

Getting Started with PIC32 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 "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 online help. Select the Help menu, and then Topics to open a list of available online help files.

INTRODUCTION

This document is intended to enable new PIC32 users to get a basic hardware and software understanding of the PIC32 architecture and quickly get started with software development for PIC32 products.

This document is primarily written for anyone wanting to get overview knowledge of PIC32 microcontrollers and associated technical collateral provided by Microchip and its third party tools partners. A basic understanding of embedded systems development and 'C' programming knowledge is required, if you are planning to follow step-by-step instructions provided later in this document.

This chapter contains general information that will be useful to know before using the PIC32. Items discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- Recommended Reading
- The Microchip Web Site
- Development Systems Customer Change Notification Service
- Customer Support
- Document Revision History

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DOCUMENT LAYOUT

This document is divided into 6 sections. Sections 1 through 4 provide an overview of PIC32 products. Section 5 provides an overview of PIC32 development tools. Section 6 describes the procedure to setup a development environment and debug a sample application. The manual layout is as follows:

- **Chapter 1. PIC32 Features**
- **Chapter 2. PIC32 Product Family**
- **Chapter 3. PIC32 Architecture**
- **Chapter 4. PIC32 Tools**
- **Chapter 5. Step-by-Step Procedures to Setup, Build, and Run a Demo Project**
- **Chapter 6. Technical Support Resources**

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CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	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 characters	A dialog button	Click **OK**
	A tab	Click the **Power** tab
N'Rnnnn	A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.	4'b0010, 2'hF1
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier New font:		
Plain Courier New	Sample source code	`#define START`
	Filenames	`autoexec.bat`
	File paths	`c:\mcc18\h`
	Keywords	`_asm, _endasm, static`
	Command-line options	`-Opa+, -Opa-`
	Bit values	`0, 1`
	Constants	`0xFF, 'A'`
Italic Courier New	A variable argument	*`file`*`.o`, where *`file`* can be any valid filename
Square brackets [ ]	Optional arguments	`mcc18 [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 user's guide describes how to use PIC32. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

Readme for the PIC32MX
For the latest information on using PIC32 microcontrollers, read the file (an ASCII text file) at the root level of the CD included in the PIC32 Starter Kit. The file generally contains the most current update information, as well as any issues that may not have been available when this document was published.

Readme Files

For the latest information on using other tools, read the tool-specific readme files in the `Readmes` subdirectory of the PIC32MX Starter Kit installation directory. The files contain update information, as well as any issues that may not have been available when this document was published.

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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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 and other language tools. These include the MPLAB C18 and MPLAB C32 C compilers; and MPLAB LIB30 object librarians.
- **Emulators** – The latest information on Microchip in-circuit emulators.This includes the MPLAB ICE 2000 and MPLAB ICE 4000.
- **In-Circuit Debuggers** – The latest information on the Microchip in-circuit debugger, MPLAB ICD 2.
- **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 SIM simulator, MPLAB IDE Project Manager and 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, PICkit® 1 and PICkit® 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
- Development Systems Information Line

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

DOCUMENT REVISION HISTORY

Revision A (October 2007)

- Initial Release of this Document.

Revision B (March 2008)

- Updates

NOTES:

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Chapter 1. PIC32 Features

1.1 INTRODUCTION

The PIC32 is a 32-bit family of general purpose microcontrollers from Microchip Technology. It offers 80+ DMIPS performance with a wide variety of on-chip peripherals. It employs industry leading M4K MIPS32 core from MIPS Technologies, Inc. All members in the PIC32 family use programming interface similar to other Microchip PIC® microcontrollers. In addition, PIC32 microcontrollers are pin-to-pin compatible with the PIC24FJ128GA family of 16-bit microcontrollers.

1.2 HIGHLIGHTS

The PIC32 family offers a number of features to enable a wide variety of applications. The following subsections list all the key features grouped in major categories.

Performance:

- Up to 80 MHz, MIPS M4K 32-bit core with 5 stage pipeline
- High-performance hardware multiply/divide unit – 1 multiply per clock
- Programmable user and kernel memory partition for enhanced application stability
- Multiple register sets for reduced interrupt latency
- Hardware assisted single-cycle register bits manipulations
- 128-bit wide Flash memory to shorten individual instruction fetch time
- 256 bytes of high-speed cache memory with instruction and ROM data prefetch buffer
- Available DMA controller with integrated CRC calculation and pattern-based transfer termination
- Includes USB On-The-Go controller for USB device, host, or dual-role applications
- USB controller has own dedicated DMA interface

Power Management:

- 2.3 to 3.6V operation
- Full-speed operation over entire voltage range
- Various low-power modes including RUN, IDLE and SLEEP
- I/O transfers via DMA in IDLE mode
- Programmable peripheral clock
- Individual peripheral ON/OFF control and operation during IDLE mode
- Multiple clock sources

Scalability:

- Industry known MIPS32-compatible M4K CPU core with 5 stage pipeline
- Large family of devices with Flash memory options from 32 KB to 512 KB
- Pin compatible with 64/100 pin PIC24FJXXXGA family of 16-bit microcontrollers

Ease of Use:

- PIC® microcontroller “look and feel” peripherals
- Standard MPLAB® tool-suite – MPLAB IDE, MPLAB C32 C Compiler, MPLAB REAL ICE™, and MPLAB ICD 2.
- Software Peripheral Libraries compatible with those for Microchip 16-bit microcontrollers
- Microchip developed middleware modules such as TCP/IP and 16-bit file system

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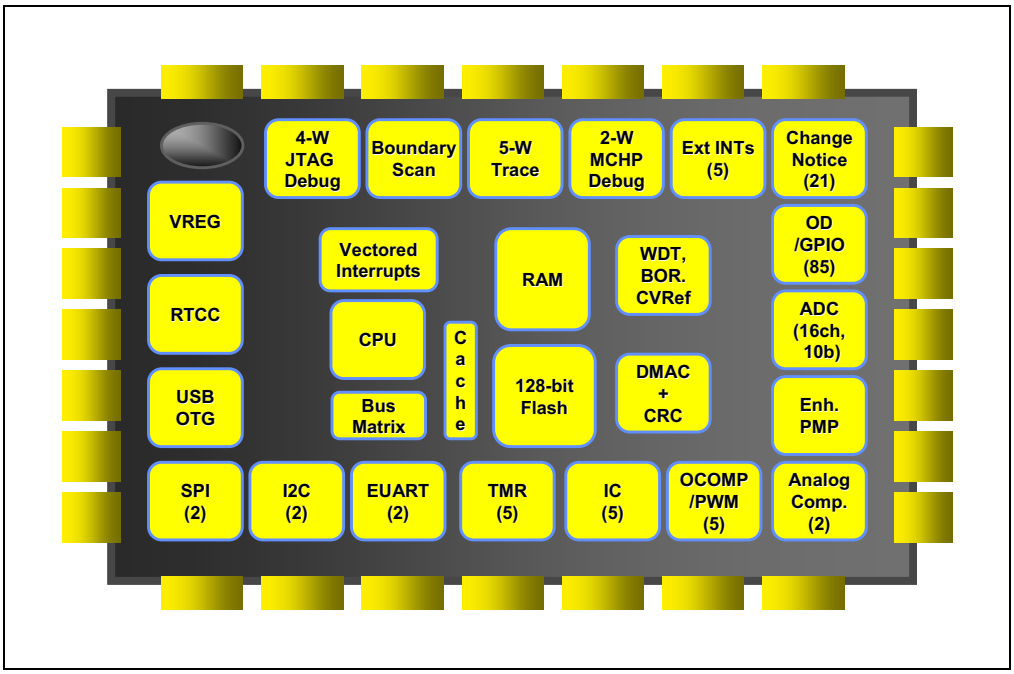
Chapter 2. PIC32 Product Family

2.1 INTRODUCTION

The PIC32 family includes scalable devices ranging from 32KB to 512KB of Flash memory. Also a rich set of peripherals – Five timers, 16 channels of 10-bit A/D Converters and communication interfaces: SPI, I^2C™ and UART.

Please consult the "*PIC32MX Family Data Sheet*" (DS61143) for a complete list of family variants, core and peripheral characteristics.

FIGURE 2-1: PIC32 MCU MODULES



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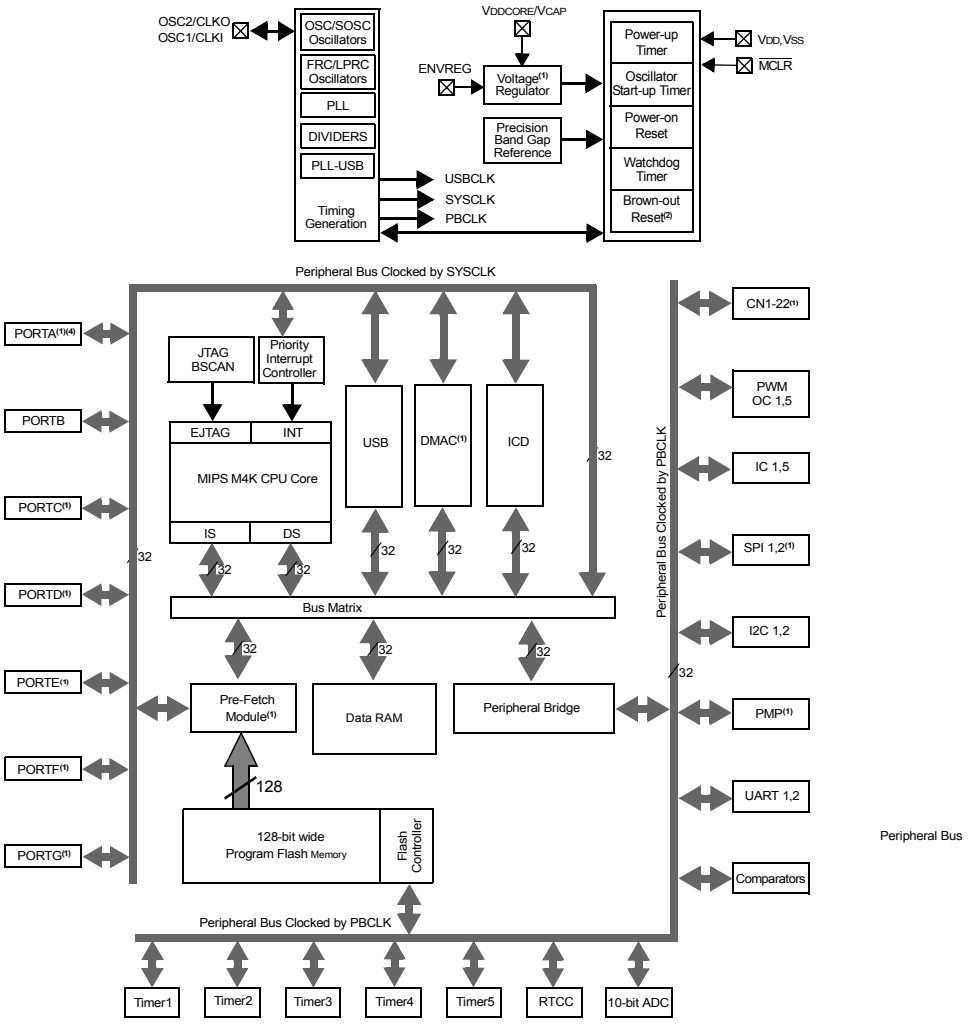
Chapter 3. PIC32 Architecture

3.1 INTRODUCTION

The PIC32 family of MCUs combines the MIPS M4K core together with powerful peripherals and embedded Flash and RAM memory to address a wide range of applications.

FIGURE 3-1: PIC32 BLOCK DIAGRAM



Note 1: Not all pins or features are implemented on all device pinout configurations. See Table 1-4 for I/O port pin descriptions.

2: Some features are not available on certain device variants.

3: BOR functionality is provided when the on-board voltage regulator is enabled.

4: PORTA is not present on 64 pin devices

Processor core:

- MIPS M4K with 5-stage pipeline
- MIPS32-compatible Release 2 Instruction Set
- MIPS16e™ Code Compression to improve code density by up to 40%
- GPR shadow registers to minimize latency for interrupt handlers
- Bit field manipulation instructions
- High-performance Multiply/Divide Unit:
  - Maximum issue rate of one 32x16 multiply per clock
  - Maximum issue rate of one 32x32 multiply every other clock
- Static implementation: minimum operating frequency 0 MHz
- 2.3 to 3.6V operation with full speed over entire range
- Low-power modes including RUN, IDLE, and SLEEP

Memory:

- Unified 4GB virtual memory space
- Fixed Memory Mapping Translation (FMT) mechanism
- Flexible partitioning into kernel and user accessible memory segments for increased application stability

Pre Fetch Cache:

- 16 lines, each 128-bit wide, instruction Prefetch buffer
- Ability to load and lock lines – useful to create SW breakpoints in Flash and minimize interrupt latency

Interrupt Controller:

- Fully programmable interrupt controller with Single or Multi vector mode, supporting up to 95 IRQs.
- Multiple priorities and subpriorities for each vector
- Highest priority interrupt has dedicated register set for reduced interrupt latency

DMA Controller:

- Up to 4 independent channels
- Memory-to-Memory, Memory-to-Peripheral, and Peripheral-to-Memory transfers
- Programmable trigger from any IRQ
- Chainable channels, stop on match detection, Auto-Enable mode
- Data transfers can occur while the core is in IDLE mode
- Integrated programmable CRC engine: calculates on the fly while the data is transferred.

Enhanced Parallel Master Port:

- 8- and 16-bit data interface
- Up to 16-bit address lines, expandable using GPIO lines
- 2 Chip Select lines

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Communication channels:

- USB 2.0 compliant (FS. 12 Mbps), OTG, Host and Device-only capable
- 2 enhanced UART channels with hardware IrDA®
- 2 Master/Slave/Frame mode SPI channels
- 2 Master/Slave I^2C channels, 10/7 bits mode addressing, broadcast capable

Analog-to-Digital Converters:

- Up to 16 Channels, each 10-bit resolution ADCs
- Up to 500+ kilo-samples per second (ksps) conversion speed
- Software selectable Internal or External voltage reference
- Automatic Channel Scan mode
- Selectable conversion trigger source
- 16 word conversion result buffer
- Selectable Buffer Fill modes
- Eight result alignment options
- Operation during CPU Sleep mode

Timers:

- 5 16-bit timer/counter with the ability to form up to (2) 32-bit timer/counters
- Software-selectable internal or external clock source
- Asynchronous timer/counter with built-in oscillator
- Programmable interrupt generation and priority
- Gated external pulse counter
- Software-selectable prescalers.
- Operational during CPU Sleep mode

Core Timer:

- 32 bit timer in CPU for implementing a timer interrupt function.

RTCC (Real-Time Clock and Calendar):

- Time with hours, minutes and seconds
- Calendar with weekday, date, month and year
- Leap year detection
- Highly configurable alarm
- Calibration of up to 260 ppm of crystal error

Debug and Programming:

- 6 instructions and 2 data breakpoints
- 2 complex breakpoint logic blocks with qualified/primed breakpoint triggers, Pass counters, and stopwatch timers.
- 4-wire EJTAG and 2-wire Microchip interface
- 2-wire Microchip Interface:
  - 6 real-time read/write capture logic blocks
  - Read/write access to all data RAM and SFRs without stopping CPU
- Instruction Trace Port:
  - 5-Wire, nonintrusive trace port
  - Triggered by complex breakpoint logic block

GPIO:

- 5V tolerant inputs
- Individual output pin open-drain enable/disable
- Individual input pin weak pull-up enable/disable
- Monitor selective inputs and generate interrupt on mismatch condition

Note:	Input pin weak pull-up and interrupt on mismatch features are available only on select I/O pins.

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Chapter 4. PIC32 Tools

4.1 INTRODUCTION

The PIC32 microcontrollers are supported by the MPLAB Integrated Development Environment and its full range of hardware and software tools.

4.2 HIGHLIGHTS

Items discussed in this chapter are:

- MPLAB IDE
- MPLAB C32 C Compiler
- Peripheral Libraries
- Software Solutions
- Demonstration, Development and Evaluation Boards
- Technical Documentation

4.3 MPLAB IDE

The Microchip MPLAB IDE is a FREE development toolsuite for Microsoft Windows® that contains:

- A single graphical interface to all debugging tools:
  - Simulator
  - Programmers
  - Emulators
  - In-Circuit Debuggers
- A full-featured editor with color-coded context
- A project manager
- Customizable data windows with in-place editable contents
- High-level source code debugging
- Extensive on-line help

The MPLAB IDE provides integrated debugging and programming facilities using any of the following probes connected to the target processor/Development Board:

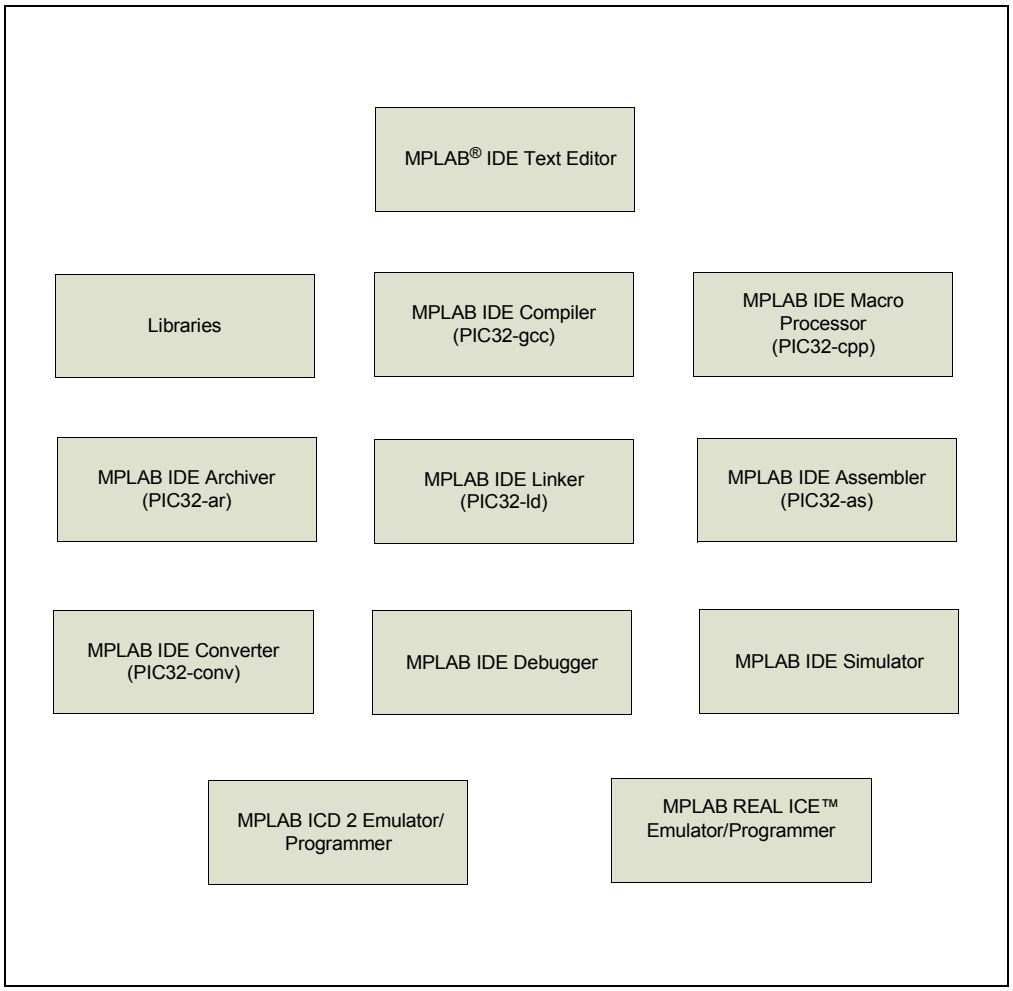
- MPLAB ICD 2 In-Circuit Debugger: a low-cost, run-time development tool.
- MPLAB REAL ICE In-Circuit Emulator: a high speed in-circuit emulator with hardware and software trace capabilities.
- FS2 JTAG probe: Developed by First Silicon Solutions, this probe uses 4-wire EJTAG interface to debug and program the PIC32 microcontrollers.
- MPLAB PM3 Device Programmer: a Microchip universal device programmer suitable for development and manufacturing purposes.
- MPLAB SIM32 Device Simulator: Accurately simulates many PIC32 peripherals and the CPU in selectable cycle and clock-accurate modes

4.4 MPLAB C32 C COMPILER

The MPLAB C32 C Compiler package allows you to build your applications and contains the following key software components (see Figure 4-1).

- **PIC32-gcc** Compiler: complete ANSI C compiler with powerful integration capabilities and efficient code optimization. The compiler provides symbol information that is used by the MPLAB IDE debugger.
- **PIC32-gpp** Macro Processor: used automatically by the compiler to transform the program before compilation.
- **PIC32-as** Assembler: full-featured macro assembler.
- **PIC32-ld** Object Linker: links relocatable objects created by the assembler/compiler with those from precompiled libraries.
- **PIC32-ar** Archiver and Librarian: manages the creation and modification of library files of precompiled code.
- **PIC32-conv**: converts ELF executable files into ASCII or binary format, suitable for downloading onto a PROM programmer or evaluation board.

FIGURE 4-1: MPLAB® IDE DEVELOPMENT TOOLS COMPONENTS



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4.5 PERIPHERAL LIBRARIES

PIC32 MCUs integrate a large number of on-chip high-performance peripherals.

To accelerate the usage of these peripherals, the MPLAB C32 compiler for PIC32 includes software peripheral libraries compatible with the 16-bit Microchip MCUs. The peripheral libraries are distributed in source and object format along with a detailed API description document. Software applications using MPLAB C32 compiler may call peripheral library functions by simply including the appropriate header file in their source files – the MPLAB C32 compiler has built-in knowledge of library header and archive files.

The peripheral include files are located in `C:\Program Files\Microchip\MPLAB C32\pic32mx\include\peripheral` and the full source code is located in `C:\Program Files\Microchip\MPLAB C32\pic32-libs\peripheral` location in corresponding peripheral sub-directory.

The Peripheral Library contains following include files:

TABLE 4-1: PERIPHERAL LIBRARY

Peripheral	Header File	Description
ADC	adc10.h	Library for the Analog-to-Digital converters support
Memory Org	bmx.h	Library for configuring the Bus Matrix internal buses, priorities and memory layout
Analog Comparators	cmp.h	Library for the Comparator modules support
Comparator Voltage Reference	cvref.h	Library for the Comparators Voltage reference support
DMA Controller	dma.h	Library for the DMA Controller and CRC module support
Nonvolatile (Flash) Memory	nvm.h	Library providing access to Flash erase/program functions
I^2C™	i2c.h	Library for I^2C™ module support
Input Capture	incap.h	Library for the Input Capture module suport
Interrupts	int.h	Library for the vectored Interrupt Controller support
Lock	lock.h	Library for the system lock and unlock support
Output Compare	outcompare.h	Library for Output Compare module support
Oscillator	osc.h	Library for Oscillators support
Prefetch Cache	pcache.h	Library for prefetch-cache module support
Power Modes	power.h	Library for Sleep and Idle operationsl power modes support
Parallel Master Port	pmp.h	Library for Parallel Master Port support
GPIO	ports.h	Library for configuring the I/O ports, reading or writing I/O data
Reset	reset.h	Library for Reset control and status
RTCC	rtcc.h	Library for Real-Time Clock and Calendar support
SYSTEM	system.h	Library for system level operations
SPI	spi.h	Library for Serial Peripheral Interface support
Timer	timer.h	Library to support 16 and 32-bit timers
UART	uart.h	Library supporting the enhanced UART module
Watchdog	wdt.h	Library to support the Watchdog Timer module

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4.6 SOFTWARE SOLUTIONS

At the time of writing this document, Microchip had not released any drivers. Microchip does intend to develop drivers for key communication peripherals.

4.6.1 Middleware

The following list provides the Microchip middleware components available at the time of writing this document:

- 16-bit file system on SD Memory to support Microsoft MS-DOS file system.
- Two types of TCP/IP stack – 1) Microchip legacy TCP/IP Stack – fully compatible with Microchip 8- and 16-bit Stack, 2) Microchip BSD TCP/IP Stack – A Berkeley socket API stack with many advanced features.
- TCP/IP middleware:
  - FTP server to allow the application running on the target PIC32 machine to be a File Transfer Protocol server.
  - SNMP Agent to monitor PIC32 products using SNMP protocol.
  - Web server to accept HTTP requests from Web browsers clients.
- USB middleware:
  - USB Embedded Host Stack (HID and Mass Storage)
  - USB Device Stack (HID, Mass Storage and CDC class)

4.6.2 3rd Party Tools

Check the PIC32 home page (www.microchip.com/PIC32) to learn about the list of companies with support for PIC32.

4.7 DEMONSTRATION, DEVELOPMENT AND EVALUATION BOARDS

A wide variety of demonstration, development and evaluation boards for PIC32 MCUs allow quick application development on fully functional systems. Most boards include prototyping areas for adding custom circuitry and provide application firmware and source code for examination and modification. These boards support a variety of features, including LEDs, switches, RS-232 interfaces, LCD displays, etc. The demonstration and development boards can be used in teaching environments, for prototyping custom circuits and for learning about various microcontroller applications.

Currently, the following boards are available:

1. PIC32MX Starter kit (DM320001).
2. Explorer 16 board (DM240001) with PIC32 Plug-in Modules.

4.8 TECHNICAL DOCUMENTATION

The current set of documents that are available for PIC32 MCUs:

- Application Notes:
  - AN833, "*Microchip TCP/IP Stack"* (DS00833)
  - AN1107, "*HTTP Server for the Microchip BSD TCP/IP Stack"* (DS01107)
  - AN1108, "*Microchip TCP/IP Stack with BSD Socket API"* (DS01108)
  - AN1109, "*An SNMP Agent for the Microchip TCP/IP Stack"* (DS01109)
  - AN1111, "*The Microchip FTP Server Using BSD Socket API"* (DS01111)
  - AN1140, "*USB Embedded Host Stack*" (DS01140)
  - AN1141, "*USB Embedded Host Stack Programmer's Guide*" (DS01141)
  - AN1142, "*USB Mass Storage Class on an Embedded Host*" (DS01142)
  - AN1143, "*USB Generic Client on an Embedded Host*" (DS01143)
  - AN1144, "*USB HID Class on an Embedded Host*" (DS01144)
  - AN1145, "*Using a USB Flash Drive on an Embedded Host*" (DS01145)
  - AN1176, "*USB Devcie Stack for PIC32 Programmer's Guide*" (DS01176)
  - AN1166, "*USB Generic Function on an Embedded Device*" (DS01166)
  - AN1163, "*USB HID Class on an Embedded Device*" (DS01163)
  - AN1169, "*USB Mass Storage Class on an Embedded Device*" (DS01169)
  - AN1164, "*USB CDC Class on an Embedded Device*" (DS01164)
- Data Sheets:
  - DS61143 – *PIC32MX Family Data Sheet*
- Family Reference Manuals:
  - DS61132 – *PIC32MX Family Reference Manual*
- Code Examples:
  - PIC32 examples available in `C:\ProgramFiles\Microchip\MPLAB C32\examples` and on www.microchip.com/pic32.
- Errata (DS80350, DS80367)
- Migration Documents – available in future
- Design Notes, Tips and Tricks – available in future
- Development Tool Ordering Guide – available in future

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Chapter 5. Step-by-Step Procedures to Setup, Build, and Run a Demo Project

5.1 INTRODUCTION

In this step-by-step procedure, the basic concepts of the MPLAB Project Manager, Editor and Debugger will be presented. You will create a simple project and understand the debug capabilities of MPLAB IDE.

No previous MPLAB IDE knowledge is assumed. For complete features set and comprehensive technical details of MPLAB IDE and its components, please visit our web site (www.microchip.com/ide).

5.2 HIGHLIGHTS

Items discussed in this chapter are:

- MPLAB IDE Setup
- Step-by-Step Guide Overview
- Selecting the Device
- Creating the Project
- Setting Up Language Tools
- Naming the Project
- Adding Files to the Project
- Attaching the Debugger
- Building the Project
- Testing the Code

5.3 MPLAB IDE SETUP

5.3.1 Install MPLAB IDE

To install the MPLAB on your system, you could either use the supplied installation CD or download the latest MPLAB IDE from the Microchip web site.

- To install from a CD-ROM, just place the disk into a CD drive and follow the on-screen prompts (you could use Windows Explorer to find and execute the CD-ROM menu, `menu.exe`).
- If the MPLAB IDE was downloaded from the Microchip web site, unzip the file and execute the resulting file to install.

Note: Administrative access will be required to install the MPLAB on a PC.

5.3.2 To uninstall MPLAB IDE

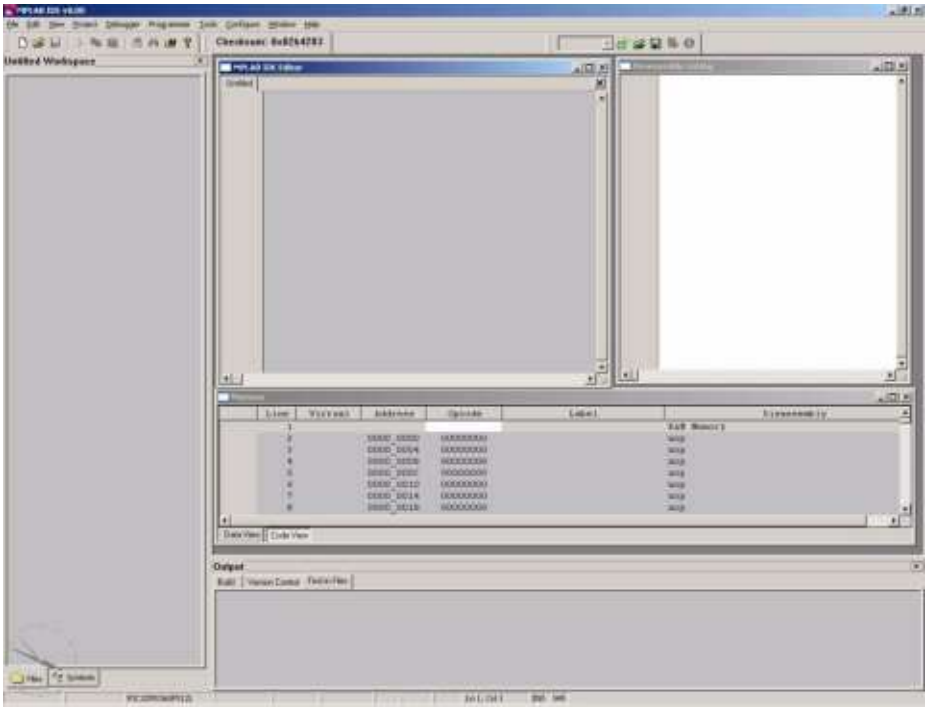
- Select *Start>Settings>Control Panel* to open the control panel.
- Double click on Add/Remove Programs. Find MPLAB IDE and select it.
- Click Change/Remove to remove the program from your system.

Note: Administrative access might be required in order to uninstall the MPLAB.

5.3.3 Running MPLAB IDE

To start MPLAB IDE, double click on the icon installed on the desktop after installation or select *Start>Programs>Microchip>MPLAB IDE vx.xx>MPLAB IDE*. A screen will display the MPLAB IDE logo followed by the MPLAB IDE desktop.

FIGURE 5-1: MPLAB IDE START SCREEN



5.4 STEP-BY-STEP GUIDE OVERVIEW

To create code that is executable by the PIC32 MCU, source files need to be part of a project. The code can then be built into executable code using selected language tools (assemblers, compilers, linkers, etc.). In MPLAB IDE, the project manager controls this process and will guide us through most of these steps.

All projects will have these basic steps:

- Select Device

The capabilities of MPLAB IDE vary according to which device is selected. Device selection should be completed before starting a project.

- Create Project

MPLAB IDE Project Wizard will be used to create a project.

- Select Language Tools

In the Project Wizard the language tools will be selected. For this tutorial, the PIC32 tools will be used. For other projects, either other Microchip or third party tools might be selected.

- Add Files in Project

We'll add a template file and a linker script to the project.

- Create Code

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Some very simple code will be added to the template file to print a “Hello World…” string to a serial console connected to the evaluation board. We will use the UART Peripheral Library provided by Microchip.

- Build Project

The project will be built – causing the source files to be compiled and linked into machine code that can run on the selected PIC32 MCU.

- Test Code

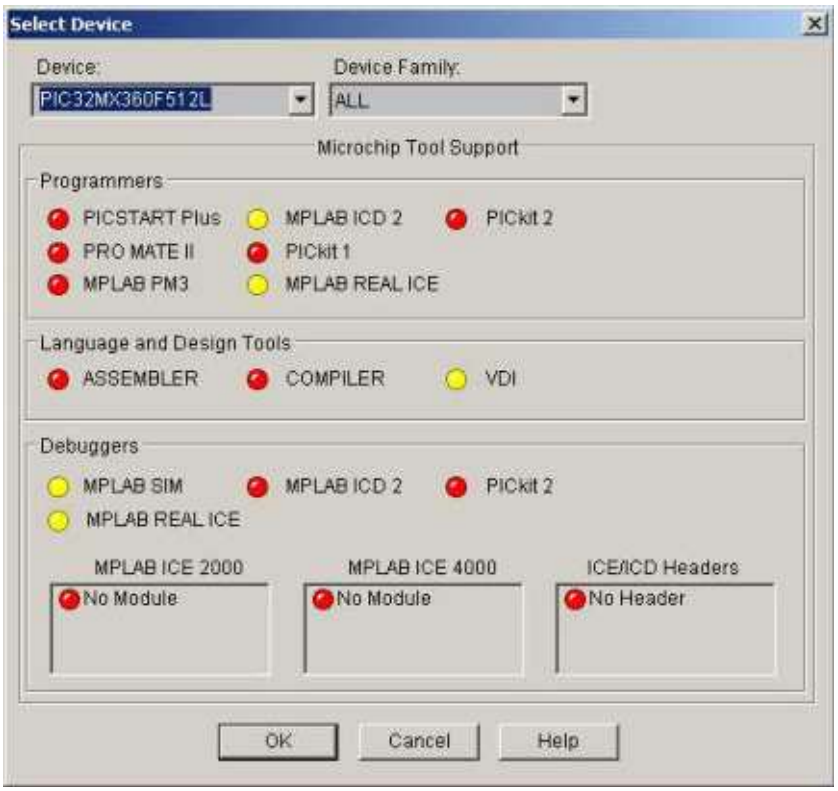
Finally, the code will be tested by running it on the evaluation board.

Note:	Some aspects of the user interface will change in future product releases and the screen shots in this guide may not exactly match the appearance of the MPLAB IDE desktop in later releases.

5.5 SELECTING THE DEVICE

Choose *Configure>Select Device* from the top IDE menu. In the Device dialog, select the PIC32 variant from the drop-down list.

FIGURE 5-2: MPLAB IDE SELECT DEVICE



The “lights” indicate which MPLAB IDE components support this device.

- A green light indicates full support.
- A yellow light indicates preliminary support for an upcoming part by the particular MPLAB IDE tool component. Components with a yellow light instead of a green light are often intended for early adopters of new parts who need quick support and understand that some operations or functions may not be available.
- A red light indicates no support for this device. Support may be forthcoming or inappropriate for the tool.

5.6 CREATING THE PROJECT

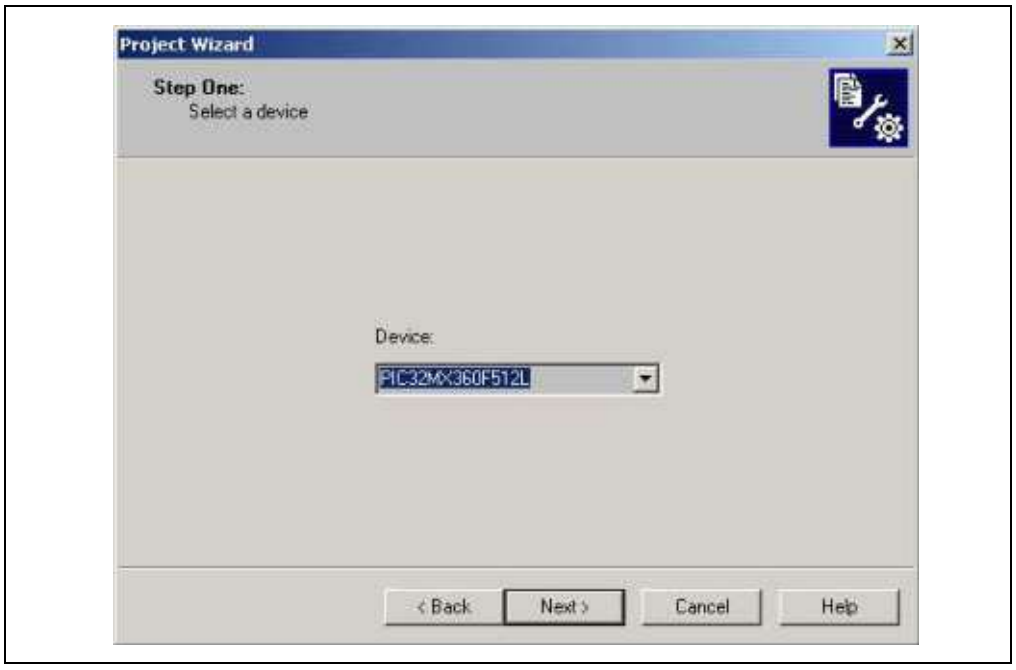
The next step is to create a project using the Project Wizard. A project is the way the files are organized to be compiled, assembled and linked. We will use a single "C" file for this project and a linker script.

Choose *Project>Project Wizard*.

From the Welcome dialog, click on **Next>** to advance.

The Step One dialog allows you to select the device, which we've already done. Make sure that it displays the proper PIC32 variant. If not, select the required PIC32 variant from the drop down menu. Click **Next>**.

FIGURE 5-3: MPLAB IDE WIZARD SELECT DEVICE



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5.7 SETTING UP LANGUAGE TOOLS

Step Two of the Project Wizard sets up the language tools that are used with this project. Make sure the “Show all installed toolsuites” checkbox is checked. Select Microchip PIC32 C Compiler Toolsuite in the Active Toolsuite list box.

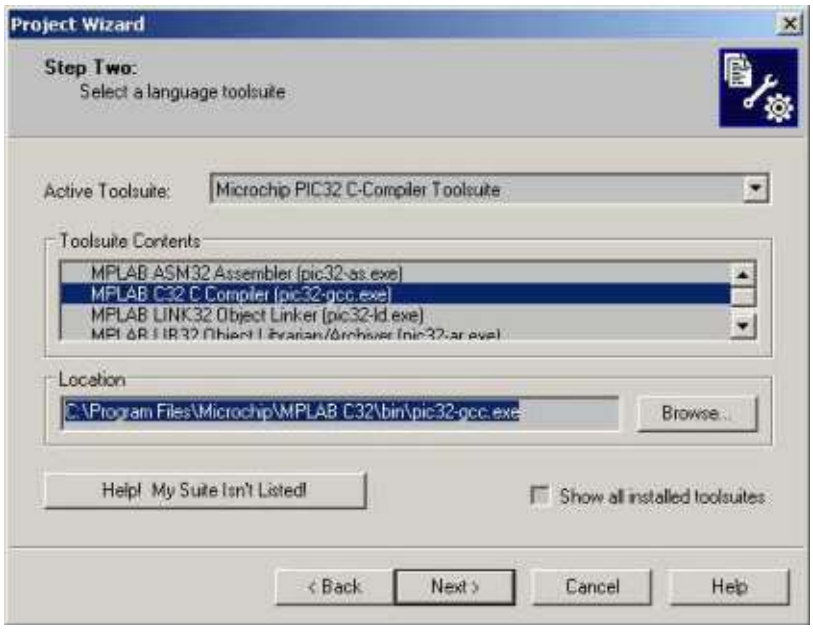
Then “MPLAB PIC32 Assembler (PIC32-as.exe)”, “MPLAB PIC32 C Compiler (PIC32-gcc.exe)”, “MPLAB PIC32 Object Linker (PIC32-ld.exe)”, and “MPLAB PIC32 Archiver (PIC32-ar.exe)”, should be visible in the Toolsuite Contents box. Click on each one to see its location. If MPLAB IDE was installed into the default directory, the paths for these files will be:

- for the MPLAB PIC32 assembler:
  - `C:\Program Files\Microchip\MPLAB IDE\ MPLAB C32\bin\PIC32-as.exe`
- for the MPLAB PIC32 compiler:
  - `C:\Program Files\Microchip\MPLAB IDE\ MPLAB C32\bin\ PIC32-gcc.exe`
- for the MPLAB PIC32 Object Linker:
  - `C:\Program Files\Microchip\MPLAB IDE\ MPLAB C32\bin\PIC32-ld.exe`
- for the MPLAB PIC32 Archiver:
  - `C:\Program Files\Microchip\MPLAB IDE\ MPLAB C32\bin\PIC32-ar.exe`

If these paths do not show up correctly, use the **Browse** button to set them to the proper files in the MPLAB IDE subfolders.

When you are finished, click **Next>**.

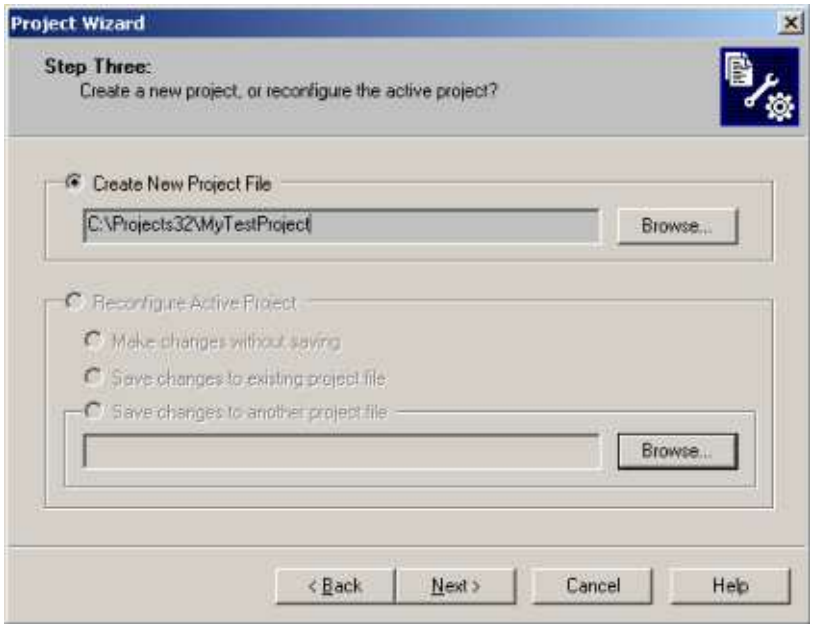
FIGURE 5-4: MPLAB IDE SELECT LANGUAGE TOOLSUITE



5.8 NAMING THE PROJECT

Step Three of the wizard allows you to name the project and put it into a folder. This sample project will be called MyTestProject. Using the **Browse** button, place the project in a folder named Projects32. Click **Next>**.

FIGURE 5-5: MPLAB IDE NAMING THE PROJECT



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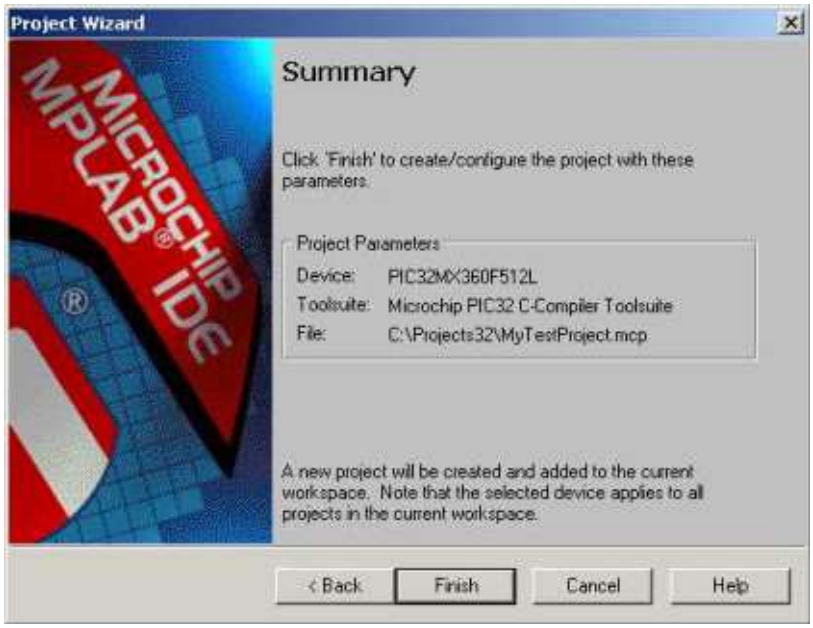
5.9 ADDING FILES TO THE PROJECT

Step Four of the Project Wizard allows file selection for the project. This is where we can add existing files to our project. In the current example we don't have a previously created file but we'll create one once we're done with the new project setting.

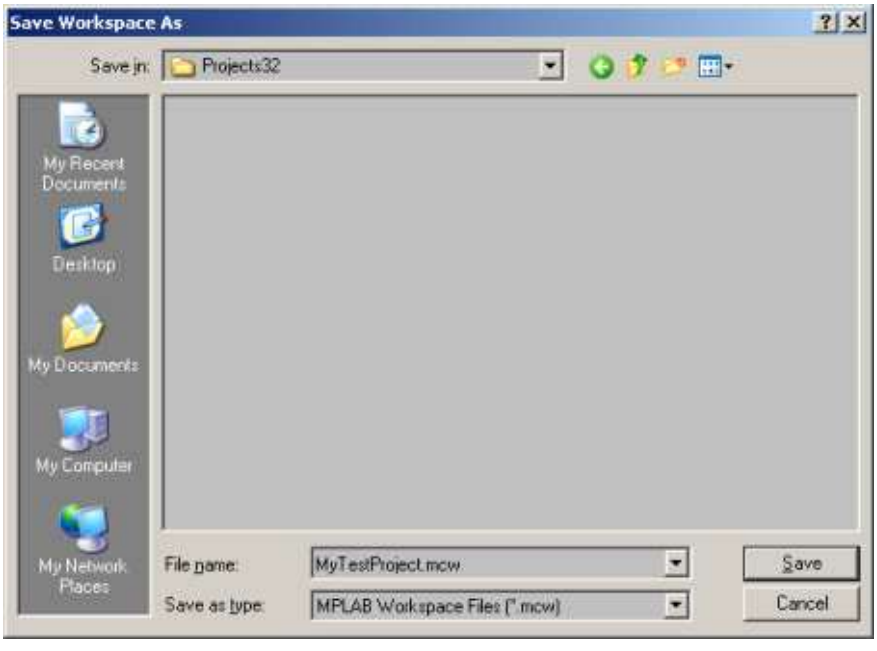
Just press **Next>** and the following Summary Screen will show up:

FIGURE 5-6: MPLAB IDE SUMMARY SCREEN



Press **Finish** and the workspace dialog shows up:

FIGURE 5-7: MPLAB IDE SAVE WORKSPACE

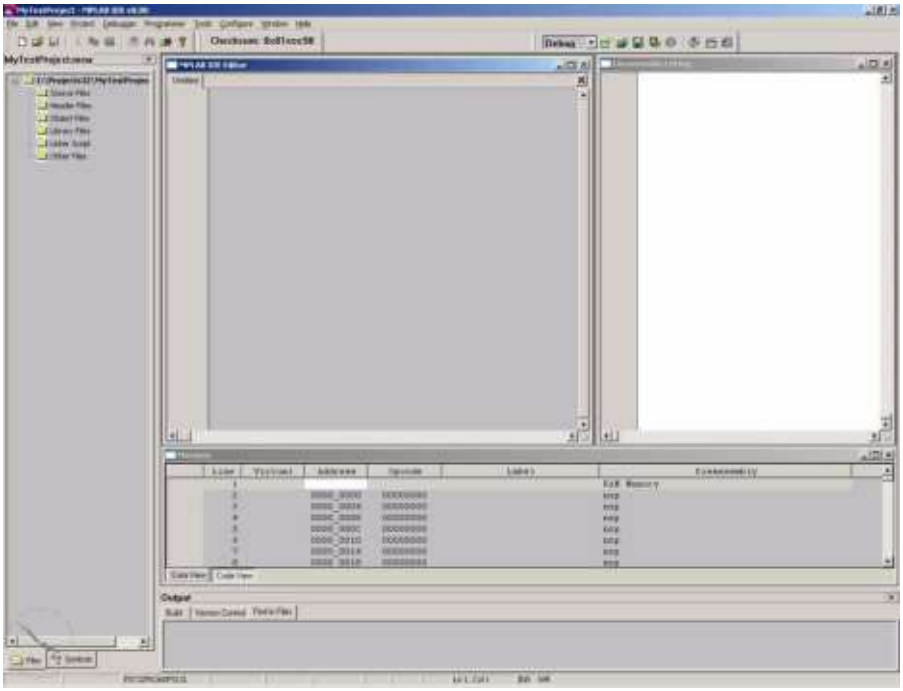


Be sure to save the workspace in the Projects32 directory and name this workspace using the same name as for the project: MyTestProject.

Click **Save**.

The project space is now completely created and it should look like that:

FIGURE 5-8: MPLAB IDE PROJECT SAVE



Now we'll create our C source file. If the MPLAB IDE Editor window is not open, click *File->New* from the top menu or the New File menu shortcut on the standard toolbar. The Editor window will show up.

Let's type in a very simple Hello World program in the Editor window and save it in Projects32 directory as `main.c`. We'll use the UART Peripheral Library provided by Microchip:

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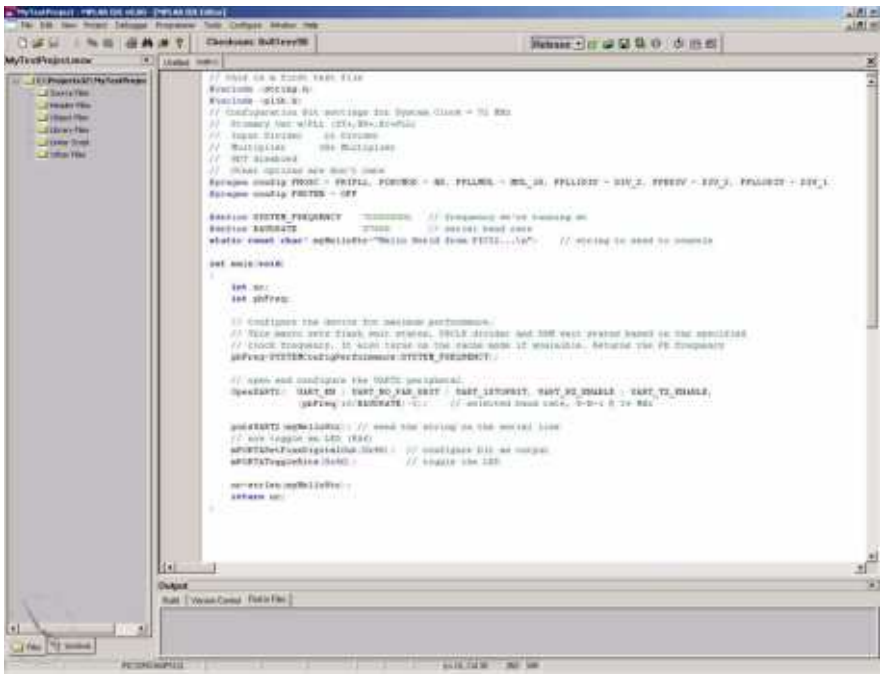
FIGURE 5-9: MPLAB IDE MAIN.C FILE



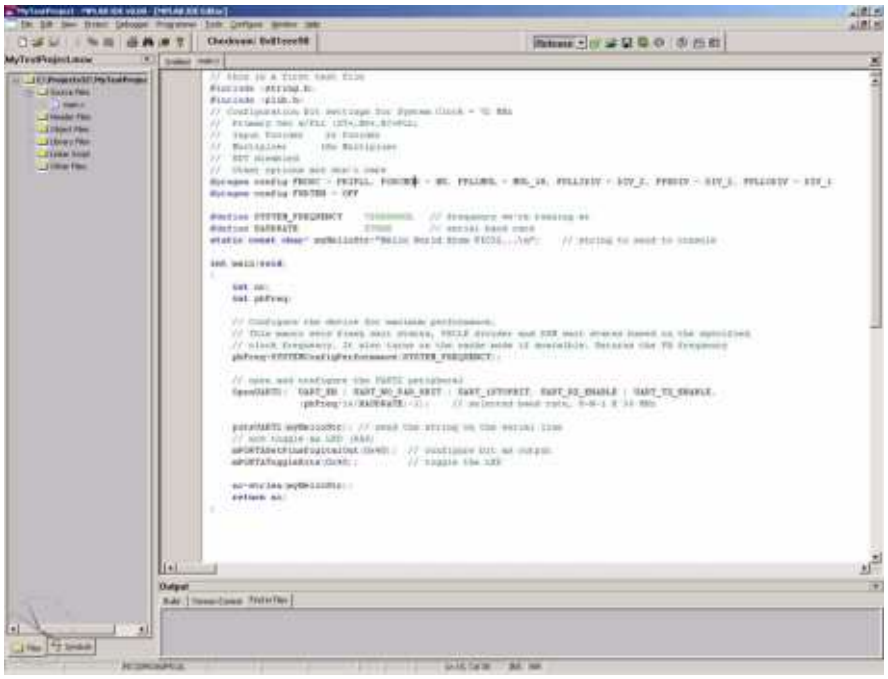
To add the newly created `main.c` file to our project just right click on the Source Files folder in the MPLAB IDE MyTestProject.mcp window and select Add File. Browse and select `main.c` file from the Projects32 directory.

Note:	If the Project window is not open, select View->Project from the top IDE menu.

The linker script that's needed for this project is selected automatically by the MPLAB IDE. We don't need to add any other file to our project.

Right click on MyTestProject.mcp window and select **Save**. The test project should be saved. The MyTestProject.mcp should look like:

FIGURE 5-10: MPLAB IDE PROJECT SAVED



TIP: Files can be added and projects saved by using the right mouse button in the project window. In case of error, files can be manually deleted by selecting them and using the right mouse click menu.

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5.10 ATTACHING THE DEBUGGER

In order to test the code using the PIC32 Starter Kit, please refer to the PIC32MX Starter Kit User's Guide (DS61144) for a sample project and a step-by-step getting started info.

For the purpose of testing our code in this document we will use an Explorer 16 Development board (DM240001), a MPLAB REAL ICE In-Circuit Debugger (DV244005) and a PIC32MX360F512L PIM (MA320001) together with a 9V universal power supply, a serial cable and a USB cable for connecting the REAL ICE to the development board.

FIGURE 5-11: EXPLORER 16, MPLAB® REAL ICE™ AND PIC32MX360F512L PIM



Take the following steps to ensure proper connection of the REAL ICE to the Explorer 16 development board:

1. Connect the MPLAB REAL ICE module to the PC with the USB cable.
2. Connect the MPLAB REAL ICE to the Explorer 16 Development Board with the short RJ-11 cable.
3. Apply power to the Explorer 16 board.
4. From the Debugger menu, click *Select Tool > MPLAB REAL ICE* to set the MPLAB REAL ICE as the debug tool in MPLAB IDE.
5. From the Debugger menu, select Connect to connect the debugger to the device. MPLAB IDE should report in the Output window that it found the PIC32MX360F512L device.

Note: MPLAB IDE may need to download new firmware if this is the first time the MPLAB REAL ICE is being used with a PIC32 device. Allow it to do so.

Once you have performed these steps, go to the MPLAB IDE window and from the *Debugger->Select Tool* menu select the debugging tool you're using to connect to the board (i.e., MPLAB REAL ICE should be within the available choices).

Once you have selected the tool, the "Debug Toolbar" should be present just below the main menu bar, together with other toolbars that may be selected.

Note: Be sure to select Debug from the MPLAB IDE Build Configuration drop down list.

5.11 BUILDING THE PROJECT

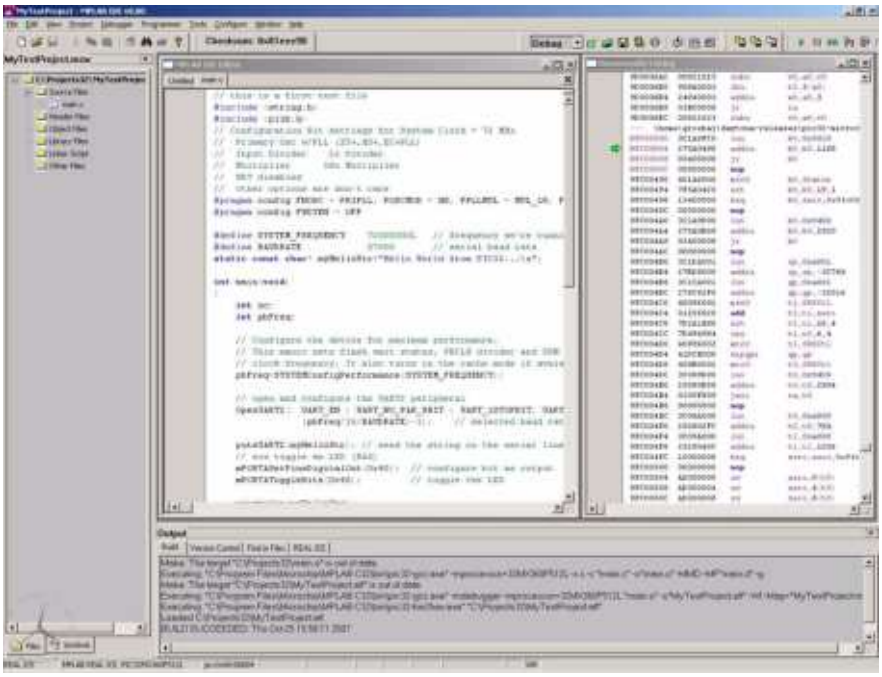
From the Project menu, we can compile and link the current files.

To build the project, select either:

- *Project>Build All*
- Right click on the project name in the project window and select Build All
- Click the Build All icon on the Project toolbar. Hover the mouse over icons to see pop-up text of what they represent.

The Output window shows the result of the build process. There should be no errors on any step.

FIGURE 5-12: MPLAB IDE PROJECT BUILD



5.12 TESTING THE CODE

First download the hex image of the program we just built by selecting Debugger->Program from the Debugger menu or directly program from the “Debug Toolbar”. The programming operation should occur with no errors.

In order to test our example application, we need to set-up the PC part too.

Connect a serial cable between the board RS-232 connector and one of the PC’s COM ports and open a Hyper Terminal application on the PC (Programs->Accessories->Communications->Hyper Terminal).

Select a proper name for this connection, click **OK** and then, in the “Connect To” screen select the COM port that’s connected to the development board.

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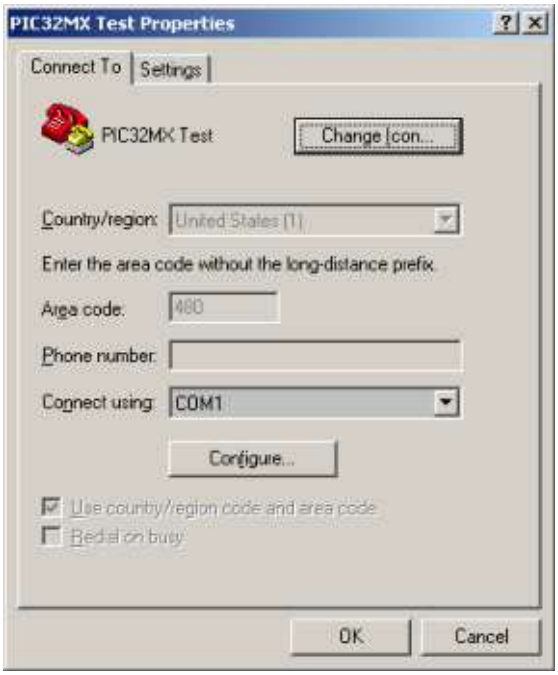
FIGURE 5-13: HYPER TERMINAL CONNECTION SCREEN



Click **OK** and, on the next screen, select the following communication settings:

- Bits Per Second: 57600
- Data Bits: 8
- Parity: None
- Stop Bits: 1
- Flow Control: None

Click **OK** and the Hyper Terminal session should be connected to the serial port on the development board.

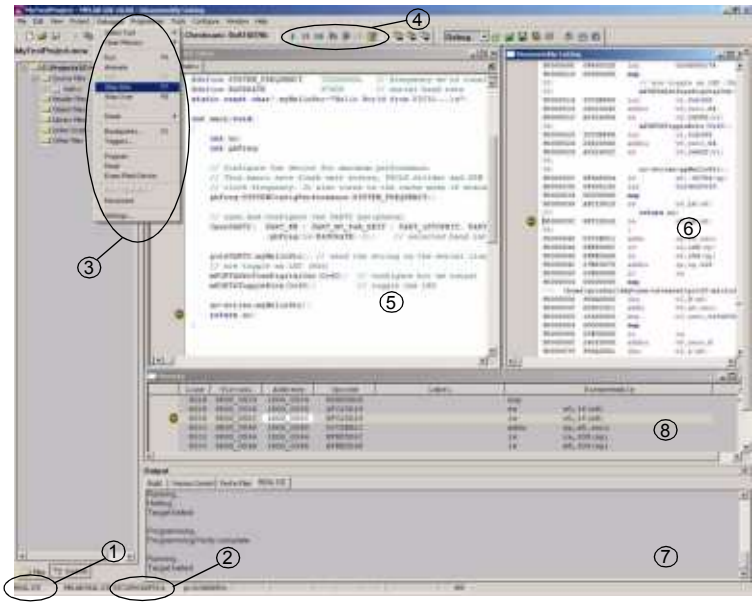
Now return to the MPLAB IDE and double click on the line:

return nc;

in the MPLAB IDE Editor window, the `main.c` program, to set a breakpoint on that line, just after the call to `strlen()`.

Click Debugger->Run from the main menu, or Run from the Debug toolbar. The program should start running and it will reach the set breakpoint. The MPLAB IDE window will look very similar to this one:

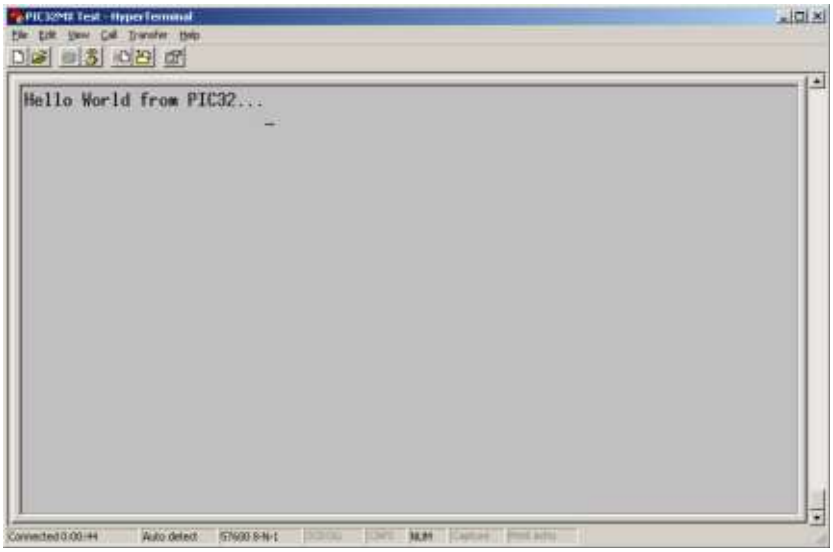
FIGURE 5-14: MPLAB IDE BREAKPOINT REACHED



1. The debugging tool selected to connect to the demo board
2. The device selected on the target board
3. The menus available under the Debugger top menu
4. The Debug toolbar
5. The Source window, with the breakpoint reached
6. The Disassembly window
7. The Output window
8. The Program Memory window

Now, if you take a look to the PC Hyper Terminal window, you should see the output sent by our simple test program to the serial line:

FIGURE 5-15: HYPER TERMINAL RECEIVED CHARACTERS



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Also, if you look at the Explorer 16 board, you should see the LED D9 lit on.

This shows that the PIC32 Explorer16 demo board and the MPLAB IDE operate correctly.

We just made our first “Hello World” program for PIC32.

There are many other things that you can do in the MPLAB IDE to debug your program. For example, you can notice in that by hovering the mouse over the variable “nc” we can see its actual value (which should be the number of characters sent to the serial port by the `putsUART2()` function).

Other MPLAB IDE debug features:

- Watch window: you can add variables of peripheral SFRs to the watch window and monitor their values
- Complex Breakpoint manipulation
- All the useful debug commands: step into, step over, etc, using both the C Source window and the disassembly listing window.
- Profile your code execution and calculate delay times between different points in your program.

We presented here the essential steps for getting started with PIC32 using the MPLAB IDE. You are now ready to continue exploring the capabilities of PIC32 and MPLAB IDE. For further information about PIC32 please see the documentation list provided in this document. For more information about the MPLAB IDE please see the “*MPLAB IDE Quick Start Guide*” (DS51281) available on our site at www.microchip.com following the Design link.

NOTES:

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Chapter 6. Technical Support Resources

6.1 INTRODUCTION

For information about the Technical Support provided please visit Support.microchip.com.

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