +852 2886-9022

Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

Renesas Electronics Singapore Pte. Ltd.
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

Renesas Electronics Malaysia Sdn.Bhd.
Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

Renesas Electronics India Pvt. Ltd.
No.777C, 100 Feet Road, HAL 2nd Stage, Indiranagar, Bangalore 560 038, India
Tel: +91-80-67208700, Fax: +91-80-67208777

Renesas Electronics Korea Co., Ltd.
17F, KAMCO Yangjae Tower, 262, Gangnam-daero, Gangnam-gu, Seoul, 06265 Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5338

© 2018 Renesas Electronics Corporation. All rights reserved.