

Creating a Hello World Application on PIC32 Microcontrollers Using MPLAB Harmony v3 and the MPLAB Code Configurator (MCC)

TB3259



Introduction

MPLAB® Harmony v3 is a software 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 v3 modules. The MCC is a plug-in for the MPLAB X Integrated Development Environment (IDE).

This document describes how to create an application on a 32-bit PIC32 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
- GPIO PLIB using the Pin manager to configure the microcontroller I/Os
- UART PLIB to configure UART peripheral as serial port

1. Creating a "Hello World" Application

This document describes how to create a "Hello World" application on PIC32 devices using the MPLAB Code Configurator (MCC) tool. It also covers the process which is shown in the following sections. The following software and hardware tools are used for this demonstration:

- [MPLAB X IDE v6.15](#)
- [MPLAB Code Configurator \[MCC\] Plugin v5.3.7](#)
- [MPLAB XC32 Compiler v4.30](#)
- MPLAB Harmony v3 repositories:
 - [MPLAB Harmony v3 "dev_packs" repo v3.18.0](#)
 - [MPLAB Harmony v3 "csp" repo v3.18.0](#)
- [Curiosity PIC32MZ EF 2.0 Development Board](#)

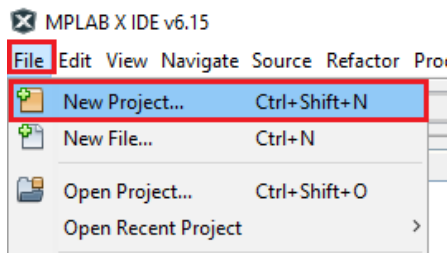
Note: Updated versions of the above listed tools can also be used to create the applications, and users are not restricted to use the older versions.

1.1 Creating an MPLAB Harmony v3-based Project

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

1. Launch MPLAB X IDE.
2. In MPLAB X IDE, from the Menu bar select *File > New Project* (or click on the New Project icon).

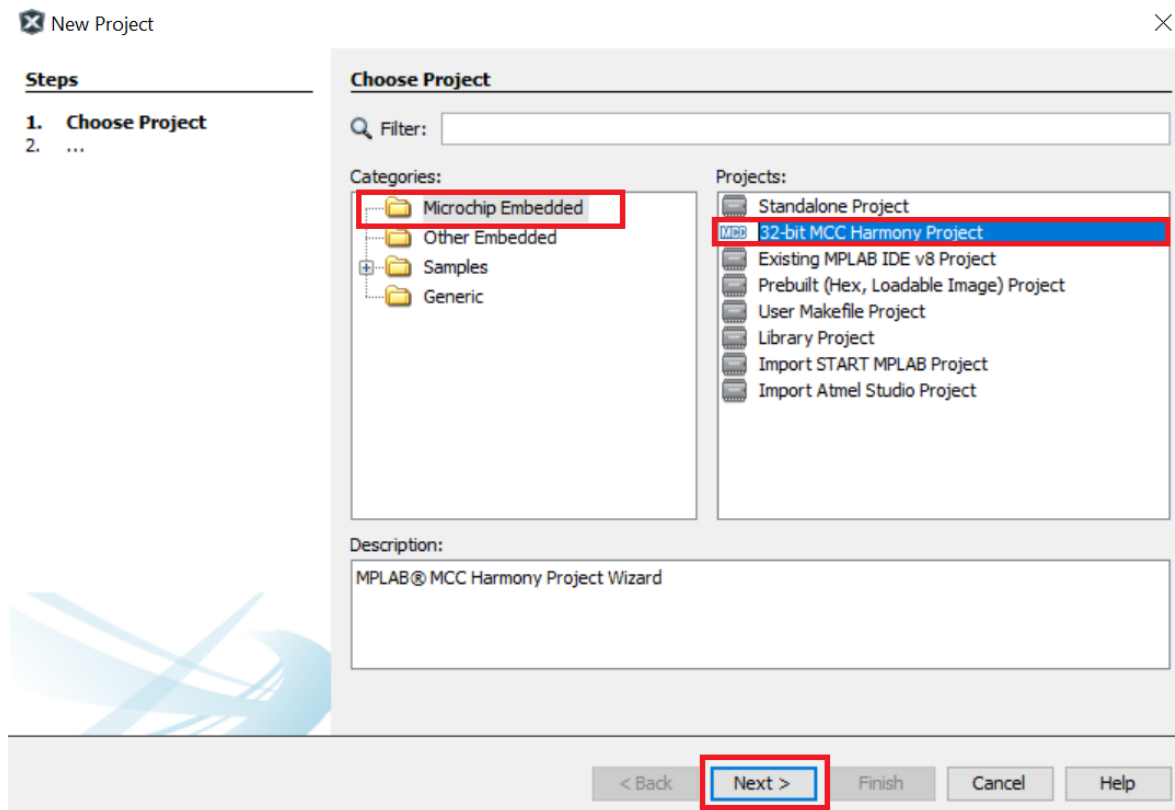
Figure 1-1. New Project



3. In the New Project window, under Steps Navigation pane, select **Choose Project**.
4. In the right Choose Project property sheet, under Categories select **Microchip Embedded** and under Projects select **32-bit MCC Harmony Project**.

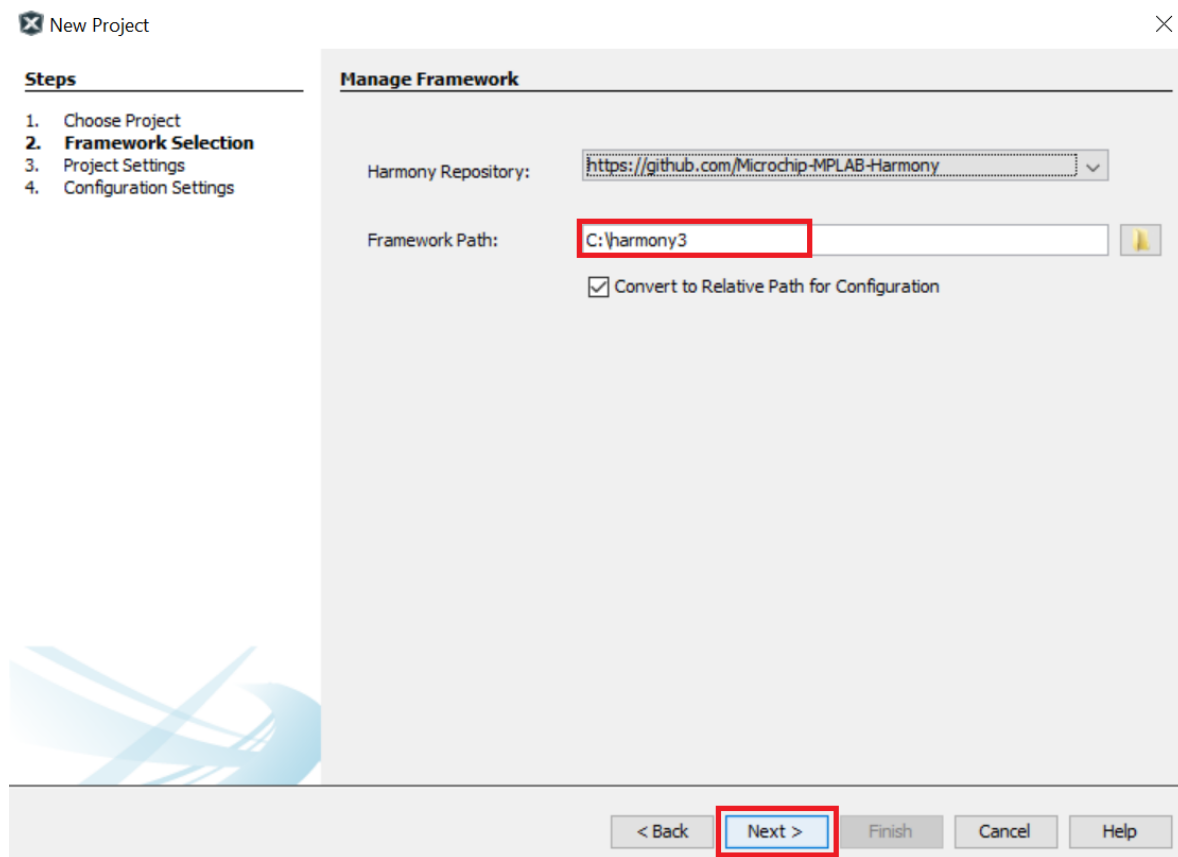
Note: If the 32-bit MCC Harmony Project is not available, install the MCC plug-in from *Tools > Plugins > Available Plugins* before continuing with this demonstration.

Note: For additional information, visit [MPLAB® Code Configurator Overview with MPLAB Harmony Content](#).

Figure 1-2. Creating MPLAB Harmony v3-Based Project - Choose Project

5. Click **Next**.
6. Under Steps Navigation pane, select **Framework Selection**.
7. In the right Manage Framework property sheet, for Framework Path enter `C:\harmony3` (i.e., the path to the folder in which the MPLAB Harmony v3 packages are downloaded).

Figure 1-3. Creating 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 it.

8. Click **Next**.
9. Under Steps Navigation pane, select **Project Settings**.
10. In the right Name and Location property sheet, enter these details:
 - **Location:** Indicates the path to the root folder of the new project. All project files are available in this folder. The project location can be any valid path, for example: *C:\Users\xxxx\HarmonyProjects\tech_brief* (where, xxxx indicates the user ID).
 - **Folder:** Indicates the name of the MPLAB X IDE folder. Enter *hello_world* to create a *hello_world.X* folder.
 - **Name:** Enter name of the project as *hello_world_pic32mz_ef_curiosity2*. This name will be displayed in the MPLAB X IDE.
 - **Path:** The path information will be updated automatically when users make changes to other fields.

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

The screenshot shows the 'New Project' dialog box with the 'Project Settings' step selected. The 'Name and Location' section contains the following fields:

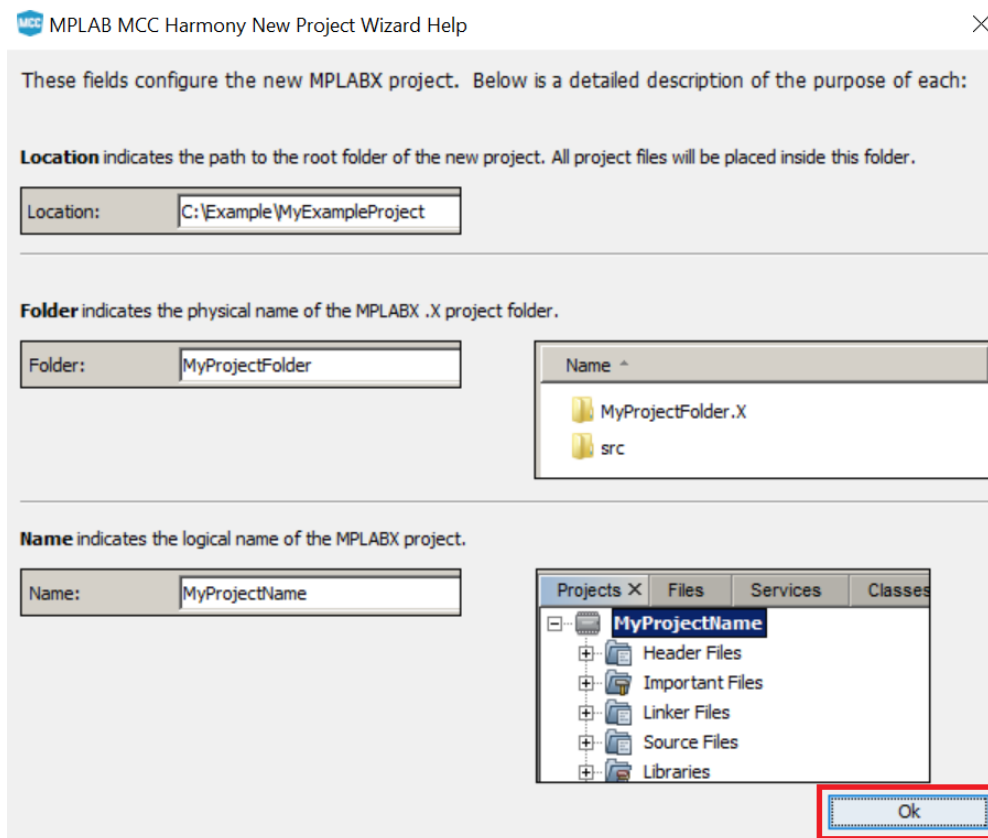
- Location: C:\Users\... \HarmonyProjects\tech_brief
- Folder: hello_world
- Name: hello_world_pic32mz_ef_curiosity2
- Path: C:\Users\... \HarmonyProjects\tech_brief\firmware\hello_word.X

A red box highlights the Location, Folder, Name, and Path fields. At the bottom of the dialog, the 'Next >' button is also highlighted with a red box. Other buttons include '< Back', 'Finish', 'Cancel', and 'Help'. A 'Show Visual Help' button is located below the input fields.

11. Click **Next**.

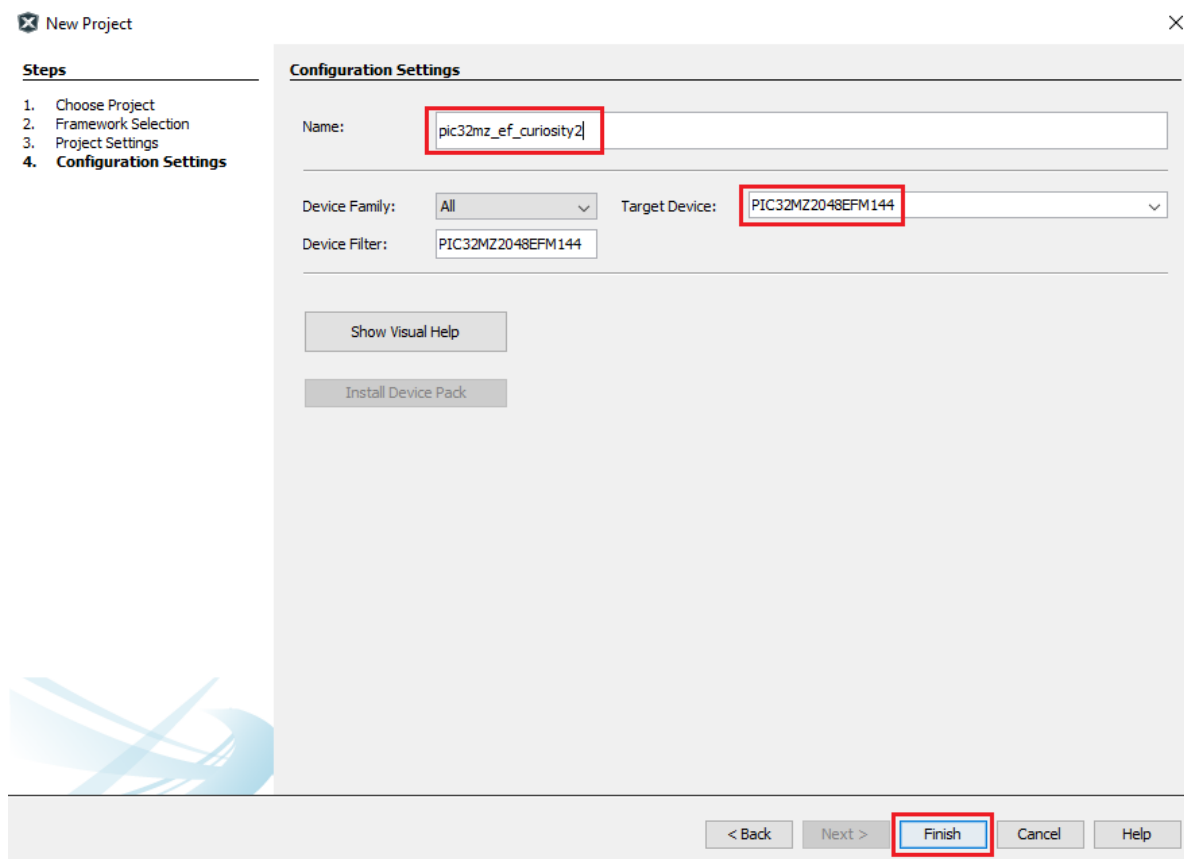
Note: To open a contextual help window for a detailed description of the various fields in the Project Settings, click on the **Show Visual Help** button. The MPLAB MCC Harmony New Project Wizard Help dialogue box will be displaced as shown below.

Figure 1-5. MPLAB MCC Harmony New Project Wizard Contextual Help



12. Under Steps Navigation pane, select **Configuration Settings**.
13. In the right Configuration Settings property sheet, enter these details:
 - Name: Enter configuration name as **pic32mz_ef_curiosity2**.
 - Target Device: In the item list, choose **PIC32MZ2048EFM144**.

Figure 1-6. Creating MPLAB Harmony v3-Based Project - Configuration Settings

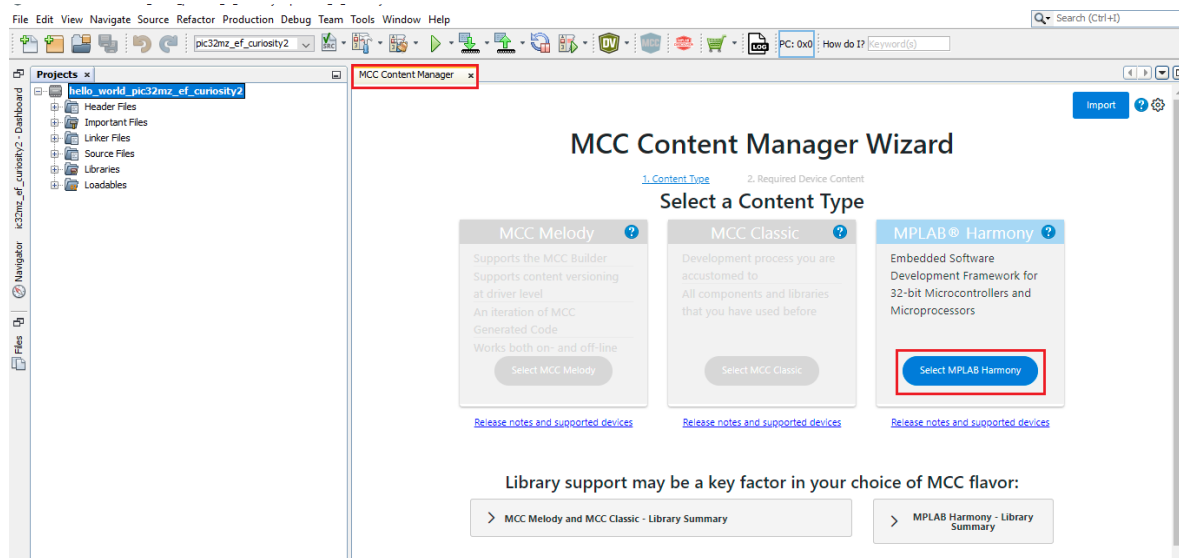


14. Click **Finish** to launch MCC.

Note: If MCC is not launched, from the Tools menu, select Embedded > *Code Configurator v5: Open/Close* from MPLAB X IDE.

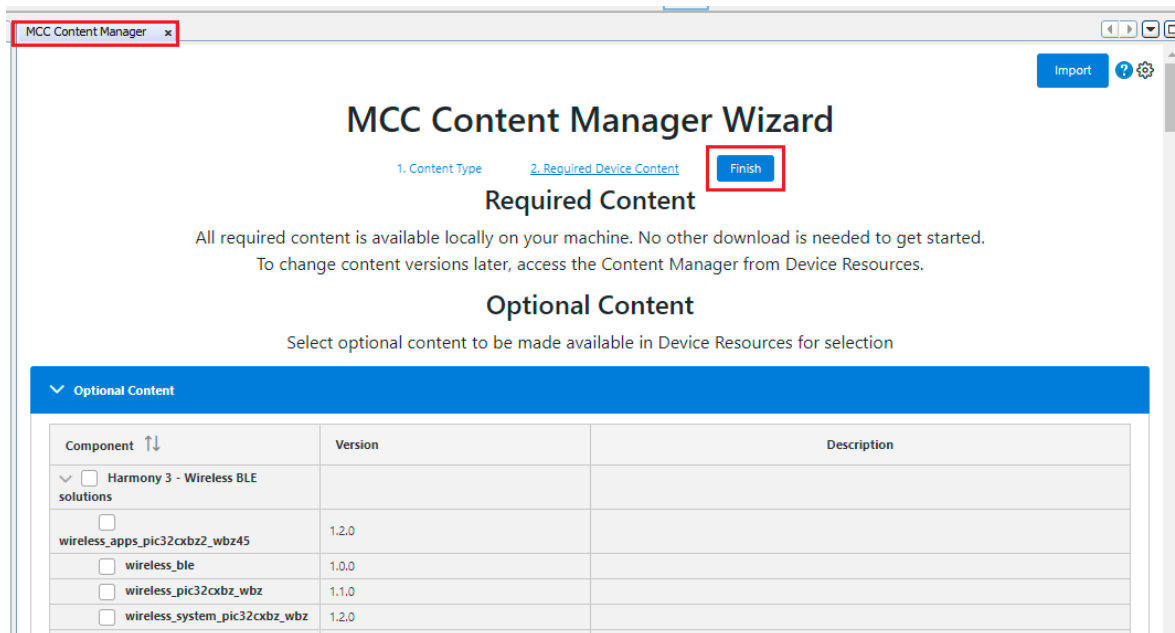
15. The MCC Content Manager property sheet is displayed, click **Select MPLAB Harmony**.

Figure 1-7. MCC Content Manager



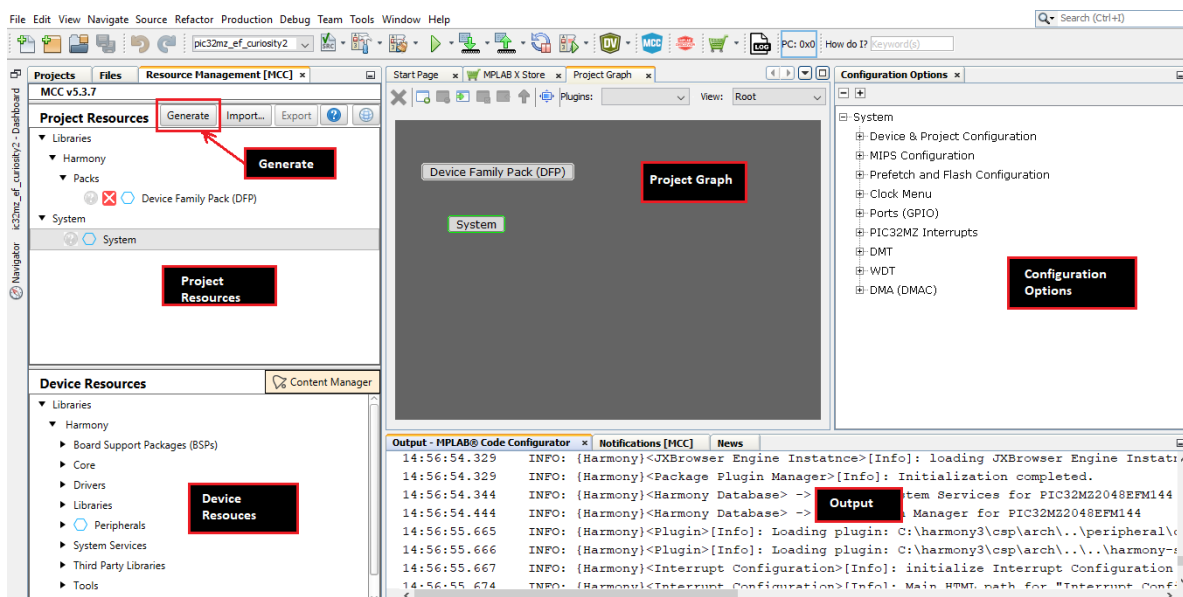
16. Click **Finish** to launch the MCC tool with packages.

Figure 1-8. MCC Setup



17. The MCC plug-in main window for the project will be displayed.

Figure 1-9. MCC Launch View

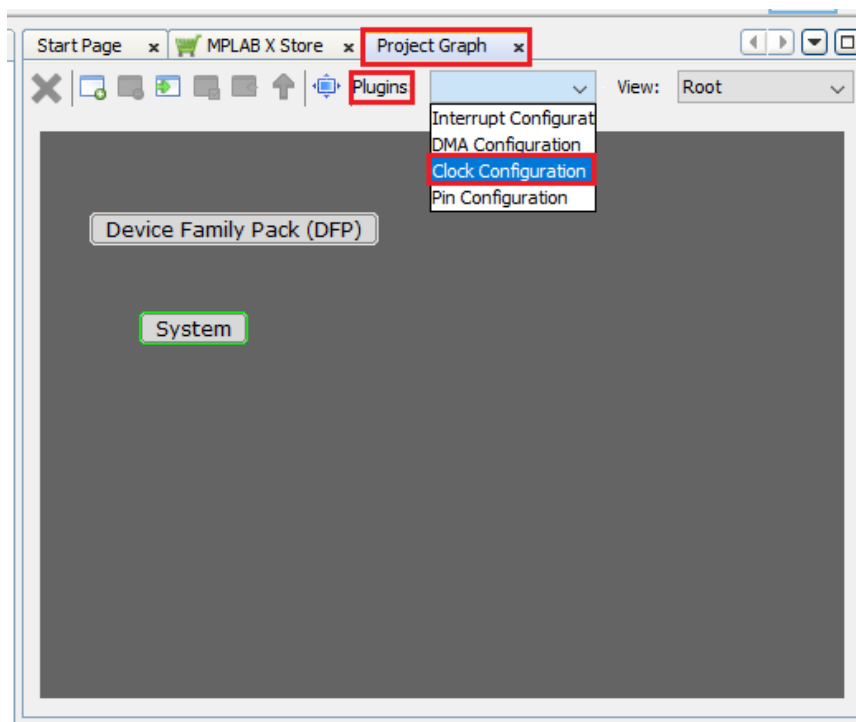


18. For additional information on MCC and how to create the MPLAB Harmony v3 project, visit: [MPLAB® Code Configurator Overview](#).

1.2 Adding and Configuring MPLAB Harmony Components

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

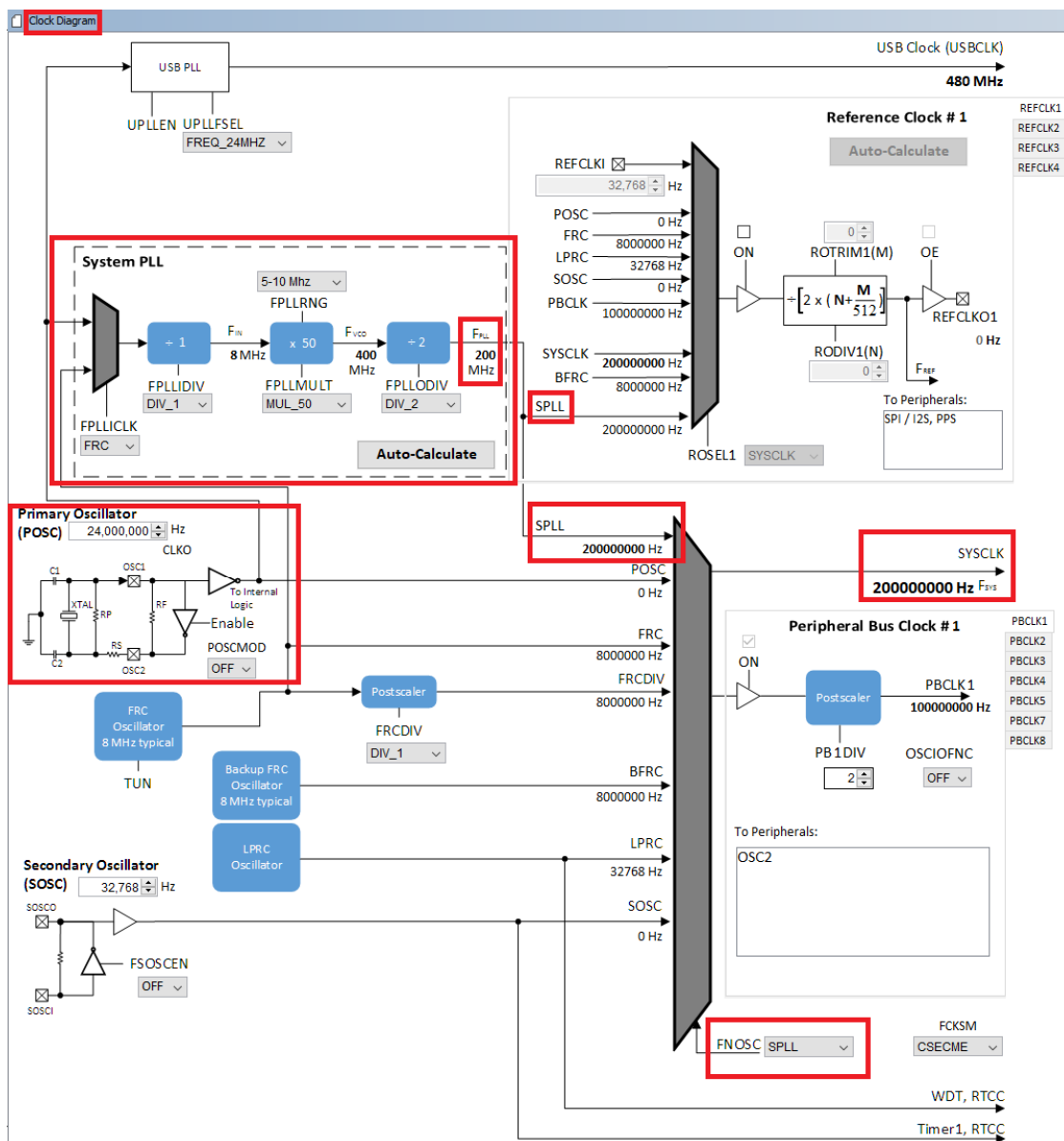
1. In MPLAB X IDE, click **Project Graph** and in the Plugins drop-down item list, select **Clock Configuration** to launch the Clock Diagram.

Figure 1-10. Clock Diagram Launch

Note: The Clock Diagram window will be launched within the MCC window.

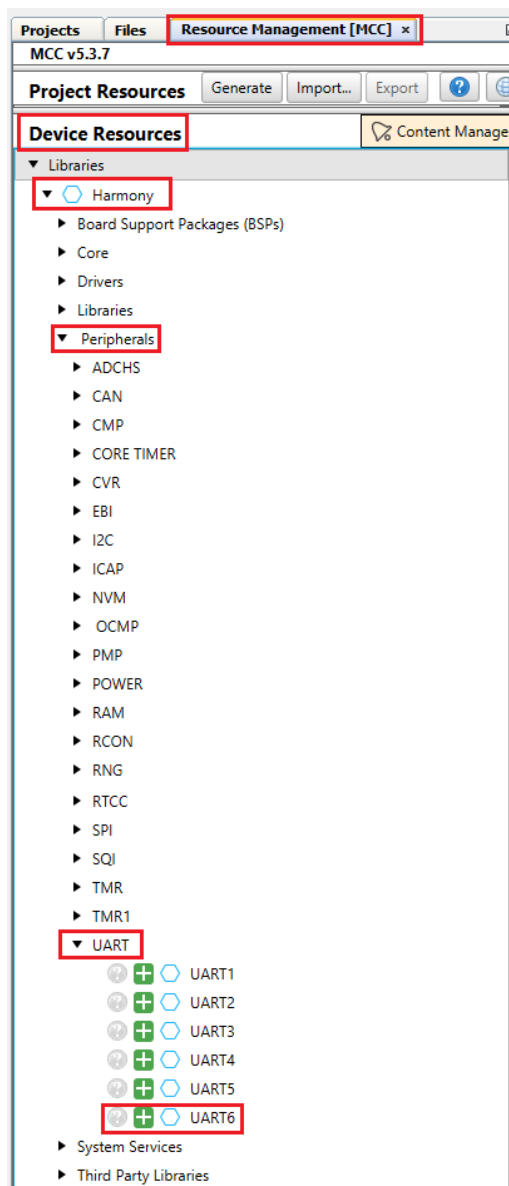
2. In the Clock Diagram window, scroll to the right and verify that the SYSCLK is set to 200 MHz.

Figure 1-11. MPLAB Harmony V3 Clock Configurator - Clock Diagram



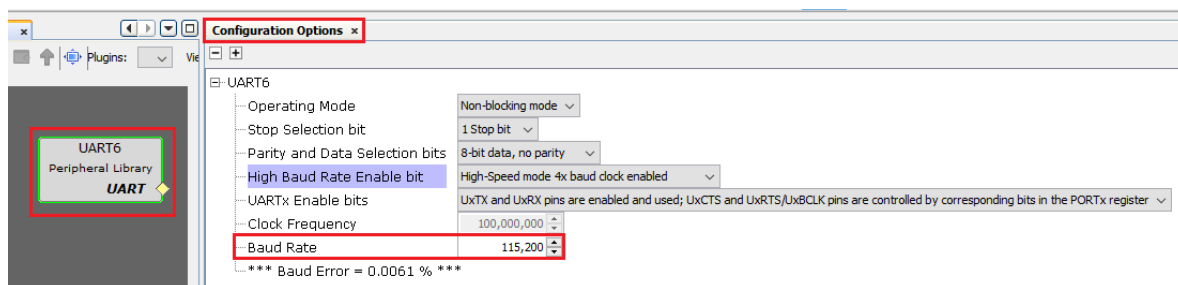
3. To add and configure the UART Peripheral Library follow these steps:
 - a. Click **Resource Management (MCC)**, and then go to **Project Resources**.
 - b. Click on the Libraries under Device Resources, and then expand *Libraries > Harmony > Peripherals > UART*, and then double-click on the **UART6** to add it to the project graph.

Figure 1-12. MCC Device Resources



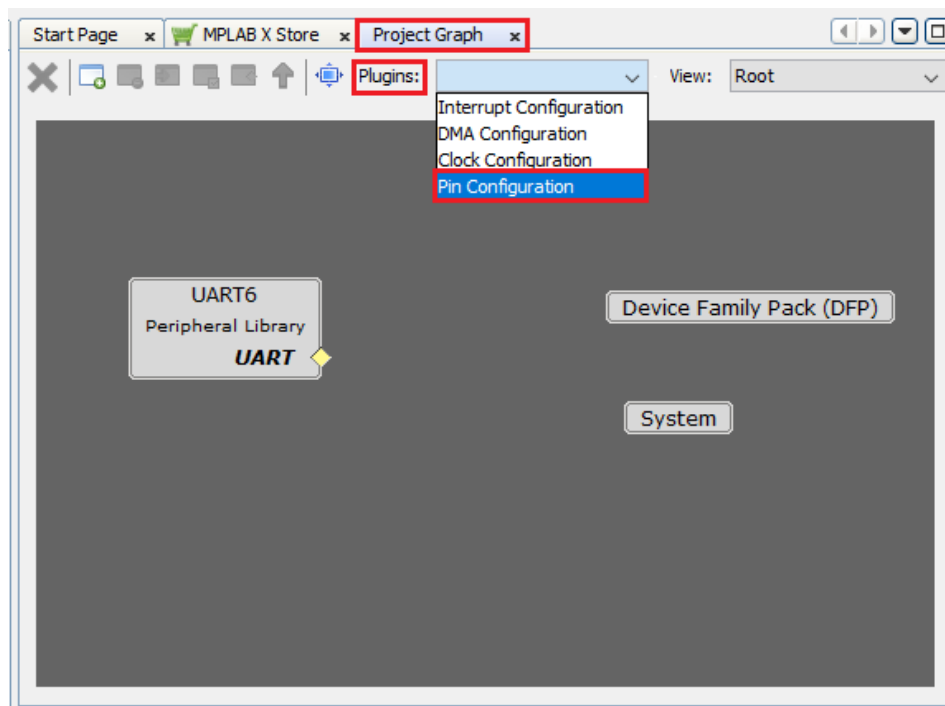
- In the Project Graph, select **UART6 Peripheral Library UART**, and in the right **Configuration Options** property sheet verify that the default Baud Rate is set to **115,200**.

Figure 1-13. MCC UART Configuration



- Configure the UART pins in the Pin Settings window. Click **Project Graph** and from the Plugins drop-down item list, select **Pin Configuration**.

Figure 1-14. MCC Pin Configuration



- The MCC Pin Configuration window will display these options: Pin Diagram, Pin Table, and Pin Settings.

Figure 1-15. MCC Pin Settings

Pin Number	Port	Voltage Tolerance	Custom Name	Function	Direction (TRIS)	Latch (LAT)
22	RA0			Available	In	n/a
56	RA1			Available	In	n/a
85	RA2	5V		Available	In	n/a
86	RA3	5V		Available	In	n/a
87	RA4	5V		Available	In	n/a
?	RA5			Available	In	n/a

Note: According to schematic of the Curiosity PIC32MZ EF 2.0 Development Board, the PICkit™ On Board 4 (PKOB4) can be used as Virtual Com Port to have serial communication between the PIC32MZ EF device and connected computer console, and for that RF2 (Pin #79) of the PIC32MZ EF must be configured as U6TX.

- Click on the **Pin Settings** tab, and then scroll down to the UART6 module. Enable the UART_TX (U6TX) function on the RF2 (pin number 79) as shown in the following figure.

Figure 1-16. UART Pin Settings

Pin Number	Pin ID	Voltage Tolerance	Custom Name	Function	Direction (TRIS)
23	RE8			Available	In
24	RE9			Available	In
124	RF0	5V		Available	In
125	RF1	5V		Available	In
79	RF2	5V		U6TX	n/a
78	RF3	5V		Available	In
90	RF4	5V		Available	In

8. Users must configure the pin number 79 (pin ID RF2) by clicking the **Pin Table** tab.

Figure 1-17. UART Pin Table

Package: TQFP		143	144	3	4	5	23	24	124	125	79	78	90	91	80	58	57
		E							F								
Module	Function	3	4	5	6	7	8	9	0	1	2	3	4	5	8	12	13
UART 5 (USART_ID_5)	U5TX																
	U5CTS																
	U5RTS											UART_TX					
UART 6 (USART_ID_6)	U6RX																
	U6TX																
	U6CTS																
USB (USBHS_ID_0)	USBID																

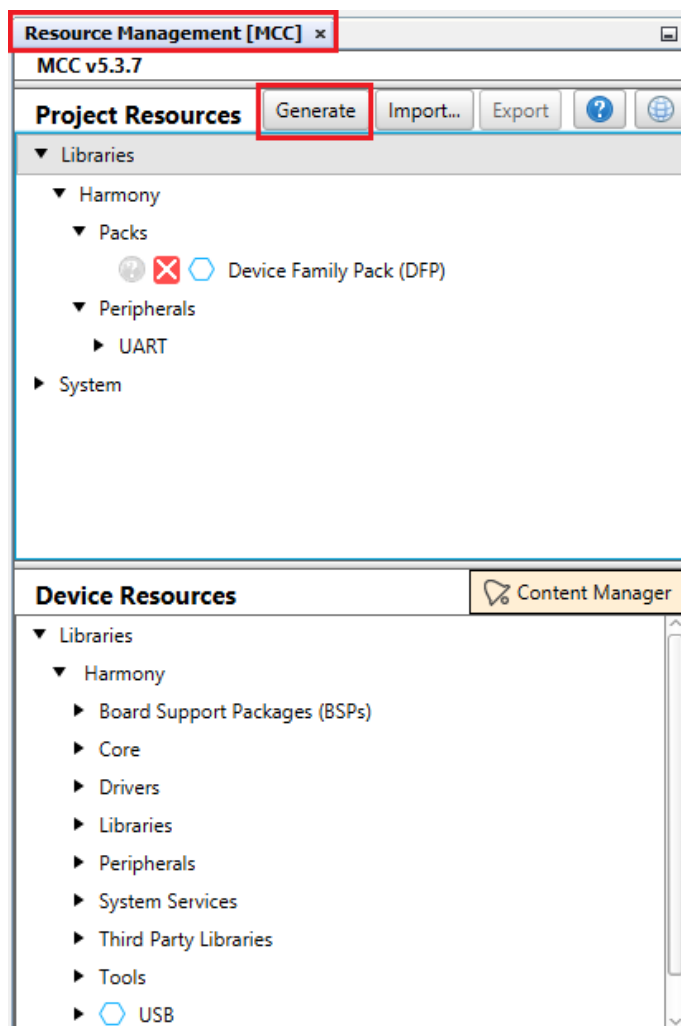
Note: The demonstration application will use the UART peripheral libraries (PLIBs) for printing messages on the serial terminal. Therefore, in the UART6 configuration, only the transmit pin is configured and the receive pin is not configured.

1.3 Generating the Code

To generate the code, follow these steps:

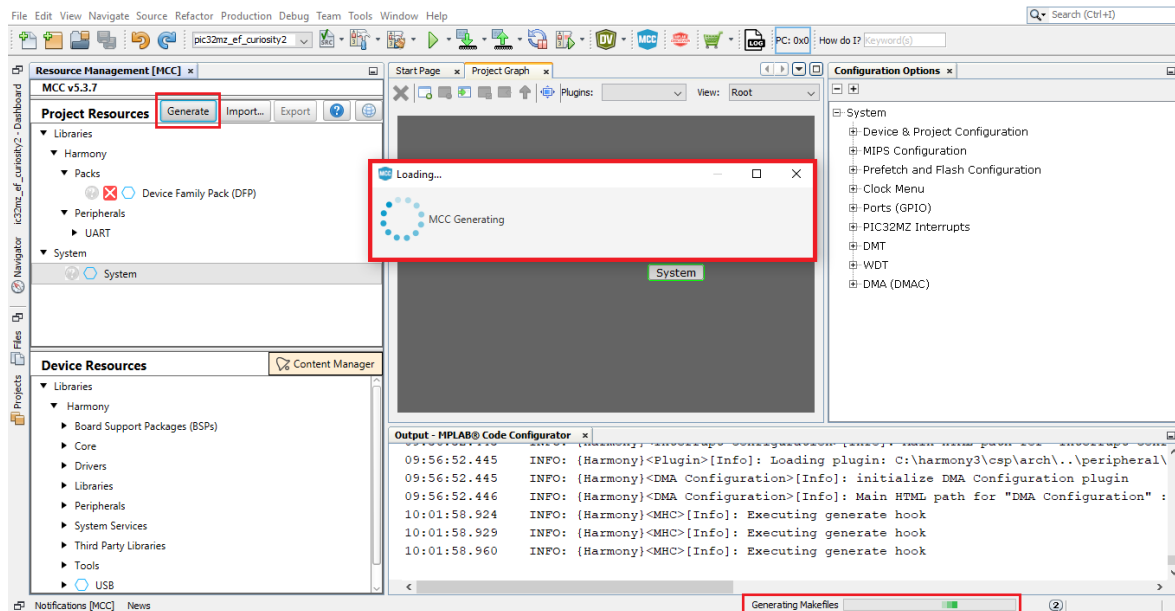
1. In the left pane, click on the **Resource Management [MCC]** tab and then click **Generate**.

Figure 1-18. MCC Generate Code



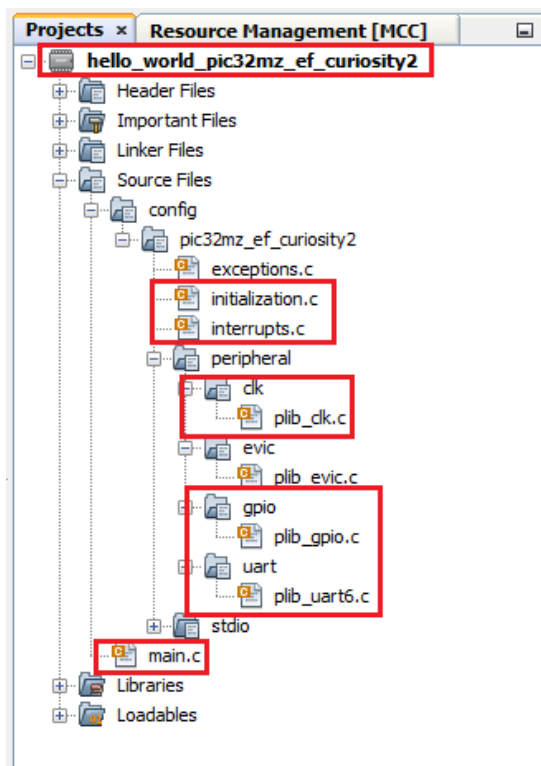
2. As code is generated, MPLAB Code Configurator will display the progress bar as shown in the following figure.

Figure 1-19. MCC Generating the Code



3. Navigate to the **Project Resources** tab to view the project tree structure, and it triggers these actions in MCC:
 - a. Generates the code as per the user configurations.
 - b. Place the generated code and required Harmony framework files in the MPLAB Harmony project directory, in this case: `C:\Users\lxxx\HarmonyProjects\tech_brief\firmware\src` (where, xxx means user ID).
 - c. Adds all generated codes and MPLAB Harmony framework files to the MPLAB Harmony project, as shown in the following figure.

Figure 1-20. MCC Generated Code

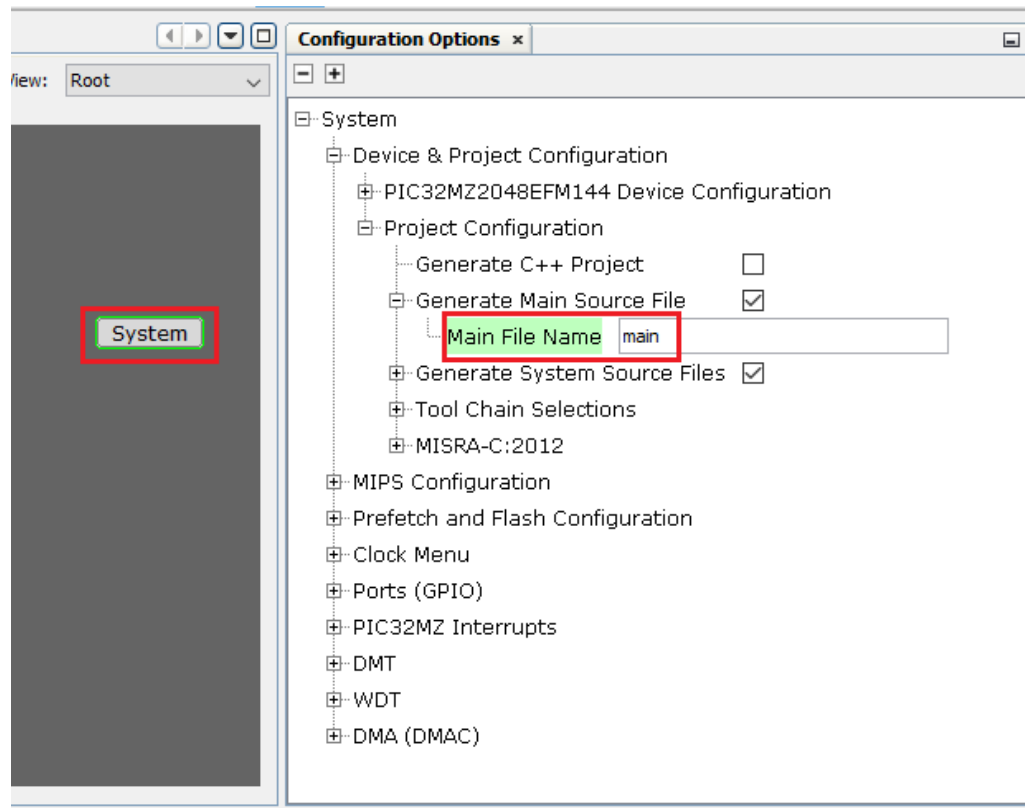



4. The generated code descriptions are as follows:

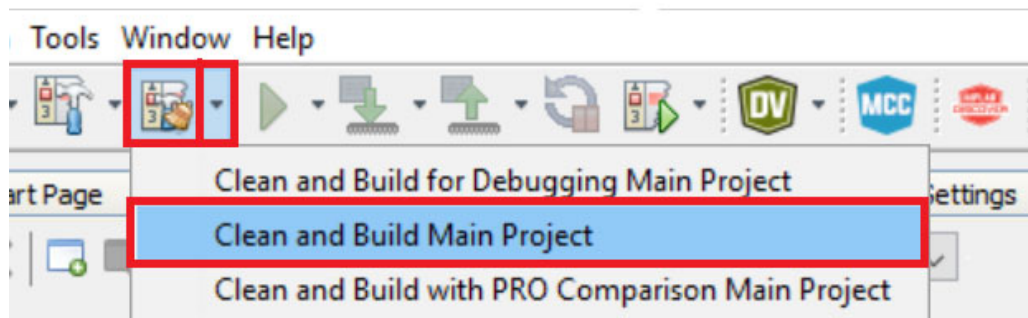
- `definitions.h`: Includes all header file definitions required for the project.
- `initialization.c`: Initializes all Harmony modules which are used in the application.
- `interrupts.c`: Contains the mapping of all interrupt vectors on the selected device.
- `main.c`: A function call to initialize the system which is 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, the default option file name `main.c` is generated.

Figure 1-21. MCC System Configuration



5. To build the project, click  (the Clean and Build icon) or click on the drop-down menu icon to select **Clean and Build Main Project**.



6. Verify that the project builds successfully. At this point, the application code can be implemented.

1.4 Developing and Running an Application

To develop and run an application, follow these steps:

1. Developing an application: For this demonstration application, add the highlighted codes (as shown below) to 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";

UART6_Write(&buffer[0], sizeof(buffer));
```

Figure 1-22. Developing Application

```
uint8_t buffer[] = "Hello World!\r\n";
// *****
// *****
// Section: Main Entry Point
// *****
// *****

int main ( void )
{
    /* Initialize all modules */
    SYS_Initialize ( NULL );

    UART6_Write(&buffer[0], sizeof(buffer));

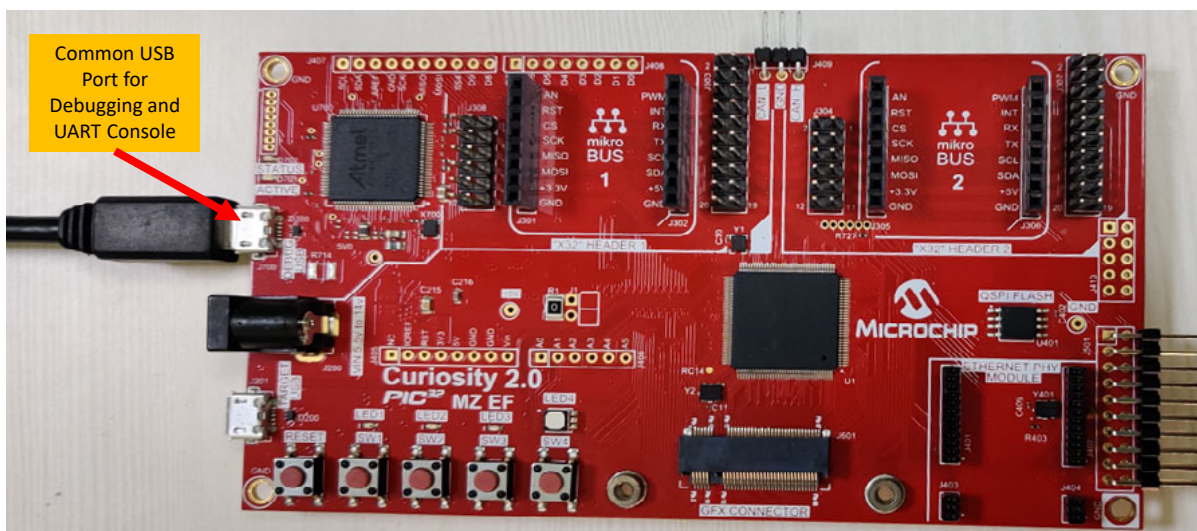
    while ( true )
    {
        /* Maintain state machines of all polled MPLAB Harmony modules. */
        SYS_Tasks ( );
    }

    /* Execution should not come here during normal operation */

    return ( EXIT_FAILURE );
}
```

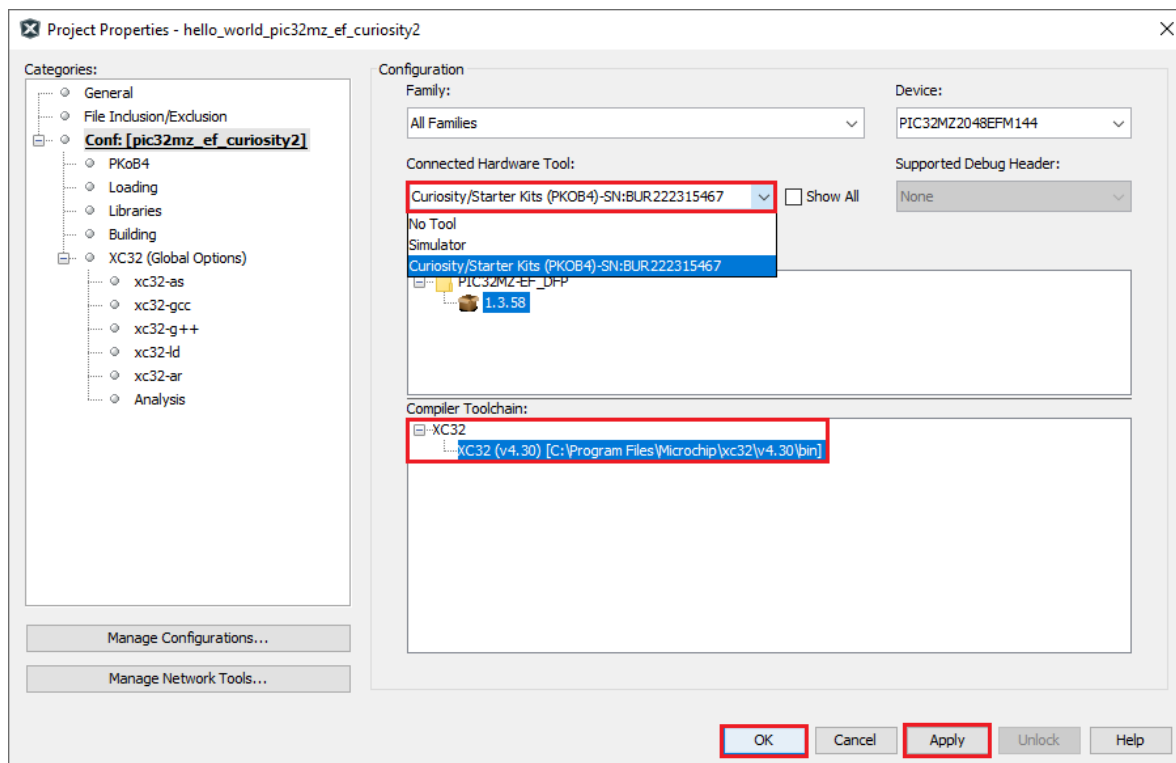
2. Connecting hardware: Connect a micro-USB cable between the DEBUG USB on the board and the PC. This enables the programming of the microcontroller and provides a serial connection with the console device.

Figure 1-23. Hardware Connection



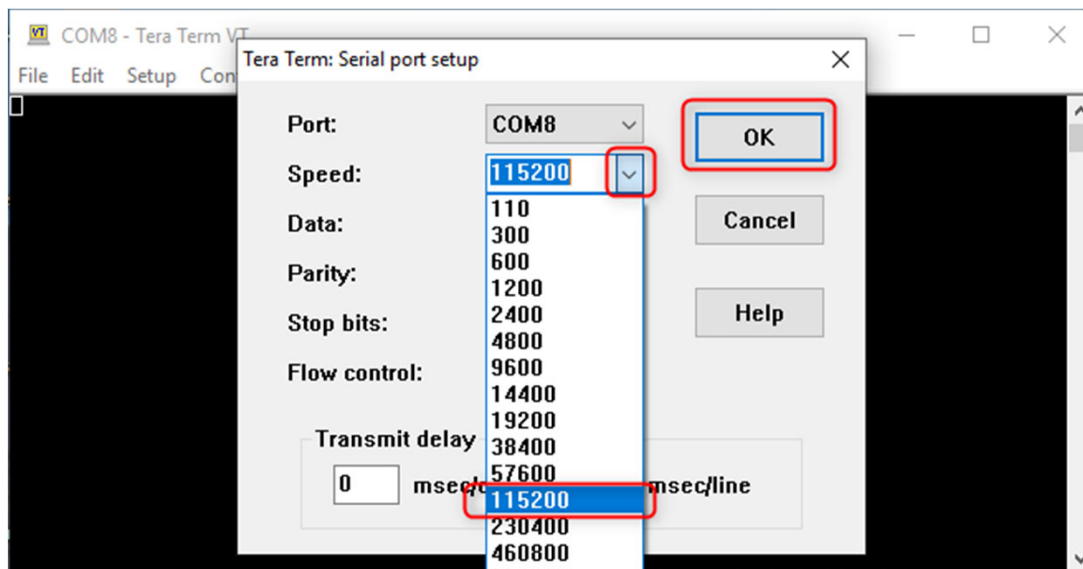
3. Selecting the hardware tool and compiler: In the MPLAB X IDE Project Properties window perform these actions.
 - a. Under the Categories section, select **Conf: [pic32mz_ef_curiosity2]**.
 - b. In the right Configuration properties sheet, select the Connected Hardware Tool and Compiler Toolchain.

Figure 1-24. Project Properties



4. Click **Apply**, and then click **OK**.
5. Setting up the serial console: Open the terminal application, Tera Term, on the PC and perform the serial port setup. The following figure shows the Tera Term setup details.

Figure 1-25. Serial Port Setup



6. Programming and running the application: To build and program the Curiosity PIC32MZ EF 2.0


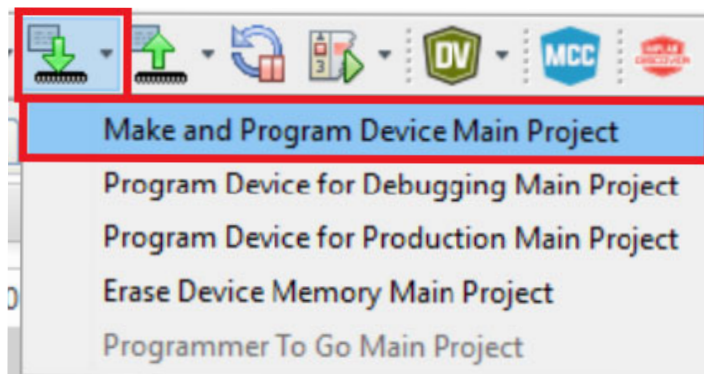
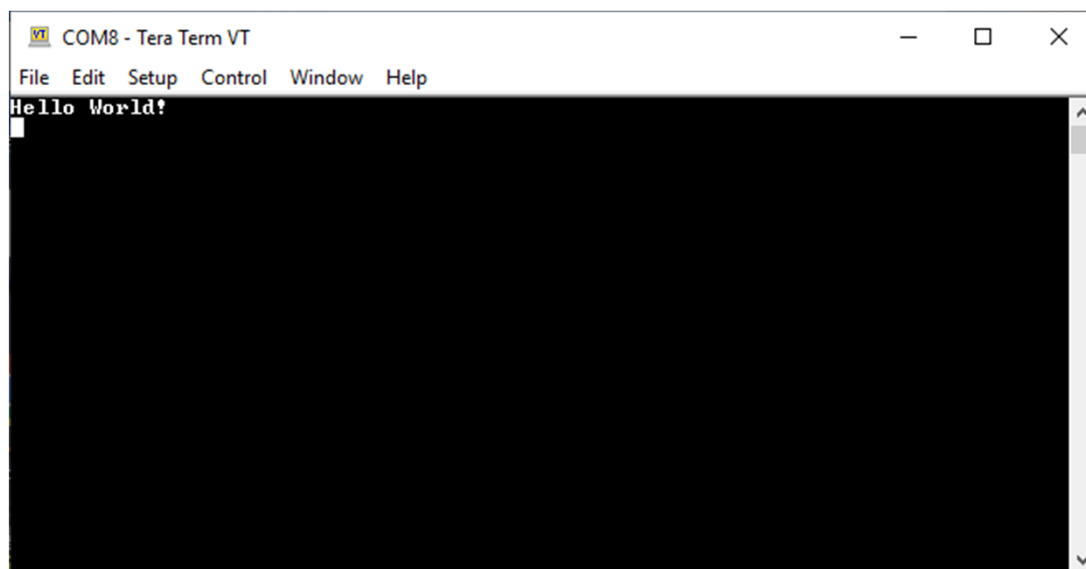
Development Board by using the MPLAB X IDE, from the MPLAB X IDE toolbar click  (the Make and Program icon) or click on the drop-down menu icon to select **Make and Program Device Main Project**.

Figure 1-26. Make and Program



7. Observing the output: Observe the "Hello World!" string on the console. If the desired output is not found on the console, press the **Reset** button on the Curiosity Development Board to reset the device, and ensure that the UART message is communicated.

Figure 1-27. Output



2. References

- For additional information on MPLAB Harmony v3, go to the Microchip web site: <https://www.microchip.com/mplab/mplab-harmony>
And
microchipdeveloper.com/harmony3:start
- For additional information about 32-bit Microcontroller collaterals and solutions, refer to: ww1.microchip.com/downloads/aemDocuments/documents/MCU32/ProductDocuments/ReferenceManuals/32-bit-Microcontroller-Collateral-and-Solutions-Reference-Guide-DS70005534.pdf
- Detailed documentation on various MPLAB Harmony v3 components can be found in the "Doc" folder of the corresponding repository.
- The Curiosity PIC32MZ EF 2.0 Development Board details are available at this location: www.microchip.com/DevelopmentTools/ProductDetails/DM320209

3. Revision History

Revision B - January 2024

The following updates were performed for this revision:

- Terminology for the MHC was converted to MCC throughout the entire document
- Applied new updated images and texts for the MCC processes in the following sections:
 - [Creating an MPLAB Harmony v3-based Project](#)
 - [Adding and Configuring the MPLAB Harmony Components](#)
 - [Generating the Code](#)
 - [Developing and Running an Application](#)

Revision A - April 2020

This is the initial version of this document.

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