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PICkit™ 3
Programmer/Debugger
User's Guide

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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 “DSXXXXA”, where “XXXX” 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 useful to know before using PICKit™ 3 programmer/debugger. 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 PICkit 2 as a development tool to emulate and debug firmware on a target board. The manual layout is as follows:

- **Chapter 1. Overview** – An overview of the PICkit 3 programmer/debugger.
- **Chapter 2. Theory of Operation** – A simplified description of how the PICkit 3 programmer/debugger works.
- **Chapter 3. Installation** – How to install the PICkit 3 programmer/debugger.
- **Chapter 4. General Setup** – Provides instructions on how to get started using the PICkit 3 programmer/debugger to program supported devices.
- **Chapter 5. PICkit 3 Debug Express** – Provides basic information on using the PICkit™ 3 Debug Express.
- **Chapter 6. Troubleshooting First Steps** – Begins the troubleshooting process by identifying first steps and common reasons for problems with debugging.
- **Chapter 7. Frequently Asked Questions (FAQs)** – Provides information on solving common problems.
- **Chapter 8. Error Messages** – Provides specific error messages and general corrective actions.
- **Chapter 9. Debugger Function Summary** – Summarizes the available debugging functions.
- **Chapter 10. Hardware Specification** – Details hardware and electrical specifications for the PICkit 3.
- **Appendix A. PICkit 3 Schematics** – Provides hardware schematic diagrams for the PICkit 3 programmer/debugger.
- **Appendix B. Operational Advisory** – Addresses operational issues to be considered when designing applications.

CONVENTIONS USED IN THIS GUIDE

The following conventions may appear in this documentation:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic	Referenced books	<i>MPLAB[®] IDE User's Guide</i>
	Emphasized text	...is the <i>only</i> 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 with right angle bracket	A menu path	<u><i>File>Save</i></u>
Bold characters	A dialog button	Click OK
	A tab	Click the Power tab
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier New 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	<i>file.o</i> , where <i>file</i> can be any valid filename
Square brackets []	Optional arguments	mpasmwin [options] <i>file</i> [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) { ... }

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WARRANTY REGISTRATION

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

RECOMMENDED READING

This user's guide describes how to use PICKit 2. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

44-Pin Demo Board User's Guide (DS41296)

Consult this document for instructions on how to use the 44-Pin demo board as a development tool to emulate and debug firmware on a target board.

Low Pin Count Demo Board User's Guide (DS51556)

Consult this document for instructions on how to use Microchip Technology's low pin count device (8-pin, 14-pin and 20-pin). This document includes a series of tutorials.

MPLAB® IDE User's Guide/Help (DS51519)

Consult this document for more information pertaining to the installation and features of the MPLAB Integrated Development Environment (IDE) software. An on-line Help version is also available.

In-Circuit Serial Programmer™ (ICSP™) Guide (DS30277)

This document contains helpful design guidelines for successful ICSP programming. It includes application notes on hardware designs and the ICSP programming specifications.

MPASM™ Assembler, MPLINK™ Object Linker, MPLIB™ Object Librarian User's Guide (DS33014)

Describes how to use the Microchip PIC® MCU assembler (MPASM assembler), linker (MPLINK linker), and librarian (MPLIB librarian).

README for PICKit™ 3 Debug Express

For the latest information on using the PICKit 3 Debug Express, read the "Readme for PICKit 3.htm" file (an HTML file) in the Readmes subdirectory of the MPLAB IDE installation directory. The Readme file contains updated information and known issues that may not be included in this user's guide.

PICKit™ 3 Debug Express C18 Lessons

These tutorials guide you through using the PICKit 3 Debug Express with the MPLAB C Compiler for PIC18 MCU's. They are available on the MPLAB IDE CDROM and on the Microchip web site.

Readme Files

For the latest information on using other tools, read the tool-specific Readme files in the Readmes subdirectory of the MPLAB IDE installation directory. The Readme files contain updated information and known issues that may not be included in this user's guide.

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

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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 in-circuit emulators
- **In-Circuit Debuggers** – The latest information on the Microchip in-circuit debuggers. These include the MPLAB ICD 2, ICD 3, PICKit™ 2 and PICKit™ 3.
- **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 device programmer and the PICSTART® Plus, PICKit 2 and PICKit 3 development programmers.

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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. See our web site for a complete, up-to-date listing of sales offices.

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



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NOTES:

Chapter 1. Overview

1.1 INTRODUCTION

An overview of the PICKit 3 programmer/debugger system is given.

- PICKit 3 Programmer/Debugger Defined
- How the PICKit 3 Programmer/Debugger Helps You
- PICKit 3 Programmer/Debugger Components
- Device and Feature Support

1.2 PICKIT 3 PROGRAMMER/DEBUGGER DEFINED

The PICKit 3 programmer/debugger (see Figure 1-1) is a simple, low-cost in-circuit debugger that is controlled by a PC running MPLAB IDE (v8.20 or greater) software on a Windows® platform. The PICKit 3 programmer/debugger is an integral part of the development engineer's toolsuite. The application usage can vary from software development to hardware integration.

The PICKit 3 programmer/debugger is a debugger system used for hardware and software development of Microchip PIC® microcontrollers (MCUs) and dsPIC® Digital Signal Controllers (DSCs) that are based on In-Circuit Serial Programming™ (ICSP™) and Enhanced In-Circuit Serial Programming 2-wire serial interfaces. In addition to debugger functions, the PICKit 3 programmer/debugger system also may be used as a development programmer.

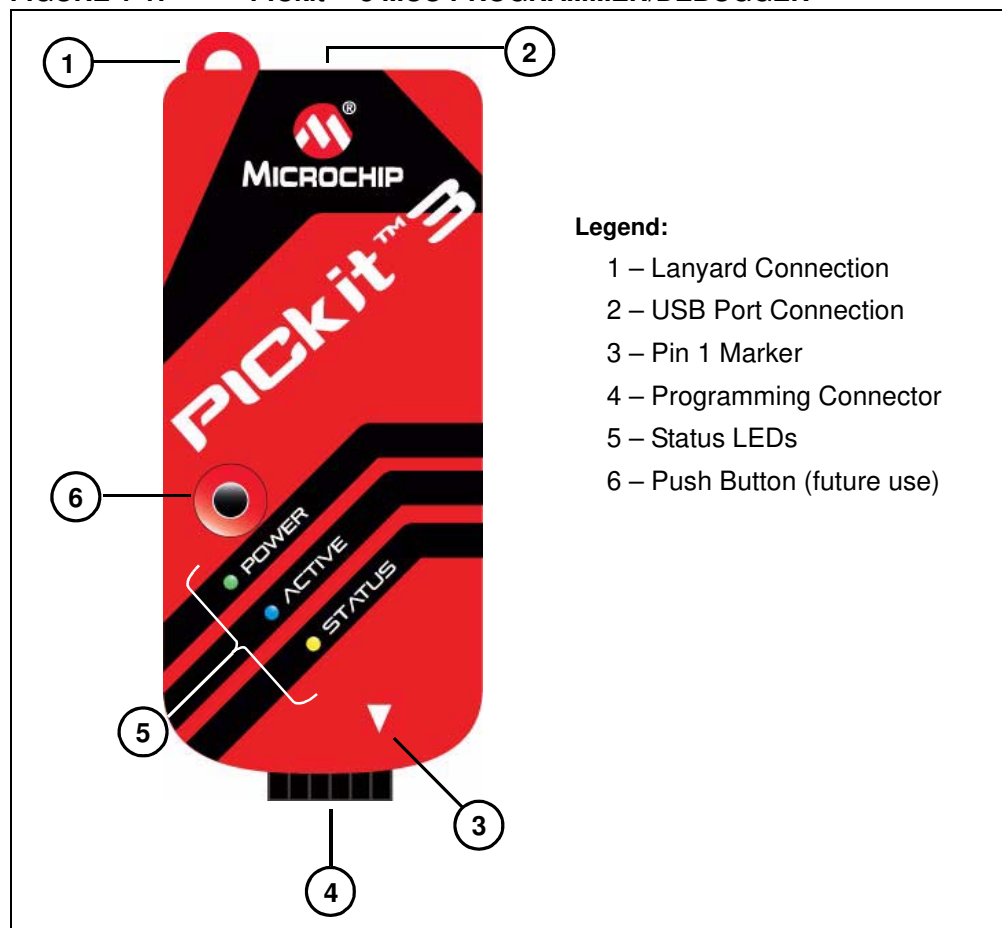
The debugger system executes code like an actual device because it uses a device with built-in emulation circuitry, instead of a special debugger chip, for emulation. All available features of a given device are accessible interactively, and can be set and modified by the MPLAB IDE interface.

The PICKit 3 debugger was developed for emulating embedded processors with debug facilities. The PICKit 3 features include:

- Full-speed USB support using Windows standard drivers
- Real-time execution
- Processors run at maximum speeds
- Built-in over-voltage/short circuit monitor
- Low voltage to 5V (1.8-5V range)
- Diagnostic LEDs (power, active, status)
- Read/write program and data memory of microcontroller
- Erase of all memory types (EEPROM, ID, configuration and program) with verification
- Peripheral freeze at breakpoint

Note: The PICKit 3 is intended for development programming. For production programming, please consider the MPLAB PM3 device programmer or other third party programmers designed for a production environment.

FIGURE 1-1: PICKit™ 3 MCU PROGRAMMER/DEBUGGER



1.2.1 Lanyard Connection

A convenient lanyard connection is available on the programmer.

1.2.2 USB Port Connection

The USB port connection is a USB mini-B connector. Connect the PICKit 3 to the PC using the supplied USB cable.

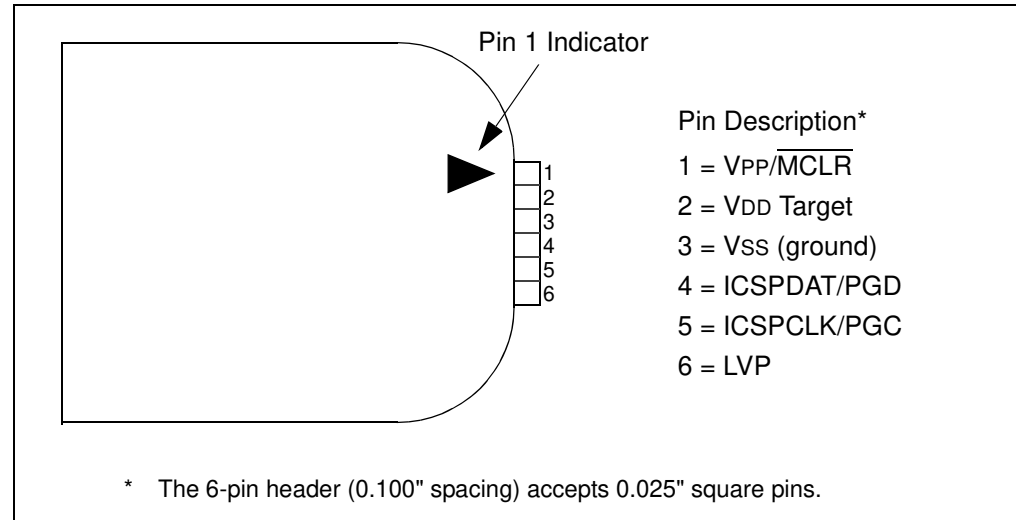
1.2.3 Pin 1 Marker

This marker designates the location of pin 1 for proper connector alignment.

1.2.4 Programming Connector

The programming connector is a 6-pin header (0.100" spacing) that connects to the target device. See the pinout specification in Figure 1-2.

FIGURE 1-2: PICKIT™ 3 PROGRAMMER CONNECTOR PINOUT



Note: The programming connector pin functions are different for programming Serial EEPROMS and HCS devices. See the ReadMe file for the PICKit 3 ([Help>Readme](#)) included with the MPLAB IDE software for these pinouts.

1.2.5 Status LEDs

The Status LEDs indicate the status of the PICKit 3.

1. **Power** (green) – Power is supplied to the PICKit 3 via the USB port.
2. **Active** (blue) – The PICKit 3 has connection to the PC USB port and the communication link is active.
3. **Status:**
 - Busy** (yellow) – The PICKit 3 is busy with a function in progress, such as programming.
 - Error** (red) – The PICKit 3 has encountered an error.

1.3 HOW THE PICKIT 3 PROGRAMMER/DEBUGGER HELPS YOU

The PICKit 3 programmer/debugger allows you to:

- Debug your application on your own hardware in real time
- Debug with hardware breakpoints
- Set breakpoints based on internal events
- Monitor internal file registers
- Emulate at full speed
- Program your device

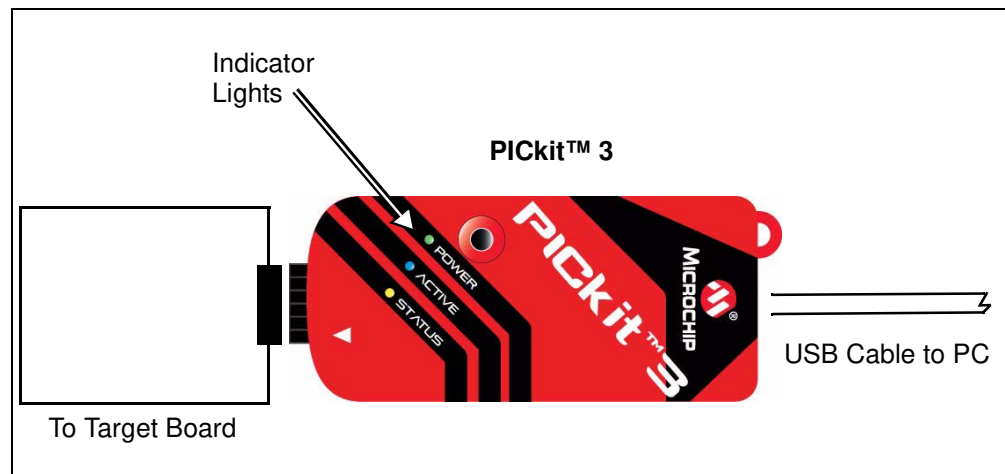
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1.4 PICKIT 3 PROGRAMMER/DEBUGGER COMPONENTS

The components of the PICKit 3 programmer/debugger system are:

1. PICKit 3 with indicator lights for power, activity and status.
2. USB cable to provide communications between the debugger and a PC and to provide power to the debugger.
3. CD-ROM with MPLAB IDE software and on-line documentation.

FIGURE 1-3: BASIC DEBUGGER SYSTEM



Additional hardware that may be ordered separately:

- PICKit 3 Debug Express Kit which includes:
 - a 44-pin demo board with a PIC18F45K20 MCU
 - free version of MPLAB C Compiler for PIC18 MCUs
 - easy-to-understand lessons and tutorials
 - other software utilities, examples with source code and full documentation
- Transition socket
- ICD headers
- MPLAB IDE processor extension kits

1.5 DEVICE AND FEATURE SUPPORT

Table 1-1 and Table 1-2 show the support for devices and device features.

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

Feature	dsPIC33F, PIC24F/H	dsPIC30F SMPS ⁽¹⁾	dsPIC30F
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
Peripheral freeze ⁽²⁾	C	C	C
Break on data fetch or write	C	C	C
Break on stack overflow	N	N	N
Stopwatch	C	C	N
Pass counter	C	C	C
WDT overflow	C	C	N
Standard speed communication	C	C	C
Processor Pak	F	F	N

Legend:

C = Current support

D = Support dependent on device

F = No support now, but planned in the future

N = Support not available

Note 1: Current Switch Mode Power Supply (SMPS) devices: dsPIC30F1010/2020/2023.

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

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

Feature	PIC18FXXJ	PIC18F, PIC18F Enh, PIC18FXXK	PIC12F, 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
Peripheral freeze ⁽¹⁾	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
Standard speed communication	C	C	C
Processor Pak	F	F	F

Legend:

C = Current support

F = No support now, but planned in the future

N = Support not available

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

Chapter 2. Theory of Operation

2.1 INTRODUCTION

A simplified description of how the PICKit 3 programmer/debugger system works is provided here. It is intended to provide enough information so a target board can be designed that is compatible with the debugger 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.

- PICKit 3 vs. PICKit 2
- Debugger to Target Communication
- Communication Connections
- Debugging
- Requirements for Debugging
- Programming
- Resources Used by the Debugger

2.2 PICKit 3 VS. PICKit 2

The PICKit 3 programmer/debugger system is similar in function to the PICKit 2 in-circuit debugger system. Similarities of the two debuggers include:

- Powered via USB cable to PC
- Provides a programmable voltage power supply

The PICKit 3 differs from the PICKit 2 by providing:

- Extended EE program image space (512 Kbytes)
- True voltage reference
- Increased voltage range (1.8-5V V_{DD} ; 1.8-14V V_{PP})

2.3 DEBUGGER TO TARGET COMMUNICATION

The debugger system configurations are discussed in the following sections.

CAUTION

Do not change hardware connections while the PICKit 3 or target is powered.
--

Standard ICSP Device Communication

The debugger system can be configured to use standard ICSP communication for both programming and debugging functions. This 6-pin connection is the same one used by the PICKit 2 programmer/debugger.

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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 2-1), or (2) inserted into a standard adapter/header board combo (available as a Processor Pak), which is then plugged into the target board (Figure 2-2).

Note: Older header boards used a 6-pin (RJ-11) connector instead of an 8-pin connector, so these headers may be connected to the debugger with the AC164110 ICSP adapter.

For more on standard communication, see **Chapter 10. "Hardware Specification"**.

FIGURE 2-1: STANDARD DEBUGGER SYSTEM – DEVICE WITH ON-BOARD ICE CIRCUITRY

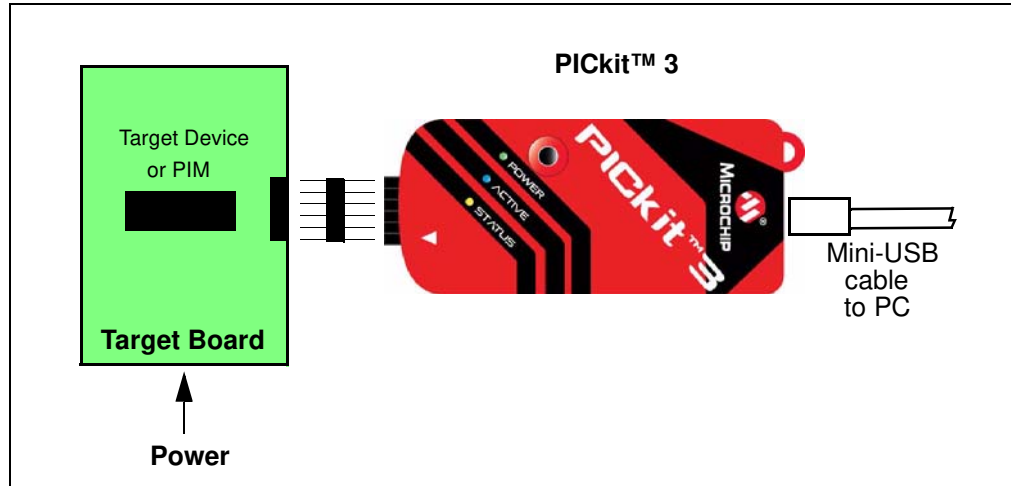
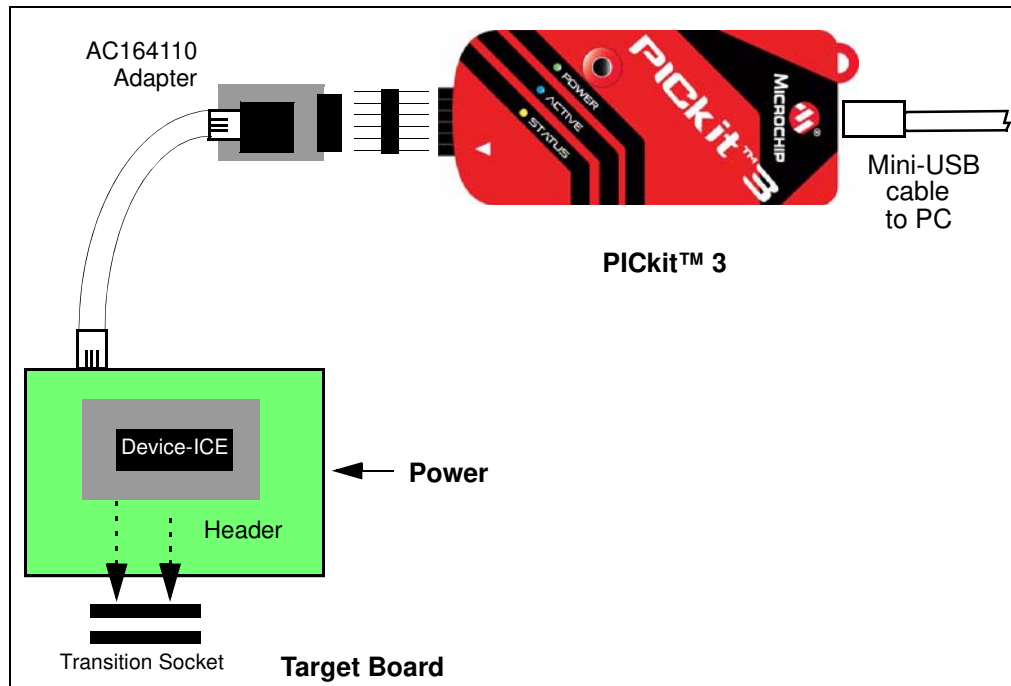


FIGURE 2-2: STANDARD DEBUGGER SYSTEM – ICE DEVICE



2.4 COMMUNICATION CONNECTIONS

2.4.1 Communication Target Connections

2.4.1.1 USING SINGLE IN-LINE CONNECTOR

Use the 6-pin in-line connector between the PICkit 3 programmer/debugger and the target board connector. See Figure 2-1. Also see Table 2-1 and Section 10.6 “Standard Communication Hardware”.

TABLE 2-1: TARGET CONNECTOR PINOUT

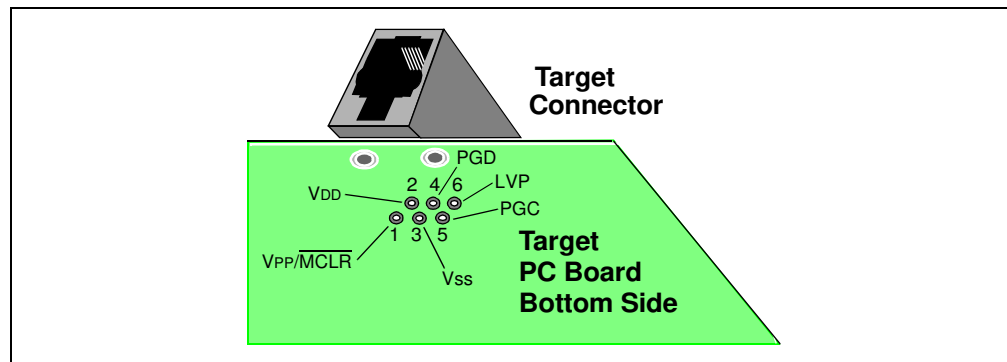
Connector Pin	Microcontroller Pin
1	MCLR/VPP
2	VDD
3	Ground
4	PDG (ICSPDAT)
5	PGC (ICSPCLK)
6	LVP

2.4.1.2 USING AN ADAPTER

Use the AC164110 adapter between the PICkit 3 programmer/debugger and 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 2-3.

Note: Cable connections at the debugger 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 10.6.2.3 “Modular Cable Specification”.

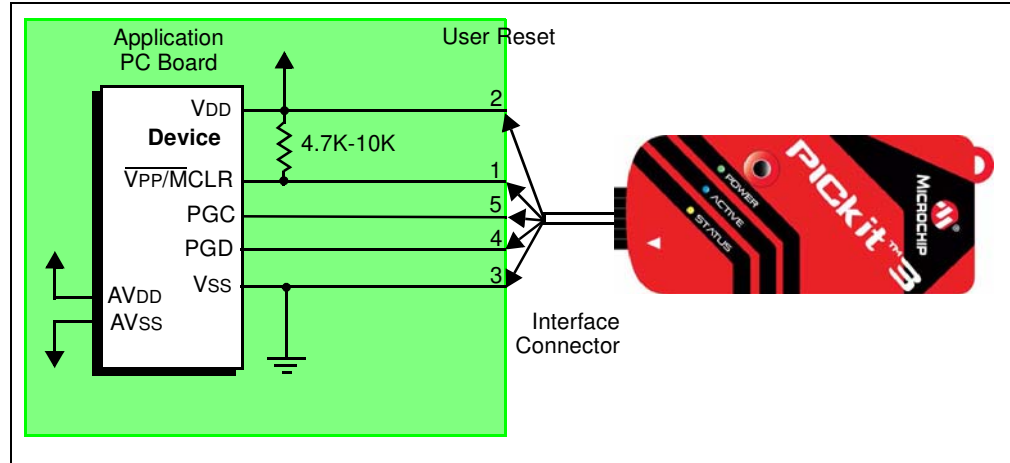
FIGURE 2-3: STANDARD RJ-11 CONNECTION AT TARGET



2.4.2 Target Connection Circuitry

Figure 2-4 shows the interconnections of the PICkit 3 programmer/debugger 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 (usually around 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 2-4: STANDARD CONNECTION TARGET CIRCUITRY



2.4.3 Target Powered

In the following descriptions, only three lines are active and relevant to core debugger operation: pins 1 (VPP/MCLR), 5 (PGC) and 4 (PGD). Pins 2 (VDD) and 3 (VSS) are shown on Figure 2-4 for completeness. PICKit 3 has two configurations for powering the target device: internal debugger and external target power.

The recommended source of power is external and derived from the target application. In this configuration, target VDD is sensed by the debugger to allow level translation for the target low voltage operation. If the debugger does not sense voltage on its VDD line (pin 2 of the interface connector), it will not operate.

2.4.4 Debugger Powered

The internal debugger power is limited to 30 mA. This may be of benefit for very small applications that have the device VDD separated from the rest of the application circuit for independent programming, but is not recommended for general usage as it imposes more current demands from the USB power system derived from the PC.

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 debugger to operate. They cannot be left floating.

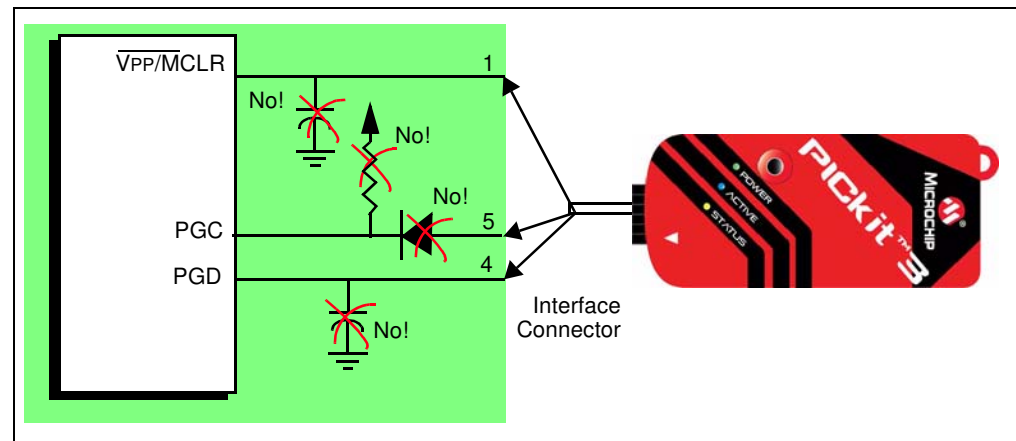
In general, it is recommended that all VDD/AVDD and VSS/AVSS lines be connected to the appropriate levels. Also, devices with a VCAP line (PIC18FXXJ for example) should be connected to the appropriate capacitor or level.

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 PICKit 3 programmer/debugger, as discussed in the following section.

2.4.5 Circuits That Will Prevent the Debugger From Functioning

Figure 2-5 shows the active debugger lines with some components that will prevent the PICkit 3 debugger system from functioning.

FIGURE 2-5: IMPROPER CIRCUIT COMPONENTS



Specifically, these guidelines must be followed:

- Do not use pull-ups on PGC/PGD – they will disrupt the voltage levels, since these lines have 4.7 k Ω pull-down resistors in the debugger.
- 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{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 debugger and the target device.

2.5 DEBUGGING

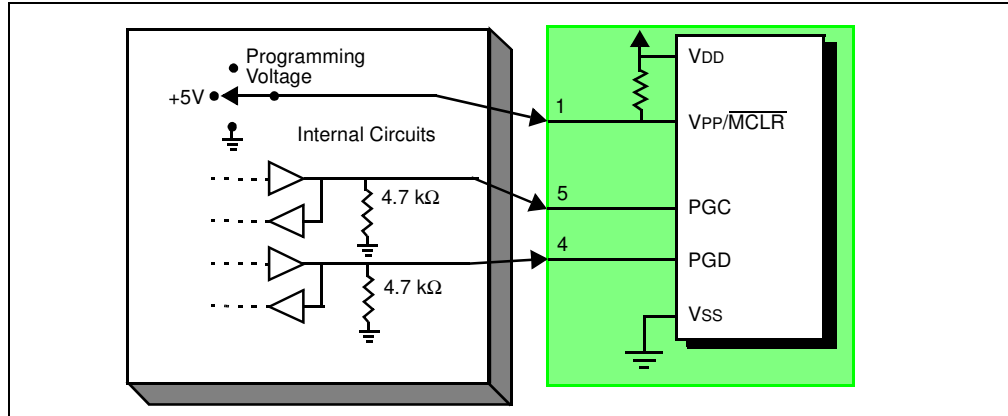
There are two steps to using the PICkit 3 programmer/debugger system as a debugger. The first requires that an application be programmed into the target device (usually with the PICkit 3 itself). The second uses the internal in-circuit debug hardware of the target Flash device to run and test the application program. These two steps are directly related to the MPLAB IDE operations:

1. Program the code into the target and activate special debug functions (see the next section for details).
2. Use the debugger to set breakpoints and run.

If the target device cannot be programmed correctly, the PICkit 3 programmer/debugger will not be able to debug.

Figure 2-6 shows the basic interconnections required for programming. Note that this is the same as Figure 2-4, but for the sake of clarity, the VDD and VSS lines from the debugger are not shown.

FIGURE 2-6: PROPER CONNECTIONS FOR PROGRAMMING



A simplified diagram of some of the internal interface circuitry of the PICKit 3 programmer/debugger is shown. For programming, no clock is needed on the target device, but power must be supplied. When programming, the debugger puts programming levels on VPP/MCLR, 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.

2.6 REQUIREMENTS FOR DEBUGGING

To debug (set breakpoints, see registers, etc.) with the PICKit 3 programmer/debugger system, there are critical elements that must be working correctly:

- The debugger must be connected to a PC. It must be powered by the PC via the USB cable, and it must be communicating with the MPLAB IDE software via the USB cable. See **Chapter 3. "Installation"** for details.
- The debugger must be connected as shown to the VPP, PGC and PGD pins of the target device with the modular interface cable (or equivalent). VSS and VDD are also required to be connected between the debugger and target device.
- The target device must have power and a functional, running oscillator. If the target device does not run, for any reason, the PICKit 3 programmer/debugger 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.
- LVP should be disabled.

Once the above conditions are met, you may proceed to the following:

- Sequence of Operations Leading to Debugging
- Debugging Details

2.6.1 Sequence of Operations Leading to Debugging

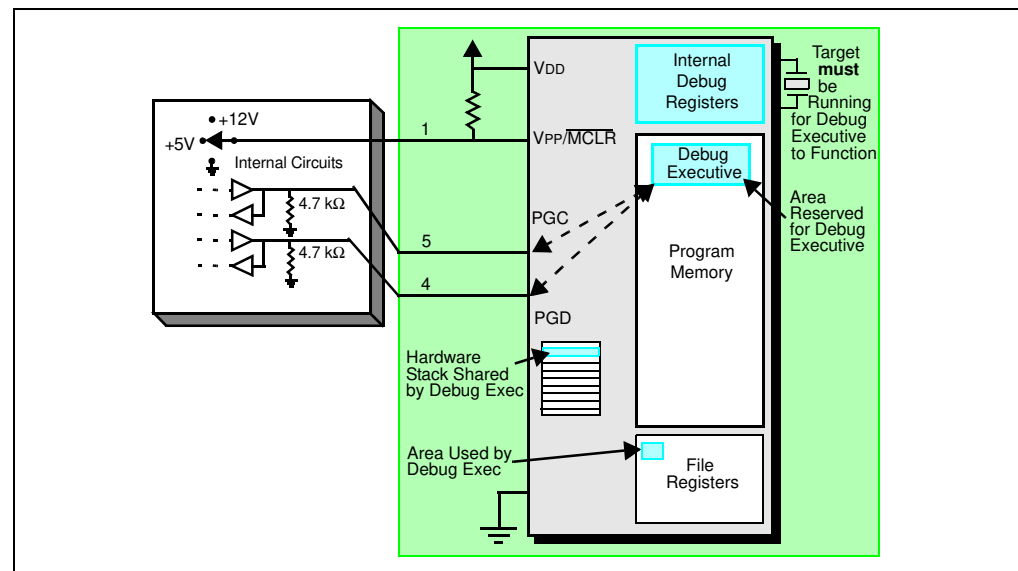
Given that the requirements for debugging (see previous section) are met, these actions can be performed when the PICkit 3 programmer/debugger is set as the current debugger from the MPLAB IDE menu (*Debugger>Select Tool>PICkit 3*):

- The application code is compiled/assembled by selecting *Project>Build Configuration>Debug*.
- When *Debugger>Program* is selected, the application code is programmed into the device's memory via the ICSP protocol as described above.
- A small "debug executive" program is loaded into the high area of program memory of the target device automatically by MPLAB IDE. 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. These allow the debug executive to be activated by the debugger.
- The target device is held in reset by keeping the VPP/MCLR line low.

2.6.2 Debugging Details

Figure 2-7 illustrates the PICkit 3 programmer/debugger system when it is ready for debugging.

FIGURE 2-7: PICkit™ 3 DEBUGGER 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 *Debugger>Run* function or the Run icon (forward arrow) is usually pressed from MPLAB IDE. The debugger 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 the device's Program Counter to the debug executive (much like an interrupt) and the user's application is effectively