AN4495

MPLAB Harmony v3 Project Migration

Introduction

MPLAB® Harmony v3 is a modular framework that provides interoperable firmware libraries for application development on 32-bit microcontrollers and microprocessors. It includes an easy-to-use graphical user interface (GUI), MPLAB Code Configurator (MCC), or MPLAB Harmony Configurator (MHC) for selection, configuration, code generation, peripheral libraries, drivers, and extensive middlewares such as, USB, TCP/IP, Graphics.

This document discusses the migration of an existing MPLAB Harmony v3 based project developed on a particular hardware (microcontroller or development board) platform to another one of Microchip's 32-bit hardware platforms of the user's choice.

Note: In this document, the phrase *code generation tool* refers to any one of the Microchip code generation tools: MPLAB Code Configurator (MCC) and MPLAB Harmony Configurator (MHC). At the time of publication of this document, the MPLAB Harmony v3 library code can be generated using either of these tools. However, in the future, only MCC will support MPLAB Harmony v3 code generation.

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1. Overview

Typically, the application project development for an embedded product starts by using the available reference collateral. As part of the MPLAB Harmony v3 packages, Microchip provides reference application demonstrations for customers to develop their projects. These MPLAB Harmony v3 projects are developed on Microchip's development boards, such as 32-bit SAM or PIC32 microcontrollers (MCUs). The users can start with these application demonstrations and migrate them to the hardware platform of their choice.

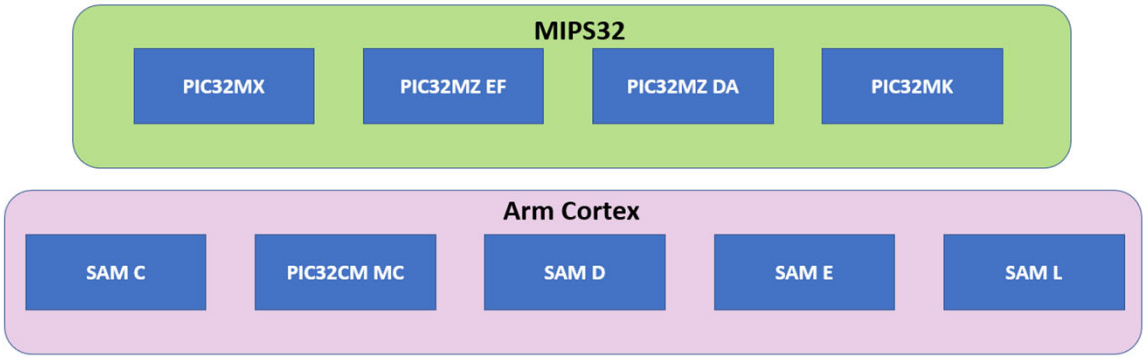
This document discusses migrating an MPLAB Harmony v3 application demonstration project developed on Microchip's development board or kit in the following scenarios.

- **Scenario #1**: Enhance or customize the existing application demonstration
- **Scenario #2**: Migrating to a custom board having an MCU with the same device ID
- **Scenario #3**: Migrating to an MCU with a different device ID within the same family
- **Scenario #4**: Migrating to an MCU with a different device ID in another MCU family with the same processor core

Notes:

1. The following figure shows some of the 32-bit microcontroller product families in the Arm® Cortex® and MIPS core architectures. For additional information on Microchip 32-bit microcontroller families, refer to https://www.microchip.com/en-us/products/microcontrollers-and-microprocessors/32-bit-mcus.

   Figure 1-1. 32-bit Microcontroller Families



2. Several MCU parts with varying features are provided within each family shown for Arm Cortex and MIPS32 core architectures, for example, the PIC32MX family has PIC32MX250F128B, PIC32MX470F512L, PIC32MX795F512L, and so on.
3. Scenario #3 and Scenario #4, as mentioned above, covers migration within the family of devices and outside of the family, but within the same core architecture.
4. There could be another possible scenario, Scenario #5, wherein a user would like to migrate an application developed on a MIPS-based MCU to an Arm Cortex-based MCU, or Arm to MIPS. This document does not cover such a scenario, because the processor architectures are entirely different, creating a project from scratch is advised instead of attempting the migration.

2. Migration Components

In the following sections, the MPLAB Harmony v3 project SD Card, USB Data Logger Application on SAM D21 Xplained Pro Evaluation Kit is used as a reference and referred to as the 'Reference Project'.

2.1 MPLAB X IDE Project

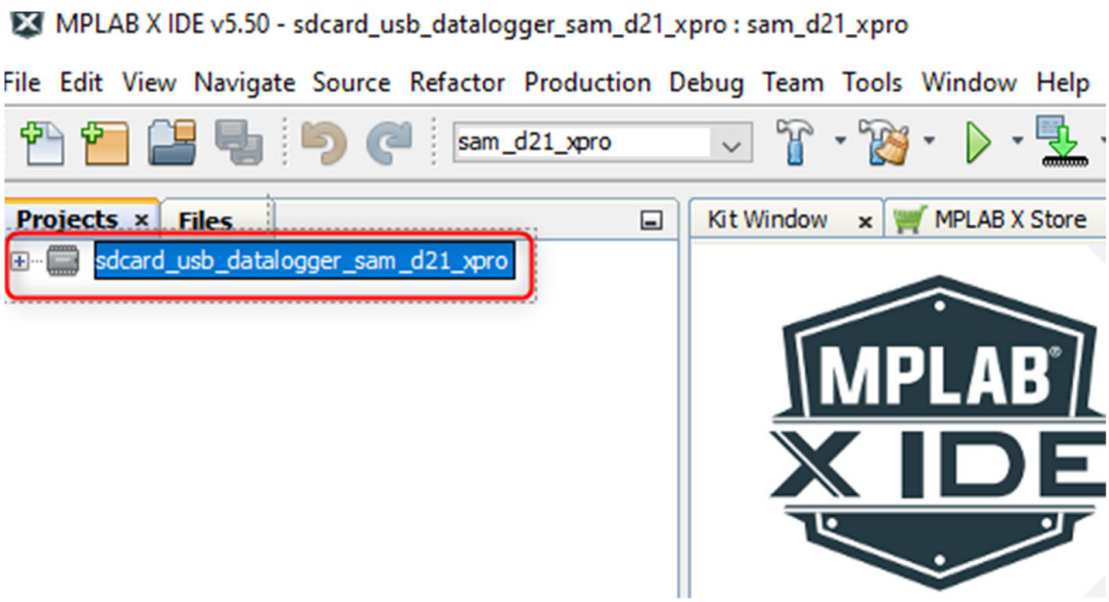
The MPLAB X IDE project configuration parameters to be considered for migration are as follows.

1. **Location:** The path to the root folder of the project.
2. **Folder name:** The name of the `.X` folder.

Figure 2-1. Project Folder Name

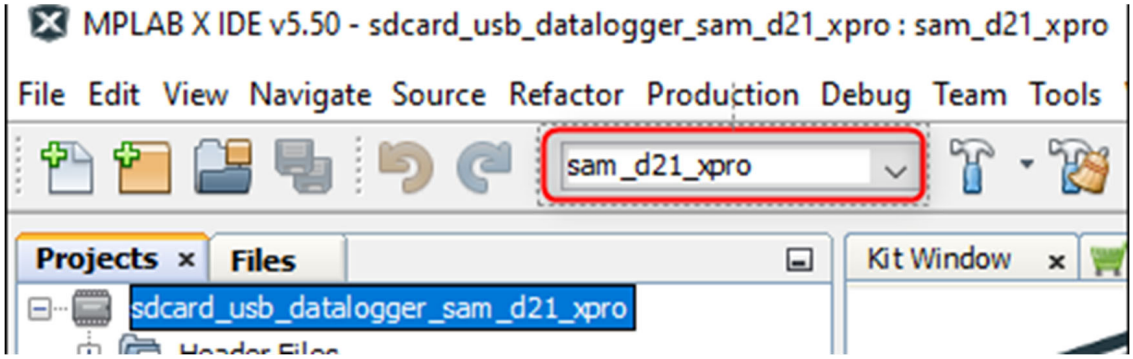
3. **Name:** The project's logical name, which is available in the MPLAB X IDE project explorer.

Figure 2-2. MPLAB X Project Name



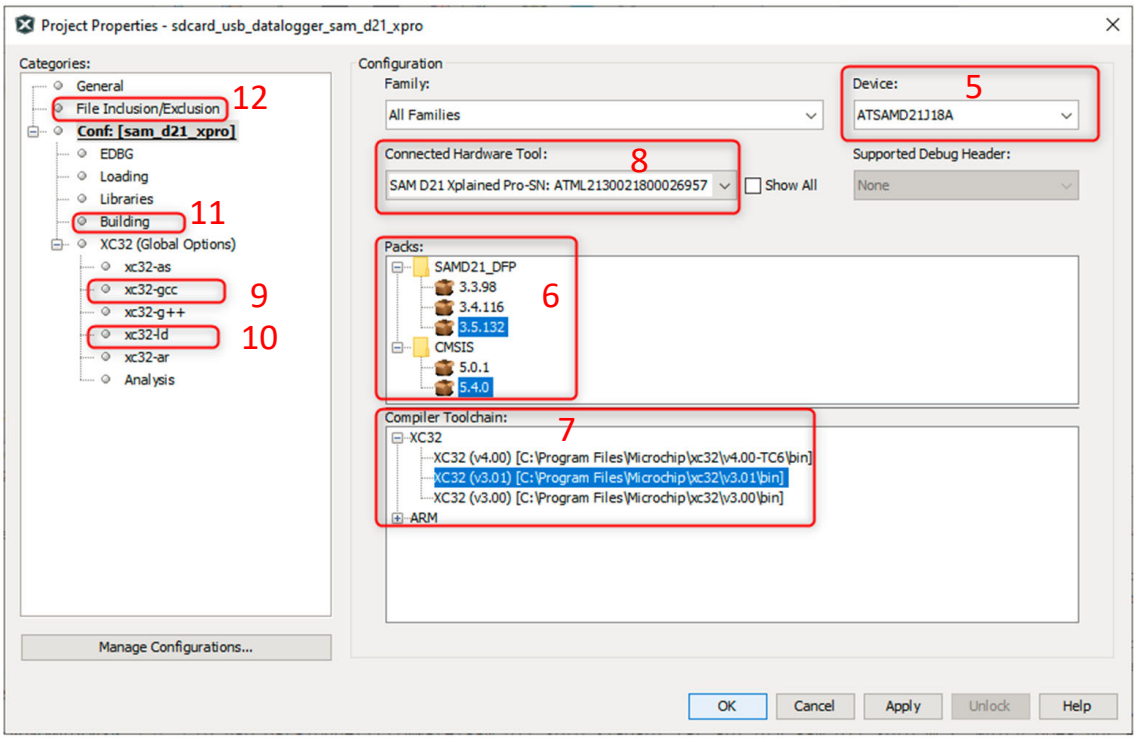
4. **Configuration name:** A feature in MPLAB X IDE that enables a platform or target specific build and programming.

Figure 2-3. MPLAB X Project Configuration Name



5. **Target device:** The MCU device ID on which the project is developed.
6. **Support packages:** The device family packages (DFP) include the macro definitions to access the peripheral registers of the target MCU. On Arm Cortex devices, the CMSIS packages are also included.
7. **Compiler toolchain:** This shows the compiler toolchain and its version.
8. **Programming or debugging tool:** The hardware tool used for debugging or programming the MCU.
9. **Build options:** The compiler build options and any other options enabled for source code optimization.
10. **Linker options:** The default settings for the heap, stack memory, and other related parameters.
11. **Pre or Post-build scripts:** Specifies any scripts or command lines that must be run before or after the project build.
12. **Source and library files reference:** The relative path to the MPLAB Harmony v3 generated, user-added source, header, and library files.

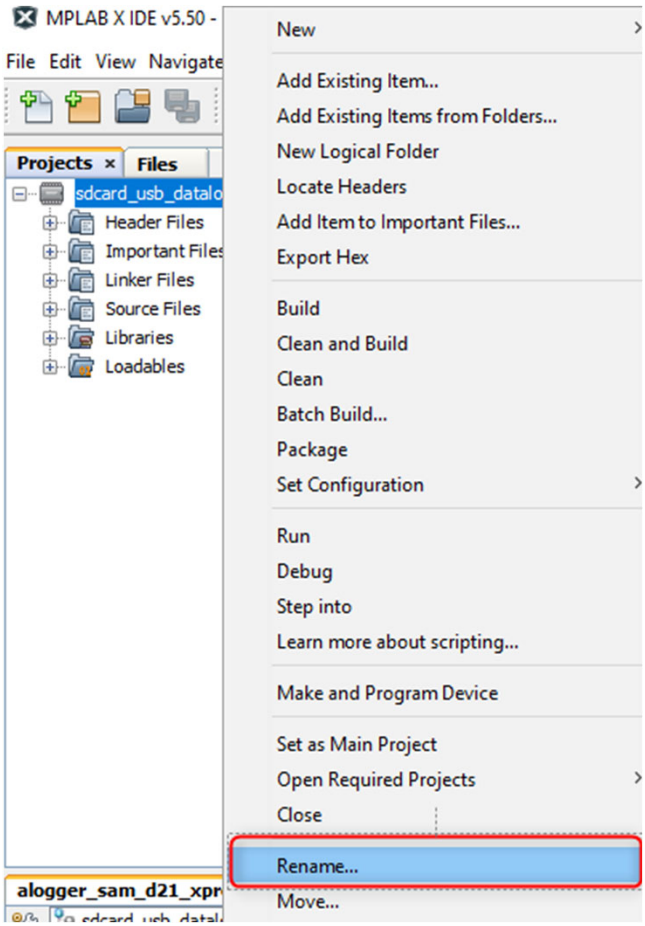
Figure 2-4. MPLAB X Project Properties



The MPLAB X IDE configuration parameters are saved in the `configurations.xml` file in the MPLAB X IDE project folder. The Reference Project is found at *samd21_sdcard_usb_datalogger\firmware\sam_d21_xpro.X\nbproject*.

- For Scenario #1, the existing MPLAB Harmony v3 application demonstration developed on Microchip's development board or kit is used and customized to add or remove MPLAB Harmony v3 modules. The existing MPLAB X IDE project's configuration parameters will suffice and do not require changes. However, the user can change some parameters to suit the end application.
  - To rename the MPLAB X IDE project and folder names, open the project in MPLAB X IDE, and then right-click on the project name, and select **Rename**.

    Figure 2-5. MPLAB X Project Renaming



  - To rename an MPLAB X IDE configuration parameter, refer to the technical brief How to Add a New Configuration to an Existing MPLAB Harmony v3 Project. Renaming a configuration is not advised for scenario #1, as renaming a configuration in MPLAB Harmony v3 essentially creates a new MPLAB X IDE project.
  - The other MPLAB X IDE parameters, listed in Step 5 through Step 12, can be changed or modified through the Project Properties window shown in Figure 2.4.
- For Scenarios #2, #3, and #4, for the MCU device ID, under the **Adding a New Configuration section** section, go to the sub section **Creating a project in MPLAB X IDE**, and then follow the details given in the document How to Add a New Configuration to an Existing MPLAB Harmony v3 Project . Ensure to provide the required MPLAB X IDE configuration parameters listed in the preceding Step 1 through Step 12, specifically, the Target device ID.

2.2 Tool Configurations

The MCC or MHC tool saves the configurations of all the components used in the project graph in separate files. Additionally, it allows the import and export of these configurations.

The action of saving the selected component's configuration to an external file is called export. Import reads the external configuration of a component, or a group of components saved in an external file and incorporates that configuration in the current project.

The MCC tool configuration file, `.mc3`, is available in the MPLAB X IDE project folder. For the Reference Project, it is available in the following location: *samd21_sdcard_usb_datalogger\firmware\sam_d21_xpro.X*.

The MHC tool configuration file is available in the MHC folder. For the Reference Project, it is available in the following location: *samd21_sdcard_usb_datalogger\firmware\src\config\sam_d21_xpro\sam_d21_xpro.mhc*.

The import feature is useful for the migration scenarios discussed above.

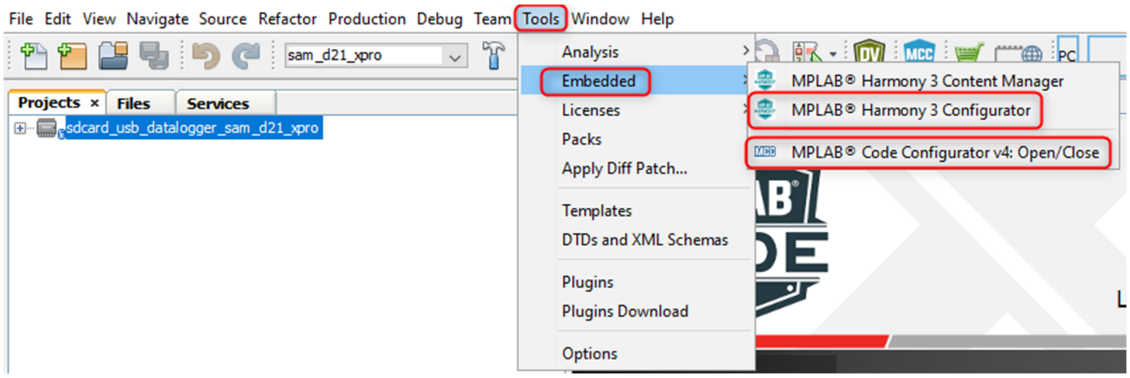
Launching MCC:

1. Open the Reference project in MPLAB X IDE.
2. To launch MCC go to *Tools* > *Embedded* > *MPLAB Code Configurator v4*.

Launching MHC:

1. Open the Reference Project in MPLAB X IDE.
2. To launch the MHC go to *Tools* > *Embedded* > *MPLAB Harmony 3 Configurator*.

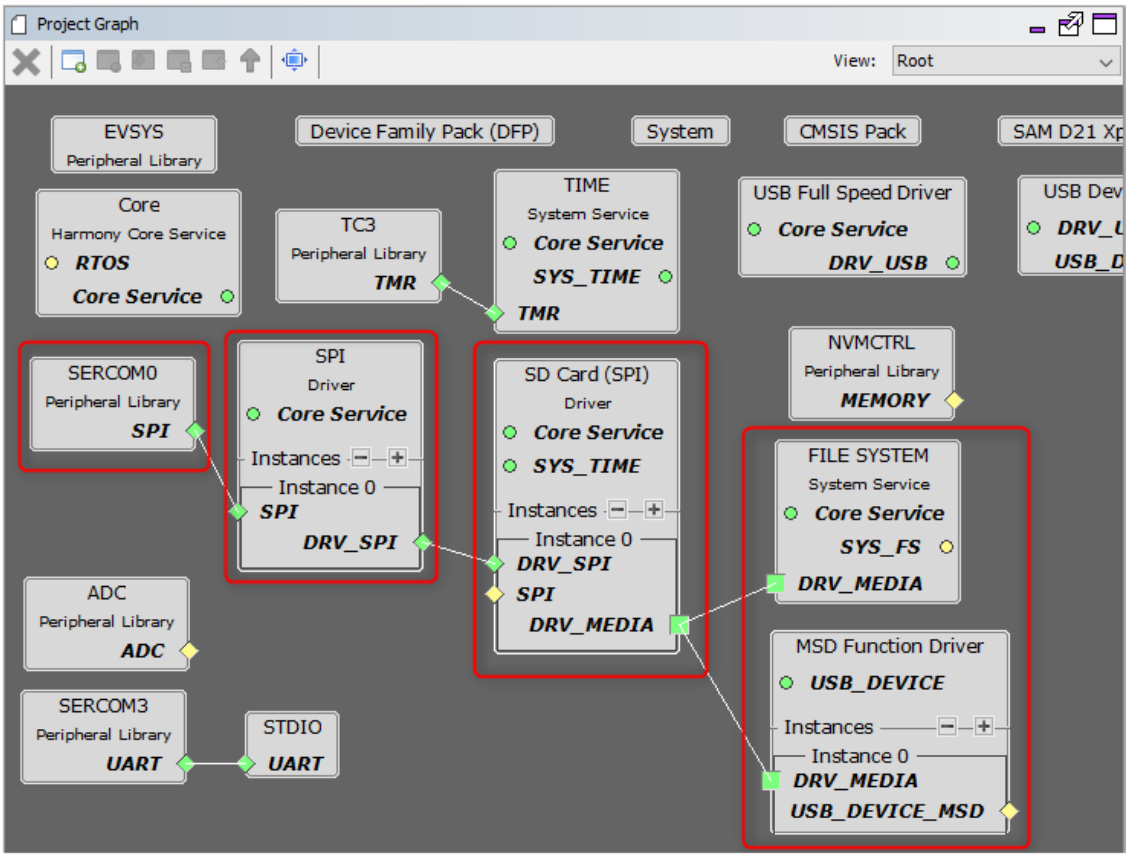
Figure 2-6. Launching MCC or MHC



For example, if the user wants the following configurations from the Reference Project, the export and import features in the MCC or MHC tool can be used to bring these features into the new project:

- SD Card SPI Driver
- File System Service
- MSD Function Driver
- SPI Driver
- SERCOM PLIB

Figure 2-7. Reference Project Configuration

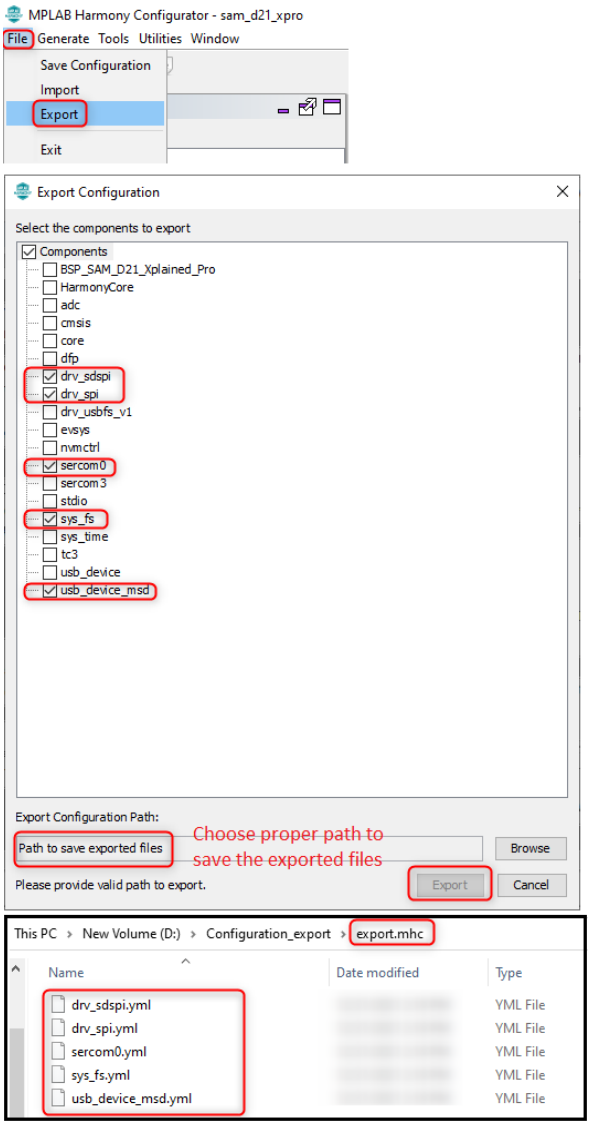


Importing and Exporting MHC

Follow these steps to import and export MHC:

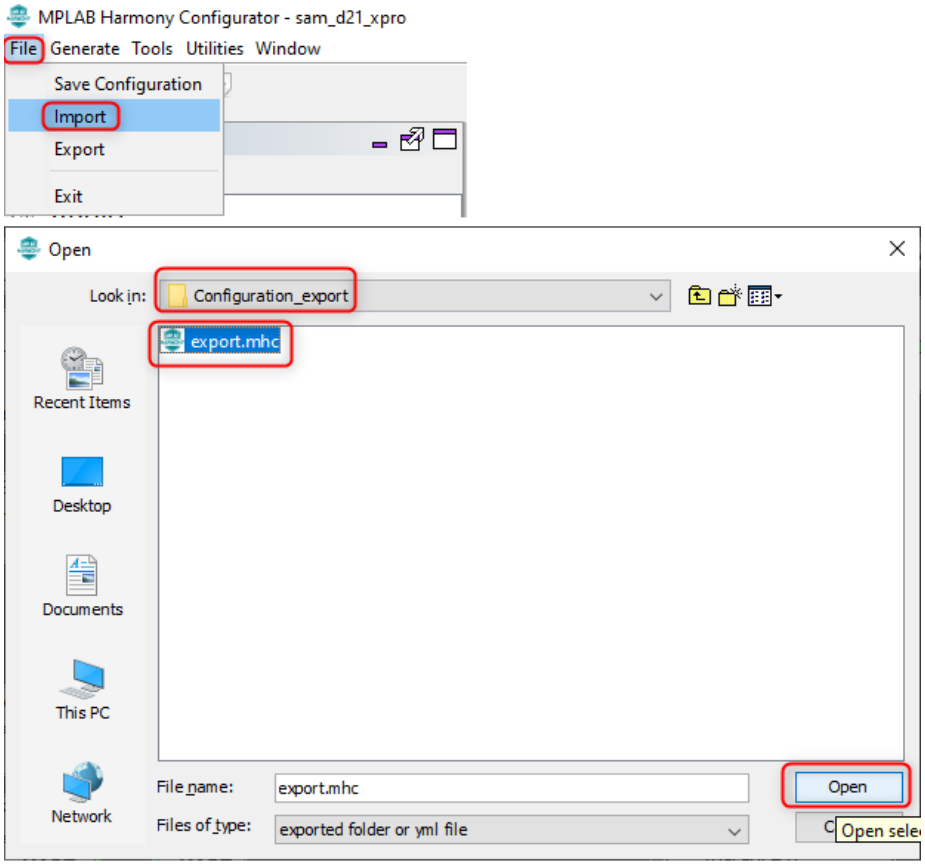
1. In the MHC, from *File* > *Export*.
2. Select the required components from the **Export Configuration** dialogue box.
3. Specify the path to save the exported files, and then click **Export** to export the selected component configurations, as shown in the following figure.

Figure 2-8. MHC Export



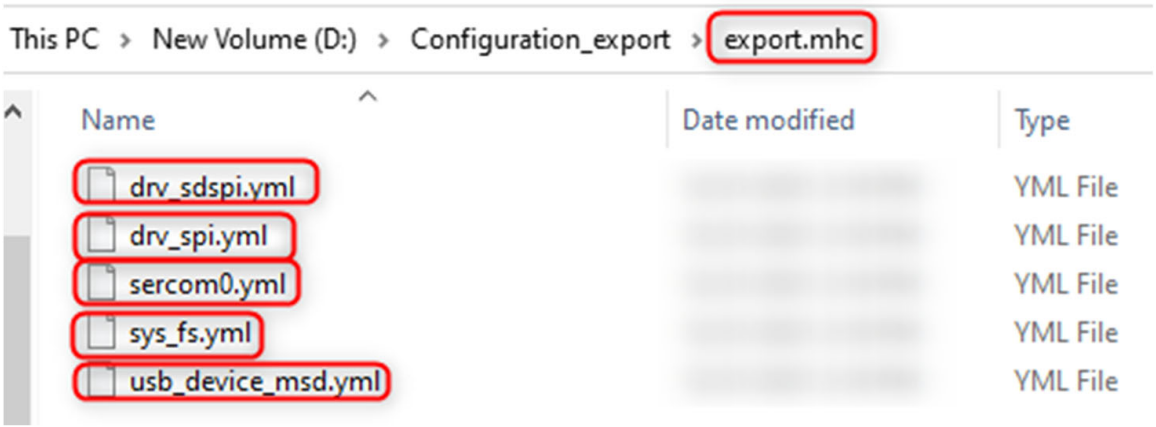
4. In the MHC new project, select *File* > *Import* to redirect to the path where the export files are saved.
5. Select the file to export and click **Open**.

Figure 2-9. MHC Import



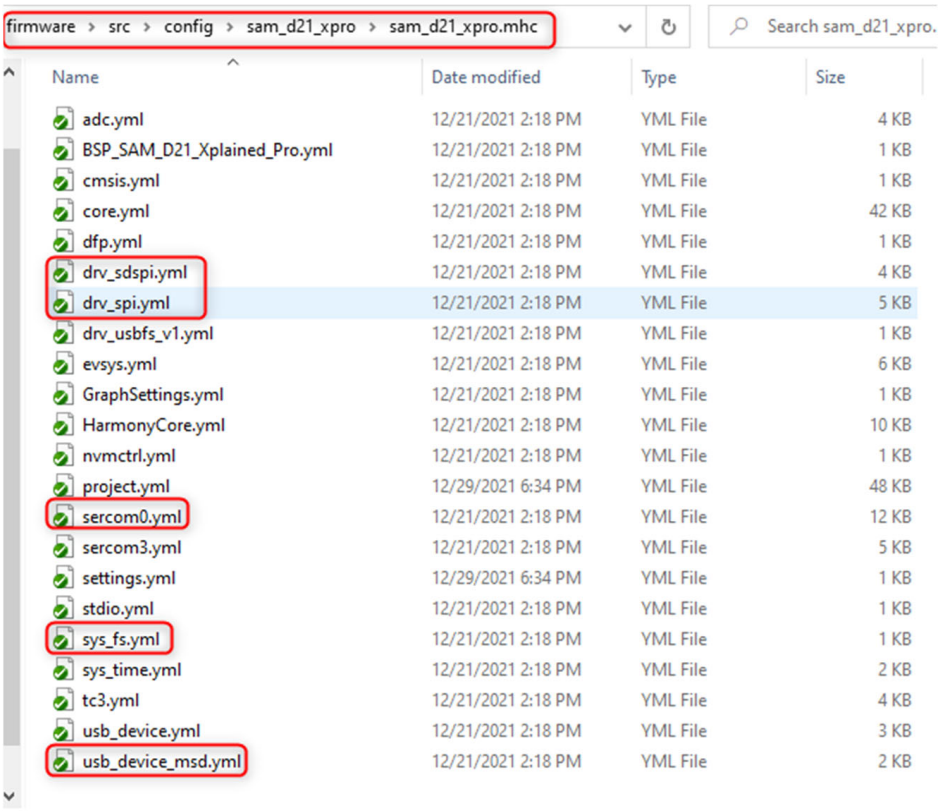
6. The user can also import individual configurations, by selecting one `.yml` file at a time from the `.mhc` folder.

Figure 2-10. Importing an Individual Configuration on the MHC



Note: The user can also import directly from the saved peripheral configuration files (`.yml`) under the `.mhc` folder of the Reference Project source files.

Figure 2-11. Import Using Saved Peripheral Configuration Files Under the .mhc Folder

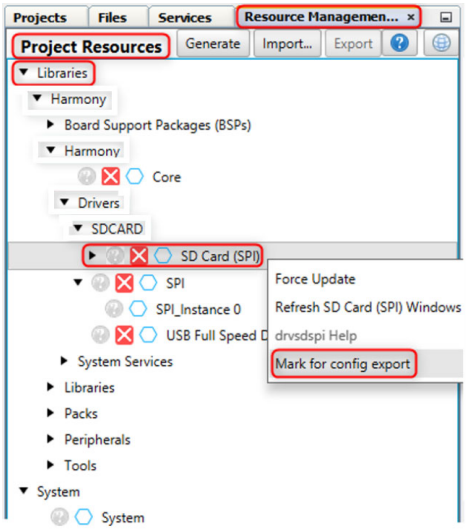


Importing or Exporting MCC

Follow these steps to import and export MCC:

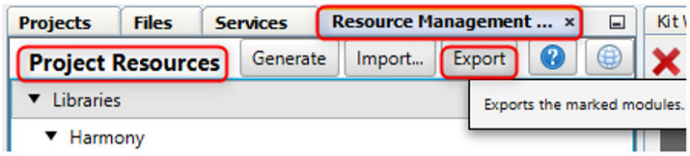
1. In MPLAB X IDE, click **Resource Management (MCC)**.
2. Click the **Project Resources** tab and expand Libraries.
3. Right-click on the required component and select **Mark for config export**.

Figure 2-12. Mark for Export on MCC



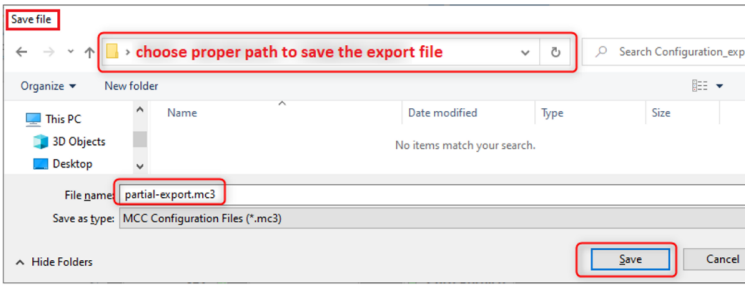
4. Follow the preceding steps for all remaining components, such as SERCOM0 in Peripherals, SPI in Drivers, File System in System Services, and MSD Function Driver in USB device stack libraries.
5. After marking all the required components for export, click **Export**.

Figure 2-13. Export on MCC



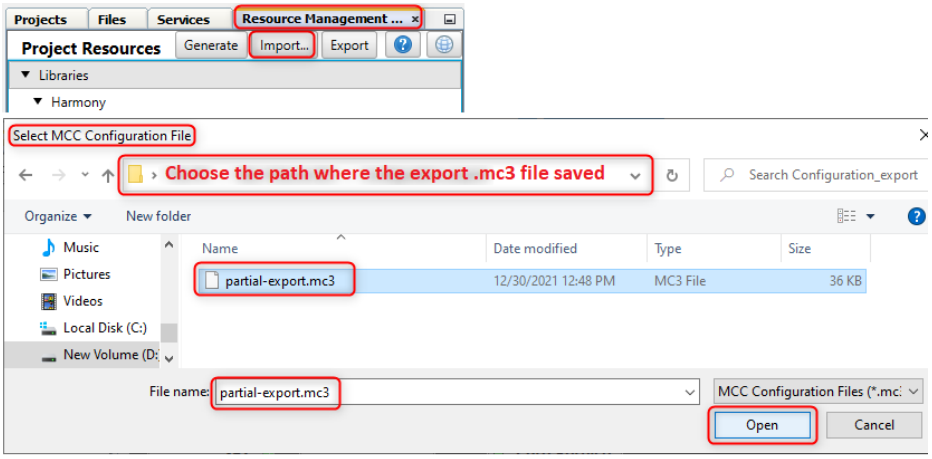
6. Specify the path to save the export file, `.mc3`, and then click **Save**.

Figure 2-14. Save Export File



7. In MPLAB X IDE, in the new project, select *Resource Management (MCC) > Import* to redirect to the path where the export file `.mc3` is saved.
8. Select the export file and click **Open**.

Figure 2-15. MCC Import



2.3 Clock

An essential element in migrating embedded application projects is the CPU clock and the peripheral clocks generated based on the CPU clock.

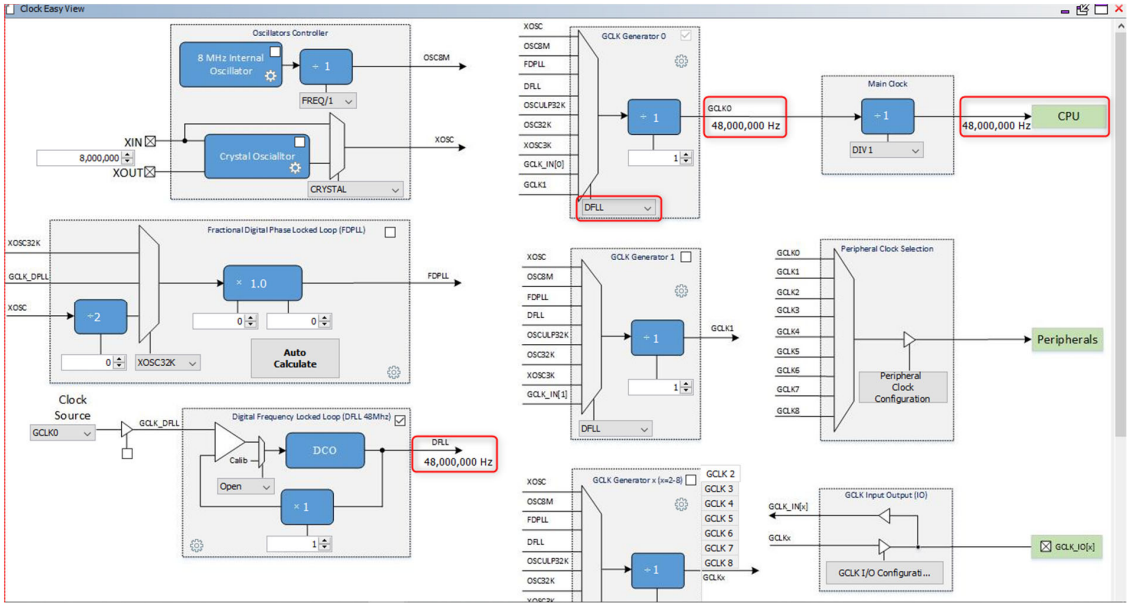
For Scenarios #1 and #2, the CPU clock will remain the same, because the MCU device ID is the same. In these scenarios, the existing clocks configured in the MPLAB Harmony v3 demonstration application can be used in the user application. If required, the user can change the clock.

For Scenario #3, though the clock module may be the same within a family of devices, the clock speed of the target MCU can be different. This change means the clock for the target MCU must be changed. The user needs to verify the clock setting and change as required.

For Scenario #4, there is a higher probability that the clock module may be different from the MCU running the existing MPLAB Harmony v3 demonstration application to the MCU device ID being migrated to. This means the clock for the target MCU needs to be changed. The user needs to verify the clock setting and change it as required.

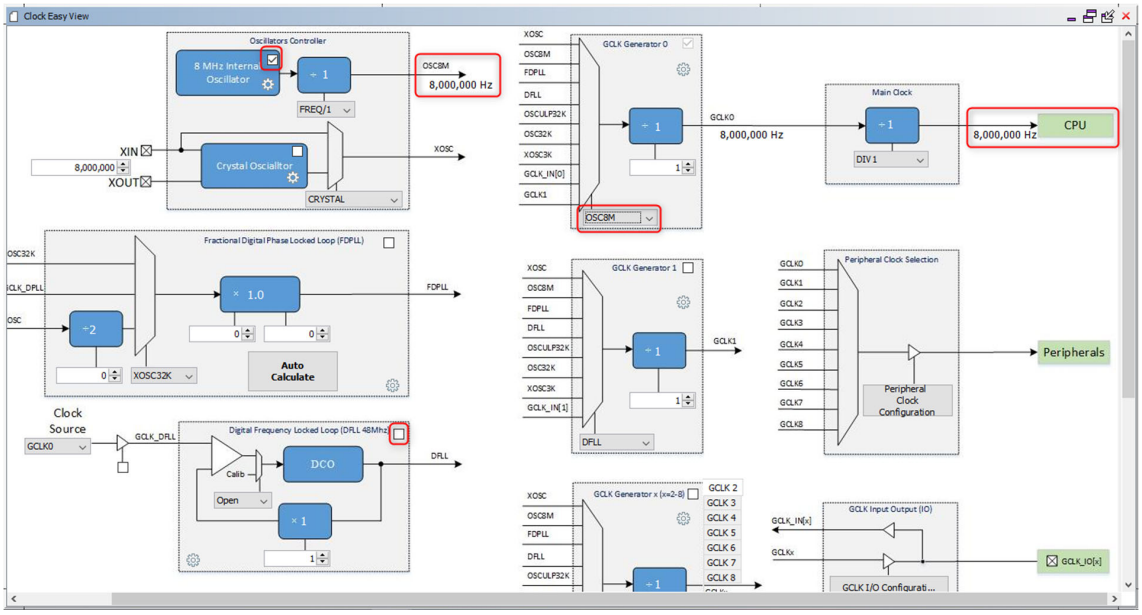
The CPU clock configuration in the Reference Project is shown in the following figure:

Figure 2-16. Reference Project CPU Clock Settings



The following figure shows changing the CPU clock source from the DFLL to the internal Oscillator 8 MHz (OSC8M), and disabling the DFLL clock source.

Figure 2-17. Change the CPU Clock Source



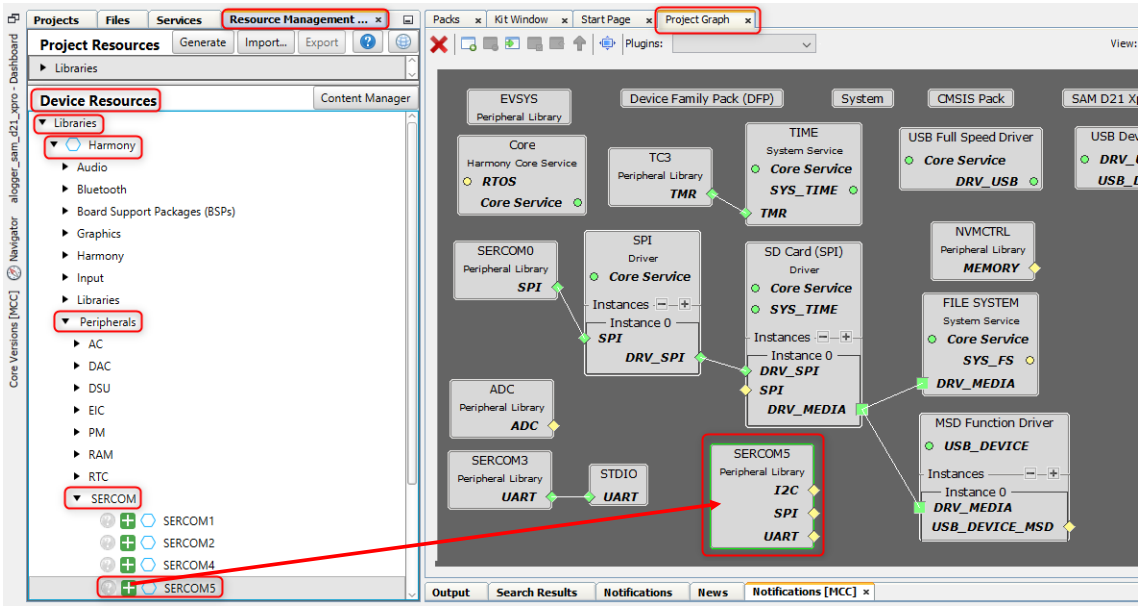
2.4 Peripheral Libraries

The MPLAB Harmony v3 Peripheral Libraries (PLIBs) provide a Hardware Abstraction Layer (HAL) interface to access peripherals on MCUs. The PLIB Application Program Interfaces (APIs) hide peripheral register details and make it easier to configure the peripheral per the application requirements by calling the PLIB APIs.

The PLIBs are added to the project and configured through the code generation tool (MCC or MHC) project graph.

- For Scenario #1, there is no special consideration for adding, deleting, modifying, or retaining existing PLIBs. Launch the code generation tool (MCC or MHC) project graph, perform any of these operations, and generate the code. For example, the following figure shows adding a new PLIB to the Reference Project. The user must configure each newly added peripheral.

  Figure 2-18. Adding a New PLIB



- For Scenarios #2, #3, and #4
  - Ensure to import the required code generation tool (MCC or MHC) configurations from the existing MPLAB Harmony v3 application demonstration. Refer to Tool Configurations for more information.
  - For the PLIBs added in the MPLAB Harmony v3 application demonstration, the user must verify the peripherals routed in the custom or user board. Suppose different peripherals or a different instance of the same peripheral is used. In that case, the PLIB blocks of the code generation tool (MCC or MHC), and the project graph must be updated. The project requires regeneration.
    For example, if SERCOM2 is used instead of SERCOM3 as the UART debug interface in the custom board, the SERCOM block must be updated by deleting SERCOM3 and adding the SERCOM2 in the Reference Project graph as shown in the following figure. The user must configure each newly added peripheral.

Figure 2-19. The Existing UART Debug SERCOM Instance

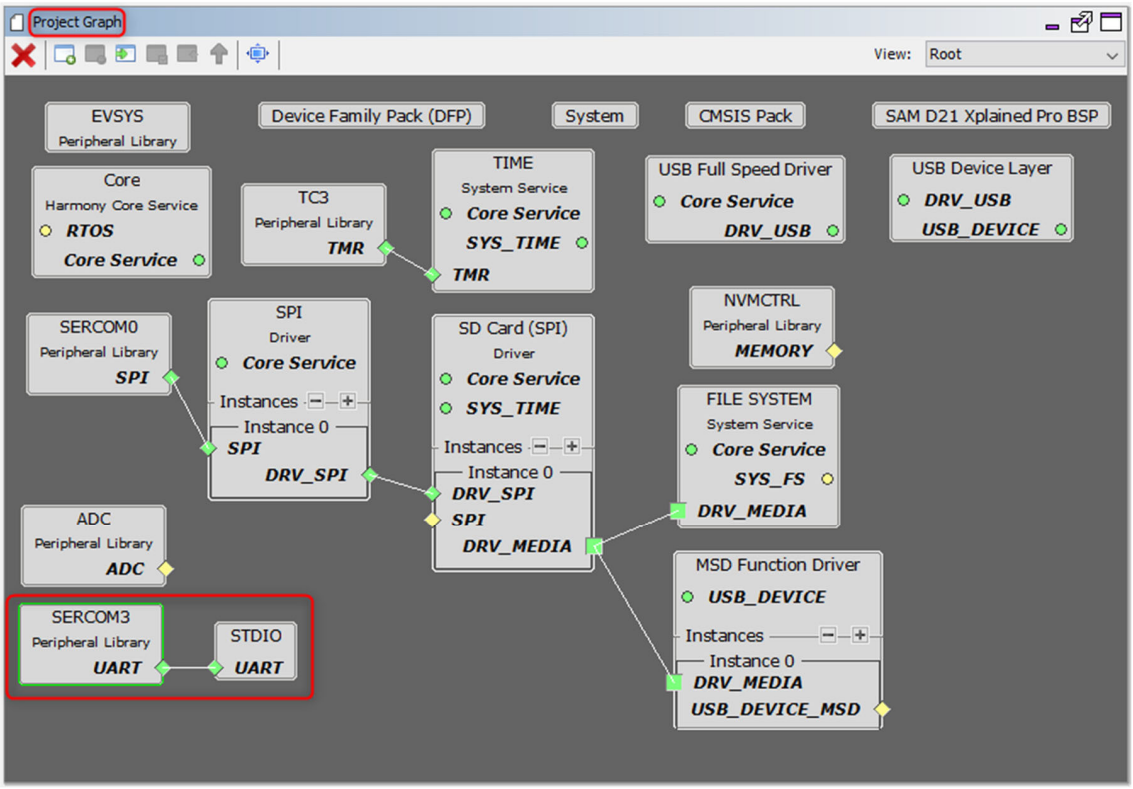
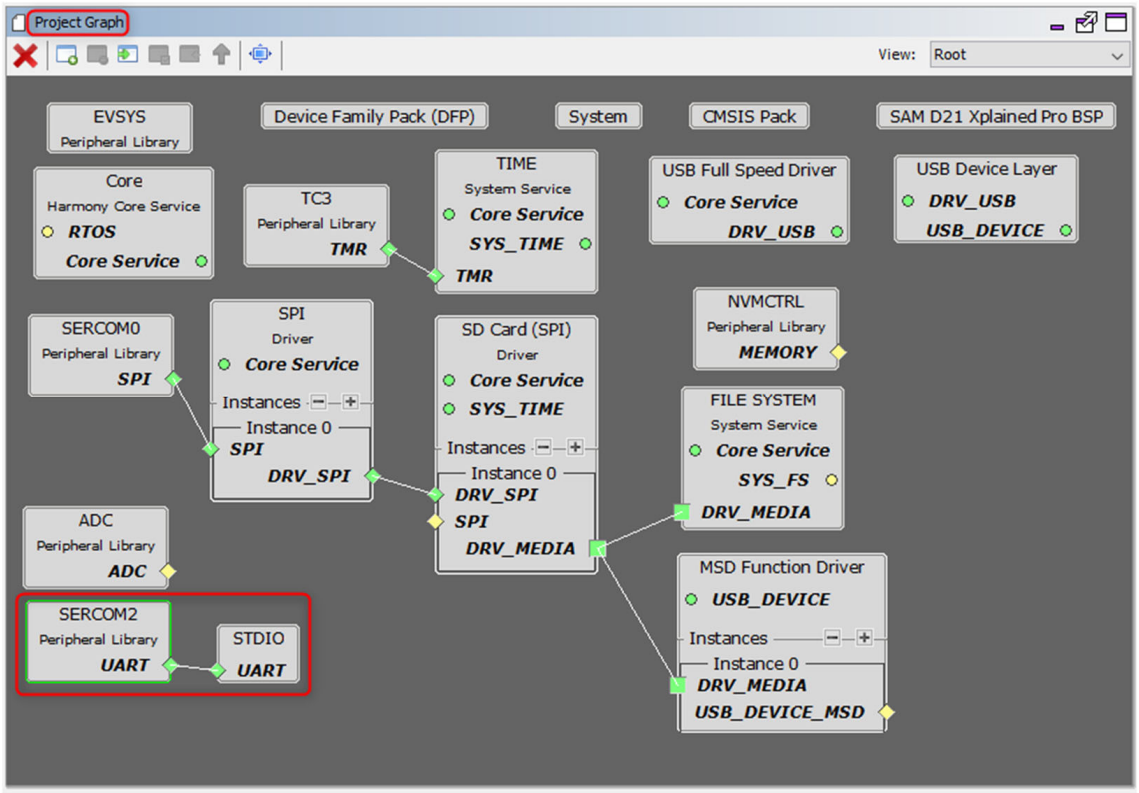


Figure 2-20. The Updated UART Debug SERCOM Instance



- If the user has changed the PLIBs used in the project graph, the same change must be reflected in the API calls if the application calls the PLIB APIs. For example, if the UART debug interface has changed, the PLIB block in the project graph from SERCOM3 to SERCOM2, the same must be changed in the following APIs:
  - Replace `SERCOM3_USART_Write` API in the application code with `SERCOM2_USART_Write`.

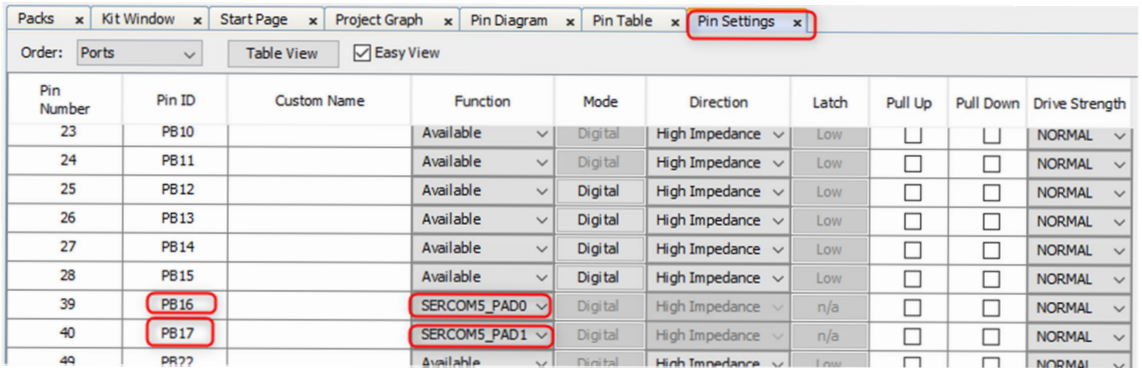
2.5 PORT Pins

The PORT pins on the SAM and PIC32 MCUs have multiplexed functionality, which means keeping track of available or assigned pins and deciding on assigning I/O pins to a given peripheral can be challenging. The challenge is aggravated when migrating a project from one platform to another.

The code generation tool (MCC or MHC) provides the Pin Configuration window to configure or reconfigure the PORT pins.

- For Scenario #1, if a new pin functionality is added or removed by adding or removing PLIBs, the configurations of the corresponding pins can be performed through the code generation tool (MCC or MHC) in the Pin Configuration window. For example, the following figure shows the configuration pins of the PLIB added in Scenario#1 in PLIBs.

Figure 2-21. Configure Pins for Adding a New PLIB



- For Scenarios #2, #3, and #4:
  - Be sure to import the required code generation tool (MCC or MHC) configurations from the existing MPLAB Harmony v3 application demonstration. Refer to the Tool Configurations for additional information.
  - For the PLIBs added in the MPLAB Harmony v3 application demonstration, the user must verify the peripherals routed in the custom or user board. If different peripherals or different instances of the same peripheral are used, the pins for the peripheral also need to be verified and updated in the code generation tool (MCC or MHC) Pin Configuration window. The project will require regeneration.
    For example, if SERCOM2 is used instead of SERCOM3 as the UART debug interface in the custom board using different UART pins, then the debug UART pins must be reconfigured in the Reference Project graph, as shown in the following figure.

Figure 2-22. The Existing SERCOM Instance Pin Configuration

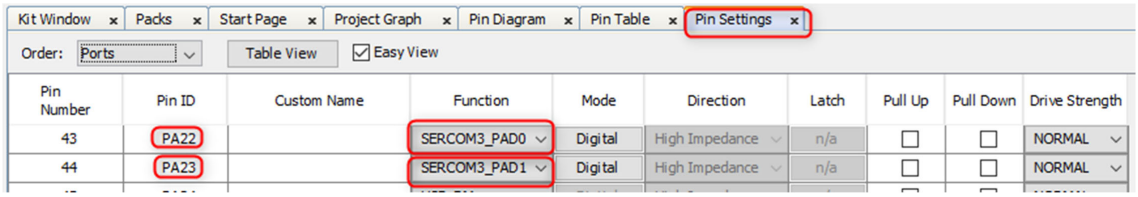


Figure 2-23. Reconfigure the Existing SERCOM3 Instance Pins as Available

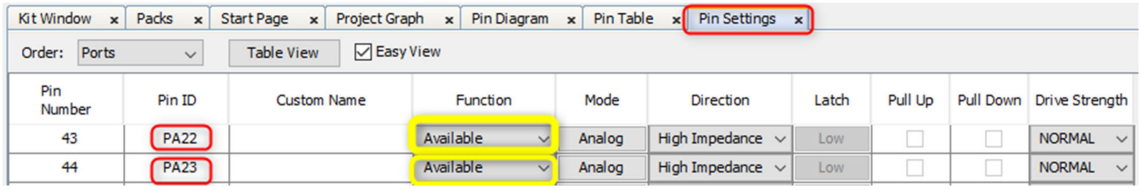
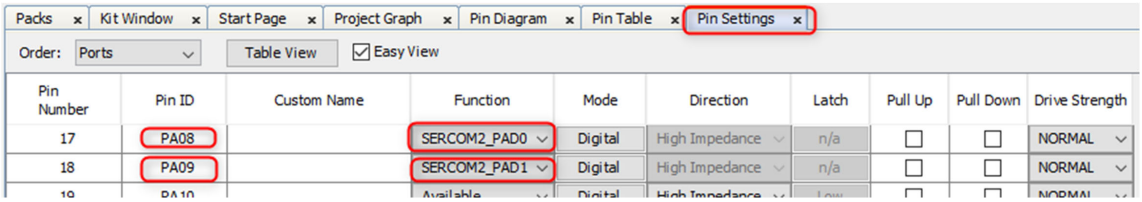


Figure 2-24. Reconfigure Pins for Updated Debug SERCOM2 Instance

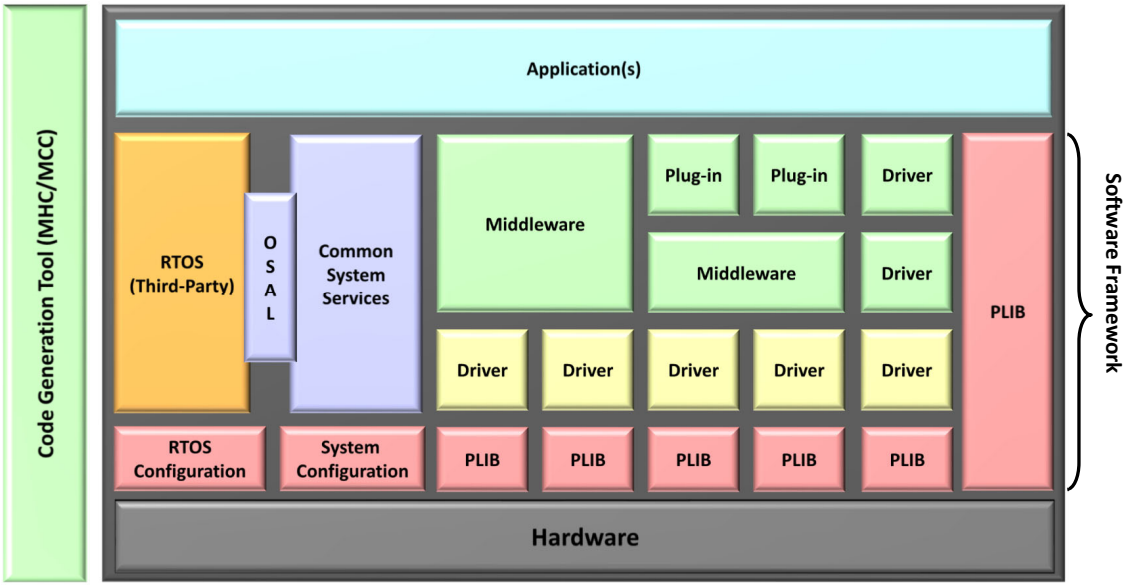


2.6 Drivers

The MPLAB Harmony v3 drivers are an interface to control, access, manage peripherals, and other resources on the 32-bit SAM and PIC32 microcontrollers. The driver interface allows applications and other client modules (drivers, middleware libraries, and system services) to interact with the peripheral.

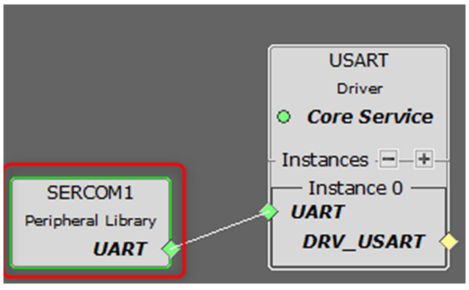
The following figure illustrates the MPLAB Harmony v3 architecture showing the locations of the PLIBs and drivers. The PLIBs have direct access to the hardware, where the drivers are built on the top of the PLIBs and provide an abstracted interface to other MPLAB Harmony v3 software components (plug-ins, Middleware, and system services) and applications.

Figure 2-25. MPLAB Harmony v3 Architecture



- For Scenario #1, there are no special considerations for adding, deleting, modifying, or retaining existing drivers. Launch the code generation tool (MCC or MHC) project graph, perform any of these operations, and generate the code. For example, if the Reference Project has an additional requirement to use the USART to interact with an external device. The following figure adds a USART driver to the Reference Project with SERCOM1 as the underlying peripheral module.

  Figure 2-26. Adding a Driver



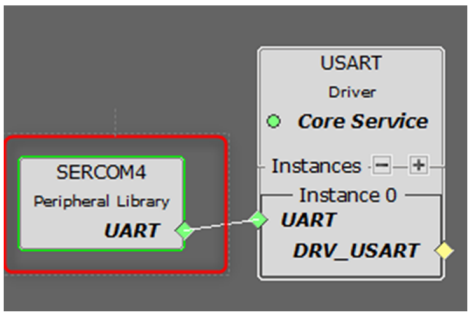
- The application will use the following API to transfer data to the external device:

```
DRV_USART_WriteBufferAdd(appData.usartHandle, (void*)messageBuffer,
strlen(messageBuffer), &appData.bufferHandle);
```

- For Scenarios #2, #3, and #4:
  - Be sure to import the required code generation tool (MCC or MHC) configurations from the existing MPLAB Harmony v3 application demonstration. Refer to Tool Configurations for additional information.

– Because drivers provide an abstracted interface to the MCU peripherals, the driver API calls used in the user application need not change when the project is ported from one platform to another. However, the underlying PLIBs on top of which drivers are built, must be migrated as described in the PLIBs and PORT Pins.

Figure 2-27. Driver with a Different PLIB Block



The above change in the USART block (shown in Figure 2-8 MHC Export) in the project graph does not require any change in the application calling the USART driver APIs.

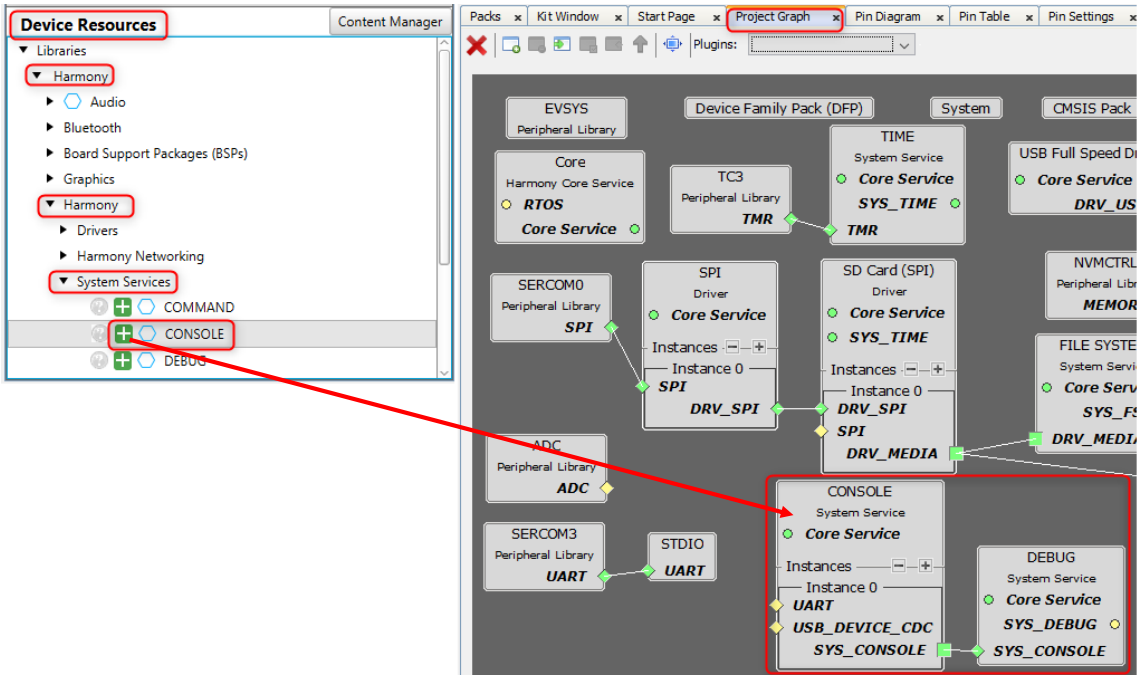
```
DRV_USART_WriteBufferAdd(appData.usartHandle, (void*)messageBuffer,
strlen(messageBuffer), &appData.bufferHandle);
```

2.7 System Services

MPLAB Harmony v3 provides common functionality required by different drivers, middleware, or applications. It manages shared resources and eliminates potential resource conflict by keeping the underlying requests separate. MPLAB Harmony v3 Architecture shows the location of system services in the MPLAB Harmony architecture.

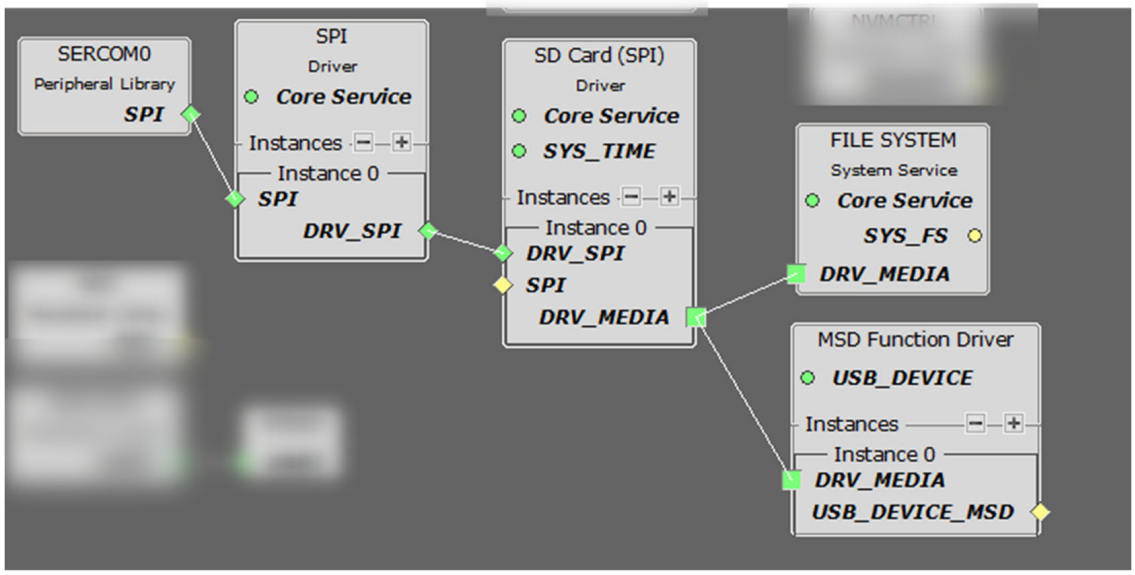
- For Scenario #1, there is no special consideration for adding, deleting, modifying, or retaining existing system services. Launch the code generation tool (MCC or MHC) project graph, perform any of these operations, and generate the code.
  For example, if the Reference Project has an additional requirement to use a console system service, the following figure shows adding a console system service to the Reference Project.

Figure 2-28. Add Console System Service and Configure SYS_DEBUG



- For Scenarios #2, #3, and #4:
  - Be sure to import the required code generation tool (MCC or MHC) configurations from the existing MPLAB Harmony v3 application demonstration. Refer to the Tool Configurations for additional information.
  - Like drivers, *System Services* provide an abstracted interface to the shared resources. The system service API calls used in the user application need not change when the project is ported from one platform to another. However, the underlying resources (PLIBs, drivers) on top of which the system services are built must be migrated as discussed in Drivers, PLIBs and PORT Pins.
    For example, In the Reference Project, the File System services uses the SDSPI driver, which uses the SPI driver, and which in turn uses the SERCOM0 (SPI) PLIB.

Figure 2-29. File System Service and Dependent Blocks



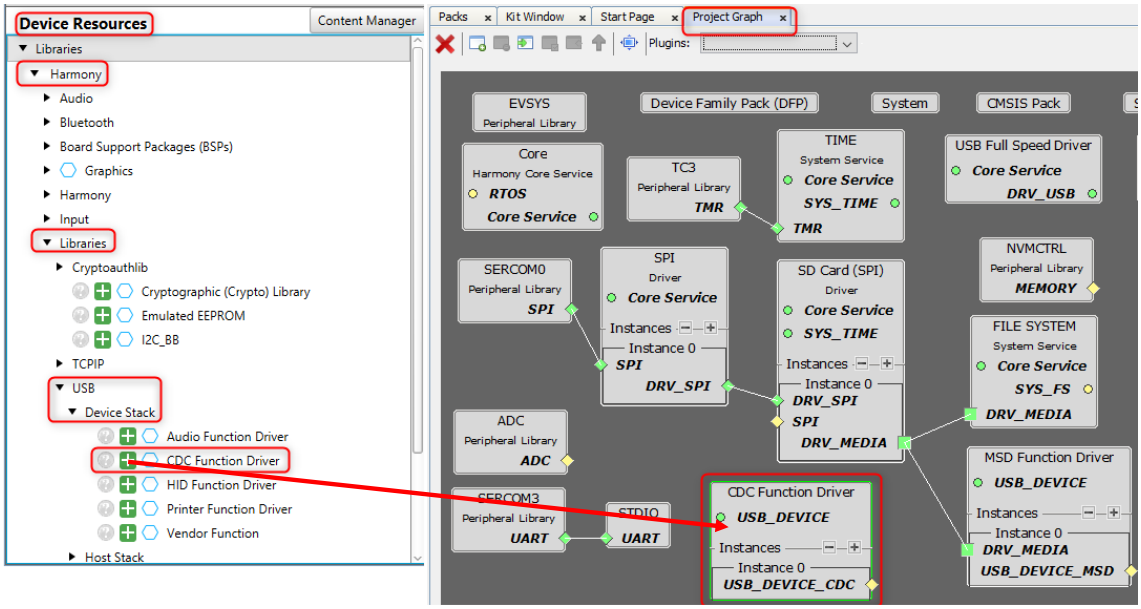
In the previous figure, a change to the SERCOM0 PLIB does not require a change in the application code, which uses the file system service APIs for sensor data, as the APIs provide an abstracted interface.

2.8 Middleware

MPLAB Harmony v3 provides middleware libraries for complex protocols and technologies, such as USB, TCP/IP, audio, and crypto. The middleware uses drivers and system services. MPLAB Harmony v3 Architecture shows the location of middleware in the Harmony architecture.

- For Scenario #1, there is no special consideration for adding, deleting, modifying, or retaining existing system services. Launch the code generation tool (MCC or MHC) project graph, and perform any of these operations and generate the code, for example, if the Reference Project has an additional requirement to use the USB CDC class. The following figure shows how to add a USB CDC class to the reference project.

  Figure 2-30. Add USB CDC Class



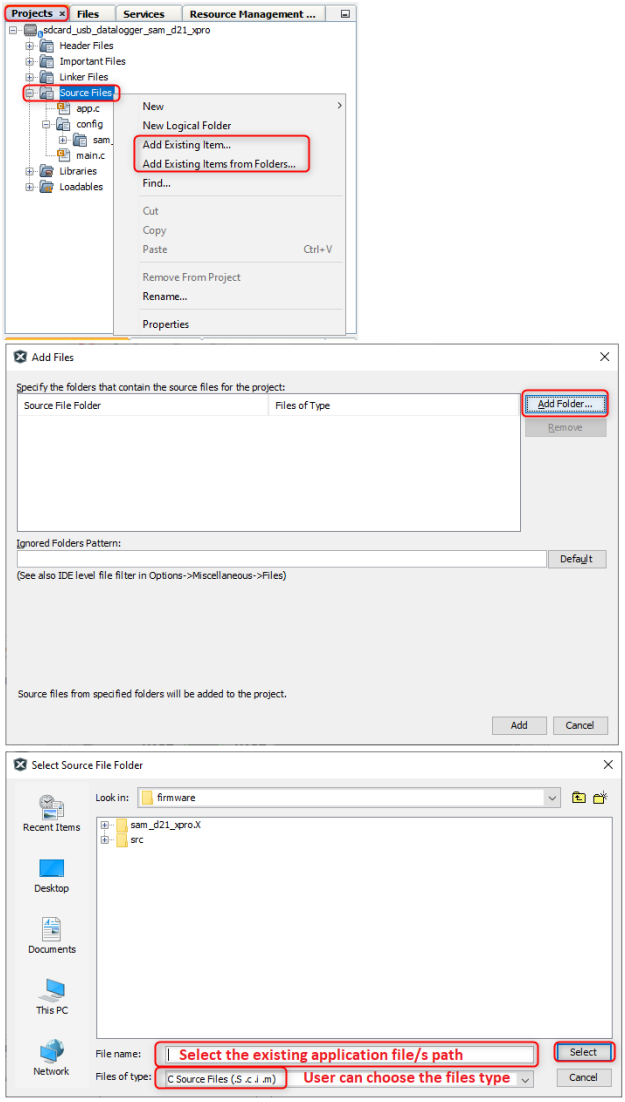
- For Scenarios #2, #3, and #4:
  - Be sure to import the required code generation tool (MCC or MHC) configurations from the existing MPLAB Harmony v3 application demonstration. Refer to the Tool Configurations for additional information.
  - As in drivers and system services, middleware also provides an abstracted interface. The middleware API calls used in the user application need not change when the project is ported from one platform to another. However, the underlying resources (PLIBs, drivers, system service) on top of which the system services are built must be migrated as discussed in System Services, Drivers, PLIBs and PORT Pins.

2.9 Application

An MPLAB Harmony v3 application is generally developed in the `main.c` and `app.c` files. The application files can also have several other required source files, header files or library files.

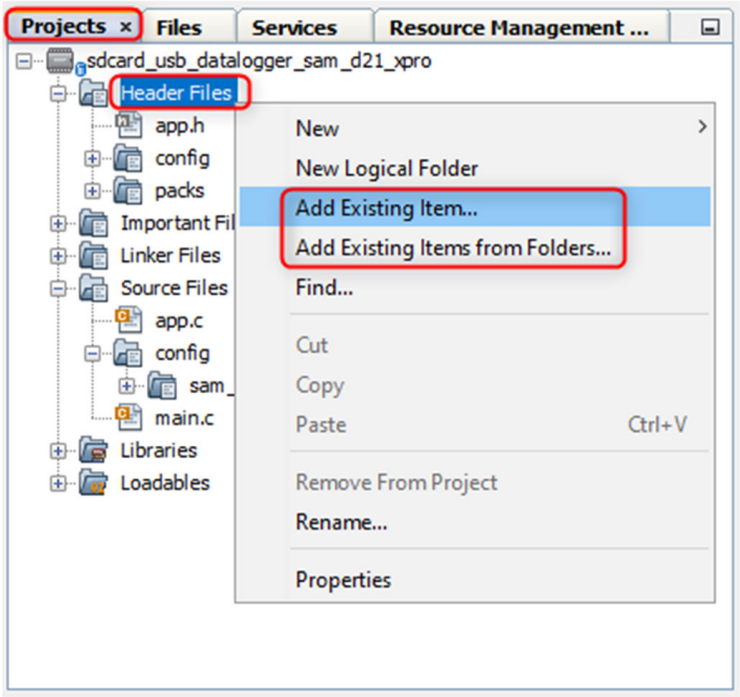
- For Scenario #1, there is no special consideration for adding, deleting, modifying, or retaining application files. The user can use the MPLAB X IDE feature shown in the following figure to add application files to the existing project.

Figure 2-31. Add Application Source Files



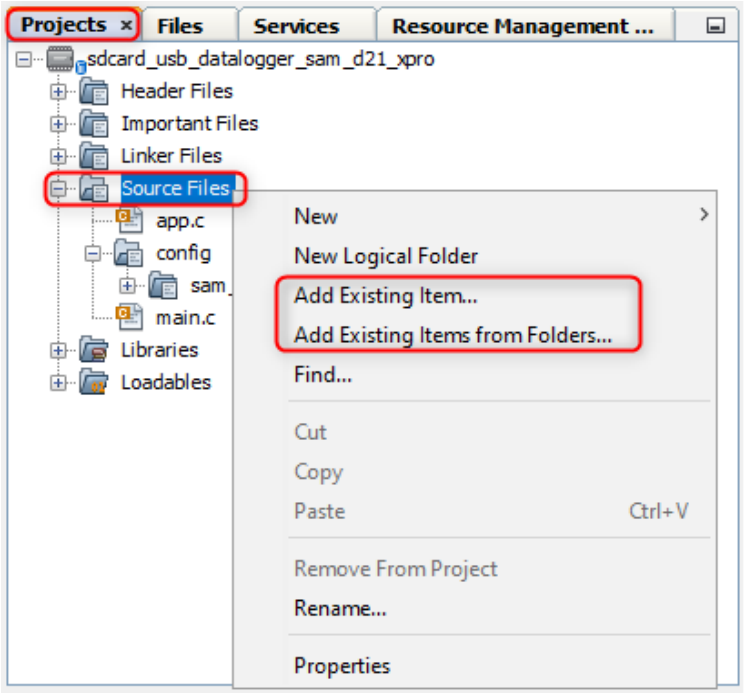
Similarly the user can also add application header files.

Figure 2-32. Add Application Header Files



- For Scenarios #2, #3, and #4, use any one of the following methods to move the application files from the existing project to the new project.
  - **Method 1. Adding Existing Item**
    In this method, users can manually add user application files to the new project by selecting any one of the options highlighted in the following figure. This method is suitable if the number of application files added to the project is less than ten.

Figure 2-33. Add Application Files



- **Method 2. Adding Existing Items from Folders**
  a. This method is suitable when the number of application files added to the project is large (more than ten or multiple files in several directories and sub-directories).
  For example, the application files from the reference project are required to be added into a new project having MPLAB X IDE project folder name as `sam_e51_cnano.X` on ATSAME51J20A MCU.
  b. Copy and paste all required application source (`.C, .cpp, .h`) files (with folder structure if any) from the reference project under the `src` folder to the `src` folder under the user created project.
  c. Copy and overwrite the `configurations.xml` file from the Reference Project MPLAB X IDE project folder `sam_d21_xpro.X\nbproject` to the user project folder `sam_e51_cnano.X\nbproject`.
  d. Open the overwritten `configuration.xml` file and replace all instances as shown below:
    - Change the existing project configuration name to a new project configuration name:
      Replace `sam_d21_xpro` with `sam_e51_cnano`.
    - Change existing project MCU part number with the new project MCU part number:
      Replace SAMD21J18A with SAME51J20A, and also replace D21/d21 with E51/e51.

Notes:

1. This change is not required if the MCU part number is same as the existing project and new project.
2. Modifying the `configurations.xml` file can be tricky, care must be taken while replacing the part number to ensure the correct part numbers.

3. References

For additional information on Microchip products, availability, and MPLAB Harmony v3, visit the Microchip Website, or contact a local sales representative.

- The MPLAB Harmony v3 Quick Docs repository provides standalone help pages for users to get started developing applications on Microchip's 32-bit SAM and PIC32 MCUs. Start from the `index.html` present in the docs folder.
  The online version is available at https://microchip-mplab-harmony.github.io/quick_docs/
- Harmony landing page:
  www.microchip.com/harmony
- Create a new MPLAB Harmony v3 project using MCC:
  microchipdeveloper.com/harmony3:getting-started-training-module-using-mcc
- Update and Configure an Existing MHC-based MPLAB Harmony v3 Project to MCC-based Project:
  microchipdeveloper.com/harmony3:update-and-configure-existing-mhc-proj-to-mcc-proj
- How to Add a New Configuration to an Existing MPLAB Harmony v3 Project:
  www.microchip.com/DS90003304
- How to Build an Application by Adding a New PLIB, Driver, or Middleware to an Existing MPLAB Harmony v3 Project:
  www.microchip.com/DS90003253
- MPLAB Harmony v3 Developer help page:
  microchipdeveloper.com/harmony3:start
- Overview of MHC user interface in Import/Export feature:
  microchip-mplab-harmony.github.io/mhc/doc/readme_mhc_import_export.html

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