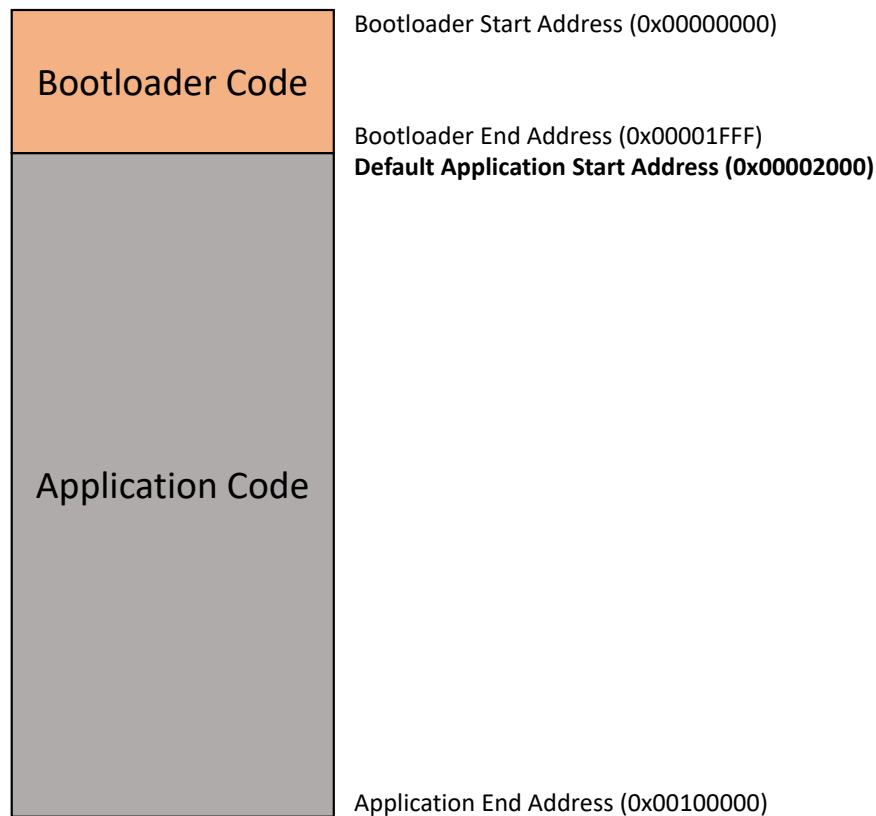

How to Move an Application into a Desired Flash Memory Location with the Help of Linker Script on SAM E54

Introduction

An application can be placed into a desired Flash memory location of a SAM E54 microcontroller (MCU) with the Harmony v3 bootloaders. The desired Flash memory location address must be within the start and end addresses of the dedicated application code location in the Flash memory, as shown in the following SAM E54 memory layout. For example, the bootloader code is placed at the start of the Flash, and the application code can be placed anywhere after the bootloader end address. The application start address must be aligned to sector (or page) size.

Figure 1. Basic Bootloader - Memory Layout



Note: The bootloader section's start and end address and the application code section will vary for different devices. Refer to the respective device data sheet for details of the Flash memory layout.

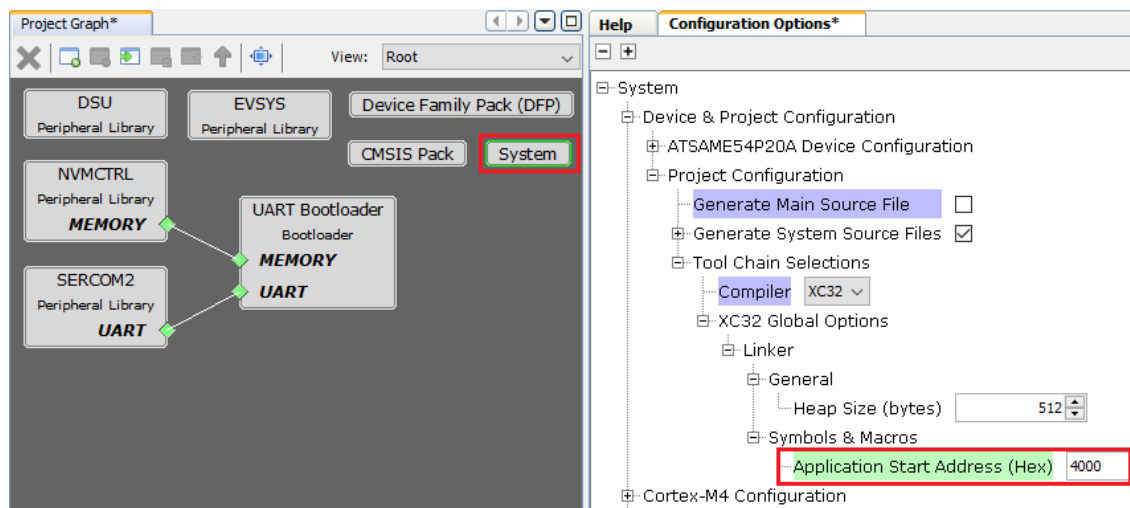
1. Configure the Desired Application Start Address in the Bootloader Project

The bootloader must know the Flash memory address where the bootloader will program the application. This value will be used by the bootloader to jump to the application at device reset. The default application start address is 0x2000. The MPLAB Harmony v3 bootloader requires the application start address to be mentioned at compile time. The application start address mentioned in the bootloader configuration must match the application start address mentioned in the application's configuration.

As an example, the following steps are used to set 0x4000 as the desired address in the Flash memory where an application must be placed.

1. Connect the Debug USB port on the SAM E54 Xplained Pro board to the computer using a micro-USB cable.
2. Download the [MPLAB Harmony v3 Bootloader UART Examples Repository](#) and open the UART Basic bootloader project from the path: <MPLAB Harmony v3 Bootloader UART Examples Repository>/apps/uart_bootloader/bootloader/firmware/sam_e54_xpro.X using MPLAB® X IDE.
3. Launch MHC and configure the required start address of the application.

Figure 1-1. UART Basic Bootloader Project - Set Desired Flash Memory Address for the Application



4. Save and regenerate the project.
5. Build and program the UART bootloader using MPLAB X IDE.

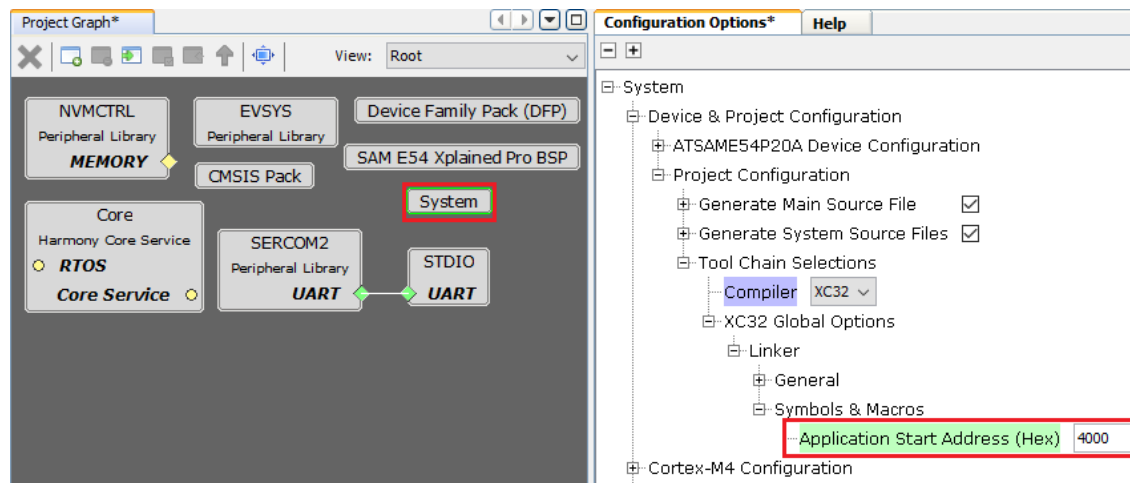
2. Configure the Desired Application Start Address in the Application Project

The desired application start address is the address where the application runs. This value must be equal to or greater than the bootloader size as this value will be used by the bootloader to jump to the application at device reset, it must match with the value provided to the bootloader during configuration.

To configure the desired start address in an application, use the following steps, which use the MPLAB Harmony v3 bootloader test application as an example.

1. Open the UART Basic Bootloader test application project (<MPLAB Harmony v3 Bootloader UART Examples Repository>/apps/uart_bootloader/test_app/firmware/sam_e54_xpro.X) using the MPLAB X IDE.
2. Launch the MHC and configure the required start address of the application to 0x4000.

Figure 2-1. UART Basic Bootloader Test Application Project - Application Code Start Address

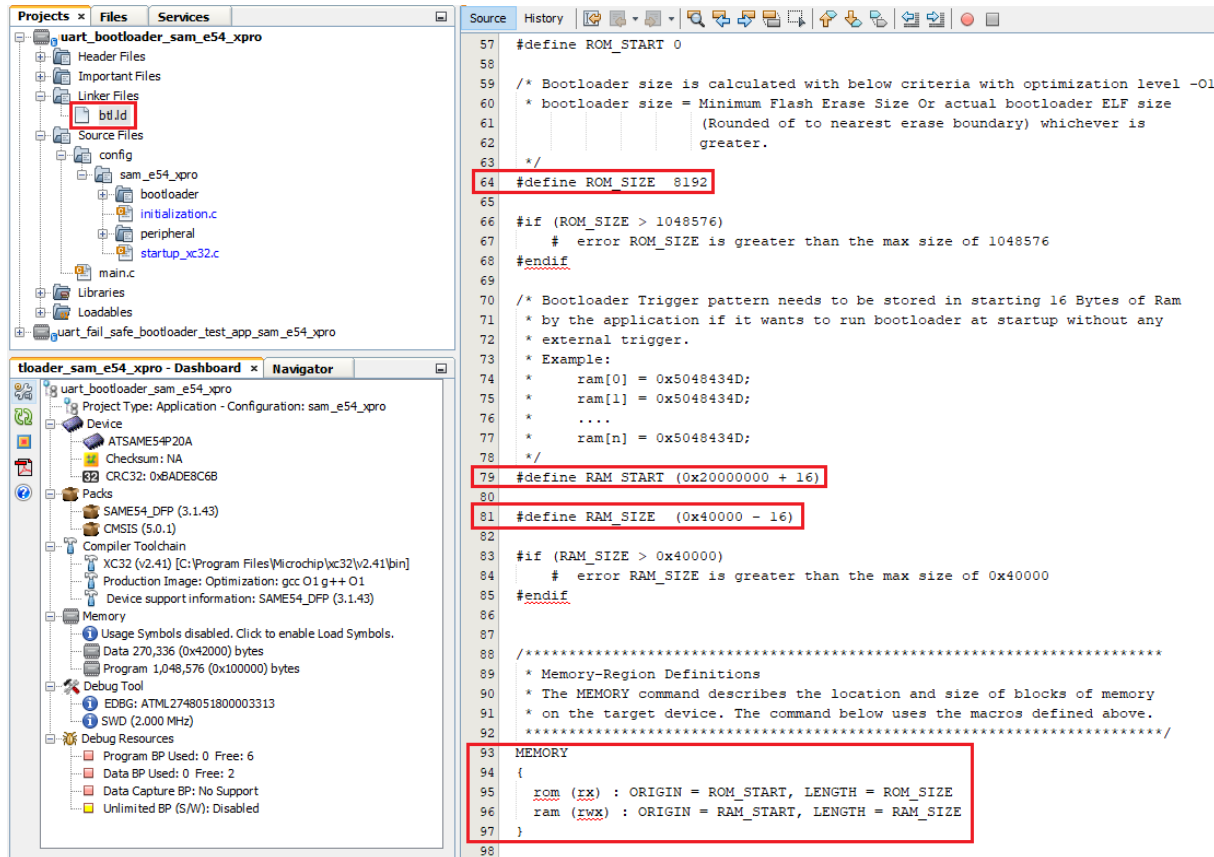


3. Save and Regenerate the project.
4. Build the UART bootloader test application project to generate the binary (Do not program the binary).

3. Linker Settings in MPLABX IDE

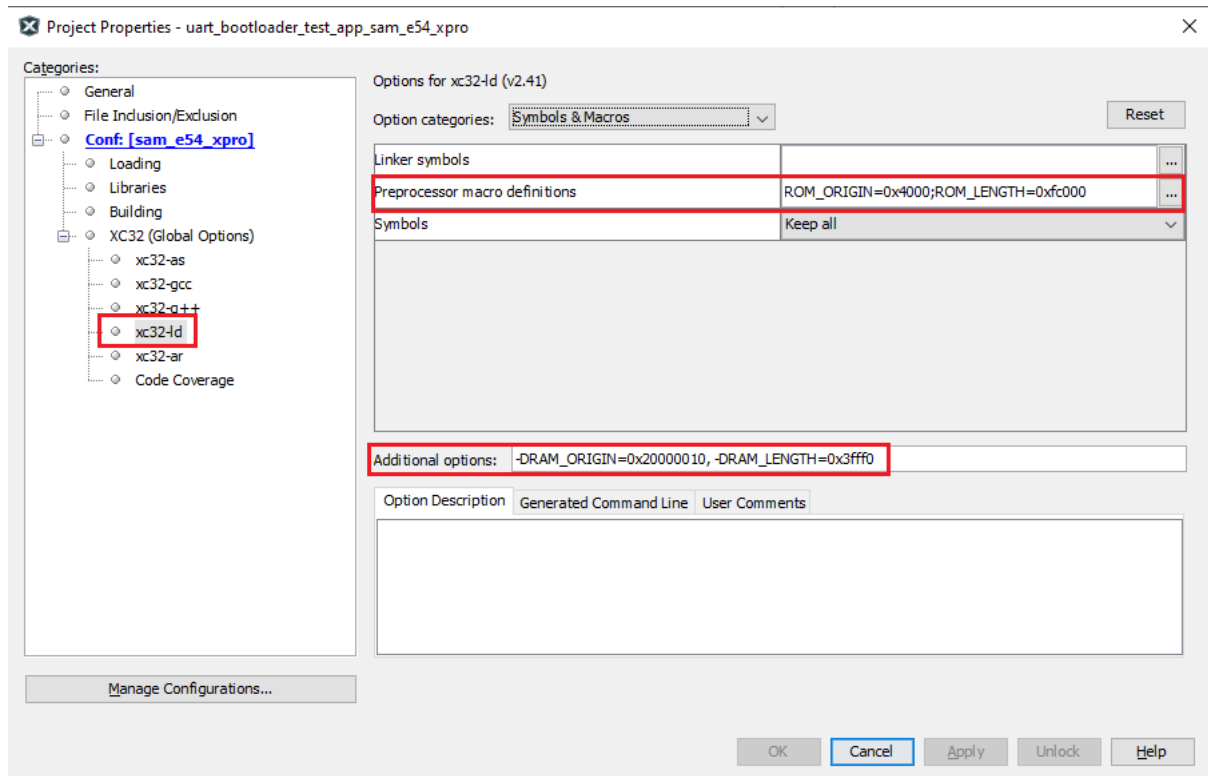
The bootloader project uses a custom linker script generated through the MHC. The values populated in the linker script are based on the bootloader MHC configuration. The bootloader is configured to run from the RAM to achieve simultaneous Flash memory write and read of the next block of data.

Figure 3-1. UART Basic Bootloader - Custom Linker Script



The bootloader test application project overrides the XC32 linker variables, ROM_ORIGIN and ROM_LENGTH, with the value provided for the application start address in the MHC configuration. This value can be verified in the XC32 linker options under Project Properties in MPLABX IDE, as shown in the following figure.

Figure 3-2. UART Bootloader Test Application - Project Properties

**Preprocessor Macro Definitions:**

- ROM_ORIGIN and ROM_LENGTH are the XC32 linker variables which will be overridden with values provided here.
- These values are auto-populated with the value of the application start address provided in the MHC after regeneration.

Additional Options:

- The Bootloader trigger pattern needs to be stored in the starting 16 Bytes of RAM by the application if it wants to run the bootloader at startup without any external trigger. Therefore, the RAM_ORIGIN and RAM_LENGTH values should be provided for reserving 16 bytes at the start of the RAM to trigger the bootloader. The RAM_ORIGIN is calculated using the RAM_START, and the RAM_LENGTH is calculated using the RAM_SIZE, as shown in the following figure.

```
#define RAM_START (0x20000000 + 16)
#define RAM_SIZE (0x40000 - 16)

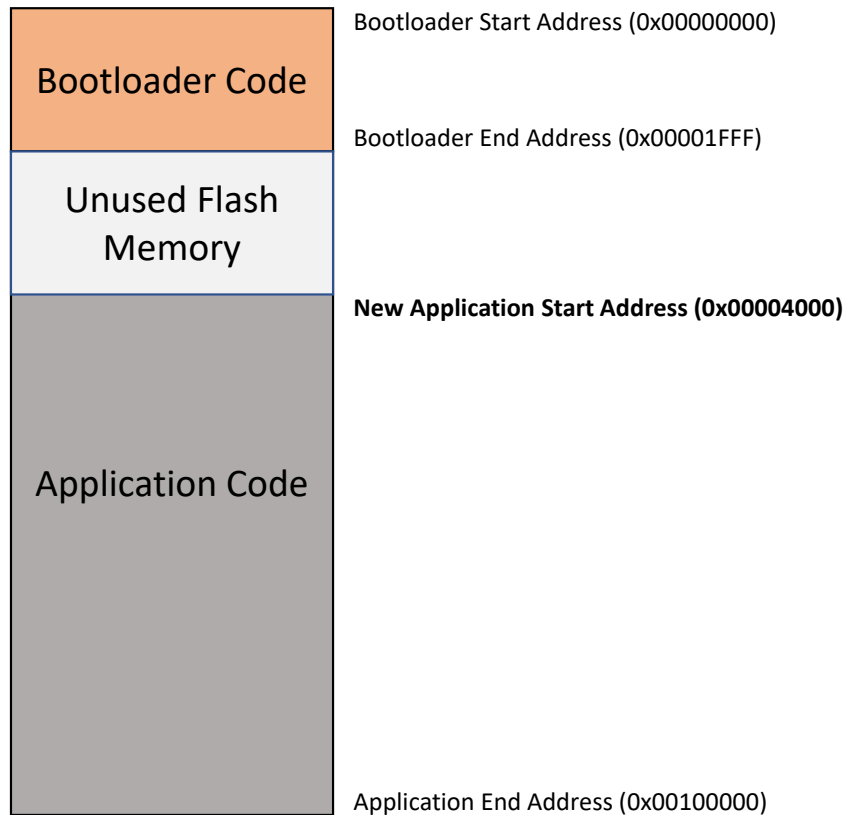
/*****
 * Memory-Region Definitions
 * The MEMORY command describes the location and size of blocks of memory
 * on the target device. The command below uses the macros defined above.
 *****/
MEMORY
{
  rom (rx) : ORIGIN = ROM_START, LENGTH = ROM_SIZE
  ram (rwx) : ORIGIN = RAM_START, LENGTH = RAM_SIZE
}
```

- This setting is optional and can be ignored if not required.

4. Example of Programming an Application into a Desired Flash Memory Location

This section provides an example of changing the application start address from 0x2000 to 0x4000. The following figure shows the new memory layout after changing the application start address.

Figure 4-1. Basic Bootloader - New Memory Layout



Follow these steps to change the application start address:

1. Follow the steps mentioned in [Configure the Desired Application Start Address in the Bootloader Project](#) and Configure the desired application start address in the application project.
2. Connect the Debug USB port on the SAM E54 Xplained Pro board to the computer using a micro-USB cable.
3. Download the [MPLAB Harmony v3 Bootloader Repository](#) and run the Bootloader Tools script `btl_host.py` from a command prompt to program the application binary. Ensure that the new start address is used to program the application into the desired Flash memory location, as shown below.

```
python <MPLAB Harmony v3 Bootloader Repository>\tools\btl_host.py -v -i <COM PORT> -d
same5x -a 0x4000 -f
<MPLAB Harmony v3 Bootloader UART Examples
Repository>\apps\uart_bootloader\test_app\firmware\sam_e54_xpro.X\dist\sam_e54_xpro\produ
ction\sam_e54_xpro.X.production.bin
```

4. The following figure shows the output of successfully programming the test application:
 - "Rebooting" and "Reboot Done" messages in the following output signify that bootloading is successful:

Figure 4-2. Basic Bootloader - Application Programming Success

```
Unlocking
Uploading 1 blocks at address 16384 (0x4000)
... block 1 of 1
Verification
... success
Rebooting
Reboot Done
```

5. If the above step is successful, then the LED0 must start blinking, indicating the application is written into the required Flash memory location.
6. Change the start address in the bootloader and test application project. Repeat the above steps to write the application in a different Flash address.

Note: The UART Fail-Safe bootloader and its test application present in <MPLAB Harmony v3 Bootloader UART Examples Repository>\apps can also be used to change the application start address. The method is shown in section [Configure the Desired Application Start Address in the Bootloader Project](#) and [Configure the Desired Application Start Address in the Application Project](#). The steps discussed in this document apply to the UART Fail-Safe bootloader, except that the UART Fail-Safe bootloader uses the dual-bank memory layout. Refer to the UART Fail-Safe bootloader documentation for details.

5. Tips: Bootloader and Application Size Considerations

The example bootloaders provided in the *apps/uart_bootloader/bootloader/* folder have optimization settings for use by most MPLAB XC32 C/C++ Compiler users, which is `-O1`.

Turning on the `-Os` will further reduce the size of the bootloader.

Note: The minimum size of the bootloader may also vary based on the Device BOOTPROT configuration bit value for SAM devices.

Size Change Considerations:

It must be ensured that the user application's memory region does not overlap with the memory region reserved for the bootloader.

If the size of the bootloader changes, the following steps must be performed to adjust both the bootloader and the application, ensure that both fit and make the best use of the device memory:

1. Increase the bootloader size in the bootloader MHC configuration menu to some approximate value and regenerate the code.
2. Determine the new ending address of the bootloader. This can be done by using either the `.map` file generated by MPLAB X IDE or by using the ELFViewer plug-in for MPLAB X IDE.
3. Round the size from the map file to the nearest ERASE unit size or the nearest BOOTPROT configuration value.
4. Enter the new value again in Bootloader Size in the bootloader MHC configuration menu.
5. Change the Application start address in the system settings for both the bootloader and application projects accordingly.
6. Recompile both the bootloader and the application, as well as the test operations.

If only the Application start address needs to be modified, then perform the following steps:

1. Change the Application start address in system settings for both the bootloader and application projects accordingly.
2. Recompile both the bootloader and the application, as well as the test operations.

6. References

- MPLAB® Harmony v3:
www.microchip.com/mplab/mplab-harmony
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<Harmony framework download folder>\bootloader\doc\help_bootloader.chm
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- MPLAB® Harmony v3 UART Bootloader Application Examples:
microchip-mplab-harmony.github.io/bootloader_apps_uart/
- MPLAB Harmony v3 Bootloader application:
<Harmony framework download folder>\bootloader\apps
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- Create Your First USB Host MSD Application:
github.com/Microchip-MPLAB-Harmony/usb/wiki/Create-your-first-usb-host-msd-application
- MPLAB Harmony v3 TCP/IP Help:
microchip-mplab-harmony.github.io/net/frames.html?frmname=topic&frmfile=index.html

- Create Your First TCP/IP Application:
github.com/Microchip-MPLAB-Harmony/net/wiki/Create-your-first-tcpip-application
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[ww1.microchip.com/downloads/en/Appnotes/
MPLAB_Harmonyv3_Application_Development_%20Guide_for_%20MPLAB_Harmonyv2_Users_DS00003388
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