MPLAB® ICE 4 Breakout Board User's Guide

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Documents are identified with a DS number located on the bottom of each page. The DS format is DS<DocumentNumber><Version>, where <DocumentNumber> is an 8-digit number and <Version> is an uppercase letter.

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Table of Contents

1. Preface

MPLAB® ICE 4 Breakout Board documentation and support information is discussed in this section.

1.1 Conventions Used in This Guide

The following conventions may appear in this documentation:

Table 1-1. Documentation Conventions

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	*MPLAB® ICE 4 Breakout Board*
	Emphasized text	...is the *only* compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	Select File and then Save.
Quotes	A field name in a window or dialog	“Save project before build”
Underlined, italic text with right angle bracket	A menu path	*File>Save*
Bold characters	A dialog button	Click **OK**
	A tab	Click the **Power** tab
N‘Rnnnn	A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.	4‘b0010, 2‘hF1
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier New font:		
Plain Courier New	Sample source code	`#define START`
	Filenames	`autoexec.bat`
	File paths	`C:\Users\User1\Projects`
	Keywords	`static`, `auto`, `extern`
	Command-line options	`-Opa+, -Opa-`
	Bit values	`0, 1`
	Constants	`0xFF, ‘A’`
Italic Courier New	A variable argument	*file.o*, where *file* can be any valid filename
Square brackets [ ]	Optional arguments	`xc8 [`*options*`]` *files*
Curly brackets and pipe character: { | }	Choice of mutually exclusive arguments; an OR selection	`errorlevel {0|1}`

...........continued		
Description	**Represents**	**Examples**
Ellipses...	Replaces repeated text	*var_name* [, *var_name*...]
	Represents code supplied by user	void main (void) { ... }

1.2 Recommended Reading

This document describes how to use the MPLAB® ICE 4 Breakout Board. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

MPLAB® ICE 4 In-Circuit Emulator User's Guide (DS-50003242)

Read about the MPLAB ICE 4 In-Circuit Emulator/Programmer (DV244140), Microchip's latest fast and feature-rich emulation and programming tool for Microchip microcontrollers (MCUs), which include PIC, dsPIC, AVR and SAM devices.

2. About the Breakout Board

The MPLAB® ICE 4 Breakout Board (AC244141) can be used to facilitate connections between the MPLAB ICE 4 in-circuit emulator and target, which other connectors do not provide.

Figure 2-1. MPLAB ICE 4 Breakout Board

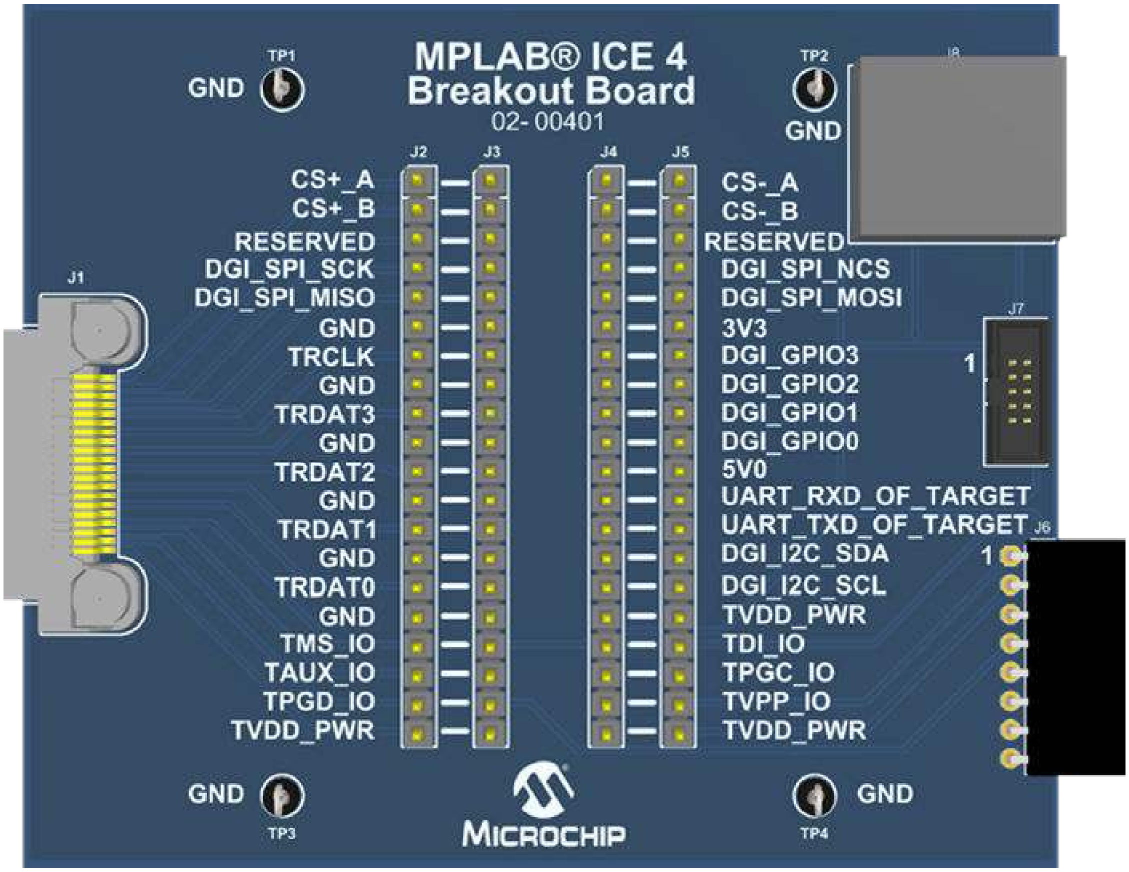
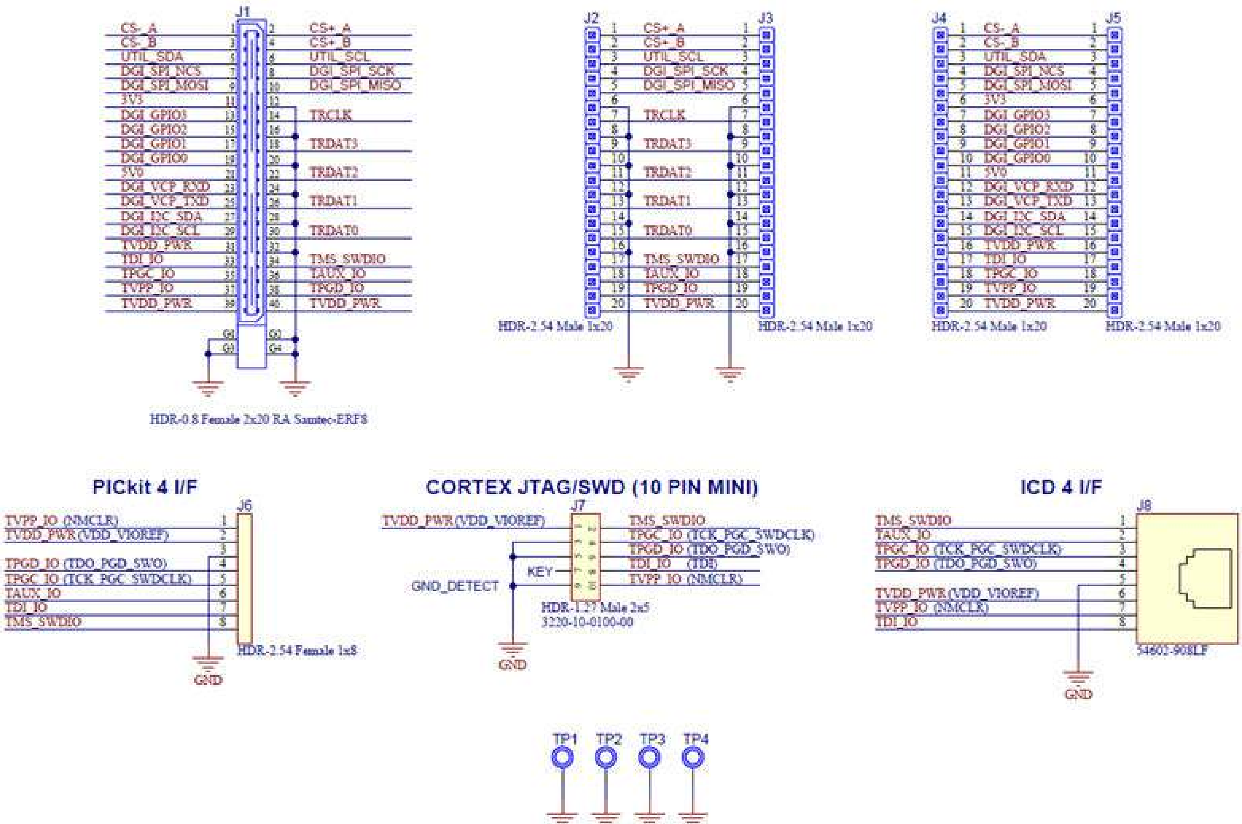


Figure 2-2. MPLAB ICE 4 Breakout Board Schematic



3. CI/CD Hardware-in-the-Loop Example - 32-bit Target

The following example demonstrates how to perform CI/CD hardware-in-loop functionality using the MPLAB ICE 4 Breakout Board with the MPLAB ICE 4 in-circuit emulator and an 32-bit device target.

Important: Please see the *CI/CD Wizard in MPLAB X IDE User's Guide* (DS-50003243), **1. CI/CD Wizard**, “CI/CD Requirements” and **1.3 Getting Started with Jenkins**, 1.3.1 “Prerequisites,” to determine what licenses, along with general software and hardware will be required to use this example. The user’s guide and additional information on CI/CD may be found on the MPLAB® X IDE CI/CD Wizard webpage.

3.1 Software Used

The following software was used when developing this example.

Number	Software Name	Used For	Documentation
1	MPLAB X IDE v6.00 or greater	Develop example code.	*MPLAB X IDE User’s Guide* (DS-50002027), 5. “Basic Development and Debug Flow” for information on working with projects.
2	MPLAB Code Configurator (available in MPLAB X IDE)	Select MPLAB Harmony for 32-bit device development.	MPLAB Harmony
3	MPLAB XC32 C Compiler	Build project code (with appropriate licenses*).	MPLAB XC32 C Compiler Documentation
4	CI/CD Wizard (available in MPLAB X IDE)	Set up an automated build and test pipeline tailored to the example project.	*CI/CD Wizard in MPLAB X IDE User's Guide* (DS-50003243)
5	Microchip Debugger (MDB) (available with MPLAB X IDE)	Headless version of MPLAB X IDE for use in Docker containers.	*Microchip Debugger (MDB) User's Guide* (DS-50002102)
6	Docker (must be installed and running on a Linux system*)	Creates standardized units called containers that have everything the software needs to run.	Docker Getting Started
7	Jenkins (Server with an agent set up on a Linux system*)	Automates the parts of software development related to building, testing, and deploying.	Jenkins website

* See *CI/CD Wizard in MPLAB X IDE User's Guide*, **1. CI/CD Wizard**, “CI/CD Requirements” and **1.3 Getting Started with Jenkins**, 1.3.1 “Prerequisites.”

3.2 Hardware Used

The following hardware was used to develop this example.

Number	Hardware Name	Used For	Documentation
1	MPLAB ICE 4 Breakout Board (AC244141)	Connecting any MPLAB ICE 4 communication pins to a target.	This document.

...........continued

Number	Hardware Name	Used For	Documentation
2	MPLAB ICE 4 in-circuit emulator (DV244140)	Connecting to a network using Ethernet in support of CI/CI.	*MPLAB ICE 4 In-Circuit Emulator User's Guide* (DS-50003242), 3.2. “PC Connections” for information on connecting Ethernet mode. Also see 5.4. “CI/CD Support” for a brief discussion of using the emulator for CI/CD.
3	SAME54 Xplained Pro Evaluation Kit (ATSAME54-XPRO)	ATSAME54P20A microcontroller code development.	ATSAME54 Xplained PRO User's Guide
4	Jumper wires	Connecting from the MPLAB ICE 4 breakout board to the Xplained PRO board.	N/A

Figure 3-1. MPLAB ICE 4 in Ethernet Mode

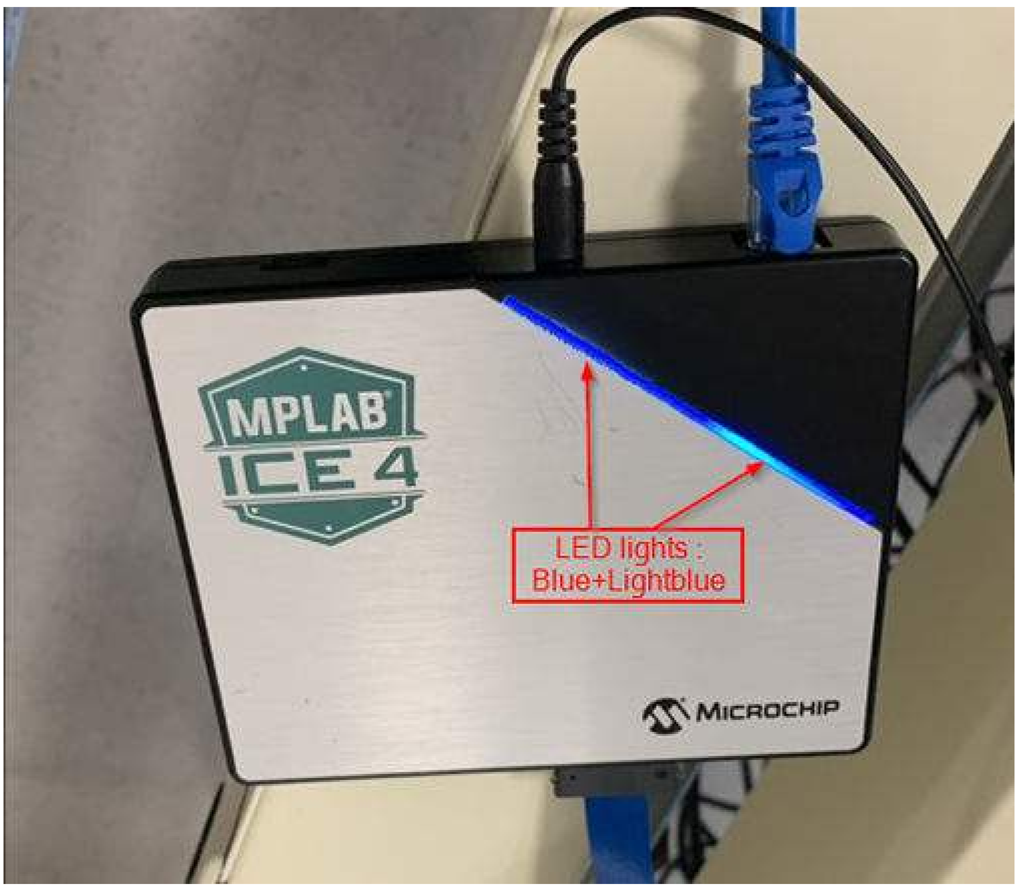


Figure 3-2. ATSAME54 Xplained PRO Board

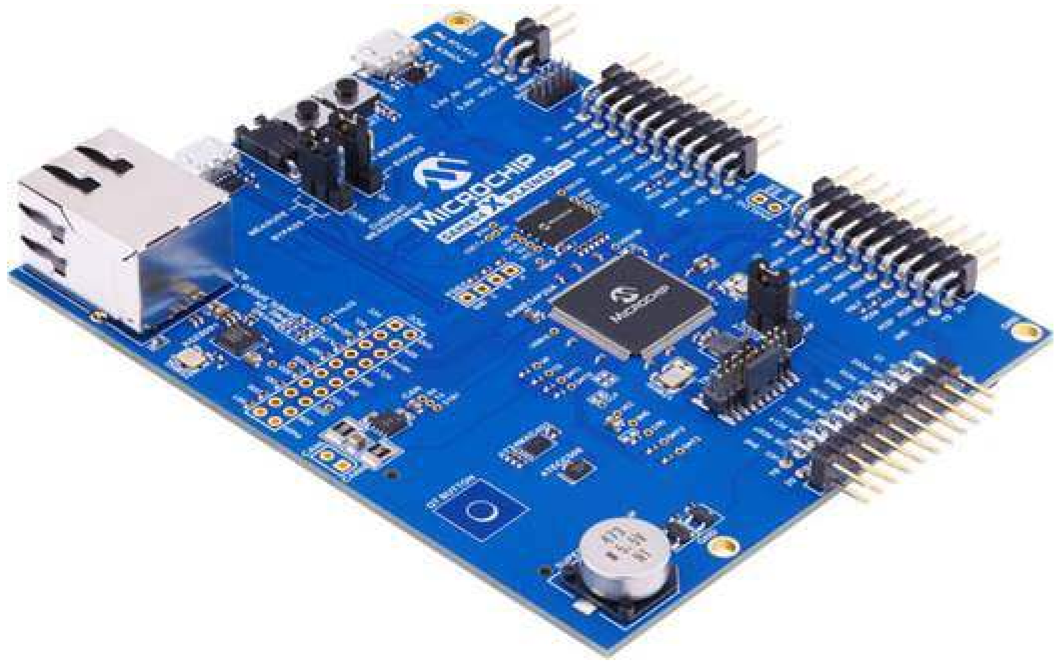


Figure 3-3. Jumper Wires

3.3 CI/CD 32-bit Example Flow

Follow the steps above to setup and execute the hardware-in the-loop feature for an 32-bit project using CI/CD wizard generated files.

Step 1. Extract Example Files
Find the example zip file with the PDF of this document posted on the MPLAB ICE 4 Breakout Board webpage.

Unzip and import the project `sam_e54_xpro.X` into MPLAB X IDE v6.00 or later.

The contents of the project are:

- MPLAB harmony project which demonstrates how to use the DMAC peripheral to do a memory-to-memory transfer
- CI/CD Wizard generated files:
  - DockerFile
  - JenkinsFile
  - `mdb-hardware-script.txt`
- Unity test runner files

The `main.c` file contains code for the application which uses a software trigger to initiate a memory-memory transfer from the source buffer to the destination buffer with 16-bit beat size and 32-bit beat size. The number of cycles taken for the DMA transfer is measured using the System timer (SysTick) and reported on the console. For details, see: DMAC memory transfer.

Step 2. Connect Hardware
Assemble the system as shown in the figures and table below.

Figure 3-4. Hardware Connections

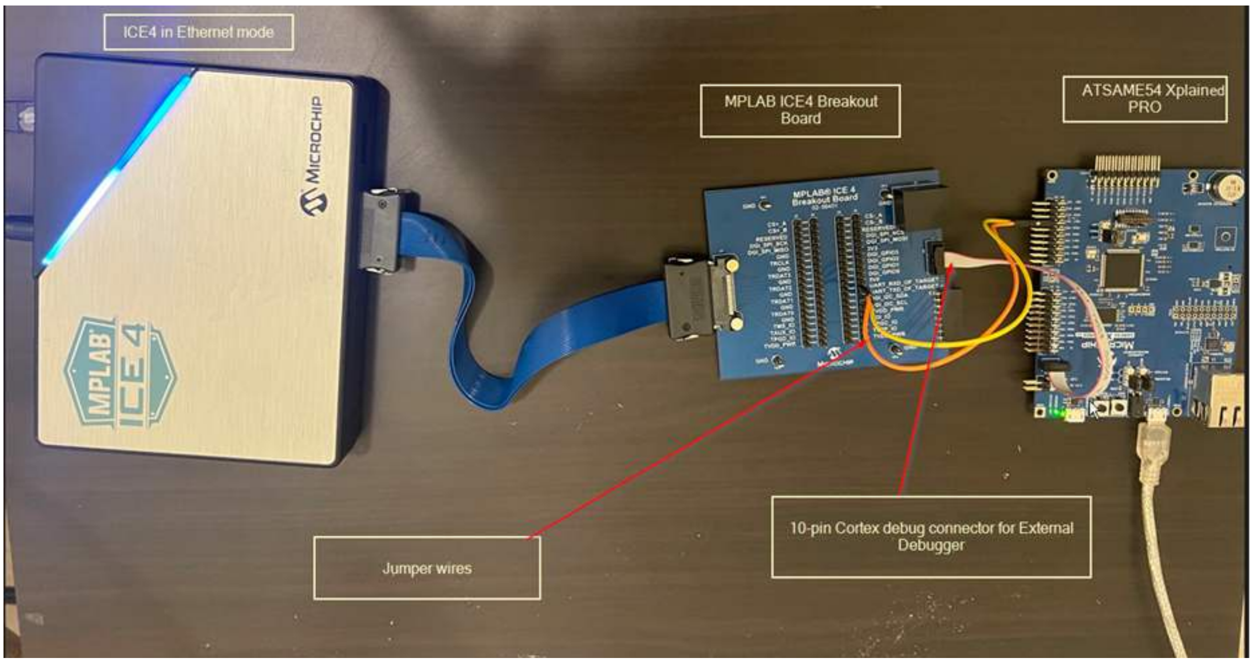
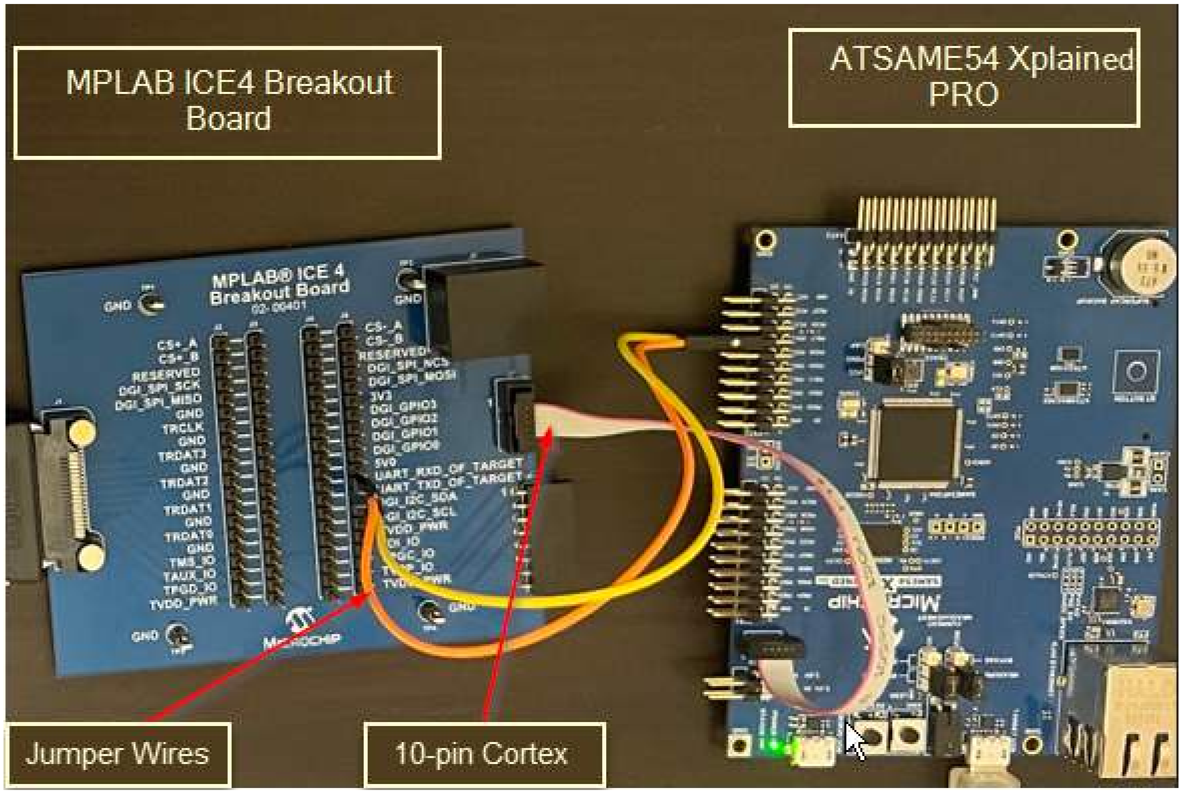


Figure 3-5. Board-to-Board Connections Zoom



MPLAB ICE 4 Breakout Board	ATSAME54 Xplained Pro
UART_RXD_OF_TARGET	PB17 (Extension Header EXT2)
UART_TXD_OF_TARGET	PB16 (Extension Header EXT2)
J7	SAME54 SWD DEBUG

Step 3. Update Generated Files

1. Update the network server license information into the Dockerfile as shown below.

Figure 3-6. Dockerfile Update

```
# Install MPLAB XC network license
RUN /opt/microchip/mplabx/v${MPLABX_VERSION}/mplab_platform/bin/xclm -netfile ${
'Port'} ${'MPLAB XC Network License Server Address'}; exit 0

ENV TOOLCHAIN xc32
ENV TOOLCHAIN_VERSION 4.10

# Download and install toolchain
RUN curl -fSL -A "Mozilla/4.0" -o /tmp/${TOOLCHAIN}.run \

    "https://ww1.microchip.com/downloads/aemDocuments/documents/DEV/ProductDocume
    nts/SoftwareTools/${TOOLCHAIN}-v${TOOLCHAIN_VERSION}-linux-installer.run" \
 && chmod a+x /tmp/${TOOLCHAIN}.run \
 && /tmp/${TOOLCHAIN}.run --mode unattended --unattendedmodeui none \
    --netservername localhost --LicenseType NetworkMode \
 && rm /tmp/${TOOLCHAIN}.run
ENV PATH /opt/microchip/${TOOLCHAIN}/v${TOOLCHAIN_VERSION}/bin:$PATH

# Install MPLAB XC network license
RUN /opt/microchip/${TOOLCHAIN}/v${TOOLCHAIN_VERSION}/bin/xclm -netfile ${'Port'
} ${'MPLAB XC Network License Server Address'}; exit 0
```

2. If needed, based on the Linux/MPLAB X IDE version, please install additional packages from the Dockerfile, e.g `libusb.so` (see figure below).

Figure 3-7. Dockerfile Additional Package Example

```
ENV DEBIAN_FRONTEND noninteractive

USER root
RUN dpkg --add-architecture i386 \
 && apt-get update -yq \
 && apt-get install -yq --no-install-recommends \
    ca-certificates=20211016~20.04.1 \
    curl \
    make=4.2.1-1.2 \
    unzip \
    procps
RUN apt-get update -yq \
&& apt-get install -yq \
    libusb-1.0-0 \
&& apt-get clean && rm -rf /var/lib/apt/lists/* /tmp/* /var/tmp/*
```

3. Update the IP address for MPLAB ICE 4 connected in Ethernet mode in the `mdb-hardware-script.txt` file and the JenkinsFile (as shown below).

Figure 3-8. mdb-hardware-script Update

```
# This file was generated by the CI/CD Wizard version 1.0.421.
# For information on MDB and how to extend this script see: https://microchipdeveloper.com/mplabx:mdb

# Disable all dialogs
set system.yestoalldialog true

# Set tool and device
device ATSAME54P20A
# Add IP of tool so it can be detected
addip xxx.xxx.xxx.xxx
# (Optional) List tools to verify that tool was detected
hwtool
sleep 3000
# Connect to network configured tool
hwtool ICE4 <ipa>xxx.xxx.xxx.xxx

```

Figure 3-9. Jenkinsfile Updates

```
stage('Hardware Test') {
    agent {
        dockerfile  {
            // Build agent label to select build agent
            // to host docker container.
            // NOTE: This must be a linux based container.
            label 'docker'
            filename 'sam_e54_xpro.X/Dockerfile'

            registryUrl "https://registry.hub.docker.com/"
        }
    }
    environment {
        HARDWARE_TEST_TOOL_IP = 'xxx.xxx.xxx.xxx'
        HARDWARE_TEST_TOOL_SERIAL_PORT = 'xxxx'
        HARDWARE_TEST_MDB_SCRIPT_FILE = 'sam_e54_xpro.X/mdb-hardware-script.txt'
        HARDWARE_TEST_BINARY_FILE = './sam_e54_xpro.X/dist/build.elf'
    }
    steps {
        sh(
            label: 'Generate hardware test makefiles',
            script: "prjMakefilesGenerator.sh -v -f ./sam_e54_xpro.X/@${env.HARDWARE_TEST_BUILD_CONFIGURATION}"
        )
        sh(
            label: 'Running Makefile',
            script: """
```

Step 4. Add Project Files to Version Control

Add the project source code to a source control system (example: Subversion, CVS, or Git).

Make sure the Jenkins server supports your source control system and can access to your project repository.

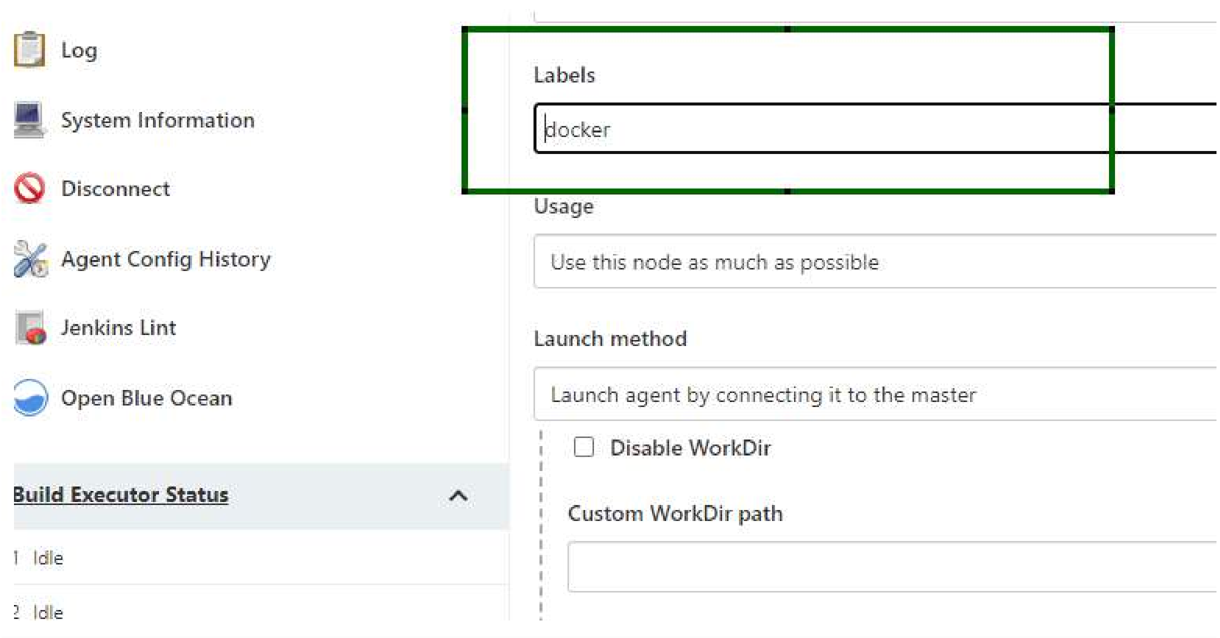
Step 5. Create a Jenkins Pipeline

Create a Jenkins pipeline.

Edit the label of the Jenkins agent you are planning to run these tests with as ‘docker’ (see figure) or update the JenkinsFile with the label name based on your node label.

Make sure that the node you select to run the Jenkins Pipeline has Docker installed and running and is a Linux system.

Figure 3-10. Edit Jenkins Agent Label



Step 6. Execute the Pipeline
The pipeline job will execute all the stages (Build, Analyze, Hardware Test, etc.) as seen below.

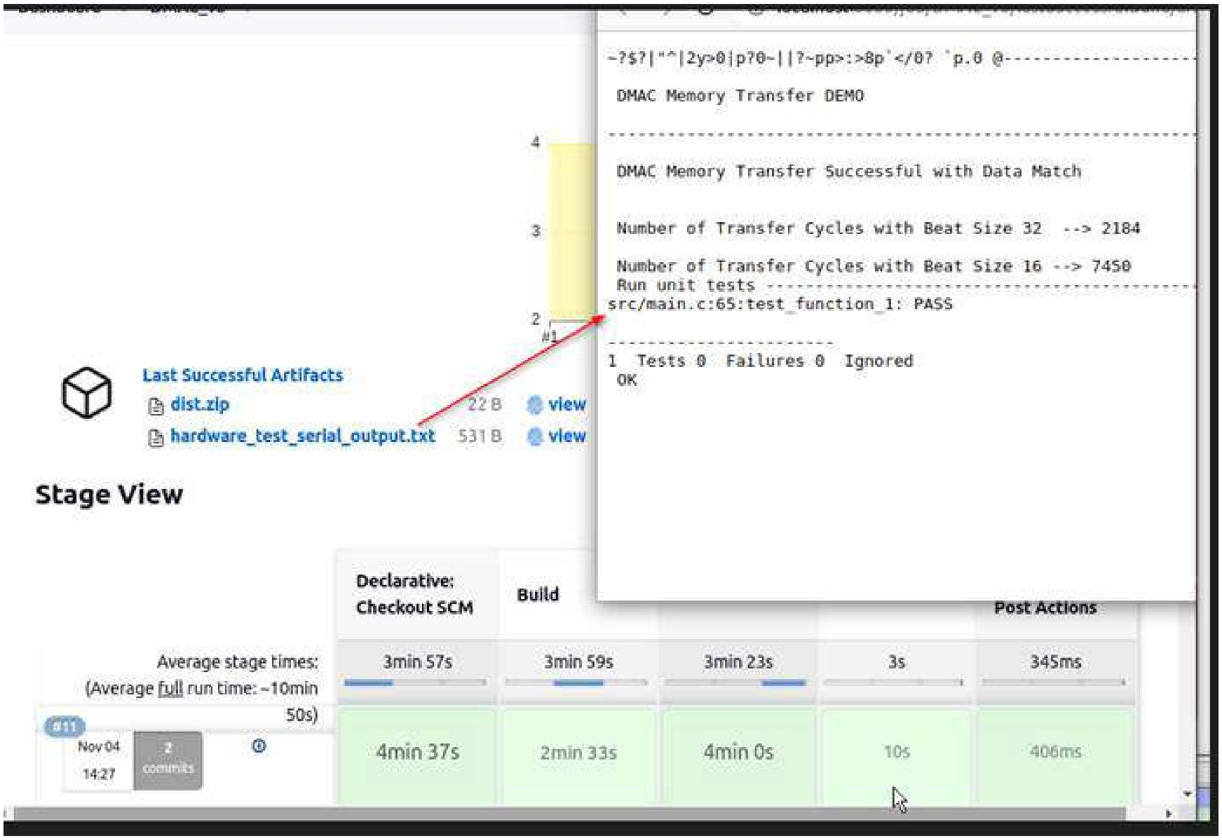
Figure 3-11. Pipeline Stages

When executing the ‘Hardware Test’ stage, the `mdb-hardware-script.txt` file is executed.

Step 7. View Execution Results

Once the Jenkins job is complete, the following files will be generated as a part of the post declarative action (see figure.)

Figure 3-12. Hardware Test Serial Output



The files are:

- **Dist.zip** – Collection of the build artifacts from the compiler. .hex-files, .elf-files and similar.
- **Hardware_test_serial_output.txt** – text file with the Unit test Pass/Fail results (see figure).

Optional: Customize Execution

For customizing the `mdb-hardware.txt` file with more commands supported by the MDB tool, you can also refer the *Microchip Debugger (MDB) User's Guide* (DS-50002102).

In the `main.c` file you can also add some additional assertions to check what is expected to be true about your embedded system. Please see the example code below where tests `test_function_2`, `test_funtion_3`, and `test_function_4` have been added in `main.c`.

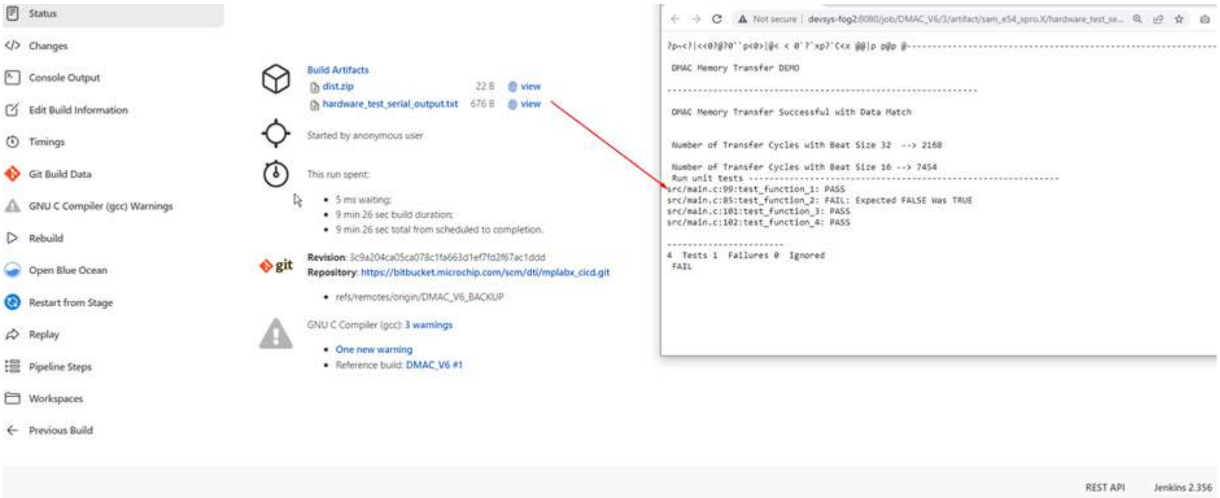
For more on rewriting your `main.c` and adding more advanced tests to it, see: https://github.com/ThrowTheSwitch/Unity/blob/master/docs/UnityGettingStartedGuide.md.

Figure 3-13. Updated main.c for Tests

```c
char dstBuffer1[TRANSFER_SIZE] = {};
char dstBuffer2[TRANSFER_SIZE] = {};
volatile bool completeStatus = false;
volatile bool errorStatus = false;
volatile uint8_t transfersDone = 0;
volatile uint32_t timeStamp=0;
uint32_t transferCyclesBeatSize32=0,transferCyclesBeatSize16=0;


void setUp (void) {}
void tearDown (void) {}

void test_function_1(void) {
    // Simple demo of working test
    TEST_ASSERT_TRUE(1);
}

void test_function_2(void) {
    // Simple demo of failing test
    TEST_ASSERT_FALSE(1);
}

void test_function_3(void) {
     // test if the value of 'transferCyclesBeatSize32' is not zero
     TEST_ASSERT_GREATER_THAN(0, transferCyclesBeatSize32);
}

void test_function_4(void) {
     // test if the value of 'transferCyclesBeatSize16' is not zero
     TEST_ASSERT_GREATER_THAN(0, transferCyclesBeatSize16);
}

int run_unit_tests(void)
{
    UnityBegin("src/main.c");
    RUN_TEST(test_function_1);
    RUN_TEST(test_function_2);
    RUN_TEST(test_function_3);
    RUN_TEST(test_function_4);
    return (UnityEnd());
}
```

The `hardware_test_serial_output.txt` generated after completion of the Jenkins pipeline will look as seen below.

Figure 3-14. Hardware Test Serial Output



4. Revision History

The following is a list of changes by version to this document.

Note: Some revision letters are not used - the letters `I` and `O` - as they can be confused for numbers in some fonts.

Revision A (January 2023)

Initial release of this document.

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PART NO.	[X][1]	-	X	/XX	XXX
Device	Tape and Reel Option		Temperature Range	Package	Pattern

Device:	PIC16F18313, PIC16LF18313, PIC16F18323, PIC16LF18323	
Tape and Reel Option:	Blank	= Standard packaging (tube or tray)
	T	= Tape and Reel[1]
Temperature Range:	I	= -40°C to +85°C (Industrial)
	E	= -40°C to +125°C (Extended)
Package:[2]	JQ	= UQFN
	P	= PDIP
	ST	= TSSOP
	SL	= SOIC-14
	SN	= SOIC-8
	RF	= UDFN
Pattern:	QTP, SQTP, Code or Special Requirements (blank otherwise)	

Examples:

- PIC16LF18313- I/P Industrial temperature, PDIP package
- PIC16F18313- E/SS Extended temperature, SSOP package

Notes:

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