Creating a "Hello World" Application on SAM Microcontrollers Using Harmony 3 MPLAB Harmony Configurator (MHC)

Introduction

MPLAB® Harmony 3 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 Harmony Configurator (MHC) is a GUI-based tool that provides an easy way to enable and configure various MPLAB Harmony modules. The MHC is a plug-in to the MPLAB X Integrated Development Environment (IDE).

This document explains how to create a simple application on a SMART Arm®-based Microcontroller (SAM) device using Harmony v3 MHC. This application sends a “Hello World!” string to a console running on a computer. For this demonstration, the following Harmony v3 modules are used and configured using the MHC:

- 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
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1. Creating “Hello World” Application

This document describes how to create a “Hello World” application on SAM devices using the Harmony v3 MHC tool. It also covers the process that involves few steps as shown below. The following software and hardware tools are used for this demonstration:

- MPLAB X IDE v5.25
- MHC v3 MPLAB Plug-in v3.3.0.1
- XC32 v2.20
- Harmony v3 repositories:
  - csp v3.4.0
  - mhc v3.3.1
  - dev Packs v3.4.0
- SAMD21 Xplained Pro board

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

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

1. Launch MPLAB X IDE.
2. In MPLAB X IDE, select *File > New Project* (or click the New Project icon).
3. In New Project window, under Steps, select Choose Project, and then under Choose Project section, select these options: for Categories select Microchip Embedded, and for Projects select 32-bit MPLAB Harmony 3 Project.

   **Note:** If the option 32-Bit MPLAB Harmony v3 Project is not available, install the MPLAB Harmony v3 Configurator plug-in from *Tools > Plugins > Available Plugins* before continuing with this demonstration. The MPLAB Harmony v3 Configurator overview is available for download at [https://microchipdeveloper.com/harmony3:mhc-overview](https://microchipdeveloper.com/harmony3:mhc-overview).
4. Click **Next**.

5. Under **Steps**, select **Framework Selection**, and under **Manage Framework section**, enter **Framework Path** (Path to the folder in which the MPLAB Harmony v3 packages are downloaded). For this demonstration, the MPLAB Harmony v3 packages are downloaded in the following location: `D:\microchip\github\h3`.
**Figure 1-2. Creating MPLAB Harmony v3-Based Project - Framework Selection**

**Note:**

1. The Framework Downloader tool simplifies the downloading of the MPLAB Harmony v3 packages. If these packages are not downloaded, then the user can use the Framework Downloader tool.

2. For this demo application, the following Harmony v3 packages are required: mhc, dev_packs, and csp

6. Click **Next**.

7. Under Steps, select Project Settings, and in the Name and Location 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: `D:\microchip\github\h3\tech_brief`.
   - Folder: Indicates the name of the MPLABX X IDE folder. Enter `hello_world` to create a `hello_world.X` folder.
   - Name: Enter name of the project as `hello_world_sam_d21_xpro`. This name will be displayed in the MPLAB X IDE.
   - Path: The path information will be updated as and when users make changes to other fields.
Figure 1-3. Creating an MPLAB Harmony v3-Based Project - Project Settings

8. Click **Next**.
9. Under Steps, select Configuration Settings, and in the Configuration Settings section enter the details as given below:
   - Name: Enter the configuration name as *sam_d21_xpro*.
   - Target Device: Choose ATSAMD21J18A.

**Note:** Click the **Show Visual Help** button to open a contextual help window for a detailed description of various fields in the Project 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 the MHC.  
**Note:** After clicking the **Finish** button, if MHC does not launch, users can launch it by selecting **Tools > Embedded > MPLAB® Harmony 3 Configurator** from the MPLAB X IDE.

11. Before launching the MHC, the Configuration Database Setup window will be displayed, where MPLAB Harmony v3 packages to be used are selected or deselected. The Device Family Pack (DFP) and Cortex Microcontroller Software Interface Standard (CMSIS) path can be changed, if required. For this demonstration, the default settings are used. Apart from “csp”, the user can clear other packages, if any, as shown in figure below.
Figure 1-5. Configuration Database Setup

12. Click Launch.
13. The MHC plug-in will open in a new window. The image below highlights different section available in the MHC.

Figure 1-6. MPLAB Harmony v3 Configurator Window
Note: For this demonstration, Stand-alone mode is used for the MHC Window Manager by changing the settings in the MPLAB X IDE, by selecting > Tools > Options > Plugins > MPLAB Harmony Configurator 3 > Window Manager. If the Native Netbeans mode of the MHC is required, users can set it as default mode by configuring it.

14. For additional information on MHC and how to create MPLAB Harmony v3 project, visit: https://microchipdeveloper.com/harmony3:mhc-overview.

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

1. From Tools, select Clock Configuration to launch the Clock Easy View.

   ![Figure 1-7. MPLAB Harmony Configurator Tools](image)

   The Clock Easy View window will be displayed inside the MHC Window.

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

   ![Figure 1-8. MPLAB Harmony 3 Clock Configurator - Clock Easy View](image)

3. To add and configure the USART Peripheral Library follow these steps:
   - Under Available Components, expand Peripherals and then expand the options available for SERCOM.
   - Double-click on the SERCOM3 to add it to the project.
4. Select the SERCOM3 Peripheral Library in the Project Graph, and in the Configuration Options window, 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 9600 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.
5. Configure the USART pin in the Pin Settings: In the MHC, select Tools > Pin Configuration to open the Pin Settings window.

Figure 1-11. MHC Pin Configuration

6. The MHC Pin Settings window will open and display these options: Pin Diagram, Pin Table, and Pin Settings.
According to the schematic of the SAMD21 Xplained Pro board, the on-board Embedded Debugger (EDBG) can be used as Virtual Com Port to have serial communication between the SAMD21 device and a connected computer console. Therefore, the PA22 (Pin #43) of the SAMD21 must be configured as UART_TX (SERCOM3_PAD0).

7. Click the Pin Settings tab and configure the PA22 pin as SERCOM3_PAD0.

8. The same pin (PA22) can be configured by clicking the Pin Table tab.
Figure 1-14. SERCOM Pin Table

Note:
1. The USART_TX function (Transmit Pinout) is by default configured to be on SERCOM3 PAD0, for additional information, refer to MHC 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 MHC click on the save icon to save the MHC state before generating the code.
   Figure 1-15. Save MHC State
2. Save the configuration in its default location, when prompted.
3. Click on the generate code icon to generate the code.
4. The Modified Configuration window is prompted, click **Save** to save the configuration.

**Figure 1-17. Saving Configuration**

5. In the Generate Project window, click **Generate** to generate the code.
6. The above step triggers these actions in MHC:
   - Generate 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: `D:\microchip\github\h3\tech_brief\firmware\src`.
   - Add all generated codes and MPLAB Harmony framework files into the MPLAB Harmony project, as shown in the following figure.
Figure 1-19. MHC Generated Code

Note: The MPLAB Harmony project will be shown in another window as this project is in Standalone mode.

7. The generated code descriptions are as follows:
   - definitions.h: Includes all the header files required for the project.
   - initialization.c: Initializes all the Harmony modules used in the application.
   - interrupts.c: Contains the mapping of all the 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: The MHC 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.
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:

```c
tuint8_t buffer[] = "Hello World!\n";
SERCOM3_USART_Write(&buffer[0], sizeof(buffer));
```

2. Selecting Hardware Tool and Compiler: In the MPLAB X IDE Project Properties window perform these actions:
   1. Under Categories section, select Conf: (sam_d21_xpro), and in the Configuration section, select the hardware tool and compiler toolchain.
4. Click OK.

5. 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 provide a serial connection with the console device (computer).

6. 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.
7. Programming and Running the Application: Build and program the SAMD21 Xplained Pro kit by using the MPLAB X IDE.

Figure 1-25. Make and Program

8. 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 Xplained Pro board to reset the device, and ensure that the UART message is communicated.

Figure 1-26. Observing Output
2. Resources

- For additional information on MPLAB Harmony 3, refer to the Microchip web site:
  https://www.microchip.com/mplab/mplab-harmony
  https://microchipdeveloper.com/harmony3:start
- Detailed documentation on various Harmony 3 components can be found in the documentation folder of the corresponding repository.
- SAM D21 Xplained Pro kit details can be found here:
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