

## Creating a "Hello World" Application Using the MPLAB Harmony Configurator (MHC)

## Introduction

MPLAB<sup>®</sup> Harmony is a software framework consisting of compatible and interoperable libraries that include peripheral drivers, middleware, system services, 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 library components. The MHC is a plug-in to the MPLAB X IDE and is included as part of the MPLAB Harmony Software Framework installation. The MHC provides a GUI to:

- Enable and configure MPLAB Harmony libraries
- Configure the system clock
- Assign pins to peripherals and configure various options available on the I/O pins
- Design a UI for displays using the Graphics Composer Suite
- Configure a new display using the Display Manager, and many more functionalities

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## 1. Creating a Hello World Application Using the MHC

This section describes how to create a simple MPLAB Harmony application using the MHC. The application sends a "Hello World!" string to a console running on a computer.

Before beginning, it is assumed that you have already installed MPLAB Harmony and the MHC plug-in. Please refer to *Volume I: Getting Started With MPLAB Harmony Libraries and Applications > Prerequisites* to understand the requirements. If the MHC plug-in is not installed, refer to the steps provided at http://microchipdeveloper.com/harmony:mhc-installation.

The demonstration board used in this example is the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit. MPLAB X IDE version 3.61 and the MHC plug-in version 2.04 are used in this example.

### Step 1: Create a MPLAB Harmony-based Project

- 1. In MPLAB X IDE, select File > New Project (or click the New Project icon).
- In Categories, select Microchip Embedded and in Projects select 32-bit MPLAB Harmony Project, and then click Next, see Figure 1-1.
   Note: If the option 32-Bit MPLAB Harmony Project is not visible, please download and install MPLAB Harmony before continuing with this tutorial.

### Figure 1-1. Creating a MPLAB Harmony-based Project

🔀 New Project	
Steps	Choose Project
1. Choose Project 2	Q Filter:
	Categories: Microchip Embedded Other Embedded Samples Project: Samples Project: Prebuilt (Hex, Loadable Image) Project User Makefile Project Library Project
	Description:
	MPLAB® Harmony Project Wizard
	< Back Next > Finish Cancel Help

3. Specify the project details in the New Project dialog, as shown in Figure 1-2.

teps	Name and Location	
. Choose Project . Name and Location	Harmony Path:	C: \microchip\harmony\v2_04
	Project Location:	C:\microchip\harmony\v2_04\apps
	Project Name:	hello_world
	Project Path:	C: microchip \harmony \v2_04\apps \hello_world \firmware \hello_world.X
	Configuration Name:	pic32mz_ef_sk
	Device Family:	PIC32MZ   Target Device: PIC32MZ2048EFM144  Help
	Target Board:	PIC32MZ (EF) Starter Kit
	Note: Press "Help" butt	on for additional information.

Figure 1-2. Creating a MPLAB Harmony-based Project (Continued)

4. Click Finish.

This will create a MPLAB Harmony-based project and launch the MHC, as shown in Figure 1-3. MHC can be launched anytime in MPLAB X IDE by navigating to *Tools > Embedded*. **Note:** 

- 1. The path to MPLAB Harmony will be different if a different version of MPLAB Harmony is used or if MPLAB Harmony is not installed at its default location.
- 2. Based on the selected Target Board, the corresponding Board Support Package (BSP) will be selected. The BSP assigns device pins to various board functions and sets up the device's clock tree based on the board's clock source.

- <b>J</b>		
MPLAB X IDE v3.61 - hello_world : pic32mz_ef_sk	the second se	
File Edit View Navigate Source Refactor Run Debug Team	Tools Window Help	Q • Search (Ctrl+I)
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MPLAB® Harmon 1 2 3 4 Options Clock D	y Configurator & Sode 6 Z × 88 iagram × Pin Diagram × Pin Settings ×	1.       Open configuration       of module of PIC3         2.       Save configuration       strution         3.       Import configuration       figuration         4.       Export configuration       figuration         5.       Generate Code       6.         6.       Harmony Framework Configuration       figuration         7.       Launch Utility (ADC, Clock, Display., Graphics, Pin Configuration.)       ,         8.       Option Tree View (Full or Active only)       ,
helio_world - Dashboard #	MPLAB8 Harmony Configurator	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
	Output         Pin Table         x <htps: finib<="" finibilia.com="" go="" td=""><td>ystem_config/bic32mz_ef_sk/pic32mz_ef_sk.mhc r.jar adsoreen/mzef.jar Ie ger.jar r/dodsoreen/mz.jar anager.jar</td></htps:>	ystem_config/bic32mz_ef_sk/pic32mz_ef_sk.mhc r.jar adsoreen/mzef.jar Ie ger.jar r/dodsoreen/mz.jar anager.jar
🗗 🔁 Output 🔍 Search Results		1

### Figure 1-3. MHC User Interface

**Note:** For detailed information on the MHC, please refer to *Volume III: MPLAB Harmony Configurator* (*MHC*) > *MPLAB Harmony Configurator User's Guide* in the MPLAB Harmony help.

### Step 2: Add and Configure MPLAB Harmony Libraries Using MHC

 In MHC, expand Options > Application Configuration > Application 0 Configuration, and set the Application Name to hello, as shown in Figure 1-4. This will create an HELLO\_Initialize() routine and a template state machine by the name HELLO\_Tasks().



 In MHC, select the Clock Diagram Tab and verify that the clock is configured correctly for the selected target board. The Clock Diagram tab allows for easy setup of the system clocks (see Figure 1-5).

Figure 1-5. Clock Configuration



3. In MHC, go back to the Options tab and expand *BSP Configuration > Select BSP Features* and check the Use USART to USB Bridge option, as shown in Figure 1-6. This will map the USART

lines - U2RX pin-to-pin 14 and the U2TX pin-to-pin 61. This will also map the USART driver instance 0 to USART2.

### Figure 1-6. Enable BSP Features



Verify the mapping of the UART lines by opening the Pin Table tab and scrolling down to the UART2 module, as shown in Figure 1-7. The Pin Manager consists of the Pin Settings, Pin Diagram and the Pin Table tabs and allows users to configure (assign peripheral function, set pin direction, configure pull-up/pull-down etc.,) and map the I/O pins, as shown in Figure 1-7.

Figure 1-7. Pin Manager - Pin Settings, Pin Diagram, and Pin Table Tabs

MPLAB® I	Harmony Configur	ator %																							4	Ð
Options	● ●   がや Clock Diagram →	ode 🛛 🤹 🗍	ord N x Pin Se	er: F	Pins ×		•		T	able V	liew															
Pin Number	Pin ID	Voltage Tolerance	,	lame	-		_	Fund	tion	_	Dir (TF	ection RIS)	Latch (LAT)	Oper (ODC	Drain	M (4	lode ANSEL	.) (.	Change (CNEN)	e Notif	ficatio	n	Pull U (CNPI	φ U)	Pull (	Down D)
12	RC3							Ava	lable			In	n/a	] [		A	nalog	,		[""]			[""]		-	
13	RC4							Ava	iable			In	n/a	) (		A	nalog									
14	RG6		USART to U	JSB Bri	dge (BS	;P)		U2	RX			n/a	] n/a	) [			Digital								[	
15	RG7							Ava	iable			In	n/a	) [		A	nalog	,								
16	RG8							Ava	iable			In	n/a	] [		A	nalog	,							[	
C MPLAB®	Config Settin See Re Diagra Easy F	gure F g <b>gs</b> esult am PPS w	Pins ir in the ith <b>Pi</b>	n tl e P n 1	he in Fak	Pi	n		US	ART to L	JSB Brid	RG15 RE5 RE5 RE7 RC1 R39 RJ12 RJ10 RC3 RC4 RC3 RC4 RC4 RC4 RC4 RC4 RC4 RC4 RC4 RC4 RC4	0         ▼         0         ▼         0         ▼         0         1         0         1		Not Av	음원료 Ava vaila sign PIC3	ilak able ned	ble : : : : : : :	500000 500000 50014	911 921 94		+ II I	111	06 05 06 09 99 96 99 96 91 91 91 91 91 91 91 91 91 91 91 91 91	1 VS5 1 VD0 1 RC14 1 RC13 2 RD0 0 RH15 0 RH14 0 RH12 0 RH14 0 RH12 0 RH14 0 RH12 0 RH14 0 RH12 0 RH14 0 RH14 0 RH12 0 RH14 0 RH15 0 RH14 0 RH15 0 RH14 0 RH15 0 RH14 0 RH15 0 RH14 0 RH15 0 RH15 0 RH14 0 RH15 0	
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Output	Pin Table 🗙												_			- 1	1.1									
Output Package:	Pin Table X			R.110	8G	50		USART	RG7	RG8	VSS	VDO	RKO	RF12	BSP_SW	BSP_SW.	USART .	RB15	VSS	<u>ş</u>	RH4	£F2	RH6	RH7	RD14	RD15
Output Package:	Pin Table ×	Func	tion	01CN 10	22 52 11 1	2 1	3	11 USART	258 15	852 16	SSA 17	00A 18	82	66 RF12	S BSP_SW.	BSP_SW.	DISART	RB15	SSV 63	00A 64	¥ 65	542 66	위 문 67	68	69 RD14	C RD15
Output Package:	Pin Table X	Func	tion RX	01CN 10	02 02 11 1	2 1	3	+ USART	658 15	82 16 Ass	SSA 17	00, 18 2d	02 15	8 RF12	W BSP_SW.	8 BSP_SW.	DISART .	62	69 VSS	64 Not	± 65 Ava	또 66	¥ 67 Dle	68 68	68 RD14	d RD15
Output Package:	Pin Table X	Fun U2 U2	tion RX TX	01CN 10	වූ (2 11 1	2 13	3	14 + INSART	15 0	<u>ම</u> 16 Ass	I7	9 18 2d	02 15	88 RF12	8 BSP_SW	8 BSP_SW.	P USART	51812	60 VSS	م 64 Not	₽ 65 Ava	뚶 66 ilat	울 67 ble	89 RH7	69 RD14	d RD15
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4. In MHC, expand *Options > Harmony Framework Configurator*. Peripheral drivers, system services and middleware libraries can be configured under this tree. Expand *System Services > Console* 

and select the **Use Console System Service?** option. Expand the Use Console System Service? option and set the Select Peripheral For Console Instance to **UART\_CONSOLE**, as shown in Figure 1-8. The Console System Service will use the UART instance 0.

 In MHC, expand Options > Harmony Framework Configurator > System Services > Debug and select the Use Debug System Service? option, as shown in Figure 1-8. The Debug System Service is used to send formatted messages to the console.

Figure 1-8. Harmony Framework Configuration



6. Expand Options > Harmony Framework Configurator > Drivers > USART and verify that the USART driver is automatically enabled by MHC because the Console System Service is configured to use USART, as shown in Figure 1-8. The USART Module ID for USART Driver Instance 0 is automatically set to USART\_ID\_2 because the BSP is configured to use the USART-to-USB Bridge. Also, notice that the USART driver is configured for 9600 baud, 8 data bits, no parity and 1 stop bit.

**Note:** Support for third-party libraries, such as RTOS, Graphics, Cryptography, etc., is integrated in MHC under *Options > Third Party Libraries*. The Project configurations and fuse settings can be configured under *Options > Device & Project Configuration*.

7. Save the MHC configuration ( ), click Generate Code ( ), and then click **Generate**, as shown in Figure 1-9.

Figure 1-9. Generate Project

🚑 Generate Project	
Merging Strategy Generated code merging strategy: Description:	Prompt Merge For All User Changes
Create a backup of the current pro Create a backup of the current pro Copy framework files to local config	uject state (recommended) mizations (if not set) guration directory. Generate Cancel

### Step 3: Add Application Code and Test the Demonstration

Upon clicking **Generate**, MHC will include MPLAB Harmony library files for the modules enabled in MHC to your project, as shown in Figure 1-10.



#### Figure 1-10. Project Files

The files generated by MHC are located in the firmware/src/system\_config/pic32mz\_ef\_sk folder and mainly consists of the following files:

- system\_config.h contains the configuration definitions based on MHC selection
- system init.c initializes the Harmony modules and calls the application initialization routine
- system\_tasks.c runs the Harmony library tasks and the application task routines in a *while (1)* loop
- system\_interrupts.c contains the interrupt service routines for the peripherals configured for interrupt mode of operation in MHC

In addition to this, it also includes the template application files hello.h and hello.c. The hello.c file contains an application initialization routine, which is called by the system to allow initialization of the user application and an application task routine that maintains the application state. The application task routine is called by the system in a while (1) loop (see Figure 1-11).





Users can extend this template state machine to add their application specific code.

- 1. For this simple application, add the lines of code in the <code>HELLO\_Tasks()</code> routine in the <code>hello.c</code> file, as highlighted in Figure 1-12. This will send the "Hello World!" string to the console running on the PC whenever the switch, SW1, is pressed.
- 2. Build and program the PIC32MZ EF Starter Kit by connecting a mini USB cable between port J3 on the board and the PC, as shown in Figure 1-13.
- 3. Connect a mini USB cable between port J11 on the board and the PC, as shown in Figure 1-13.
- 4. Open a terminal application (e.g., Tera Term) on the PC (configure: 9600, 8, N, 1) and observe the "Hello World!" string on the console whenever the switch SWI is pressed, as shown in Figure 1-14.

Getting the terminal application to identify the COM port belonging to the MCP2221A (either on-board or in a Breakout Module) can be a difficult and frustrating process. For example, there may be times when you cannot find the COM port. In these instances on a Windows PC, you can try the following:

- 1. In the Control Panel, select *System > Device Manager*.
- 2. Within Ports (COM & LPT), identify the COM port belonging to the MCP2221A. Double click this port to open its Properties window.
- 3. Select the Driver tab and disable, and then enable the driver.
- 4. Close the window. This should allow your HyperTerminal to see the port.

**Note:** In a worst case situation, use an oscilloscope to ensure that the USART TX signal is getting to the MCP2221A and that the USB data lines are working.



Figure 1-12. Application Initialization and State Machine





Figure 1-14. "Hello World!" String Output

📒 CON	M16:9600ba	aud - Tera T	erm VT
File E	dit Setup	Control	Window
Hello Hello Hello Hello Hello Hello Hello Hello Hello	World World World World World World World World World World	Control	Window
Hello Hello Hello Hello Hello Hello Hello Hello	World World World World World World World World World World		



**Tip:** MHC provides an option to generate a stand-alone project (*Options > Device & Project Configuration > Project Configuration > Generate Standalone Project?*), whereby all of the MPLAB Harmony library files referred by your project will be copied to the project folder. This project can then be compiled from any path in your system.

### 2. References

For additional information on MHC and MPLAB Harmony, download the MPLAB Harmony Integrated Software Framework from the Microchip web site: http://www.microchip.com/mplab/mplab-harmony.

Detailed documentation on various MHC options and windows is included in your installation of MPLAB Harmony within the <harmony-install-path>/doc/ folder. PDF, Compiled HTML (.CHM), and HTML Help formats are available.

Additional resources include:

- Microchip Developer Help http://microchipdeveloper.com/harmony:mhc-overview
- Video Tutorials on MHC http://microchipdeveloper.com/harmony:mhc-videos
- PIC32MZ EF Starter Kit www.microchip.com/PIC32MZEFStarterKit4233990
- PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit User's Guide (DS70005230)

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