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MPLAB® REAL ICE™ In-Circuit Emulator User's Guide For MPLAB X IDE

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ISBN: 978-1-62076-490-9

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This declaration of conformity is issued by the manufacturer.
The development/evaluation tool is designed to be used for research and development in a laboratory environment. This development/evaluation tool is not intended to be a finished appliance, nor is it intended for incorporation into finished appliances that are made commercially available as single functional units to end users. This development/evaluation tool complies with EU EMC Directive 2004/108/EC and as supported by the European Commission's Guide for the EMC Directive 2004/108/EC (8th February 2010).
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Derek Carlson

Derek Carlson
VP Development Tools

02-MAY-12
Date

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MPLAB® REAL ICE™ IN-CIRCUIT EMULATOR USER'S GUIDE FOR MPLAB X IDE

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Part 4 – Reference

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Preface

NOTICE TO CUSTOMERS

All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our web site (www.microchip.com) to obtain the latest documentation available.

Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXA", where "XXXXX" is the document number and "A" is the revision level of the document.

For the most up-to-date information on development tools, see the MPLAB® X IDE help. Select the Help menu, and then Topics to open a list of available help files.

INTRODUCTION

This chapter contains general information that will be helpful to know before using the MPLAB REAL ICE in-circuit emulator. Items discussed include:

- Document Layout
- Conventions Used in this Guide
- Recommended Reading

DOCUMENT LAYOUT

This document describes how to use the MPLAB REAL ICE in-circuit emulator as a development tool to emulate and debug firmware on a target board, as well as how to program devices. The document is organized as follows:

Part 1 – **Getting Started**

- **Chapter 1: About the Emulator** – What the MPLAB REAL ICE in-circuit emulator is, and how it can help you develop your application.
- **Chapter 2: Operation** – The theory of MPLAB REAL ICE in-circuit emulator operation. Explains configuration options.

Part 2 – **Features**

- **Chapter 3: General Setup** – How to set up MPLAB IDE to use the emulator.
- **Chapter 4: Common Debug Functions** – A description of basic emulator features available in MPLAB IDE when the MPLAB REAL ICE in-circuit emulator is chosen as the debug tool. This includes the debug features breakpoints, stopwatch, and external triggering.
- **Chapter 5: Specific Debug Functions: 8- and 16-Bit Devices** – A description of data capture, runtime watches and trace for 8- and 16-bit (data memory) devices. Includes the types of trace available and how to setup and use trace.
- **Chapter 6: Specific Debug Functions: 32-Bit Devices** – A description of data capture, runtime watches and trace for 32-bit devices. Includes hardware and software setup for use of PIC32 instruction trace.

Part 3 – **Troubleshooting**

- **Chapter 7: Troubleshooting First Steps** – The first things you should try if you are having issues with emulator operation.
- **Chapter 8: Frequently Asked Questions (FAQ)** – A list of frequently asked questions about emulator operation and issues.
- **Chapter 9: Messages** – A list of error messages and suggested resolutions.

Part 4 – **Reference**

- **Chapter 10: Emulator Function Summary** – A summary of emulator functions available in MPLAB IDE when the MPLAB REAL ICE emulator is chosen as the debug or program tool.
- **Chapter 11: Hardware Specification** – The hardware and electrical specifications of the emulator system. Includes a description of how to use the loop-back test board.

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CONVENTIONS USED IN THIS GUIDE

The following conventions may appear in this documentation:

TABLE 1: DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic	Referenced books	*MPLAB® X IDE User's Guide*
	Emphasized text	...is the *only* compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	<u>*File>Save*</u>
Bold	A dialog button	Click **OK**
	A tab	Click the **Power** tab
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier font:		
Plain	Sample source code	`#define START`
	Filenames	`autoexec.bat`
	File paths	`c:\mcc18\h`
	Keywords	`_asm, _endasm, static`
	Command-line options	`-Opa+, -Opa-`
	Bit values	`0, 1`
	Constants	`0xFF, 'A'`
Italic	A variable argument	*`file`*`.o`, where *`file`* can be any valid filename
Square brackets [ ]	Optional arguments	`mpasmwin [options]` *`file`* `[options]`
Curly brackets and pipe character: { | }	Choice of mutually exclusive arguments; an OR selection	`errorlevel {0|1}`
Ellipses...	Replaces repeated text	`var_name [, var_name...]`
	Represents code supplied by user	`void main (void) { ... }`

RECOMMENDED READING

This document describes how to use the MPLAB REAL ICE in-circuit emulator. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

Release Notes for MPLAB REAL ICE In-Circuit Emulator

For the latest information on using the emulator, read the release notes under “Release Notes and Support Documentation” on the Start page. The release notes contain update information and known issues that may not be included in this user’s guide.

Using the MPLAB REAL ICE In-Circuit Emulator (DS51749)

This poster shows you how to hook up the hardware and install the software for the MPLAB REAL ICE in-circuit emulator.

MPLAB REAL ICE Isolation Unit Setup (DS51858)

This poster shows you how to hook up the optoisolation unit hardware for high power applications. This information is also included in this document in **Section 13.4 “MPLAB REAL ICE Isolator Unit (Opto-Isolator)”**.

Debugger Design Advisory (DS51764)

A small document on guidelines and implementation considerations to ensure proper interfacing to the various development tools.

MPLAB REAL ICE In-Circuit Emulator Help File

A comprehensive help file for the emulator is included with MPLAB X IDE. Usage, troubleshooting and hardware specifications are covered. This may be more up-to-date than the printed documentation. Also, emulator reserved resources and limitations are listed for various devices.

Processor Extension Pak and Header Specification (DS51292)

This booklet describes how to install and use Processor Extension Paks (PEPs) and related debug headers to better debug selected devices without the loss of pins or resources. See also the PEP and Header online help file.

Transition Socket Specification (DS51194)

Consult this document for information on transition sockets available for use with headers.

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Part 1 – Getting Started

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Chapter 1. About the Emulator

1.1 INTRODUCTION

The MPLAB REAL ICE in-circuit emulator is a modern emulator that supports hardware and software development for selected Microchip PIC® microcontrollers (MCUs) and dsPIC® Digital Signal Controllers (DSCs).

An overview of the emulator is provided in this chapter:

- Emulator Features
- How the Emulator Helps You
- Emulator System
- Emulator Kit Components

1.2 EMULATOR FEATURES

The MPLAB REAL ICE emulation concept has these features:

- Processors run at maximum speeds
- Debugging can be done with the device in-circuit
- No emulation load on the processor bus
- Simple interconnection
- Capability to incorporate I/O data
- Instrumented Trace (MPLAB IDE and Compiler Assisted)
- PIC32 Instruction Trace (Hardware trace)

In addition to emulator functions, the MPLAB REAL ICE in-circuit emulator system also may be used as a production programmer.

1.3 HOW THE EMULATOR HELPS YOU

The MPLAB REAL ICE in-circuit emulator is an integral part of the development engineer's toolsuite. Application usage can vary from software development to hardware integration, to manufacturing test, to field service.

The MPLAB REAL ICE in-circuit emulator system enables you to:

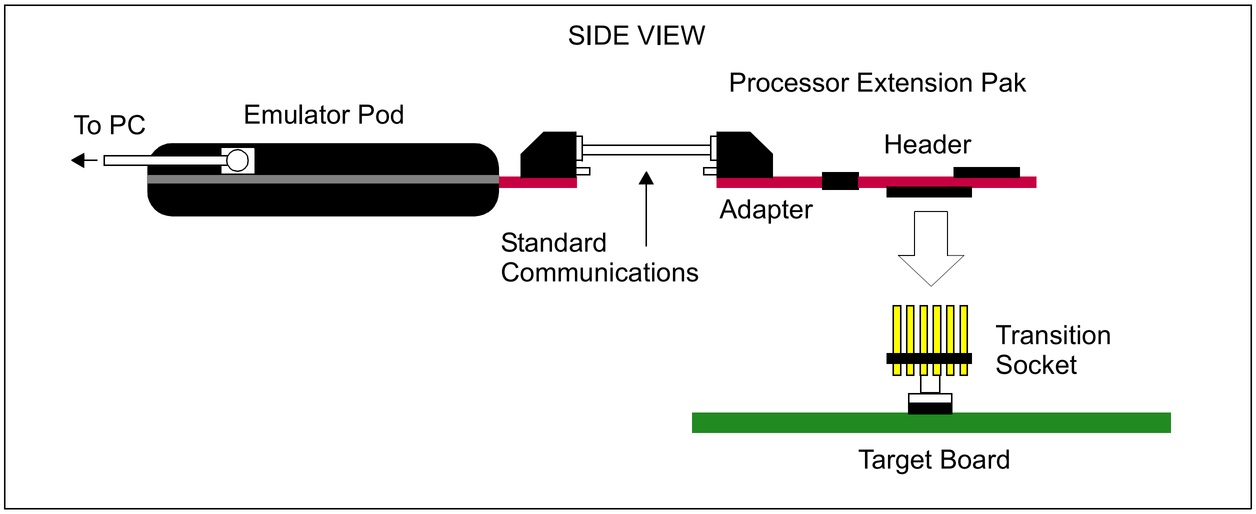
- Debug an application on hardware in real time
- Debug with hardware breakpoints
- Debug with software breakpoints (device-dependent)
- Halt, based on internal events and/or external signals
- Monitor internal file registers
- Emulate full speed
- Program devices as a production programmer
- Trace lines of code or log variable/expression values

1.4 EMULATOR SYSTEM

The MPLAB REAL ICE in-circuit emulator is an in-circuit emulator that is controlled by a PC running MPLAB X IDE cross-platform software. The emulator communicates with a device or debug header that has on-board debug/emulation circuitry. A device is usually connected directly to a target board, whereas a header may be connected directly to or through a transition socket.

An example emulator system configuration is shown in Figure 1-1. For other possible configurations, see **Section 3.4.1 "Standard Communication"** and **Section 3.4.2 "High-Speed/LVDS Communication (Performance Pak)"**.

FIGURE 1-1: EXAMPLE EMULATOR SYSTEM SETUP



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1.5 EMULATOR KIT COMPONENTS

The components of the MPLAB REAL ICE in-circuit emulator system kit are listed below.

1. Emulator pod – main unit.
2. USB cable – provides communications between the emulator and a PC and power to the emulator.
3. Standard driver board and cable – connects the emulator pod to a header module or target board.
4. Logic probes – used for external triggers and I/O port trace.
5. Loop-back test board – verifies emulator operation.

Additional hardware may be ordered separately. See the Microchip website (www.microchip.com) for available items. Some popular items are:

- Processor Extension Pak – provides a debug header for standard communications. Contains an ICE header/receiver board and a standard adapter board for debug headers with 8-pin connectors instead of 6-pin.
- Performance Pak – provides high-speed/LVDS communications. Useful for managing high data rates, noisy environments and long distances between the emulator and the target. Also supports SPI trace.
  Contains a high-speed driver board, a high-speed receiver board, a high-speed to standard converter board, and cables to connect the emulator pod to a target board.
- Transition socket – connects the debug header to the target.
- MPLAB REAL ICE Isolator unit – optically isolates the emulator from the target. It is useful for high-power applications.

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Chapter 2. Device and Feature Support

For the specified tools, the following topics show the current and future support for devices, as well as the device features, depending on the selected device.

Note:	MPLAB X IDE Users: For a list of currently supported devices and related features, click on "Release Notes" on the "Learn & Discover" tab of the Start Page.

- 32-Bit (Data Memory) Devices
- 16-Bit (Data Memory) Devices
- 8-Bit (Data Memory) Devices - PIC18
- 8-Bit (Data Memory) Devices - PIC10/12/16

2.1 32-BIT (DATA MEMORY) DEVICES

The following table shows feature support for PIC32 MCUs.

Feature	Tools	PIC32MX5xx/ PIC32MX6xx/ PIC32MX7xx	PIC32MX3xx/ PIC32MX4xx	PIC32MX1xx/ PIC32MX2xx
Reset application	All	C	C	C
Run, Halt	All	C	C	C
Single Step	All	C	C	C
Full Speed Emulation	All	C	C	C
Hardware Breakpoints	All	C	C	C
Advanced Breakpoints	RI, ICD3	C	C	C
Software Breakpoints	RI, ICD3	C	C	N
Peripheral Freeze (1)	All	C	C	C
Break on data fetch or write	All	C	C	C
Break on Stack overflow	All	C	C	C
Stopwatch	All	C	C	C
Pass Counter	All	C	C	C
WDT overflow	All	C	C	C
PIC32 Instruction Trace - built-in	RI	D	D	D
Native Trace - built-in	RI	D	N	N
SPI Trace	RI	N	N	N
I/O Port Trace	RI	N	N	N
Trace Macros for C code	RI	D	N	N
Data Capture (2)	RI	C	N	N
Runtime Watch (2)	RI	C	C(3)	N
Application Input/Output	RI,ICD3	C	N	N
Standard Speed Comm.	All	C	C	C
High Speed Comm. (LVDS)	RI	C	C	C
Processor Pak	All	N	N	N
External triggers (logic probes)	RI	C	C	C
MPLAB REAL ICE Isolator Unit	RI	C	C	C

Legend:
Tools = MPLAB REAL ICE in-circuit emulator (RI), MPLAB ICD 3 (ICD3), PICkit 3 (PK3), All 3 (All)
C = Current support (Green)
D = Support dependent on device (Yellow)
F = No support now, but planned in the future (Orange)
N = Support Not Available (Red)

Note 1: This feature operates differently depending on the selected device.
Note 2: At speeds higher than 15 MIPS, the Performance Pak may be needed.
Note 3: The Data Monitor and Control Interface can capture data using a form of Runtime Watch for these devices. Not all data points will be captured.

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2.2 16-BIT (DATA MEMORY) DEVICES

The following table shows feature support for dsPIC30F/33F DSCs and PIC24F/H MCUs.

Feature	Tools	dsPIC33EP, PIC24EP	dsPIC33F, PIC24H	PIC24F	dsPIC30F SMPS(3)	dsPIC30F
Reset application	All	C	C	C	C	C
Run, Halt	All	C	C	C	C	C
Single Step	All	C	C	C	C	C
Full Speed Emulation	All	C	C	C	C	C
Hardware Breakpoints	All	C	C	C	C	C
Advanced Breakpoints	RI, ICD3	C	C	C	C	C
Software Breakpoints	RI, ICD3	C	C	C	C	C
Peripheral Freeze (1)	All	C	C	C	C	C
Break on data fetch or write	All	C	C	C	C	C
Break on Stack overflow	All	N	N	F	F	N
Stopwatch	All	C	C	C	C	N
Pass Counter	All	C	C	C	C	C
WDT overflow	All	C	C	C	C	N
Native Trace - built-in (2)	RI	C	C	C	C	N
SPI Trace	RI	F	C	C	D(4)	D(4)
I/O Port Trace	RI	F	C	C	D(5)	D(5)
Trace Macros for C code	RI	C	C	C	C	C
Data Capture (2)	RI	C	C	C	C	N
Runtime Watch (2)	RI	C	C	C	C	N
Application Input/Output	RI,ICD3	C	N	N	N	N
High Speed Comm. (LVDS)	RI	C	C	C	C	C
Processor Pak	All	F	F	D	F	N
External triggers (logic probes)	RI	C	C	C	C	C
MPLAB REAL ICE Isolator Unit	RI	C	C	C	N	N

Legend:
Tools = MPLAB REAL ICE in-circuit emulator (RI), MPLAB ICD 3 (IICD3), PICkit 3 (PK3), All 3 (All)
C = Current support (Green)
D = Support dependent on device (Yellow)
F = No support now, but planned in the future (Orange)
N = Support Not Available (Red)

Note 1: This feature operates differently depending on the selected device.
Note 2: At speeds higher than 15 MIPS, the Performance Pak may be needed.
Note 3: dsPIC30F Switch Mode Power Supply (SMPS) devices: dsPIC30F1010/2020/2023.
Note 4: No SPI Trace for devices with SPI port pins multiplexed with PGC/PGD pins.
Note 5: No I/O Port Trace for devices without a port with a full 8 bits available for trace OR devices with pin counts of 44 or less.

2.3 8-BIT (DATA MEMORY) DEVICES - PIC18

The following table shows feature support for PIC18 MCUs.

Feature	Tools	PIC18FxxJ	PIC18FxxK	PIC18F, PIC18F Enh
Reset application	All	**C**	**C**	**C**
Run, Halt	All	**C**	**C**	**C**
Single Step	All	**C**	**C**	**C**
Full Speed Emulation	All	**C**	**C**	**C**
Hardware Breakpoints	All	**C**	**C**	**C**
Advanced Breakpoints	RI, ICD3	**C**	**C**	**C**
Software Breakpoints	RI, ICD3	**C**	**D**(3)	**C**
Peripheral Freeze (1)	All	**C**	**C**	**C**
Break on data fetch or write	All	**C**	**C**	**C**
Break on Stack overflow	All	**C**	**C**	**C**
Stopwatch	All	**C**	**D**(3)	**N**
Pass Counter	All	**C**	**C**	**C**
WDT overflow	All	**C**	**N**	**N**
Native Trace - built-in (2)	RI	**C**	**D**(4)	**N**
SPI Trace	RI	**C**	**C**	**C**
I/O Port Trace	RI	**C**	**C**	**C**
Trace Macros for C code	RI	**C**	**D**(4)	**C**
Data Capture (2)	RI	**C**	**D**(4)	**N**
Runtime Watch (2)	RI	**C**	**D**(4)	**N**
Application Input/Output	RI,ICD3	**N**	**N**	**N**
Standard Speed Comm.	All	**C**	**C**	**C**
High Speed Comm. (LVDS)	RI	**C**	**C**	**C**
Processor Pak	All	**F**	**D**	**F**
External triggers (logic probes)	RI	**C**	**C**	**C**
MPLAB REAL ICE Isolator Unit	RI	**C**	**N**	**N**

Legend:
Tools = MPLAB REAL ICE in-circuit emulator (RI), MPLAB ICD 3 (ICD3), PICkit 3 (PK3), All 3 (All)
C = Current support (Green)
D = Support dependent on device (Yellow)
F = No support now, but planned in the future (Orange)
N = Support Not Available (Red)

Note 1: This feature operates differently depending on the selected device.
Note 2: At speeds higher than 15 MIPS, the Performance Pak may be needed.
Note 3: Families not supported: PIC18F14K22, PIC18F14K50.
Note 4: Families not supported: PIC18F14K22, PIC18F14K50, PIC18F2xK20/4xK20.

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2.4 8-BIT (DATA MEMORY) DEVICES - PIC10/12/16

The following table shows feature support forPIC10/12/16 MCUs.

Feature	Tools	PIC12F/16F1xxx	PIC10F/12F/16F
Reset application	All	**C**	**C**
Run, Halt	All	**C**	**C**
Single Step	All	**C**	**C**
Full Speed Emulation	All	**C**	**C**
Hardware Breakpoints	All	**C**	**C**
Advanced Breakpoints	RI, ICD3	**N**	**N**
Software Breakpoints	RI, ICD3	**C**	**N**
Peripheral Freeze [(1)]	All	**C**	**C**
Break on data fetch or write	All	**D**	**N**
Break on Stack overflow	All	**D**	**N**
Stopwatch	All	**D**	**N**
Pass Counter	All	**D**	**N**
WDT overflow	All	**D**	**N**
Native Trace - built-in [(2)]	RI	**F**	**N**
SPI Trace	RI	**N**	**N**
I/O Port Trace	RI	**N**	**N**
Trace Macros for C code	RI	**N**	**N**
Data Capture [(2)]	RI	**F**	**N**
Runtime Watch [(2)]	RI	**C**[(3)]	**N**
Application Input/Output	RI,ICD3	**N**	**N**
Standard Speed Comm.	All	**C**	**C**
High Speed Comm. (LVDS)	RI	**C**	**C**
Processor Pak	All	**D**	**D**
External triggers (logic probes)	RI	**C**	**C**
MPLAB REAL ICE Isolator Unit	RI	**N**	**N**

Legend:
Tools = MPLAB REAL ICE in-circuit emulator (RI), MPLAB ICD 3 (ICD3), PICkit 3 (PK3), All 3 (All)
C = Current support (Green)
D = Support dependent on device (Yellow)
F = No support now, but planned in the future (Orange)
N = Support Not Available (Red)

Note 1: This feature operates differently depending on the selected device.

Note 2: At speeds higher than 15 MIPS, the Performance Pak may be needed.

Note 3: Working At 8MHz or below.

NOTES:

Chapter 3. Operation

3.1 INTRODUCTION

A simplified description of how the MPLAB REAL ICE in-circuit emulator system works is provided here. It is intended to provide enough information so that a target board can be designed that is compatible with the emulator for both emulation and programming operations. The basic theory of in-circuit emulation and programming is described so that problems, if encountered, are quickly resolved.

- Tools Comparison
- Operational Overview
- Emulator Communications with the PC and Target
- Target Communication Connections
- Trace Connections
- Debugging with the Emulator
- Requirements For Debugging
- Programming with the Emulator
- Resources Used by the Emulator

3.2 TOOLS COMPARISON

The MPLAB REAL ICE in-circuit emulator system differs physically and operationally from other Microchip debug tools as shown below. Specific features may vary by device (see the online help file for "Device and Feature Support".)

TABLE 3-1: DEBUG TOOLS COMPARISON

Features	MPLAB REAL ICE in-circuit emulator	MPLAB ICD 3 in-circuit debugger	PICkit 3 programmer/debug express
USB Speed	High and Full	High and Full	Full Only
USB Driver	Microchip	Microchip	HID
USB Powered	Yes	Yes	Yes
Power to Target	No	Yes	Yes
Programmable Vpp and Vdd	Yes	Yes	Yes
Vdd Drain from Target	<1ma	<1ma	20ma
Overvoltage/Overcurrent Protection	Yes (HW)	Yes (HW)	Yes (SW)
Device emulation	Full speed	Full speed	Full speed
HW Breakpoints	Complex	Complex	Simple
Stopwatch	Yes	Yes	Yes
SW Breakpoints	Yes	Yes	No
Non-Volatile Program Image	No	No	512K bytes
Serialized USB	Yes	Yes	Yes
Trace	Yes	No	No
Data Capture	Yes	No	No
Logic Probe Triggers	Yes	No	No
High Speed/LVDS Connection	Yes	No	No
Production Programmer	Yes	Yes	No

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3.3 OPERATIONAL OVERVIEW

The emulator is connected to the PC via a USB port for communication and emulator power (but not target power).

The emulator is connected to the target application for communication and data collection, such as trace.

Below is a summary of possible connection configurations.

TABLE 3-2: CONNECTIONS FOR EMULATING 8-BIT AND 16-BIT DEVICES

Connection	Speed	Debug Support (1,2)	Trace Support (1,3)
Standard Communications	15 MIPS or less	Data Capture, Runtime Watch	Native Trace
High-Speed Communications	Greater than 15 MIPS	Data Capture, Runtime Watch	Native Trace, SPI Trace
Logic Port Probes (4)	Device Dependent	N/A	I/O Port Trace

Note 1: Support is device dependent. See online help.

Note 2: For details see **Section 6.2 "Data Capture and Runtime Watches"**.

Note 3: For details see .**Section 6.3.3 "Types of Trace"**

Note 4: For details see **Section 3.6.3 "I/O Port Trace Connections"**.

TABLE 3-3: CONNECTIONS FOR EMULATING 32-BIT DEVICES

Connection	Speed	Debug Support (1,2)	Trace Support (1,3)
Standard Communications or High-Speed Communications	Device Dependent	Data Capture, Runtime Watch	N/A
MPLAB REAL ICE Trace Interface Kit (Logic Port)	Device Dependent	N/A	PIC32 Instruction Trace

Note 1: Support is device dependent. See online help.

Note 2: For details see **Section 7.2 "Data Capture and Runtime Watches"** and **Section 7.6 "Application In/Out"**.

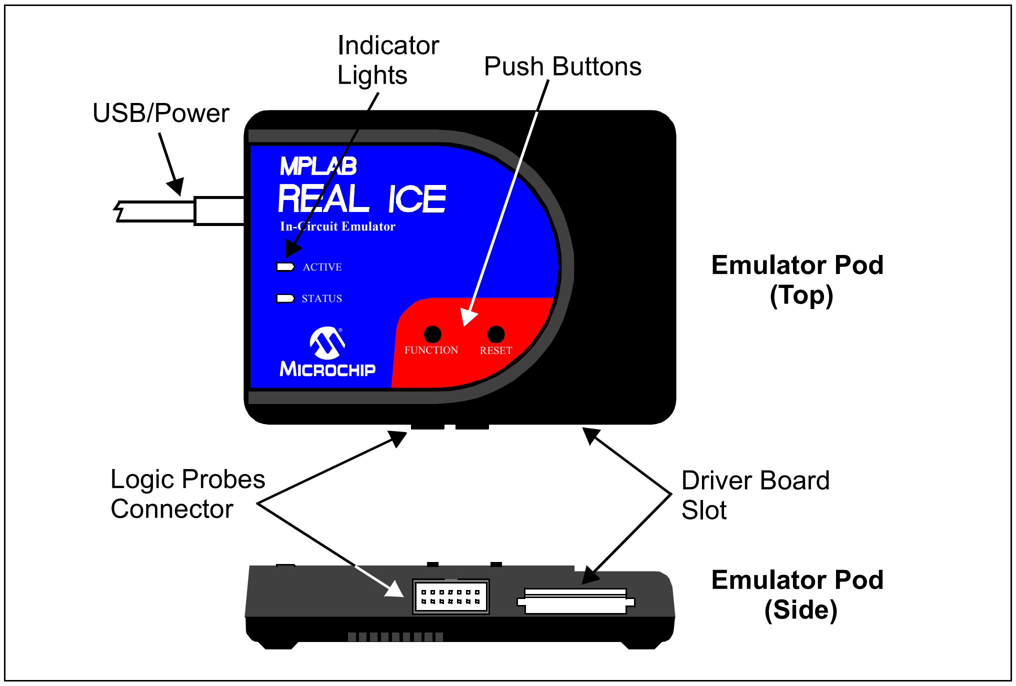
Note 3: For details see **Section 7.3 "PIC32 Instruction Trace"**.

3.4 EMULATOR COMMUNICATIONS WITH THE PC AND TARGET

The MPLAB REAL ICE in-circuit emulator system consists of these items:

1. Emulator pod with indicator lights, push buttons and a logic probe connector
2. USB cable to connect a PC to the emulator pod and power the pod
3. Driver board and modular cable(s) to connect the emulator pod to an ICE header or target board

FIGURE 3-1: BASIC EMULATOR POD



The emulator communicates with the PC and is powered through the USB cable.

The emulator communicates with the target through the configurations discussed in the following sections.

CAUTION

Do not connect the hardware before installing the software and USB drivers. Also, do not change hardware connections while the pod or target is powered.

DANGER

If your application uses AC line or high voltage power not referenced to ground, you should use an isolation circuit. See Section 13.4 “MPLAB REAL ICE Isolator Unit (Opto-Isolator)”.

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3.4.1 Standard Communication

The emulator system can be configured to use the standard connection for communicating debug and programming instructions to the target. This 6-pin connection is the same one used by other Microchip in-circuit debuggers.

The standard driver board is plugged into the emulator pod to configure the system for communication with the target. The modular cable can be either (1) inserted into a matching socket at the target, where the target device is on the target board, as shown in Figure 3-2, or (2) inserted into a standard adapter/debug header combo – available as a Processor Pak – which is then plugged into the target board, as shown in Figure 3-3.

A debug header is a small circuit board with an -ME2/-ICE/-ICD device mounted onto it. These devices provide debug functionality for production devices that (1) do not have on-board debug circuitry or (2) cannot afford to lose I/O pins for debugging. For more on debug headers, see the "*Debug Header Specification*" (in "Recommended Reading").

Note:	Older debug headers used a 6-pin (RJ-11) connector instead of an 8-pin connector, so these headers may be connected directly to the emulator.

To see the debug features of a device versus those of a debug header, see the *Development Tools Selector* on the Development Tools home page on the Microchip website (http://www.microchip.com/dts).

For more on the hardware, see **Section 12.5 "Standard Communication Hardware"**.

FIGURE 3-2: STANDARD CONNECTION – DEVICE WITH ON-BOARD ICE CIRCUITRY

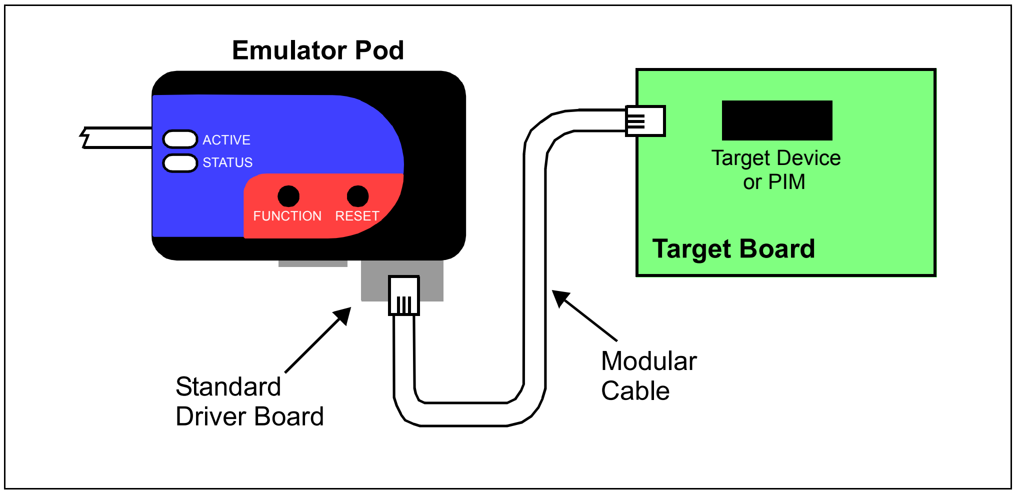
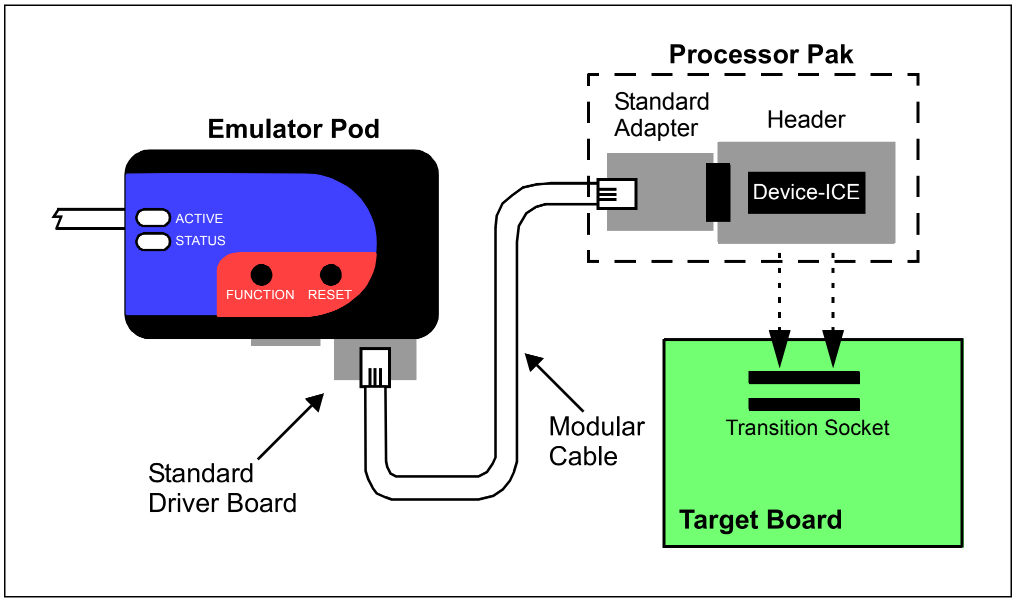


FIGURE 3-3: STANDARD CONNECTION – ICE DEVICE



3.4.2 High-Speed/LVDS Communication (Performance Pak)

The emulator system can be configured to use the high-speed/LVDS connection for communicating debug and programming instructions to the target. Compared to standard communication, this form of communication provides the following features.

- Noise cancellation from the low-voltage differential signal (LVDS) technology, which allows:
  - Data rates greater than 15 MIPS for data capture, runtime watches,and Native trace.
  - Longer distances between the emulator and the target.
  - Operation in noisy environments.
- Two additional pins used for SPI trace.

The high-speed driver board (from the Performance Pak) is plugged into the emulator pod to configure the system for this type of communication with the target. The modular cables can be inserted into matching connectors at the high-speed receiver board. The high-speed receiver board is attached via an 8-pin connector into either (1) the target board, with an on-board target device as shown in Figure 3-4, or (2) the debug header (from the Processor Pak), which is then plugged into the target board (Figure 3-5).

If your application is high-voltage, you will also need to replace the high-speed receiver board with an A/C isolator unit to isolate the target. See **Section 13.4 "MPLAB REAL ICE Isolator Unit (Opto-Isolator)"**.

For more on the hardware, see **Section 13.3 "High-Speed/LVDS Communication Hardware (Performance Pak)"**.

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FIGURE 3-4: HIGH-SPEED/LVDS CONNECTION – DEVICE WITH ON-BOARD ICE CIRCUITRY

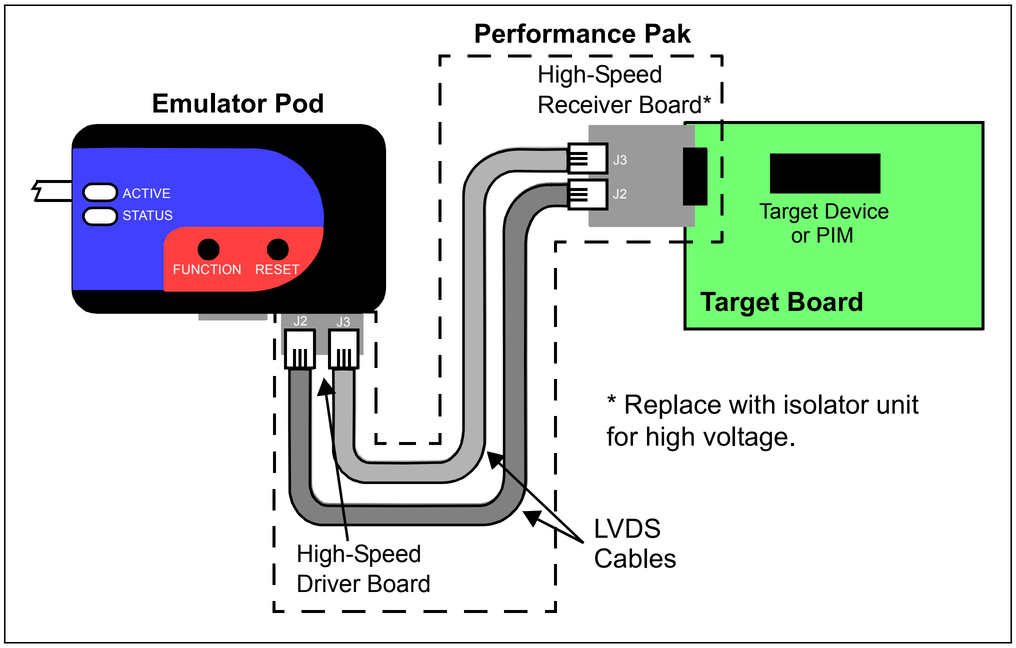
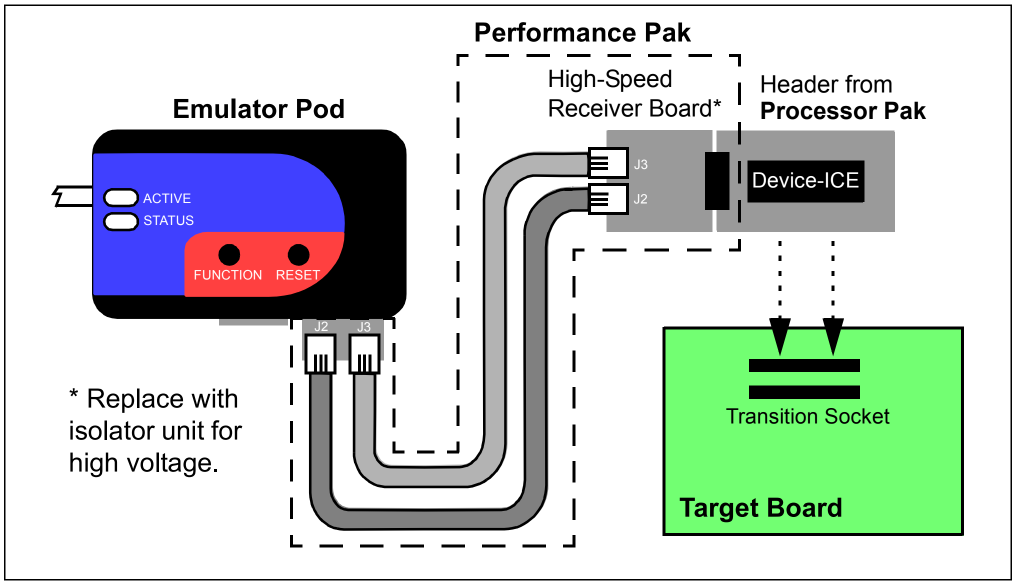


FIGURE 3-5: HIGH-SPEED/LVDS CONNECTION – ICE DEVICE



3.5 TARGET COMMUNICATION CONNECTIONS

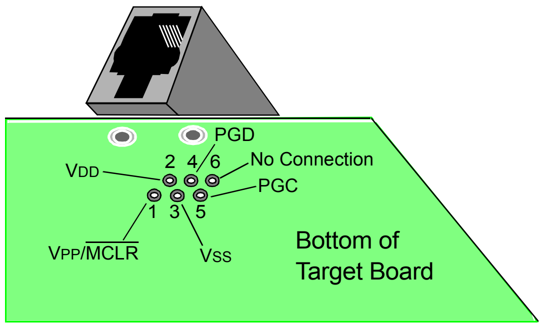
There are two driver boards available to closely match most application requirements. The standard driver board can be used to connect to the myriad of demo boards and applications that contain the RJ11 connector. The high-speed driver/receiver board combination can be used for high-speed communications, for additional trace features, for large (several feet) emulator-to-target distances and for noisy environments.

3.5.1 Standard Connector

Using the standard driver board, the MPLAB REAL ICE in-circuit emulator is connected to the target device with the modular interface (six-conductor) cable. The pin numbering for the connector is shown from the bottom of the target PC board in Figure 3-6.

Note: Cable connections at the emulator and target are mirror images of each other, i.e., pin 1 on one end of the cable is connected to pin 6 on the other end of the cable. See **Section 12.5.2.1 "Modular Cable Specification"**.

FIGURE 3-6: STANDARD CONNECTION AT TARGET

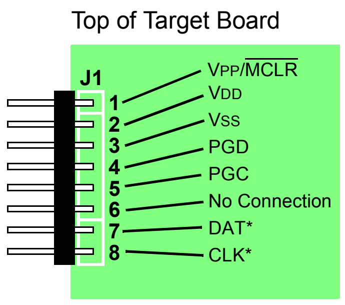


3.5.2 High-Speed/LVDS Connector

Using the high-speed driver/receiver board combination, the MPLAB REAL ICE in-circuit emulator is connected to the target device with an 8-pin interface. The pin numbering for the connector is shown from the top of the target PC board in Figure 3-7.

Note: Connections from the emulator to the target are shown in **Section 13.3 "High-Speed/LVDS Communication Hardware (Performance Pak)"**.

FIGURE 3-7: HIGH-SPEED CONNECTION AT TARGET



* Used for optional SPI trace capability. See **Section 3.6.2 "SPI Trace Connections (High-Speed/LVDS Connection)"**.

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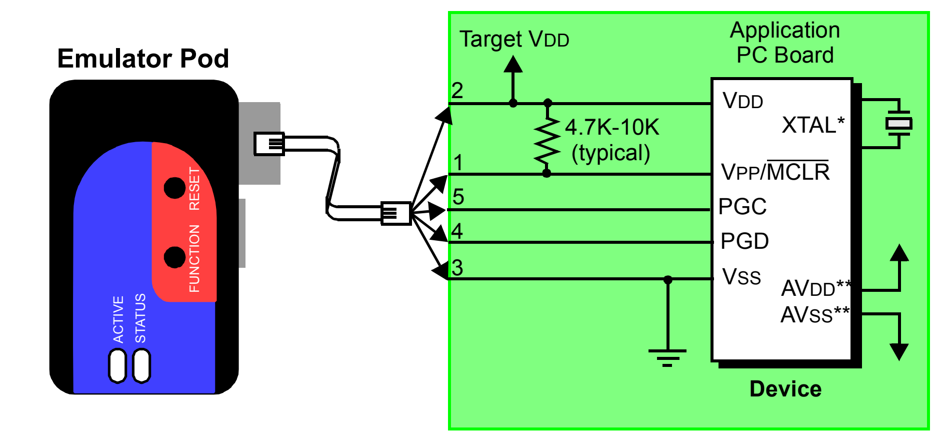
3.5.3 Target Connection Circuitry

Figure 3-8 shows the interconnections of the MPLAB REAL ICE in-circuit emulator to the connector on the target board. The diagram also shows the wiring from the connector to a device on the target PC board. A pull-up resistor (typically 10 kΩ) is recommended to be connected from the VPP/$\overline{\text{MCLR}}$ line to VDD so that the line may be strobed low to reset the device.

FIGURE 3-8: STANDARD CONNECTION TO TARGET CIRCUITRY



* Target device must be running with an oscillator for the emulator to function as a debugger.

** If the device has AVDD and AVSS lines, they must be connected for the emulator to operate.

In the following descriptions, only three lines are active and relevant to core emulator operation: pins 1 (VPP/$\overline{\text{MCLR}}$), 5 (PGC) and 4 (PGD). Pins 2 (VDD) and 3 (VSS) are shown on the above diagram for completeness, but are only sensed, not provided or controlled, by the emulator.

Be aware that the target VDD is sensed by the emulator to allow level translation for target low-voltage operation and to detect a device. If the emulator does not sense voltage on its VDD line (pin 2 of the interface connector), it will not connect with the device.

Not all devices have the AVDD and AVSS lines, but if they are present on the target device, all must be connected to the appropriate levels in order for the emulator to operate. This also applies to voltage regulator pins (e.g., ENVREG/DISVREG on PIC24FJ MCUs).

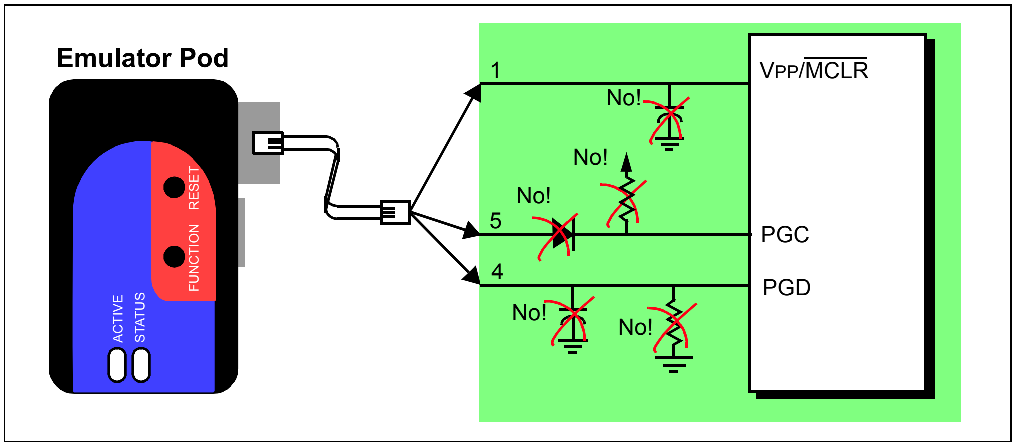
In general, it is recommended per device data sheet that all VDD/AVDD and VSS/AVSS lines be connected to the appropriate levels. Also, devices with a VCAP pin (e.g., PIC18FXXJ devices) should be connected as close to the device as possible and to the appropriatly-valued capacitor or other internal regulator device. See your device data sheet for proper values.

Note: The interconnection is very simple. Any problems experienced are often caused by other connections or components on these critical lines that interfere with the operation of the MPLAB REAL ICE in-circuit emulator system, as discussed in the next section.

3.5.4 Circuits That Will Prevent the Emulator From Functioning

Figure 3-9 shows the active emulator lines with some components that will prevent the MPLAB REAL ICE in-circuit emulator system from functioning.

FIGURE 3-9: IMPROPER CIRCUIT COMPONENTS



For the Vpp/MCLR pin:

- Do not use capacitors on $\overline{\text{MCLR}}$ – they will prevent fast transitions of VPP. A simple pull-up resistor is generally sufficient.

For the programming pins (PGC/PGD), no compoents should be connected, or more specifically:

- Do not use pull-ups or pull-downs on PGC/PGD – they will affect the voltage levels, since these lines already have 4.7 kΩ pull-down resistors in the emulator.
- Do not use capacitors on PGC/PGD – they will prevent fast transitions on data and clock lines during programming and debug communications, and may cause debugging or programming failures
- Do not use diodes on PGC/PGD – they will prevent bidirectional communication between the emulator and the target device.

Additional design information may be found in the "*Development Tools Design Advisory*" (DS51764).

For other operational issues, see:

- **Chapter 10. "Messages"**
- **Chapter 9. "Frequently Asked Questions (FAQ)"**
- **Section 10.3.6 "Debug Failure Actions"** (Top Reasons Why You Can't Debug)
- **Section 12.6 "Loop-Back Test Board"**

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3.6 TRACE CONNECTIONS

Depending on your selected device, one or more trace capabilities may be available when the emulator is selected as the debug tool.

3.6.1 Native Trace Connections

No additional connections are necessary to use Native trace. The communications connection will carry the trace information using the PGD/PGC/EMUC/EMUD pins. However, the selected device must have this feature. If it does not, one of the other trace methods may be used.

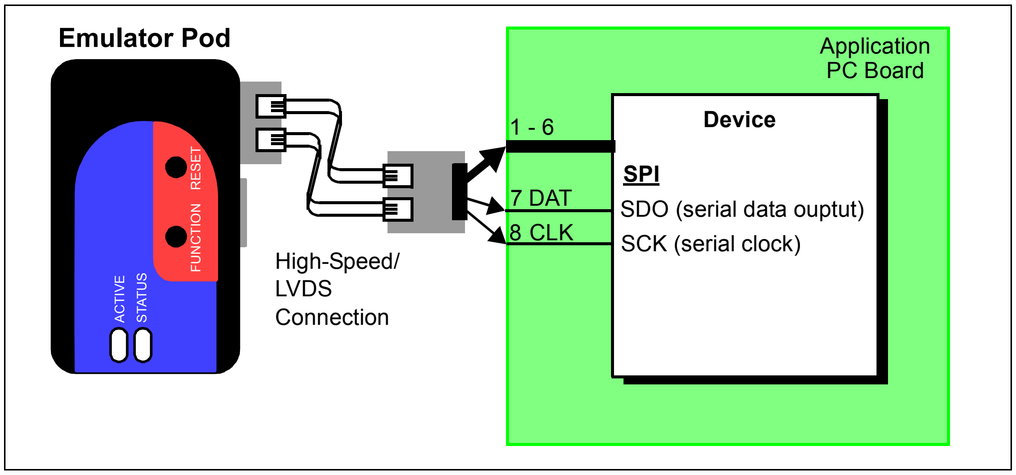
For more on this type of trace, see **Section 6.3.3.1 “Native Trace”**.

3.6.2 SPI Trace Connections (High-Speed/LVDS Connection)

Serial trace is an optional trace available using the device SPI and pins 7 (DAT) and 8 (CLK). The device is connected to the target using high-speed/LVDS communication hardware (Performance Pak) which provides the extra lines for clock and data. The device does not have to be operating at high speeds to use this feature.

Figure 3-10 shows the proper connections. As with pins 4 (PGD) and 5 (PGC) (**Section 3.5.4 “Circuits That Will Prevent the Emulator From Functioning”**), do not use pull-up or pull-down resistors, capacitors or diodes.

FIGURE 3-10: SERIAL TRACE CONNECTIONS



The DAT and CLK lines are intended for use with devices that do not have built-in debug logic that allows tracing (Native trace) to use the PGD/PGC/EMUC/EMUD pins. The DAT line connects to either the target device SPI port SDO1 or SDO2. The CLK line connects to SCK1 or SCK2.

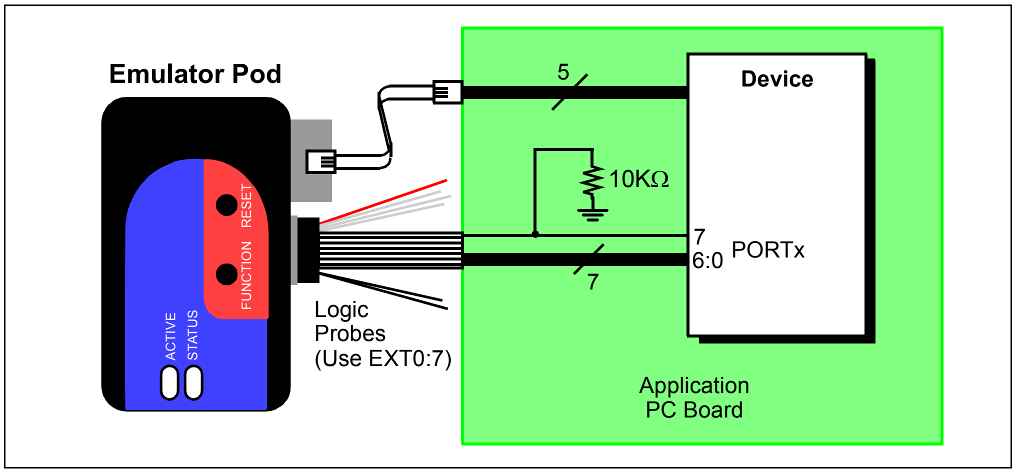
When you dedicate these pins to tracing, then any multiplexed function on these pins can no longer be used by the application.

For more on this type of trace, see **Section 6.3.3.2 “SPI Trace”**.

3.6.3 I/O Port Trace Connections

Parallel trace is possible using a device 8-pin I/O port and the emulator logic probes. This provides greater trace speed and data quantity, but limits emulator-to-target distance by the length of the logic probes. Figure 3-11 shows these additional connections.

FIGURE 3-11: PARALLEL TRACE CONNECTIONS



For this trace configuration, seven (7) lines of data and one (1) line for clock are transmitted. PORTx must be a port with 8 pins that has all 8 pins available for trace. The port does not have to be one physical port but can be made up of pins from more than one one port (see <u>*Project>Build Options>Project*</u>, **Trace** tab, “I/O Port” drop-down box, for allowable PORTx configurations). The port pins must not be multiplexed with the currently-used PGC and PGM pins.

A basic configuration is shown in the following table.

TABLE 3-4: I/O PORT TRACE CONNECTION EXAMPLE

PORTx pin	Logic Probe pin(1)	Content
0	EXT0	Data
1	EXT1	Data
2	EXT2	Data
3	EXT3	Data
4	EXT4	Data
5	EXT5	Data
6	EXT6	Data
7	EXT7(2)	Clock

Note 1: For pin descriptions, see **Section 12.4.4 “Logic Probe/External Trigger Interface”**.

2: Use a 10KΩ pull-down resistor for noise reduction.

As in **Section 3.5.4 “Circuits That Will Prevent the Emulator From Functioning”**, do not use pull-up or pull-down resistors, capacitors or diodes on port pins, except as specified.

For more on this type of trace, see **Section 6.3.3.3 “I/O Port Trace”**.

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3.6.4 PIC32 Instruction Trace Connections

PIC32 Instruction Trace is only available for PIC32 MCU devices. Also, only some PIC32 MCU devices have the trace feature. Consult your device data sheet for details.

To use this trace, you will need the following hardware:

- PIC32 Plug-In Module (PIM) containing a device that supports trace and a trace port
- PIC32 Trace Interface Kit containing a 12-inch trace cable and a trace adapter board

If you do not have a trace cable, you can use the logic probes. Connect them as below.

TABLE 3-5: LOGIC PROBE CONNECTIONS

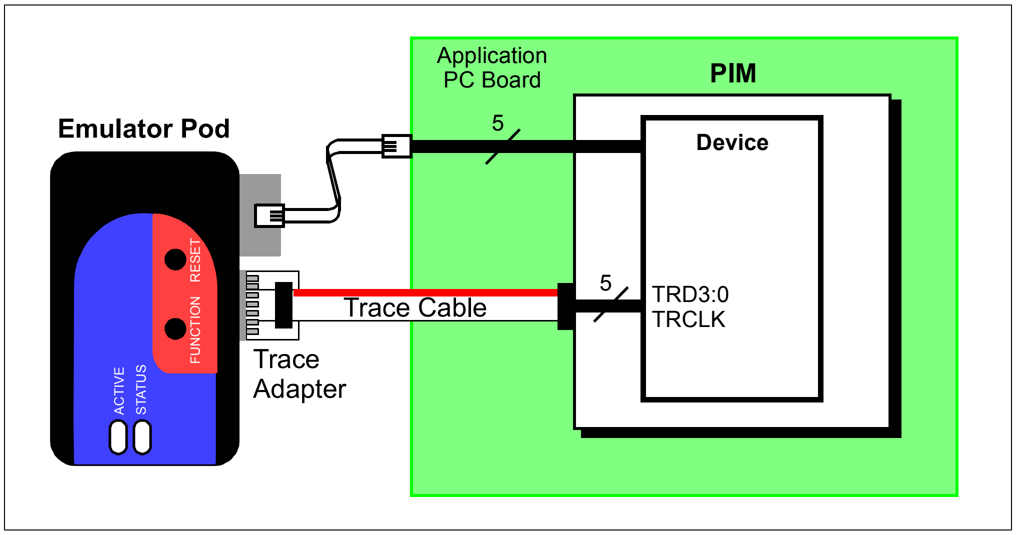
Logic Probe Port Pins(1)		PIM Trace Pins(2)	
No.	**Name**	**No.**	**Name**
4	TCLK	1	TRCLK
12	EXT0 (TRIG1)	3	TRD0
11	EXT1 (TRIG2)	5	TRD1
10	EXT2 (TRIG3)	7	TRD2
9	EXT3 (TRIG4)	9	TRD3

Note 1: For more information, see **Section 12.4.4 "Logic Probe/External Trigger Interface"**.

2: For more information, see **Section 7.3.4 "Trace Hardware Specifications"**.

To use the PIC32 Instruction Trace feature, see **Section 7.3 "PIC32 Instruction Trace"**.

FIGURE 3-12: PIC32 TRACE CONNECTION WITH PIM



3.7 DEBUGGING WITH THE EMULATOR

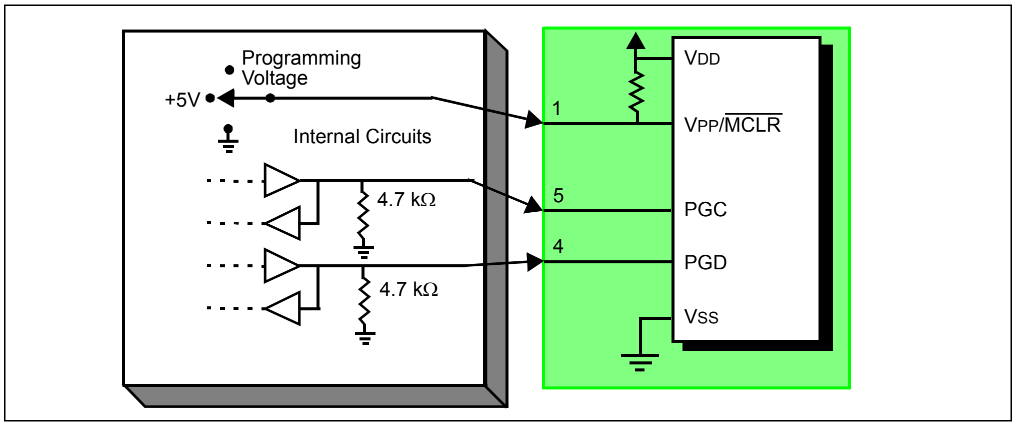
There are two steps to using the MPLAB REAL ICE in-circuit emulator system as a debugger. The first requires that an application be programmed into the target device. The second uses the internal in-circuit debug hardware of the target Flash device to run and test the application program. These two steps are directly related to the MPLAB IDE operations:

1. Programming the code into the target and activating special debug functions (see the next section for details).
2. Debugging the code using features such as breakpoints.

If the target device cannot be programmed correctly, the MPLAB REAL ICE in-circuit emulator will not be able to debug.

Figure 3-13 shows the basic interconnections required for programming and debugging. Note that this is the same as Figure 3-8, but for the sake of clarity, the VDD and VSS lines from the emulator are not shown.

FIGURE 3-13: PROPER CONNECTIONS FOR PROGRAMMING



A simplified diagram of some of the internal interface circuitry of the MPLAB REAL ICE in-circuit emulator pod is shown. For programming, no clock is needed on the target device, but power must be supplied. When programming, the emulator puts programming levels on VPP, sends clock pulses on PGC and serial data via PGD. To verify that the part has been programmed correctly, clocks are sent to PGC and data is read back from PGD. This conforms to the ICSP protocol of the device under development. See the device programming specification for details.

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3.8 REQUIREMENTS FOR DEBUGGING

To debug (set breakpoints, see registers, etc.) with the MPLAB REAL ICE in-circuit emulator system, there are critical elements that must be working correctly:

- The emulator must be connected to a PC. It must be powered by the PC via the USB cable, and it must be communicating with MPLAB IDE software via the USB cable. See **Chapter 5. "Common Debug Functions"** for details.
- The emulator must be connected as shown to the V_{PP}, PGC and PGD pins of the target device with the modular interface cable (or equivalent). V_{SS} and V_{DD} are also required to be connected between the emulator and target device.
- The target device must have power and a functional, running oscillator, either internal or external. If the target device will not run, for whatever reason, the MPLAB REAL ICE in-circuit emulator cannot debug.
- The target device must have its configuration words programmed correctly:
  - The oscillator Configuration bits should correspond to RC, XT, etc., depending upon the target design.
  - For some devices, the Watchdog Timer is enabled by default and needs to be disabled.
  - The target device must not have code protection enabled.
  - The target device must not have table read protection enabled.
  - For some devices with more than one PGC/PGD pair, the correct pair needs to be configured. This is only needed for debugging since programming will work over any PGC/PGD pair.

3.8.1 Sequence of Operations Leading to Debugging

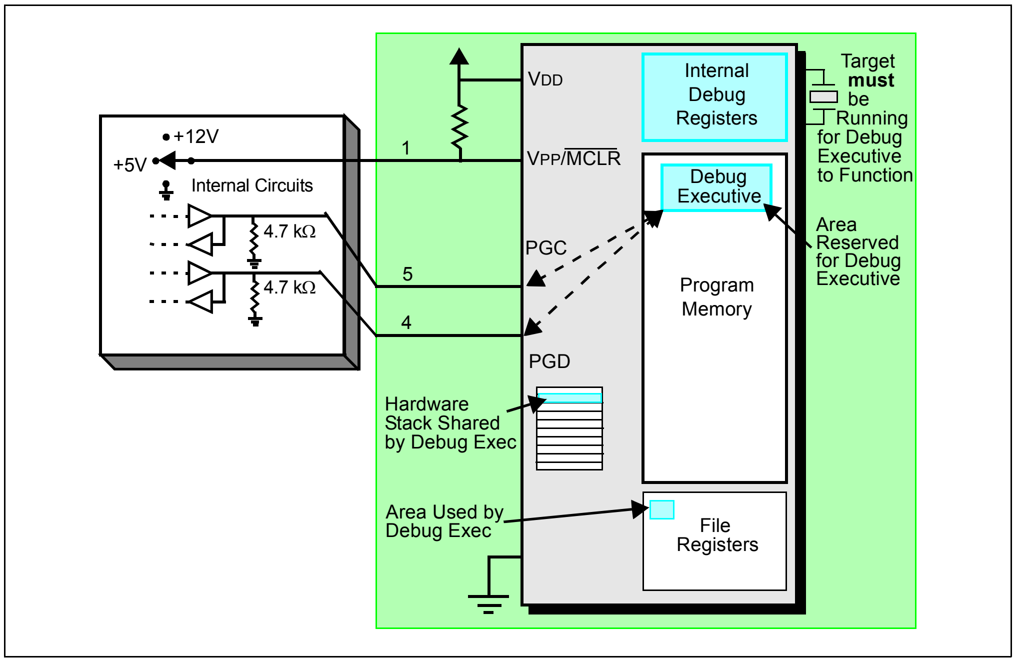
Given that the Requirements For Debugging are met, these actions can be performed when the MPLAB REAL ICE in-circuit emulator is set as the current tool (*File>Project Properties*, Embedded category):

- When *Debug>Debug Project* is selected, the application code is programmed into the device's memory via the ICSP protocol as described earlier.
- A small "debug executive" program is loaded into the high area of program memory of the target device. Since the debug executive must reside in program memory, the application program must not use this reserved space. Some devices have special memory areas dedicated to the debug executive. Check your device data sheet for details.
- Special "in-circuit debug" registers in the target device are enabled by MPLAB IDE. These allow the debug executive to be activated by the emulator. For more on device reserved resources, see the online help file.
- The target device is run in debug mode.

3.8.2 Debugging Details

Figure 3-14 illustrates the MPLAB REAL ICE in-circuit emulator system when it is ready for debugging.

FIGURE 3-14: MPLAB® REAL ICE™ IN-CIRCUIT EMULATOR READY FOR DEBUGGING



Typically, in order to find out if an application program will run correctly, a breakpoint is set early in the program code. When a breakpoint is set from the user interface of MPLAB IDE, the address of the breakpoint is stored in the special internal debug registers of the target device. Commands on PGC and PGD communicate directly to these registers to set the breakpoint address.

Next, the *Debug>Debug Project* function is usually selected in MPLAB IDE. The emulator will then tell the debug executive to run. The target will start from the Reset vector and execute until the Program Counter reaches the breakpoint address previously stored in the internal debug registers.

After the instruction at the breakpoint address is executed, the in-circuit debug mechanism of the target device "fires" and transfers control to the debug executive (much like an interrupt) and the user's application is effectively halted. The emulator communicates with the debug executive via PGC and PGD, gets the breakpoint status information and sends it back to MPLAB IDE. MPLAB IDE then sends a series of queries to the emulator to get information about the target device, such as file register contents and the state of the CPU. These queries are ultimately performed by the debug executive.

The debug executive runs just like an application in program memory. It uses some locations on the stack for its temporary variables. If the device does not run, for whatever reason, such as no oscillator, a faulty power supply connection, shorts on the target board, etc., then the debug executive cannot communicate to the MPLAB REAL ICE in-circuit emulator and MPLAB IDE will issue an error message.

Another way to stop execution is to select *Debug>Pause*. This toggles the PGC and PGD lines so that the in-circuit debug mechanism of the target device switches execution from the user's code in program memory to the debug executive. Again, the target application program is effectively halted, and MPLAB IDE uses the emulator communications with the debug executive to interrogate the state of the target device.

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3.9 PROGRAMMING WITH THE EMULATOR

Use the MPLAB REAL ICE in-circuit emulator as a programmer to program a production device, i.e., a device not on a debug header. Set the MPLAB REAL ICE in-circuit emulator as the current tool (*File>Project Properties*, Advanced, MPLAB Environment) to perform these actions:

- When *Run>Run Project* is selected, the application code is programmed into the device's memory via the ICSP protocol as described above. No target oscillator clock is required while programming, and all modes of the processor can be programmed, including code protect, Watchdog Timer enabled and table read protect.
- A small "program executive" program may be loaded into the high area of program memory for some target device. This increases programming speeds for devices with large memories.
- Special "in-circuit debug" registers in the target device are disabled by MPLAB IDE, along with all debug features. This means that a breakpoint cannot be set, and register contents cannot be seen or altered.
- The target device is run in release mode. As a programmer, the emulator can only toggle the $\overline{\text{MCLR}}$ line to reset and start the target.

3.10 RESOURCES USED BY THE EMULATOR

For a complete list of resources used by the emulator for your device, please see the online help file in MPLAB IDE for the MPLAB REAL ICE in-circuit emulator.

NOTES:

Part 2 – Features

NOTES:

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Chapter 4. General Setup

4.1 INTRODUCTION

How to get started using the MPLAB REAL ICE in-circuit emulator is discussed.

- Installation and Setup
- Common Debug Features
- Emulator-Specific Debug Features
- Quick Debug/Program Reference
- Debugger/Programmer Limitations

4.2 INSTALLATION AND SETUP

Refer to the Help file "Getting Started with MPLAB X IDE" for details on installing the IDE and setting up the emulator to work with it.

In summary:

1. Install MPLAB X IDE.
2. Install the USB drivers as specified.
3. Connect to the PC. For infomation on target and trace connections, see **Chapter 3. "Operation"**.

Note:	The emulator CANNOT power a target board.

4. Install the language toolsuite/compiler you want to use for development.
5. Launch MPLAB X IDE.
6. Use the New Project wizard (*File>New Project*) to add your "Real ICE" emulator to your project.
7. Use the project Properties dialog (*File>Project Properties*) to set up emulator options.
8. Run the project (build and run) from *Run>Run Project*.

Items of note are:

1. Installing USB drivers on Windows OS systems requires following specific instructions. See MPLAB X IDE documentation for details.
2. Each emulator contains a unique identifier which, when first installed, will be recognized by the OS, regardless of which computer USB port is used.
3. MPLAB X IDE operation connects to the hardware tool at runtime (Run or Debug Run). To always be connected to the hardware tool (like MPLAB IDE v8), click in the *Tools>Options*, **Embedded** button, **Generic Settings** tab, "Keep hardware tool connected" checkbox.
4. Configuration bits must now be set in code. They can only be viewed in the Configuration bits window (*Window>Memory*, Format drop-down set as "Code", Memory drop-down set as "Configuration Bits".)

4.3 COMMON DEBUG FEATURES

Refer to the Help file “Getting Started with MPLAB X IDE”, Debugging Code section, for details on debug features. This section includes:

1. Debug Running the Project (build, program and run) from *Debug>Debug Project*.
2. Using Breakpoints
3. Stepping Through Code
4. Using the Watch Window
5. Viewing Memory, Variables and the Call Stack
6. Using the Call Graph

4.4 EMULATOR-SPECIFIC DEBUG FEATURES

Emulator-specific debug features can be found under:

- **Chapter 5. “Common Debug Functions”**
- **Chapter 6. “Specific Debug Functions: 8- and 16-Bit Devices”**
- **Chapter 7. “Specific Debug Functions: 32-Bit Devices”**

Debug features in these sections include:

- Breakpoints and Stopwatch
- External Triggers (Logic Probes)
- Data Capture, Runtime Watches and the DMCI
- Trace

If errors occur, see:

- **Part 4 – “Troubleshooting”**
- **Section 12.6 “Loop-Back Test Board”**

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4.5 QUICK DEBUG/PROGRAM REFERENCE

The following table is a quick reference for using the MPLAB REAL ICE in-circuit emulator as either a debug or program tool. Please see previous chapters for information on proper emulator setup and configuration.

TABLE 4-1: DEBUG VS. PROGRAM OPERATION

Item	Debug	Program
Needed Hardware	A PC and target application (Microchip demo board or your own design.)	
	Emulator pod, USB cable, communication driver board(s) and cable(s).	
	Device with on-board debug circuitry or debug header with special -ME2/-ICE/-ICD device.	Device (with or without on-board debug circuitry.)
MPLAB IDE selection	Project Properties, REAL ICE as Hardware Tool	
	Debug>Debug Run	Program Target Project toolbar button
Program operation	Programs appliation code into the device. Depending on the selections on the Project Properties dialog, this can be any range of program memory. In addition, a small debug executive is placed in program memory and other debug resources are reserved.	Programs appliation code into the device. Depending on the selections on the Project Properties dialog, this can be any range of program memory.
Debug features available	All for device - breakpoints, trace, etc.	N/A.
Command-line operation	N/A	Use REALICECMD, found by default in: `C:\Program Files\Microchip\MPLAB IDE\Programmer Utilities\RealICE`.
Serial Quick-Time Programming (SQTP)	N/A	Use the MPLAB PM3 to generate the SQTP file. Then use REALICECMD to program the device.

4.6 DEBUGGER/PROGRAMMER LIMITATIONS

For a complete list of emulator limitations for your device, please see the online help file in MPLAB IDE for the MPLAB REAL ICE in-circuit emulator.

NOTES:

Chapter 5. Common Debug Functions

5.1 INTRODUCTION

Common MPLAB REAL ICE in-circuit emulator debug functions are discussed.

- Starting and Stopping Emulation
- Viewing Processor Memory and Files
- Breakpoints and Stopwatch
- External Triggers (Logic Probes)

5.2 STARTING AND STOPPING EMULATION

To debug an application in MPLAB X IDE, you must create a project containing your source code so that the code may be built, programmed into your device, and executed as specified below:

- To run your code, select either *Debug>Debug Project* or **Debug Project** from the Run toolbar.
- To halt your code, select either *Debug>Pause* or **Pause** from the Debug toolbar.
- To run your code again, select either *Debug>Continue* or **Continue** from the Debug toolbar.
- To step through your code, select either *Debug>Step Into* or **Step Into** from the Debug toolbar. Be careful not to step into a Sleep instruction or you will have to perform a processor Reset to resume emulation.
- To step over a line of code, select either *Debug>Step Over* or **Step Over** from the Debug toolbar.
- To end code execution, select either *Debug>Finish Debugger Session* or **Finish Debugger Session** from the Debug toolbar.
- To perform a processor Reset on your code, select either *Debug>Reset* or **Reset** from the Debug toolbar. Additional Resets, such as POR/BOR, MCLR and System, may be available, depending on device.

5.3 VIEWING PROCESSOR MEMORY AND FILES

MPLAB X IDE provides several windows for viewing debug and various processor memory information, selectable from the Window menu. See MPLAB IDE online help for more information on using these windows.

- Window>PIC Memory Views - View the different types of device memory. Depending on the selected device, memory types include Program Memory SRFs, Configuration Memory, etc.
- Window>Debugging - View debug information. Select from varibles, watches, call stack, breakpoints, stopwatch, and trace.

Trace is discussed more thoroughly in upcoming chapters.

To view your source code, find the source code file you wish to view in the Project window and double click to open in a File window. Code in this window is color-coded according to the processor and build tool selected. To change the style of color-coding, select *Tools>Options*, **Fonts & Colors**, **Syntax** tab.

For more on the Editor, see NetBeans Help, IDE Basics>Basic File Features.

5.4 BREAKPOINTS AND STOPWATCH

Use breakpoints to halt code execution at specified lines in your code. Use the stopwatch with breakpoints to time code execution.

- Breakpoint Resources
- Hardware or Software Breakpoint Selection
- Breakpoint and Stopwatch Usage

5.4.1 Breakpoint Resources

For 16-bit devices, breakpoints, data captures, and runtime watches use the same resources. So, the available number of breakpoints is actually the available number of combined breakpoints/triggers.

For 32-bit devices, breakpoints use different resources than data captures and runtime watches. So, the available number of breakpoints is independent of the available number of triggers.

The number of hardware and software breakpoints available and/or used is displayed in the Dashboard window (*Window>Dashboard*). See the MPLAB IDE documentation for more on this feature. Not all devices have software breakpoints.

For limitations on breakpoint operation, including the general number of hardware breakpoints per device and hardware breakpoint skidding amounts, see "Limitations" in the online help file.

5.4.2 Hardware or Software Breakpoint Selection

The following table compares hardware and software breakpoints:

TABLE 5-1: HARDWARE VS. SOFTWARE BREAKPOINTS

Feature	HW Breakpoints	SW Breakpoints
Number of breakpoints	Limited	Unlimited
Breakpoints written to*	Debug registers	Program memory
Breakpoints applied to**	Memory registers	Code
Time to set breakpoints	Minimal	Oscillator speed dependent; programming Flash memory
Breakpoint skidding	Most devices. See the online help, Limitations section, for details.	No
* Where information about the breakpoint is written in the device. ** What kind of device feature applies to the breakpoint. This is where the breakpoint is set.		

To select hardware or software breakpoints:

1. Select your project in the Project window. Then select either *File>Project Properties* or right click and select "Properties".
2. In the Project Properties dialog, select "REAL ICE" under "Categories".
3. Under "Option Categories" select "Debug Options".
4. Check "Use software breakpoints" to use software breakpoints. Uncheck to use hardware breakpoints.

Note: Using software breakpoints for debug impacts device endurance. Therefore, it is recommended that devices used in this manner not be used as production parts.

5.4.3 Breakpoint and Stopwatch Usage

Breakpoints halt execution of code. To determine the time between the breakpoints, use the stopwatch.

Please refer to the MPLAB X IDE Help for how to set up and use breakpoints and the stopwatch.

5.5 EXTERNAL TRIGGERS (LOGIC PROBES)

Use external triggers to set up hardware triggers using the logic probes. All pins (whether used or unused) should either be pulled up or grounded. Floating pins may produce false triggers.

External triggers can be used as input to halt program execution when an external event occurs. They can also be used as output to control external devices.

To use probe pins as inputs, you must provide the circuitry to drive them (see **Table 12-3: "Logic Probe Electrical Specifications"** for drive levels.)

You will not be able to use external triggers if you are using the logic probe port for another debug feature such as:

- I/O Port trace (see **Section 6.3.3.3 "I/O Port Trace"**.)
- PIC32 Instruction trace (see **Section 7.3 "PIC32 Instruction Trace"**.)

For more on external trigger hardware, see **Section 12.4.4 "Logic Probe/External Trigger Interface"**.

NOTES:

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Chapter 6. Specific Debug Functions: 8- and 16-Bit Devices

6.1 INTRODUCTION

The following debug functions are specific to 8- and 16-bit devices.

- Data Capture and Runtime Watches
- Instrumented Trace
- PC Sampling
- Application In/Out
- Additional Debug Features

6.2 DATA CAPTURE AND RUNTIME WATCHES

Not all 8- and 16-bit devices support data capture and/or runtime watches. A list of supported features by device is available in online help.

For 8- and 16-bit devices, breakpoints, data captures and runtime watches use the same resources. Therefore, setting a data capture or runtime watch uses the resource for the selected symbol. An 8-bit PIC can only watch 8-bit variables and a 16-bit PIC can only watch 16-bit variable.

For data captures and runtime watches at speeds higher than 15 MIPS, the Performance Pak may be needed. The actual cutoff speed may vary depending on layout, noise, and similar considerations.

- Data Capture and DMCI
- Runtime Watches and the Watch Window

6.2.1 Data Capture and DMCI

Data capture provides streaming data from a device to the following:

- Data Monitoring and Control Interface (DMCI) – Plug-in

To install the DMCI plug-in:

1. Select *Tools>Plugins*. The Plugins window will open.
2. Click on the **Available Plugins** tab.
3. Find DMCI and check the checkbox next to it.
4. Click **Install** and follow the screens.

See also the “Add Plug-in Tools” in the “Additional Tasks” section of the MPLAB X IDE help file.

To set up data capture:

1. Build the project (In the Projects window, right click on the project name and select “Build”). The project must be built to see the available symbols.
2. Select *Window>Debugging>Watches* to open the Watches window.
3. Right click in the window and select “New Watch”. Select the symbol or SFR wish to watch in the New Watch window. Click **OK**.
4. Right click on the project and select “Properties” to open the Project Properties dialog. Then click on the “Real ICE” category and select the “Clock” option category. Enter instruction speed information.
5. Select *Tools>Embedded>DMCI>DMCI Window* to open the DMCI dialog.
6. Set up the DMCI for this data capture. See the DMCI help file for details (*Help>Help Contents*, “Plug-In Tools” section).
7. Begin a debug session (*Debug>Debug Project*). Input data using DMCI controls or view data in a DMCI graphical window.

6.2.2 Runtime Watches and the Watch Window

A runtime watch provides updating of a variable in the following windows during program execution instead of on halt:

- Watches – Window > Debugging menu
- Memory – Window > PIC Memory Views menu

To set up runtime watches:

1. Build the project (In the Projects window, right click on the project name and select “Build”). The project must be built to see the available symbols.
2. Select *Window>Debugging>Watches* to open the Watches window.
3. Right click in the window and select “New Runtime Watch”. Select the symbol or SFR wish to watch in the New Run Time Watch window. Click **OK**.
4. Right click on the project and select “Properties” to open the Project Properties dialog. Then click on the “Real ICE” category and select the “Clock” option category. Enter instruction speed information.
5. Begin a debug session (*Debug>Debug Project*). Watch variable values change in the Watch window.
6. Pause (halt) and open another window containing the watched variable. Continue the program and watch the values change in this window.

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6.3 INSTRUMENTED TRACE

This section will discuss the available types of instrumented trace and how to use them.

6.3.1 Requirements for Trace

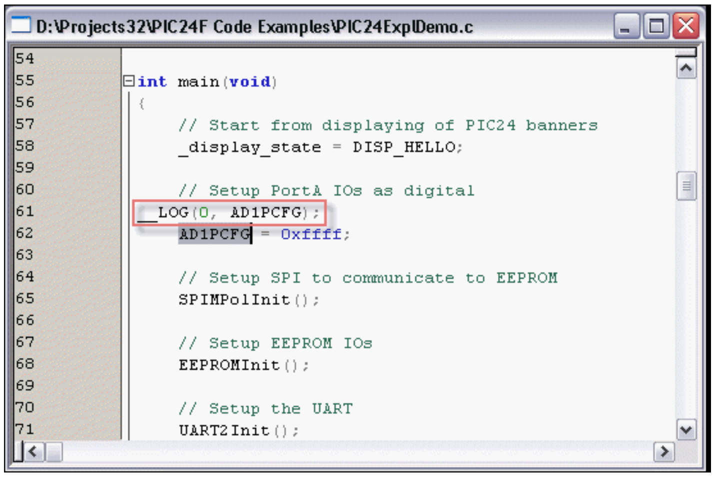
The following is required to use trace:

- Devices that support trace. See "MPLAB X IDE Limitations" on the "Learn & Discover" tab of the Start Page.
- In-line assembly code (assembly code within C code) cannot be traced.

6.3.2 How Trace Works

Trace for the MPLAB REAL ICE in-circuit emulator (Instrumented Trace) is a solution for providing basic trace information. Through the use of `TRACE()` and `LOG()` macros, you can report program locations or variable values to MPLAB IDE while the application is running and examine them via the Trace window once the application halts. You may type these macro names in manually or right click in the editor and select the macro to be inserted from the context menu. To log a variable value, the variable should be highlighted before selecting from the context menu.

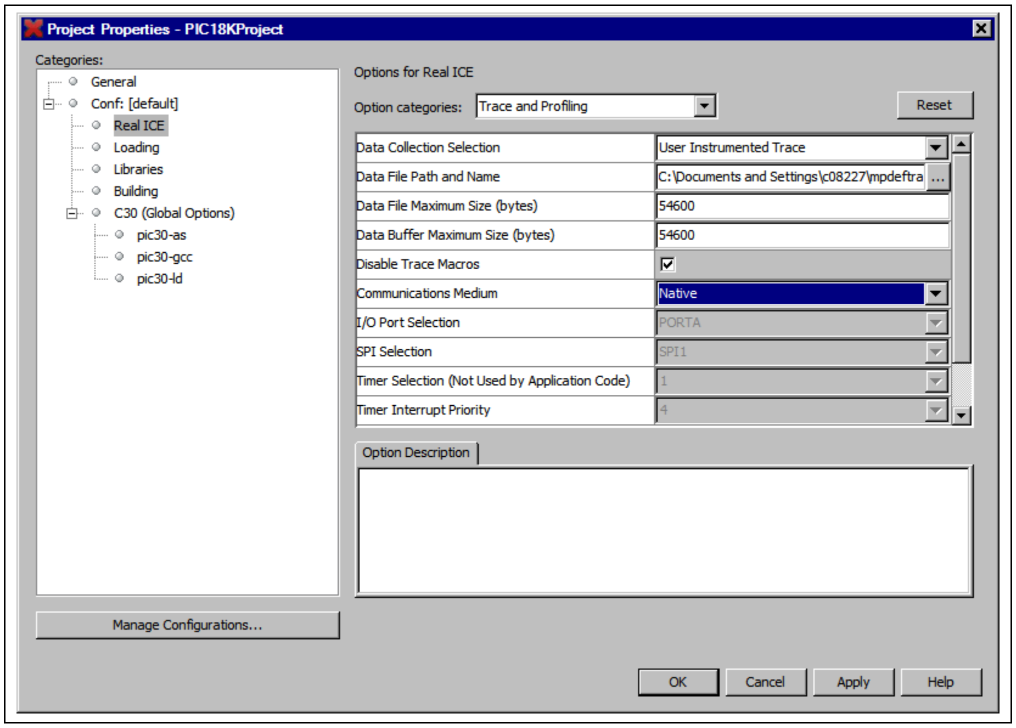
FIGURE 6-1: EXAMPLE OF INSERTED LOG MACRO


D:\Projects32\PIC24F Code Examples\PIC24ExplDemo.c

```

int main(void)
{
    // Start from displaying of PIC24 banners
    _display_state = DISP_HELLO;

    // Setup PortA IOs as digital
  __LOG(0, AD1PCFG);
    AD1PCFG = 0xffff;

    // Setup SPI to communicate to EEPROM
    SPIMPolInit();

    // Setup EEPROM IOs
    EEPROMInit();

    // Setup the UART
    UART2Init();
```

There are three trace methods available at this time (see **Section 6.3.3 "Types of Trace"**). The methods can be found on the Project Properties dialog, REAL ICE Category, Trace Options Category page. The choices include Native Trace (utilizes PGC/PGD communication lines), SPI Trace, and I/O Port Trace. Not every method is available on every part; i.e., the options are device specific. The Instrumented Trace library supports C and assembly projects on PIC18F MCU devices, but only C projects on 16-bit devices.

FIGURE 6-2: BUILD OPTIONS TRACE TAB – NATIVE TRACE SELECTION



Option categories: Trace and Profiling

Data Collection Selection	User Instrumented Trace
Data File Path and Name	C:\Documents and Settings\c08227\mpdeftra
Data File Maximum Size (bytes)	54600
Data Buffer Maximum Size (bytes)	54600
Disable Trace Macros	✓
Communications Medium	Native
I/O Port Selection	PORTA
SPI Selection	SPI1
Timer Selection (Not Used by Application Code)	1
Timer Interrupt Priority	4

The trace and log information transmitted is identical regardless of the trace method used. For `TRACE()`, a single value in the range of 64-127 is sent. A label generated using this number is automatically inserted into the code, so MPLAB IDE can identify in the trace buffer the location that sent the value. For `LOG()`, a two-byte header is sent followed by the value of the variable being logged. The first byte indicates the variable type and is a value between 0 and 63. The second byte indicates the location which sent the variable. Here, the location is represented by a value between 0 and 127. (See **Section 6.3.9 "More on Trace/Log ID Numbers"**.)

Interrupts are disabled during every `TRACE()` and `LOG()` call. This is to ensure that trace or log statements at an interrupt level do not interfere with a trace or log statement that may already be in progress at the application level. A similar argument holds for protecting statements within a low priority interrupt from being corrupted by those from a high priority interrupt.

6.3.3 Types of Trace

Currently there are three types of trace. All types are language tool version dependent, and stream data in real time to MPLAB IDE.

The pluses and minuses of using each trace type, as well as the type of communication available (standard and/or high-speed), are summarized below.

Type of Trace	Speed	Code Size Impact	Real Time Op	Pin Usage	Device Feature Needed	Communication	
						Std	HS
Native Trace	Fast[(1)]	Large	Close	None	Built-in debug	15 MIPS or less	Greater than 15 MIPS
SPI Trace	Faster[(1)]	Medium	Closer	SPI pins	SPI	No	Yes
I/O Port Trace	Fastest	Small	Closest	8-pin port	None	Yes[(2)]	Yes[(2)]

Note 1: For Native trace running at speeds higher than 15 MIPS and for SPI Trace capability, the Performance Pak may be needed. The actual cutoff speed may vary depending on layout, noise, and similar considerations.

Note 2: Also requires connection from device port to emulator logic probe port.

6.3.3.1 NATIVE TRACE

Native trace can be used with either standard or high-speed communications, with no additional connections - the information is conveyed via the PGD/PGC/EMUC/EMUD pins. This two-wire interface uses the trace macro format (see **Section 6.3.4 “Setting Up Trace in MPLAB IDE”**).

Native trace requires that you enter the clock speed (Properties dialog, REAL ICE category, Clock options category.)

If Native trace is used, then data captures cannot be used as these features use the same device resource. Breakpoints are still available but be aware that Native trace will use one breakpoint for tracing. This will NOT be reflected on the Device Debug Resource toolbar.

To use data capture triggers, you must disable Native trace (see **Section 6.3.7 “Disabling Trace”**).

6.3.3.2 SPI TRACE

SPI trace can be used only with high-speed communication hardware (LVDS cables). Trace clock and data are provided through pins 7 (DAT) and 8 (CLK) on the receiver board of the LVDS connection. The device does not have to be operating at high speeds to use this feature.

For devices with remappable peripheral pins, be aware that the SPI trace macro does not touch any PPS register and does not need to know how the peripheral is mapped to a certain pin - it will write to the SPI1 or SPI2 selected in MPLAB IDE.

SPI trace does require that you enter the clock speed (Properties dialog, REAL ICE category, Clock options category.)

For hardware connections, see **Section 3.6.2 “SPI Trace Connections (High-Speed/LVDS Connection)”**.

The SPI interface uses the trace macro format (see **Section 6.3.4 “Setting Up Trace in MPLAB IDE”**).

6.3.3.3 I/O PORT TRACE

I/O Port trace can be used with either standard or high-speed communications. Trace clock and data are provided from a device 8-pin I/O port through the MPLAB REAL ICE in-circuit emulator logic probe connector.

The I/O port must have all 8 pins available for trace. The port must not be multiplexed with the currently-used PGC and PGM pins. Therefore, review the data sheet of the selected device to determine the uninitialized/default port pin states and change them as necessary.

For hardware connections, see **Section 3.6.3 “I/O Port Trace Connections”**.

The port interface uses the trace macro format (see **Section 6.3.4 “Setting Up Trace in MPLAB IDE”**).

6.3.4 Setting Up Trace in MPLAB IDE

To set up MPLAB X IDE to use trace for the MPLAB REAL ICE in-circuit emulator:

1. Right click on the project name and select “Properties”. In the Project Properties dialog click on “Real ICE” under “Categories”.
2. Under “Option categories”, select “Clock”. For data capture and trace, the emulator needs to know the instruction cycle speed.
3. Under “Option categories”, select “Trace and Profiling”.
4. Under “Data Collection Selection”, choose “User Instrumented Trace”.
5. Under “Communications Medium” choose either Native, I/O PORT or SPI trace.
6. Set up any other trace-related options. (See **Section 11.3.1 “Trace and Profiling”**.)
7. Click **OK**.

Next, enter trace macros in your application code.

- To record a PC location, click on or highlight a line of code and then right click to select “Insert *Language* Line Trace” fro m the pop-up menu, where *Language* can be either C or ASM. This causes the following macro line to be inserted above the selected line:

  ```
  __TRACE(id);
  ```

  where `id` is a line trace number auto-generated during the build. For more information, see **Section 6.3.9 “More on Trace/Log ID Numbers”**.

Note:	Inserting a macro into code may modify the logic flow of the program. Please be sure that braces are present where necessary.

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- The recording of a variable value is performed much in the same way. First highlight the variable name or expression and then right click to select "Log Selected *Language* Value" from the pop-up menu, where *Language* can be either C or ASM. This causes the following macro line to be inserted above the line containing the variable:

  `__LOG(id,`*`selected variable`*`);`

  where `id` is a log number auto-generated during build and *`selected variable`* is the highlighted variable. For more information, see **Section 6.3.9 "More on Trace/Log ID Numbers"**.
- To remove a trace point, simply highlight and then delete the Trace/Log macro.

6.3.5 Running Trace

1. Debug Run (*Debug>Debug Project*) your application.
2. Pause the application.
3. View the trace data in the Trace window (*Window>Debugging>Trace*). For each `__TRACE` macro, the line of code following the macro will appear in the trace window each time it is passed. For each `__LOG` macro, the selected variable in the line of code following the macro will appear in the trace window each time it is passed.

> **Note:** To trace multiple lines of code or variables, you must place a macro before each line/variable that you wish to trace.

Repeat these steps each time you change a trace point.

6.3.6 Tracing Tips

When using `__TRACE` and `__LOG` macros in your code, consider the following:

- Focus on one area of an application and place `__TRACE` and `__LOG` macros so that they form a "flow" in the Trace window. That way, you can follow the execution flow and debug the application based on missing/incorrect trace points or an abrupt end to the trace flow.
- Use `__TRACE` and `__LOG` macros with conditional statements in your code to aid in debugging. Example: When a variable reaches a certain value, start logging it.

```
If(var > 5)
{
   __LOG(ID, var)
}
```

- Leave `__TRACE` and `__LOG` macros in your code for future debugging, if this is allowable. (For Project Properties dialog, REAL ICE Category, Trace Options Category page, select "Disable Trace Macros".)

6.3.7 Disabling Trace

To temporarily turn off trace data collection:

1. Select *File>Project Properties* dialog, Categories: REAL ICE, Options categories: Trace and Profiling.
2. Check "Disable Trace Macros".
3. Click **OK**.

To disable the full trace capability:

1. Remove all trace and log macros from code.
2. Select *File>Project Properties* dialog, Categories: REAL ICE, Options categories: Trace and Profiling.
3. Under "Data Collection Selection", choose "Off".
4. Click **OK**.

6.3.8 Resource Usage Examples

The following examples are for illustration only. Your results may vary based upon compiler/assembler version, command line options, MPLAB IDE version, size of data variable being logged, interrupt state, and device in use. All examples include argument setup, function call, and return time in their cycle counts.

The PIC18FXXJ MCU examples are compiled/assembled for non-priority interrupt usage (30 instructions). For priority interrupt usage, the value is 57; and for no interrupt usage, the value is 15.

The dsPIC33F DSC examples show 9 instructions specified in the 16-bit library size for `memcpy()`.

EXAMPLE 6-1: PIC18FXXJ DEVICE RUNNING AT 4MHZ (1 MIPS) WITH ASSEMBLY PROJECT

	Native	SPI	I/O Port
Library Size (in instructions)	23 + 30	37 + 30	25 + 30
GPRs Used (in bytes)	8	6	6
`__TRACE(id)` instruction cycles	80	54	42
`__LOG(id, BYTE)` instruction cycles	168	90	57

EXAMPLE 6-2: PIC18FXXJ DEVICE RUNNING AT 40MHZ (10 MIPS) WITH C PROJECT

	Native	SPI	I/O Port
Library Size (in instructions)	75 + 30	87 + 30	112 + 30
GPRs Used (in bytes)	10	8	8
`__TRACE(id)` instruction cycles	79	71	55
`__LOG(id, INT)` instruction cycles	225	169	162

EXAMPLE 6-3: dsPIC33F DEVICE RUNNING AT 10 MIPS WITH C PROJECT

	Native	SPI	I/O Port
Library Size (in instructions)	87 + 9	92 + 9	93 + 9
GPRs Used (in bytes)	18	14	0
`__TRACE(id)` instruction cycles	80	53	32
`__LOG(id, INT)` instruction cycles	212	124	106

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EXAMPLE 6-4: dsPIC33F DEVICE RUNNING AT 16 MIPS WITH C PROJECT

	Native	SPI	I/O Port
`__TRACE(id)` instruction cycles	88	53	32
`__LOG(id, INT)` instruction cycles	227	138	106

EXAMPLE 6-5: dsPIC33F DEVICE RUNNING AT 34 MIPS WITH C PROJECT

	Native	SPI	I/O Port
`__TRACE(id)` instruction cycles	100	53	32
`__LOG(id, INT)` instruction cycles	251	152	106

6.3.9 More on Trace/Log ID Numbers

MPLAB IDE will automatically generate the ID numbers required for a trace or log macro. However, to understand the method behind the numbering, read further.

You can have 64 trace points and 128 log points. These limits are determined by port trace (8 bits). Bit 7 is used as a clock, thus leaving 7 bits for data (128). Bit 6 is a flag which indicates a trace record instead of a log record.

For a trace record (bit 6 is 1), the low order bits represent the trace number (nnnnnn). You could say 0-63 are the legal trace numbers and require the trace flag be set, but it was just easier to combine the flag with the number and say the valid numbers are 64-127.

clock	1	n	n	n	n	n	n
bit 7							bit 0

For a log record (bit 6 is 0), the low order bits identify the data type (t) and the log number is sent in the next byte (nnnnnnn), thus freeing up a full 128 values.

clock	0	t	t	t	t	t	t
bit 7							bit 0

clock	n	n	n	n	n	n	n
bit 7							bit 0

6.3.10 Quick Trace Reference

If you are new to using the MPLAB REAL ICE in-circuit emulator trace feature, it is recommended that you read through the entire trace section for a full understanding.

Use this section as a quick reference for trace.

1. Select File>Project Properties dialog, Categories: REAL ICE, Options categories: Trace. Enable trace, choose the type of trace and set other trace options.
2. Select Window>Debugging>Trace to open the trace window in which to view trace data.
3. Right click in your code to enter trace macros (`__TRACE`, `__LOG`) as desired.
4. Debug Run your project.

6.4 PC SAMPLING

PC sampling is a method for examining C code to determine how much time is spent in each function. This information can show you where your program time is being spent so you may work to optimize your code.

For PC sampling, a device timer is set up to take samples of program execution and display the results in the PC profiling window.

PC profiling is similar to PC sampling. For details see **Section 7.5 "PC Profiling"**.

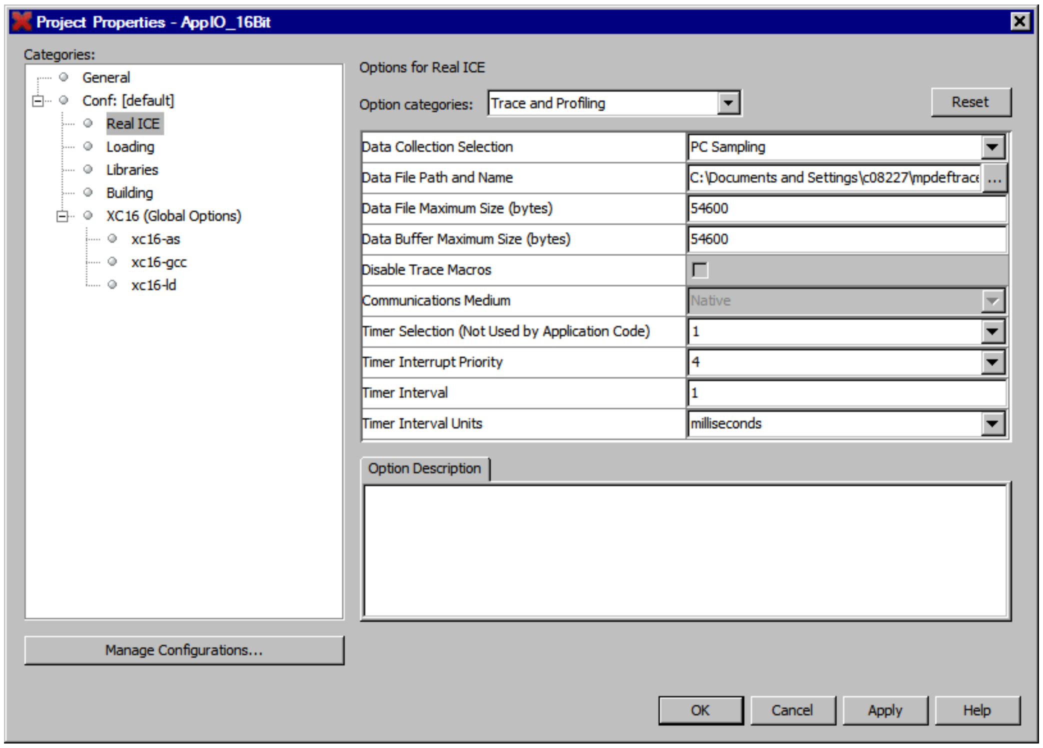
Currently, to use PC sampling your project must be set up for:

- a 16-bit device
- the MPLAB XC16 C Compiler version 1.10 or above

To perform sampling:

1. Open the Project properties window (*File>Project Properties*).
2. Click on "REAL ICE" under "Categories" and select "Trace and Profiling" from the "Options categories" drop-down box.
3. Under "Data Collection Selection", select "PC Sampling".
4. Set up your data file and timer in this window. For reference, see **Section 11.3.1 "Trace and Profiling"**. Then click **OK**.
5. Select *Window>Debugging>PC Profiling*. This will open the PC Profiling window.
6. Run your code and then halt.
7. View the sampling data in the window. Data is only displayed on halt.
8. Right click in the window to pop up a menu to either clear the data or reload the data.

FIGURE 6-3: PC SAMPLING SELECTION AND SETUP



Data Collection Selection	PC Sampling
Data File Path and Name	C:\Documents and Settings\c08227\mpdeftrace
Data File Maximum Size (bytes)	54600
Data Buffer Maximum Size (bytes)	54600
Disable Trace Macros	☐
Communications Medium	Native
Timer Selection (Not Used by Application Code)	1
Timer Interrupt Priority	4
Timer Interval	1
Timer Interval Units	milliseconds

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6.5 APPLICATION IN/OUT

Note: This window is only available for devices that support the application in/out function used with the MPLAB REAL ICE in-circuit emulator or MPLAB ICD 3 in-circuit debugger. For details, see online help, “Device and Feature Support”.

The Application In/Out window allows you to interact with a running application using the Application Input/Output feature supported on some devices. Using this feature, data may be sent serially to and from the target application and, during runtime, over the same PGC/PGD lines used for debugging. Data written to the APPOUT register will be displayed to the window, while user input will be sent to the target application and available in the APPIN register.

To use the Application In/Out window:

- Use the device-specific header file when building your application to use the macros assigned in the header (per Example 6-6.)
- In the future, the 16-bit device library will have `printf()` and `scanf()` functions for use with the Application In/Out feature, as referenced in the “16-Bit Debug-Support Library” chapter of the *16-Bit Language Tools Libraries* (DS51456) document.

EXAMPLE 6-6: APPLICATION IN/OUT MACRO USAGE

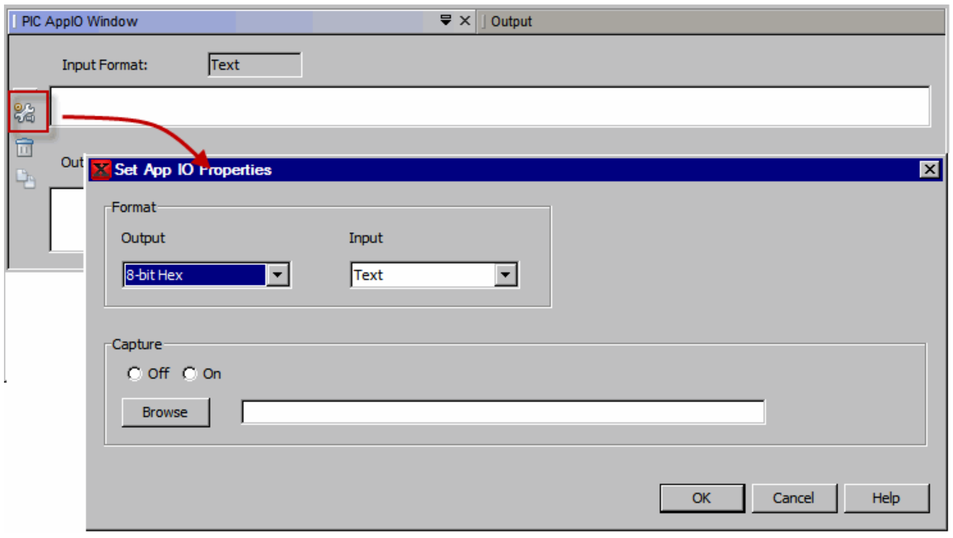
The following application code reads the application input register and writes out a padded value of the input to the application output register.

```
// include file
#include <p33Exxxx.h>

// set up config bits
_FWDT( FWDTEN_OFF )

// initialize variables
unsigned int val;
int i;
unsigned int oval;

int main(void)
{
   while(1)
   {
    if(APPSbits.APIFUL) // APPI is full?
      {
       val = _APPIN;          // Read User Input
       for(i=0; i<4; i++)
         {
          while(APPSbits.AROFUL); // APPO is full?
          oval =  val&0xFF;
          if(oval < 0x20)
             oval = 0x20;
          oval |= 0x20202000;
          _APPO = oval;                 // Send to MPLAB X IDE
          val >>= 8;
         }
      }
   }
}
```

To run this application:

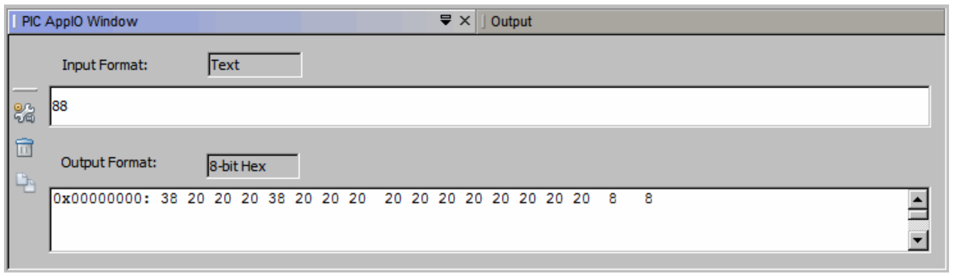
1. Create a project using the Project wizard:
   a) Select a supported device.
   b) Select REAL ICE or ICD 3 as the hardware tool.
   c) Use the “MPLAB C Compiler for PIC24 MCUs and dsPIC DSCs” or the “MPLAB XC16 C Compiler” as the language toolsuite.
2. Select *File>New File* to create and name a new C Source File. In the Editor window that opens, add the previous code and save.
3. Right click on the project name in the Projects window and select “Properties”. In the Project Properties window, click on “pic32-gcc” under “Categories”. Under “Option Categories”, select “General” and check the “Enable App IO” checkbox.
4. Build the project (Right click on the project name and select “Build”).
5. Select *Window>Debugging>PIC App IO* to open the Application In/Out window.
6. Click on the “Properties” button (on the left of the window) to launch the Set App IO Properties dialog. Under “Capture” click “On”.

FIGURE 6-4: SET APP I/O PROPERTIES



7. Debug Run or Run the project.
8. Enter an text value in the Input text box. Hit Enter.
9. View the output in the Output text box.

FIGURE 6-5: APP IN/OUT WINDOW



```
88
```

```
0x00000000: 38 20 20 20 38 20 20 20  20 20 20 20 20 20 20 20  8   8
```

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Change Input and Output Formats by opening Set App IO Properties dialog and running the program again to see what outputs result for different inputs.

For more on options avaiable in this window, see **Section 11.4.2 "Application In/Out Window and Related Dialogs"**.

6.6 ADDITIONAL DEBUG FEATURES

In addition to the debug features covered previously, 8- and 16-bit devices have the other debug features, such as "Freeze on Halt", which allows you to freeze selected peripherals on a halt. For a complete list of debug functions, windows and dialogs, see **Chapter 11. "Emulator Function Summary"**.

NOTES:

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Chapter 7. Specific Debug Functions: 32-Bit Devices

7.1 INTRODUCTION

The following debug functions are specific to 32-bit devices:

Note: For PIC32 devices, the JTAG port may need to be disabled to prevent conflicts when using trace and other ICE features where pin conflicts can result.

- Data Capture and Runtime Watches
- PIC32 Instruction Trace
- Instrumented Trace
- PC Profiling
- Application In/Out
- Additional Debug Features

7.2 DATA CAPTURE AND RUNTIME WATCHES

Not all 32-bit devices support data capture and/or runtime watches. A list of supported features by device is available in online help.

For PIC32 devices, breakpoints use different resources than data captures and runtime watches. However data captures and runtime watches use the same resources. Therefore, setting a data capture or runtime watch uses the resource for the selected symbol.

Note: The Performance Pak is not required for debugging at maximum speeds as the capture clock speed is independent of the target system clock.

- Data Capture and DMCI
- Runtime Watches and DMCI
- Runtime Watches and the Watch Window

7.2.1 Data Capture and DMCI

Data capture provides streaming data from a device to the following:

- Data Monitoring and Control Interface (DMCI) – Plug-in

To install the DMCI plug-in:

1. Select *Tools>Plugins*. The Plugins window will open.
2. Click on the **Available Plugins** tab.
3. Find DMCI and check the checkbox next to it.
4. Click **Install** and follow the screens.

See also the "Add Plug-in Tools" in the "Additional Tasks" section of the MPLAB X IDE help file.

To set up data capture:

1. Build the project (In the Projects window, right click on the project name and select "Build"). The project must be built to see the available symbols.
2. Select *Window>Debugging>Watches* to open the Watches window.
3. Right click in the window and select "New Watch". Select the symbol or SFR wish to watch in the New Watch window. Click **OK**.
4. Select *Tools>Embedded>DMCI>DMCI Window* to open the DMCI dialog.
5. Set up the DMCI for this data capture. See the DMCI help file for details (*Help>Help Contents*, "Plug-In Tools" section).
6. Begin a debug session (*Debug>Debug Project*). Input data using DMCI controls or view data in a DMCI graphical window.

7.2.2 Runtime Watches and DMCI

For devices without data capture, the runtime watch can provide data polling to the following:

- Data Monitoring and Control Interface (DMCI) – Plug-in

To install the DMCI plug-in:

1. Select *Tools>Plugins*. The Plugins window will open.
2. Click on the **Available Plugins** tab.
3. Find DMCI and check the checkbox next to it.
4. Click **Install** and follow the screens.

See also the "Add Plug-in Tools" in the "Additional Tasks" section of the MPLAB X IDE help file.

To set up runtime watches:

1. Build the project (In the Projects window, right click on the project name and select "Build"). The project must be built to see the available symbols.
2. Select *Window>Debugging>Watches* to open the Watches window.
3. Right click in the window and select "New Runtime Watch". Select the symbol or SFR wish to watch in the New Run Time Watch window. Click **OK**.
4. Right click on the project and select "Properties" to open the Project Properties dialog. Then click on the "Real ICE" category and select the "Clock" option category. Enter instruction speed information.
5. Select *Tools>Embedded>DMCI>DMCI Window* to open the DMCI dialog.
6. Set up the DMCI for this runtime watch. See the DMCI help file for details (*Help>Help Contents*, "Plug-In Tools" section).
7. Begin a debug session (*Debug>Debug Project*). Input data using DMCI controls or view data in a DMCI graphical window.

7.2.3 Runtime Watches and the Watch Window

A runtime watch provides updating of a variable in the following windows during program execution instead of on halt:

- Watches – Window > Debugging menu
- Memory – Window > PIC Memory Views menu

To set up runtime watches:

1. Build the project (In the Projects window, right click on the project name and select “Build”). The project must be built to see the available symbols.
2. Select *Window>Debugging>Watches* to open the Watches window.
3. Right click in the window and select “New Runtime Watch”. Select the symbol or SFR wish to watch in the New Run Time Watch window. Click **OK**.
4. Right click on the project and select “Properties” to open the Project Properties dialog. Then click on the “Real ICE” category and select the “Clock” option category. Enter instruction speed information.
5. Begin a debug session (*Debug>Debug Project*). Watch variable values change in the Watch window.
6. Pause (halt) and open another window (e.g., SFR) containing the watched variable. Continue the program again and watch the values change in this window.

7.3 PIC32 INSTRUCTION TRACE

This section will discuss trace for 32-bit devices and how to use it. Not all PIC32 devices have instruction trace so refer to your device data sheet.

- Requirements for Trace
- How Instruction Trace Works
- Setting Up and Using Trace
- Trace Hardware Specifications

7.3.1 Requirements for Trace

The following is required to use trace for 32-bit (PIC32) devices:

- MPLAB X IDE and a compatible 32-bit toolchain
- PIC32MX Plug-In Module (PIM) containing a device that supports trace and a trace port
- MPLAB REAL ICE Trace Interface Kit containing a 12-inch trace cable and a trace adapter board

7.3.2 How Instruction Trace Works

PIC32 instruction trace uses a MIPS32 M4K iFlowtrace™ mechanism, which is a non-intrusive hardware instruction trace You can use this trace to capture every instruction executed by the device. The trace data is sent from the device using the pins TRCLK and TRD3:0 to the emulator. The emulator streams this data to a trace buffer on the PC that acts like a rolling FIFO.

The amount of trace data is limited only by the size of the trace buffer. This buffer can fill quickly even when set to the maximum size, so it is wise to determine exactly what you need to capture.

Enable and set trace options in the Project Properties dialog, Categories: REAL ICE, Option categories: Trace and Profiling. Here you may set:

- Data selection - enable/disable trace and select the type of trace.
- Data file path and name - location of trace file
- Data file maximum size - size of trace file
- Data Buffer maximum size - size of the trace buffer

The maximum off-chip (PC) trace buffer size is 22MB. Execution will not halt when this external buffer is full.

See also **Section 11.3.1 "Trace and Profiling"**.

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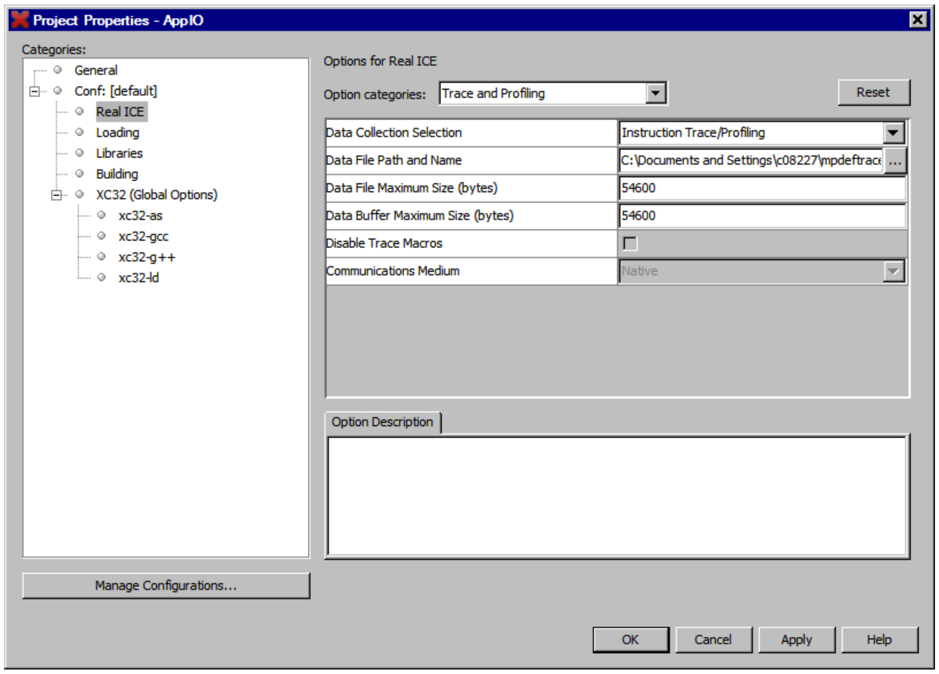
FIGURE 7-1: PIC32 INSTRUCTION TRACE OPTIONS



Options for Real ICE

Option categories: Trace and Profiling

Data Collection Selection	Instruction Trace/Profiling
Data File Path and Name	C:\Documents and Settings\c08227\mpdeftrace
Data File Maximum Size (bytes)	54600
Data Buffer Maximum Size (bytes)	54600
Disable Trace Macros	☐
Communications Medium	Native

7.3.3 Setting Up and Using Trace

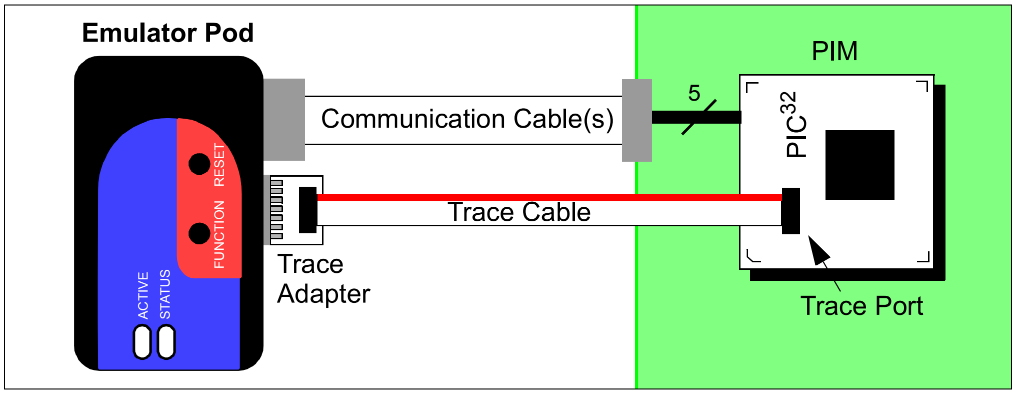
PIC32 Instruction Trace requires hardware and software setup before you can trace.

7.3.3.1 HARDWARE SETUP – PIC32 MCU ON PIM

To use the PIC32 Instruction Trace feature with the PIM do the following:

1. Plug the PIM into an **unpowered** target board.
2. Install communication cable(s) between the emulator and your target board. See **Section 3.5 "Target Communication Connections"**.
3. Connect the trace cable from the trace port on the PIM to the trace adapter board. Orient the cable as show in Figure 7-2.

FIGURE 7-2: TRACE CONNECTION WITH PIM



4. Plug the trace adapter board into the MPLAB REAL ICE in-circuit emulator logic probe port. The top of the adapter board contains the connectors and should be oriented upwards when plugging the board into the logic probe port (Figure 7-2).
5. Power the target.

Note:	When using trace, pins TRCLK and TRD3:0 are used. Therefore, you cannot use the other functions multiplexed on these pins. For PIC32MX360F512L, multiplexed functions are RG14:12 and RA7:6. Check your device data sheet for details.

7.3.3.2 HARDWARE SETUP – PIC32 MCU ON TARGET

When designing instruction trace capability onto your own board, the following provisions will need to be made.

- Termination series resistors will need to be added as depicted in Figure 7-5.
- Depending on your board routing and loading of the signals used for trace; it is a good idea to place 0 ohm resistors that can be unpopulated to isolate the trace signals TRCLK and TRD3:0.

To use the PIC32 Instruction Trace feature with your own board do the following:

1. The target board should initially be **unpowered**.
2. Install communication cable(s) between the emulator and your target board. See **Section 3.5 "Target Communication Connections"**.
3. Connect the trace cable from the target board to the trace adapter board. Make sure the PIC32 MCU on your target board is connected to accomodate trace, as per Figure 7-5.
4. Plug the trace adapter board into the MPLAB REAL ICE in-circuit emulator logic probe port. The top of the adapter board contains the connectors and should be oriented upwards when plugging the board into the logic probe port (Figure 7-3).

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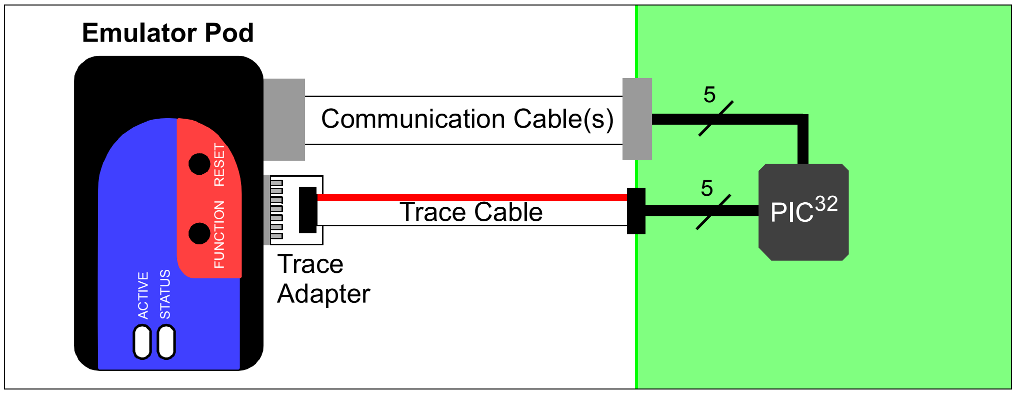
5. Power the target.

Note: When using trace, pins TRCLK and TRD3:0 are used. Therefore, you cannot use the other functions multiplexed on these pins. For PIC32MX360F512L, multiplexed functions are RG14:12 and RA7:6.

FIGURE 7-3: TRACE CONNECTION WITH DEVICE ON TARGET



7.3.3.3 MPLAB X IDE SETUP

To set up MPLAB X IDE to use trace for the MPLAB REAL ICE in-circuit emulator:

1. Right click on the project name and select “Properties”. In the Project Properties dialog click on “Real ICE” under “Categories”.
2. Under “Option categories”, select “Clock”. For data capture and trace, the emulator needs to know the instruction cycle speed.
3. Under “Option categories”, select “Trace and Profiling”.
4. Under “Data Collection Selection”, choose “Instruction Trace/Profiling”.
5. Set up any other trace-related options. (See **Section 11.3.1 “Trace and Profiling”**.)
6. Click **OK**.

On a Debug Run, trace will continue to fill the trace buffer with data, rolling over when the buffer is full, until a program Halt.

7.3.3.4 VIEWING TRACE DATA

When trace is enabled and code is run, trace data will be collected by the emulator. Once the device is halted, trace data will be decoded and displayed in the Trace window (*Window>Debugging>Trace*).

7.3.4 Trace Hardware Specifications

Specifications for hardware that supports PIC32 Instruction Trace are listed below.

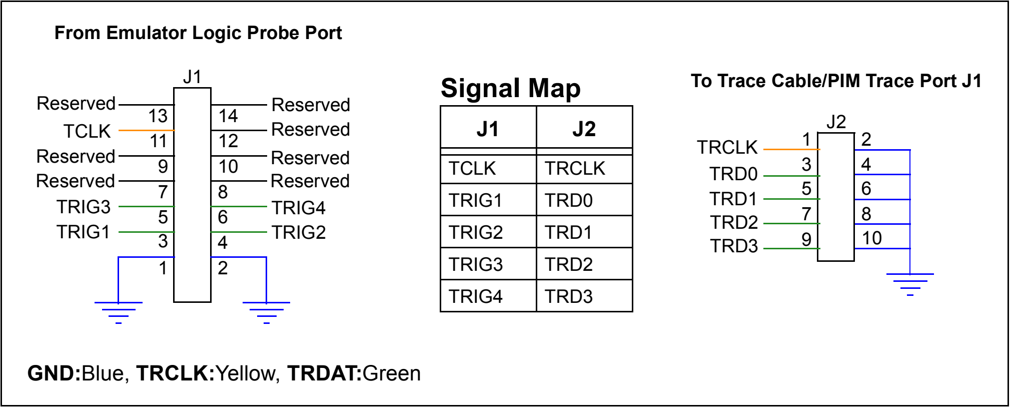
7.3.4.1 MPLAB REAL ICE TRACE INTERFACE KIT (AC244006)

The MPLAB REAL ICE Trace Interface Kit consists of an adapter board and trace cable. Kit component dimensions and a pin connection diagram for the adapter board are shown below.

TABLE 7-1: KIT COMPONENT DIMENSIONS IN INCHES

Component	Length	Width	Height
Adapter Board	0.900	0.800	0.6
Cable	12.0	0.5	0.0625

FIGURE 7-4: ADAPTER BOARD PIN CONNECTION DIAGRAM



J1	J2
TCLK	TRCLK
TRIG1	TRD0
TRIG2	TRD1
TRIG3	TRD2
TRIG4	TRD3

To use the logic probes instead of the trace cable, see **Section 3.6.4 “PIC32 Instruction Trace Connections”**.

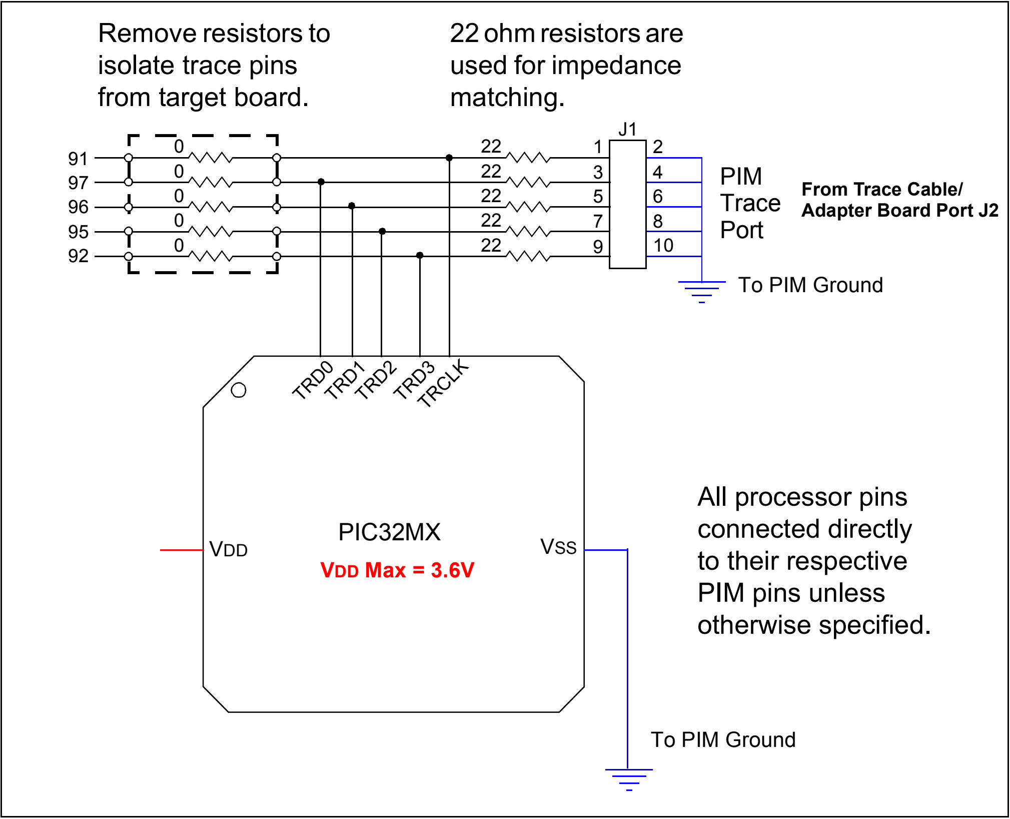
7.3.4.2 PIC32MX PIM

The PIC32MX PIM contains a PIC32 device that supports PIC32 Instruction Trace and a trace port connector. Two current PIMs and their dimensions are shown in Table 7-2 (see the Microchip website for up-to-date information). A pin connection diagram is shown in Figure 7-5.

TABLE 7-2: PIM DIMENSIONS IN INCHES

PIM #	PIM Name	Device	Length	Width	Height
MA320001	PIC32 PIM	PIC32MX360F512L	1.55	1.55	0.9
MA320002	PIC32 USB PIM	PIC32MX460F512L	1.55	1.55	0.9

FIGURE 7-5: PIC32MX PIM PIN CONNECTION DIAGRAM


Remove resistors to isolate trace pins from target board.
22 ohm resistors are used for impedance matching.
91
97
96
95
92
0
22
J1
1
3
5
7
9
2
4
6
8
10
PIM Trace Port
From Trace Cable/ Adapter Board Port J2
To PIM Ground
TRD0
TRD1
TRD2
TRD3
TRCLK
PIC32MX
VDD
VDD Max = 3.6V
VSS
All processor pins connected directly to their respective PIM pins unless otherwise specified.
To PIM Ground

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7.4 INSTRUMENTED TRACE

For some PIC32 devices, instrumented trace is available (see **Chapter 2. “Device and Feature Support”**).

For information on this trace, see **Section 6.3 “Instrumented Trace”**.

7.5 PC PROFILING

PC profiling is a method for examining C code to determine how much time is spent in each function. This information can show you where your program time is being spent so you may work to optimize your code.

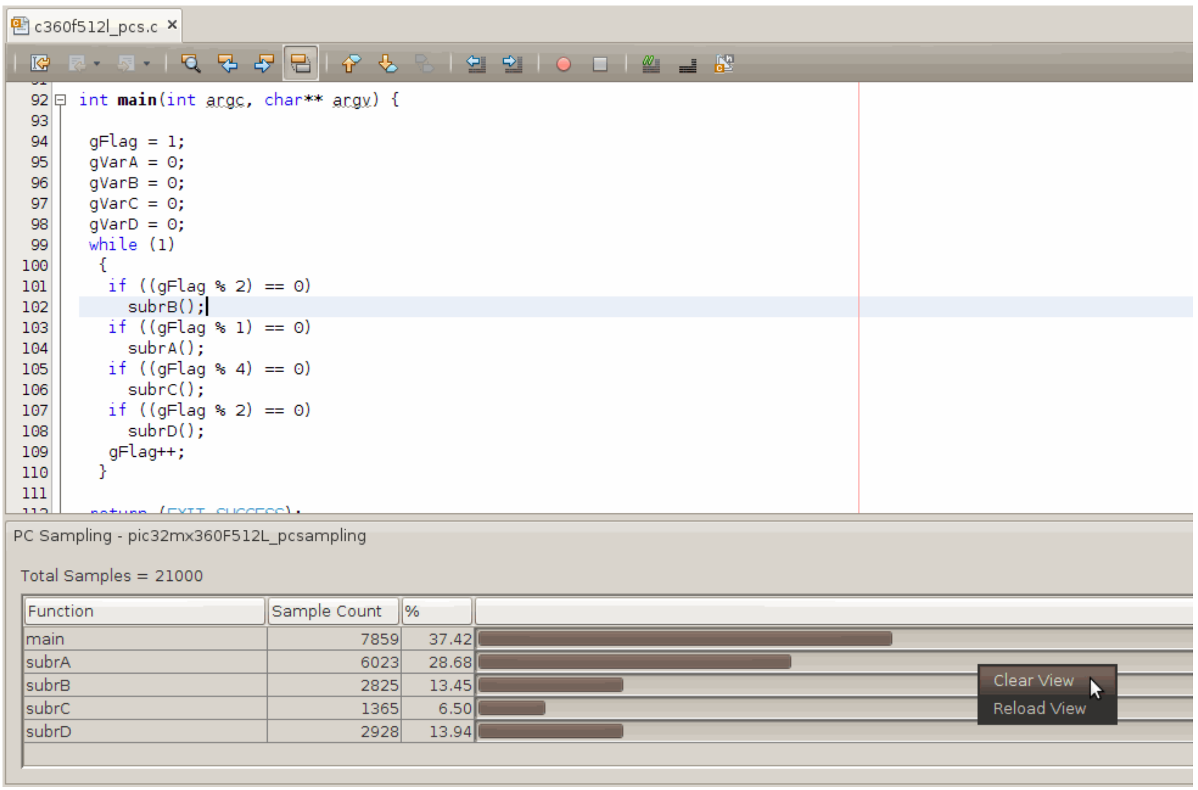
For PC profiling, every program counter (PC) trace sample is taken from the trace (data) buffer and profiled. This data is displayed in the PC Profiling window, as shown in Figure 7-6. In this example, the trace buffer contains 21,000 PC sample data points. Of these, 7859 (or 37.42%) where associated with the `main()` function, 6023 (or 28.68%) with the `subrA()` function, etc.

PC profiling is similar to PC sampling. For details see **Section 6.4 “PC Sampling”**.

To perform profiling:

1. Set up your hardware for PIC32 Instruction trace (see **Section 7.3 “PIC32 Instruction Trace”**.)
1. Open the Project properties window (*File>Project Properties*).
2. Click on “REAL ICE” under “Categories” and select “Trace and Profiling” from the “Options categories” drop-down box.
3. Under “Data Collection Selection”, select “Instruction Trace/Profiling”.
4. Set up your data file in this window. For reference, see **Section 11.3.1 “Trace and Profiling”**. Then click **OK**.
5. Select *Window>Debugging>PC Profiling*. This will open the PC Profiling window.
6. Run your code and then pause/halt.
7. View the profiling data in the window. Data is only displayed on halt.
8. Right click in the window to pop up a menu to either clear the data or reload the data.

FIGURE 7-6: PC SAMPLING WINDOW



```
int main(int argc, char** argv) {

  gFlag = 1;
  gVarA = 0;
  gVarB = 0;
  gVarC = 0;
  gVarD = 0;
  while (1)
   {
    if ((gFlag % 2) == 0)
      subrB();
    if ((gFlag % 1) == 0)
      subrA();
    if ((gFlag % 4) == 0)
      subrC();
    if ((gFlag % 2) == 0)
      subrD();
    gFlag++;
   }
```

PC Sampling - pic32mx360F512L_pcsampling

Total Samples = 21000

Function	Sample Count	%
main	7859	37.42
subrA	6023	28.68
subrB	2825	13.45
subrC	1365	6.50
subrD	2928	13.94

7.6 APPLICATION IN/OUT

> **Note:** This window is only available for devices that support the application in/out function used with the MPLAB REAL ICE in-circuit emulator or MPLAB ICD 3 in-circuit debugger. For details, see online help, "Device and Feature Support".
> The application in/out function cannot be used with PIC32 instruction trace.

The Application In/Out window allows you to interact with a running application using the Application Input/Output feature supported on some devices. Using this feature, data may be sent serially to and from the target application and, during runtime, over the same PGC/PGD lines used for debugging. Data written to the APPOUT register will be displayed to the window, while user input will be sent to the target application and available in the APPIN register.

To use the Application In/Out window:

- Use the device-specific header file when building your application to use the macros assigned in the header (per Example 7-1.)
- Alternatively, the PIC32 MCU library has `printf()` and `scanf()` functions for use with the Application In/Out feature. Refer to the "PIC32 Debug-Support Library" chapter in *32-Bit Language Tools Libraries* (DS51685).

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EXAMPLE 7-1: APPLICATION IN/OUT MACRO USAGE

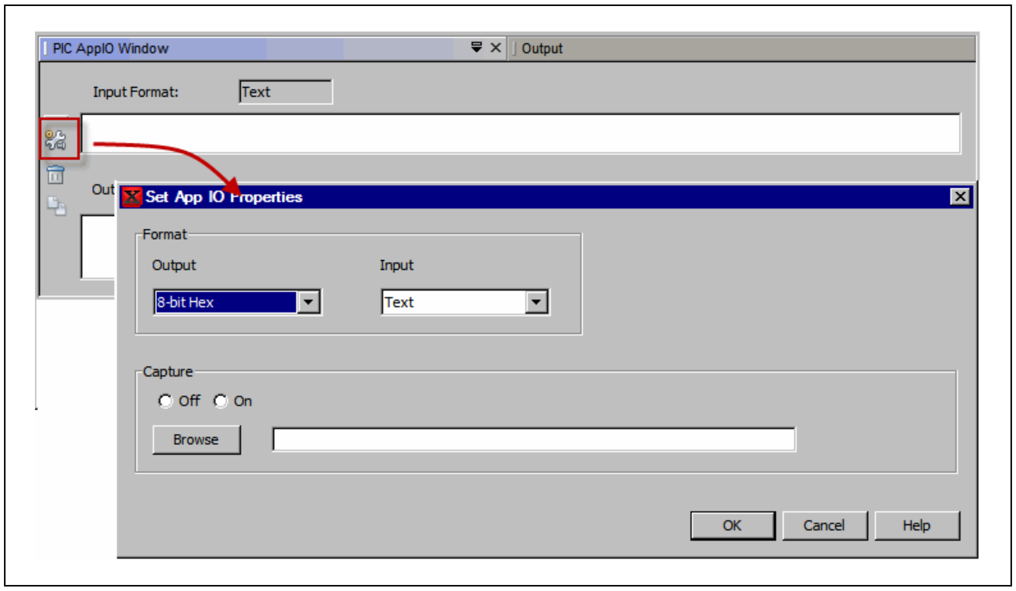
The following application code reads the application input register and writes out a padded value of the input to the application output register.

```
// include file
#include <p32xxxx.h>

// set up config bits
#pragma config FWDTEN = OFF

// initialize variables
unsigned int val;
int i;
unsigned int oval;

int main(void)
{
   while(1)
   {
    if(_DDPSTATbits.APIFUL) // APPI is full?
      {
       val = _APPI;         // Read User Input
       for(i=0; i<4; i++)
         {
          while(_DDPSTATbits.APOFUL); // APPO is full?
          oval =  val&0xFF;
          if(oval < 0x20)
             oval = 0x20;
          oval |= 0x20202000;
          _APPO = oval;               // Send to MPLAB X IDE
          val >>= 8;
         }
      }
   }
}
```

To run this application:

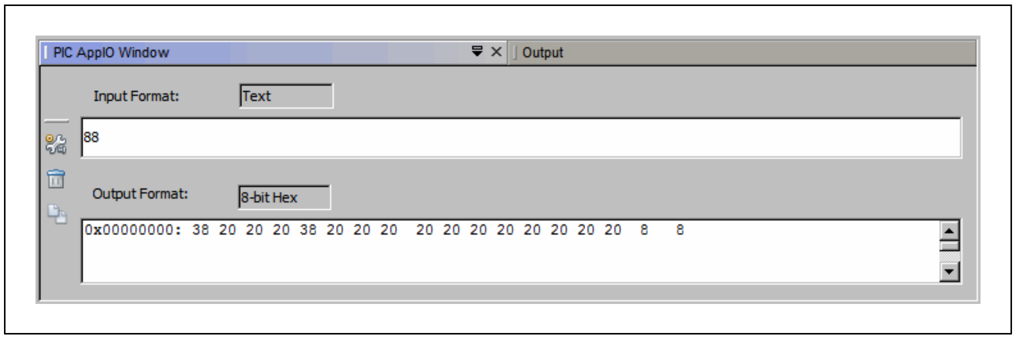
1. Create a project using the Project wizard:
   a) Select a supported device.
   b) Select REAL ICE or ICD 3 as the hardware tool.
   c) Use the “MPLAB C Compiler for PIC32 MCUs” or the “MPLAB XC32 C Compiler” as the language toolsuite.
2. Select *File>New File* to create and name a new C Source File. In the Editor window that opens, add the previous code and save.
3. Right click on the project name in the Projects window and select “Properties”. In the Project Properties window, click on “pic32-gcc” under “Categories”. Under “Option Categories”, select “General” and check the “Enable App IO” checkbox.
4. Build the project (Right click on the project name and select “Build”).
5. Select *Window>Debugging>PIC App IO* to open the Application In/Out window.
6. Click on the “Properties” button (on the left of the window) to launch the Set App IO Properties dialog. Under “Capture” click “On”.

FIGURE 7-7: SET APP I/O PROPERTIES



7. Debug Run or Run the project.
8. Enter an text value in the Input text box. Hit Enter.
9. View the output in the Output text box.

FIGURE 7-8: APP IN/OUT WINDOW



```
88
```

```
0x00000000: 38 20 20 20 38 20 20 20  20 20 20 20 20 20 20 20  8   8
```

Change Input and Output Formats by opening Set App IO Properties dialog and running the program again to see what outputs result for different inputs.

For more on options avaiable in this window, see **Section 11.4.2 "Application In/Out Window and Related Dialogs"**.

7.7 ADDITIONAL DEBUG FEATURES

In addition to the debug features covered previously, 32-bit devices have the other debug features, such as "Freeze on Halt", which allows you to freeze selected peripherals on a halt. For a complete list of debug functions, windows and dialogs, see **Chapter 11. "Emulator Function Summary"**.

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Part 3 – Troubleshooting

NOTES:

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Chapter 8. Troubleshooting First Steps

8.1 INTRODUCTION

If you are having problems with MPLAB REAL ICE in-circuit emulator operation, start here.

- The 5 Questions to Answer First
- Top Reasons Why You Can't Debug
- Other Things to Consider

8.2 THE 5 QUESTIONS TO ANSWER FIRST

1. What device are you working with? Often an upgrade to a newer version of MPLAB IDE is required to support newer devices. That is, yellow light = untested support.
2. Are you using a Microchip demo board or one of your own design? Have you followed the guidelines for resistors/capacitors for communications connections? See **Chapter 3. "Operation"**.
3. Have you powered the target? The emulator cannot power the target.
4. Are you using a USB hub in your set up? Is it powered? If you continue to have problems, try using the emulator without the hub (plugged directly into the PC.)
5. Are you using the standard communiction cable (RJ-11) shipped with emulator? If you have made a longer cable, it can have communications errors. If longer cables are required, you should consider using high-speed communications. See **Section 3.4.2 "High-Speed/LVDS Communication (Performance Pak)"**.

8.3 TOP REASONS WHY YOU CAN'T DEBUG

1. The oscillator is not working. Check your Configuration bits setting for the oscillator. If you are using an external oscillator, try using an internal oscillator. If you are using an internal a PLL, make sure your PLL settings are correct.
2. The target board is not powered. Check the power cable connection.
3. The Vdd voltage is outside the specifications for this device. See the device programming specification for details.
4. The emulator has somehow become physically disconnected from the PC and/or the target board. Check the communications cables' connections.
5. Emulator to PC communications has somehow been interrupted. Reconnect to the emulator in MPLAB IDE.
6. The device is code-protected. Check your Configuration bits setting for code protection.
7. You have not programmed your part in Debug mode.
8. You are trying to debug a production device that doesn't have debugging capabilities. Use a debug header instead. (See **"Processor Extension Pak and Header Specification (DS51292)"** in **"Recommended Reading"**.)

9. The target application has somehow become corrupted or contains errors. Try rebuilding and reprogramming the target application. Then initiate a Power-On-Reset of the target.
10. You do not have the correct PGC/PGD pin pairs programmed in your Configuration bits (for devices with multiple PGC/PGD pin pairs).
11. Other configuration settings are interfering with debugging. Any configuration setting that would prevent the target from executing code will also prevent the emulator from putting the code into debug mode.
12. Brown-out Detect voltage is greater than the operating voltage V_{DD}. This means the device is in Reset and cannot be debugged.
13. You have not followed the guidelines in **Chapter 3.** for communication connections.
14. The emulator cannot always perform the action requested. For example, it cannot debug when in Run mode.

8.4 OTHER THINGS TO CONSIDER

1. It is possible the error was a one-time glitch. Try the operation again.
2. There may be a problem programming in general. As a test, switch to programmer mode and program the target with the simplest application possible (e.g., a program to blink an LED). If the program will not run, then you know that something is wrong with the target setup.
3. It is possible that the target device has been damaged in some way (e.g., over current). Development environments are notoriously hostile to components. Consider trying another target device.
4. Microchip Technology Inc. offers myriad demonstration boards to support most of its microcontrollers. Consider using one of these applications, which are known to work, to verify correct MPLAB REAL ICE in-circuit emulator functionality. Or, use the Loop-Back Test board to verify the emulator itself (**Section 12.6 “Loop-Back Test Board”**.)
5. Review emulator debug operation to ensure proper application setup (**Chapter 3. “Operation”**.)
6. If the problem persists contact Microchip.

Chapter 9. Frequently Asked Questions (FAQ)

9.1 INTRODUCTION

Look here for answers (A) to frequently asked questions (Q) about the MPLAB REAL ICE in-circuit emulator system.

- How The Emulator Works
- How Trace Works – 8 and 16 Bit Devices
- General Issues

9.2 HOW THE EMULATOR WORKS

Q: *What's in the silicon that allows it to communicate with the MPLAB REAL ICE in-circuit emulator?*

A: Most silicon contains a debug module that can communicate with the REAL ICE. A small debug executive program is also needed to be programmed in the high area of memory (sometimes in a separate area of memory called test memory). On some small devices without on-chip debugging capability, an emulation header may be purchased to allow debugging.

Q: *How is the throughput of the processor affected by having to run the debug executive?*

A: The debug executive doesn't run while in Run mode, so there is no throughput reduction when running your code, i.e., the emulator doesn't 'steal' any cycles from the target device. However, when you are doing Native trace, each macro inserted takes about 200 instructions. Therefore, this will affect timing.

For more information, see **Section 6.3.8 "Resource Usage Examples"**.

Q: *How does the MPLAB REAL ICE in-circuit emulator compare with other in-circuit emulators/debuggers?*

A: Please refer to **Section 3.2 "Tools Comparison"**.

Q: *How does MPLAB IDE interface with the MPLAB REAL ICE in-circuit emulator to allow more features than in-circuit debuggers?*

A: For some devices, the MPLAB REAL ICE in-circuit emulator communicates using the debug executive located in a special area of memory that does not use application program memory. Also, the debug exec is streamlined for more efficient communication. The emulator contains an FPGA, large SRAM Buffers (1Mx8), and a high speed USB interface. The program memory image is downloaded and is contained in the SRAM to allow faster programming. The FPGA in the emulator serves as an accelerator for interfacing with the device in-circuit debugger modules.

Q: On traditional emulators, the data must come out on the bus in order to perform a complex trigger on that data. Is this also required on the MPLAB REAL ICE in-circuit emulator? For example, could I halt based on a flag going high?

A: Traditional emulators use a special emulator chip (-ME) for monitoring. There is no -ME with the MPLAB REAL ICE in-circuit emulator so there are no busses to monitor externally. With the MPLAB REAL ICE in-circuit emulator, rather than using external breakpoints, the built-in breakpoint circuitry of the debug engine is used; the busses and breakpoint logic are monitored inside the part.

Q: Does the MPLAB REAL ICE in-circuit emulator have complex breakpoints?

A: Yes. You can break based on pass counts, program memory execution at a specific address or data memory reads/writes at a specific address. You can also do event breakpoints (break on an event) sequenced breakpoints (break after events occur in a specific order), or ANDed breakpoint (break when events occur all together).

Q: One of the probe pins is labeled 5V. How much drive capability does this probe have?

A: This is a monitoring function (allows you to see what VDD is actually being applied and used on the driver buffers). The MPLAB REAL ICE in-circuit emulator cannot provide power to the target.

Q: Are any of the driver boards optoisolated or electrically isolated?

A: They are DC optoisolated, but not AC optoisolated. To apply high voltage (120V) to the current system, see **Section 13.4 "MPLAB REAL ICE Isolator Unit (Opto-Isolator)"**.

Q: What limitations are there with the 4 (PGC) or 5 (PGD) pins only?

A: There are several limiations on these pins:

- The standard ICSP RJ-11 cable does not allow for clock speeds greater than about 15 Mb/sec. For these high-speed applications, the Performance Pak (high-speed/LVDS) cable interface is required.

- Some circuitry should not be used on these pins. See **Section 3.5.4 "Circuits That Will Prevent the Emulator From Functioning"**. Also refer to "Development Tools Design Advisory" (DS51764).

Q: Will this slow down the running of the program?

A: There is no cycle stealing with the MPLAB REAL ICE in-circuit emulator. The output of data is performed by the state machine in the silicon.

Q: How do I connect CLK and DAT when using high-speed communications?

A: These connections are optional and used for SPI trace. For more information, see **Section 3.6.2 "SPI Trace Connections (High-Speed/LVDS Connection)"**.

Q: What is meant by the data rate is limited to 15 MIPS, when using the standard board? Is this caused by the core processor or transfer rate?

A: The standard board uses the RJ-11 cable and has a limitation on how fast data can reliably be transmitted when using trace, runtime watches, and data capture. The top end is when the processor has an operational speed of 15 MIPS. The trace clock is derived from the main system clock of the device.

The 15 MIPS limit is a worst case limit. For well designed boards with less signal integrity problems, the limit may be higher.

Q: Does the 15 MIPS limit apply to PIC32 devices?

A: No. The PIC32 MCU uses a fixed rate clock that doesn't derive from the target system clock. It also uses a more robust communication protocol.

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Q: *To debug a dsPIC® DSC running at 30 MIPS, is high-speed communications necessary to do even basic debugging?*

A: Basic debugging at any device frequency can be accomplished with either standard or high-speed (Performance Pak) communications.

Q: *My target board connector is for standard communications but I want to use high-speed communications. Can I use the high-speed/LVDS communications (Performance Pak) cables, high-speed-to-standard converter board, and standard communication (ICSP) cable?*

A: No. You cannot use the standard/ICSP cable for high-speed communications, i.e., high device operational frequencies. This introduces signal integrity issues, due to the lower quality of cable transmission, when using the RJ-11 converter board.

Q: *If the high-speed receiver board is used, do pins 7-8 have to be connected, or can they just be left open?*

A: They can be left open. The high-speed receiver board weakly pulls them down.

Q: *What is the function of pin 6, the auxiliary pin?*

A: There is no function on pin 6. It is a legacy connection, compatible with the typical ICSP 6-pin header definition.

9.3 HOW TRACE WORKS – 8 AND 16 BIT DEVICES

Q: *When using trace, is this connection electrically isolated in any way, i.e., do the triggers have any isolation?*

A: They are buffered and DC adjusted to whatever V_{DD} level you are running. The buffers tristate when off. This minimal isolation makes the system fast and opens the door to adapt to new and faster technologies. However, you may implement more RS-232 isolation (4-6 lines) if desired, but this may impact your speed.

Q: *Can we do trace by using the 5 or 6 ICSP pins only?*

A: Tracing is possible using the standard ICSP interface.

Q: *Does inputting execution speed in the Project Properties dialog (File>Project Properties, REAL ICE category, Clock option) actually set communication clock?*

A: No. The input box in this tab merely reports the speed to the emulator so that it can accurately control timing. The actual communication speed is based on the target system clock. Reporting the clock is needed only for Native trace, data capture, and runtime watches.

Q: *When would SPI trace be used? What extra advantage does this have?*

A: SPI trace is faster than Native trace and impacts code size less. It can also be used on many devices that do not have Native trace. See the online help, “Device and Feature Support”.

Q: *In order to use the SPI trace, what is the hardware connection?*

A: For serial SPI port trace, the device SPI SDO (serial data output) and SCK (serial clock) are required. These pins must be connected, respectively, to the DAT and CLK pin interface on the Performance Pak receiver board. See **Section 3.6.2 “SPI Trace Connections (High-Speed/LVDS Connection)”** for more information.

Q: For SPI trace, which two pins are used?

A: The pins are:

SDO (Serial Data Output) $\rightarrow$ DAT (pin 7)

SCK (Serial Clock Output) $\rightarrow$ CLK (pin 8)

Q: What are the correct port settings to use SPI trace, i.e., mode, sync/async, etc.?

A: The setup is taken care of by MPLAB IDE, so you will not need to be concerned about the code required for setting this. Trace will support 64 trace points and 128 log points.

SPI – Comm Protocol MODE1, clock high, sampled falling edge.

Q: What is the correct connection for using I/O Port (parallel port) trace?

A: The connection varies depending on the PORT used. There are port assignments in MPLAB IDE that are displayed when the PORT is selected in the property sheet. See **Section 3.6.3 “I/O Port Trace Connections”** for more information.

Q: Can we use any port?

A: The port must be available on the device and not multiplexed with the currently used PGC and PGM pins.

Q: Of the 7 data and one clock, which one is the clock?

A: There are 7 bits of data to set up to 128 trace points. The clock is the MSB of the port.

Q: Are these I/O ports used for trace available as general I/O during debugging?

A: For dsPIC30F/33F and PIC24F/H devices, you may write to the opposing 8-bit part of the port provided byte write operations are used. The following example will write to the high side of the port only.

```
#define high(num)   (((BYTE *)&num)[1])
#define low(num)    (((BYTE *)&num)[0])
high(PORTA) = 0x12;
```

For PIC18 devices, once the ports are defined to be used for trace, you **should not** access them in your code.

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9.4 GENERAL ISSUES

Q: *Performing a Verify fails after programming the device. Is this a programming issue?*

A: If Run (*Run>Run Project*) is selected, the device will automatically run immediately after programming. Therefore, if your code changes the flash memory, verification could fail. To prevent the code from running after programming, please select 'Hold in Reset'.

Q: *I have set a breakpoint but my program doesn't stop there. Why?*

A: Consider the following:

1- Are you setting those breakpoint in Debug mode and then choosing Run? Breakpoints are ineffective in Programmer mode.

2- Are these breakpoints part of a sequence? Remember, sequence breakpoints will only halt execution if they are followed in the exact sequence.

3- Are these breakpoints part of PIC32 instruction trace triggers? Once you choose them as trace triggers they are not functional breakpoints anymore. See **Section 7.3 “PIC32 Instruction Trace”** for more information.

4- Are you seeing breakpoint skid? See next question.

5- Finally, your program may not have executed the instruction at which you wish to break. Try setting a breakpoint earlier in your code and single step from there to see the actual code flow executed by the device.

Q: *I can't set a breakpoint on a particular line of code. Why?*

A: MPLAB IDE will allow setting breakpoints only on executable code.

Example 1: The line you are trying to break on may have been optimized out by the compiler. In that case, try turning optimizations off.

Example 2: The line you are trying to break on may be a compiler directive, and not actual code.

Q: *I didn’t set a breakpoint, yet I have one in my code. What’s going on?*

A: What you are seeing is a phantom breakpoint. Occasionally, a breakpoint can become enabled when it shouldn’t be. Simply disable or delete the breakpoint. You may need to go to the disassembly window to do so, or simply right click and choose delete all breakpoints. If this does not work, try closing and reopening the disassembly window.

Q: *Can I use the debugger with optimized code?*

A: It is strongly recommended that C compiler optimization is turned off during debugging (see the Build Options dialog). Optimization will greatly alter how the executable code corresponds to the source files and hence the debugger may appear to behave strangely with some code.

Q: *Data capture has become flaky. What is going on?*

A: The speed of data capture may be too high for your PC or target environment (noise). There are several things you can do:

1- Reduce the clock speed. Refer to **Section 11.3.3 “Clock”**.

2- Reduce the rate at which you capture data. In the Watches window, right click on the symbol, select “Run Time Update Interval” and set a delay.

Q: *I cannot get trace to work. What’s wrong?*

A: Consider the following:

- Certain tool versions are required to use trace. Please refer to either **Chapter 6. “Specific Debug Functions: 8- and 16-Bit Devices”** or **Chapter 7. “Specific Debug Functions: 32-Bit Devices”**.

- For dsPIC30F/33F and PIC24F/H devices, only C code can be used with trace, not assembly.

- In-line assembly code (assembly code within C code) cannot be traced.

- Code must be rebuilt and reprogrammed when trace macros are added.

- Ensure you do not have trace macros disabled on the Build Options Trace tab.

- Native trace, data captures and runtime watches cannot be used together.

- The target clock frequency must be reported to MPLAB IDE on the Settings Clock tab for Native and SPI trace.

- For Port I/O Trace, all 8 pins must be dedicated to trace (i.e., not multiplexed with the currently used PGC and PGM pins.)

- For Port I/O Trace, ensure that the chosen port is able to output 0x00 and 0xFF. As a test, set the port TRIS to 0 (all outputs) and set the LAT to a value in the watch window. The value written to LAT should appear on the port pins.

Q: *My program halts while I am tracing, corrupting my trace data. What’s happening?*

A: The Watchdog timer can cause this behavior. Ensure it is disabled by properly setting the configuration bits

Q: *My PC went into power-down/hibernate mode, and now my emulator won’t work. What happened?*

A: When using the emulator for prolonged periods of time, and especially as a debugger, be sure to disable the Hibernate mode in the Power Options Dialog window of your PC’s operating system. Go to the Hibernate tab and clear or uncheck the “Enable hibernation” check box. This will ensure that all communication is maintained across all the USB subsystem components.

Q: *I set my peripheral to NOT freeze on halt, but it is suddenly freezing. What's going on?*

A: For dsPIC30F/33F and PIC24F/H devices, a reserved bit in the peripheral control register (usually either bit 14 or 5) is used as a Freeze bit by the debugger. If you have performed a write to the entire register, you may have overwritten this bit. (The bit is user accessible in Debug mode.)

To avoid this problem, write only to the bits you wish to change for your application (`BTS`, `BTC`) instead of to the entire register (`MOV`).

Q: *When using a 16-bit device, unexpected Reset occurred. How do I determine what caused it?*

A: Consider the following:

- Ensure the Watchdog Timer is disabled in the configuration bits.

- To determine a Reset source, check the RCON register.

- Handle traps/interrupts in an interrupt service routine (ISR). You should include `trap.c` style code, i.e.,

```
  void __attribute__((__interrupt__))
_OscillatorFail(void);
          :
   void __attribute__((__interrupt__))
_AltOscillatorFail(void);
          :
   void __attribute__((__interrupt__))
_OscillatorFail(void)
   {
       INTCON1bits.OSCFAIL = 0;       //Clear the trap flag
        while (1);
   }
          :
   void __attribute__((__interrupt__))
_AltOscillatorFail(void)
   {
        INTCON1bits.OSCFAIL = 0;
        while (1);
   }
          :
```

Q: *How can I manually download the firmware?*

A: For an active project that uses the emulator:

- Select *File>Project Properties* to open the Properties window.

- Click on the “Real ICE” category and select “Firmware” from the drop-down Option Categories.

- Uncheck “Use Latest Firmware” and browse for the Firmware File at location: `<install path>MPLABX/mplab_ide/mplablibs/modules/ext/REALICE.jar`.

- Select the `.jam` file you want and click **OK**. Click **Reset**.

Q: *I accidentally disconnected my emulator while firmware was downloading. What do I do now?*

A: Reconnect the emulator. It will begin to erase what had been written so it can restart. This erasing will take about 75 seconds (1:15 mins). Please be patient. You will see:

- the orange busy light turn on for about 25 seconds

- the light turn red for about another 25 seconds

- the light turn orange again for about another 25 seconds

When it turns back to red again, MPLAB IDE will recognize the device and start the recovery process, i.e., begin firmware download.

Q: *My memory window does not reflect changes*

A: In order to see changes in the window, you must do a read of the memory.

Q: *I don't see my problem here. Now what?*

A: Try the following resources:

Section 3.10 "Resources Used by the Emulator"

Section 10.2 "Error Messages"

Section 10.3 "General Corrective Actions"

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Chapter 10. Messages

10.1 INTRODUCTION

The MPLAB REAL ICE in-circuit emulator produces many different output messages. Some are error messages, many of which can often be resolved with general corrective actions. And some are informational only.

- Error Messages
- General Corrective Actions
- Informational Messages

10.2 ERROR MESSAGES

MPLAB REAL ICE in-circuit emulator error messages are listed below. Text in error messages listed below of the form %x (a variable) will display as text relevant to your particular situation in the actual error message.

- Read/Write Errors
- Emulator-to-Target Communication Errors
- Emulator-to-PC Communcation Errors
- Corrupted/Outdated Installation Errors
- Debug Failure Errors
- Hardware/Firmware Errors
- Miscellaneous Errors
- Internal Errors

10.2.1 Read/Write Errors

For the errors below, read any instructions under your error message. If these fail to fix the problem or if there are no instructions, see **Section 10.3.1 "Read/Write Error Actions"**.

Failed while writing to %s

Failed while reading %s

Failed to program device

Failed to read device

Failed to write to %s memory

Failed to erase the device

Unable to read target register(s).

Unable to write target register(s).

Programming debug executive failed

Programming program executive failed

Failed to get Device ID

10.2.2 Emulator-to-Target Communication Errors

For the errors below, read any instructions under your error message. If these fail to fix the problem or if there are no instructions, see **Section 10.3.2 "Emulator-to-Target Communication Error Actions"**.

Failed to reset the device

Failed while sending cmd_INITCOMM command

Failed while sending cmd_SETPROBES command

Failed while sending cmd_SETBRACKET

Failed to get status

Failed to send database

If you receive this error:

1. Try downloading again. It may be a one-time error.
2. Try manually downloading the highest-number `.jam` file.

Invalid command response (sent 0x%x, received 0x%x)

Failed while trying to enter ICE test mode

Failed while trying to start DMA test

Failed to properly receive DMA test data

Timed out while waiting to process data from endpoint 0x%x

transmission failure while receiveing streaming data

Interrupted Exception occurred %s

Unable to start streaming data reception

Unable to start run time data reception

Failed getting PC

10.2.3 Emulator-to-PC Communcation Errors

For the errors below, read any instructions under your error message. If these fail to fix the problem or if there are no instructions, see **Section 10.3.3 "Emulator-to-PC Communication Error Actions"**.

Failed to set debug options

Failed while stepping the target

Failed while halting the target

Cannot communicate with %s

10.2.4 Corrupted/Outdated Installation Errors

For the errors below, read any instructions under your error message. If these fail to fix the problem or if there are no instructions, see **Section 10.3.4 "Corrupted Installation Actions"**.

Failed to download firmware

If the Hex file exists:

- Reconnect and try again.
- If this does not work, the file may be corrupted. Reinstall MPLAB IDE.

If the Hex file does not exist:

- Reinstall MPLAB IDE.

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The MPLAB REAL ICE is missing its Program Executive. Please reconnect to the PC and try again.

The MPLAB REAL ICE is missing its Debug Executive. Please reconnect to the PC and try again.

The MPLAB REAL ICE is missing its Device Database. Please reconnect to the PC and try again.

The MPLAB REAL ICE is missing a Memory Object.

The current memory object in the MPLAB REAL ICE is corrupted. Please retry the operation.

Unable to download debug executive

If you receive this error while attempting to debug:

1. Deselect the emulator as the debug tool.
2. Close you project and then close MPLAB IDE.
3. Restart MPLAB IDE and re-open your project.
4. Reselect the emulator as your debug tool and attempt to program your target device again.

Unable to download program executive

If you receive this error while attempting to program:

1. Deselect the emulator as the programmer.
2. Close your project and then close MPLAB IDE.
3. Restart MPLAB IDE and re-open your project.
4. Reselect the emulator as your programmer and attempt to program your target device again.

10.2.5 Debug Failure Errors

For the errors below, read any instructions under your error message. If these fail to fix the problem or if there are no instructions, see **Section 10.3.6 "Debug Failure Actions"**.

Unable to open debug executive file %s

The target device is not ready for debugging. Please check your configuration bit settings and program the device before proceeding.

You will receive this message when you have not programmed your device for the first time and try to Run. If you receive this message after this, or immediately after programming your device, please refer to **Section 10.3.6 "Debug Failure Actions"**.

An unknown exception has occurred. Please unplug the MPLAB REAL ICE and reconnect.

The Target is held in Reset. Please ensure the MCLR line is pulled up or High-Z'd.

The Debug Executive is found but can't be communicated with. Please ensure your oscillator settings are correct. If the device supports internal RC try to connect via that mode first.

See also **Section 10.3.2 "Emulator-to-Target Communication Error Actions"**.

REAL ICE was unloaded while still busy. Please unplug and reconnect the USB cable before using REAL ICE again.

Target device was not found. You must connect to a target device to use MPLAB REAL ICE.

See also **Section 10.3.2 “Emulator-to-Target Communication Error Actions”**.

Invalid streaming data was been detected. Run time watch or trace data may no longer be valid. Is recommended that you restart your debug session.

See the FAQ, “Data capture has become flaky. What is going on?”.

10.2.6 Hardware/Firmware Errors

For the errors below, read any instructions within your error message.

The 17.5 rail is unable to turn on. Please unplug the MPLAB REAL ICE and reconnect. If the problem persists contact Microchip for assistance.

The SRAM has failed its self test. Please unplug the MPLAB REAL ICE and reconnect. If the problem persists contact Microchip for assistance.

The FPGA has failed its self test. MPLAB IDE will attempt to download the latest firmware.

Please do not disconnect the REAL ICE during the download process. If the problem persists contact Microchip for assistance.

The Driver board is missing. Please unplug the MPLAB REAL ICE, make sure the driver board is properly seated and reconnect. If the problem persists contact Microchip for assistance.

The Main board serial EEPROM is missing. Please unplug the MPLAB REAL ICE and reconnect. If the problem persists contact Microchip for assistance.

The Driver board serial EEPROM is missing. Please unplug the MPLAB REAL ICE and reconnect. If the problem persists contact Microchip for assistance.

The DAC is missing. Please unplug the MPLAB REAL ICE and reconnect. If the problem persists contact Microchip for assistance.

The Main boards' trigger IO expander is missing. Please unplug the MPLAB REAL ICE and reconnect. If the problem persists contact Microchip for assistance.

The Data pin I/O test failed. Please unplug the MPLAB REAL ICE and reconnect. If the problem persists contact Microchip for assistance.

The Driver I/O expander is missing. Please unplug the MPLAB REAL ICE and reconnect. If the problem persists contact Microchip for assistance.

The VPP generator could not set the proper voltage. Please unplug the MPLAB REAL ICE and then reconnect. If problem persists, contact Microchip for assistance.

The VDD generator could not set the proper voltage. Please unplug the MPLAB REAL ICE and then reconnect. If problem persists, contact Microchip for assistance.

The Clock or Data line has clamped the external voltage! Please remove your target, probe the voltage levels and then reconnect.

Too much current has been drawn on VPP. Please disconnect your circuit, check the MCLR line for shorts and then reconnect.

Too much current has been drawn on VDD. Please disconnect your circuit, check the CLK and DATA lines for shorts and then reconnect.

Target Vdd not detected. Please ensure the target device is connect

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10.2.7 Miscellaneous Errors

For the errors below, read any instructions under your error message.

could not open file

There was a problem reading file

Failed to set firmware suite.

Database intitialization failure.

Connection failed (timed out waiting to REAL ICE to respond)

MPLAB has lost communication with REAL ICE.

Unable to connect to REAL ICE (MPLABComm connect failure)

REAL ICE is busy. Please wait for the current operation to finish.

If you receive this error when attempting to deselect the emulator as a debugger or programmer:

1. Wait - give the emulator time to finish any application tasks. Then try to deselect the emulator again.
2. Select Halt to stop any running applications. Then try to deselect the emulator again.
3. Unplug the emulator from the PC. Then try to deselect the emulator again.
4. Shut down MPLAB IDE.

REAL ICE failed to request DMA reads.

Unable to intialize REAL ICE database.

An Error occurred while running

Address: %x Expected Value: %x Received Value: %x

Target Device ID (0x%x) does not match expected Device ID (0x%x).

Unable to properly create REAL ICE database.

10.2.8 Internal Errors

See **Section 10.3.7 "Internal Error Actions"**.

Initialization failed: Unable to create ControlPointMediator

Initialization failed: Unable to create com object

Initialization failed: Unable to retrieve device information for device %s

Initialization failed: Family class is unrecognized

Initialization failed: Failed while retrieving device database (.pic) information

Initialization failed: Failed while retrieving tool database (.rice) information

Initialization failed: Unable to load debug executive

Initialization failed: Unable to acquire emulation memory object

Initialization failed: Unable to acquire ToolExecMediator

10.3 GENERAL CORRECTIVE ACTIONS

These general corrective actions may solve your problem:

- Read/Write Error Actions
- Emulator-to-Target Communication Error Actions
- Emulator-to-PC Communication Error Actions
- Corrupted Installation Actions
- USB Port Communication Error Actions
- Debug Failure Actions
- Internal Error Actions

10.3.1 Read/Write Error Actions

If you receive a read or write error:

1. Did you hit Abort? This may produce read/write errors.
2. Try the action again. It may be a one time error.
3. Ensure that the target is powered and at the correct voltage levels for the device. See the device data sheet for required device voltage levels.
4. Ensure that the emulator-to-target connection is correct (PGC and PGD are connected.)
5. For write failures, ensure that “Erase all before Program” is checked on the Program Memory tab of the Settings dialog.
6. Ensure that the cable(s) used are of the correct length - maximum 6” for standard communications and 10’ for high-speed communications.

10.3.2 Emulator-to-Target Communication Error Actions

The MPLAB REAL ICE in-circuit emulator and the target device are out-of-synch with each other.

1. Select **Reset** and then try the action again.
2. Ensure that the cable(s) used are of the correct length - maximum 6” for standard communications and 10’ for high-speed communications.

10.3.3 Emulator-to-PC Communication Error Actions

The MPLAB REAL ICE in-circuit emulator and MPLAB IDE are out of synch with each other.

1. Unplug and then plug in the emulator.
1. Reconnect to the emulator.
2. Try the operation again. It is possible the error was a one time glitch.
3. The version of MPLAB IDE installed may be incorrect for the version of firmware loaded on the MPLAB REAL ICE in-circuit emulator. Follow the steps outlined in **Section 10.3.4 “Corrupted Installation Actions”**.
4. There may be an issue with the PC USB port. See **Section 10.3.5 “USB Port Communication Error Actions”**.

10.3.4 Corrupted Installation Actions

The problem is most likely caused by a incomplete or corrupted installation of MPLAB IDE.

1. Uninstall all versions of MPLAB IDE from the PC.
2. Reinstall the desired MPLAB IDE version.
3. If the problem persists contact Microchip.

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10.3.5 USB Port Communication Error Actions

The problem is most likely caused by a faulty or non-existent communications port.

1. Reconnect to the MPLAB REAL ICE in-circuit emulator
2. Make sure the emulator is physically connected to the PC on the appropriate USB port.
3. Make sure the appropriate USB port has been selected in the emulator Settings.
4. Make sure the USB port is not in use by another device.
5. If using a USB hub, make sure it is powered.
6. Make sure the USB drivers are loaded.

10.3.6 Debug Failure Actions

The MPLAB REAL ICE in-circuit emulator was unable to perform a debugging operation. There are numerous reasons why this might occur. See **Chapter 8. “Troubleshooting First Steps”**.

10.3.7 Internal Error Actions

Internal errors are unexpected and should not happen. They are primarily used for internal Microchip development.

The most likely cause is a corrupted installation (**Section 10.3.4 “Corrupted Installation Actions”**).

Another likely cause is exhausted system resources.

1. Try rebooting your system to free up memory.
2. Make sure you have a reasonable amount of free space on your hard drive (and that it is not overly fragmented.)

If the problem persists contact Microchip.

10.4 INFORMATIONAL MESSAGES

MPLAB REAL ICE in-circuit emulator informational messages are listed below in numeric order.

Note: Numbers may not yet appear in displayed messages. Use the Search tab on the Help viewer to find your message and highlight it below.

Loopback test completed successfully. Your REAL ICE is functioning properly. If you are still having problems with your target circuit please check the Target Board Considerations section of the online help.

See **Section 12.7 “Target Board Considerations”**.

NOTES:

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Part 4 – Reference

NOTES:

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Chapter 11. Emulator Function Summary

11.1 INTRODUCTION

A summary of the MPLAB REAL ICE in-circuit emulator functions is listed here.

- Emulator Selection and Switching
- Emulator Options Selection
- Emulator Windows & Dialogs

11.2 EMULATOR SELECTION AND SWITCHING

Use the Project Properties dialog to select or switch emulators for a project. To switch you must have more than one MPLAB REAL ICE in-circuit emulator connected to your computer. MPLAB X IDE will differentiate between the two by displaying two different serial numbers.

To select or change the emulator used for a project:

1. Open the Project Properties dialog by doing one of the following:
   a) Click on the project name in the Project window and select *File>Project Properties*.
   b) Right click on the project name in the Project window and select "Properties".
2. Under "Categories", click on "[[default]]"
3. Under "Hardware Tools", find "REAL ICE" and click on a serial number (SN) to select an emulator for use in the project.

11.3 EMULATOR OPTIONS SELECTION

Set up emulator options on the emulator property pages of the Project Properties dialog.

1. Open the Project Properties dialog by doing one of the following:
   a) Click on the project name in the Project window and select *File>Project Properties*.
   b) Right click on the project name in the Project window and select "Properties".
2. Under "Categories", click on "REAL ICE"
3. Select property pages from "Options categories". Click on an option to see its description in the text box below. Click to the right of an option to change it.

Available option categories are:

- Trace and Profiling
- External Triggers
- Clock
- Freeze Peripherals
- Debug Options
- Program Options
- Firmware
- Memories to Program

11.3.1 Trace and Profiling

Depending on the device you have selected for your project, you may be able to use trace or PC sampling/profiling when debugging. Enable and set up these features as specified below.

8-Bit and 16-Bit Devices

Options available on this page depend on the trace/profiling features of the project device. For more on trace and profiling, see **Chapter 6. "Specific Debug Functions: 8- and 16-Bit Devices".**

TABLE 11-1: TRACE/PROFILING OPTION CATEGORY

Data Collection Selection	Enable/Disable data collection. • Off - Do not use trace or PC sampling. • User Instrumented Trace - see **Section 6.3 "Instrumented Trace"**. • PC Sampling - see **Section 6.4 "PC Sampling"**.
Data File Path and Name	Enter or change the path and/or name of the file used to store data.
Data File Maximum Size (bytes)	Set the maximum size of the data file.
Data Buffer Maximum Size (bytes)	Set the size of the data buffer, up to 54600 bytes (on board the emulator unit.)
User Instrumented Trace Items	
Disable Trace Macros	Check to temporarily disable trace macros or uncheck to enable trace macros. To disable trace, remove all macros and select "Off" under "Data Collection Selection".
Communications Medium	Select the trace medium, if available (device dependent): Native, I/O Port, SPI.
I/O Port Selection	Specify the device port to be used for I/O port trace. The available combinations for the selected device will be listed.
SPI Selection	Specify the device SPI pins to be used for SPI trace. The available pins for the selected device will be listed.
PC Sample Items - Only on Some 16-bit Devices	
Timer Selection (Not Used by Application Code)	Select a device timer to use to count PC samples. **Note:** You will no longer be able to use this timer in your application. It will be dedicated to PC sampling. **Note:** You may select only one timer; you cannot combine two timers to get a 32-bit timer. Use of one of a 32-bit timer pair will prohibit that pair from operating as a 32-bit timer.
Timer Interrupt Priority	Select an interrupt priority for the timer. **Note:** Select a priority that is higher than other priorities you have set in your application. If you do not, the other priorities will preempt the sampling priority and you will not capture these samples.
Timer Interval	Enter a sampling interval. This must be integer values (1, 2, 3, and so forth). If you are not capturing data, you may be missing samples given your current interval. Try adjusting the unit selection and interval, for example, if you had 1 millisecond, try 990 microseconds.

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TABLE 11-1: TRACE/PROFILING OPTION CATEGORY (CONTINUED)

Timer Interval Units	Select a sampling interval unit: • microseconds • milliseconds • seconds • instruction cycles

32-Bit Devices

Options available on this page depend on the trace/profiling features of the project device. For more on trace and profiling, see **Chapter 7. "Specific Debug Functions: 32-Bit Devices"**.

TABLE 11-2: TRACE/PROFILING OPTION CATEGORY

Data Collection Selection	Enable/Disable data collection. • Off - Do not use trace of PC sampling • Instruction Trace/Profiling - see **Section 7.3 "PIC32 Instruction Trace"** and **Section 7.5 "PC Profiling"**. • User Instrumented Trace - see **Section 7.4 "Instrumented Trace"**.
Data File Path and Name	Enter or change the path and/or name of the file used to store data.
Data File Maximum Size (bytes)	Set the maximum size of the data file.
Data Buffer Maximum Size (bytes)	Set the size of the data buffer, up to 54600 bytes (on board the emulator unit.)
User Instrumented Trace Items	
Disable Trace Macros	Check to temporarily disable trace macros or uncheck to enable trace macros. To disable trace, remove all macros and select "Off" under "Data Collection Selection".
Communications Medium	Select the trace medium, if available (device dependent): Native.

11.3.2 External Triggers

Select external triggers for Triggers 0 through 7. For more on triggers, see **Section 5.5 "External Triggers (Logic Probes)"**.

11.3.3 Clock

Enter the runtime clock (instruction) speed on this tab. This does not set the speed, but informs the emulator of its value for runtime watch, data capture and trace.

Note: Clock switching is available for data capture and trace, but you must set the clock correctly or you may see issues. Enter the fastest instruction speed you will be using on this tab.

TABLE 11-3: CLOCK OPTION CATEGORY

Use FRC in debug mode (dsPIC33F and PIC24F/H devices only)	When debugging, use the device fast internal RC (FRC) for clocking instead of the oscillator specified for the application. This is useful when the application clock is slow. Checking this checkbox will let the application run at the slow speed but debug at the faster FRC speed. Reprogram after changing this setting. **Note:** Peripherals that are not frozen will operate at the FRC speed while debugging.
Target run-time instruction speed	Enter a value for the "Speed unit" selected. **Example 1:** For a PIC24 MCU and a target clock oscillator at 32 MHz (HS), instruction speed = 32 MHz/2 = 16 MIPS. **Example 2:** For a PIC18F8722 MCU and a target clock oscillator at 10 MHz (HS) making use of the PLL (x4 = 40 MHz), instruction speed = 40 MHz/4 = 10 MIPS.
Instruction speed units	Select either: KIPS – Thousands (10^3) of instructions per second MIPS – Millions (10^6) of instructions per second

11.3.4 Freeze Peripherals

Select peripherals to freeze or not freeze on program halt.

TABLE 11-4: FREEZE PERIPHERALS OPTION CATEGORY

Freeze Peripherals	Freeze all peripherals on halt. This options applies to PIC12/16/18 MCUs.
Peripheral	Freeze this peripheral on halt. This options applies to 16- and 32-bit MCUs.

PIC12/16/18 MCU Devices

To freeze/unfreeze all device peripherals on halt, check/uncheck the "Freeze on Halt" checkbox. If this does not halt your desired peripheral, be aware that some peripherals have no freeze on halt capability and cannot be controlled by the emulator.

dsPIC30F/33F, PIC24F/H and PIC32 Devices

For peripherals in the list "Peripherals to Freeze on Halt", check to freeze that peripheral on a halt. Uncheck the peripheral to let it run while the program is halted. If you do not see a peripheral on the list, check "All Other Peripherals". If this does not halt your desired peripheral, be aware that some peripherals have no freeze on halt capability and cannot be controlled by the emulator.

To select all peripherals, including "All Other Peripherals", click **Check All**. To deselect all peripherals, including "All Other Peripherals", click **Uncheck All**.

11.3.5 Debug Options

Use software breakpoints, if available for the project device.

TABLE 11-5: DEBUG OPTIONS OPTION CATEGORY

Use Software Breakpoints	Check to use software breakpoints. Uncheck to use hardware breakpoints. See discussion below to determine which type is best for your application.

TABLE 11-6: SOFTWARE VS HARDWARE BREAKPOINTS

Features	Software Breakpoints	Hardware Breakpoints
Number of breakpoints	unlimited	limited
Breakpoints are written to	program memory	debug registers
Time to set breakpoints	oscillator speed dependent – can take minutes	minimal
Skidding	no	yes
Note: Using software breakpoints for debug impacts device endurance. Therefore, it is recommended that devices used in this manner not be used as production parts.		

11.3.6 Program Options

Choose to erase all memory before programming or to merge code.

TABLE 11-7: PROGRAM OPTIONS OPTION CATEGORY

Erase All Before Program	Check to erase all memory before programming begins. Unless programming new or already erased devices, it is important to have this box checked. If not checked, the device is not erased and program code will be merged with the code already in the device.
Enable Low Voltage Programming	*For Programmer Settings only, PIC12F/16F1xxx devices:* • For the LVP configuration bit set to "Low-voltage programming enabled", you may program in either high-voltage (default) or low-voltage (enabled here.) • For the LVP configuration bit set to "High-voltage on MCLR/Vpp must be used for programming", you may only program in high-voltage.

11.3.7 Firmware

Select and load emulator firmware. MPLAB X IDE automatically downloads the correct firmware for your project. Only change this setting if you are having issues.

TABLE 11-8: FIRMWARE OPTION CATEGORY

Use Latest Firmware	Check to use the latest firmware. Uncheck to select the firmware version below.
Firmware File	Click in the right-hand text box to search for a firmware file (`.jam`) to associate with the emulator: `<install path>MPLABX/mplab_ide/ mplablibs/modules/ext/REALICE.jar`

11.3.8 Memories to Program

Select the memories to be programmed into the target.

TABLE 11-9: MEMORIES TO PROGRAM OPTION CATEGORY

Auto select memories and ranges	**Allow REAL ICE to Select Memories** - The emulator uses your selected device and default settings to determine what to program. **Manually select memories and ranges** - You select the type and range of memory to program (see below.)
Memory	Check to program *Memory*, where *Memory* is the type of memory. Types include: EEPROM, ID, Boot Flash, Auxilliary.
Program Memory	Check to program the target program memory range specified below.
Program Memory Start (hex) Program Memory End (hex)	The starting and ending hex address range in program memory for programming, reading, or verification. If you receive a programming error due to an incorrect end address, correct the end address and program again. **Note:** The address range does not apply to the Erase function. The Erase function will erase all data on the device.
Preserve Program Memory	Check to not program the target program memory range specified below.
Preserve Program Memory Start (hex) Preserve Program Memory End (hex)	The starting and ending hex address range in target program memory to preserve when programming, reading, or verifying. This memory is read from the target and overlayed with existing MPLAB X IDE memory.
Preserve *Memory*	Check to not erase *Memory* when programming, where *Memory* is the type of memory. Types include: EEPROM, ID, Boot Flash, Auxilliary.

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11.4 EMULATOR WINDOWS & DIALOGS

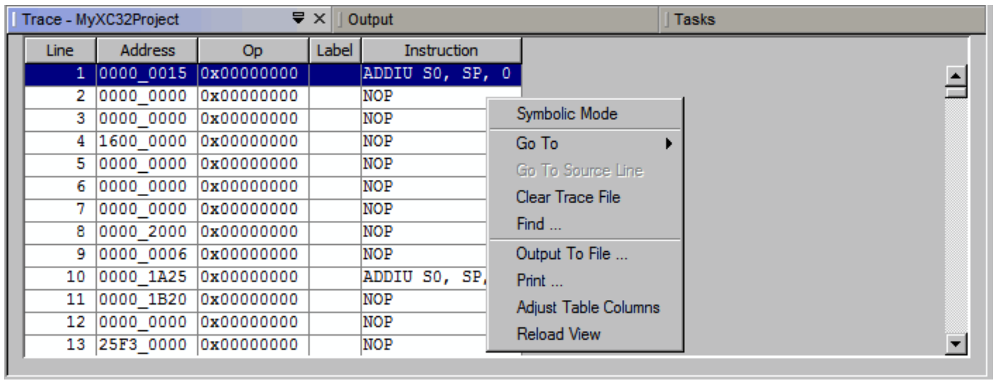
The following windows and dialogs are used specifically for the emulator and/or other debug tools.

- Trace Window and Releated Dialogs
- Application In/Out Window and Related Dialogs
- PC Sampling Window and Related Dialogs

11.4.1 Trace Window and Releated Dialogs

The trace window displays the results of a trace. This window is available for the emulator and the simulator.

FIGURE 11-1: TRACE WINDOW



Line	Address	Op	Label	Instruction
1	0000_0015	0x00000000		ADDIU S0, SP, 0
2	0000_0000	0x00000000		NOP
3	0000_0000	0x00000000		NOP
4	1600_0000	0x00000000		NOP
5	0000_0000	0x00000000		NOP
6	0000_0000	0x00000000		NOP
7	0000_0000	0x00000000		NOP
8	0000_2000	0x00000000		NOP
9	0000_0006	0x00000000		NOP
10	0000_1A25	0x00000000		ADDIU S0, SP,
11	0000_1B20	0x00000000		NOP
12	0000_0000	0x00000000		NOP
13	25F3_0000	0x00000000		NOP

Right clicking in a column will pop up a menu with the following functions. For more on these functions, see the MPLAB X IDE User's Guide (DS52027), "MPLAB X IDE Windows and Dialogs", "Trace Window".

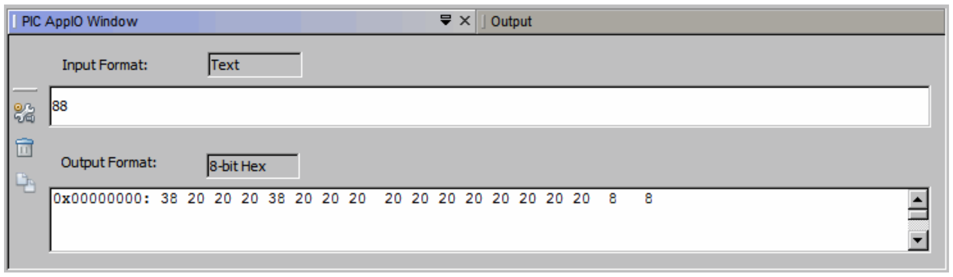
For more on using trace, see:

- **Section 6.3 "Instrumented Trace"** – 8- and 16-bit Devices
- **Section 7.3 "PIC32 Instruction Trace"** – 32-bit Devices

11.4.2 Application In/Out Window and Related Dialogs

The Application In/Out window supports the App IO function where runtime control information can be sent to an application through MPLAB IDE (APPIN) and status information can be sent by the application to MPLAB IDE (APPOUT).

FIGURE 11-2: APP IN/OUT WINDOW



88

```
0x00000000: 38 20 20 20 38 20 20 20  20 20 20 20 20 20 20 20  8   8
```

Other actions are available from the buttons. Right clicking in the Ouput text box will pop up a menu with the same functions.

TABLE 11-10: APP IN/OUT WINDOW BUTTONS

Button	Description
Properties	Open the Set App IO Properties dialog. Set the format of the input and output: Text, 8-bit Hex, 16-bit Hex, or 32-bit Hex. Enable/disable data capture. Browse to a location to save the output to a file.
Clear App IO Output	Clear the output content from the Output text box.
Copy App IO Output to Output View	Copy the Output text box content to the Output window.

For more on using this window and its related dialogs, see:

- **Section 6.5 "Application In/Out"** – 8- and 16-bit Devices
- **Section 7.6 "Application In/Out"** – 32-bit Devices

11.4.3 PC Sampling Window and Related Dialogs

Program Counter (PC) sampling is a method of determining the amount of time spent in each application function for use in code optimization. The PC Sampling window will show the function name, sample count for that function, percentage sample count is of the total samples, and a bar graph of the count.

For more on PC Sampling and Profiling, see:

- **Section 6.4 "PC Sampling"** – 8- and 16-bit Devices
- **Section 7.5 "PC Profiling"** – 32-bit Devices

Chapter 12. Hardware Specification

12.1 INTRODUCTION

The hardware and electrical specifications of the basic MPLAB REAL ICE in-circuit emulator system are detailed.

12.2 HIGHLIGHTS

This chapter discusses:

- USB Port/Power
- Emulator Pod
- Standard Communication Hardware
- Loop-Back Test Board
- Target Board Considerations

12.3 USB PORT/POWER

The MPLAB REAL ICE in-circuit emulator is connected to the host PC via a Universal Serial Bus (USB) port, version 2.0 compliant. The USB connector is located on the back of the pod.

The system is capable of reloading the firmware via the USB interface.

System power is derived from the USB interface. The emulator is classified as a high power system per the USB specification, and requires 300 mA of power from the USB to function in all operational modes (emulator/programmer).

Note: The MPLAB REAL ICE in-circuit emulator is powered through its USB connection. The target board is powered from its own supply. The emulator cannot provide power to the target board.

Cable Length – The PC-to-emulator cable length for proper operation has been tested for each driver board and is shipped in the emulator kit.

Powered Hubs – If you are going to use a USB hub, make sure it is powered. Also, USB ports on PC keyboards do not have enough power for the emulator to operate.

12.4 EMULATOR POD

The emulator pod (DV244005) consists of a main board enclosed in the casing with a port for either of two driver boards (for standard or high-speed communication with a target). On the emulator encloser are push buttons, indicator lights (LEDs) and a logic probe connector interface.

12.4.1 Main Board

This component has an interface processor (dsPIC DSC), a USB 2.0 interface capable of USB speeds of 480 Mb/sec, a Field Programmable Gate Array (FPGA) for general system control and increased communication throughput, an SRAM for holding the program code image for programming into the emulation device on-board Flash, the external trigger logic, user interface push buttons and LED indicators.

The MPLAB REAL ICE in-circuit emulator system supports two types of interfaces to the target processor. They consist of the standard driver board and an optional high-speed driver board. These boards are inserted into the emulator pod via a card guide.

Durability/insertion life cycle of the card guide: 10,000 cycles

12.4.2 Push Buttons

The push buttons have the following significance.

Push Button	Related LED	Description
Reset	Status	Push to Reset the device.
Function	Status	Halt – When running, push to put the emulator in the Break or halted condition.

12.4.3 Indicator Lights (LEDs)

The indicator lights have the following significance.

TABLE 12-1: LED INDICATORS

Type	Color	Condition	Description
Active	Blue	Lit	Power has been applied or target has been connected.
Status	Green	Lit	The emulator is operating normally – standby.
	Red	Lit	An operation has failed.
		Blinking	USB Comm error or driver not installed.
	Orange	Lit	The emulator is busy.

12.4.4 Logic Probe/External Trigger Interface

Probes can be connected to the 14-pin header on the side of the unit for processing external signals that are used for triggering external equipment. This header contains 8 input/output connections that are user selectable as inputs or outputs with logic levels that are proportional to the target operating voltage.

The outputs can be used for triggering an external logic analyzer or oscilloscope to allow the developer to capture events of interest based on trigger criteria set within MPLAB IDE. The external trigger is a pulse of approximately 1.5 μs. This value is not determinsitic and the external tool should be triggered on a pulse edge.

The inputs are part of a trigger bus.

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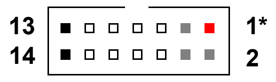
FIGURE 12-1: LOGIC PROBE PINOUT ON EMULATOR



Logic probes may be attached to this connector to give the functionality described in Table 12-2. The probes are color coded and labeled for easy identification.

TABLE 12-2: LOGIC PROBE PINOUT DESCRIPTION

Pin	I/O	Name	Function	Color
1	O	VDD(1)	VDD reference	Red
2	O	NC	No connection	Gray
3	O	NC	No connection	Gray
4	I	TCLK	External synchronous clock	Gray
5	I/O	EXT7(2)	External input/output bit 7	White
6	I/O	EXT6	External input/output bit 6	White
7	I/O	EXT5	External input/output bit 5	White
8	I/O	EXT4	External input/output bit 4	White
9	I/O	EXT3	External input/output bit 3	White
10	I/O	EXT2	External input/output bit 2	White
11	I/O	EXT1	External input/output bit 1	White
12	I/O	EXT0(2)	External input/output bit 0	White
13	Gnd	GND	System Ground	Black
14	Gnd	GND	System Ground	Black

Note 1: Do not connect VDD to the target.

Note 2: EXT0 and EXT7 are temporarily used during loop-back test. Ensure that they are not connected together.

The electrical specifications for logic probes are listed in Table 12-3.

TABLE 12-3: LOGIC PROBE ELECTRICAL SPECIFICATIONS

Logic Inputs	VIH = VDD x 0.7V (min)			
	VIL = VDD x 0.3V (max)			
Logic Outputs	VDD = 5V	VDD = 3V	VDD = 2.3V	VDD = 1.65V
	VOH = 3.8V min	VOH = 2.4V min	VOH = 1.9V min	VOH = 1.2V min
	VOL = 0.55V max	VOL = 0.55V max	VOL = 0.3V max	VOL = 0.45V max

12.5 STANDARD COMMUNICATION HARDWARE

For standard emulator communication with a target (**Section 3.4.1 "Standard Communication"**), use the standard driver board.

To use this type of communication with a debug header, you may need a device-specific Processor Pak, which includes an 8-pin connector debug header containing the desired ICE/ICD device and a standard adapter board (8-pin to 6-pin connection).

Note:	Older debug headers used a 6-pin (RJ-11) connector instead of an 8-pin connector, so these headers may be connected directly to the emulator.

For more on available debug headers, see the "*Debug Header Specification"* in "Recommended Reading".

12.5.1 Standard Driver Board

The standard driver board is the main interface to the target processor. It contains the connections to the high voltage (VPP), VDD sense lines, and clock and data connections required for programming and connecting with the target devices.

The VPP high-voltage lines can produce a variable voltage that can swing from 14 to 0 volts to satisfy the voltage requirements for the specific emulation processor.

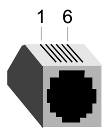
The VDD sense connection draws very little current from the target processor. The actual power comes from the MPLAB REAL ICE in-circuit emulation system as the VDD sense line is used as a reference only to track the target voltage. The VDD connection is isolated with an optical switch.

The clock and data connections are interfaces with the following characteristics:

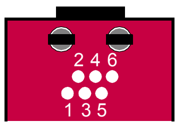
- Clock and data signals are in high-impedance mode (even when no power is applied to the MPLAB REAL ICE in-circuit emulator system)
- Clock and data signals are protected from high voltages caused by faulty targets systems, or improper connections
- Clock and data signals are protected from high current caused from electrical shorts in faulty target systems

Note:	When using the standard driver board, the rate for real-time streaming data and tracing is limited to 15 MIPS.

FIGURE 12-2: MODULAR CONNECTOR PINOUT OF STANDARD DRIVER BOARD



Front view of Modular Connector on Std Driver Board



Bottom view of Modular Connector Pinout on Std Driver Board

Modular Connector Pin	Microcontroller Pin
1	Not Used
2	RB6
3	RB7
4	Ground
5	VDD Target
6	VPP

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12.5.2 Modular Cable and Connector

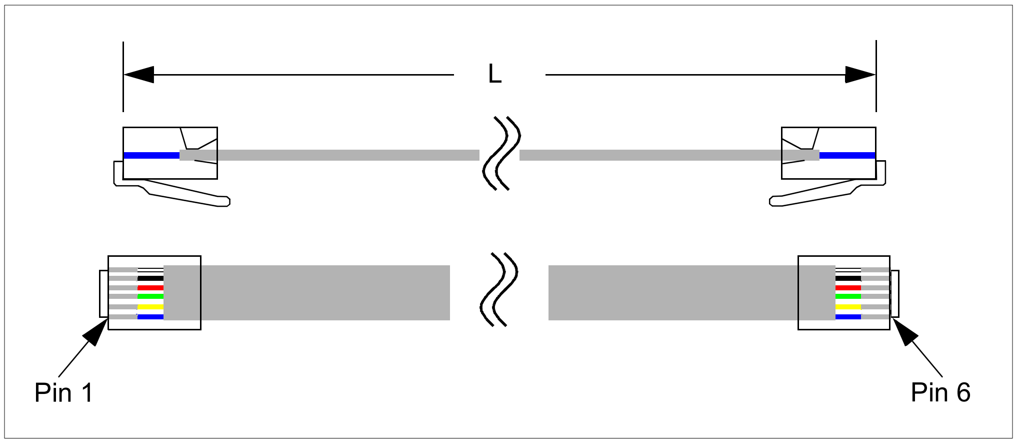
For standard communications, a modular cable connects the emulator and the target application. The specifications for this cable and its connectors are listed below.

12.5.2.1 MODULAR CABLE SPECIFICATION

- Manufacturer, Part Number – Microchip Technology, 07-00024

The length for this cable (L) is 6 inches. If you require a longer cable, consider purchasing the Performance Pak. For details see **Section 13.3 "High-Speed/LVDS Communication Hardware (Performance Pak)"**. It is not recommended that you use a modular cable shorter than 6 inches or you may experience communication problems.

FIGURE 12-3: MODULAR CABLE



12.5.2.2 MODULAR PLUG SPECIFICATION

- Manufacturer, Part Number – AMP Incorporated, 5-554710-3
- Distributor, Part Number – Digikey, A9117ND

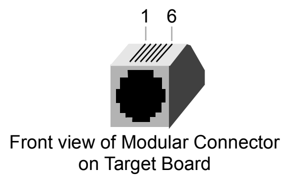
12.5.2.3 MODULAR CONNECTOR SPECIFICATION

- Manufacturer, Part Number – AMP Incorporated, 555165-1
- Distributor, Part Number – Digikey, A9031ND

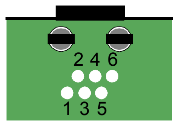
The following table shows how the modular connector pins on an application correspond to the microcontroller pins. This configuration provides full ICD functionality.

FIGURE 12-4: MODULAR CONNECTOR PINOUT OF TARGET BOARD

Modular Connector Pin	Microcontroller Pin
6	Not Used
5	RB6
4	RB7
3	Ground
2	VDD Target
1	VPP



Front view of Modular Connector on Target Board



Bottom view of Modular Connector Pinout on Target Board

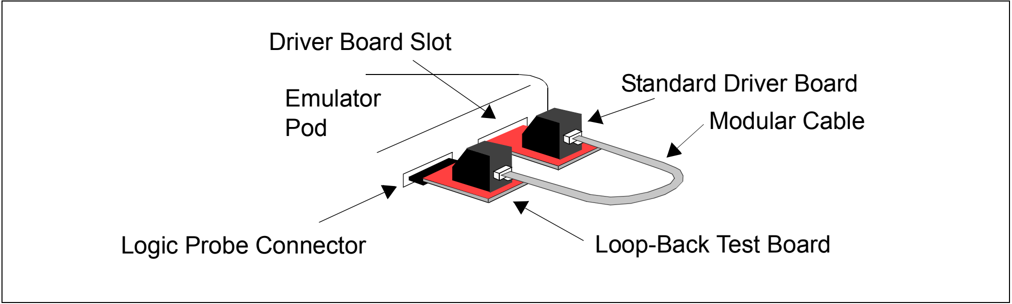
12.6 LOOP-BACK TEST BOARD

This board (included with DV244005) can be used to verify that the emulator is functioning properly. To use this board:

1. Disconnect the emulator from the target and the PC.
2. Insert the standard driver board if it is not already installed.
3. Plug the loopback test board into the pod's logic probe connector.
4. Connect the loop-back test board to the standard driver board using the modular cable.
5. Reconnect the emulator to the computer.
6. Launch MPLAB X IDE. Ensure that all existing projects are closed.
7. Select *Debug>Run Debugger/Programmer Self Test*, then, select the specific "REAL ICE" you want to test and click **OK**.
8. Ensure the loopback test board and cable are connected and click **Yes** to continue.
9. View the self test results in the emulator's Output window.
10. After the emulator passes the self test, disconnect the loopback test board from the emulator.

MPLAB IDE will detect and run the complete loop-back test and give you a status (PASS/FAIL). The loop-back test board detection works by applying a short pulse on EXT0 and detecting it on EXT7 on the logic probe connector (**Section 12.4.4 "Logic Probe/External Trigger Interface"**). Once the board is detected, the emulator applies stimulus to the clock/data and VPP lines and reads the sequence back from the logic probe connector interface, thus confirming proper signals levels and connectivity down to the connector interfaces.

FIGURE 12-5: LOOP-BACK TEST BOARD CONNECTIONS



12.7 TARGET BOARD CONSIDERATIONS

The target board should be powered according to the requirements of the selected device (1.6V-5.5V) and the application.

Note: The emulator cannot power the target.

The emulator does sense target power. There is a 10 KΩ load on VDD_TGT.

Depending on the type of emulator-to-target communications used, there will be some considerations for target board circuitry:

- **Section 3.5.3 "Target Connection Circuitry"**
- **Section 3.5.4 "Circuits That Will Prevent the Emulator From Functioning"**

Additional design considerations may be found in "*Development Tools Design Advisory*" (DS51764).

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Chapter 13. Emulator Accessories

13.1 INTRODUCTION

The MPLAB REAL ICE in-circuit emulator has several different accessories to aid in different debugging conditions.

13.2 HIGHLIGHTS

This chapter discusses:

- High-Speed/LVDS Communication Hardware (Performance Pak)
- MPLAB REAL ICE Isolator Unit (Opto-Isolator)
- MPLAB REAL ICE JTAG Adaptor Board
- Other Accessories

13.3 HIGH-SPEED/LVDS COMMUNICATION HARDWARE (PERFORMANCE PAK)

For high-speed/LVDS communication with a target (**Section 3.4.2 "High-Speed/LVDS Communication (Performance Pak)"**), use the Performance Pak (AC244002).

- High-Speed Driver Board
- High-Speed Receiver Board
- LVDS Cables and Target Pinout

To use this type of communication with a debug header, you will need a device-specific Processor Pak, which includes an 8-pin connector debug header containing the desired ICE/ICD device and a standard adapter board (8-pin to 6-pin connection.)

Note: You will not need the standard adapter board for high-speed communications. Instead, you will plug the 8-pin connector end of the high-speed receiver board directly into the 8-pin connector of the debug header.

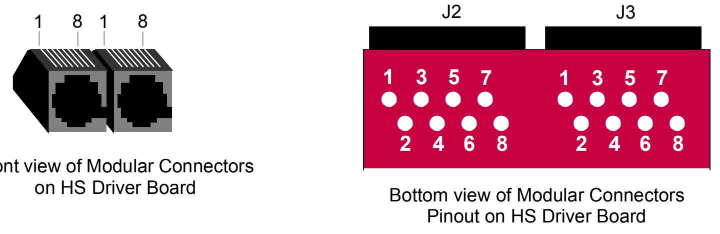
For more on available debug headers, see the **"Processor Extension Pak and Header Specification (DS51292)"** in **"Recommended Reading"**.

13.3.1 High-Speed Driver Board

The high-speed driver board consists of two separate multipoint LVDS (Low Voltage Differential Signaling) transmitters and receivers for clock and data. Multipoint LVDS requires 100 ohm terminations at each driver output and receiver input, per the standard, and multipoint configurations type 2 receivers are used, as these are intended for control signals or where fail-safe provisions are needed. Even though the standard allows for any combination of drivers, receivers and/or transceivers of up to 32 on the line, only two will be used. The driver board has a port expansion which is controlled by an I^{2}C™ interface for sending/receiving status information to/from the emulator. The high-speed driver board assembly is inserted into the emulator pod via the card guide.

Note: The driver board can support data rates up to 100M/bits. However, due to device speeds, the acutal rate is up to 20M/bits.

FIGURE 13-1: MODULAR CONNECTORS PINOUT OF HIGH-SPEED DRIVER BOARD


1
8
1
8
Front view of Modular Connectors on HS Driver Board
J2
J3
1 3 5 7
2 4 6 8
1 3 5 7
2 4 6 8
Bottom view of Modular Connectors Pinout on HS Driver Board

J2 Pinout

Pin	Name	Function	Pin	Name	Function
1	LVD+	LV Std Data +	5	GND	Ground
2	LVD–	LV Std Data –	6	LVC–	LV Std Clock –
3	LVC+	LV Std Clock +	7	VDD_TGT	VDD on target
4	LV_VDD	Power	8	VPP_TGT	VPP on target

J3 Pinout

Pin	Name	Function	Pin	Name	Function
1	DATAEN+	Std Data Enable +	5	USPID–	*Serial Data –
2	DATAEN–	Std Data Enable –	6	CLKEN–	Std Clock Enable –
3	CLKEN+	Std Clock Enable +	7	USPIC+	*Serial Clock +
4	USPID+	*Serial Data +	8	USPIC–	*Serial Clock –

* Optional - see **Section 3.6.2 "SPI Trace Connections (High-Speed/LVDS Connection)"**.

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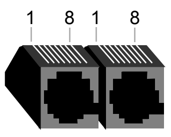
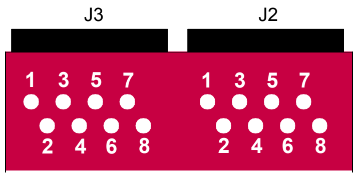
13.3.2 High-Speed Receiver Board

A high-speed receiver board assembly is also required when using LVDS connectivity. This board is a counterpart to the high-speed driver board assembly in the pod. When the driver is active on the pod, the receiver is active in the receiver board. Alternatively, when the driver is active on the receiver board, the corresponding receiver is active in the driver board, providing transmitting and receiving capability at both ends. The receiver board contains an 8-pin, 0.100 inch centers header, and is used to connect to the target board or a debug header. The receiver board circuitry may be implemented on the target system to avoid using the receiver board.

FIGURE 13-2: MODULAR CONNECTORS PINOUT OF HIGH-SPEED RECEIVER BOARD



Front view of Modular Connectors on HS Receiver Board



Bottom view of Modular Connectors Pinout on HS Receiver Board

J3 Pinout

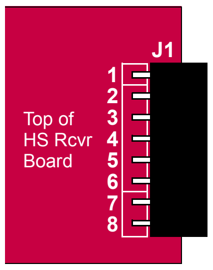
Pin	Name	Function	Pin	Name	Function
1	DATAEN+	Std Data Enable +	5	USPID–	*Serial Data –
2	DATAEN–	Std Data Enable –	6	CLKEN–	Std Clock Enable –
3	CLKEN+	Std Clock Enable +	7	USPIC+	*Serial Clock +
4	USPID+	*Serial Data +	8	USPIC–	*Serial Clock –

* Optional - see **Section 3.6.2 "SPI Trace Connections (High-Speed/LVDS Connection)"**.

J2 Pinout

Pin	Name	Function	Pin	Name	Function
1	LVD+	LV Std Data +	5	GND	Ground
2	LVD–	LV Std Data –	6	LVC–	LV Std Clock –
3	LVC+	LV Std Clock +	7	VDD_TGT	VDD on target
4	LV_VDD	Power	8	VPP_TGT	VPP on target

FIGURE 13-3: 8-PIN HEADER PINOUT OF HIGH-SPEED RECEIVER BOARD



Pin	Name	Function	Pin	Name	Function
1	VPP	Power	5	ICSPCLK	Standard Com Clock
2	VDD_TGT	Power on target	6	AUX	Auxiliary
3	GND	Ground	7	DAT	*Trace Data
4	ICSPDAT	Standard Com Data	8	CLK	*Trace Clock

* Optional – see **Section 3.6.2 "SPI Trace Connections (High-Speed/LVDS Connection)"**.

FIGURE 13-4: RECEIVER BOARD SCHEMATIC – ICSPDAT

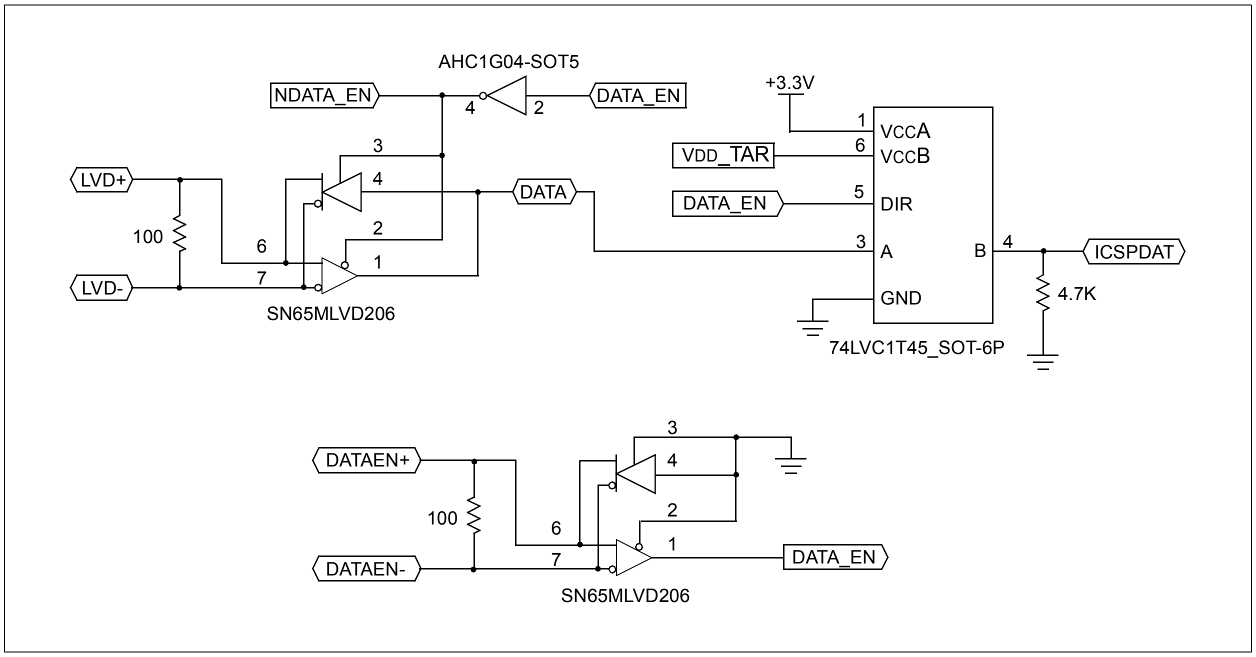


FIGURE 13-5: RECEIVER BOARD SCHEMATIC – ICSPCLK

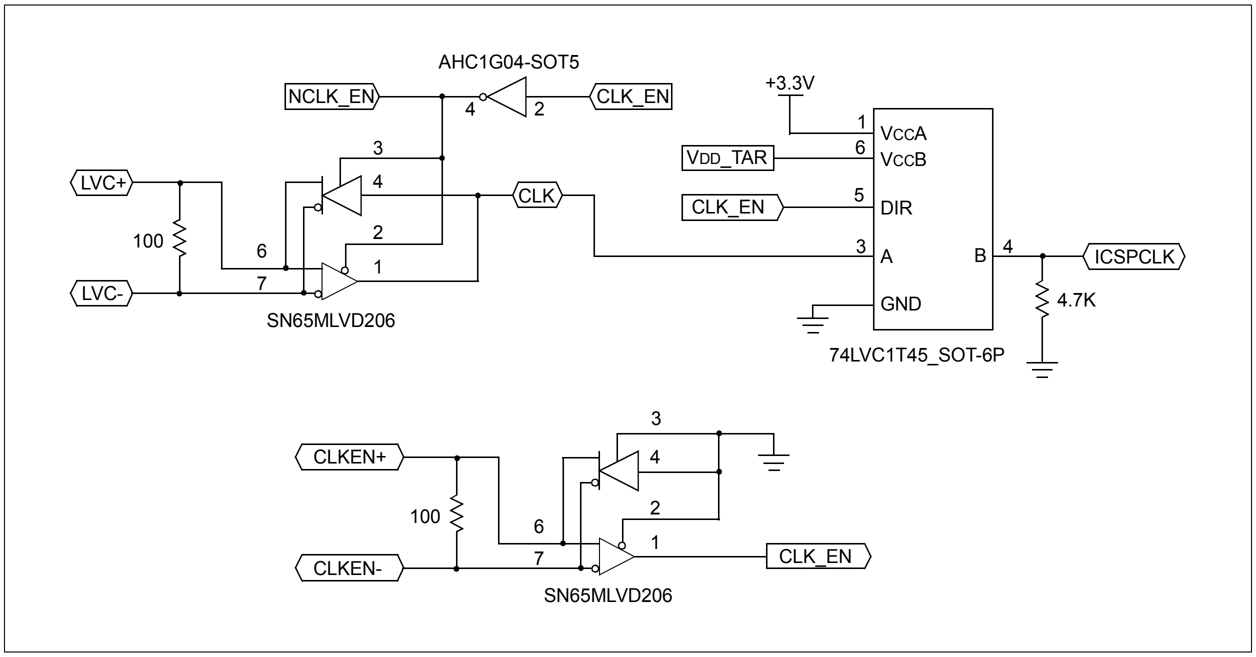


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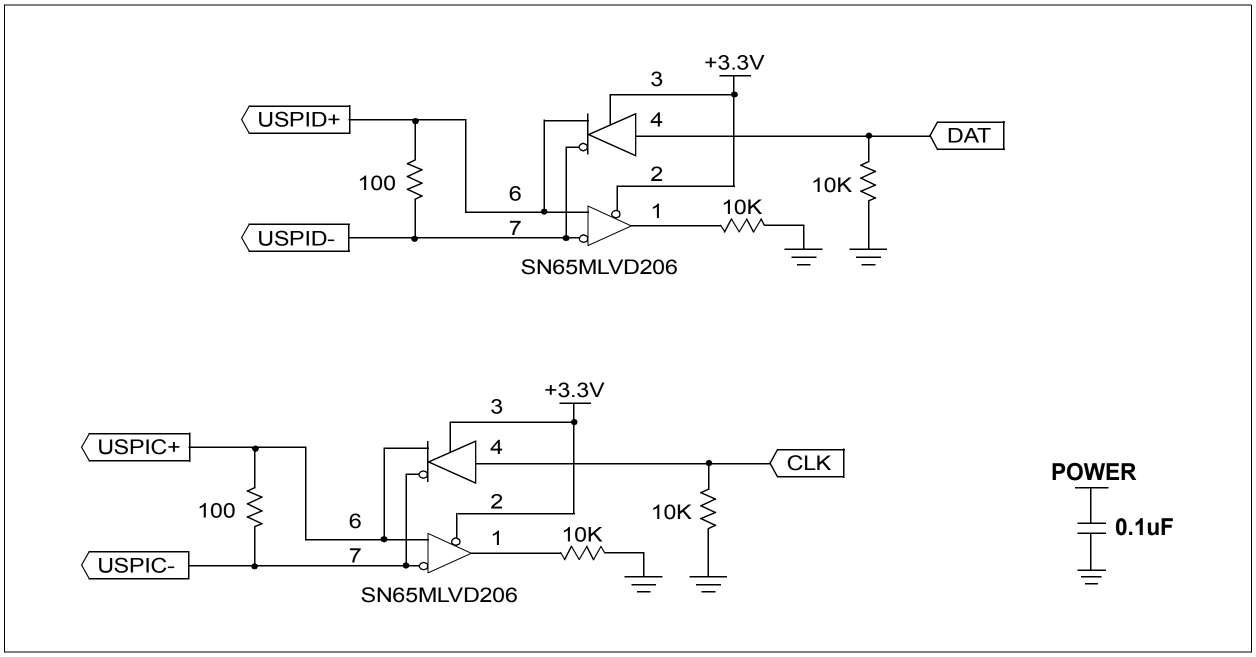
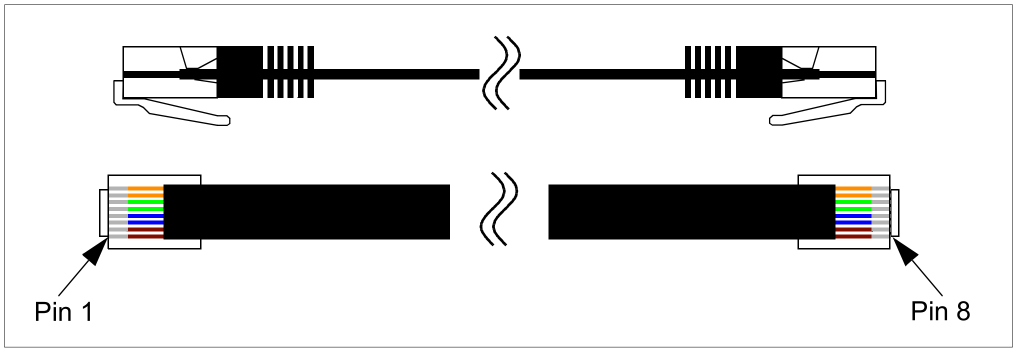
FIGURE 13-6: RECEIVER BOARD SCHEMATIC – DAT & CLK



13.3.3 LVDS Cables and Target Pinout

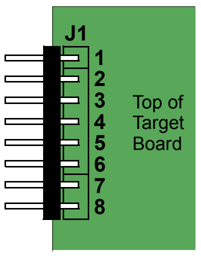
The emulator-to-target cable length for proper operation has been tested for this driver/receiver board combination and is shipped in the Performance Pak. The recommended lengths are 3 feet, with a maximum of 10 feet.

FIGURE 13-7: LVDS CABLE



The target board should have the following 8-pin connection pin-out to plug in to the receiver board.

FIGURE 13-8: 8-PIN HEADER PINOUT AT TARGET



Pin	Name	Function	Pin	Name	Function
1	VPP	Power	5	ICSPCLK	Standard Com Clock
2	VDD_TGT	Power on target	6	AUX	Auxiliary
3	GND	Ground	7	DAT	*Trace Data
4	ICSPDAT	Standard Com Data	8	CLK	*Trace Clock

* Optional – see **Section 3.6.2 "SPI Trace Connections (High-Speed/LVDS Connection)"**.

13.4 MPLAB REAL ICE ISOLATOR UNIT (OPTO-ISOLATOR)

The MPLAB REAL ICE Isolator Unit (AC244005) is a useful accessory to the MPLAB REAL ICE in-circuit emulator system. The isolator enables connectivity for AC line and high voltage applications not referenced to ground. Typically, these are consumer applications such as light dimmers, vacuum cleaners, washing machines, and other types of motor-based systems where the MCU uses a non-isolated power supply

DANGER

Do not remove the board enclosure. Depending on your application, you could be exposing yourself to dangerous voltage levels.

The isolator connects on one end to the Performance Pak high-speed cables. The isolator connects on the other end to the target using an 8-pin, single-line ICSP connector. See Figure 13-9.

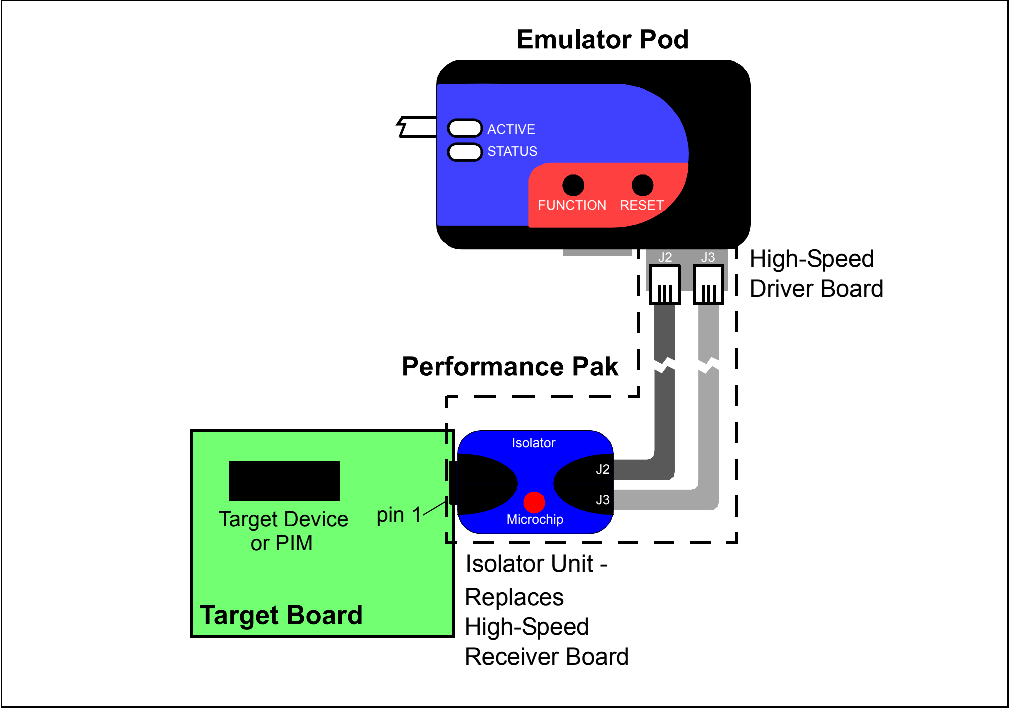
To use this board:

1. Obtain a Performance Pak (AC244002). This board can **only** be used with the Performance Pak.
2. Use this board instead of the high-speed receiver board. See **Section 13.3 “High-Speed/LVDS Communication Hardware (Performance Pak)”** for pin-outs.

Because of the complexity and high dynamic voltage range, the isolator currently provides MCU technology support only for some devices. See online help, “Device and Feature Support” for details.

Note:	Isolation does not support trace.

FIGURE 13-9: HIGH-SPEED EMULATOR SYSTEM USING ISOLATOR UNIT



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13.4.1 Isolator Unit Design

The isolator is a bridge where electrically hot signals are passed through transparently to the emulator. The ICSP interface signals are magnetically or optically isolated providing up to 2.5KV equivalent isolation protection. The isolator is housed in its own enclosure providing an additional measure of safety.

This unit contains the same circuitry as the high-speed receiver board (see **Section 13.3.2 "High-Speed Receiver Board"**) plus isolation circuitry (see the following schematics).

FIGURE 13-10: ISOLATOR UNIT SCHEMATIC - ICSPDAT

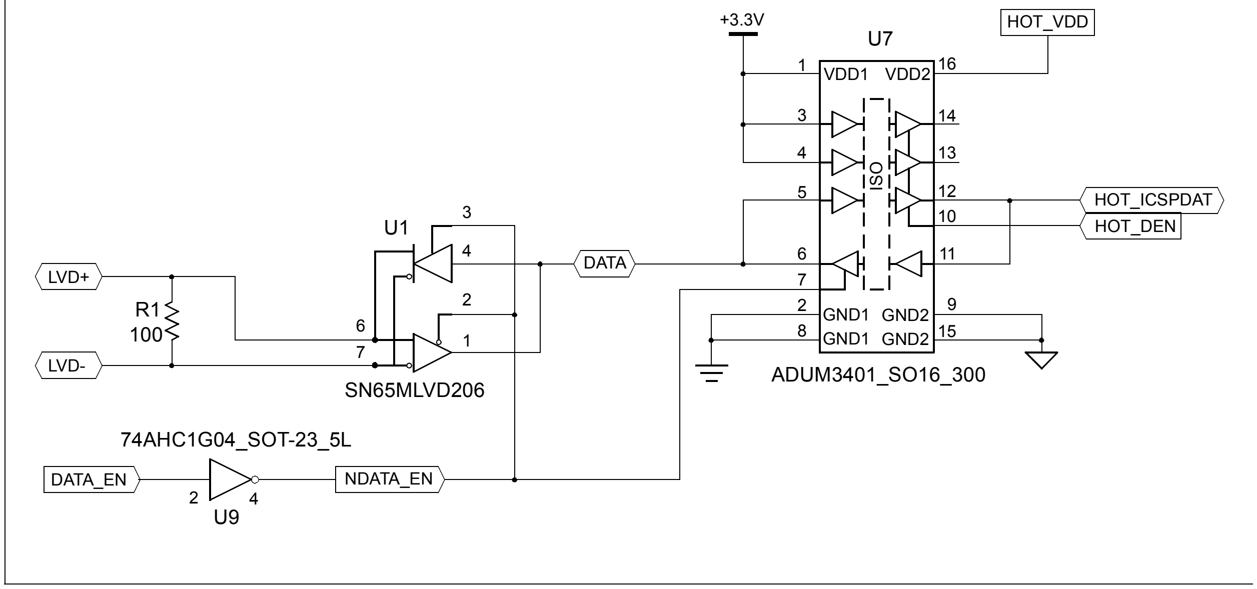

FIGURE 13-11: ISOLATOR UNIT SCHEMATIC - ICSPCLK

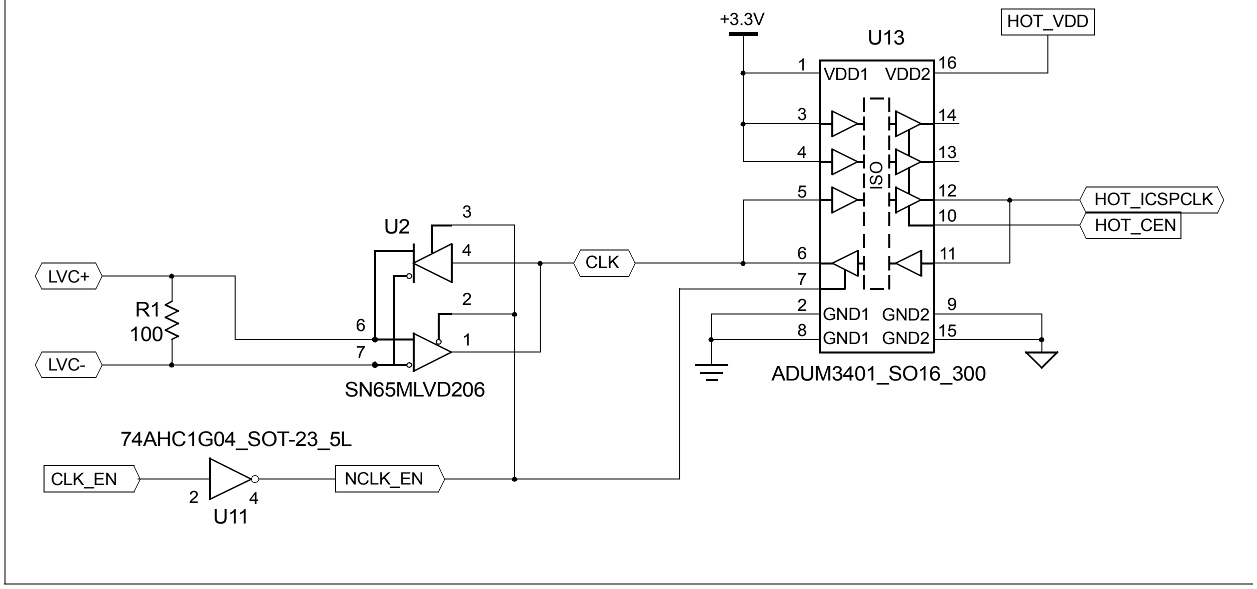

FIGURE 13-12: ISOLATOR UNIT SCHEMATIC - DAT & CLK

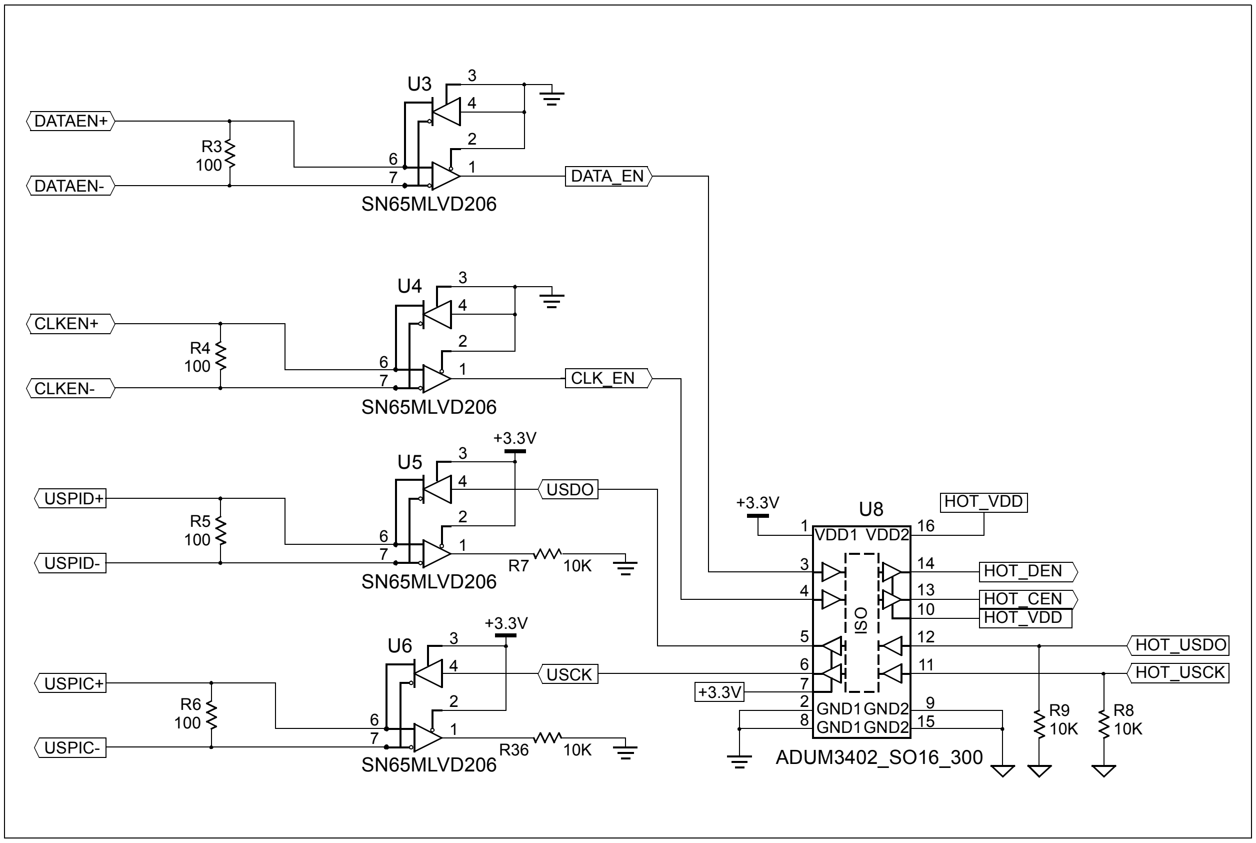

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FIGURE 13-13: ISOLATOR UNIT SCHEMATIC - POWER

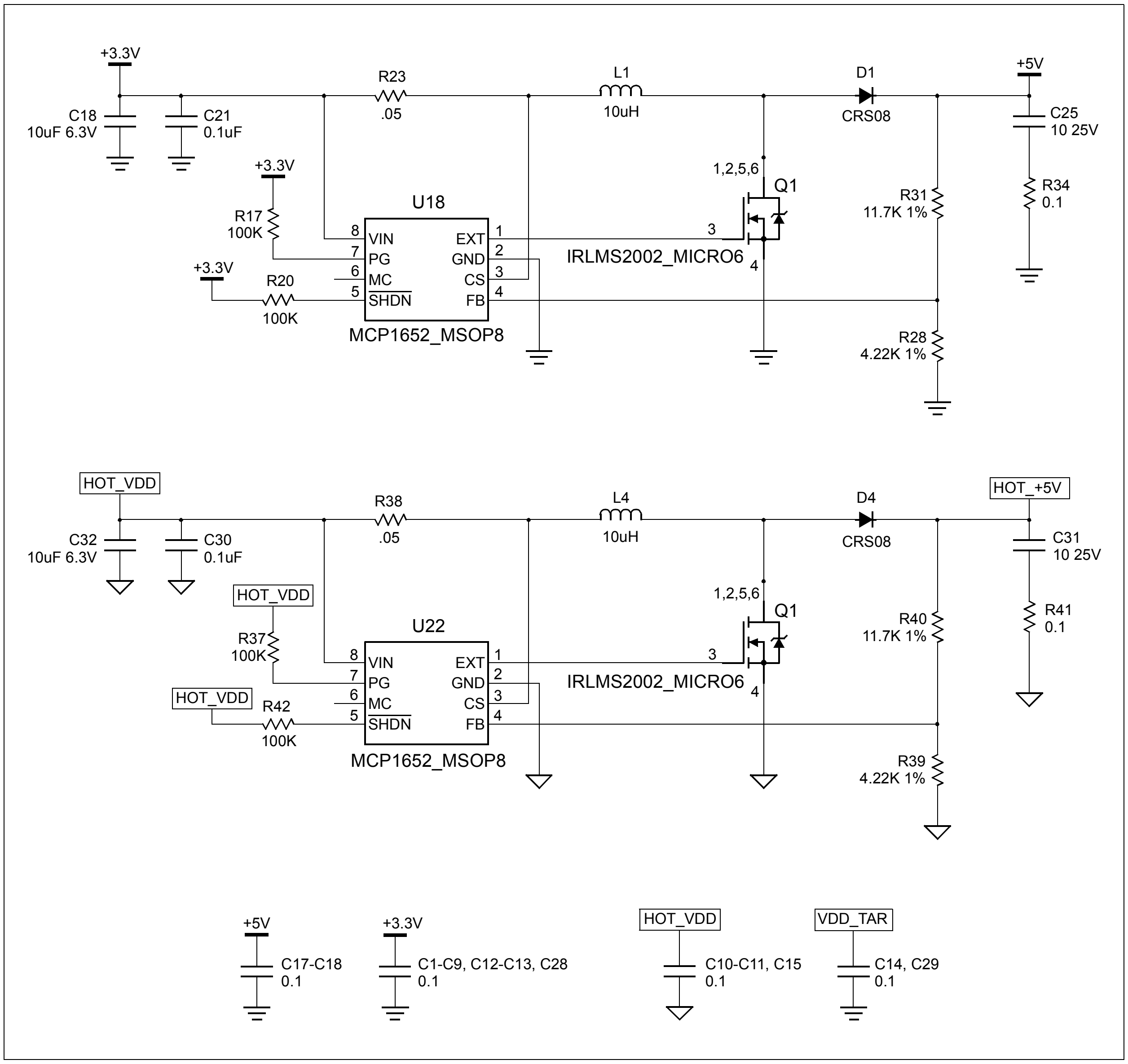
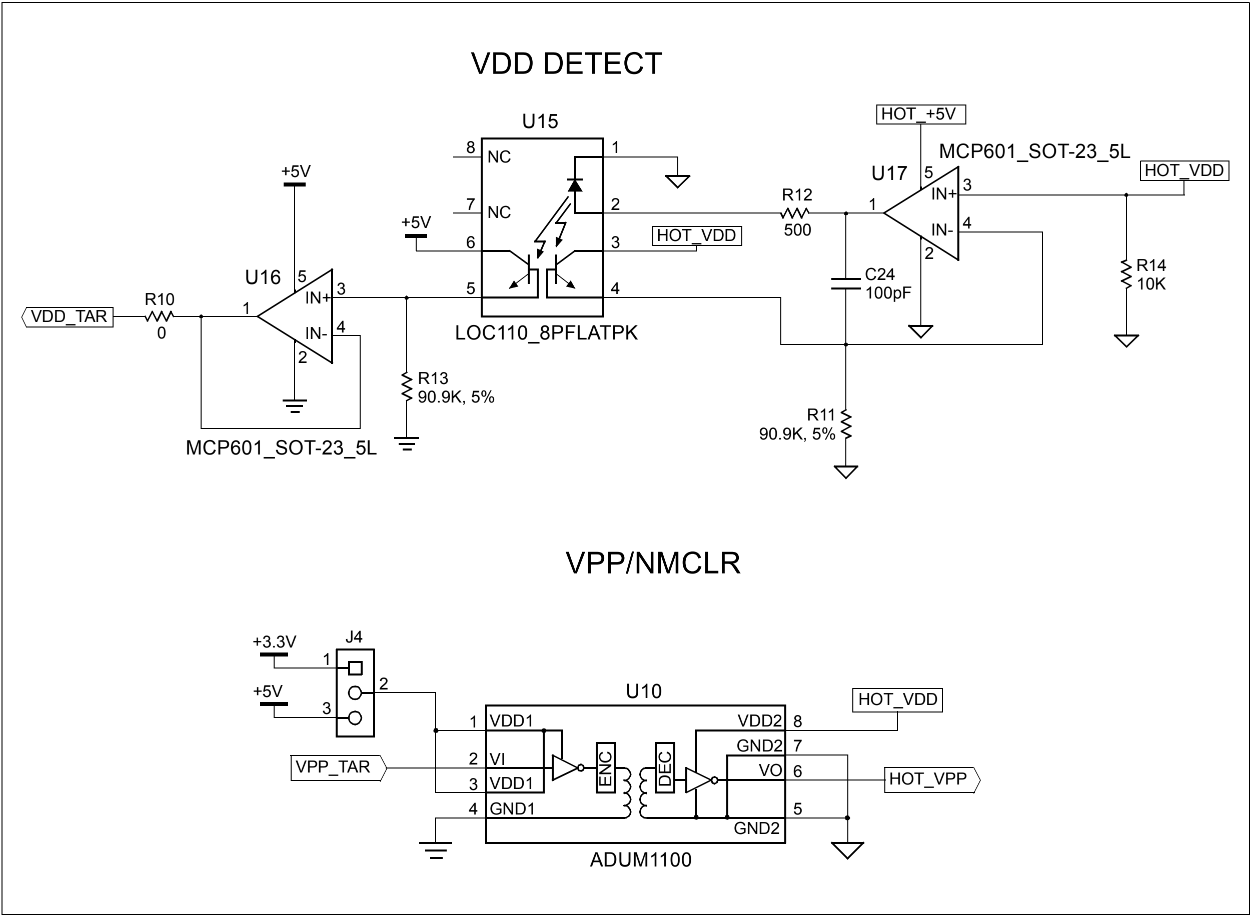


FIGURE 13-14: ISOLATOR UNIT SCHEMATIC - VDD, VPP, MCLR



13.4.2 Third Party Isolator Support

If the MPLAB REAL ICE Isolator Unit does not fit your needs, there are several third parties which provide isolators that work with Microchip devices, such as Keterex. See our website (www.microchip.com) for more details.

13.5 MPLAB REAL ICE JTAG ADAPTOR BOARD

The MPLAB REAL ICE JTAG Adaptor (AC244007) may be used to provide JTAG communication between the MPLAB REAL ICE in-circuit emultor and the target. The kit contains a JTAG adaptor board, ribbon cable, and this insert.

13.5.1 JTAG Support

- The JTAG adaptor board is supported on MPLAB X IDE 1.60 and above.
- The JTAG adaptor board supports all PIC32 devices.
- Only basic debug features are available when using JTAG: Run, Halt, and Single Step. No advanced features are available, i.e., data capture, runtime watches, application in/out, DMA reads/writer, RTDM, and instrumented trace.

13.5.2 Switch from Standard Communications to JTAG

To switch the hardware:

1. While connected to the target using Standard Communications, erase the target device. You may need to add “Erase Device Memory Main Project” to a toolbar using *View>Toolbars>Customize*.

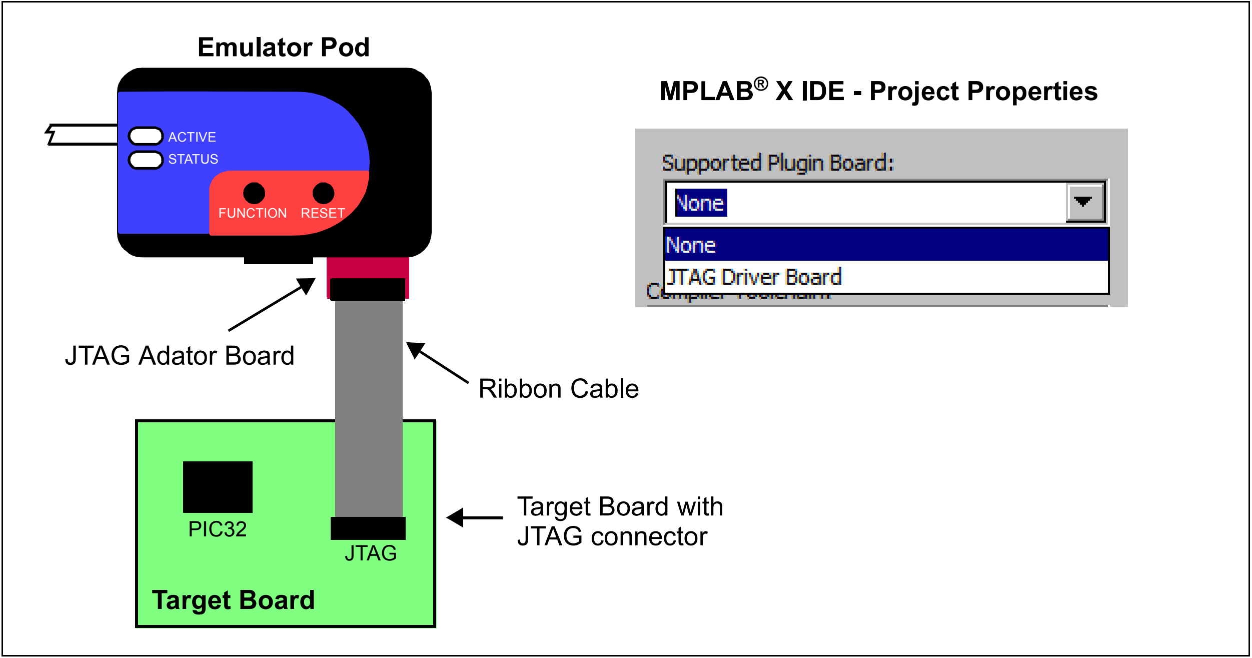
   Note: The target device MUST BE ERASED before switching from Standard Communications to JTAG communications.

2. Power down the target board.
3. Disconnect the Standard Communciations cable from the target, disconnect the USB cable from the emulator, and unplug the Standard Driver Board from the emulator.
4. Connect one end of the ribbon cable to the connector on the JTAG adaptor board (it should plug in only one way) and insert the JTAG adaptor board into the emulator driver board slot.
5. Connect the other end of the ribbon cable to the connector on a target board, such as the Microchip Explorer 16 development board. The plug is keyed to fit only one way.
6. Connect the USB cable to the emulator and power the target board.

To set up MPLAB X IDE for JTAG operation:

1. Select *File>Project Properties*. In the Project Properties dialog, click on your desired configuration, e.g., “Conf: [default]”.
2. Click on the down arrow on the “Supported Plugin Board” dropdown box and select “JTAG Driver Board”. Click **OK** to accept the setup.

FIGURE 13-15: JTAG ADAPTOR BOARD CONNECTIONS AND SET UP



13.5.3 Switch from JTAG to Standard Communications

To switch the hardware:

1. Device memory does not need to be erased in this case.

> **Note:** The target device DOES NOT NEED TO BE ERASED before switching from JTAG communications to Standard Communications.

2. Power down the target board.
3. Disconnect the JTAB ribbon cable from the target, disconnect the USB cable from the emulator, and unplug the JTAB adaptor board from the emulator.
4. Connect one end of the Standard Communications cable to the connector on the Standard driver board and insert the board into the emulator driver board slot.
5. Connect the other end of the modular cable to the connector on a target board, such as the Microchip Explorer 16 development board.
6. Connect the USB cable to the emulator and power the target board.

To set up MPLAB X IDE for Standard Communications operation:

1. Select *File>Project Properties*. In the Project Properties dialog, click on your desired configuration, e.g., "Conf: [default]".
2. Click on the down arrow on the "Supported Plugin Board" dropdown box and select "None". Click **OK** to accept the setup.

13.5.4 Switch between High-Speed Communications and JTAG

Switching between High-Speed (LVDS) Communications and JTAG communications is the same as switching between Standard Communications and JTAG communications.

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FIGURE 13-16: JTAG ADAPTOR BOARD SCHEMATICS - PART 1

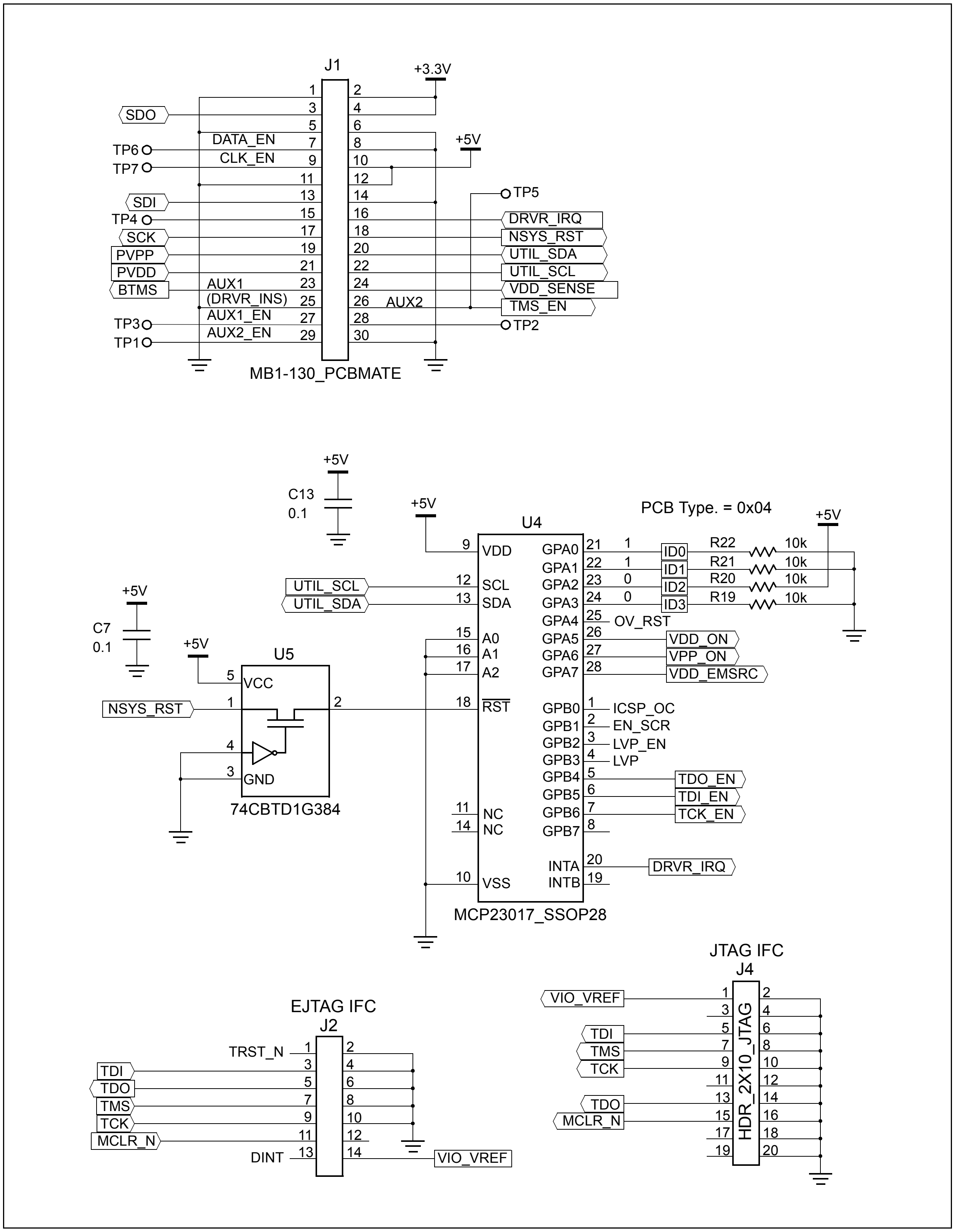

FIGURE 13-17: JTAG ADAPTOR BOARD SCHEMATICS - PART 2

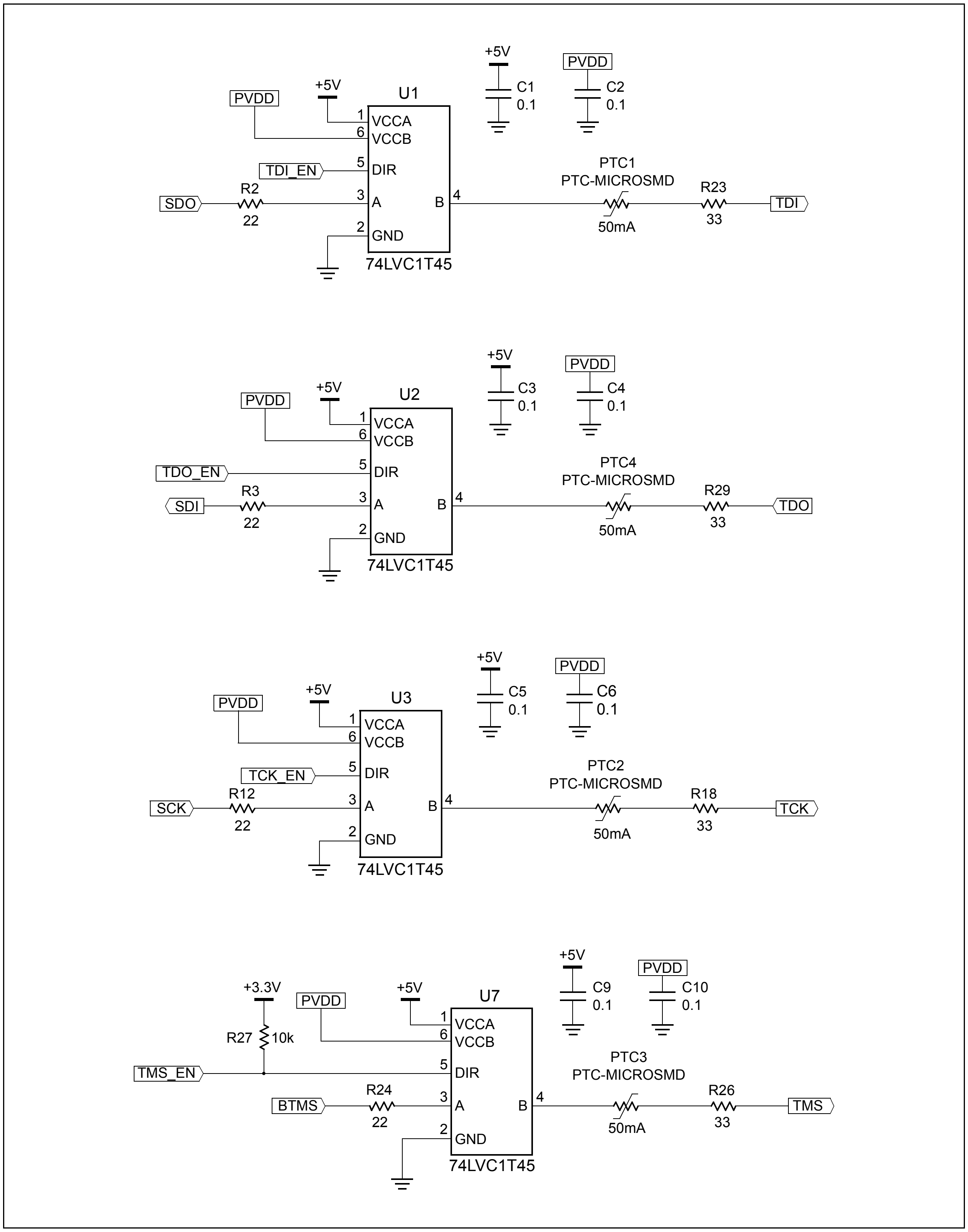

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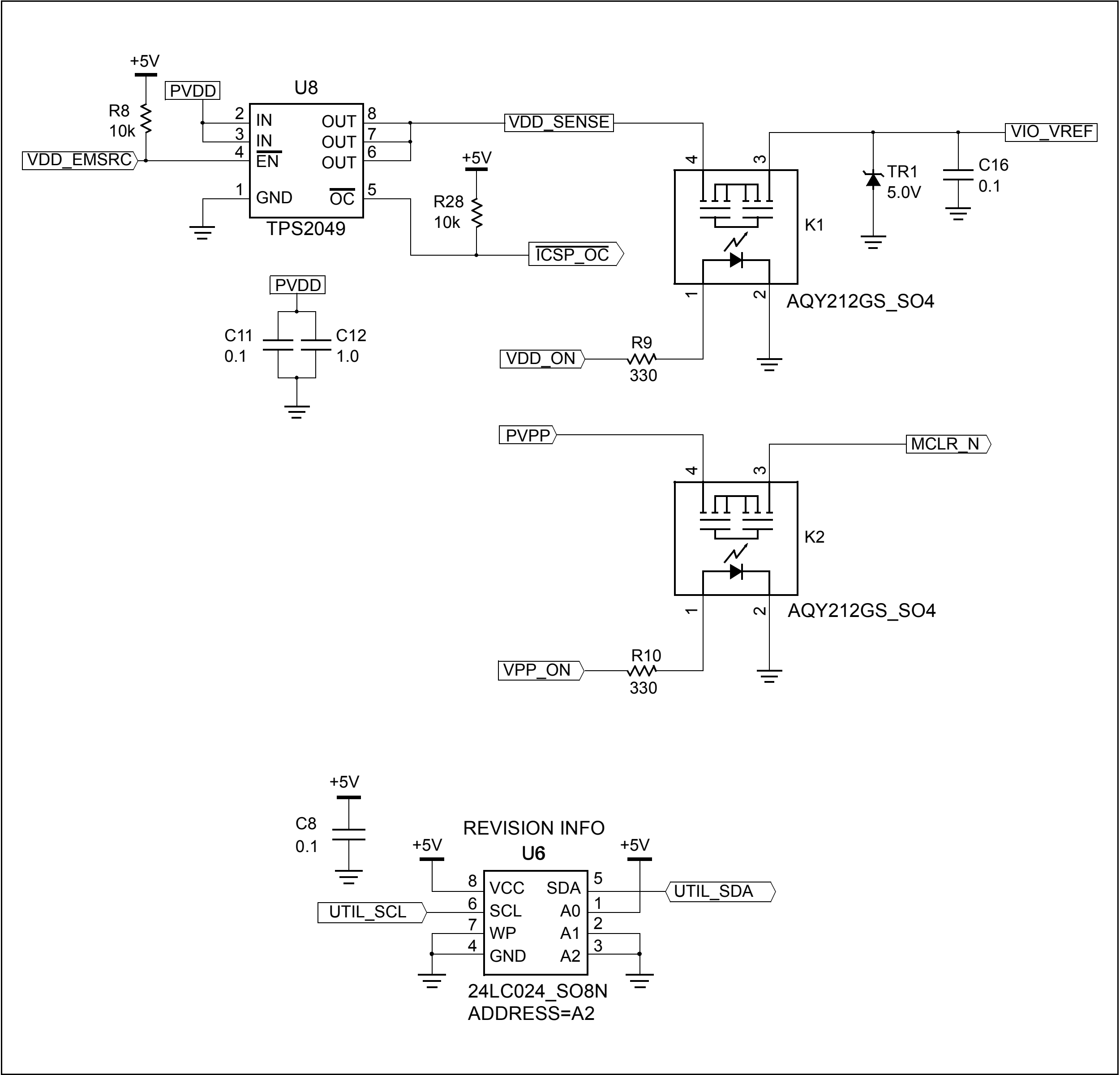
FIGURE 13-18: JTAG ADAPTOR BOARD SCHEMATICS - PART 3



13.6 OTHER ACCESSORIES

For additional accessories for the emulator and other hardware tools, such as Processor Extension Paks and Debug Headers, see the Microchip website for "MPLAB Emulator and Debugger Accessories".

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Support

INTRODUCTION

Please refer to the items discussed here for support issues.

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WARRANTY REGISTRATION

Registering your development tool entitles you to receive new product updates. Interim software releases are available at the Microchip web site:

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When you are selecting your preferences, choosing "Development Systems" will populate the list with available development tools. The main categories of tools are listed below:

- **Compilers** – The latest information on Microchip C compilers, assemblers, linkers and other language tools. These include all MPLAB C compilers; all MPLAB assemblers (including MPASM™ assembler); all MPLAB linkers (including MPLINK™ object linker); and all MPLAB librarians (including MPLIB™ object librarian).
- **Emulators** – The latest information on Microchip in-circuit emulators.This includes the MPLAB REAL ICE™ in-circuit emulator.
- **In-Circuit Debuggers** – The latest information on Microchip in-circuit debuggers. These include the PICkit™ 2, PICkit 3 and MPLAB ICD 3 in-circuit debuggers.
- **MPLAB® IDE** – The latest information on Microchip MPLAB IDE, the Windows® Integrated Development Environment for development systems tools. This list is focused on the MPLAB IDE, MPLAB IDE Project Manager, MPLAB Editor and MPLAB SIM simulator, as well as general editing and debugging features.

- **Programmers** – The latest information on Microchip programmers. These include the device (production) programmers MPLAB REAL ICE in-circuit emulator, MPLAB ICD 3 in-circuit debugger, MPLAB PM3 and development (nonproduction) programmers PICkit 2 and 3.
- **Starter/Demo Boards** – These include MPLAB Starter Kit boards, PICDEM demo boards, and various other evaluation boards.

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- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
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- 8-bit PIC MCUs
- 16-bit PIC MCUs
- 32-bit PIC MCUs

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Appendix A. Revision History

Revision A (January 2013)

- Initial release of this document.

NOTES:

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Glossary

This glossary applies to al Microchip development tools documentation. Therefore, some terms have tool-dependent meanings. An abbreviation of each tool is used to identify each meaning. Currently, the following abbreviations are used:

IDE - MPLAB IDE

PM3 - MPLAB PM3 Programmer

C18 - MPLAB C Compiler for PIC18 MCUs

C30 - MPLAB C Compiler for PIC24 MCUs and dsPIC DSCs

ASM30 - MPLAB Assembler for PIC24 MCUs and dsPIC DSCs

Absolute Section

A section with a fixed (absolute) address that cannot be changed by the linker.

Access Memory

PIC18 Only – Special registers on PIC18 devices that allow access regardless of the setting of the Bank Select Register (BSR).

Access Entry Points

Access entry points provide a way to transfer control across segments to a function which may not be defined at link time. They support the separate linking of boot and secure application segments.

Address

Value that identifies a location in memory.

Alphabetic Character

Alphabetic characters are those characters that are letters of the English alphabet (a, b, …, z, A, B, …, Z).

Alphanumeric

Alphanumeric characters are comprised of alphabetic characters and integers (0,1, …, 9).

ANDed Breakpoints

Set up an ANDed condition for breaking, i.e., breakpoint 1 AND breakpoint 2 must occur at the same time before a program halt. This can only be accomplished if a data breakpoint and a program memory breakpoint occur at the same time.

Anonymous Structure

C30 – An unnamed structure.

C18 – An unnamed structure that is a member of a C union. The members of an anonymous structure may be accessed as if they were members of the enclosing union. For example, in the following code, `hi` and `lo` are members of an anonymous structure inside the union `caster`.

```
union castaway
 int intval;
 struct {
  char lo; //accessible as caster.lo
  char hi; //accessible as caster.hi
 };
} caster;
```

ANSI

American National Standards Institute is an organization responsible for formulating and approving standards in the United States.

Application

A set of software and hardware that may be controlled by a PIC® microcontroller.

Archive

A collection of relocatable object modules. It is created by assembling multiple source files to object files, and then using the archiver to combine the object files into one library file. A library can be linked with object modules and other libraries to create executable code.

Archiver

A tool that creates and manipulates libraries.

ASCII

American Standard Code for Information Interchange is a character set encoding that uses seven binary digits to represent each character. It includes upper and lower case letters, digits, symbols, and control characters.

Assembler

A language tool that translates assembly language source code into machine code.

Assembly Language

A programming language that describes binary machine code in a symbolic form.

Assigned Section

A section which has been assigned to a target memory block in the linker script file.

Asynchronously

Multiple events that do not occur at the same time. This is generally used to refer to interrupts that may occur at any time during processor execution.

Asynchronous Stimulus

Data generated to simulate external inputs to a simulator device.

Attribute

Characteristics of variables or functions in a C program that are used to describe machine-specific properties.

Attribute, Section

Characteristics of sections, such as “executable”, “readonly”, or “data” that can be specified as flags in the assembler `.section` directive.

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Binary

The base two numbering system that uses the digits 0-1. The rightmost digit counts ones (2^0), the next counts multiples of two (2^1), the next counts multiples of four (2^2), etc.

Bookmarks

Use bookmarks to easily locate specific lines in a file.

Under the Edit menu, select Bookmarks to manage bookmarks. Toggle (enable/disable) a bookmark, move to the next or previous bookmark, or clear all bookmarks.

Breakpoint

Hardware Breakpoint: An event whose execution will cause a halt.

Software Breakpoint: An address where execution of the firmware will halt. Usually achieved by a special break instruction.

Build

Compile and link all the source files for an application.

C

A general-purpose programming language which features economy of expression, modern control flow and data structures, and a rich set of operators.

Calibration Memory

A special function register or registers used to hold values for calibration of a PIC microcontroller on-board RC oscillator or other device peripherals.

Central Processing Unit

The part of a device that is responsible for fetching the correct instruction for execution, decoding that instruction, and then executing that instruction. When necessary, it works in conjunction with the arithmetic logic unit (ALU) to complete the execution of the instruction. It controls the program memory address bus, the data memory address bus, and accesses to the stack.

Clean

Under the MPLAB X IDE Project menu, Clean removes all intermediary project files, such as object, hex and debug files, for the active project. These files are recreated from other files when a project is built.

COFF

Common Object File Format. An object file of this format contains machine code, debugging and other information.

Command Line Interface

A means of communication between a program and its user based solely on textual input and output.

Compiler

A program that translates a source file written in a high-level language into machine code.

Conditional Assembly

Assembly language code that is included or omitted based on the assembly-time value of a specified expression.

Conditional Compilation

The act of compiling a program fragment only if a certain constant expression, specified by a preprocessor directive, is true.

Configuration Bits

Special-purpose bits programmed to set PIC microcontroller modes of operation. A Configuration bit may or may not be preprogrammed.

Control Directives

Directives in assembly language code that cause code to be included or omitted based on the assembly-time value of a specified expression.

CPU

See Central Processing Unit.

Cross Reference File

A file that references a table of symbols and a list of files that references the symbol. If the symbol is defined, the first file listed is the location of the definition. The remaining files contain references to the symbol.

Data Directives

Data directives are those that control the assembler's allocation of program or data memory and provide a way to refer to data items symbolically; that is, by meaningful names.

Data Memory

On Microchip MCU and DSC devices, data memory (RAM) is comprised of General Purpose Registers (GPRs) and Special Function Registers (SFRs). Some devices also have EEPROM data memory.

Debugger

Hardware that performs debugging.

Debugger System

The Debugger systems include the pod, processor module, device adapter, target board, cables, and MPLAB X IDE software.

Debugging Information

Compiler and assembler options that, when selected, provide varying degrees of information that is used to debug application code. See compiler or assembler documentation for details on selecting debug options.

Deprecated Features

Features that are still supported for legacy reasons, but will eventually be phased out and no longer used.

Device Programmer

A tool used to program electrically programmable semiconductor devices such as microcontrollers.

Digital Signal Controller

A microcontroller device with digital signal processing capability, i.e., Microchip dsPIC DSC devices.

Digital Signal Processing

The computer manipulation of digital signals, i.e., analog signals (sound or image) which have been converted to digital form (sampled).

Digital Signal Processor

A microprocessor that is designed for use in digital signal processing.

Directives

Statements in source code that provide control of the language tool's operation.

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Download

Download is the process of sending data from a host to another device, such as an emulator, programmer or target board.

DSC

See Digital Signal Controller.

DSP

See Digital Signal Processor.

dsPIC DSCs

dsPIC Digital Signal Controllers (DSCs) refers to all Microchip DSC families.

DWARF

Debug With Arbitrary Record Format. DWARF is a debug information format for ELF files.

EEPROM

Electrically Erasable Programmable Read Only Memory. A special type of PROM that can be erased electrically. Data is written or erased one byte at a time. EEPROM retains its contents even when power is turned off.

ELF

Executable and Linking Format. An object file of this format contains machine code. Debugging and other information is specified in DWARF. ELF/DWARF provide better debugging of optimized code than COFF.

Emulation

The process of executing software loaded into emulation memory as if it were firmware residing on a microcontroller device.

Emulation Memory

Program memory contained within the emulator.

Emulator

Hardware that performs emulation.

Emulator System

The MPLAB REAL ICE system consists of a pod, a driver (and potentially a receiver) card, target board, cables, and MPLAB X IDE software.

Endianness

The ordering of bytes in a multi-byte object.

Environment

IDE **–** The particular layout of the desktop for application development.

PM3 **–** A folder containing files on how to program a device. This folder can be transferred to a SD/MMC card.

Epilogue

A portion of compiler-generated code that is responsible for deallocating stack space, restoring registers and performing any other machine-specific requirement specified in the runtime model. This code executes after any user code for a given function, immediately prior to the function return.

EPROM

Erasable Programmable Read Only Memory. A programmable read-only memory that usually can be erased by exposure to ultraviolet radiation.

Error File

A file containing error messages and diagnostics generated by a language tool.

Errors

Errors report problems that make it impossible to continue processing your program. When possible, errors identify the source file name and line number where the problem is apparent.

Event

A description of a bus cycle which may include address, data, pass count, external input, cycle type (e.g., fetch, R/W), and time stamp. Events are used to describe triggers, breakpoints and interrupts.

Executable Code

Software that is ready to be loaded for execution.

Export

Send data out of the MPLAB X IDE in a standardized format.

Expressions

Combinations of constants and/or symbols separated by arithmetic or logical operators.

Extended Microcontroller Mode

In Extended Microcontroller mode, on-chip program memory as well as external memory is available. Execution automatically switches to external if the program memory address is greater than the internal memory space of the PIC18 device.

Extended Mode (PIC18 MCUs)

In Extended mode, the compiler will utilize the extended instructions (i.e., `ADDFSR`, `ADDULNK`, `CALLW`, `MOVSF`, `MOVSS`, `PUSHL`, `SUBFSR` and `SUBULNK`) and the indexed with literal offset addressing.

External Label

A label that has external linkage.

External Linkage

A function or variable has external linkage if it can be referenced from outside the module in which it is defined.

External Symbol

A symbol for an identifier which has external linkage. This may be a reference or a definition.

External Symbol Resolution

A process performed by the linker in which external symbol definitions from all input modules are collected in an attempt to resolve all external symbol references. Any external symbol references that do not have a corresponding definition cause a linker error to be reported.

External Input Line

An external input signal logic probe line (TRIGIN) for setting an event based on external signals.

External RAM

Off-chip Read/Write memory.

Fatal Error

An error that will halt compilation immediately. No further messages will be produced.

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File Registers

On-chip data memory, including GPRs and SFRs.

Filter

Determine by selection what data is included/excluded in a trace display or data file.

Flash

A type of EEPROM where data is written or erased in blocks instead of bytes.

FNOP

Forced No Operation. A forced NOP cycle is the second cycle of a two-cycle instruction. Since the PIC microcontroller architecture is pipelined, it prefetches the next instruction in the physical address space while it is executing the current instruction. However, if the current instruction changes the PC, this prefetched instruction is explicitly ignored, causing an FNOP cycle.

Frame Pointer

A pointer that references the location on the stack that separates the stack-based arguments from the stack-based local variables. Provides a convenient base from which to access local variables and other values for the current function.

Free-Standing

An implementation that accepts any strictly conforming program that does not use complex types and in which the use of the features specified in the library clause (ANSI '89 standard clause 7) is confined to the contents of the standard headers `<float.h>`, `<iso646.h>`, `<limits.h>`, `<stdarg.h>`, `<stdbool.h>`, `<stddef.h>` and `<stdint.h>`.

GPR

General Purpose Register. The portion of device data memory (RAM) available for general use.

Halt

A stop of program execution. Executing Halt is the same as stopping at a breakpoint.

Header, Debug

A circuit board containing a special debug device (-ICE/-ICD) used with in-circuit debuggers and emulators to debug application code. For low pin count devices, resources can be recovered when using a debug header. See the *Header Board Specification* (DS51292) for details.

Heap

An area of memory used for dynamic memory allocation where blocks of memory are allocated and freed in an arbitrary order determined at runtime.

Hex Code

Executable instructions stored in a hexadecimal format code. Hex code is contained in a hex file.

Hex File

An ASCII file containing hexadecimal addresses and values (hex code) suitable for programming a device.

Hexadecimal

The base 16 numbering system that uses the digits 0-9 plus the letters A-F (or a-f). The digits A-F represent hexadecimal digits with values of (decimal) 10 to 15. The rightmost digit counts ones (16^0), the next counts multiples of 16 (16^1), the next counts multiples of 256 (16^2), etc.

High Level Language

A language for writing programs that is further removed from the processor than assembly.

ICD

In-Circuit Debugger. The MPLAB ICD3 In-Circuit Debugger, MPLAB ICD2 In-Circuit Debugger, PICkit 3 D.E. In-Circuit Debugger (Debug Express add-on), and PICkit 2 D.E. In-Circuit Debugger (Debug Express add-on) are the Microchip in-circuit debuggers.

ICE

In-Circuit Emulator. The MPLAB REAL ICE system is Microchip's next-generation in-circuit emulator.

ICSP

In-Circuit Serial Programming. A method of programming Microchip embedded devices using serial communication and a minimum number of device pins.

IDE

Integrated Development Environment. MPLAB X IDE is Microchip's integrated development environment.

Identifier

A function or variable name.

IEEE

Institute of Electrical and Electronics Engineers.

Import

Bring data into the MPLAB X IDE from an outside source, e.g., from a hex file.

Initialized Data

Data that is defined with an initial value. In C,

```
int myVar=5;
```

defines a variable that will reside in an initialized data section.

Instruction Set

The collection of machine language instructions that a particular processor understands.

Instructions

A sequence of bits that tells a central processing unit to perform a particular operation and can contain data to be used in the operation.

Internal Linkage

A function or variable has internal linkage if it can not be accessed from outside the module in which it is defined.

International Organization for Standardization

An organization that sets standards in many businesses and technologies, including computing and communications.

Interrupt

A signal to the CPU that suspends the execution of a running application and transfers control to an Interrupt Service Routine (ISR) so that the event may be processed. Upon completion of the ISR, normal execution of the application resumes.

Interrupt Handler

A routine that processes special code when an interrupt occurs.

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Interrupt Request

An event which causes the processor to temporarily suspend normal instruction execution and to start executing an interrupt handler routine. Some processors have several interrupt request events allowing different priority interrupts.

Interrupt Service Routine

ALU30, C18, C30 **–** A function that handles an interrupt.

IDE **–** User-generated code that is entered when an interrupt occurs. The location of the code in program memory will usually depend on the type of interrupt that has occurred.

Interrupt Vector

Address of an interrupt service routine or interrupt handler.

IRQ

See Interrupt Request.

ISO

See International Organization for Standardization.

ISR

See Interrupt Service Routine.

L-value

An expression that refers to an object that can be examined and/or modified. An l-value expression is used on the left-hand side of an assignment.

Latency

The time between an event and its response.

Librarian

See Archiver.

Library

See Archive.

Linker

A language tool that combines object files and libraries to create executable code, resolving references from one module to another.

Linker Script Files

Linker script files are the command files of a linker. They define linker options and describe available memory on the target platform.

Listing Directives

Listing directives are those directives that control the assembler listing file format. They allow the specification of titles, pagination, and other listing control.

Listing File

A listing file is an ASCII text file that shows the machine code generated for each C source statement, assembly instruction, assembler directive, or macro encountered in a source file.

Little Endian

A data ordering scheme for multi-byte data whereby the least significant byte is stored at the lower addresses.

Local Label

A local label is one that is defined inside a macro with the LOCAL directive. These labels are particular to a given instance of a macro’s instantiation. In other words, the symbols and labels that are declared as local are no longer accessible after the ENDM macro is encountered.

Logic Probes

Up to 14 logic probes can be connected to some Microchip emulators. The logic probes provide external trace inputs, trigger output signal, +5V, and a common ground.

Loop-Back Test Board

Used to test the functionality of the MPLAB REAL ICE in-circuit emulator.

LVDS

Low Voltage Differential Signaling. A low noise, low-power, low amplitude method for high-speed (gigabits per second) data transmission over copper wire.

LVDS differs from normal input/output (I/O) in a few ways:

Normal digital I/O works with 5 volts as a high (binary ‘`1`’) and 0 volts as a low (binary ‘`0`’). When you use a differential, you add a third option (-5 volts), which provides an extra level with which to encode, and results in a higher maximum data transfer rate.

A higher data transfer rate means fewer wires are required, as in UW (Ultra Wide) and UW-2/3 SCSI hard disks, which use only 68 wires. These devices require a high transfer rate over short distances. Using standard I/O transfer, SCSI hard drives would require a lot more than 68 wires.

Low voltage means that the standard 5 volts is replaced by either 3.3 volts or 1.5 volts.

LVDS uses a dual wire system, running 180 degrees of each other. This enables noise to travel at the same level, which in turn can get filtered more easily and effectively.

With standard I/O signaling, data storage is contingent on the actual voltage level. Voltage level can be affected by wire length (longer wires increase resistance, which lowers voltage). But with LVDS, data storage is distinguished only by positive and negative voltage values, not the voltage level. Therefore, data can travel over greater lengths of wire while maintaining a clear and consistent data stream.

Source: http://www.webopedia.com/TERM/L/LVDS.html.

Machine Code

The representation of a computer program that is actually read and interpreted by the processor. A program in binary machine code consists of a sequence of machine instructions (possibly interspersed with data). The collection of all possible instructions for a particular processor is known as its “instruction set”.

Machine Language

A set of instructions for a specific central processing unit, designed to be usable by a processor without being translated.

Macro

A macro instruction is an instruction that represents a sequence of instructions in abbreviated form.

Macro Directives

Directives that control the execution and data allocation within macro body definitions.

Makefile

Export to a file the instructions to Make the project. Use this file to Make your project outside of MPLAB X IDE, i.e., with a `make`.

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Under *Project>Build Options>Project*, **Directories** tab, you must have selected "Assemble/Compile/Link in the project directory" under "Build Directory Policy" for this feature to work.

Make Project

A command that rebuilds an application, recompiling only those source files that have changed since the last complete compilation.

MCLR - Master Clear

Master Clear (MCLR) is a function on a pin that causes a processor Reset. MCLR is usually multiplexed with other functions such as V_{PP}. Also, MCLR is usually complementary ($\overline{\text{MCLR}}$); that is, when the pin is pulled low, a Reset occurs, and when the pin is pulled high, the device operates normally.

Internal MCLR – When the MCLR enable configuration bit is cleared (`0`), a Reset signal is generated internally.

External MCLR – When the MCLR enable configuration bit is set (`1`), the pin becomes an external Reset input.

MCU

Microcontroller Unit. An abbreviation for microcontroller. Also uC.

Memory Model

C30 **–** A representation of the memory available to the application.

C18 **–** A description that specifies the size of pointers that point to program memory.

Message

Text displayed to alert you to potential problems in language tool operation. A message will not stop operation.

Microcontroller

A highly integrated chip that contains a CPU, RAM, program memory, I/O ports and timers.

Microcontroller Mode

One of the possible program memory configurations of PIC18 microcontrollers. In Microcontroller mode, only internal execution is allowed. Thus, only the on-chip program memory is available in Microcontroller mode.

Microprocessor Mode

One of the possible program memory configurations of PIC18 microcontrollers. In Microprocessor mode, the on-chip program memory is not used. The entire program memory is mapped externally.

Mnemonics

Text instructions that can be translated directly into machine code. Also referred to as opcodes.

MPASM™ Assembler

Microchip Technology's relocatable macro assembler for PIC microcontroller devices, KeeLoq® devices, and Microchip memory devices.

MPLAB *Language Tool* for *Device*

Microchip's C compilers, assemblers and linkers for specified devices. Select the type of language tool based on the device you will be using for your application, e.g., if you will be creating C code on a PIC18 MCU, select the MPLAB C Compiler for PIC18 MCUs.

MPLAB ICD

Microchip in-circuit debuggers that work with MPLAB X IDE. The ICDs support Flash devices with built-in debug circuitry. The main component of each ICD is the pod. A complete system consists of a pod, debug header (with a *device*-ICD), target board, cables, and MPLAB X IDE software.

MPLAB X **IDE**

Microchip's Integrated Development Environment. MPLAB X IDE comes with an editor, project manager, and simulator.

MPLAB PM3

A device programmer from Microchip. Programs PIC18 microcontrollers and dsPIC digital signal controllers. Can be used with MPLAB X IDE or as a stand-alone programmer. Replaces PRO MATE II.

MPLAB REAL ICE™ In-Circuit Emulator

Microchip next-generation in-circuit emulator that works with MPLAB X IDE. The MPLAB REAL ICE emulator supports PIC MCUs and dsPIC DSCs. The main component of each ICE is the pod. A complete system consists of a pod, a driver (and, potentially, a receiver) card, cables, and MPLAB X IDE software.

MPLAB SIM

Microchip's simulator that works with MPLAB X IDE in support of PIC MCU and dsPIC DSC devices.

MPLIB™ Object Librarian

Microchip's librarian that can work with MPLAB X IDE. MPLIB librarian is an object librarian for use with COFF object modules created using either MPASM assembler or MPLAB C18 C compiler.

MPLINK™ Object Linker

MPLINK linker is an object linker for the Microchip MPASM assembler and the Microchip C18 C compiler. MPLINK linker also may be used with the Microchip MPLIB librarian. MPLINK linker is designed to be used with MPLAB X IDE, though it is not a necessity.

MRU

Most Recently Used. Refers to files and windows available to be selected from MPLAB X IDE main pull-down menus.

Native Data Size

For Native trace, the size of the variable used in a Watch window must be of the same size as the selected device's data memory: bytes for PIC18 devices and words for 16-bit devices.

Nesting Depth

The maximum level to which macros can include other macros.

Node

MPLAB X IDE project component.

Non-Extended Mode (PIC18 MCUs)

In Non-Extended mode, the compiler will not use the extended instructions nor the indexed with literal offset addressing.

Non Real Time

Refers to the processor at a breakpoint, or executing single-step instructions, or MPLAB X IDE being run in simulator mode.

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Non-Volatile Storage

A storage device whose contents are preserved when its power is off.

NOP

No Operation. An instruction that has no effect when executed except to advance the PC.

Object Code

The machine code generated by an assembler or compiler.

Object File

A file containing machine code and possibly debug information. It may be immediately executable or it may be relocatable, requiring linking with other object files, e.g., libraries, to produce a complete executable program.

Object File Directives

Directives that are used only when creating an object file.

Octal

The base 8 number system that only uses the digits 0-7. The rightmost digit counts ones (8^0), the next digit counts multiples of eight (8^1), the next digit counts multiples of 64 (8^2), etc.

Off-Chip Memory

Off-chip memory refers to the memory selection option for the PIC18 device where memory may reside on the target board, or where all program memory may be supplied by the emulator. The **Memory** tab accessed from *Options>Development Mode* provides the Off-Chip Memory selection dialog box.

One-to-One Project-Workspace Model

The most common configuration for application development in MPLAB X IDE to is have one project in one workspace. Select *Configure>Settings*, **Projects** tab and check "Use one-to-one project-workspace model".

Opcodes

Operational Codes. *See* Mnemonics.

Operators

Symbols, like the plus sign '+' and the minus sign '-', that are used when forming well-defined expressions. Each operator has an assigned precedence that is used to determine order of evaluation.

OTP

One Time Programmable. EPROM devices that are not in windowed packages. Since EPROM needs ultraviolet light to erase its memory, only windowed devices are erasable.

Pass Counter

A counter that decrements each time an event (such as the execution of an instruction at a particular address) occurs. When the pass count value reaches zero, the event is satisfied. You can assign the Pass Counter to break and trace logic, and to any sequential event in the complex trigger dialog.

PC

Personal Computer or PC.

PC Host

Any PC running a supported Windows operating system.

Persistent Data

Data that is never cleared or initialized. This allows an application to preserve data across a device Reset.

Phantom Byte

An unimplemented byte in the dsPIC architecture that is used when treating the 24-bit instruction word as if it were a 32-bit instruction word. Phantom bytes appear in dsPIC hex files.

PIC MCUs

PIC microcontrollers (MCUs) refers to all Microchip microcontroller families.

PICkit 1, 2, and 3

Microchip's developmental device programmers with debug capability through Debug Express. See the Readme files for each tool to see which devices are supported.

Plug-ins

The MPLAB X IDE has both built-in components and plug-in modules to configure the system for a variety of software and hardware tools. Several plug-in tools may be found under the Tools menu.

Pod

MPLAB REAL ICE system: The box that contains the emulation control circuitry for the ICE device on the header or target board. An ICE device can be a production device with built-in ICE circuitry or a special ICE version of a production device (i.e., *device*-ICE).

MPLAB ICD: The box that contains the debug control circuitry for the ICD device on the header or target board. An ICD device can be a production device with built-in ICD circuitry or a special ICD version of a production device (i.e., *device*-ICD).

Power-on-Reset Emulation

A software randomization process that writes random values in data RAM areas to simulate uninitialized values in RAM upon initial power application.

Pragma

A directive that has meaning to a specific compiler. Often a pragma is used to convey implementation-defined information to the compiler. MPLAB C30 uses attributes to convey this information.

Precedence

Rules that define the order of evaluation in expressions.

Production Programmer

A production programmer is a tool that has resources designed into it that program devices rapidly. It has the capability to program at various voltage levels and completely adheres to the programming specification. Programming a device as fast as possible is of prime importance in a production environment where time is of the essence as the application circuit moves through the assembly line.

Microchip production programmers, such as MPLAB PM3, MPLAB REAL ICE in-circuit emulator, and MPLAB ICD 3, have been designed to be robust enough to tolerate these demanding environments.

Some top-end tools have additional accessories. The MPLAB REAL ICE Performance Pak has accelerators to speed up the communication and ICSP process. The MPLAB PM3 programmer has interchangeable socket modules to support various devices out-of-circuit.

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Profile

For MPLAB SIM simulator, a summary listing of executed stimulus by register.

Program Counter

The location that contains the address of the instruction that is currently executing.

Program Counter Unit

ALU30 – A conceptual representation of the layout of program memory. The program counter increments by 2 for each instruction word. In an executable section, 2 program counter units are equivalent to 3 bytes. In a read-only section, 2 program counter units are equivalent to 2 bytes.

Program Memory

IDE – The memory area in a device where instructions are stored. Also, the memory in the emulator or simulator containing the downloaded target application firmware.

ALU30, C30 – The memory area in a device where instructions are stored.

Project

A project contains the files that are needed to build an application (source code, linker script files, etc.) along with their associations, to various build tools and build options.

Prologue

A portion of compiler-generated code that is responsible for allocating stack space, preserving registers and performing any other machine-specific requirement that is specified in the runtime model. This code executes before user code for a given function.

Prototype System

A term referring to a user's target application, or target board.

PWM Signals

Pulse Width Modulation Signals. Certain PIC MCU devices have a PWM peripheral.

Qualifier

An address or an address range that is used by the Pass Counter or as an event before another operation in a complex trigger.

Radix

The number base, hex, or decimal, used in specifying an address.

Random Access Memory (RAM)

Data emory in which information can be accessed in any order.

Raw Data

The binary representation of code or data associated with a section.

Read-Only Memory (ROM)

Memory hardware that allows fast access to permanently stored data, but prevents addition to, or modification of, the data.

Real Time

When an in-circuit emulator or debugger is released from the Halt state, the processor runs in Real Time mode and behaves exactly as the normal chip would behave. In Real Time mode, the real time trace buffer of an emulator is enabled and constantly captures all selected cycles, and all break logic is enabled. In an in-circuit emulator or debugger, the processor executes in real time until a valid breakpoint causes a halt, or until the user halts the execution.

In the simulator, real time simply means execution of the microcontroller instructions as fast as they can be simulated by the host CPU.

Real-Time Watch

A Watch window where the variables change in real time as the application is run. See individual tool documentation to determine how to set up a real-time watch. Not all tools support real-time watches.

Recursive Calls

A function that calls itself, either directly or indirectly.

Recursion

The concept that a function or macro, having been defined, can call itself. Great care should be taken when writing recursive macros; it is easy to get caught in an infinite loop where there will be no exit from the recursion.

Reentrant

A function that may have multiple, simultaneously active instances. This may happen due to either direct or indirect recursion, or through execution during interrupt processing.

Relaxation

The process of converting an instruction to an identical, but smaller, instruction. This is useful for saving on code size. MPLAB ASM30 currently knows how to `RELAX` a `CALL` instruction into an `RCALL` instruction. This is done when the symbol that is being called is within +/- 32k instruction words from the current instruction.

Relocatable

An object whose address has not been assigned to a fixed location in memory.

Relocatable Section

ALU30 – A section whose address is not fixed (absolute). The linker assigns addresses to relocatable sections through a process called relocation.

Relocation

A process performed by the linker in which absolute addresses are assigned to relocatable sections and all symbols in the relocatable sections are updated to their new addresses.

ROM

Read-Only Memory (Program Memory). Memory that cannot be modified.

Run

The command that releases the emulator from halt, allowing it to run the application code and change or respond to I/O in real time.

Run-time Model

Describes the use of target architecture resources.

Scenario

For MPLAB SIM simulator, a particular setup for stimulus control.

Section

A portion of an application located at a specific address of memory.

Section Attribute

A characteristic ascribed to a section (e.g., an `access` section).

Sequenced Breakpoints

Breakpoints that occur in a sequence. Sequence execution of breakpoints is bottom-up, i.e., the last breakpoint in the sequence occurs first.

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Serialized Quick Turn Programming

Serialization allows you to program a serial number into each microcontroller device that the Device Programmer programs. This number can be used as an entry code, password or ID number.

SFR

See Special Function Registers.

Shell

The MPASM assembler shell is a prompted input interface to the macro assembler. There are two MPASM assembler shells: one for the DOS version, and one for the Windows version.

Simulator

A software program that models the operation of devices.

Single Step

This command steps though code, one instruction at a time. After each instruction, MPLAB X IDE updates register windows, watch variables, and status displays so you can analyze and debug instruction execution. You can also single step C compiler source code, but instead of executing single instructions, MPLAB X IDE will execute all assembly level instructions generated by the line of the high level C statement.

Skew

The information associated with the execution of an instruction appears on the processor bus at different times. For example, the executed opcode appears on the bus as a fetch during the execution of the previous instruction. The source data address and value, and the destination data address appear when the opcode is actually executed, and the destination data value appears when the next instruction is executed. The trace buffer captures the information that is on the bus at one instance. Therefore, one trace buffer entry will contain execution information for three instructions. The number of captured cycles from one piece of information to another for a single instruction execution is referred to as the skew.

Skid

When a hardware breakpoint is used to halt the processor, one or more additional instructions may be executed before the processor halts. The number of extra instructions executed after the intended breakpoint is referred to as the skid.

Source Code

A text listing of commands that may be completed or assembled into object code. Source code is written in a formal programming language that can be translated into machine code or executed by an interpreter.

Source File

An ASCII text file containing source code.

Special Function Registers

The portion of data memory (RAM) dedicated to registers that control I/O processor functions, I/O status, timers, or other modes or peripherals.

SQTP

See Serialized Quick Turn Programming.

Stack, Hardware

Locations in MCU or DSC where the return address is stored when a function call is made.

Stack, Software

Memory used by an application for storing return addresses, function parameters, and local variables. This memory is typically managed by the compiler when developing code in a high-level language.

MPLAB Starter Kit for *Device*

Microchip’s starter kits contains everything needed to begin exploring the specified device. View a working application and then debug and program your own changes.

Static RAM or SRAM

Static Random Access Memory. Program memory you can read/write on the target board that does not need refreshing frequently.

Status Bar

The Status Bar is located on the bottom of the MPLAB X IDE window and indicates current information, such as cursor position, development mode and device, and active tool bar.

Step Into

This command is the same as Single Step. Step Into (as opposed to Step Over) follows a CALL instruction into a subroutine.

Step Over

Step Over allows you to debug code without stepping into subroutines. When stepping over a `CALL` instruction, the next breakpoint will be set at the instruction after the `CALL`. If for some reason the subroutine gets into an endless loop or does not return properly, the next breakpoint will never be reached. The Step Over command is the same as Single Step except for its handling of `CALL` instructions.

Step Out

Step Out allows you to step out of a subroutine which you are currently stepping through. This command executes the rest of the code in the subroutine and then stops execution at the return address to the subroutine.

Stimulus

Input to the simulator, i.e., data generated to exercise the response of simulation to external signals. Often the data is put into the form of a list of actions in a text file. Stimulus may be asynchronous, synchronous (pin), clocked, or register.

Stopwatch

A counter for measuring execution cycles.

Storage Class

Determines the lifetime of the memory associated with the identified object.

Storage Qualifier

Indicates special properties of the objects being declared (e.g., `const`).

Symbol

A symbol is a general purpose mechanism for describing the various pieces which comprise a program. These pieces include function names, variable names, section names, file names, struct/enum/union tag names, etc. Symbols in MPLAB X IDE refer mainly to variable names, function names and assembly labels. The value of a symbol after linking is its value in memory.

Symbol, Absolute

Represents an immediate value, such as a definition, through the assembly `.equ` directive.

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System Window Control

The system window control is located in the upper left corner of windows and some dialogs. Clicking on this control usually pops up a menu that has the items “Minimize,” “Maximize,” and “Close.”

Target

Refers to user hardware.

Target Application

Software residing on the target board.

Target Board

The circuitry and programmable device that makes up the target application.

Target Processor

The microcontroller device on the target application board.

Template

Lines of text that you build to insert into your files at a later time. The MPLAB Editor stores templates in template files.

Tool Bar

A row or column of icons that you can click on to execute MPLAB X IDE functions.

Trace

An emulator or simulator function that logs program execution. The emulator logs program execution into its trace buffer which is uploaded to MPLAB X IDE’s trace window.

Trace Memory

Trace memory contained within the emulator. Trace memory is sometimes called the trace buffer.

Trace Macro

A macro that will provide trace information from emulator data. Since this is a software trace: the macro must be added to code, the code must be recompiled or reassembled, and the target device must be programmed with this code before trace will work.

Trigger Output

Trigger output refers to an emulator output signal that can be generated at any address or address range, and is independent of the trace and breakpoint settings. Any number of trigger output points can be set.

Trigraphs

Three-character sequences, all starting with `??`, that are defined by ISO C as replacements for single characters.

Unassigned Section

A section that has not been assigned to a specific target memory block in the linker script file. The linker must find a target memory block in which to allocate an unassigned section.

Uninitialized Data

Data that is defined without an initial value. In C,

```
int myVar;
```

defines a variable which will reside in an uninitialized data section.

Upload

The Upload function transfers data from a tool (such as an emulator or programmer) to the host PC, or from the target board to the emulator.

USB

Universal Serial Bus. An external peripheral interface standard for communication between a computer and external peripherals over a cable using bi-serial transmission. USB 1.0/1.1 supports data transfer rates of 12 Mbps. USB 2.0 supports data rates up to 480 Mbps and is often referred to as high-speed USB.

Vector

The memory locations that an application will jump to when a Reset or an interrupt occurs.

Warning

IDE – An alert that is provided to warn you of a situation that would cause physical damage to a device, software file, or equipment.

ALU30, C30 – Warnings report conditions that may indicate a problem, but do not halt processing. In MPLAB C30, warning messages report the source file name and line number, but include the text '`warning:`' to distinguish them from error messages.

Watch Variable

A variable that you may monitor during a debugging session in a Watch window.

Watch Window

Watch windows contain a list of watch variables that are updated at each breakpoint.

Watchdog Timer

A timer on a PIC microcontroller that resets the processor after a selectable length of time. The WDT is enabled or disabled and set up using Configuration bits.

WDT

See Watchdog Timer.

Workbook

For MPLAB SIM stimulator, a setup for generation of SCL stimulus.

WorkSpace

A workspace contains MPLAB X IDE information on the selected device, selected debug tool and/or programmer, open windows and their location, and other IDE configuration settings.

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11/29/12

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