Creating a 'Hello World' Application on Arm Microcontrollers Using MPLAB Harmony v3 with MPLAB Code Configurator (MCC)

TB3231

Introduction

MPLAB® Harmony v3 is a software development framework consisting of compatible and interoperable modules that include peripheral libraries (PLIBs), drivers, system services, middleware, and third-party libraries. The MPLAB Code Configurator (MCC) is a GUI-based tool that provides an easy way to enable and configure various MPLAB Harmony modules. The MCC is a plug-in to the MPLAB X Integrated Development Environment (IDE).

This document explains how to create a simple application on an Arm® Cortex®-based 32-bit Microcontroller (MCU) using the MCC with MPLAB Harmony v3 modules. This application sends a “Hello World!” string to a console running on a computer. For this demonstration, the following MPLAB Harmony v3 modules are used and configured using the MCC:

- Clock PLIB using the Clock Manager to configure the microcontroller clock.
- PORT PLIB using the Pin Manager to configure the microcontroller I/Os.
- Serial Communication (SERCOM) USART PLIB to configure USART peripheral as serial port.

Table of Contents

1. Creating Hello World Application

This document describes how to create a "Hello World" application on the 32-bit Arm microcontrollers using MPLAB Harmony v3 with the MPLAB Code Configurator (MCC) tool. It also covers the necessary procedures that must be adhered to for this demonstration.

The following software and hardware tools are used for this demonstration:

- MPLAB X IDE v6.15
- MPLAB Code Configurator (MCC) Plug-in v5.3.7
- MPLAB XC32 v4.30
- MPLAB Harmony v3 repositories:
  - csp v3.18.0
  - dev_packs v3.18.0
- SAM D21 Xplained Pro Board

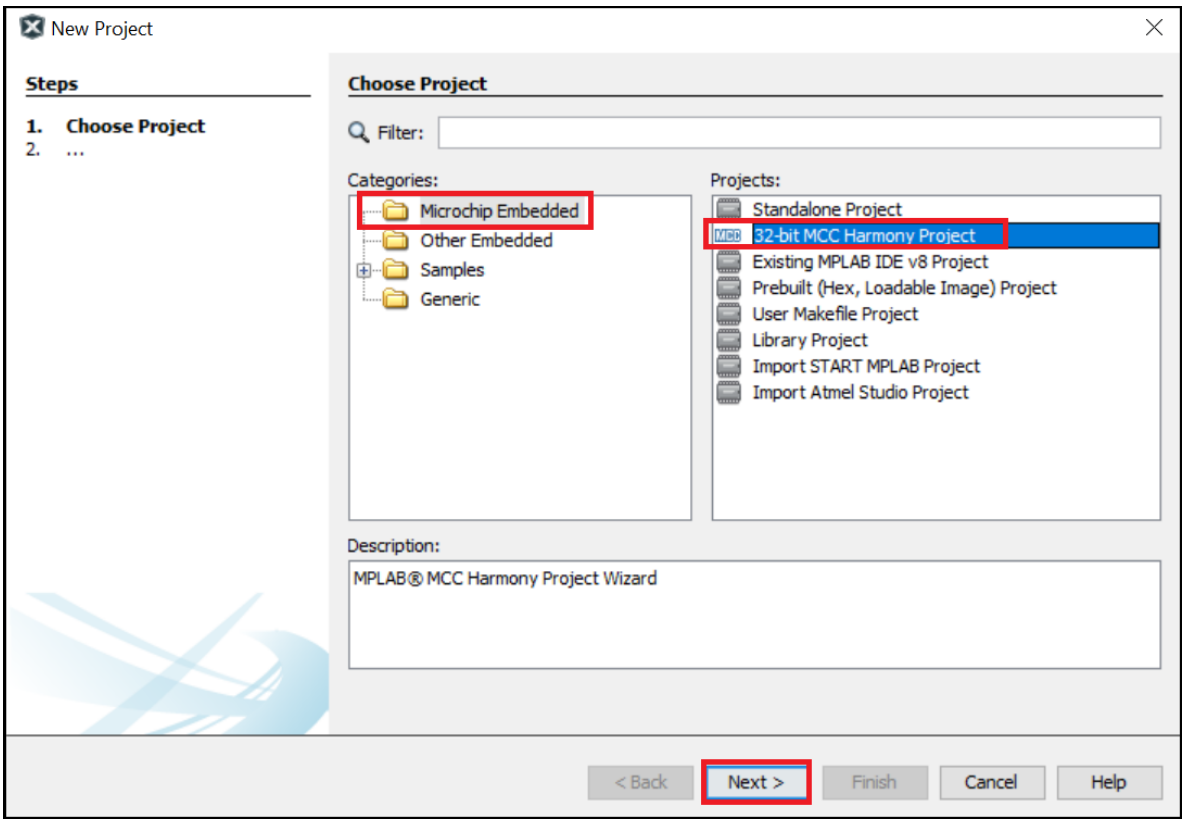
Note: The updated versions of the above listed tools can also be used to create the application, however, users are not restricted to use the older versions.

Note: The flow and steps explained in this document can be reused for other 32-bit Arm Microcontrollers. The user must take care of the differences in peripherals and pin configurations.

Step 1: To create an MPLAB Harmony v3-based project, follow these steps:

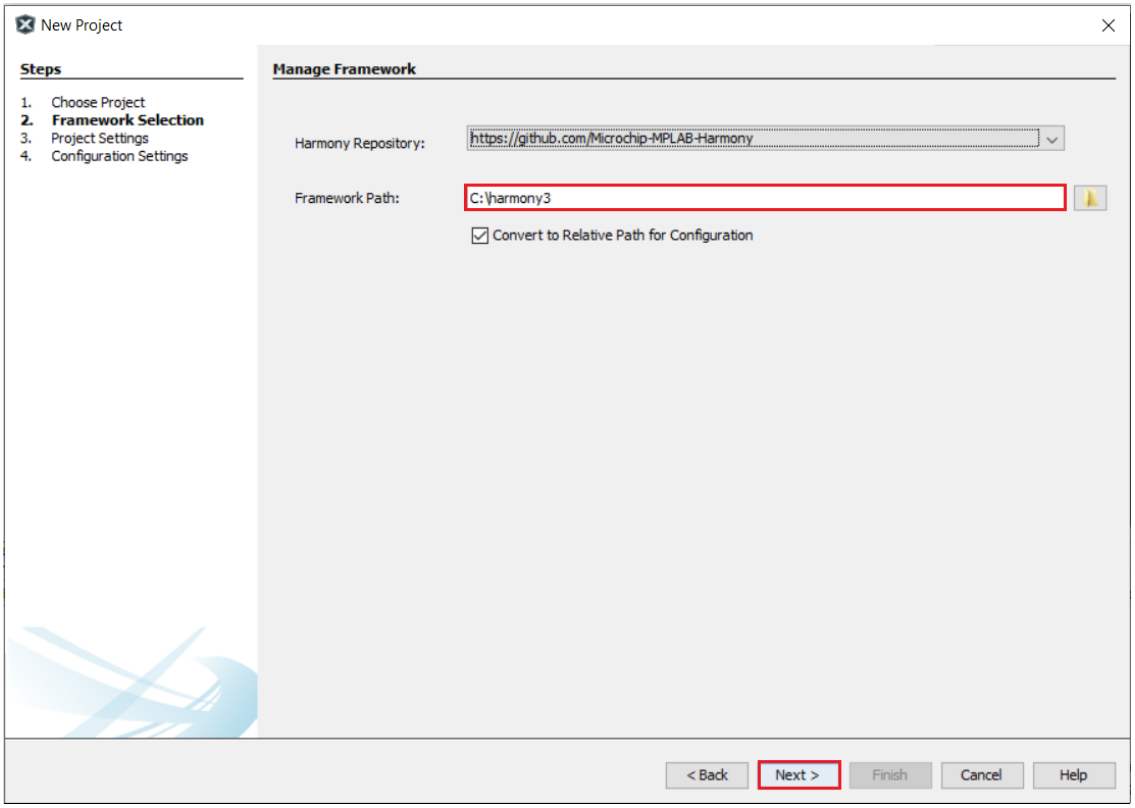
1. From the Start Menu launch MPLAB X IDE.
2. Once MPLAB X IDE is open, on the File menu, select **New Project** or click on the New Project icon.
3. In the New Project window, under Steps navigation pane, select **Choose Project**. In the right Choose Project properties section, under Categories, select **Microchip Embedded** and under Projects select **32-bit MCC Harmony Project.**

Figure 1-1. Creating an MPLAB Harmony v3-Based Project - Choose Project



4. Click **Next**.
5. In the left navigation pane, select **Framework Selections** and in the right Manage Framework properties section, enter these details:
   a. Harmony Repository: Enter the path https://github.com/Microchip-MPLAB-Harmony.
   b. Framework Path: Enter C:\harmony3 (i.e., the path to the folder in which the MPLAB Harmony v3 packages are downloaded).

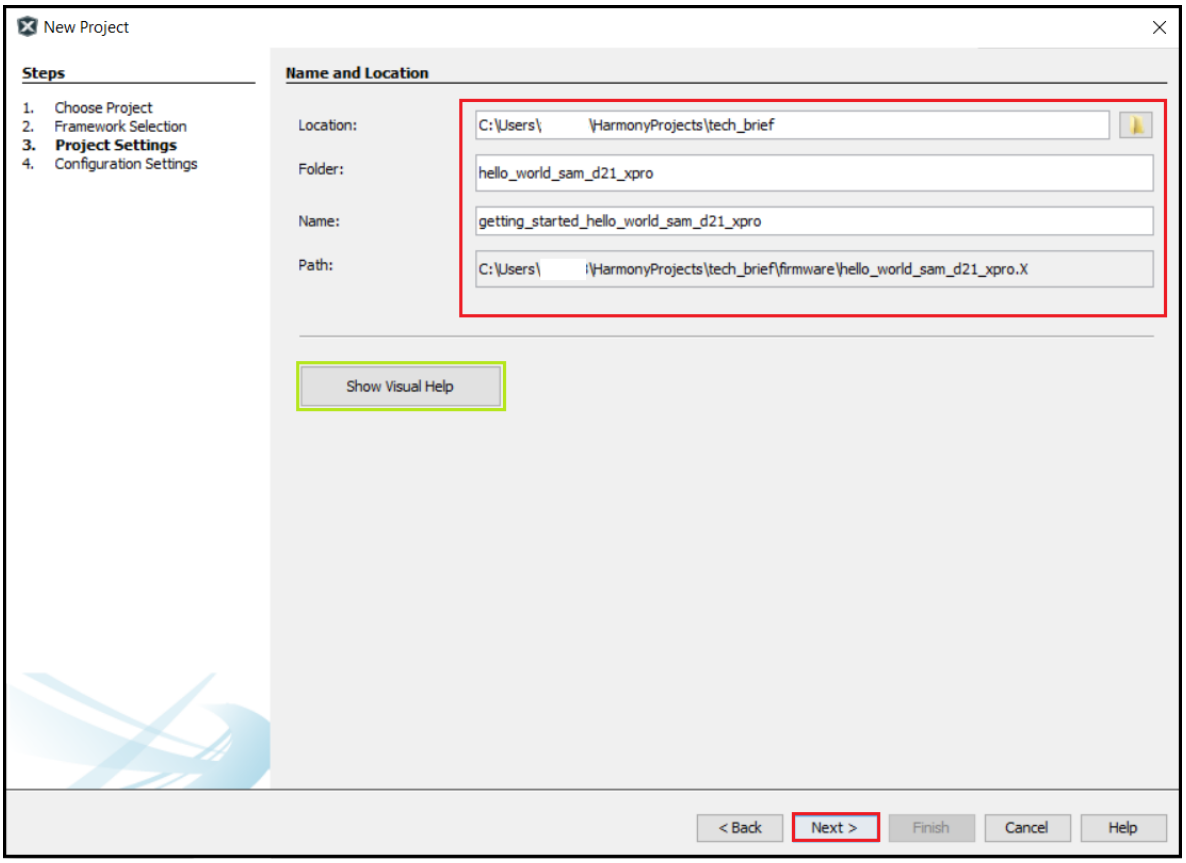
Figure 1-2. Creating an MPLAB Harmony v3-Based Project - Framework Selection



Note: For this demonstration application, the following MPLAB Harmony v3 packages are required: *dev_packs* and *csp*. The MPLAB Harmony v3 Content Manager tool simplifies the downloading of the MPLAB Harmony v3 packages. If these packages are not downloaded, then the user can use the MPLAB Harmony v3 Content Manager tool to download.

6. Click **Next.**
7. In the left navigation pane, select **Project Settings**, and in the Name and Location properties section, enter these details:
   - Location: Indicates the path to the root folder of the new project. All project files will be placed in this folder. The project location can be any valid path, for example: *C:\Users\HarmonyProjects\tech_brief*.
   - Folder: Indicates the name of the MPLAB X IDE folder. Enter hello_world_sam_d21_xpro to create a `hello_world_sam_d21_xpro.x` folder.
   - Name: Enter project name as *getting_started_hello_world_sam_d21_xpro*. This name will be displayed in the MPLAB X IDE.
   - Path: The path information will be updated automatically as and when users make changes to other fields.

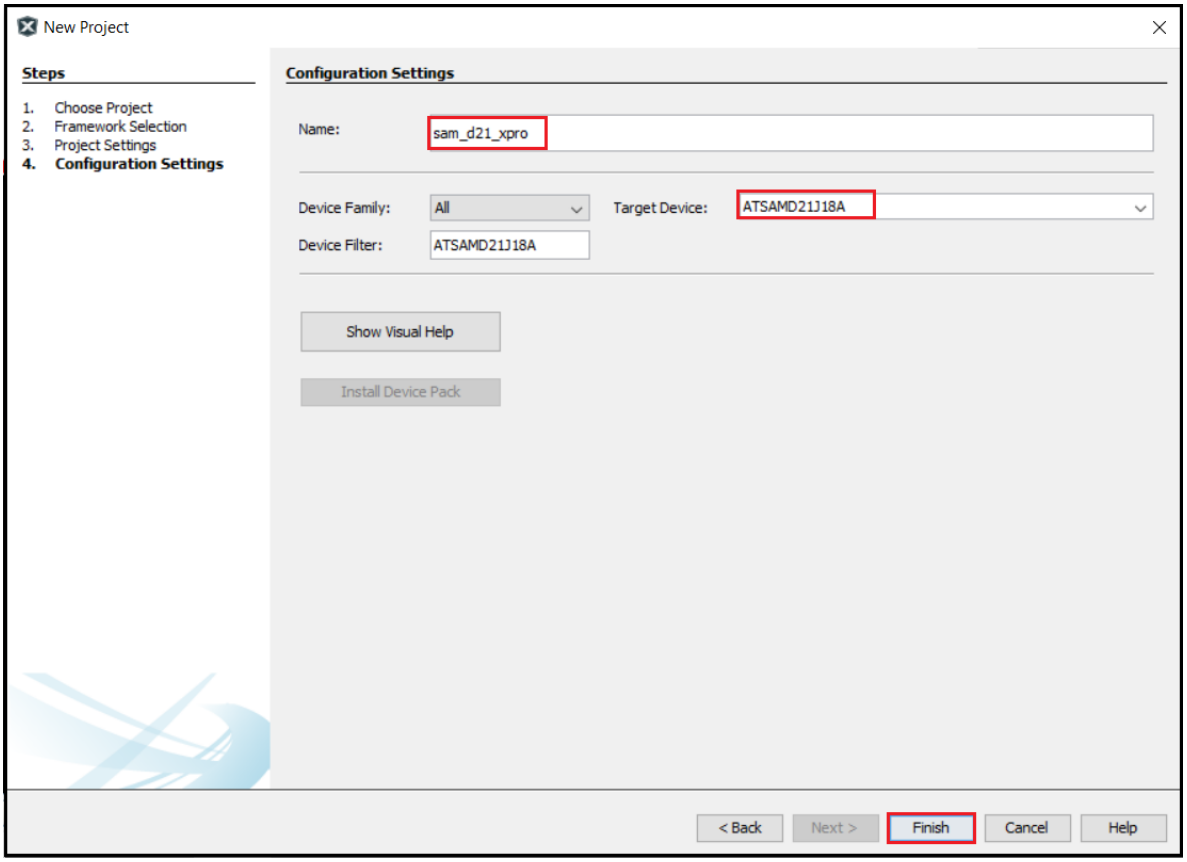
Figure 1-3. Creating an MPLAB Harmony v3-Based Project - Project Settings



Note: Click the **Show Visual Help** button to open a Contextual Help window for a detailed description of various fields in the Project Settings.

8. Click **Next**.
9. In the left navigation pane, select **Configuration Settings** and in the Configutation Settings properies page, enter these details:
   - Name: Enter the configuration name as *sam_d21_xpro*.
   - Target Device: Choose ATSAMD21J18A.

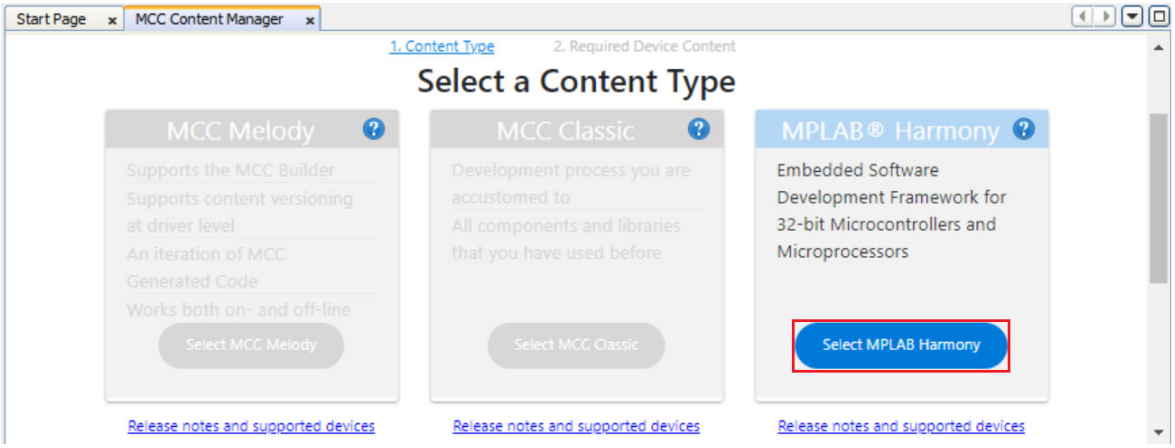
Figure 1-4. Creating an MPLAB Harmony v3-Based Project - Configuration Settings



Note: Click the **Show Visual Help** button to open a Contextual Help window for a detailed description of various fields in the Configuration Settings.

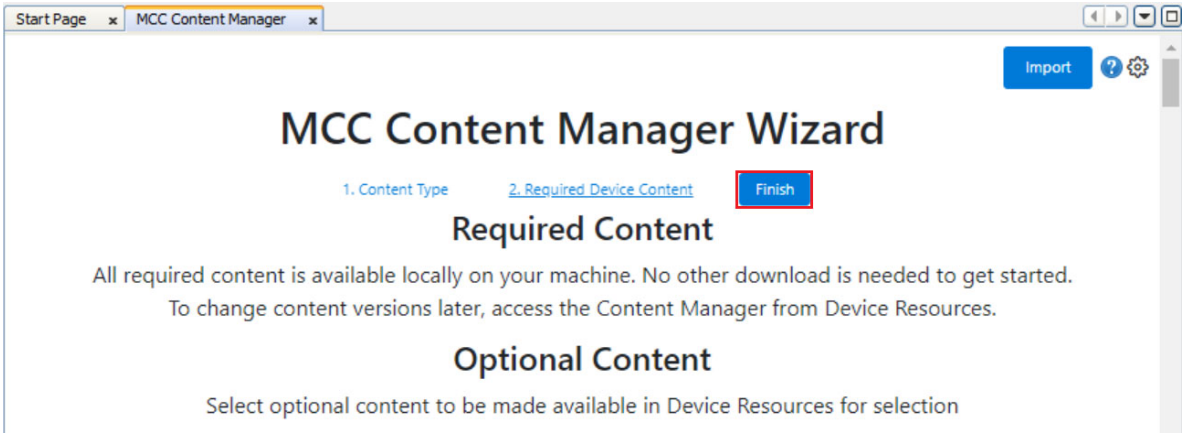
10. Click **Finish** to launch MCC.
    Note: If MCC is not launched after clicking the **Finish** button, users can launch it by selecting *Tools* > *Embedded* > *MPLAB® Code Configurator v5* from the MPLAB X IDE.
11. In the MCC Content Manager Window, click **Select MPLAB Harmony**.

Figure 1-5. Configuration Database Setup



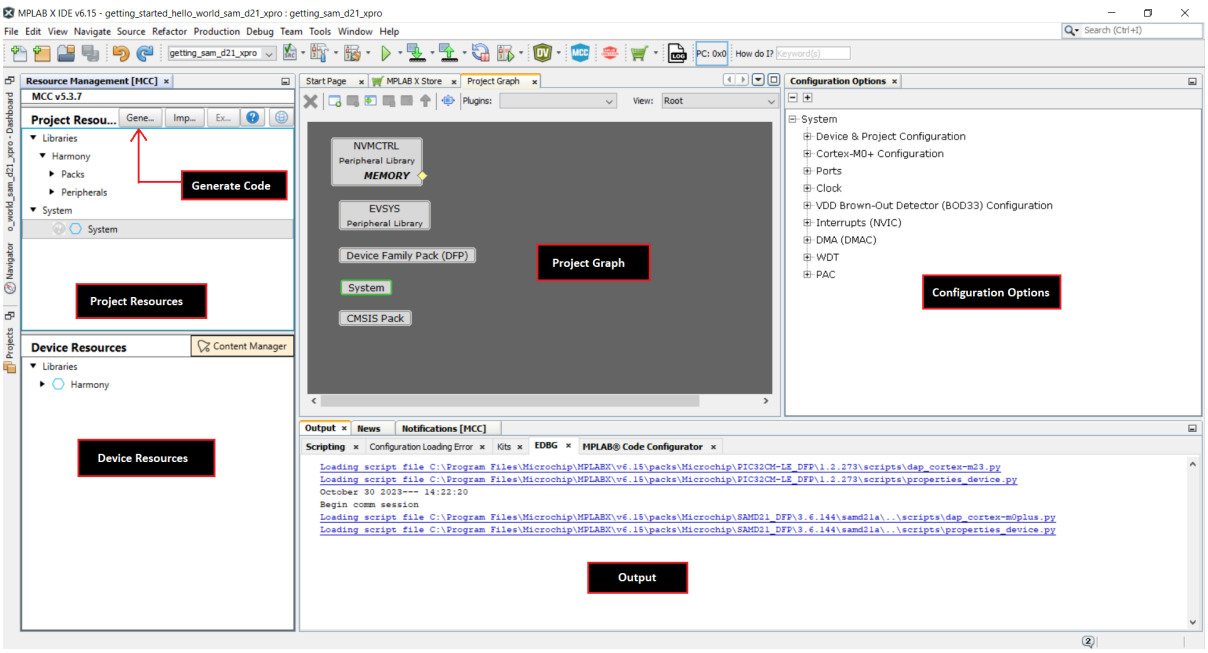
12. Click **Finish**.

Figure 1-6. Finishing Database Setup



13. The MCC plugin will open in a new window. The image below highlights different sections available in MCC.

Figure 1-7. MPLAB Harmony v3 Configurator Window

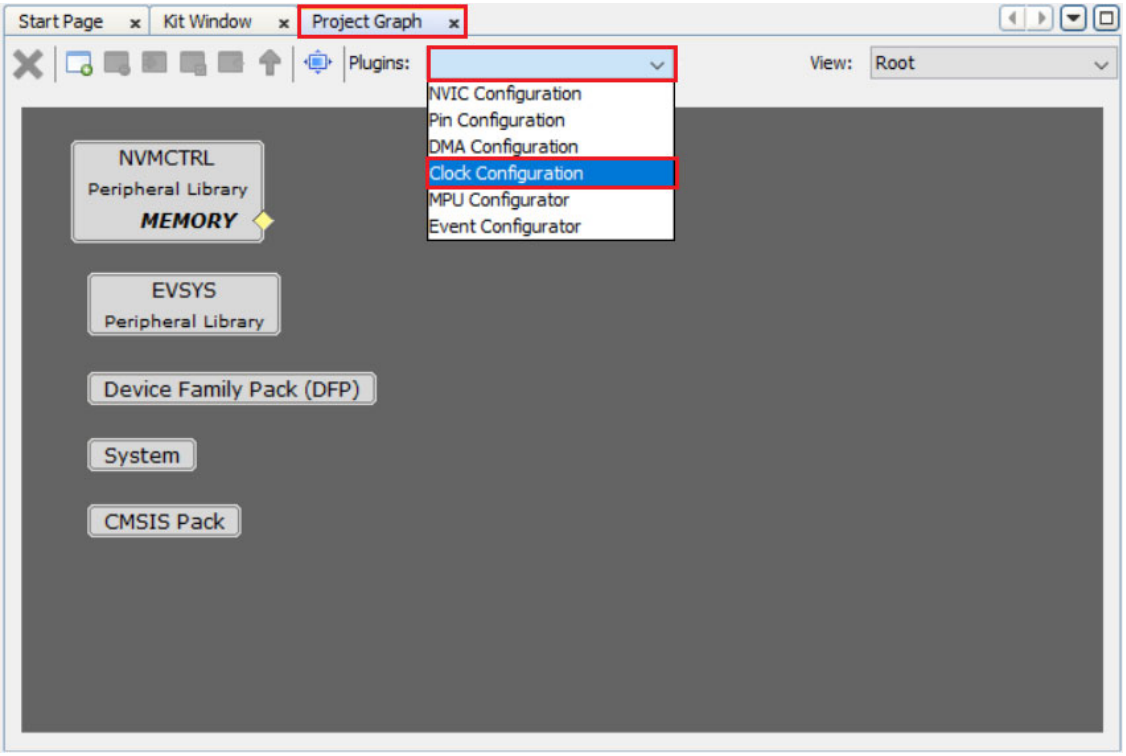


14. For additional information on MCC and how to create the MPLAB Harmony v3 project, visit: microchipdeveloper.com/harmony3:mcc-overview.

Step 2: To add and configure the MPLAB Harmony components using MCC, follow these steps:

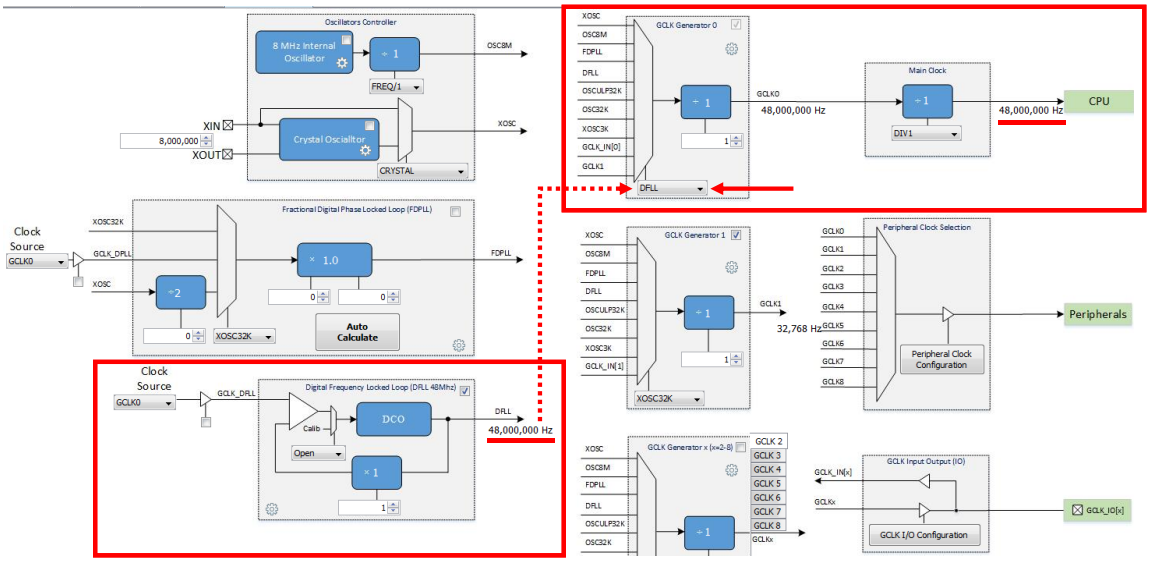
1. To launch Clock Easy View in MPLAB X IDE, click **Project Graph**. In the Plugins drop-down list, select **Clock Configuration**. The Clock Easy View will be displayed within the MCC Window.

Figure 1-8. MCC Clock Configuration



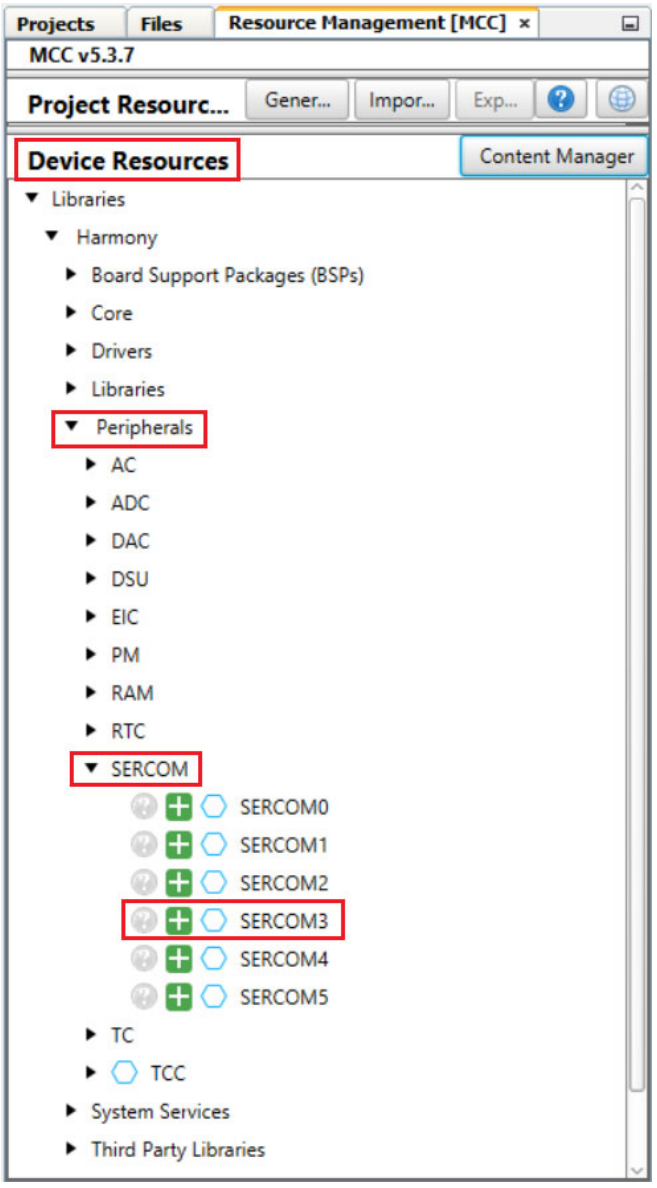
2. In the Clock Easy View window, scroll to the right and verify the main clock is set to 48 MHz.

Figure 1-9. MPLAB Harmony v3 Clock Configurator - Clock Easy View



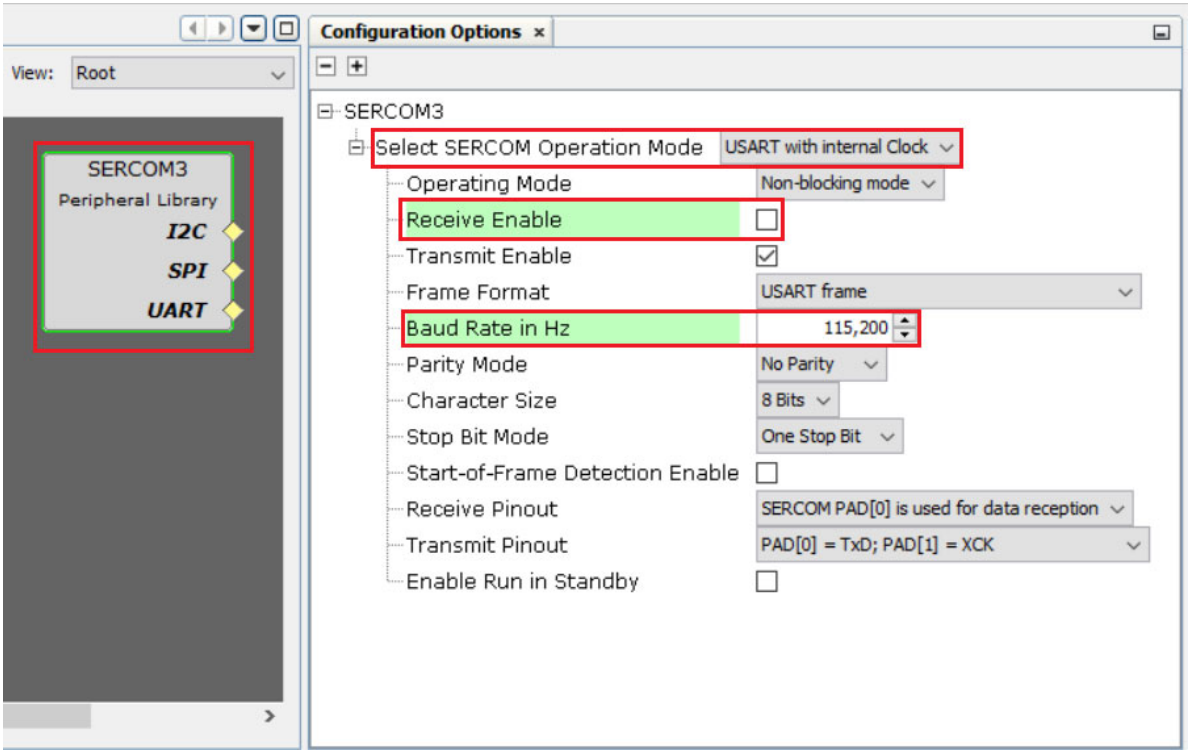
3. To add and configure the USART Peripheral Library, follow these steps:
   a. Select **Resource Management (MCC)**.
   b. Under Device Resources, select *Libraries* > *Harmony* > *Peripherals* > *SERCOM*.

c. Double-click on the **SERCOM3** Peripheral Libray to add it to the project.



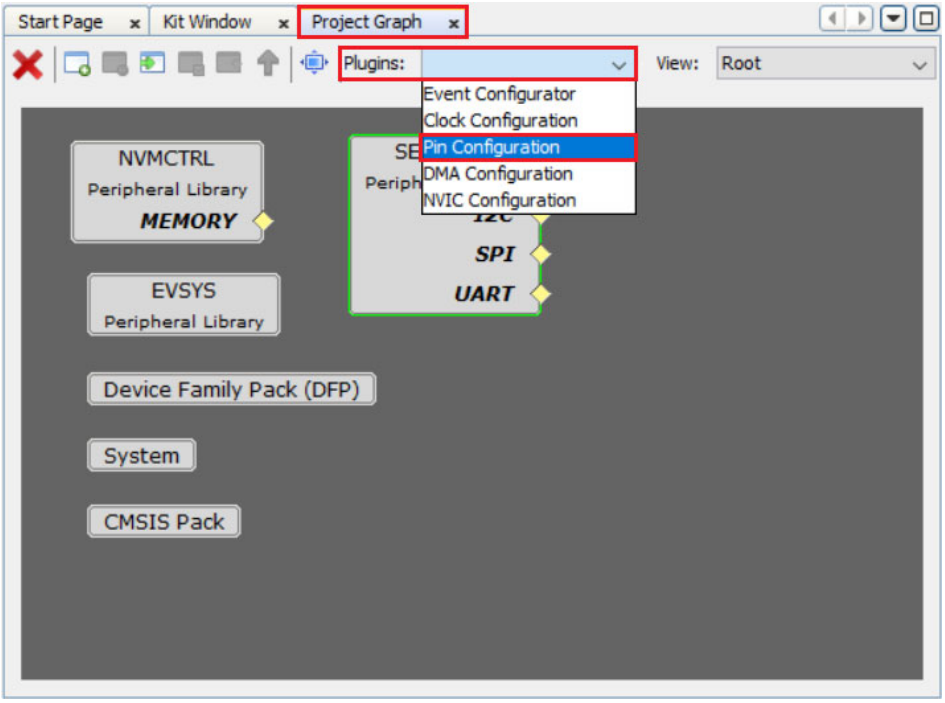
4. Select the SERCOM3 Peripheral Library in the Project Graph, and in the Configuration Options properties section configure it as follows:
   - SERCOM Operation mode is set for USART with Internal Clock (default setting).
   - Clear Receive Enable, as the string will only be transmitted in this example.
   - Set the Baud Rate to 115200 Hz.
   - For Transmit Pinout choose SERCOM PAD[0] (default setting)
   - By default, the Receive Pinout is SERCOM PAD[0]. If the Receive Pinout feature is disabled, it will not affect the operation.

Figure 1-10. MCC SERCOM Configuration



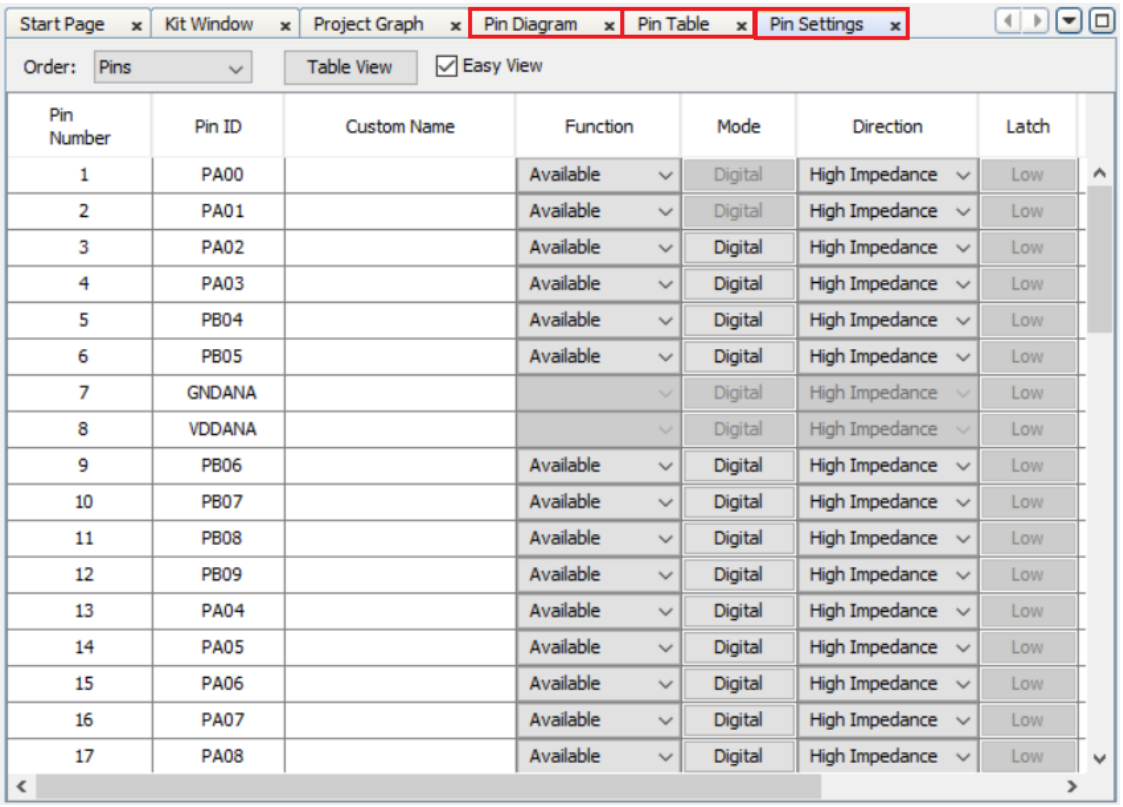
5. Configure the USART pin in the Pin Settings: In the MCC, select **Project Graph**.
6. In the Plugins item list, select **Pin Configuration** to open the Pin Settings window.

Figure 1-11. MCC Pin Configuration



7. The MCC Pin Settings window will open and display these options: Pin Diagram, Pin Table, and Pin Settings.

Figure 1-12. MCC Pin Settings Window

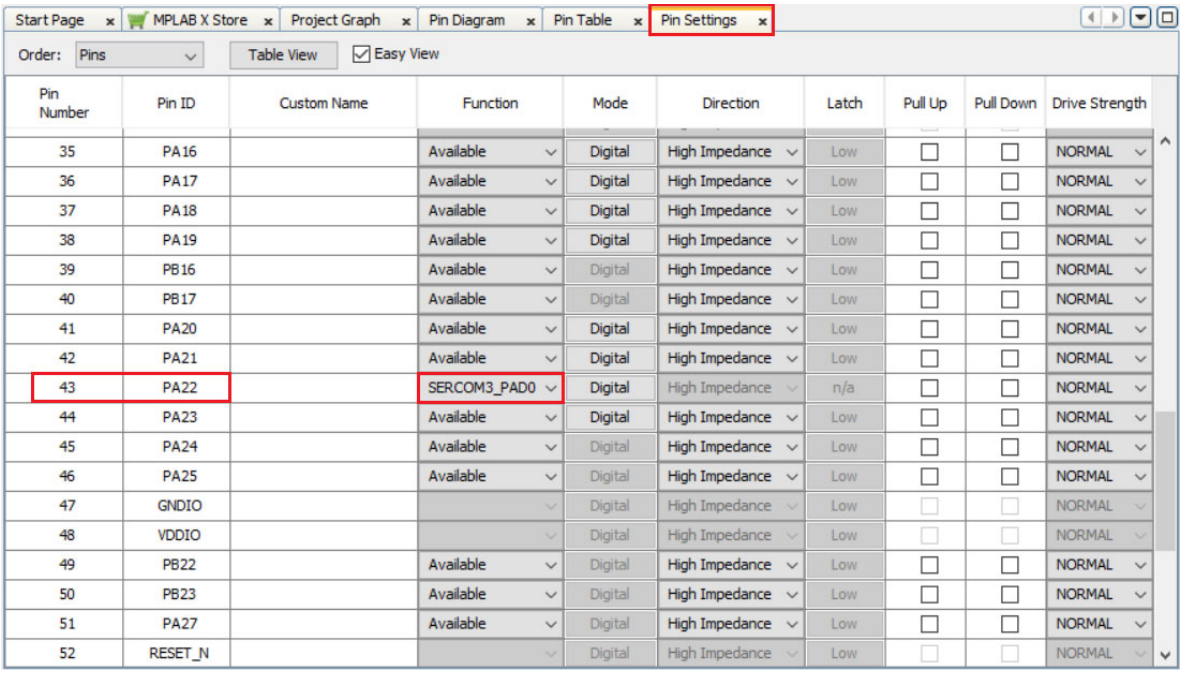


Pin Number	Pin ID	Custom Name	Function	Mode	Direction	Latch
1	PA00		Available	Digital	High Impedance	Low
2	PA01		Available	Digital	High Impedance	Low
3	PA02		Available	Digital	High Impedance	Low
4	PA03		Available	Digital	High Impedance	Low
5	PB04		Available	Digital	High Impedance	Low
6	PB05		Available	Digital	High Impedance	Low
7	GNDANA			Digital	High Impedance	Low
8	VDDANA			Digital	High Impedance	Low
9	PB06		Available	Digital	High Impedance	Low
10	PB07		Available	Digital	High Impedance	Low
11	PB08		Available	Digital	High Impedance	Low
12	PB09		Available	Digital	High Impedance	Low
13	PA04		Available	Digital	High Impedance	Low
14	PA05		Available	Digital	High Impedance	Low
15	PA06		Available	Digital	High Impedance	Low
16	PA07		Available	Digital	High Impedance	Low
17	PA08		Available	Digital	High Impedance	Low

Note: According to the schematic of the SAM D21 Xplained Pro Board, the on-board Embedded Debugger (EDBG) can be used as Virtual Com Port to have serial communication between the SAM D21 device and a connected computer console. Therefore, the PA22 (Pin #43) of the SAM D21 device must be configured as `USART_TX` (SERCOM3 PAD0).

8. Click **Pin Settings** and configure the PA22 pin as SERCOM3_PAD0.

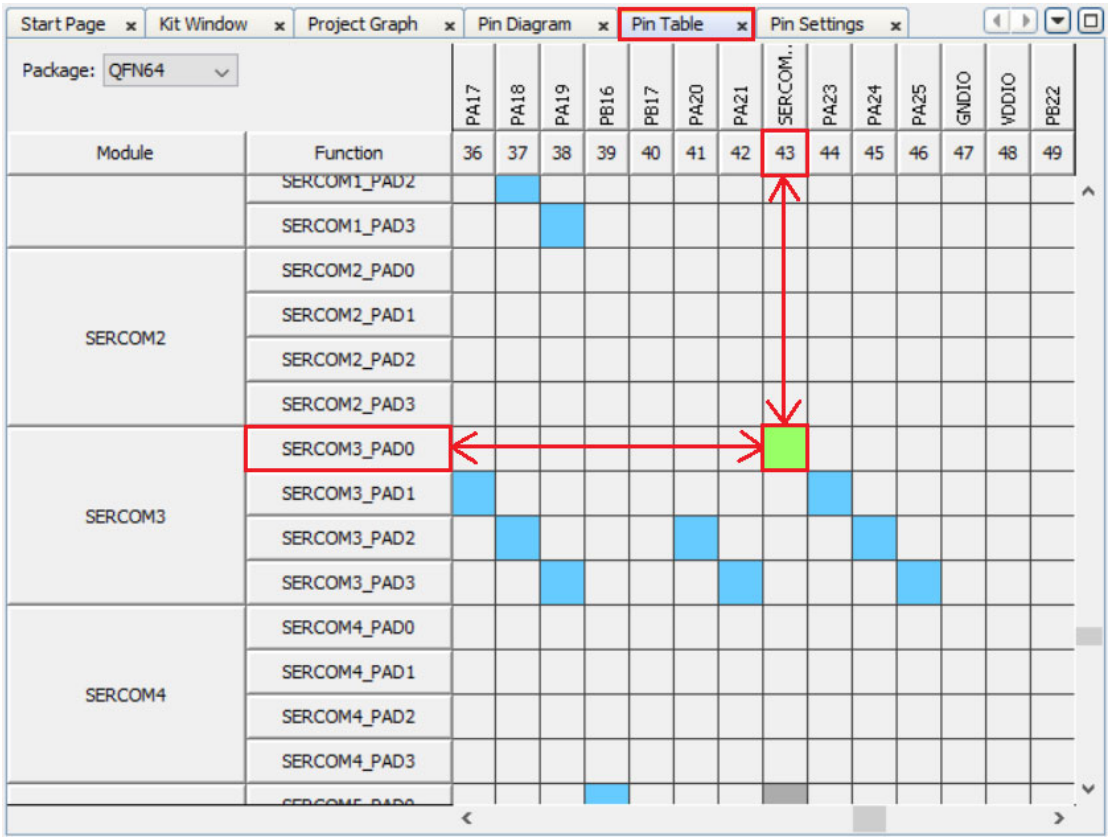
Figure 1-13. SERCOM Pin Settings



Pin Number	Pin ID	Custom Name	Function	Mode	Direction	Latch	Pull Up	Pull Down	Drive Strength
35	PA16		Available	Digital	High Impedance	Low	☐	☐	NORMAL
36	PA17		Available	Digital	High Impedance	Low	☐	☐	NORMAL
37	PA18		Available	Digital	High Impedance	Low	☐	☐	NORMAL
38	PA19		Available	Digital	High Impedance	Low	☐	☐	NORMAL
39	PB16		Available	Digital	High Impedance	Low	☐	☐	NORMAL
40	PB17		Available	Digital	High Impedance	Low	☐	☐	NORMAL
41	PA20		Available	Digital	High Impedance	Low	☐	☐	NORMAL
42	PA21		Available	Digital	High Impedance	Low	☐	☐	NORMAL
43	PA22		SERCOM3_PAD0	Digital	High Impedance	n/a	☐	☐	NORMAL
44	PA23		Available	Digital	High Impedance	Low	☐	☐	NORMAL
45	PA24		Available	Digital	High Impedance	Low	☐	☐	NORMAL
46	PA25		Available	Digital	High Impedance	Low	☐	☐	NORMAL
47	GNDIO			Digital	High Impedance	Low	☐	☐	NORMAL
48	VDDIO			Digital	High Impedance	Low	☐	☐	NORMAL
49	PB22		Available	Digital	High Impedance	Low	☐	☐	NORMAL
50	PB23		Available	Digital	High Impedance	Low	☐	☐	NORMAL
51	PA27		Available	Digital	High Impedance	Low	☐	☐	NORMAL
52	RESET_N			Digital	High Impedance	Low	☐	☐	NORMAL

9. The PA22 pin can also be configured by clicking the **Pin Table** tab.

Figure 1-14. SERCOM Pin Table



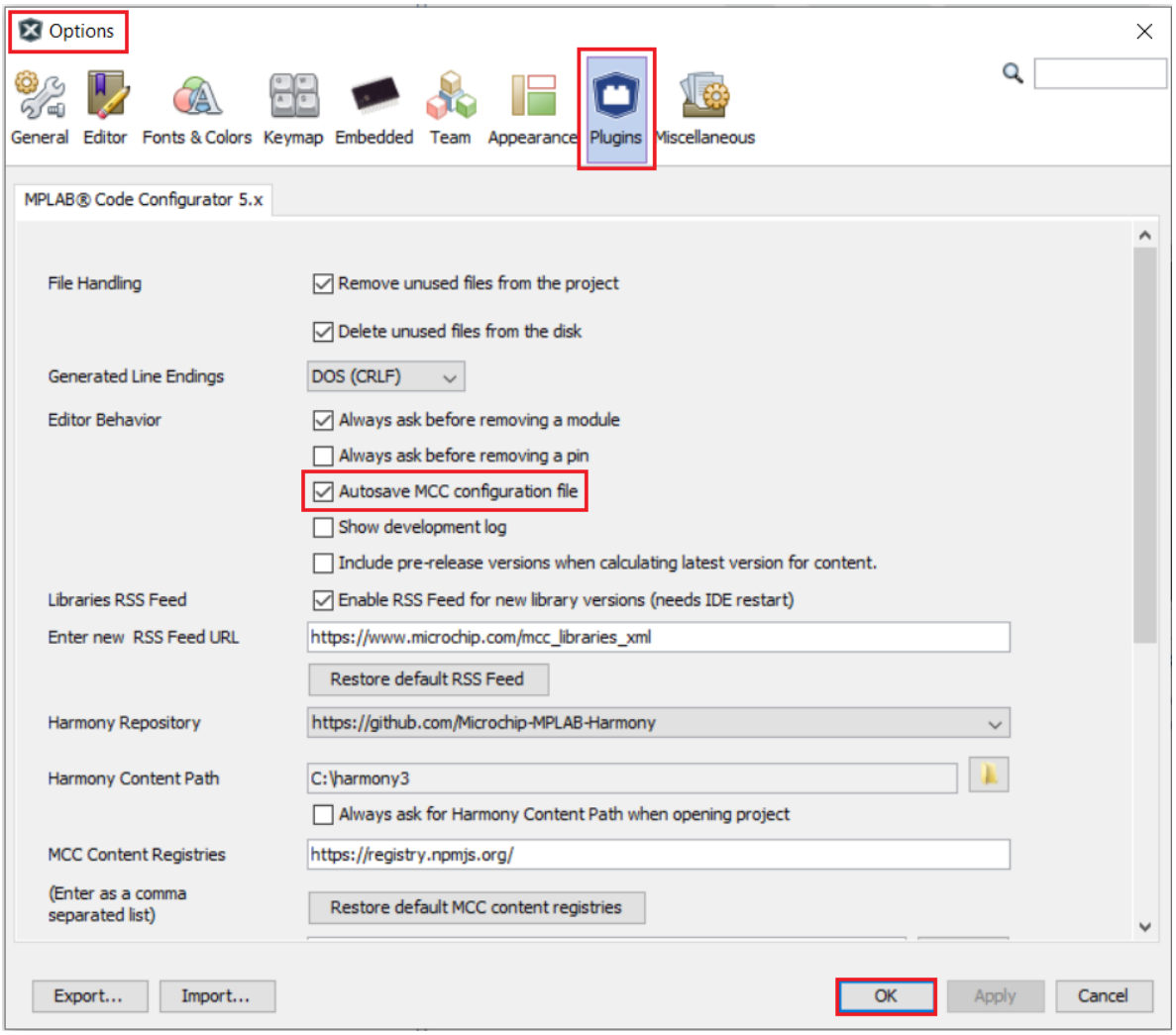
Notes:

1. The `USART_TX` function (Transmit Pinout) is by default configured to be on SERCOM3 PAD0, for additional information, refer to the MCC SERCOM Configuration.
2. In the SERCOM3 USART configuration, the USART is enabled only for transmit functionality. Therefore, the USART receive pin is not configured.

Step 3: To generate the code, follow these steps:

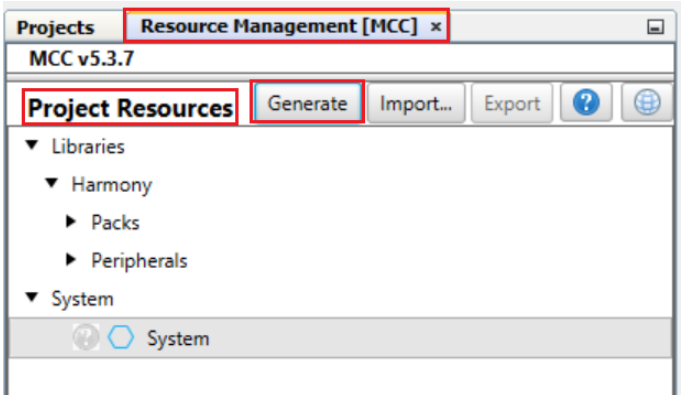
1. In the Tools drop-down menu, select Options, and in the Options Window, select **Plugins.**
2. By default, the Autosave MCC configuration file option is selected (That means MCC automatically saves any configurations done).

Figure 1-15. MCC Autosave



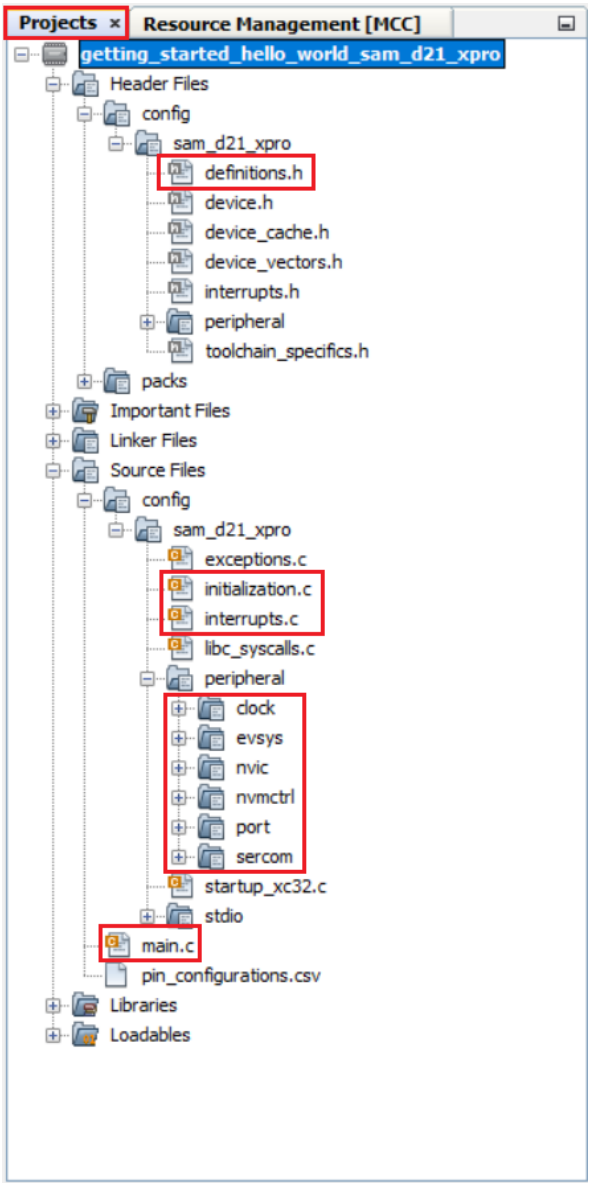
3. Click **OK**.
4. Click **Resource Management (MCC)**, and then click **Generate** to generate the code.

Figure 1-16. MCC Generate Code



5. The above step triggers these actions in MCC:
   - Generates the code as per the configurations done.
   - Place the generated code and required MPLAB Harmony framework files in the MPLAB Harmony project directory, in this case the project directory is *C:\Users\HarmonyProjects\tech_brief* .
   - MCC will include all MPLAB Harmony library files and generate the code based on the MCC selections. The generated code will add files and folders to the MPLAB Harmony v3 project as shown in the following figure.

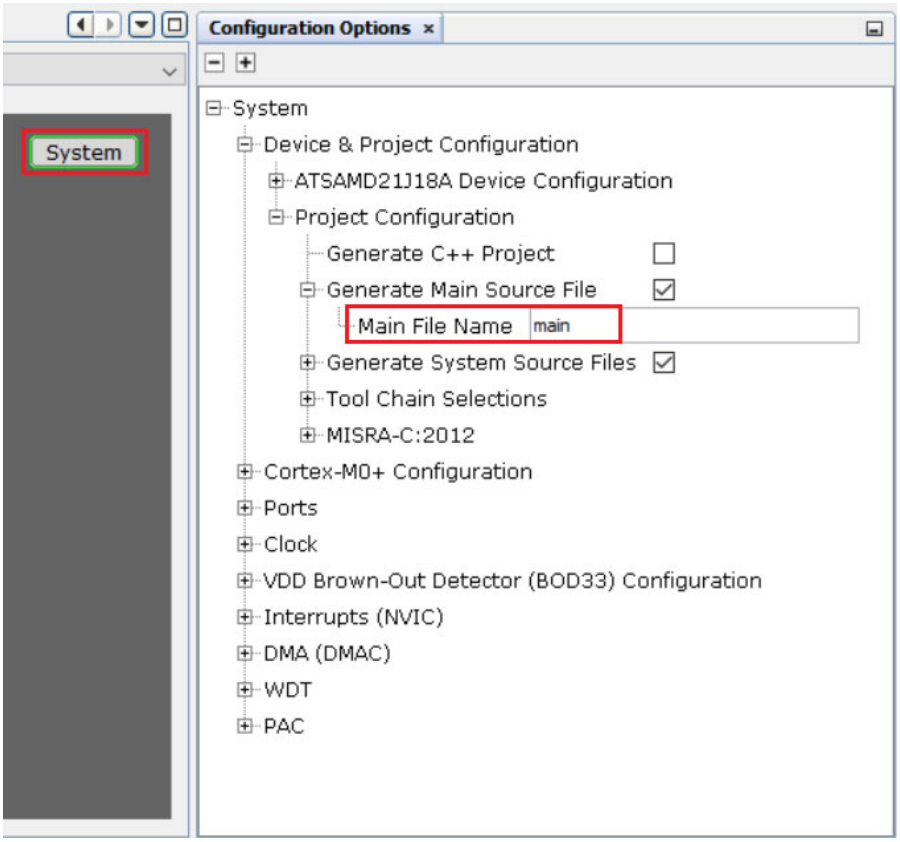
Figure 1-17. MCC Generated Code



6. The generated code descriptions are as follows:
   - `definitions.h`: Includes all header files required for the project.
   - `initialization.c`: Initializes all the MPLAB Harmony modules used in the application.
   - `interrupts.c`: Contains the mapping of all interrupt vectors on the selected device.
   - `main.c`: A function call to initialize the system present in this file. The user needs to develop their application in this file.
   - `peripheral`: All peripheral source codes are added in this folder.

   Note: MCC provides an option to change the generated file name, and if this option is not used, by default, the file name `main.c` is generated.

Figure 1-18. MCC System Configuration



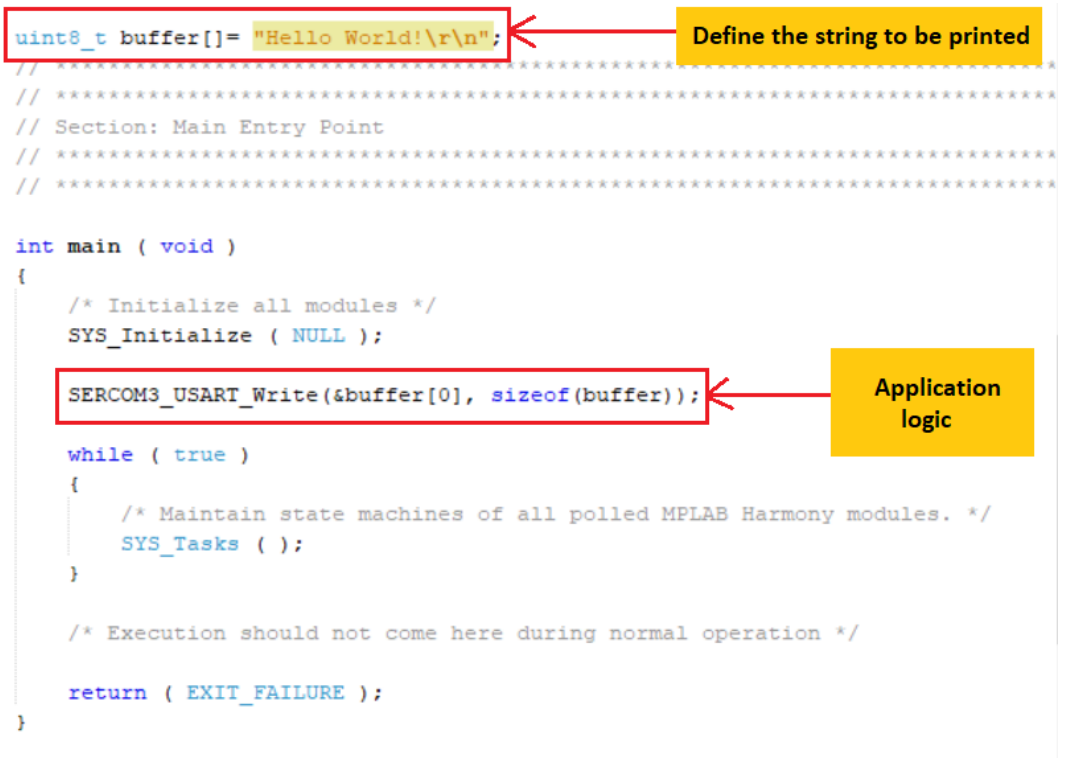
Step 4: To develop and run an application, follow these steps:

1. Developing an application: For this demo application, add the highlighted codes (as shown in image below) in the `main.c` file. This will send the “Hello World!” string to the console running on the PC.
   The following code is provided for convenience:

```
uint8_t buffer[]= "Hello World!\r\n";
```

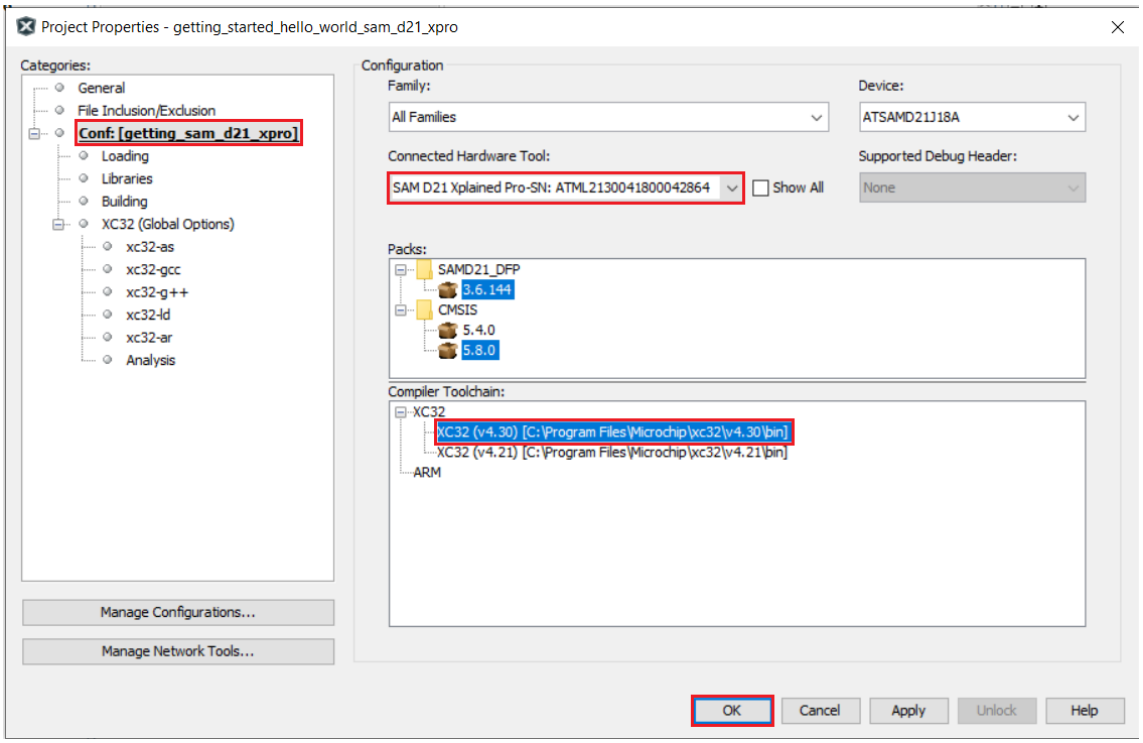
```
SERCOM3_USART_Write(&buffer[0], sizeof(buffer));
```

Figure 1-19. Developing Application



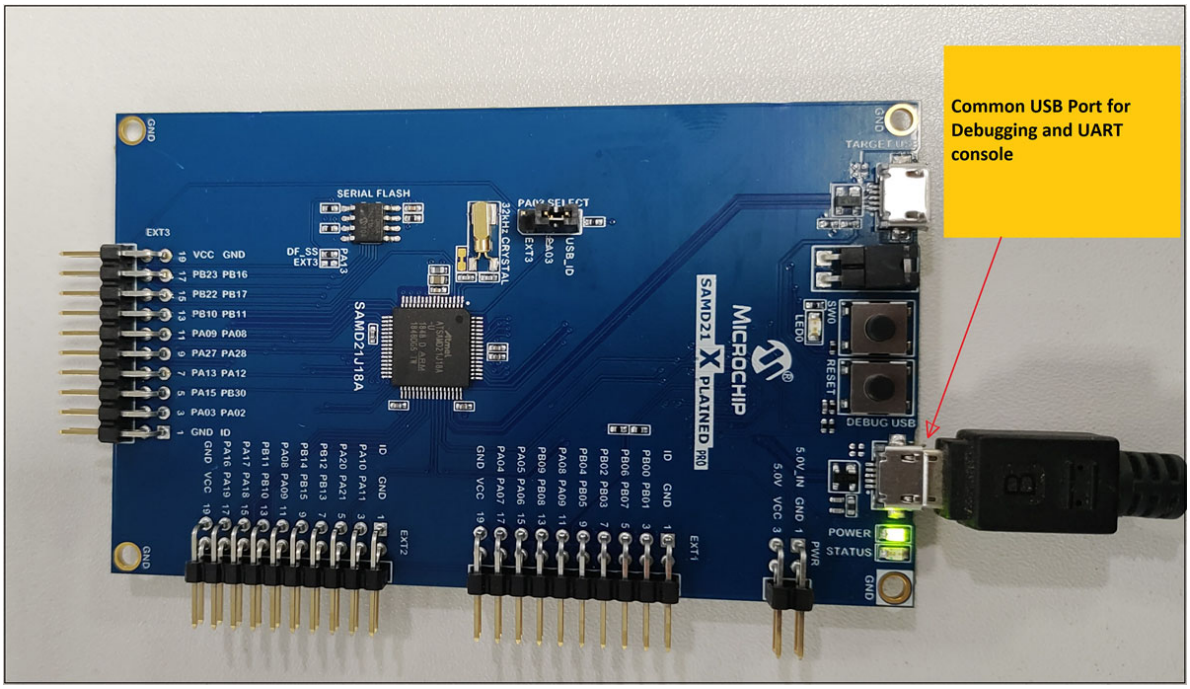
2. Selecting Hardware Tool and Compiler: In the MPLAB X IDE Project Properties window perform these actions:
   a. In the Categories section, select Conf: (sam_d21_xpro).
   b. In the Configuration section, select the Connected Hardware Tool and compiler toolchain as shown below.

Figure 1-20. MPLAB X IDE Project Properties



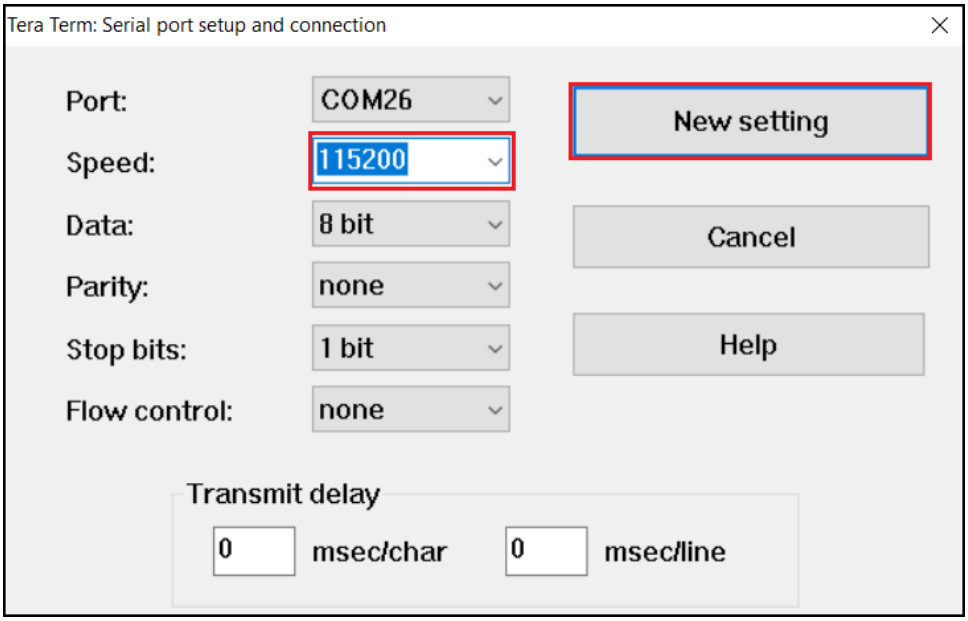
3. Click **OK**.
4. Connecting Hardware: Connect a micro-USB cable between the Debug USB port on the board and the PC. This enables the programming of the microcontroller and provides a serial connection with the console device (computer).

Figure 1-21. Hardware Connection



5. Setting up the Serial Console: Open a terminal application, such as Tera Term on the PC and perform the Serial Port setup. Below is the default setup details for Tera Term.

Figure 1-22. Serial Port Setup

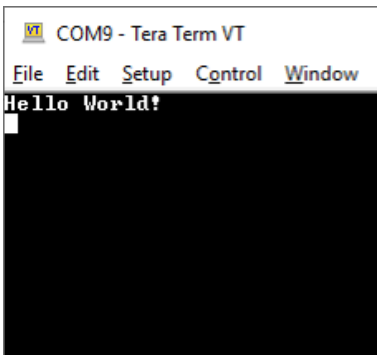


6. Programming and Running the Application: In MPLAB X IDE, click the **Make and Program** icon on the SAM D21 Xplained Pro Kit.

Figure 1-23. Make and Program

7. Observing the Output: Observe the “Hello World!” string on the console and if it is not found, press the Reset button on the SAM D21 Xplained Pro Board to reset the device, and ensure that the USART message is communicated.

Figure 1-24. Observing Output



2. Resources

- For additional information on MPLAB Harmony v3, refer to the Microchip web site:
  https://www.microchip.com/mplab/mplab-harmony
  microchipdeveloper.com/harmony3:start
- Detailed documentation on various MPLAB Harmony v3 components can be found in the documentation folder of the corresponding repository.
- SAM D21 Xplained Pro kit details can be found here:
  www.microchip.com/DevelopmentTools/ProductDetails/ATSAMD21-XPRO
- For additional informaiton on 32-bit Microcontroller Collaterals, Solutions, and Reference Guides, refer to:
  ww1.microchip.com/downloads/aemDocuments/documents/MCU32/ProductDocuments/ReferenceManuals/32-bit-Microcontroller-Collateral-and-Solutions-Reference-Guide-DS70005534.pdf

3. Revision History

Revision C - 11/2023

Made numerous editorial updates along with the following revisions throughout the document:

- Updated all references of the MHC to read MCC
- Updated numbered processes to describe the new MCC content
- Replaced all images in the document to reflect the update to the MCC

Revision B - 02/2020

Typographical updates.

Updated all references for MPLAB Harmony to display MPLAB Harmony v3.

Revision A - 12/2019

This is the initial released version of this document.

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ISBN: 978-1-6683-3554-3

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