Chipsmall Limited consists of a professional team with an average of over 10 year of expertise in the distribution of electronic components. Based in Hongkong, we have already established firm and mutual-benefit business relationships with customers from,Europe,America and south Asia,supplying obsolete and hard-to-find components to meet their specific needs.

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

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
ISO/TS 16949:2002

Microchip received ISO/TS-16949:2002 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.

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

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Part 3 – Reference

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

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® IDE on-line help. Select the Help menu, and then Topics to open a list of available on-line 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
- Warranty Registration
- Recommended Reading
- The Microchip Web Site
- Development Systems Customer Change Notification Service
- Customer Support

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: Overview** – 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.
- **Chapter 3: Installation** – How to install the emulator software and hardware.
- **Chapter 4: Tutorial** – A brief tutorial on using the emulator.

Part 2 – Features

- **Chapter 5: General Setup** – How to set up MPLAB IDE to use the emulator.
- **Chapter 6: Basic 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 7: Debug for 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 8: Debug for 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 – Reference

- **Chapter 9: Frequently Asked Questions** – A list of frequently-asked questions, useful for troubleshooting.
- **Chapter 10: Error Messages** – A list of error messages and suggested resolutions.
- **Chapter 11: 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 12: Hardware Specification** – The hardware and electrical specifications of the emulator system. Includes a description of how to use the loop-back test board.

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® 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	*File>Save*
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) { ... }`

WARRANTY REGISTRATION

Please complete the enclosed Warranty Registration Card and mail it promptly. Sending in your Warranty Registration Card entitles you to receive new product updates. Interim software releases are available at the Microchip web site.

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 MPLAB REAL ICE in-circuit emulator, read the "`Readme for MPLAB REAL ICE Emulator.htm`" file (an HTML file) in the Readmes subdirectory of the MPLAB IDE installation directory. The release notes (Readme) contains update information and known issues that may not be included in this user's guide.

MPLAB REAL ICE In-Circuit Emulator Setup (DS51615)
MPLAB REAL ICE In-Circuit Emulator Setup - PIC32MX (DS51687)

These posters show you how to hook up the hardware and install the software for the MPLAB REAL ICE in-circuit emulator.

MPLAB REAL ICE In-Circuit Emulator On-line Help File

A comprehensive help file for the emulator is included with MPLAB 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.

Header Board Specification (DS51292)

This booklet describes how to install and use MPLAB REAL ICE in-circuit emulator headers. Headers are used to better debug selected devices using special -ICE device versions, without the loss of pins or resources.

Transition Socket Specification (DS51194)

Consult this document for information on transition sockets available for use with MPLAB REAL ICE in-circuit emulator and MPLAB ICD 2 in-circuit debugger headers, as well as MPLAB ICE 2000/4000 device adaptors.

THE MICROCHIP WEB SITE

Microchip provides online support via our web site at www.microchip.com. This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site contains the following information:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

DEVELOPMENT SYSTEMS CUSTOMER CHANGE NOTIFICATION SERVICE

Microchip's customer notification service helps keep customers current on Microchip products. Subscribers will receive e-mail notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, access the Microchip web site at www.microchip.com, click on Customer Change Notification and follow the registration instructions.

The Development Systems product group categories are:

- **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.These include the MPLAB REAL ICE™, MPLAB ICE 2000 and MPLAB ICE 4000 in-circuit emulators
- **In-Circuit Debuggers** – The latest information on Microchip in-circuit debuggers. These include the MPLAB ICD 2 in-circuit debugger and PICkit™ 2 debug express.
- **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 MPLAB PM3 and PRO MATE® II device programmers and the PICSTART® Plus and PICkit 1 and 2 development programmers.

CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

Customers should contact their distributor, representative or field application engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

Technical support is available through the web site at: http://support.microchip.com

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

Part 1 – Getting Started

NOTES:

Chapter 1. Overview

1.1 INTRODUCTION

An overview of the MPLAB REAL ICE in-circuit emulator system is given.

- Emulator Defined
- How the Emulator Helps You
- Emulator Kit Components
- Device and Feature Support

1.2 EMULATOR DEFINED

The MPLAB REAL ICE in-circuit emulator is an in-circuit emulator that is controlled by a PC running MPLAB IDE software on a Windows® platform. The MPLAB REAL ICE in-circuit emulator is an integral part of the development engineer's toolsuite. The application usage can vary from software development to hardware integration to manufacturing test to field service.

The MPLAB REAL ICE in-circuit emulator is a modern emulator system that supports hardware and software development for selected Microchip PIC® microcontrollers (MCUs) and dsPIC® Digital Signal Controllers (DSCs) that are based on In-Circuit Serial Programming™ (ICSP™) programming capability and Standard DUT Programming (STDP) 2-wire serial interfaces.

The emulator system will execute code in an actual device because these Microchip devices have built-in emulation circuitry, instead of a special emulator chip, for emulation. All available features of a given device are accessible interactively, and can be set and modified by the MPLAB IDE interface.

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 port data input
- Trace (MPLAB IDE and Compiler Assisted) – 8 and 16-bit devices
- Hardware Trace – 32-bit devices

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

1.3 HOW THE EMULATOR HELPS YOU

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

- Debug application on hardware in real time
- Debug with hardware breakpoints
- Debug with software breakpoints (device-dependent)
- Set breakpoints based on internal and/or external signals
- Monitor internal file registers
- Emulate full speed
- Program device
- Trace lines of code or log variable/expression values

1.4 EMULATOR KIT COMPONENTS

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

1. CD-ROM with MPLAB IDE software and on-line documentation
2. Emulator pod
3. USB cable to provide communications between the emulator and a PC and to provide power to the emulator
4. Standard driver board (MPLAB ICD 2 compatible) and cable to connect the emulator pod to a header module or target board
5. Logic probes
6. Loop-back test board

Additional hardware that may be ordered separately:

7. Processor Extension Pack: High-speed driver board, ICE header/receiver board and cables to connect the emulator pod to a target board
8. Performance Pack: High-speed driver board, high-speed receiver board and cables to connect the emulator pod to a target board
9. High-speed to standard converter board
10. Transition socket
11. Opto-isolation board

1.5 DEVICE AND FEATURE SUPPORT

The following shows the current and future support for devices and device features, depending on your selected device.

TABLE 1-1: 32-BIT AND 16-BIT (DATA MEMORY) DEVICES

Feature	PIC32MX	dsPIC33F, PIC24F/H	dsPIC30F SMPS(3)	dsPIC30F
Reset application	C	C	C	C
Run, Halt	C	C	C	C
Single Step	C	C	C	C
Animate	C	C	C	C
Full Speed Emulation	C	C	C	C
Hardware Breakpoints	C	C	C	C
Advanced Breakpoints	C	C	C	C
Software Breakpoints	N	C	C	C
Peripheral Freeze(4)	C	C	C	C
Break on data fetch or write	C	C	C	C
Break on Stack overflow	C	C	C	C
Stopwatch	C	C	C	C
Pass Counter	C	C	C	C
WDT overflow	C	C	C	N
PIC32 Instruction Trace (built-in)	C	N	N	N
Native Trace (built-in)	N	C	C	N
SPI Trace	N	C	N(1)	D(1)
I/O Port Trace	N	C	N(2)	D(2)
Trace Macros for C code	N	C	C	C
Trace Macros for ASM code	N	N	N	N
Runtime Watch	C	C	C	N
Standard Speed Comm.	C	C	C	C
High Speed Comm.	C	C	C	C
Processor Pak	N	F	F	N
Probe trigger	C	C	C	C

Legend:
C = Current support
D = Support dependent on device
F = No support now, but planned in the future
N = Support Not Available

Note 1: No SPI Trace for devices with SPI port pins multiplexed with PGC/PGD pins.

2: 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.

3: Current Switch Mode Power Supply (SMPS) devices: dsPIC30F1010/2020/2023.

4: This feature operates differently depending on the selected device.

TABLE 1-2: 8-BIT (DATA MEMORY) DEVICES

Feature	PIC18FXXJ	PIC18F, PIC18F Enh, PIC18FXXK	PIC16F
Reset application	C	C	C
Run, Halt	C	C	C
Single Step	C	C	C
Animate	C	C	C
Full Speed Emulation	C	C	C
Hardware Breakpoints	C	C	C
Advanced Breakpoints	C	C	N
Software Breakpoints	C	C	N
Peripheral Freeze(3)	C	C	C
Break on data fetch or write	C	C	N
Break on Stack overflow	C	C	N
Stopwatch	C	N	N
Pass Counter	C	C	N
WDT overflow	C	N	N
Native Trace (built-in)	C	N	N
SPI Trace	C	C	N
I/O Port Trace	C	C	N
Trace Macros for C code	C	C	N
Trace Macros for ASM code	C	C	N
Runtime Watch	C	N	N
Standard Speed Comm.	C	C	C
High Speed Comm.	C	C	C
Processor Pak	F	F	F
Probe trigger	C	C	C

Legend:
C = Current support
D = Support dependent on device
F = No support now, but planned in the future
N = Support Not Available

Note 1: No SPI Trace for devices with SPI port pins multiplexed with PGC/PGD pins.

2: 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.

3: This feature operates differently depending on the selected device.

Chapter 2. Operation

2.1 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 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.

- Tool Comparisons
- 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

2.2 TOOL COMPARISONS

The MPLAB REAL ICE in-circuit emulator system is a next generation In-Circuit Emulator (ICE) system. It differs from classical in-circuit emulator systems in a single, but important way: the production device and emulation device are the same. This means that the actual device/emulated device differences are all but eliminated. For example, speed bottlenecks caused by bringing internal busses off-chip and using external memories on classical emulator systems are eliminated by using the actual device for emulation.

Another significant benefit is that there is no time lag from when the device is released to when an emulator module to support the device can be released. If a header board is required, it can be developed to coincide with the device release, or lag it by a small amount, which is a great improvement over the longer processor module development times.

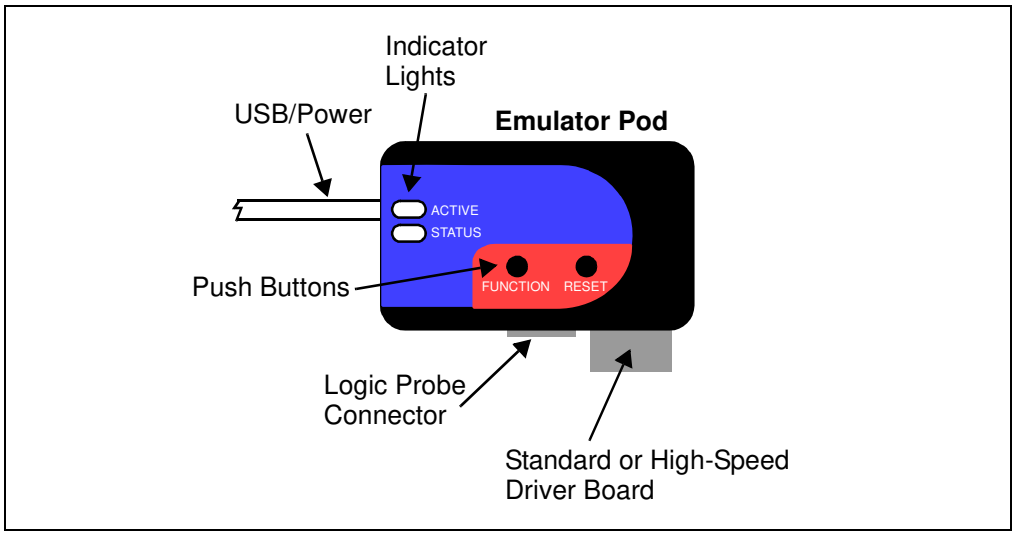
The MPLAB REAL ICE in-circuit emulator system surpasses in-circuit debugger systems in speed and functionality (e.g., trace).

2.3 EMULATOR COMMUNICATIONS WITH THE PC AND TARGET

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

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

FIGURE 2-1: BASIC EMULATOR SYSTEM



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 when the pod or target is powered.

2.3.1 Standard Communication

The emulator system can be configured to use standard communication for both programming and debugging functions. 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 (Figure 2-2), or (2) inserted into a standard adapter/header board combo (available as a Processor Pak), which in then plugged into the target board (Figure 2-3).

Note: Older header boards 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 standard communication, see **Chapter 12. "Hardware Specification"**.

FIGURE 2-2: STANDARD EMULATOR SYSTEM – DEVICE WITH ON-BOARD ICE CIRCUITRY

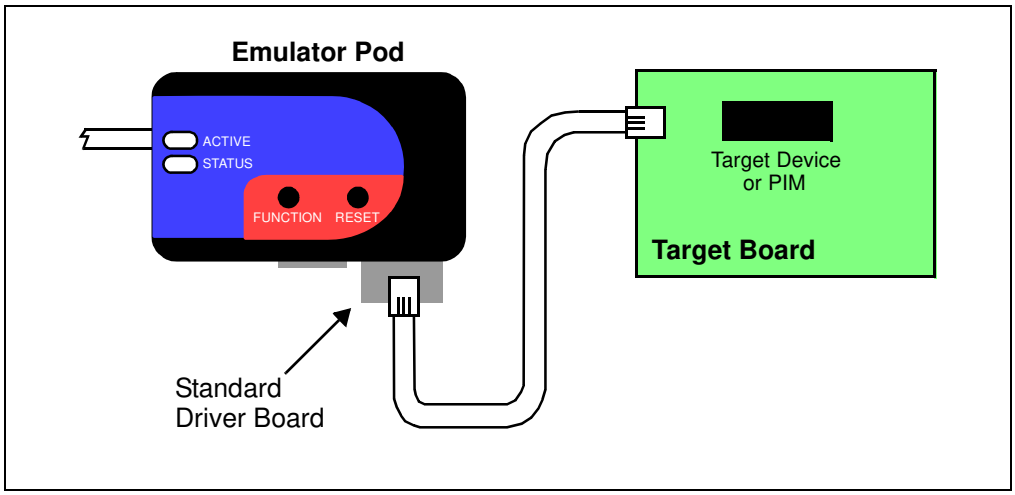
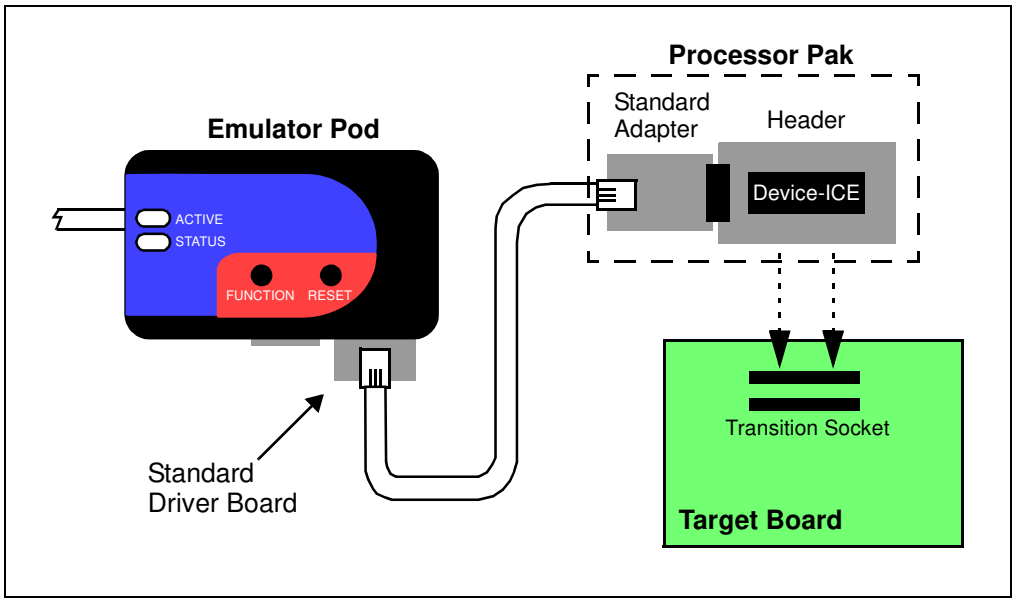


FIGURE 2-3: STANDARD EMULATOR SYSTEM – ICE DEVICE



2.3.2 High-Speed Communication

The emulator system can be configured to use high-speed communication for both programming and debugging functions. This connection allows for higher speed operations, a longer distance between the emulator and target, and additional tracing functionality over a standard connection.

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 sockets at the high-speed receiver board, which is attached via an 8-pin connector into either (1) the target board, with an on-board target device (Figure 2-4), or (2) the header board (from the Processor Pak), which in then plugged into the target board (Figure 2-5).

For more on high-speed communication, see **Chapter 12. "Hardware Specification"**.

FIGURE 2-4: HIGH-SPEED EMULATOR SYSTEM – DEVICE WITH ON-BOARD ICE CIRCUITRY

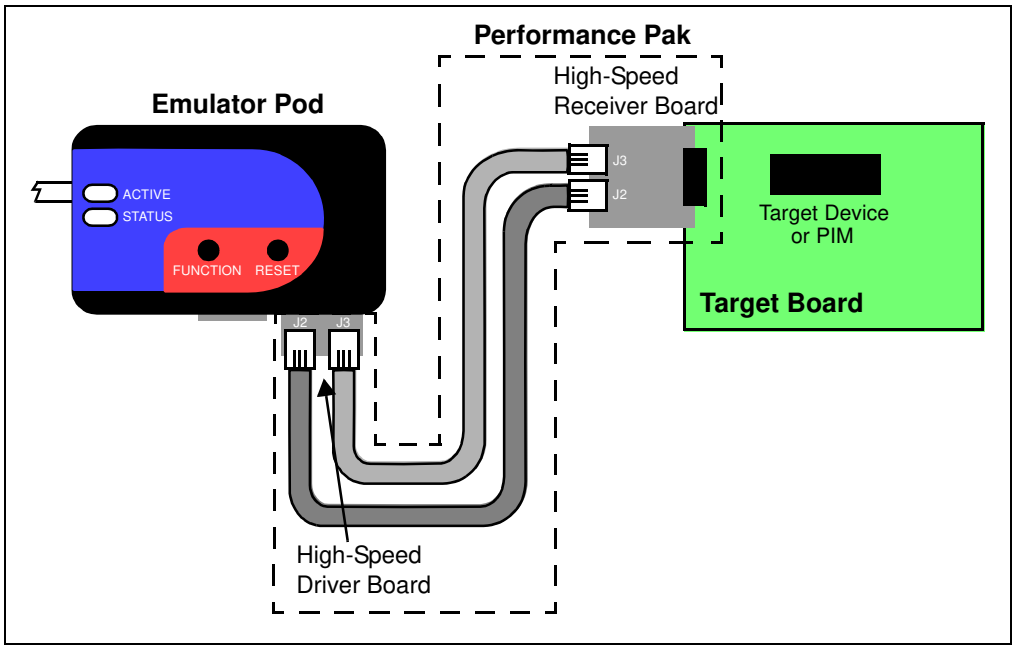
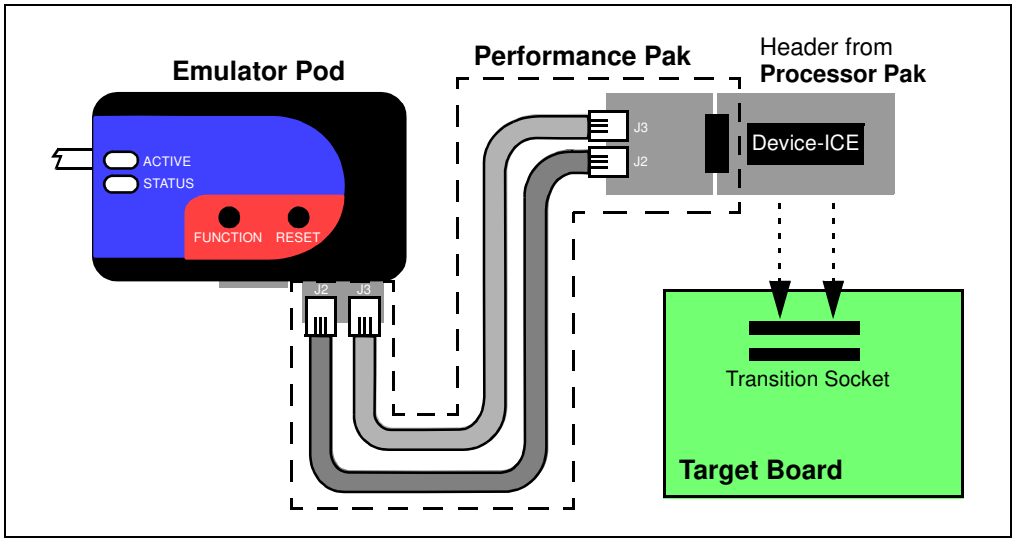


FIGURE 2-5: HIGH-SPEED EMULATOR SYSTEM – ICE DEVICE



2.4 TARGET COMMUNICATION CONNECTIONS

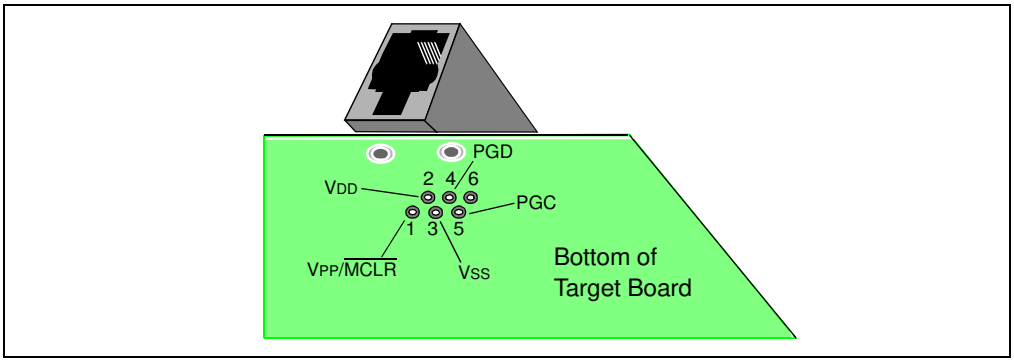
There are two driver boards available to closely match most application requirements. The standard driver board can be used to connect to the myriad of demo boards and applications that contain the RJ11 connector. The high-speed driver/receiver board combination can be used for high-speed applications,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

2.4.1 Standard Communication Connection

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 2-6.

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 12.6.2.3 "Modular Cable Specification"**.

FIGURE 2-6: STANDARD CONNECTION AT TARGET

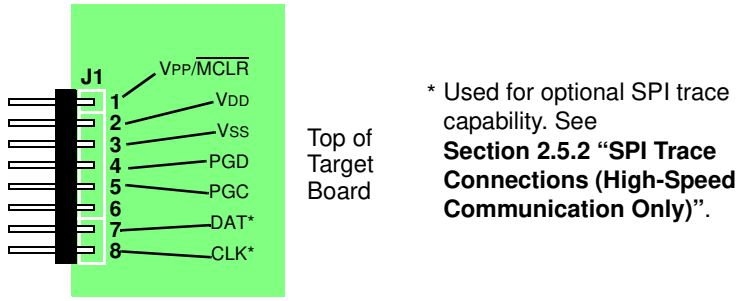


2.4.2 High-Speed Communication Connection

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 2-7.

Note: Connections from the emulator to the target are shown in **Section 12.7 "High-Speed Communication Hardware"**.

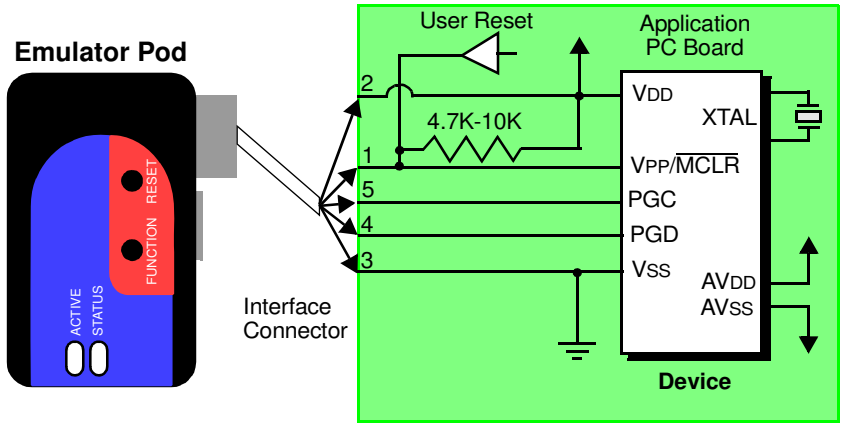
FIGURE 2-7: HIGH-SPEED CONNECTION AT TARGET



2.4.3 Target Connection Circuitry

Figure 2-8 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/MCLR line to VDD so that the line may be strobed low to reset the device.

FIGURE 2-8: STANDARD CONNECTION TARGET CIRCUITRY



In the following descriptions, only three lines are active and relevant to core emulator operation: pins 1 (VPP/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. If the emulator does not sense voltage on its VDD line (pin 2 of the interface connector), it will not operate.

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.

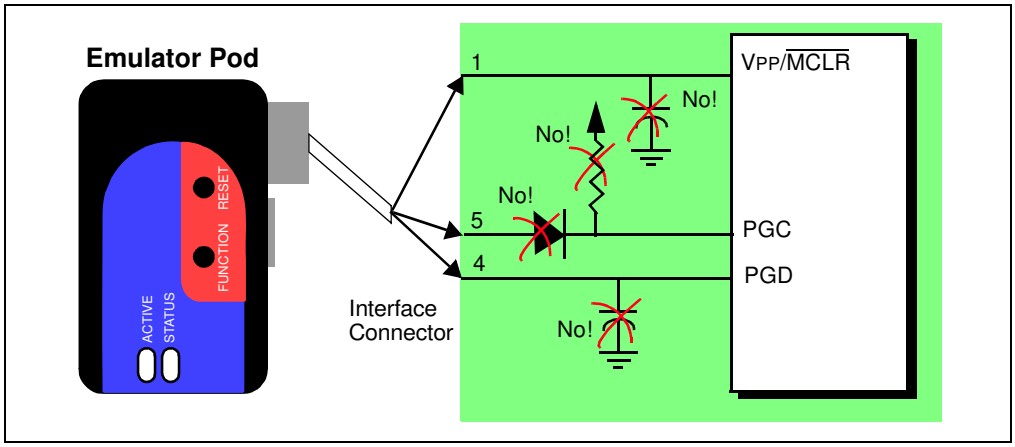
In general, it is recommended per device data sheet that all VDD/AVDD and VSS/AVSS lines be connected to the appropriate levels. Also, devices with a VCAP pin (like PIC18FXXJ devices) should be connected to the appropriate capacitor or other internal regulator device.

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.

2.4.4 Circuits That Will Prevent the Emulator From Functioning

Figure 2-9 shows the active emulator lines with some components that will prevent the MPLAB REAL ICE in-circuit emulator system from functioning.

FIGURE 2-9: IMPROPER CIRCUIT COMPONENTS



Specifically, these guidelines must be followed:

- Do not use pull-ups on PGC/PGD – they will divide the voltage levels, since these lines 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.
- Do not use capacitors on $\overline{\text{MCLR}}$ – they will prevent fast transitions of VPP. A simple pull-up resistor is generally sufficient.
- Do not use diodes on PGC/PGD – they will prevent bidirectional communication between the emulator and the target device.

For other operational issues, see:

- **Chapter 10. “Error Messages”**
- **Chapter 9. “Frequently Asked Questions (FAQ)”**
- **Section 10.3.6 “Debug Failure Actions”** (Top Reasons Why You Can’t Debug)
- **Section 12.8 “Loop-Back Test Board”**