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Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832

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**MPLAB[®] C18
C COMPILER
GETTING STARTED**

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- Microchip believes that its family of PICmicro microcontrollers is one of the most secure products 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 PICmicro microcontroller in a manner outside the operating specifications contained in the data sheet. The person doing so may be engaged in theft of intellectual property.
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- Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our product.

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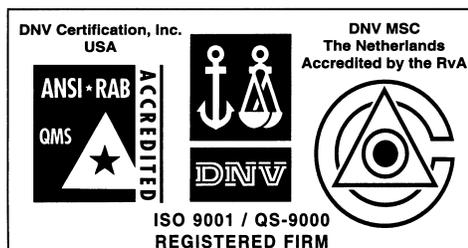
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Preface

INTRODUCTION

The purpose of this document is to help you get up and running with Microchip's MPLAB C18 C compiler.

HIGHLIGHTS

Items discussed in this chapter are:

- About this Guide
- Recommended Reading
- Warranty Registration
- Troubleshooting
- The Microchip Internet Web Site
- Development Systems Customer Notification Service
- Customer Support

ABOUT THIS GUIDE

Document Layout

This document describes how to install/uninstall MPLAB C18 and provides several examples of writing C code for PICmicro® microcontroller applications. For a detailed discussion about basic MPLAB IDE v6.xx functions, refer to the MPLAB IDE Help on-line help file.

This document includes:

- **Chapter 1: Overview** – defines system requirements and provides a brief description of the installed programs and directories created by the installation process.
- **Chapter 2: Installation** – provides instructions on how to install the compiler onto your system. Also provides uninstall instructions.
- **Chapter 3: Examples of Use** – uses a tutorial style to illustrate effective use of the MPLAB C18 C compiler. All examples use MPLAB IDE v6.xx with PIC18F452 as the selected device and MPLAB SIM simulator as a debug tool. Some examples use the additional tools MPLAB ICD 2 in-circuit debugger and PICDEM™ 2 Plus demo board.
 - **Example 1** demonstrates how to set up and build a project; run, step and set breakpoints in the example code; and debug the code.
 - **Example 2** demonstrates the use of the MPLAB C18 peripheral libraries and the C standard library, as well as the allocation of variables into program memory.
 - **Example 3** demonstrates the allocation of variables in access RAM.
 - **Example 4** demonstrates the use of interrupt service routines with MPLAB C18 and provides an example of the use of the MPLAB C18 peripheral libraries.

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- **Glossary** – A glossary of terms used in this guide.
- **Index** – Cross-reference listing of terms, features and sections of this document.

Conventions Used in this Guide

This manual uses the following documentation conventions:

Description	Represents	Examples
Code (Courier font):		
Plain characters	Sample code Filenames and paths	#define START c:\autoexec.bat
Square brackets: []	Optional arguments	MPASMWIN [main.asm]
Curly brackets and pipe character: { }	Choice of mutually exclusive arguments An OR selection	errorlevel {0 1}
Ellipses...	Used to imply (but not show) additional text	list [<i>list_option...</i> , <i>list_option</i>]
0xnnnn	A hexadecimal number where <i>n</i> is a hexadecimal digit	0xFFFF, 0x007A
Italic characters	A variable argument	char isascii (char <i>ch</i>);
Interface (Arial font):		
Underlined, italic text with “arrow”	A menu selection from the menu bar	<i>File > Save</i>
Bold characters	A window or dialog button to click	OK, Cancel
Characters in angle brackets: < >	A key on the keyboard	<Tab>, <Ctrl-C>
Documents (Arial font):		
Italic characters	Referenced books	<i>MPLAB IDE User's Guide</i>

Documentation Updates

All documentation becomes dated, and this guide is no exception. Since MPLAB IDE, MPLAB C18 and other Microchip tools are constantly evolving to meet customer needs, some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our web site to obtain the latest documentation available.

Documentation Numbering Conventions

Documents are numbered with a “DS” number. The 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 = The document number.
- A = The revision level of the document.

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

For more information on included libraries and precompiled object files for the compilers, the operation of MPLAB IDE and the use of other tools, the following are recommended reading.

README.C18

For the latest information on using MPLAB C18 C compiler, read the README.C18 file (ASCII text) included with the software. This README file contains update information that may not be included in this document.

README.XXX

For the latest information on other Microchip tools (MPLAB IDE, MPLINK™ linker, etc.), read the associated README files (ASCII text file) included with the MPLAB IDE software.

MPLAB C18 C Compiler User's Guide (DS51288)

Comprehensive guide that describes the operation and features of Microchip's MPLAB C18 C compiler for PIC18 devices.

MPLAB C18 C Compiler Libraries (DS51297)

Reference guide for MPLAB C18 libraries and precompiled object files. Lists all library functions with a detailed description of their use.

MPLAB IDE User's Guide (DS51025)

Comprehensive guide that describes installation and features of Microchip's MPLAB Integrated Development Environment (IDE), as well as the editor and simulator functions in the MPLAB IDE environment.

MPASM™ User's Guide with MPLINK™ and MPLIB™ (DS33014)

This user's guide describes how to use the Microchip PICmicro MCU MPASM assembler, the MPLINK object linker and the MPLIB object librarian.

PIC18 Device Data Sheets

These data sheets describe the operation and electrical specifications of PIC18 devices and may be found on the Technical CD-ROM or the Microchip web site.

Technical Library CD-ROM (DS00161)

This CD-ROM contains comprehensive application notes, data sheets and technical briefs for all Microchip products. To obtain this CD-ROM, contact the nearest Microchip Sales and Service location (see back page).

Microchip Web Site

The Microchip web site (www.microchip.com) contains a wealth of documentation. Individual data sheets, application notes, tutorials and user's guides are all available for easy download. All documentation is in Adobe™ Acrobat (pdf) format.

Microsoft® Windows® Manuals

This manual assumes that users are familiar with the Microsoft Windows operating system. Many excellent references exist for this software program, and should be consulted for general operation of Windows.

TROUBLESHOOTING

If you encounter problems with any of the procedures or tutorial steps in this document, please see the README files or other recommended reading documents for additional information. If these are not helpful, check out the Technical Support section of our web site or contact customer support.

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ON-LINE SUPPORT

Microchip provides on-line support on the Microchip web site at:

www.microchip.com

A file transfer site is also available by using an FTP service connecting to:

<ftp://ftp.microchip.com>

The web site and file transfer site provide a variety of services. Users may download files for the latest development tools, data sheets, application notes, user's guides, articles and sample programs. A variety of Microchip specific business information is also available, including listings of Microchip sales offices and distributors. Other information available on the web site includes:

- Latest Microchip press releases
- Technical support section with FAQs
- Design tips
- Device errata
- Job postings
- Microchip consultant program member listing
- Links to other useful web sites related to Microchip products
- Conferences for products, development systems, technical information and more
- Listing of seminars and events

CUSTOMER CHANGE NOTIFICATION SERVICE

Microchip started the customer notification service to help our customers keep current on Microchip products with the least amount of effort. Once you subscribe, you will receive email notification whenever we change, update, revise or have errata related to your specified product family or development tool of interest.

Go to the Microchip web site (www.microchip.com) and click on Customer Change Notification. Follow the instructions to register.

The Development Systems product group categories are:

- Compilers
- Emulators
- In-Circuit Debuggers
- MPLAB
- Programmers

Here is a description of these categories:

COMPILERS - The latest information on Microchip C compilers and other language tools. These include the MPLAB C17, MPLAB C18 and MPLAB C30 C Compilers; MPASM and MPLAB ASM30 assemblers; MPLINK and MPLAB LINK30 linkers; and MPLIB and MPLAB LIB30 librarians.

EMULATORS - The latest information on Microchip in-circuit emulators. This includes the MPLAB ICE 2000.

IN-CIRCUIT DEBUGGERS - The latest information on Microchip in-circuit debuggers. These include the MPLAB ICD and MPLAB ICD 2.

MPLAB - 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 device programmers. These include the PRO MATE[®] II device programmer and PICSTART[®] Plus development programmer.

CONTACT INFORMATION

Microchip product support is available through:

- Distributors
- Local Sales Offices – a list of sales office locations is available at the end of this book.
- Field Application Engineers (FAE)
- Corporate Applications Engineers (CAEs) may be contacted at (480) 792-7627.
- Hot Line

The **Systems Information and Upgrade Line** provides system users with a list of the current versions of all Microchip development systems software products. This line also provides information on how to receive available upgrade kits.

The Hot Line Numbers are:

1-800-755-2345 for U.S. and most of Canada, and

1-480-792-7302 for the rest of the world.

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NOTES:



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Chapter 1. Overview

1.1 INTRODUCTION

Congratulations on your decision to use MPLAB C18, Microchip's C compiler for its PIC18 PICmicro microcontrollers. MPLAB C18 is designed for use with Microchip's MPLINK linker. Both MPLAB C18 and the MPLINK linker can be used with the MPLAB IDE. This document is designed to get you started quickly using MPLAB C18 with the MPLINK linker to develop PICmicro applications with ease. As you read this document, please refer to the *MPLAB C18 C Compiler User's Guide* (DS51288) for more details on the features mentioned.

1.2 HIGHLIGHTS

Items discussed in this chapter include:

- System Requirements
- Quick Directory Tour
- About the Language Tools

1.3 SYSTEM REQUIREMENTS

The minimum system requirements for using MPLAB C18 and the MPLINK linker are:

- 25 MB hard disk space (50 MB recommended)
- Microsoft Windows operating system (95 or later)

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1.4 QUICK DIRECTORY TOUR

The MPLAB C18 installation directory contains the readme file for the compiler (`readme.c18`) and the readme file for the linker (`readme.lkr`). In addition, a number of subdirectories are also present:

Directory	Description
bin	Contains the executables for the compiler and linker. These are described in more detail in the following section.
cpp	Contains the source code for the MPLAB C18 C preprocessor. This source code is provided for general interest.
doc	Contains the MPLAB C18 electronic documentation. Refer to these documents for any questions you may have regarding MPLAB C18.
example	Contains sample applications to help you get started using MPLAB C18, including the examples contained in this document.
h	Contains the header files for the standard C library and the processor-specific libraries for the supported PICmicro microcontrollers.
lib	Contains the standard C library (<code>c18.lib</code>), the processor-specific libraries (<code>p18xxxx.lib</code> , where <code>xxxx</code> is the specific device number) and the startup modules (<code>c018.o</code> , <code>c018i.o</code> , <code>c018iz.o</code>).
lkr	Contains the linker script files.
mpasm	Contains the command-line version of the MPASM assembler, the assembly header files for the devices supported by MPLAB C18 (<code>p18xxx.inc</code>) and the assembly header files used by the libraries.
src	Contains the source code, in the form of C and assembly files, for the standard C library, the processor-specific libraries and the startup modules.

1.5 ABOUT THE LANGUAGE TOOLS

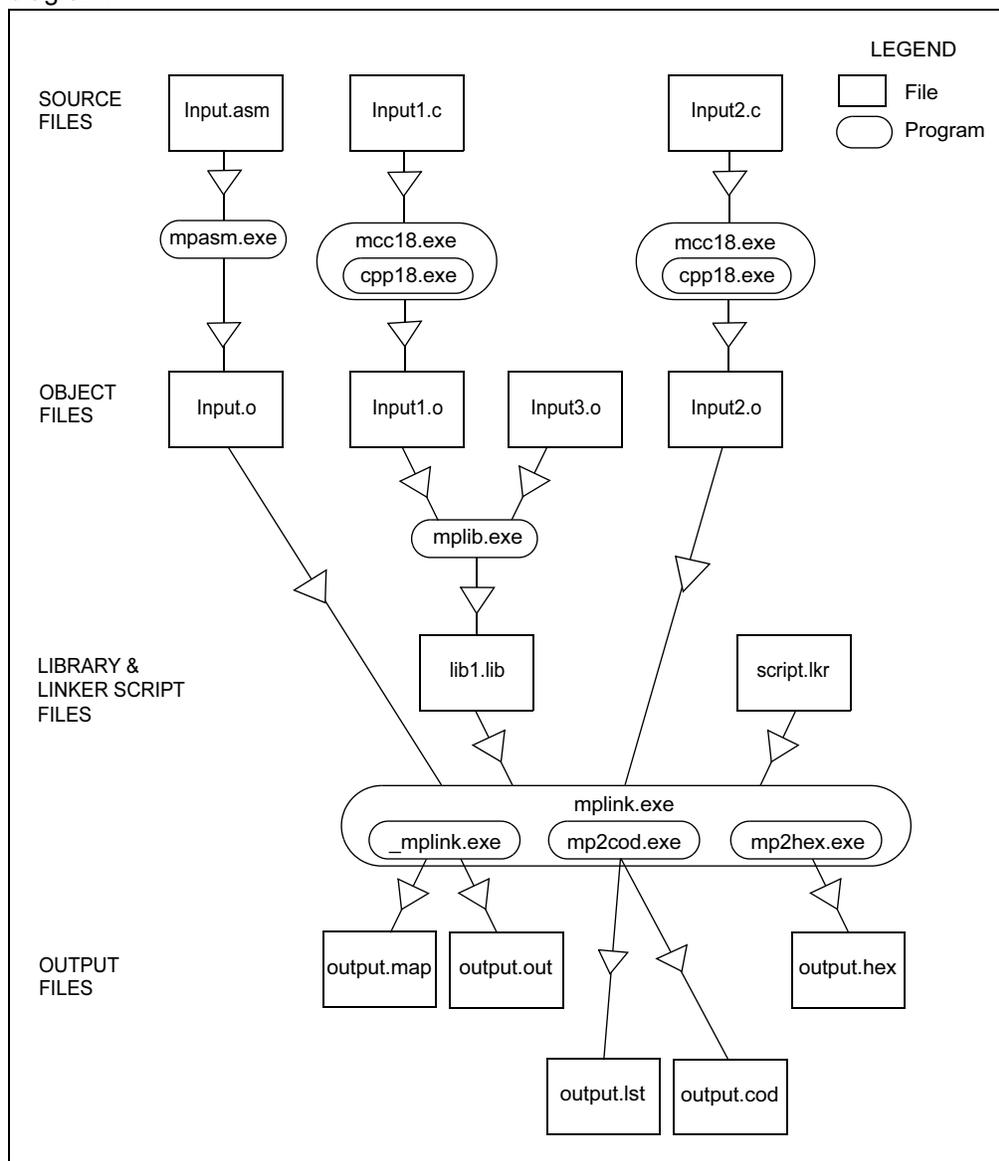
The `bin` and `mpasm` subdirectories of the MPLAB C18 installation directory contain the executables which comprise the MPLAB C18, MPASM assembler and the MPLINK linker. The following is a brief description of these programs.

Executable	Description
<code>mcc18.exe</code> <code>c18demo.exe</code>	This is the C compiler. It takes as input a C source file (e.g., <code>file.c</code>), which is passed to <code>cpp18.exe</code> for preprocessing. For demo versions of MPLAB C18, this file is called <code>c18demo.exe</code> . <code>mcc18.exe</code> then compiles the preprocessed output and generates a COFF file (e.g., <code>file.o</code>) to be passed to the linker.
<code>cpp18.exe</code>	This is the C preprocessor.
<code>mplink.exe</code>	This is the driver program for the linker. It takes as input a linker script, object files and library files and passes these to <code>_mplink.exe</code> . It then takes the output COFF file from <code>_mplink.exe</code> and passes it to <code>mp2cod.exe</code> and <code>mp2hex.exe</code> .
<code>_mplink.exe</code>	This is the linker. It takes as input a linker script (e.g., <code>p18f452.lkr</code>), object files and library files and outputs a COFF executable (e.g., <code>file.out</code> or <code>file.cof</code>). This COFF file is the result of resolving unassigned addresses of data and code of the input object files and referenced object files from the libraries. <code>_mplink.exe</code> also optionally produces a map file (e.g., <code>file.map</code>) that contains detailed information on the allocation of data and code.
<code>mp2cod.exe</code>	This is the COFF to COD file converter. The COD file is a symbolic debugging file format which is used by the MPLAB IDE v5.xx. <code>mp2cod.exe</code> takes as input the COFF file produced by <code>_mplink.exe</code> and outputs a COD file (e.g., <code>file.cod</code>). It also creates a listing file (e.g., <code>file.lst</code>) that displays the correspondence between the original source code and machine code.
<code>mp2hex.exe</code>	This is the COFF to HEX file converter. The HEX file is a file format readable by a PICmicro programmer such as the PICSTART Plus or the PROMATE II. <code>mp2hex.exe</code> takes as input the COFF file produced by <code>_mplink.exe</code> and outputs a HEX file (e.g., <code>file.hex</code>).
<code>mplib.exe</code>	This is the librarian. It allows for the creation and management of a library file (e.g., <code>file.lib</code>) that acts as an archive for the object files. Library files are useful for organizing object files into reusable code repositories.
<code>mpasm.exe</code>	This is the command-line assembler. It takes as input an assembly source file (e.g., <code>file.asm</code>) and outputs either a COFF file (e.g., <code>file.o</code>) or a HEX file and COD file (e.g., <code>file.hex</code> and <code>file.cod</code>). It also creates a listing file (e.g., <code>file.lst</code>) and an error file (e.g., <code>file.err</code>) which contains any errors or warnings emitted during the assembly process. Assembly source files may include assembly header files (e.g., <code>p18f452.inc</code>), which also contain assembly source code.

More detailed information on the language tools, including their command-line usage, can be found in the *MPLAB C18 C Compiler User's Guide* (DS51288) and the *MPASM User's Guide with MPLINK and MPLIB* (DS33014).

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An example of the flow of execution of the language tools is illustrated by the following diagram.



Chapter 2. Installation

2.1 INTRODUCTION

This chapter will discuss in detail how to install MPLAB C18 on your system. Should you need to remove it, uninstall directions are provided as well.

2.2 HIGHLIGHTS

Items discussed in this chapter include:

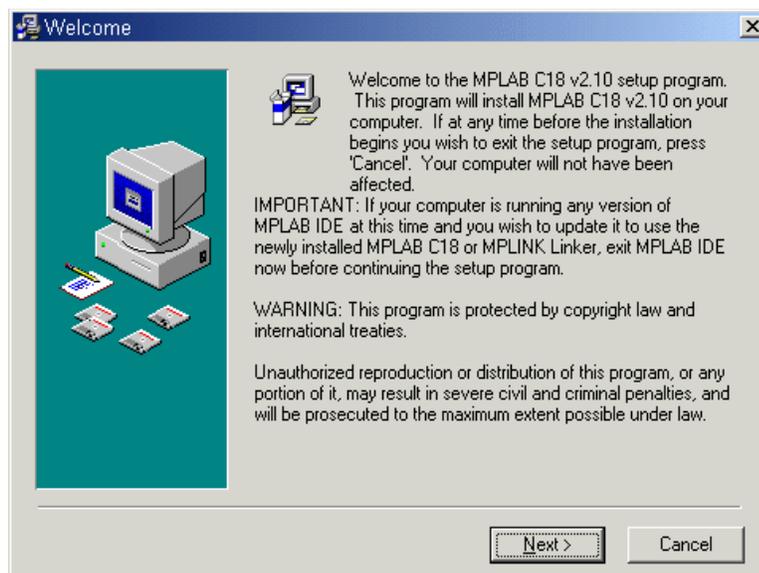
- Installing MPLAB C18
- Uninstalling MPLAB C18

2.3 INSTALLING MPLAB C18

To install MPLAB C18, run the setup program from the CD-ROM. If you are upgrading MPLAB C18, run the upgrade setup program downloaded from the Microchip web site. A series of dialogs will guide you through the setup process.

2.3.1 Welcome

A welcome screen displays the version number of MPLAB C18 that the setup program will install.

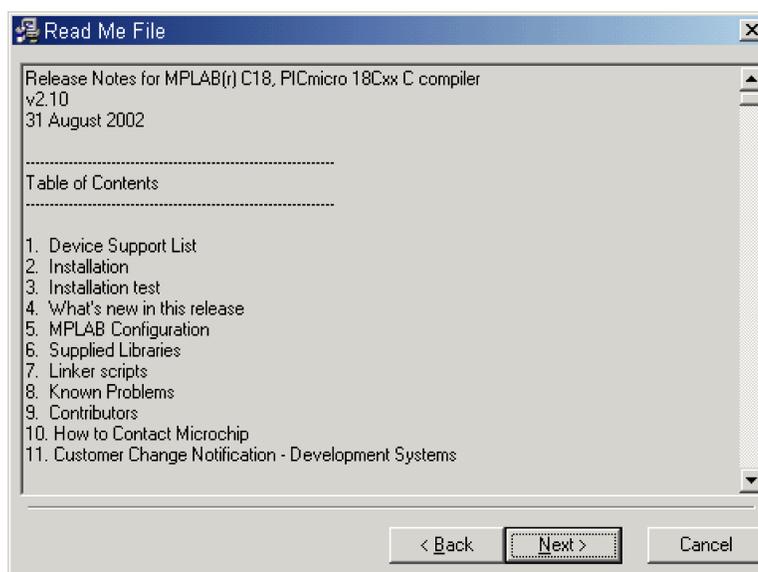


Click **Next** to continue.

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2.3.2 Read Me File

The MPLAB C18 readme file is displayed. This file contains important information about this release of MPLAB C18, such as known bugs.



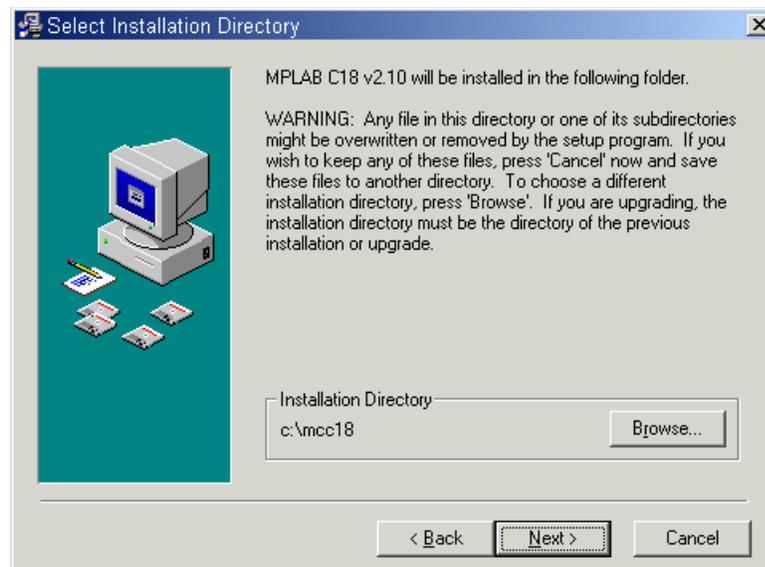
After reviewing, click **Next** to continue.

2.3.3 Select Installation Directory

This step allows you to choose the directory where MPLAB C18 will be installed. If you are installing MPLAB C18 for the first time, the default installation directory is C:\mcc18.

If you are upgrading, the setup program attempts to set the default installation directory to the directory of the previous installation. The installation directory for an upgrade must be the directory of the previous installation or upgrade.

Note: Any files in the installation directory and its subdirectories may be either overwritten or removed by the installation process. If you wish to save any files, such as modified linker scripts or library source code from a previous installation, copy those files to a directory outside the installation directory before continuing.

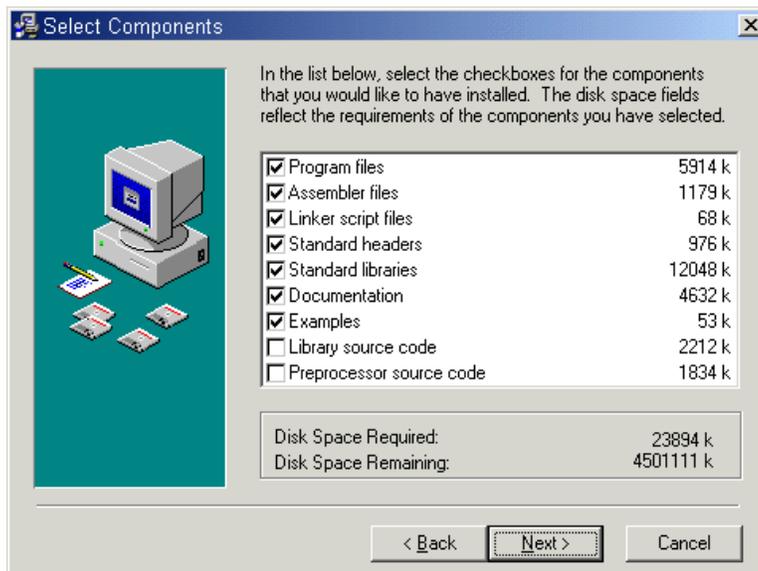


After specifying the directory, click **Next**.

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2.3.4 Select Components

You can choose which of these components to install by checking the appropriate box.



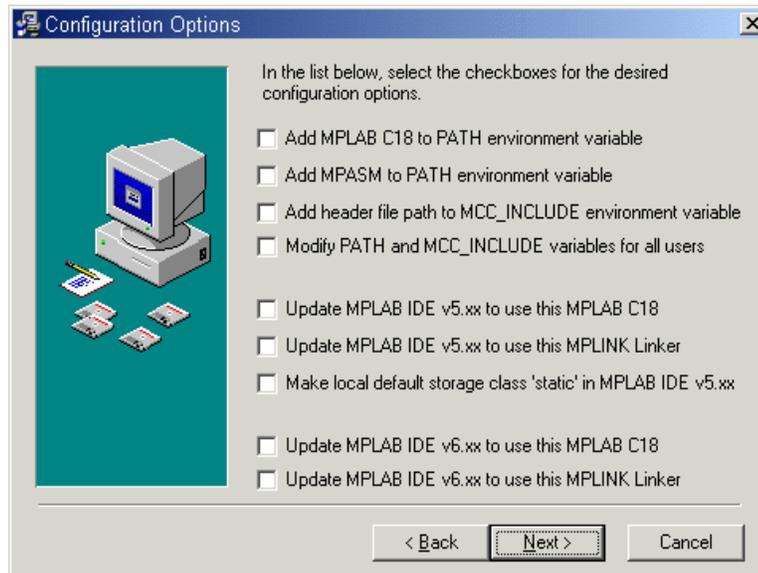
Component	Description
Program files	These are the executables for the compiler and linker. Install this component unless you are upgrading and wish to use the executables from the previously installed version.
Assembler files	These include the command-line version of the MPASM assembler (<code>mpasm.exe</code>), the assembly header files for the devices supported by MPLAB C18 (<code>p18xxxx.inc</code>) and the assembly header files used by the libraries.
Linker script files	These files are used by the MPLINK linker. There is one file for each supported PICmicro microcontroller. Each file provides a default memory configuration for the processor and directs the linker in the allocation of code and data in the processor's memory. These linker scripts differ from the linker scripts provided with the MPLAB IDE in that these are specifically designed for use with MPLAB C18. Since the MPLINK linker requires a linker script, install this component unless you plan on creating your own linker scripts.
Standard headers	These are the header files for the standard C library and the processor-specific libraries. If you choose to install the standard libraries, these will also be installed.
Standard libraries	This component contains the standard C library, the processor-specific libraries, and the startup modules. See the <i>MPLAB C18 C Compiler Libraries</i> (DS51297) and the <i>MPLAB C18 C Compiler User's Guide</i> (DS51288) for more information on the libraries and startup modules. Since most typical programs use the libraries and a startup module, it is recommended that you install this component.
Documentation	This is the electronic documentation for MPLAB C18.
Examples	These are sample applications to assist you in getting started with MPLAB C18, including the examples described in this document.

Component	Description
Library source code	This is the source code for the standard C library, the processor-specific libraries, and the startup modules. Install this component if you plan on rebuilding the libraries or startup modules.
Preprocessor source code	This is the source code for the preprocessor. It is provided for general interest.

Check the components you want to install, then click **Next**.

2.3.5 Configuration Options

This dialog allows you to select a particular set of MPLAB C18 configuration options for your system:



Configuration	Description
Add MPLAB C18 to PATH environment variable	This adds the path of the MPLAB C18 executable (<code>mcc18.exe</code>) and the MPLINK linker executable (<code>mplink.exe</code>) to the front of the <code>PATH</code> environment variable. Doing this allows you to launch the newly installed version of MPLAB C18 and the MPLINK linker at the command shell prompt from any directory.
Add MPASM to PATH environment variable	This adds the path of the MPASM executable (<code>mpasm.exe</code>) to the front of the <code>PATH</code> environment variable. Doing this allows you to launch the newly installed version of the MPASM assembler at the command shell prompt from any directory.
Add header file path to <code>MCC_INCLUDE</code> environment variable	This adds the path of the MPLAB C18 header file directory to the front of the <code>MCC_INCLUDE</code> environment variable. If this variable does not exist, it is created. <code>MCC_INCLUDE</code> is a list of semicolon-delimited directories that MPLAB C18 will search for a header file if it cannot find the file in directory list specified with the <code>-I</code> command-line option. Selecting this configuration option means you will not have to use the <code>-I</code> command-line option when including a standard header file.

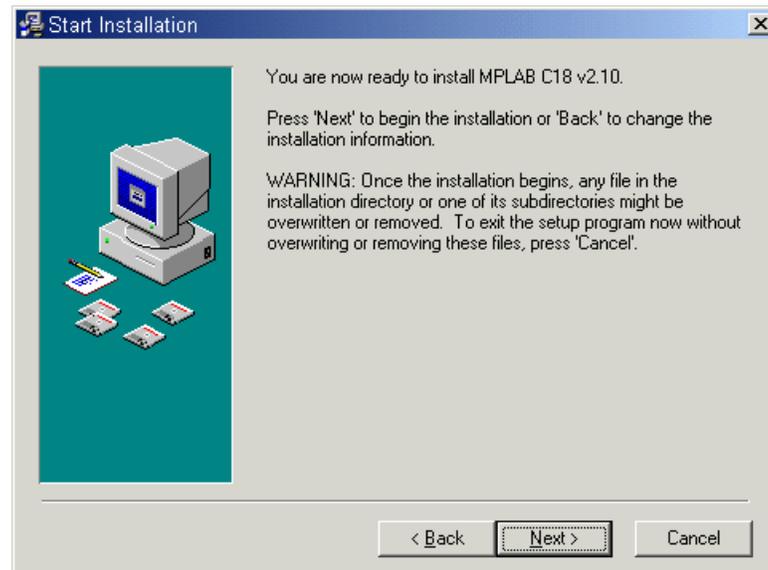
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Configuration	Description
Modify PATH and MCC_INCLUDE variables for all users	This option appears only if you are logged into a Windows NT or Windows 2000 computer as an administrator. Selecting this configuration will perform the modifications to these variables as specified in the three previous options for all users. Otherwise, only the current user's variables will be affected.
Update MPLAB IDE v5.xx to use this MPLAB C18	This option appears only if the MPLAB IDE v5.xx is installed on your system. Selecting this option configures the MPLAB IDE v5.xx to use the newly installed MPLAB C18.
Update MPLAB IDE v5.xx to use this MPLINK linker	This option appears only if the MPLAB IDE v5.xx is installed on your system. Selecting this option configures the MPLAB IDE v5.xx to use the newly installed MPLINK linker.
Make local default storage class 'static' in MPLAB IDE v5.xx	This option appears only if the MPLAB IDE v5.xx is installed on your system. When this option is in effect, it is as if the C language storage class specifier static were used with all local and formal parameter variable declarations. This allocates these variables in global memory instead of on the stack. In general, statically allocated variables require fewer instructions to access than stack-allocated variables. However, keep in mind that some functions may behave differently depending on the allocation scheme used.
Update MPLAB IDE v6.xx to use this MPLAB C18	This option appears only if the MPLAB IDE v6.xx is installed on your system. Selecting this option configures the MPLAB IDE v6.xx to use the newly installed MPLAB C18.
Update MPLAB IDE v6.xx to use this MPLINK linker	This option appears only if the MPLAB IDE v6.xx is installed on your system. Selecting this option configures the MPLAB IDE v6.xx to use the newly installed MPLINK linker.

Choose configuration options and click **Next**.

2.3.6 Start Installation

This dialog launches the installation. Once the **Next** button is pressed, all files in the installation directory and its subdirectories will be overwritten or removed.



2.3.7 Complete Installation

Congratulations! You have successfully installed MPLAB C18 on your computer. In the "Installation Complete" dialog, click **Finish**.

For MPLAB C18 to operate properly, you may need to restart your computer. If the "Restart Computer" dialog appears, select **Yes** to restart immediately, or **No** to restart your computer at a later time.

2.4 UNINSTALLING MPLAB C18

To uninstall MPLAB C18, open the Windows control panel and launch "Add/Remove Programs". Select the MPLAB C18 installation in the list of programs and follow the directions to remove the program. This will remove the MPLAB C18 directory and its contents from your computer.

Note: If you are uninstalling an upgraded version of MPLAB C18, the entire installation will be removed; MPLAB C18 cannot be "downgraded".

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NOTES:

Chapter 3. Examples of Use

3.1 INTRODUCTION

The following examples are intended to illustrate the effective use of MPLAB C18, including how to create and build projects and how to step through programs.

These examples assume that MPLAB C18 and MPLAB IDE v6.xx are installed. Some examples assume MPLAB ICD 2 is installed and connected to a PICDEM 2 Plus demo board with a PIC18F452 device. Please refer to the *PIC18FXX2 Data Sheet* (DS39564) for information regarding processor-specific items such as the special function registers, instruction set and interrupt logic.

3.2 HIGHLIGHTS

Examples presented in this chapter for using MPLAB C18 include:

- **Example 1** demonstrates how to set up and build a project; run, step and set breakpoints in the example code; and debug the code.
- **Example 2** demonstrates the use of the MPLAB C18 peripheral libraries and the C standard library, as well as the allocation of variables into program memory.
- **Example 3** demonstrates the allocation of variables in access RAM.
- **Example 4** demonstrates the use of interrupt service routines with MPLAB C18 and provides an example of the use of the MPLAB C18 peripheral libraries.

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3.3 EXAMPLE 1

This example is designed for use with the MPLAB IDE v6.xx, the MPLAB SIM simulator and the PIC18F452 device. It shows how to set up an MPLAB C18 project in the MPLAB IDE, build the project and step through the source code using the MPLAB SIM simulator. Additionally, running the program using the MPLAB ICD 2 with the PICDEM 2 Plus demo board is demonstrated. The example assumes that the directory `c:\mcc18` is the MPLAB C18 installation directory.

Here is the source code for the example.

```
#include <p18cxxx.h>    /* for TRISB and PORTB
                        declarations */

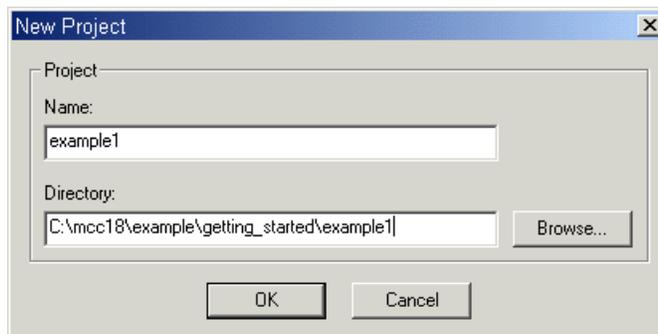
int counter;
void main (void)
{
    counter = 1;
    TRISB = 0;          /* configure PORTB for output */
    while (counter <= 15)
    {
        PORTB = counter; /* display value of 'counter'
                           on the LEDs */
        counter++;
    }
}
```

TRISB and PORTB are special function registers on the PIC18F452 device. The PORTB pins are connected to the LEDs on the PICDEM 2 demo board; the TRISB pins configure the PORTB pins for input (1) or output (0).

3.3.1 Setting Up the Project

Select *Project>New* to create a new project. Then enter the name and directory of the project in the dialog that displays and click **OK**.

If you installed the examples with MPLAB C18, then the `example\getting_started\example1` subdirectory of the MPLAB C18 installation will already contain the source file for this example.



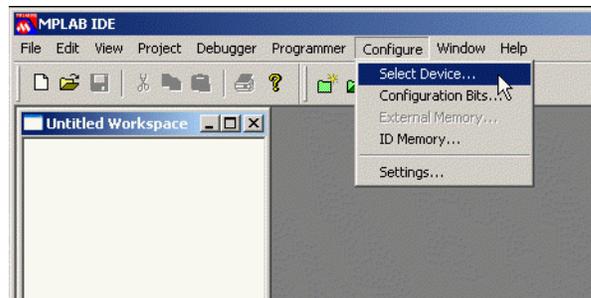
Note: The project name does not have to be the same as the directory name.

You should now see the project tree with a branch for each type of project file.



3.3.2 Select Target Processor

The target processor must be selected before anything else is done with the project. This is accomplished by choosing *Configure>Select Device*.



For this example, the PIC18F452 device will be used. Select the device and press **OK**.

