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- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as “unbreakable.”

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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 on-line help. Select the Help menu, and then Topics to open a list of available on-line help files.

INTRODUCTION

The purpose of this document is to provide detailed information on the libraries and precompiled object files that may be used with Microchip’s MPLAB® C18 C Compiler.

DOCUMENT LAYOUT

The document layout is as follows:

- **Chapter 1: Overview** – describes the libraries and precompiled object files available.
- **Chapter 2: Hardware Peripheral Functions** – describes each hardware peripheral library function.
- **Chapter 3: Software Peripheral Library** – describes each software peripheral library function.
- **Chapter 4: General Software Library** – describes each general software library function.
- **Chapter 5: Math Library** – discusses the math library functions.
- **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:

### DOCUMENTATION CONVENTIONS

<table>
<thead>
<tr>
<th>Description</th>
<th>Represents</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arial font:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italic characters</td>
<td>Referenced books</td>
<td><em>MPLAB® IDE User’s Guide</em></td>
</tr>
<tr>
<td>Courier font:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plain Courier</td>
<td>Sample source code</td>
<td>#define START</td>
</tr>
<tr>
<td></td>
<td>Filenames</td>
<td>autoexec.bat</td>
</tr>
<tr>
<td></td>
<td>File paths</td>
<td>c:\mcc18\h</td>
</tr>
<tr>
<td></td>
<td>Keywords</td>
<td>_asm, _endasm, static</td>
</tr>
<tr>
<td></td>
<td>Command-line options</td>
<td>-Opa+, -Opa-</td>
</tr>
<tr>
<td>Italic Courier</td>
<td>A variable argument</td>
<td><em>file.c</em>, where <em>file</em> can be any valid filename</td>
</tr>
<tr>
<td></td>
<td>0bnnnn</td>
<td>0b00100, 0b10</td>
</tr>
<tr>
<td></td>
<td>0xnnnn</td>
<td>0xFFFF, 0x007A</td>
</tr>
<tr>
<td></td>
<td>Square brackets [ ]</td>
<td>mcc18 [options] file [options]</td>
</tr>
<tr>
<td></td>
<td>Curly brackets and pipe character: {</td>
<td>Choice of mutually exclusive arguments: an OR selection</td>
</tr>
<tr>
<td></td>
<td>Ellipses...</td>
<td>var_name [, var_name...]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interpreted code supplied by user</td>
</tr>
</tbody>
</table>

### 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 software.

**MPLAB® C18 C Compiler Getting Started Guide (DS51295)**

Describes how to install the MPLAB C18 compiler, how to write simple programs and how to use the MPLAB IDE with the compiler.

**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® IDE Quick Start Guide (DS51281)**

Describes how to set up the MPLAB IDE software and use it to create projects and program devices.
MPASM™ Assembler, MPLINK™ Object Linker, and MPLIB™ Object Librarian User’s Guide (DS33014)

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

PICmicro® 18C MCU Family Reference Manual (DS39500)

Focuses on the Enhanced MCU family of devices. The operation of the Enhanced MCU family architecture and peripheral modules is explained but does not cover the specifics of each device.

PIC18 Device Data Sheets and Application Notes

Data sheets describe the operation and electrical specifications of PIC18 devices. Application notes describe how to use PIC18 devices.

To obtain any of the above listed documents, visit the Microchip web site (www.microchip.com) to retrieve these documents in Adobe Acrobat (.pdf) format.

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• **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 (FAQ), 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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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 C30 C compilers; MPASM™ and MPLAB ASM30 assemblers; MPLINK™ and MPLAB LINK30 object linkers; and MPLIB™ 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 and PICkit® development programmers.

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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

In addition, there is a Development Systems Information Line which lists the latest versions of Microchip’s development systems software products. This line also provides information on how customers can receive currently available upgrade kits.

The Development Systems Information Line numbers are:

1-800-755-2345 – United States and most of Canada
1-480-792-7302 – Other International Locations
Chapter 1. Overview

1.1 INTRODUCTION

This chapter gives an overview of the MPLAB C18 library files and precompiled object files that can be included in an application.

1.2 MPLAB C18 LIBRARIES OVERVIEW

A library is a collection of functions grouped for reference and ease of linking. See the MPASM™ Assembler, MPLINK™ Object Linker, MPLIB™ Object Librarian User’s Guide (DS33014) for more information about creating and maintaining libraries.

The MPLAB C18 libraries are included in the lib subdirectory of the installation. These can be linked directly into an application using the MPLINK linker.

These files were precompiled in the c:\mcc18\src directory at Microchip. The directory src\traditional contains the files for Non-extended mode and src\extended contains the files for Extended mode. If you chose not to install the compiler and related files in the c:\mcc18 directory, source code from the libraries will not show in the linker listing file and cannot be stepped through when using MPLAB IDE.

To include the library code in the .lst file and to be able to single step through library functions, follow the instructions in Section 1.3.3, Section 1.4.3 and Section 1.5.3 to rebuild the libraries using the supplied batch files (.bat) found in the src, src\traditional and src\extended directories.

1.3 START-UP CODE

1.3.1 Overview

Three versions of start-up code are provided with MPLAB C18, with varying levels of initialization. The c018*.o object files are for use with the compiler operating in the Non-extended mode. The c018*_e.o object files are for use with the compiler when operating in Extended mode. In increasing order of complexity, they are:

c018.o/c018_e.o initializes the C software stack and jumps to the start of the application function, main().

c018i.o/c018i_e.o performs all of the same tasks as c018.o/c018_e.o and also assigns the appropriate values to initialized data prior to calling the user’s application. Initialization is required if global or static variables are set to a value when they are defined. This is the start-up code that is included in the linker script files that are provided with MPLAB C18.

c018iz.o/c018iz_e.o performs all of the same tasks as c018i.o/c018i_e.o and also assigns zero to all uninitialized variables, as is required for strict ANSI compliance.
1.3.2 Source Code

The source code for the start-up routines may be found in the src\traditional\startup and src\extended\startup subdirectories of the compiler installation.

1.3.3 Rebuilding

The batch file makestartup.bat may be used to rebuild the start-up code and copy the generated object files to the lib directory.

Before rebuilding the start-up code with makestartup.bat, verify that MPLAB C18 (mcc18.exe) is in your path.

1.4 PROCESSOR-INDEPENDENT LIBRARY

1.4.1 Overview

The standard C library (clib.lib or clib_e.lib) provides functions that are supported by the core PIC18 architecture: those that are supported across all processors in the family. These functions are described in the following chapters:

• General Software Library, Chapter 4.
• Math Libraries, Chapter 5.

1.4.2 Source Code

The source code for the functions in the standard C library may be found in the following subdirectories of the compiler installation:

• src\traditional\math
• src\extended\math
• src\traditional\delays
• src\extended\delays
• src\traditional\stdclib
• src\extended\stdclib

1.4.3 Rebuilding

The batch file makeclib.bat may be used to rebuild the processor-independent library. Before invoking this batch file, verify that the following tools are in your path:

• MPLAB C18 (mcc18.exe)
• MPASM assembler (mpasm.exe)
• MPLIB librarian (mplib.exe)

Also prior to rebuilding the standard C library, be sure that the environment variable MCC_INCLUDE is set to the path of the MPLAB C18 include files (e.g., c:\mcc18\h).
1.5 PROCESSOR-SPECIFIC LIBRARIES

1.5.1 Overview

The processor-specific library files contain definitions that may vary across individual members of the PIC18 family. This includes all of the peripheral routines and the Special Function Register (SFR) definitions. The peripheral routines that are provided include both those designed to use the hardware peripherals and those that implement a peripheral interface using general purpose I/O lines. The functions included in the processor-specific libraries are described in the following chapters:

- Chapter 2. “Hardware Peripheral Functions”
- Chapter 3. “Software Peripheral Library”

The processor-specific libraries are named:

- \textit{p processor.lib} – Non-extended mode processor-specific library
- \textit{p processor\_e.lib} – Extended mode processor-specific library

For example, the library file for the PIC18F4620 is named \textit{p18f4620.lib} for the Non-extended version of the library and \textit{p18f4620\_e.lib} for the Extended version of the library.

1.5.2 Source Code

The source code for the processor-specific libraries may be found in the following subdirectories of the compiler installation:

- \textit{src\traditional\pmc}
- \textit{src\extended\pmc}
- \textit{src\traditional\proc}
- \textit{src\extended\proc}

1.5.3 Rebuilding

The batch file \texttt{makeplib.bat} may be used to rebuild the processor-specific libraries. Before invoking this batch file, verify that the following tools are in your path:

- MPLAB C18 (\texttt{mcc18.exe})
- MPASM assembler (\texttt{mpasm.exe})
- MPLIB librarian (\texttt{mplib.exe})

Also prior to invoking \texttt{makeplib.bat}, be sure that the environment variable \texttt{MCC\_INCLUDE} is set to the path of the MPLAB C18 include files (e.g., \texttt{c:\mcc18\h}).
Chapter 2. Hardware Peripheral Functions

2.1 INTRODUCTION

This chapter documents the hardware peripheral functions found in the processor-specific libraries. The source code for all of these functions is included with MPLAB C18 in the src\traditional\pmc and src\extended\pmc subdirectories of the compiler installation.

See the MPASM™ Assembler, MPLINK™ Object Linker, MPLIB™ Object Librarian User’s Guide (DS33014) for more information about managing libraries using the MPLIB librarian.

The following peripherals are supported by MPLAB C18 library routines:

- A/D Converter (Section 2.2 “A/D Converter Functions”)
- Input Capture (Section 2.3 “Input Capture Functions”)
- I²C™ (Section 2.4 “I²C™ Functions”)
- I/O Ports (Section 2.5 “I/O Port Functions”)
- Microwire (Section 2.6 “Microwire Functions”)
- Pulse-Width Modulation (PWM) (Section 2.7 “Pulse-Width Modulation Functions”)
- SPI™ (Section 2.8 “SPI™ Functions”)
- Timer (Section 2.9 “Timer Functions”)
- USART (Section 2.10 “USART Functions”)

2.2 A/D CONVERTER FUNCTIONS

The A/D peripheral is supported with the following functions:

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BusyADC</td>
<td>Is A/D converter currently performing a conversion?</td>
</tr>
<tr>
<td>CloseADC</td>
<td>Disable the A/D converter.</td>
</tr>
<tr>
<td>ConvertADC</td>
<td>Start an A/D conversion.</td>
</tr>
<tr>
<td>OpenADC</td>
<td>Configure the A/D convertor.</td>
</tr>
<tr>
<td>ReadADC</td>
<td>Read the results of an A/D conversion.</td>
</tr>
<tr>
<td>SetChanADC</td>
<td>Select A/D channel to be used.</td>
</tr>
</tbody>
</table>
### 2.2.1 Function Descriptions

#### BusyADC

**Function:** Is the A/D converter currently performing a conversion?

**Include:** adc.h

**Prototype:**
```
char BusyADC( void );
```

**Remarks:** This function indicates if the A/D peripheral is in the process of converting a value.

**Return Value:**
- 1 if the A/D peripheral is performing a conversion.
- 0 if the A/D peripheral isn’t performing a conversion.

**File Name:** adcbusy.c

#### CloseADC

**Function:** Disable the A/D converter.

**Include:** adc.h

**Prototype:**
```
void CloseADC( void );
```

**Remarks:** This function disables the A/D convertor and A/D interrupt mechanism.

**File Name:** adcclose.c

#### ConvertADC

**Function:** Starts the A/D conversion process.

**Include:** adc.h

**Prototype:**
```
void ConvertADC( void );
```

**Remarks:** This function starts an A/D conversion. The BusyADC() function may be used to detect completion of the conversion.

**File Name:** adcconv.c

#### OpenADC

**Function:** Configure the A/D convertor.

**Include:** adc.h

**Prototype:**
```
void OpenADC( unsigned char config,
             unsigned char config2 );
```

**Arguments:**
- `config`: A bitmask that is created by performing a bitwise AND operation (`&`) with a value from each of the categories listed below. These values are defined in the file adc.h.

**A/D clock source:**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADC_FOSC_2</td>
<td>FOSC / 2</td>
</tr>
<tr>
<td>ADC_FOSC_4</td>
<td>FOSC / 4</td>
</tr>
<tr>
<td>ADC_FOSC_8</td>
<td>FOSC / 8</td>
</tr>
<tr>
<td>ADC_FOSC_16</td>
<td>FOSC / 16</td>
</tr>
<tr>
<td>ADC_FOSC_32</td>
<td>FOSC / 32</td>
</tr>
<tr>
<td>ADC_FOSC_64</td>
<td>FOSC / 64</td>
</tr>
<tr>
<td>ADC_FOSC_RC</td>
<td>Internal RC Oscillator</td>
</tr>
</tbody>
</table>

**A/D result justification:**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADC_RIGHT_JUST</td>
<td>Result in Least Significant bits</td>
</tr>
<tr>
<td>ADC_LEFT_JUST</td>
<td>Result in Most Significant bits</td>
</tr>
</tbody>
</table>
Hardware Peripheral Functions

OpenADC
PIC18CXX2, PIC18FXX2, PIC18FXX8, PIC18FXX39 (Continued)

A/D voltage reference source:

<table>
<thead>
<tr>
<th>Reference Source</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADC_8ANA_0REF</td>
<td>VREF+=VDD, VREF-=VSS, all analog channels</td>
</tr>
<tr>
<td>ADC_7ANA_1REF</td>
<td>AN3=VREF+, all analog channels except AN3</td>
</tr>
<tr>
<td>ADC_6ANA_2REF</td>
<td>AN3=VREF+, AN2=VREF-</td>
</tr>
<tr>
<td>ADC_6ANA_0REF</td>
<td>VREF+=VDD, VREF-=VSS</td>
</tr>
<tr>
<td>ADC_5ANA_1REF</td>
<td>AN3=VREF+, VREF-=VSS</td>
</tr>
<tr>
<td>ADC_5ANA_0REF</td>
<td>VREF+=VDD, VREF-=VSS</td>
</tr>
<tr>
<td>ADC_4ANA_2REF</td>
<td>AN3=VREF+, AN2=VREF-</td>
</tr>
<tr>
<td>ADC_4ANA_1REF</td>
<td>AN3=VREF+</td>
</tr>
<tr>
<td>ADC_3ANA_2REF</td>
<td>AN3=VREF+, AN2=VREF-</td>
</tr>
<tr>
<td>ADC_3ANA_0REF</td>
<td>VREF+=VDD, VREF-=VSS</td>
</tr>
<tr>
<td>ADC_2ANA_2REF</td>
<td>AN3=VREF+, AN2=VREF-</td>
</tr>
<tr>
<td>ADC_2ANA_1REF</td>
<td>AN3=VREF+</td>
</tr>
<tr>
<td>ADC_1ANA_2REF</td>
<td>AN3=VREF+, AN2=VREF-, AN0=A</td>
</tr>
<tr>
<td>ADC_1ANA_0REF</td>
<td>AN0 is analog input</td>
</tr>
<tr>
<td>ADC_0ANA_0REF</td>
<td>All digital I/O</td>
</tr>
</tbody>
</table>

`config2`

A bitmask that is created by performing a bitwise AND operation (`&`) with a value from each of the categories listed below. These values are defined in the file `adc.h`.

Channel:

<table>
<thead>
<tr>
<th>Channel</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADC_CH0</td>
<td>Channel 0</td>
</tr>
<tr>
<td>ADC_CH1</td>
<td>Channel 1</td>
</tr>
<tr>
<td>ADC_CH2</td>
<td>Channel 2</td>
</tr>
<tr>
<td>ADC_CH3</td>
<td>Channel 3</td>
</tr>
<tr>
<td>ADC_CH4</td>
<td>Channel 4</td>
</tr>
<tr>
<td>ADC_CH5</td>
<td>Channel 5</td>
</tr>
<tr>
<td>ADC_CH6</td>
<td>Channel 6</td>
</tr>
<tr>
<td>ADC_CH7</td>
<td>Channel 7</td>
</tr>
</tbody>
</table>

A/D Interrupts:

<table>
<thead>
<tr>
<th>Interrupt</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADC_INT_ON</td>
<td>Interrupts enabled</td>
</tr>
<tr>
<td>ADC_INT_OFF</td>
<td>Interrupts disabled</td>
</tr>
</tbody>
</table>

Remarks: This function resets the A/D peripheral to the POR state and configures the A/D-related Special Function Registers (SFRs) according to the options specified.

File Name: `adcopen.c`

Code Example:

```c
OpenADC( ADC_FOSC_32    &
        ADC_RIGHT_JUST &
        ADC_1ANA_0REF,  
        ADC_CH0        &
        ADC_INT_OFF    );
```
OpenADC
PIC18C658/858, PIC18C601/801,
PIC18F6X20, PIC18F8X20

<table>
<thead>
<tr>
<th>Function:</th>
<th>Configure the A/D converter.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Include:</td>
<td>adc.h</td>
</tr>
<tr>
<td>Prototype:</td>
<td>void OpenADC( unsigned char</td>
</tr>
<tr>
<td></td>
<td>config, unsigned char config2</td>
</tr>
<tr>
<td></td>
<td>)</td>
</tr>
<tr>
<td>Arguments:</td>
<td>config</td>
</tr>
<tr>
<td></td>
<td>A bitmask that is created by</td>
</tr>
<tr>
<td></td>
<td>performing a bitwise AND</td>
</tr>
<tr>
<td></td>
<td>operation ('&amp;') with a value</td>
</tr>
<tr>
<td></td>
<td>from each of the categories</td>
</tr>
<tr>
<td></td>
<td>listed below. These values</td>
</tr>
<tr>
<td></td>
<td>are defined in the file adc.h.</td>
</tr>
</tbody>
</table>

A/D clock source:
- ADC_FOSC_2  FOSC / 2
- ADC_FOSC_4  FOSC / 4
- ADC_FOSC_8  FOSC / 8
- ADC_FOSC_16 FOSC / 16
- ADC_FOSC_32 FOSC / 32
- ADC_FOSC_64 FOSC / 64
- ADC_FOSC_RC Internal RC Oscillator

A/D result justification:
- ADC_RIGHT_JUST Result in Least Significant bits
- ADC_LEFT_JUST  Result in Most Significant bits

A/D port configuration:
- ADC_0ANA     All digital
- ADC_1ANA     analog:AN0  digital:AN1-AN15
- ADC_2ANA     analog:AN0-AN1 digital:AN2-AN15
- ADC_3ANA     analog:AN0-AN2 digital:AN3-AN15
- ADC_4ANA     analog:AN0-AN3 digital:AN4-AN15
- ADC_5ANA     analog:AN0-AN4 digital:AN5-AN15
- ADC_6ANA     analog:AN0-AN5 digital:AN6-AN15
- ADC_7ANA     analog:AN0-AN6 digital:AN7-AN15
- ADC_8ANA     analog:AN0-AN7 digital:AN8-AN15
- ADC_9ANA     analog:AN0-AN8 digital:AN9-AN15
- ADC_10ANA    analog:AN0-AN9 digital:AN10-AN15
- ADC_11ANA    analog:AN0-AN10 digital:AN11-AN15
- ADC_12ANA    analog:AN0-AN11 digital:AN12-AN15
- ADC_13ANA    analog:AN0-AN12 digital:AN13-AN15
- ADC_14ANA    analog:AN0-AN13 digital:AN14-AN15
- ADC_15ANA    All analog

config2
A bitmask that is created by performing a bitwise AND operation ('&')
with a value from each of the categories listed below. These values are
defined in the file adc.h.
OpenADC
PIC18C658/858, PIC18C601/801,
PIC18F6X20, PIC18F8X20 (Continued)

Channel:
- ADC_CH0 Channel 0
- ADC_CH1 Channel 1
- ADC_CH2 Channel 2
- ADC_CH3 Channel 3
- ADC_CH4 Channel 4
- ADC_CH5 Channel 5
- ADC_CH6 Channel 6
- ADC_CH7 Channel 7
- ADC_CH8 Channel 8
- ADC_CH9 Channel 9
- ADC_CH10 Channel 10
- ADC_CH11 Channel 11
- ADC_CH12 Channel 12
- ADC_CH13 Channel 13
- ADC_CH14 Channel 14
- ADC_CH15 Channel 15

A/D Interrupts:
- ADC_INT_ON Interrupts enabled
- ADC_INT_OFF Interrupts disabled

A/D VREF+ configuration:
- ADC_VREFPLUS_VDD VREF+ = AVDD
- ADC_VREFPLUS_EXT VREF+ = external

A/D VREF- configuration:
- ADC_VREFMINUS_VSS VREF- = AVSS
- ADC_VREFMINUS_EXT VREF- = external

Remarks: This function resets the A/D-related registers to the POR state and then configures the clock, result format, voltage reference, port and channel.

File Name: adcopen.c

Code Example:
```c
OpenADC( ADC_FOSC_32 &
           ADC_RIGHT_JUST &
           ADC_14ANA, 
           ADC_CH0 &
           ADC_INT_OFF );
```
### OpenADC
#### All Other Processors

**Function:** Configure the A/D convertor.

**Include:**
```c
#include adc.h
```

**Prototype:**
```c
void OpenADC(unsigned char config,
              unsigned char config2,
              unsigned char portconfig);
```

**Arguments:**
- `config`  
  A bitmask that is created by performing a bitwise AND operation (`&`) with a value from each of the categories listed below. These values are defined in the file `adc.h`.

  **A/D clock source:**
  - `ADC_FOSC_2`  
  - `ADC_FOSC_4`  
  - `ADC_FOSC_8`  
  - `ADC_FOSC_16`  
  - `ADC_FOSC_32`  
  - `ADC_FOSC_64`  
  - `ADC_FOSC_RC`  
  
  **A/D result justification:**
  - `ADC_RIGHT_JUST`  
  - `ADC_LEFT_JUST`  
  
  **A/D acquisition time select:**
  - `ADC_0_TAD`  
  - `ADC_2_TAD`  
  - `ADC_4_TAD`  
  - `ADC_6_TAD`  
  - `ADC_8_TAD`  
  - `ADC_12_TAD`  
  - `ADC_16_TAD`  
  - `ADC_20_TAD`  
  
  `config2`  
  A bitmask that is created by performing a bitwise AND operation (`&`) with a value from each of the categories listed below. These values are defined in the file `adc.h`.

  **Channel:**
  - `ADC_CH0`  
  - `ADC_CH1`  
  - `ADC_CH2`  
  - `ADC_CH3`  
  - `ADC_CH4`  
  - `ADC_CH5`  
  - `ADC_CH6`  
  - `ADC_CH7`  
  - `ADC_CH8`  
  - `ADC_CH9`  
  - `ADC_CH10`  
  - `ADC_CH11`  
  - `ADC_CH12`  
  - `ADC_CH13`  
  - `ADC_CH14`  
  - `ADC_CH15`
## OpenADC

### All Other Processors (Continued)

#### A/D Interrupts:
- ADC_INT_ON: Interrupts enabled
- ADC_INT_OFF: Interrupts disabled

#### A/D Voltage Configuration:
- ADC_VREFPLUS_VDD: VREF+ = AVDD
- ADC_VREFPLUS_EXT: VREF+ = external
- ADC_VREFMINUS_VDD: VREF- = AVDD
- ADC_VREFMINUS_EXT: VREF- = external

**portconfig**

The value of portconfig is any value from 0 to 127 inclusive for the PIC18F1220/1320 and 0 to 15 inclusive for all other processors. This is the value of bits 0 through 6 or bits 0 through 3 of the ADCON1 register, which are the port configuration bits.

**Remarks:**
This function resets the A/D-related registers to the POR state and then configures the clock, result format, voltage reference, port and channel.

**File Name:** adcopen.c

**Code Example:**
```
OpenADC( ADC_FOSC_32    &
         ADC_RIGHT_JUST &
         ADC_12_TAD,    
         ADC_CH0        &
         ADC_INT_OFF, 15  );
```

### ReadADC

**Function:** Read the result of an A/D conversion.

**Include:** adc.h

**Prototype:**
```
int ReadADC( void );
```

**Remarks:**
This function reads the 16-bit result of an A/D conversion.

**Return Value:**
This function returns the 16-bit signed result of the A/D conversion. Based on the configuration of the A/D converter (e.g., using the OpenADC() function), the result will be contained in the Least Significant or Most Significant bits of the 16-bit result.

**File Name:** adcread.c
### SetChanADC

**Function:** Select the channel used as input to the A/D converter.

**Include:** `adc.h`  

**Prototype:** `void SetChanADC( unsigned char channel );`

**Arguments:**  

- `channel`  

One of the following values (defined in `adc.h`):

- `ADC_CH0` Channel 0  
- `ADC_CH1` Channel 1  
- `ADC_CH2` Channel 2  
- `ADC_CH3` Channel 3  
- `ADC_CH4` Channel 4  
- `ADC_CH5` Channel 5  
- `ADC_CH6` Channel 6  
- `ADC_CH7` Channel 7  
- `ADC_CH8` Channel 8  
- `ADC_CH9` Channel 9  
- `ADC_CH10` Channel 10  
- `ADC_CH11` Channel 11

**Remarks:** Selects the pin that will be used as input to the A/D converter.

**File Name:** `adcsetch.c`

**Code Example:**

```c
SetChanADC( ADC_CH0 );
```

### 2.2.2 Example Use of the A/D Converter Routines

```c
#include <p18C452.h>  
#include <adc.h>  
#include <stdlib.h>  
#include <delays.h>  

int result;

void main( void )
{
    // configure A/D convertor
    OpenADC( ADC_FOSC_32 & ADC_RIGHT_JUST & ADC_SANA_0REF,
             ADC_CH0 & ADC_INT_OFF );

    Delay10TCYx( 5 );       // Delay for 50TCY
    ConvertADC();           // Start conversion
    while( BusyADC() );     // Wait for completion
    result = ReadADC();     // Read result
    CloseADC();             // Disable A/D converter
}
```
2.3 INPUT CAPTURE FUNCTIONS

The capture peripheral is supported with the following functions:

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CloseCapture(x)</td>
<td>Disable capture peripheral (x).</td>
</tr>
<tr>
<td>OpenCapture(x)</td>
<td>Configure capture peripheral (x).</td>
</tr>
<tr>
<td>ReadCapture(x)</td>
<td>Read a value from capture peripheral (x).</td>
</tr>
</tbody>
</table>
| CloseECapture\(x\)
\((1)\) | Disable enhanced capture peripheral \(x\). |
| OpenECapture\(x\)
\((1)\) | Configure enhanced capture peripheral \(x\). |
| ReadECapture\(x\)
\((1)\) | Read a value from enhanced capture peripheral \(x\). |

**Note 1:** The enhanced capture functions are only available on those devices with an ECCPxCON register.

### 2.3.1 Function Descriptions

- **CloseCapture1**
- **CloseCapture2**
- **CloseCapture3**
- **CloseCapture4**
- **CloseCapture5**
- **CloseECapture1**

**Function:** Disable input capture \(x\).

**Include:** capture.h

**Prototype:**

```c
void CloseCapture1( void );
void CloseCapture2( void );
void CloseCapture3( void );
void CloseCapture4( void );
void CloseCapture5( void );
void CloseECapture1( void );
```

**Remarks:** This function disables the interrupt corresponding to the specified input capture.

**File Name:**

- cp1close.c
- cp2close.c
- cp3close.c
- cp4close.c
- cp5close.c
- ep1close.c
### OpenCapture1

**Function:** Configure and enable input capture x.

**Include:** capture.h

**Prototype:**

```c
void OpenCapture1( unsigned char config );
void OpenCapture2( unsigned char config );
void OpenCapture3( unsigned char config );
void OpenCapture4( unsigned char config );
void OpenCapture5( unsigned char config );
void OpenECapture1( unsigned char config );
```

**Arguments:**

`config`

A bitmask that is created by performing a bitwise AND operation (‘&’) with a value from each of the categories listed below. These values are defined in the file capture.h:

**Enable CCP Interrupts:**

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAPTURE_INT_ON</td>
<td>Interrupts Enabled</td>
</tr>
<tr>
<td>CAPTURE_INT_OFF</td>
<td>Interrupts Disabled</td>
</tr>
</tbody>
</table>

**Interrupt Trigger (replace x with CCP module number):**

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cx_EVERY_FALL_EDGE</td>
<td>Interrupt on every falling edge</td>
</tr>
<tr>
<td>Cx_EVERY_RISE_EDGE</td>
<td>Interrupt on every rising edge</td>
</tr>
<tr>
<td>Cx_EVERY_4_RISE_EDGE</td>
<td>Interrupt on every 4th rising edge</td>
</tr>
<tr>
<td>Cx_EVERY_16_RISE_EDGE</td>
<td>Interrupt on every 16th rising edge</td>
</tr>
<tr>
<td>EC1_EVERY_FALL_EDGE</td>
<td>Interrupt on every falling edge (enhanced)</td>
</tr>
<tr>
<td>EC1_EVERY_RISE_EDGE</td>
<td>Interrupt on every rising edge (enhanced)</td>
</tr>
<tr>
<td>EC1_EVERY_4_RISE_EDGE</td>
<td>Interrupt on every 4th rising edge (enhanced)</td>
</tr>
<tr>
<td>EC1_EVERY_16_RISE_EDGE</td>
<td>Interrupt on every 16th rising edge (enhanced)</td>
</tr>
</tbody>
</table>

**Remarks:**

This function first resets the capture module to the POR state and then configures the input capture for the specified edge detection.

The capture functions use a structure, defined in capture.h, to indicate overflow status of each of the capture modules. This structure is called CapStatus and has the following bit fields:

- Cap1OVF
- Cap2OVF
- Cap3OVF
- Cap4OVF
- Cap5OVF
- ECap1OVF

In addition to opening the capture, the appropriate timer module must be enabled before any of the captures will operate. See the data sheet for CCP and timer interconnect configurations and Section 2.9 “Timer Functions” for the arguments used with CCP in OpenTimer3.
OpenCapture1
OpenCapture2
OpenCapture3
OpenCapture4
OpenCapture5
OpenECapture1 (Continued)

Code Example:
OpenCapture1(  CAPTURE_INT_ON &
             C1_EVERY_4_RISE_EDGE );

ReadCapture1
ReadCapture2
ReadCapture3
ReadCapture4
ReadCapture5
ReadECapture1

Function: Read the result of a capture event from the specified input capture.
Include: capture.h
Prototype:
unsigned int ReadCapture1( void );
unsigned int ReadCapture2( void );
unsigned int ReadCapture3( void );
unsigned int ReadCapture4( void );
unsigned int ReadCapture5( void );
unsigned int ReadECapture1( void );

Remarks: This function reads the value of the respective input capture's SFRs.
Return Value: This function returns the result of the capture event.
File Name:
cp1read.c
cp2read.c
cp3read.c
cp4read.c
cp5read.c
eplread.c
2.3.2 Example Use of the Capture Routines

This example demonstrates the use of the capture library routines in a “polled” (not interrupt-driven) environment.

```c
#include <p18C452.h>
#include <capture.h>
#include <timers.h>
#include <usart.h>
#include <stdlib.h>

void main(void)
{
    unsigned int result;
    char str[7];

    // Configure Capture1
    OpenCapture1( C1_EVERY_4_RISE_EDGE &
                  CAPTURE_INT_OFF );

    // Configure Timer3
    OpenTimer3( TIMER_INT_OFF &
                T3_SOURCE_INT );

    // Configure USART
    OpenUSART( USART_TX_INT_OFF &
               USART_RX_INT_OFF &
               USART_ASYNCH_MODE &
               USART_EIGHT_BIT &
               USART_CONT_RX,
               25 );

    while(!PIR1bits.CCP1IF); // Wait for event
    result = ReadCapture1(); // read result
    ultoa(result,str);       // convert to string

    // Write the string out to the USART if
    // an overflow condition has not occurred.
    if(!CapStatus.Cap1OVF)
    {
        putsUSART(str);
    }

    // Clean up
    CloseCapture1();
    CloseTimer3();
    CloseUSART();
}
```
2.4 I\(^2\)C™ FUNCTIONS

The following routines are provided for devices with a single I\(^2\)C peripheral:

**TABLE 2-3: SINGLE I\(^2\)C™ PERIPHERAL FUNCTIONS**

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AckI2C</td>
<td>Generate I(^2)C bus <em>Acknowledgment</em> condition.</td>
</tr>
<tr>
<td>CloseI2C</td>
<td>Disable the SSP module.</td>
</tr>
<tr>
<td>DataRdyI2C</td>
<td>Is the data available in the I(^2)C buffer?</td>
</tr>
<tr>
<td>getcI2C</td>
<td>Read a single byte from the I(^2)C bus.</td>
</tr>
<tr>
<td>getsI2C</td>
<td>Read a string from the I(^2)C bus operating in master I(^2)C mode.</td>
</tr>
<tr>
<td>IdleI2C</td>
<td>Loop until I(^2)C bus is idle.</td>
</tr>
<tr>
<td>NotAckI2C</td>
<td>Generate I(^2)C bus <em>Not Acknowledge</em> condition.</td>
</tr>
<tr>
<td>OpenI2C</td>
<td>Configure the SSP module.</td>
</tr>
<tr>
<td>putcI2C</td>
<td>Write a single byte to the I(^2)C bus.</td>
</tr>
<tr>
<td>putsI2C</td>
<td>Write a string to the I(^2)C bus operating in either Master or Slave mode.</td>
</tr>
<tr>
<td>ReadI2C</td>
<td>Read a single byte from the I(^2)C bus.</td>
</tr>
<tr>
<td>RestartI2C</td>
<td>Generate an I(^2)C bus <em>Restart</em> condition.</td>
</tr>
<tr>
<td>StartI2C</td>
<td>Generate an I(^2)C bus <em>Start</em> condition.</td>
</tr>
<tr>
<td>StopI2C</td>
<td>Generate an I(^2)C bus <em>Stop</em> condition.</td>
</tr>
<tr>
<td>WriteI2C</td>
<td>Write a single byte to the I(^2)C bus.</td>
</tr>
</tbody>
</table>

The following routines are provided for devices with multiple I\(^2\)C peripherals:

**TABLE 2-4: MULTIPLE I\(^2\)C™ PERIPHERAL FUNCTIONS**

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AckI2Cx</td>
<td>Generate I(^2)Cx bus <em>Acknowledgment</em> condition.</td>
</tr>
<tr>
<td>CloseI2Cx</td>
<td>Disable the SS (x) module.</td>
</tr>
<tr>
<td>DataRdyI2Cx</td>
<td>Is the data available in the I(^2)Cx buffer?</td>
</tr>
<tr>
<td>getcI2Cx</td>
<td>Read a single byte from the I(^2)Cx bus.</td>
</tr>
<tr>
<td>getsI2Cx</td>
<td>Read a string from the I(^2)Cx bus operating in master I(^2)C mode.</td>
</tr>
<tr>
<td>IdleI2Cx</td>
<td>Loop until I(^2)Cx bus is idle.</td>
</tr>
<tr>
<td>NotAckI2Cx</td>
<td>Generate I(^2)Cx bus <em>Not Acknowledge</em> condition.</td>
</tr>
<tr>
<td>OpenI2Cx</td>
<td>Configure the SSP(x) module.</td>
</tr>
<tr>
<td>putcI2Cx</td>
<td>Write a single byte to the I(^2)Cx bus.</td>
</tr>
<tr>
<td>putsI2Cx</td>
<td>Write a string to the I(^2)Cx bus operating in either Master or Slave mode.</td>
</tr>
<tr>
<td>ReadI2Cx</td>
<td>Read a single byte from the I(^2)Cx bus.</td>
</tr>
<tr>
<td>RestartI2Cx</td>
<td>Generate an I(^2)Cx bus <em>Restart</em> condition.</td>
</tr>
<tr>
<td>StartI2Cx</td>
<td>Generate an I(^2)Cx bus <em>Start</em> condition.</td>
</tr>
<tr>
<td>StopI2Cx</td>
<td>Generate an I(^2)Cx bus <em>Stop</em> condition.</td>
</tr>
<tr>
<td>WriteI2Cx</td>
<td>Write a single byte to the I(^2)Cx bus.</td>
</tr>
</tbody>
</table>
The following functions are also provided for interfacing with an EE memory device such as the Microchip 24LC01B using the I²C interface:

### TABLE 2-5: INTERFACE FUNCTIONS FOR EE MEMORY DEVICES

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEAckPolling</td>
<td>Generate the Acknowledge polling sequence.</td>
</tr>
<tr>
<td>EEByteWrite</td>
<td>Write a single byte.</td>
</tr>
<tr>
<td>EECurrentAddRead</td>
<td>Read a single byte from the next location.</td>
</tr>
<tr>
<td>EEPageWrite</td>
<td>Write a string of data.</td>
</tr>
<tr>
<td>EERandomRead</td>
<td>Read a single byte from an arbitrary address.</td>
</tr>
<tr>
<td>EESequentialRead</td>
<td>Read a string of data.</td>
</tr>
</tbody>
</table>

#### 2.4.1 Function Descriptions

**AckI2C**

**AckI2C1**

**AckI2C2**

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
<th>Include</th>
<th>Prototype</th>
</tr>
</thead>
<tbody>
<tr>
<td>AckI2C</td>
<td>Generate I²C bus Acknowledge condition.</td>
<td>i2c.h</td>
<td>void AckI2C( void ); void AckI2C1( void ); voice AckI2C2( void );</td>
</tr>
<tr>
<td>AckI2C1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AckI2C2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remarks:</td>
<td>This function generates an I²C bus Acknowledge condition.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>File Name:</td>
<td>i2c_ack.c i2c1ack.c i2c2ack.c</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CloseI2C**

**CloseI2C1**

**CloseI2C2**

<table>
<thead>
<tr>
<th>Function</th>
<th>Disable the SSPx module.</th>
<th>Include</th>
<th>Prototype</th>
</tr>
</thead>
<tbody>
<tr>
<td>CloseI2C</td>
<td></td>
<td>i2c.h</td>
<td>void CloseI2C( void ); void CloseI2C1( void ); void CloseI2C2( void );</td>
</tr>
<tr>
<td>CloseI2C1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CloseI2C2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remarks:</td>
<td>This function disables the SSPx module.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>File Name:</td>
<td>i2c_close.c i2c1close.c i2c2close.c</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
DataRdyI2C
DataRdyI2C1
DataRdyI2C2

Function: Is data available in the I²C buffer?
Include: i2c.h
Prototype: unsigned char DataRdyI2C( void );
unsigned char DataRdyI2C1( void );
unsigned char DataRdyI2C2( void );
Remarks: Determines if there is a byte to be read in the SSPx buffer.
Return Value: 1 if there is data in the SSPx buffer
0 if there is no data in the SSPx buffer
File Name: i2c_dtrd.c
i2c1dtrd.c
i2c2dtrd.c
Code Example: if (DataRdyI2C())
{
    var = getcI2C();
}

getcI2C
getcI2C1
getcI2C2

getcI2Cx is defined as ReadI2Cx. See ReadI2Cx.

getsI2C
getsI2C1
getsI2C2

Function: Read a fixed length string from the I²C bus operating in master I²C mode.
Include: i2c.h
Prototype: unsigned char getsI2C(
    unsigned char * rdptr,
    unsigned char length );
unsigned char getsI2C1(
    unsigned char * rdptr,
    unsigned char length );
unsigned char getsI2C2(
    unsigned char * rdptr,
    unsigned char length );
Arguments: rdptr Character type pointer to PICmicro MCU RAM for storage of data read from I²C device.
length Number of bytes to read from I²C device.
Remarks: This routine reads a predefined data string length from the I²Cx bus.
getsI2C
getsI2C1
getsI2C2 (Continued)

Return Value:  
0 if all bytes have been sent
-1 if a bus collision has occurred

File Name:  
i2c_gets.c
i2c1gets.c
i2c2gets.c

Code Example:  
unsigned char string[15];
getsI2C(string, 15);

IdleI2C
IdleI2C1
IdleI2C2

Function: Loop until I^2Cx bus is Idle.

Include: i2c.h

Prototype: void IdleI2C( void );

Remarks: This function checks the state of the I^2C peripheral and waits for the bus to become available. The IdleI2C function is required since the hardware I^2C peripheral does not allow for spooling of bus sequences. The I^2C peripheral must be in an Idle state before an I^2C operation can be initiated or a write collision will be generated.

File Name: idlei2c.c

NotAckI2C
NotAckI2C1
NotAckI2C2

Function: Generate I^2Cx bus Not Acknowledge condition.

Include: i2c.h

Prototype: void NotAckI2C( void );
void NotAckI2C1( void );
void NotAckI2C2( void );

Remarks: This function generates an I^2Cx bus Not Acknowledge condition.

File Name: i2c_nack.c
i2c1nack.c
i2c2nack.c
### OpenI2C

**Function:** Configure the SSPx module.

**Include:**
```
i2c.h
```

**Prototype:**
```
void OpenI2C( unsigned char sync_mode,
              unsigned char slew );
void OpenI2C1( unsigned char sync_mode,
               unsigned char slew );
void OpenI2C2( unsigned char sync_mode,
               unsigned char slew );
```

**Arguments:**

- `sync_mode`
  One of the following values, defined in `i2c.h`:
  - SLAVE_7: I²C Slave mode, 7-bit address
  - SLAVE_10: I²C Slave mode, 10-bit address
  - MASTER: I²C Master mode

- `slew`
  One of the following values, defined in `i2c.h`:
  - SLEW_OFF: Slew rate disabled for 100 kHz mode
  - SLEW_ON: Slew rate enabled for 400 kHz mode

**Remarks:**
OpenI2Cx resets the SSPx module to the POR state and then configures the module for Master/Slave mode and the selected slew rate.

**File Name:**
- i2c_open.c
- i2c1open.c
- i2c2open.c

**Code Example:**
```
OpenI2C(MASTER, SLEW_ON);
```

### putcI2C

**putcI2C**

**putcI2C1**

**putcI2C2**

putcI2Cx is defined as WriteI2Cx. See WriteI2Cx.
putsI2C
putsI2C1
putsI2C2

Function: Write a data string to the I²C bus operating in either Master or Slave mode.

Include: i2c.h

Prototype:
unsigned char putsI2C(unsigned char *wrptr);
unsigned char putsI2C1(unsigned char *wrptr);
unsigned char putsI2C2(unsigned char *wrptr);

Arguments: wrptr
Pointer to data that will be written to the I²C bus.

Remarks: This routine writes a data string to the I²C bus until a null character is reached. The null character itself is not transmitted. This routine can operate in both Master or Slave mode.

Return Value: Master I²C mode:
0 if the null character was reached in the data string
-2 if the slave I²C device responded with a NOT ACK
-3 if a write collision occurred
Slave I²C mode:
0 if the null character was reached in the data string
-2 if the master I²C device responded with a NOT ACK which terminated the data transfer

File Name: i2c_puts.c
t2c1puts.c
t2c2puts.c

Code Example:
unsigned char string[] = “data to send”;
putsI2C(string);

ReadI2C
ReadI2C1
ReadI2C2
getcI2C
getcI2C1
getcI2C2

Function: Read a single byte from the I²C bus.

Include: i2c.h

Prototype:
unsigned char ReadI2C ( void );
unsigned char ReadI2C1 ( void );
unsigned char ReadI2C2 ( void );
unsigned char getcI2C ( void );
unsigned char getcI2C1 ( void );
unsigned char getcI2C2 ( void );

Remarks: This function reads in a single byte from the I²C bus. getcI2Cx is defined to be ReadI2Cx in i2c.h.

Return Value: The data byte read from the I²C bus.
### ReadI2C
### ReadI2C1
### ReadI2C2
### getcl2C
### getcl2C1
### getcl2C2 (Continued)

<table>
<thead>
<tr>
<th>File Name:</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>i2c_read.c</td>
<td></td>
</tr>
<tr>
<td>i2c1read.c</td>
<td></td>
</tr>
<tr>
<td>i2c2read.c</td>
<td></td>
</tr>
<tr>
<td># define in i2c.h</td>
<td></td>
</tr>
<tr>
<td># define in i2c.h</td>
<td></td>
</tr>
<tr>
<td># define in i2c.h</td>
<td></td>
</tr>
</tbody>
</table>

#### Code Example:

```c
unsigned char value;
value = ReadI2C();
```

### RestartI2C
### RestartI2C1
### RestartI2C2

<table>
<thead>
<tr>
<th>Function:</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RestartI2C</td>
<td>Generate an I^2C_x bus Restart condition.</td>
</tr>
<tr>
<td>RestartI2C1</td>
<td></td>
</tr>
<tr>
<td>RestartI2C2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Include:</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>i2c.h</td>
<td></td>
</tr>
</tbody>
</table>

#### Prototype:

```c
void RestartI2C( void );
void RestartI2C1( void );
void RestartI2C2( void );
```

#### Remarks:

This function generates an I^2C_x bus Restart condition.

<table>
<thead>
<tr>
<th>File Name:</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>i2c_rstr.c</td>
<td></td>
</tr>
<tr>
<td>i2c1rstr.c</td>
<td></td>
</tr>
<tr>
<td>i2c2rstr.c</td>
<td></td>
</tr>
</tbody>
</table>

### StartI2C
### StartI2C1
### StartI2C2

<table>
<thead>
<tr>
<th>Function:</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>StartI2C</td>
<td>Generate an I^2C_x bus Start condition.</td>
</tr>
<tr>
<td>StartI2C1</td>
<td></td>
</tr>
<tr>
<td>StartI2C2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Include:</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>i2c.h</td>
<td></td>
</tr>
</tbody>
</table>

#### Prototype:

```c
void StartI2C( void );
void StartI2C1( void );
void StartI2C2( void );
```

#### Remarks:

This function generates a I^2C_x bus Start condition.

<table>
<thead>
<tr>
<th>File Name:</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>i2c_start.c</td>
<td></td>
</tr>
<tr>
<td>i2c1start.c</td>
<td></td>
</tr>
<tr>
<td>i2c2start.c</td>
<td></td>
</tr>
</tbody>
</table>
StopI2C
StopI2C1
StopI2C2

Function: Generate I2Cx bus Stop condition.  
Include: i2c.h  
Prototype: void StopI2C( void );  void StopI2C1( void );  void StopI2C2( void );  
Remarks: This function generates an I2Cx bus Stop condition.  
File Name: i2c_stop.c i2c1stop.c i2c2stop.c

WriteI2C
WriteI2C1
WriteI2C2
putcI2C
putcI2C1
putcI2C2

Function: Write a single byte to the I2Cx bus device.  
Include: i2c.h  
Prototype: unsigned char WriteI2C(  unsigned char data_out );  unsigned char WriteI2C1(  unsigned char data_out );  unsigned char WriteI2C2(  unsigned char data_out );  unsigned char putcI2C(  unsigned char data_out );  unsigned char putcI2C1(  unsigned char data_out );  unsigned char putcI2C2(  unsigned char data_out );  
Arguments: data_out A single data byte to be written to the I2Cx bus device.  
Remarks: This function writes out a single data byte to the I2Cx bus device. putcI2Cx is defined to be WriteI2Cx in i2c.h.  
Return Value: 0 if the write was successful  -1 if there was a write collision  
File Name: i2c_write.c i2c1write.c i2c2write.c  
#define in i2c.h  
#define in i2c.h  
#define in i2c.h  
Code Example: WriteI2C('a');
## 2.4.2 EE Memory Device Interface Function Descriptions

### EE Ack Polling

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE Ack Polling</td>
<td>Generate the Acknowledge polling sequence for Microchip EE I²C memory devices.</td>
</tr>
<tr>
<td>EE Ack Polling 1</td>
<td>Include: i2c.h</td>
</tr>
<tr>
<td>EE Ack Polling 2</td>
<td>Prototype:</td>
</tr>
<tr>
<td></td>
<td>unsigned char EE Ack Polling(</td>
</tr>
<tr>
<td></td>
<td>unsigned char control</td>
</tr>
<tr>
<td></td>
<td>);</td>
</tr>
<tr>
<td></td>
<td>unsigned char EE Ack Polling 1(</td>
</tr>
<tr>
<td></td>
<td>unsigned char control</td>
</tr>
<tr>
<td></td>
<td>);</td>
</tr>
<tr>
<td></td>
<td>unsigned char EE Ack Polling 2(</td>
</tr>
<tr>
<td></td>
<td>unsigned char control</td>
</tr>
<tr>
<td></td>
<td>);</td>
</tr>
<tr>
<td>Arguments:</td>
<td>control</td>
</tr>
<tr>
<td></td>
<td>EEPROM control / bus device select address byte.</td>
</tr>
<tr>
<td>Remarks:</td>
<td>This function is used to generate the Acknowledge polling sequence for EE I²C</td>
</tr>
<tr>
<td></td>
<td>memory devices that utilize Acknowledge polling.</td>
</tr>
<tr>
<td>Return Value:</td>
<td>0 if there were no errors</td>
</tr>
<tr>
<td></td>
<td>-1 if there was a bus collision error</td>
</tr>
<tr>
<td></td>
<td>-3 if there was a write collision error</td>
</tr>
<tr>
<td>File Name:</td>
<td>i2c_ecap.c</td>
</tr>
<tr>
<td></td>
<td>i2c1ecap.c</td>
</tr>
<tr>
<td></td>
<td>i2c2ecap.c</td>
</tr>
<tr>
<td>Code Example:</td>
<td>temp = EE Ack Polling(0xA0);</td>
</tr>
</tbody>
</table>

### EE Byte Write

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE Byte Write</td>
<td>Write a single byte to the I²C bus.</td>
</tr>
<tr>
<td>EE Byte Write 1</td>
<td>Include: i2c.h</td>
</tr>
<tr>
<td>EE Byte Write 2</td>
<td>Prototype:</td>
</tr>
<tr>
<td></td>
<td>unsigned char EE Byte Write(</td>
</tr>
<tr>
<td></td>
<td>unsigned char control,</td>
</tr>
<tr>
<td></td>
<td>unsigned char address,</td>
</tr>
<tr>
<td></td>
<td>unsigned char data )</td>
</tr>
<tr>
<td></td>
<td>);</td>
</tr>
<tr>
<td></td>
<td>unsigned char EE Byte Write 1(</td>
</tr>
<tr>
<td></td>
<td>unsigned char control,</td>
</tr>
<tr>
<td></td>
<td>unsigned char address,</td>
</tr>
<tr>
<td></td>
<td>unsigned char data )</td>
</tr>
<tr>
<td></td>
<td>);</td>
</tr>
<tr>
<td></td>
<td>unsigned char EE Byte Write 2(</td>
</tr>
<tr>
<td></td>
<td>unsigned char control,</td>
</tr>
<tr>
<td></td>
<td>unsigned char address,</td>
</tr>
<tr>
<td></td>
<td>unsigned char data )</td>
</tr>
<tr>
<td>Arguments:</td>
<td>control</td>
</tr>
<tr>
<td></td>
<td>EEPROM control / bus device select address byte.</td>
</tr>
<tr>
<td></td>
<td>address</td>
</tr>
<tr>
<td></td>
<td>EEPROM internal address location.</td>
</tr>
<tr>
<td></td>
<td>data</td>
</tr>
<tr>
<td></td>
<td>Data to write to EEPROM address specified in function parameter address.</td>
</tr>
</tbody>
</table>
### EEByteWrite
#### EEByteWrite1
#### EEByteWrite2 (Continued)

**Remarks:** This function writes a single data byte to the I^2^C bus. This routine can be used for any Microchip I^2^C EE memory device which requires only 1 byte of address information.

**Return Value:**
- 0 if there were no errors
- -1 if there was a bus collision error
- -2 if there was a NOT ACK error
- -3 if there was a write collision error

**File Name:**
i2c_ecbw.c  
i2c1ecbw.c  
i2c2ecbw.c

**Code Example:**
```c
temp = EEByteWrite(0xA0, 0x30, 0xA5);
```

### EECurrentAddRead
#### EECurrentAddRead1
#### EECurrentAddRead2

**Function:** Read a single byte from the I^2^C bus.

**Include:**
i2c.h

**Prototype:**
```c
unsigned int EECurrentAddRead( 
    unsigned char control );
unsigned int EECurrentAddRead1(  
    unsigned char control );
unsigned int EECurrentAddRead2(    
    unsigned char control );
```

**Arguments:**
- `control` EEPROM control / bus device select address byte.

**Remarks:** This function reads in a single byte from the I^2^C bus. The address location of the data to read is that of the current pointer within the I^2^C EE device. The memory device contains an address counter that maintains the address of the last word accessed, incremented by one.

**Return Value:**
- -1 if a bus collision error occurred
- -2 if a NOT ACK error occurred
- -3 if a write collision error occurred
- Otherwise, the result is returned as an unsigned 16-bit quantity. Since the buffer itself is only 8-bits wide, this means that the Most Significant Byte will be zero and the Least Significant Byte will contain the read buffer contents.

**File Name:**
i2c_eecr.c  
i2c1eecr.c  
i2c2eecr.c

**Code Example:**
```c
temp = EECurrentAddRead(0xA1);
```
EEPPageWrite
EEPPageWrite1
EEPPageWrite2

<table>
<thead>
<tr>
<th>Function:</th>
<th>Write a string of data to the EE device from the I²C bus.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Include:</td>
<td>i2c.h</td>
</tr>
<tr>
<td>Prototype:</td>
<td>unsigned char EEPageWrite(</td>
</tr>
<tr>
<td></td>
<td>unsigned char control,</td>
</tr>
<tr>
<td></td>
<td>unsigned char address,</td>
</tr>
<tr>
<td></td>
<td>unsigned char * wrptr );</td>
</tr>
<tr>
<td></td>
<td>unsigned char EEPageWrite1(</td>
</tr>
<tr>
<td></td>
<td>unsigned char control,</td>
</tr>
<tr>
<td></td>
<td>unsigned char address,</td>
</tr>
<tr>
<td></td>
<td>unsigned char * wrptr );</td>
</tr>
<tr>
<td></td>
<td>unsigned char EEPageWrite2(</td>
</tr>
<tr>
<td></td>
<td>unsigned char control,</td>
</tr>
<tr>
<td></td>
<td>unsigned char address,</td>
</tr>
<tr>
<td></td>
<td>unsigned char * wrptr );</td>
</tr>
<tr>
<td>Arguments:</td>
<td>control EEPROM control / bus device select address byte.</td>
</tr>
<tr>
<td></td>
<td>address EEPROM internal address location.</td>
</tr>
<tr>
<td></td>
<td>wrptr Character type pointer in PICmicro MCU RAM. The data objects pointed to by wrptr will be written to the EE device.</td>
</tr>
<tr>
<td>Remarks:</td>
<td>This function writes a null terminated string of data to the I²C EE memory device. The null character itself is not transmitted.</td>
</tr>
<tr>
<td>Return Value:</td>
<td>0 if there were no errors</td>
</tr>
<tr>
<td></td>
<td>-1 if there was a bus collision error</td>
</tr>
<tr>
<td></td>
<td>-2 if there was a NOT ACK error</td>
</tr>
<tr>
<td></td>
<td>-3 if there was a write collision error</td>
</tr>
<tr>
<td>File Name:</td>
<td>i2c_eepw.c</td>
</tr>
<tr>
<td></td>
<td>i2c1eepw.c</td>
</tr>
<tr>
<td></td>
<td>i2c2eepw.c</td>
</tr>
<tr>
<td>Code Example:</td>
<td>temp = EEPageWrite(0xA0, 0x70, wrptr);</td>
</tr>
</tbody>
</table>
### EERandomRead

**Function:** Read a single byte from the I²Cx bus.

**Include:** `i2c.h`

**Prototype:**

```c
unsigned int EERandomRead(
    unsigned char control,
    unsigned char address);
```

```c
unsigned int EERandomRead1(
    unsigned char control,
    unsigned char address);
```

```c
unsigned int EERandomRead2(
    unsigned char control,
    unsigned char address);
```

**Arguments:**

- `control`: EEPROM control / bus device select address byte.
- `address`: EEPROM internal address location.

**Remarks:**

This function reads in a single byte from the I²Cx bus. The routine can be used for Microchip I²C EE memory devices which only require 1 byte of address information.

**Return Value:** The return value contains the value read in the Least Significant Byte and the error condition in the Most Significant Byte. The error condition is:

- `-1` if there was a bus collision error
- `-2` if there was a NOT ACK error
- `-3` if there was a write collision error

**File Name:** `i2c_eerr.c`  
`i2c1eerr.c`  
`i2c2eerr.c`

**Code Example:**

```c
unsigned int temp;
temp = EERandomRead(0xA0,0x30);
```
EESequentialRead

EESequentialRead1

EESequentialRead2

<table>
<thead>
<tr>
<th>Function</th>
<th>Read a string of data from the ( \text{i}^2\text{C} ) bus.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Include</td>
<td>i2c.h</td>
</tr>
<tr>
<td>Prototype</td>
<td>unsigned char EESequentialRead(</td>
</tr>
<tr>
<td></td>
<td>unsigned char ( \text{control} ),</td>
</tr>
<tr>
<td></td>
<td>unsigned char ( \text{address} ),</td>
</tr>
<tr>
<td></td>
<td>unsigned char * ( \text{rdptr} ),</td>
</tr>
<tr>
<td></td>
<td>unsigned char ( \text{length} ));</td>
</tr>
<tr>
<td></td>
<td>unsigned char EESequentialRead1(</td>
</tr>
<tr>
<td></td>
<td>unsigned char ( \text{control} ),</td>
</tr>
<tr>
<td></td>
<td>unsigned char ( \text{address} ),</td>
</tr>
<tr>
<td></td>
<td>unsigned char * ( \text{rdptr} ),</td>
</tr>
<tr>
<td></td>
<td>unsigned char ( \text{length} ));</td>
</tr>
<tr>
<td></td>
<td>unsigned char EESequentialRead2(</td>
</tr>
<tr>
<td></td>
<td>unsigned char ( \text{control} ),</td>
</tr>
<tr>
<td></td>
<td>unsigned char ( \text{address} ),</td>
</tr>
<tr>
<td></td>
<td>unsigned char * ( \text{rdptr} ),</td>
</tr>
<tr>
<td></td>
<td>unsigned char ( \text{length} \ ));</td>
</tr>
<tr>
<td>Arguments</td>
<td>( \text{control} ) EEPROM control / bus device select address byte.</td>
</tr>
<tr>
<td></td>
<td>( \text{address} ) EEPROM internal address location.</td>
</tr>
<tr>
<td></td>
<td>( \text{rdptr} ) Character type pointer to PICmicro MCU RAM area for placement of data read from EEPROM device.</td>
</tr>
<tr>
<td></td>
<td>( \text{length} ) Number of bytes to read from EEPROM device.</td>
</tr>
<tr>
<td>Remarks</td>
<td>This function reads in a predefined string length of data from the ( \text{i}^2\text{C} ) bus. The routine can be used for Microchip ( \text{i}^2\text{C} ) EE memory devices which only require 1 byte of address information.</td>
</tr>
<tr>
<td>Return Value</td>
<td>0 if there were no errors</td>
</tr>
<tr>
<td></td>
<td>-1 if there was a bus collision error</td>
</tr>
<tr>
<td></td>
<td>-2 if there was a NOT ACK error</td>
</tr>
<tr>
<td></td>
<td>-3 if there was a write collision error</td>
</tr>
<tr>
<td>File Name</td>
<td>i2c_eesr.c</td>
</tr>
<tr>
<td></td>
<td>i2ceeesr.c</td>
</tr>
<tr>
<td></td>
<td>i2c2eessr.c</td>
</tr>
<tr>
<td>Code Example</td>
<td>unsigned char err;</td>
</tr>
<tr>
<td></td>
<td>err = EESequentialRead(0xA0,</td>
</tr>
<tr>
<td></td>
<td>0x70,</td>
</tr>
<tr>
<td></td>
<td>( \text{rdptr} ),</td>
</tr>
<tr>
<td></td>
<td>15);</td>
</tr>
</tbody>
</table>
2.4.3 Example of Use

The following is a simple code example illustrating the SSP module configured for I\(^2\)C master communication. The routine illustrates I\(^2\)C communications with a Microchip 24LC01B I\(^2\)C EE memory device.

```c
#include "p18cxx.h"
#include "i2c.h"

unsigned char arraywr[] = {1,2,3,4,5,6,7,8,0};
unsigned char arrayrd[20];

/******************************************
void main(void)
{
    OpenI2C(MASTER, SLEW_ON);// Initialize I2C module
    SSPADD = 9;              //400kHz Baud clock(9) @16MHz
    //100kHz Baud clock(39) @16MHz

    while(1)
    {
        EEByteWrite(0xA0, 0x30, 0xA5);
        EEAckPolling(0xA0);
        EECurrentAddRead(0xA0);
       EEPageWrite(0xA0, 0x70, arraywr);
        EEAckPolling(0xA0);
       EESequentialRead(0xA0, 0x70, arrayrd, 20);
        EERandomRead(0xA0,0x30);
    }
}
```

2.5 I/O PORT FUNCTIONS

PORTB is supported with the following functions:

<table>
<thead>
<tr>
<th>TABLE 2-6: I/O PORT FUNCTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Function</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>ClosePORTB</td>
</tr>
<tr>
<td>CloseRB(x)INT</td>
</tr>
<tr>
<td>DisablePullups</td>
</tr>
<tr>
<td>EnablePullups</td>
</tr>
<tr>
<td>OpenPORTB</td>
</tr>
<tr>
<td>OpenRB(x)INT</td>
</tr>
</tbody>
</table>
### 2.5.1 Function Descriptions

#### ClosePORTB

**Function:** Disable the interrupts and internal pull-up resistors for PORTB.

**Include:** portb.h

**Prototype:**

```c
void ClosePORTB( void );
```

**Remarks:**

This function disables the PORTB interrupt-on-change and the internal pull-up resistors.

**File Name:** pbclose.c

#### CloseRB0INT, CloseRB1INT, CloseRB2INT

**Function:** Disable the interrupts for the specified PORTB pin.

**Include:** portb.h

**Prototype:**

```c
void CloseRB0INT( void );
void CloseRB1INT( void );
void CloseRB2INT( void );
```

**Remarks:**

This function disables the PORTB interrupt-on-change.

**File Name:** rb0close.c, rb1close.c, rb2close.c

#### DisablePullups

**Function:** Disable the internal pull-up resistors on PORTB.

**Include:** portb.h

**Prototype:**

```c
void DisablePullups( void );
```

**Remarks:**

This function disables the internal pull-up resistors on PORTB.

**File Name:** pulldis.c

#### EnablePullups

**Function:** Enable the internal pull-up resistors on PORTB.

**Include:** portb.h

**Prototype:**

```c
void EnablePullups( void );
```

**Remarks:**

This function enables the internal pull-up resistors on PORTB.

**File Name:** pullen.c
### OpenPORTB

**Function:** Configure the interrupts and internal pull-up resistors on PORTB.

**Include:**
```c
portb.h
```

**Prototype:**
```c
void OpenPORTB( unsigned char config);
```

**Arguments:**
- `config`  
  A bitmask that is created by performing a bitwise AND operation (`&`) with a value from each of the categories listed below. These values are defined in the file `portb.h`.

  **Interrupt-on-change:**
  - PORTB_CHANGE_INT_ON: Interrupt enabled
  - PORTB_CHANGE_INT_OFF: Interrupt disabled

  **Enable Pullups:**
  - PORTB_PULLUPS_ON: pull-up resistors enabled
  - PORTB_PULLUPS_OFF: pull-up resistors disabled

**Remarks:**
This function configures the interrupts and internal pull-up resistors on PORTB.

**File Name:** `pbopen.c`

**Code Example:**
```c
OpenPORTB( PORTB_CHANGE_INT_ON & PORTB_PULLUPS_ON);
```

### OpenRB0INT

**Function:** Enable interrupts for the specified PORTB pin.

**Include:**
```c
portb.h
```

**Prototype:**
```c
void OpenRB0INT( unsigned char config);
```

**Arguments:**
- `config`  
  A bitmask that is created by performing a bitwise AND operation (`&`) with a value from each of the categories listed below. These values are defined in the file `portb.h`.

  **Interrupt-on-change:**
  - PORTB_CHANGE_INT_ON: Interrupt enabled
  - PORTB_CHANGE_INT_OFF: Interrupt disabled

  **Interrupt-on-edge:**
  - RISING_EDGE_INT: Interrupt on rising edge
  - FALLING_EDGE_INT: Interrupt on falling edge

  **Enable Pullups:**
  - PORTB_PULLUPS_ON: pull-up resistors enabled
  - PORTB_PULLUPS_OFF: pull-up resistors disabled

**Remarks:**
This function configures the interrupts and internal pull-up resistors on PORTB.

**File Name:** `rb0open.c`

**Code Example:**
```c
OpenRB0INT( PORTB_CHANGE_INT_ON & RISING_EDGE_INT & PORTB_PULLUPS_ON);
```

### OpenRB1INT

**Function:**

**Include:**
```c
portb.h
```

**Prototype:**
```c
void OpenRB1INT( unsigned char config);
```

**Arguments:**
- `config`  
  A bitmask that is created by performing a bitwise AND operation (`&`) with a value from each of the categories listed below. These values are defined in the file `portb.h`.

  **Interrupt-on-change:**
  - PORTB_CHANGE_INT_ON: Interrupt enabled
  - PORTB_CHANGE_INT_OFF: Interrupt disabled

  **Interrupt-on-edge:**
  - RISING_EDGE_INT: Interrupt on rising edge
  - FALLING_EDGE_INT: Interrupt on falling edge

  **Enable Pullups:**
  - PORTB_PULLUPS_ON: pull-up resistors enabled
  - PORTB_PULLUPS_OFF: pull-up resistors disabled

**Remarks:**
This function configures the interrupts and internal pull-up resistors on PORTB.

**File Name:** `rb1open.c`

**Code Example:**
```c
OpenRB1INT( PORTB_CHANGE_INT_ON & RISING_EDGE_INT & PORTB_PULLUPS_ON);
```

### OpenRB2INT

**Function:**

**Include:**
```c
portb.h
```

**Prototype:**
```c
void OpenRB2INT( unsigned char config);
```

**Arguments:**
- `config`  
  A bitmask that is created by performing a bitwise AND operation (`&`) with a value from each of the categories listed below. These values are defined in the file `portb.h`.

  **Interrupt-on-change:**
  - PORTB_CHANGE_INT_ON: Interrupt enabled
  - PORTB_CHANGE_INT_OFF: Interrupt disabled

  **Interrupt-on-edge:**
  - RISING_EDGE_INT: Interrupt on rising edge
  - FALLING_EDGE_INT: Interrupt on falling edge

  **Enable Pullups:**
  - PORTB_PULLUPS_ON: pull-up resistors enabled
  - PORTB_PULLUPS_OFF: pull-up resistors disabled

**Remarks:**
This function configures the interrupts and internal pull-up resistors on PORTB.

**File Name:** `rb2open.c`

**Code Example:**
```c
OpenRB2INT( PORTB_CHANGE_INT_ON & RISING_EDGE_INT & PORTB_PULLUPS_ON);
```
2.6 MICROWIRE FUNCTIONS

The following routines are provided for devices with a single Microwire peripheral:

**TABLE 2-7: SINGLE MICROWIRE PERIPHERAL FUNCTIONS**

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CloseMwire</td>
<td>Disable the SSP module used for Microwire communication.</td>
</tr>
<tr>
<td>DataRdyMwire</td>
<td>Indicate completion of the internal write cycle.</td>
</tr>
<tr>
<td>getcMwire</td>
<td>Read a byte from the Microwire device.</td>
</tr>
<tr>
<td>getsMwire</td>
<td>Read a string from the Microwire device.</td>
</tr>
<tr>
<td>OpenMwire</td>
<td>Configure the SSP module for Microwire use.</td>
</tr>
<tr>
<td>putcMwire</td>
<td>Write a byte to the Microwire device.</td>
</tr>
<tr>
<td>ReadMwire</td>
<td>Read a byte from the Microwire device.</td>
</tr>
<tr>
<td>WriteMwire</td>
<td>Write a byte to the Microwire device.</td>
</tr>
</tbody>
</table>

The following routines are provided for devices with multiple Microwire peripherals:

**TABLE 2-8: MULTIPLE MICROWIRE PERIPHERAL FUNCTIONS**

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CloseMwire*</td>
<td>Disable the SSP* module used for Microwire communication.</td>
</tr>
<tr>
<td>DataRdyMwire*</td>
<td>Indicate completion of the internal write cycle.</td>
</tr>
<tr>
<td>getcMwire*</td>
<td>Read a byte from the Microwire device.</td>
</tr>
<tr>
<td>getsMwire*</td>
<td>Read a string from the Microwire device.</td>
</tr>
<tr>
<td>OpenMwire*</td>
<td>Configure the SSP* module for Microwire use.</td>
</tr>
<tr>
<td>putcMwire*</td>
<td>Write a byte to the Microwire device.</td>
</tr>
<tr>
<td>ReadMwire*</td>
<td>Read a byte from the Microwire device.</td>
</tr>
<tr>
<td>WriteMwire*</td>
<td>Write a byte to the Microwire device.</td>
</tr>
</tbody>
</table>

### 2.6.1 Function Descriptions

**CloseMwire**

**CloseMwire1**

**CloseMwire2**

<table>
<thead>
<tr>
<th>Function:</th>
<th>Disable the SSP* module.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Include:</td>
<td>mwire.h</td>
</tr>
<tr>
<td>Prototype:</td>
<td>void CloseMwire( void );</td>
</tr>
<tr>
<td></td>
<td>void CloseMwire1( void );</td>
</tr>
<tr>
<td></td>
<td>void CloseMwire2( void );</td>
</tr>
<tr>
<td>Remarks:</td>
<td>Pin I/O returns under control of the TRISC and LATC register settings.</td>
</tr>
<tr>
<td>File Name:</td>
<td>mw_close.c</td>
</tr>
<tr>
<td></td>
<td>mw1close.c</td>
</tr>
<tr>
<td></td>
<td>mw2close.c</td>
</tr>
</tbody>
</table>
DataRdyMwire
DataRdyMwire1
DataRdyMwire2

Function: Indicate whether the Microwire\textsuperscript{x} device has completed the internal write cycle.
Include: mwire.h
Prototype:

\begin{verbatim}
unsigned char DataRdyMwire( void );
unsigned char DataRdyMwire1( void );
unsigned char DataRdyMwire2( void );
\end{verbatim}
Remarks: Determines if Microwire\textsuperscript{x} device is ready.
Return Value: 1 if the Microwire\textsuperscript{x} device is ready
\begin{verbatim}
0 if the internal write cycle is not complete or a bus error occurred
\end{verbatim}
File Name: mw_drdy.c
mw1drdy.c
mw2drdy.c
Code Example: while (!DataRdyMwire());

getcMwire
getcMwire1
getcMwire2

getcMwire\textsuperscript{x} is defined as ReadMwire. See ReadMwire\textsuperscript{x}.

getsMwire
getsMwire1
getsMwire2

Function: Read a string from the Microwire\textsuperscript{x} device.
Include: mwire.h
Prototype:

\begin{verbatim}
void getsMwire( unsigned char * rdptr,
unsigned char length);
void getsMwire1( unsigned char * rdptr,
unsigned char length);
void getsMwire2( unsigned char * rdptr,
unsigned char length);
\end{verbatim}
Arguments: \texttt{rdptr}
Pointer to PICmicro MCU RAM for placement of data read from Microwire\textsuperscript{x} device.
\texttt{length}
Number of bytes to read from Microwire\textsuperscript{x} device.
Remarks: This function is used to read a predetermined length of data from a Microwire\textsuperscript{x} device. Before using this function, a Read\textsuperscript{x} command with the appropriate address must be issued.
File Name: mw_gets.c
mw1gets.c
mw2gets.c
Code Example: unsigned char arryrd[LENGTH];
putcMwire(READ);
putcMwire(address);
getsMwire(arryrd, LENGTH);
OpenMwire
OpenMwire1
OpenMwire2

Function: Configure the SSPx module.
Include: mwire.h
Prototype: void OpenMwire(
    unsigned char sync_mode);
Arguments: sync_mode
One of the following values defined in mwire.h:
    MWIRE_FOSC_4 clock = FOSC/4
    MWIRE_FOSC_16 clock = FOSC/16
    MWIRE_FOSC_64 clock = FOSC/64
    MWIRE_FOSC_TMR2 clock = TMR2 output/2
Remarks: OpenMwire resets the SSPx module to the POR state and then
configures the module for Microwire communications.
File Name: mw_open.c
          mw1open.c
          mw2open.c
Code Example: OpenMwire(MWIRE_FOSC_16);

putcMwire
putcMwire1
putcMwire2

putcMwirex is defined as WriteMwirex. See WriteMwirex.
<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ReadMwire</td>
<td>Read a byte from a Microwire\textsubscript{x} device.</td>
</tr>
<tr>
<td>ReadMwire1</td>
<td></td>
</tr>
<tr>
<td>ReadMwire2</td>
<td></td>
</tr>
<tr>
<td>getcMwire</td>
<td></td>
</tr>
<tr>
<td>getcMwire1</td>
<td></td>
</tr>
<tr>
<td>getcMwire2</td>
<td></td>
</tr>
</tbody>
</table>

**Include:**

- mwire.h

**Prototype:**

```c
unsigned char ReadMwire(
    unsigned char high_byte,
    unsigned char low_byte);
```

```c
unsigned char ReadMwire1(
    unsigned char high_byte,
    unsigned char low_byte);
```

```c
unsigned char ReadMwire2(
    unsigned char high_byte,
    unsigned char low_byte);
```

```c
unsigned char getcMwire(
    unsigned char high_byte,
    unsigned char low_byte);
```

```c
unsigned char getcMwire1(
    unsigned char high_byte,
    unsigned char low_byte);
```

```c
unsigned char getcMwire2(
    unsigned char high_byte,
    unsigned char low_byte);
```

**Arguments:**

- `high_byte`  
  First byte of 16-bit instruction word.
- `low_byte`   
  Second byte of 16-bit instruction word.

**Remarks:**

This function reads in a single byte from a Microwire\textsubscript{x} device. The Start bit, opcode and address compose the high and low bytes passed into this function. getcMwire\textsubscript{x} is defined to be ReadMwire\textsubscript{x} in mwire.h.

**Return Value:**

The return value is the data byte read from the Microwire\textsubscript{x} device.

**File Name:**

- mw_read.c
- mw1read.c
- mw2read.c

```c
#define in mwire.h
#define in mwire.h
#define in mwire.h
```

**Code Example:**

```c
ReadMwire(0x03, 0x00);
```
<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>WriteMwire</td>
<td>This function is used to write out a single data byte (one character).</td>
</tr>
<tr>
<td>WriteMwire1</td>
<td></td>
</tr>
<tr>
<td>WriteMwire2</td>
<td></td>
</tr>
<tr>
<td>putcMwire</td>
<td></td>
</tr>
<tr>
<td>putcMwire1</td>
<td></td>
</tr>
<tr>
<td>putcMwire2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Include:</strong></td>
<td>mwire.h</td>
</tr>
<tr>
<td><strong>Prototype:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>unsigned char WriteMwire(</td>
</tr>
<tr>
<td></td>
<td>unsigned char data_out )</td>
</tr>
<tr>
<td></td>
<td>unsigned char WriteMwire1(</td>
</tr>
<tr>
<td></td>
<td>unsigned char data_out )</td>
</tr>
<tr>
<td></td>
<td>unsigned char WriteMwire2(</td>
</tr>
<tr>
<td></td>
<td>unsigned char data_out )</td>
</tr>
<tr>
<td></td>
<td>unsigned char putcMwire(</td>
</tr>
<tr>
<td></td>
<td>unsigned char data_out )</td>
</tr>
<tr>
<td></td>
<td>unsigned char putcMwire1(</td>
</tr>
<tr>
<td></td>
<td>unsigned char data_out )</td>
</tr>
<tr>
<td></td>
<td>unsigned char putcMwire2(</td>
</tr>
<tr>
<td></td>
<td>unsigned char data_out )</td>
</tr>
<tr>
<td><strong>Arguments:</strong></td>
<td>data_out</td>
</tr>
<tr>
<td></td>
<td>Single byte of data to write to Microwire x device.</td>
</tr>
<tr>
<td><strong>Remarks:</strong></td>
<td>This function writes out single data byte to a Microwire x device utilizing</td>
</tr>
<tr>
<td></td>
<td>the SSP x module. putcMwire x is defined to be WriteMwire x in mwire.h.</td>
</tr>
<tr>
<td><strong>Return Value:</strong></td>
<td>0 if the write was successful</td>
</tr>
<tr>
<td></td>
<td>-1 if there was a write collision</td>
</tr>
<tr>
<td><strong>File Name:</strong></td>
<td>mw_write.c</td>
</tr>
<tr>
<td></td>
<td>mwlwrite.c</td>
</tr>
<tr>
<td></td>
<td>mw2write.c</td>
</tr>
<tr>
<td></td>
<td>#define in mwire.h</td>
</tr>
<tr>
<td></td>
<td>#define in mwire.h</td>
</tr>
<tr>
<td></td>
<td>#define in mwire.h</td>
</tr>
<tr>
<td><strong>Code Example:</strong></td>
<td>WriteMwire(0x55);</td>
</tr>
</tbody>
</table>
2.6.2 Example of Use

The following is a simple code example illustrating the SSP module communicating with a Microchip 93LC66 Microwire EE memory device.

```c
#include "p18cxxx.h"
#include "mwire.h"

// 93LC66 x 8
// FUNCTION Prototypes
void main(void);
void ew_enable(void);
void erase_all(void);
void busy_poll(void);
void write_all(unsigned char data);
void byte_read(unsigned char address);
void read_mult(unsigned char address, unsigned char *rdptr, unsigned char length);
void write_byte(unsigned char address, unsigned char data);

// VARIABLE Definitions
unsigned char arrayrd[20];
unsigned char var;

// DEFINE 93LC66 MACROS -- see datasheet for details
#define READ   0x0C
#define WRITE  0x0A
#define ERASE  0x0E
#define EWEN1  0x09
#define EWEN2  0x80
#define ERAL1  0x09
#define ERAL2  0x00
#define WRAL1  0x08
#define WRAL2  0x80
#define EWDS1  0x08
#define EWDS2  0x00
#define W_CS   LATCbits.LATC2

void main(void)
{
    TRISCbits.TRISC2 = 0; //ensure CS is negated
    W_CS = 0;             //ensure SSP peripheral
    OpenMwire(MWIRE_FOSC_16); //enable SSP peripheral
    ew_enable();          //send erase/write enable
    write_byte(0x13, 0x34); //write byte (address, data)
    busy_poll();
    Nop();
    byte_read(0x13);      //read single byte (address)
    read_mult(0x10, arrayrd, 10); //read multiple bytes
    erase_all();          //erase entire array
    CloseMwire();         //disable SSP peripheral
}
```
void ew_enable(void)
{
    W_CS = 1;         //assert chip select
    putcMwire(EWEN1); //enable write command byte 1
    putcMwire(EWEN2); //enable write command byte 2
    W_CS = 0;         //negate chip select
}

void busy_poll(void)
{
    W_CS = 1;
    while(! DataRdyMwire() );
    W_CS = 0;
}

void write_byte(unsigned char address,
            unsigned char data)
{
    W_CS = 1;
    putcMwire(WRITE);    //write command
    putcMwire(address);  //address
    putcMwire(data);     //write single byte
    W_CS = 0;
}

void byte_read(unsigned char address)
{
    W_CS = 1;
    getcMwire(READ,address);  //read one byte
    W_CS = 0;
}

void read_mult(unsigned char address,
            unsigned char *rdptr,
            unsigned char length)
{
    W_CS = 1;
    putcMwire(READ);          //read command
    putcMwire(address);       //address (A7 - A0)
    getsMwire(rdptr, length); //read multiple bytes
    W_CS = 0;
}

void erase_all(void)
{
    W_CS = 1;
    putcMwire(ERAL1); //erase all command byte 1
    putcMwire(ERAL2); //erase all command byte 2
    W_CS = 0;
}
2.7 PULSE-WIDTH MODULATION FUNCTIONS

The PWM peripheral is supported with the following functions:

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ClosePWMx</td>
<td>Disable PWM channel x</td>
</tr>
<tr>
<td>OpenPWMx</td>
<td>Configure PWM channel x</td>
</tr>
<tr>
<td>SetDCPWMx</td>
<td>Write a new duty cycle value to PWM channel x</td>
</tr>
<tr>
<td>SetOutputPWMx</td>
<td>Sets the PWM output configuration bits for ECCP x</td>
</tr>
<tr>
<td>CloseEPWMx(1)</td>
<td>Disable enhanced PWM channel x</td>
</tr>
<tr>
<td>OpenEPWMx(1)</td>
<td>Configure enhanced PWM channel x</td>
</tr>
<tr>
<td>SetDCEPWMx(1)</td>
<td>Write a new duty cycle value to enhanced PWM channel x</td>
</tr>
<tr>
<td>SetOutputEPWMx(1)</td>
<td>Sets the enhanced PWM output configuration bits for ECCP x</td>
</tr>
</tbody>
</table>

Note 1: The enhanced PWM functions are only available on those devices with an ECCPxCON register.

2.7.1 Function Descriptions

ClosePWM1
ClosePWM2
ClosePWM3
ClosePWM4
ClosePWM5
CloseEPWM1

**Function:** Disable PWM channel.

**Include:** pwm.h

**Prototype:**
```c
void ClosePWM1( void );
void ClosePWM2( void );
void ClosePWM3( void );
void ClosePWM4( void );
void ClosePWM5( void );
void CloseEPWM1( void );
```

**Remarks:** This function disables the specified PWM channel.

**File Name:**
- pw1close.c
- pw2close.c
- pw3close.c
- pw4close.c
- pw5close.c
- ew1close.c
OpenPWM1
OpenPWM2
OpenPWM3
OpenPWM4
OpenPWM5
OpenEPWM1

Function: Configure PWM channel.
Include: pwm.h
Prototype:

void OpenPWM1( char period );
void OpenPWM2( char period );
void OpenPWM3( char period );
void OpenPWM4( char period );
void OpenPWM5( char period );
void OpenEPWM1( char period );

Arguments: period
Can be any value from 0x00 to 0xff. This value determines the PWM
frequency by using the following formula:
PWM period = ([period] + 1) x Tosc x TMR2 prescaler

Remarks: This function configures the specified PWM channel for period and for
time base. PWM uses only Timer2.
In addition to opening the PWM, Timer2 must also be opened with an
OpenTimer2(...) statement before the PWM will operate.

File Name: pw1open.c
pw2open.c
pw3open.c
pw4open.c
pw5open.c
ew1open.c

Code Example: OpenPWM1(0xff);
SetDCPWM1
SetDCPWM2
SetDCPWM3
SetDCPWM4
SetDCPWM5
SetDCEPWM1

Function: Write a new duty cycle value to the specified PWM channel duty-cycle registers.

Include: pwm.h

Prototype:
void SetDCPWM1( unsigned int dutyCycle );
void SetDCPWM2( unsigned int dutyCycle );
void SetDCPWM3( unsigned int dutyCycle );
void SetDCPWM4( unsigned int dutyCycle );
void SetDCPWM5( unsigned int dutyCycle );
void SetDCEPWM1( unsigned int dutyCycle );

Arguments: dutyCycle
The value of dutyCycle can be any 10-bit number. Only the lower
10-bits of dutyCycle are written into the duty cycle registers. The duty
cycle, or more specifically the high time of the PWM waveform, can be
calculated from the following formula:
PWM x Duty cycle = (DC<9:0>) x Tosc
where DC<9:0> is the 10-bit value specified in the call to this function.

Remarks: This function writes the new value for dutyCycle to the specified PWM
channel duty cycle registers.

The maximum resolution of the PWM waveform can be calculated from
the period using the following formula:
Resolution (bits) = log(Fosc/Fpwm) / log(2)

File Name: pw1setdc.c
pw2setdc.c
pw3setdc.c
pw4setdc.c
pw5setdc.c
ew1setdc.c

Code Example: SetDCPWM1(0);
SetOutputPWM1
SetOutputPWM2
SetOutputPWM3
SetOutputEPWM1

Function: Sets the PWM output configuration bits for ECCP.
Include: pwm.h
Prototype:
```c
void SetOutputPWM1 (unsigned char outputconfig,
                    unsigned char outputmode);
void SetOutputPWM2 (unsigned char outputconfig,
                    unsigned char outputmode);
void SetOutputPWM3 (unsigned char outputconfig,
                    unsigned char outputmode);
void SetOutputEPWM1 (unsigned char outputconfig,
                     unsigned char outputmode);
```
Arguments:
- `outputconfig`
The value of `outputconfig` can be any one of the following values (defined in `pwm.h`):
  - SINGLE_OUT single output
  - FULL_OUT_FWD full-bridge output forward
  - HALF_OUT half-bridge output
  - FULL_OUT_REV full-bridge output reverse
- `outputmode`
The value of `outputmode` can be any one of the following values (defined in `pwm.h`):
  - PWM_MODE_1 P1A and P1C active-high,
    P1B and P1D active-high
  - PWM_MODE_2 P1A and P1C active-high,
    P1B and P1D active-low
  - PWM_MODE_3 P1A and P1C active-low,
    P1B and P1D active-high
  - PWM_MODE_4 P1A and P1C active-low,
    P1B and P1D active-low

Remarks: This is only applicable to those devices with Extended or Enhanced CCP (ECCP).
File Name: pw1setoc.c
           pw2setoc.c
           pw3setoc.c
           ew1setoc.c
Code Example: SetOutputPWM1 (SINGLE_OUT, PWM_MODE_1);
2.8 SPI™ FUNCTIONS

The following routines are provided for devices with a single SPI peripheral:

**TABLE 2-10: SINGLE SPI™ PERIPHERAL FUNCTIONS**

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CloseSPI</td>
<td>Disable the SSP module used for SPI™ communications.</td>
</tr>
<tr>
<td>DataRdySPI</td>
<td>Determine if a new value is available from the SPI buffer.</td>
</tr>
<tr>
<td>getcSPI</td>
<td>Read a byte from the SPI bus.</td>
</tr>
<tr>
<td>getsSPI</td>
<td>Read a string from the SPI bus.</td>
</tr>
<tr>
<td>OpenSPI</td>
<td>Initialize the SSP module used for SPI communications.</td>
</tr>
<tr>
<td>putcSPI</td>
<td>Write a byte to the SPI bus.</td>
</tr>
<tr>
<td>.putsSPI</td>
<td>Write a string to the SPI bus.</td>
</tr>
<tr>
<td>ReadSPI</td>
<td>Read a byte from the SPI bus.</td>
</tr>
<tr>
<td>WriteSPI</td>
<td>Write a byte to the SPI bus.</td>
</tr>
</tbody>
</table>

The following routines are provided for devices with multiple SPI peripherals:

**TABLE 2-11: MULTIPLE SPI™ PERIPHERAL FUNCTIONS**

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CloseSPIx</td>
<td>Disable the SSPx module used for SPI™ communications.</td>
</tr>
<tr>
<td>DataRdySPIx</td>
<td>Determine if a new value is available from the SPIx buffer.</td>
</tr>
<tr>
<td>getcSPIx</td>
<td>Read a byte from the SPIx bus.</td>
</tr>
<tr>
<td>getsSPIx</td>
<td>Read a string from the SPIx bus.</td>
</tr>
<tr>
<td>OpenSPIx</td>
<td>Initialize the SSPx module used for SPI communications.</td>
</tr>
<tr>
<td>putcSPIx</td>
<td>Write a byte to the SPIx bus.</td>
</tr>
<tr>
<td>.putsSPIx</td>
<td>Write a string to the SPIx bus.</td>
</tr>
<tr>
<td>ReadSPIx</td>
<td>Read a byte from the SPIx bus.</td>
</tr>
<tr>
<td>WriteSPIx</td>
<td>Write a byte to the SPIx bus.</td>
</tr>
</tbody>
</table>
### 2.8.1 Function Descriptions

**CloseSPI**
**CloseSPI1**
**CloseSPI2**

<table>
<thead>
<tr>
<th>Function:</th>
<th>Disable the SSP(x) module.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Include:</td>
<td><code>spi.h</code></td>
</tr>
<tr>
<td>Prototype:</td>
<td><code>void CloseSPI( void );</code></td>
</tr>
<tr>
<td></td>
<td><code>void CloseSPI1( void );</code></td>
</tr>
<tr>
<td></td>
<td><code>void CloseSPI2( void );</code></td>
</tr>
<tr>
<td>Remarks:</td>
<td>This function disables the SSP(x) module. Pin I/O returns under the control of the appropriate TRIS and LAT registers.</td>
</tr>
<tr>
<td>File Name:</td>
<td><code>spi_clos.c</code></td>
</tr>
<tr>
<td></td>
<td><code>spi1clos.c</code></td>
</tr>
<tr>
<td></td>
<td><code>spi2clos.c</code></td>
</tr>
</tbody>
</table>

**DataRdySPI**
**DataRdySPI1**
**DataRdySPI2**

<table>
<thead>
<tr>
<th>Function:</th>
<th>Determine if the SSPBUF(x) contains data.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Include:</td>
<td><code>spi.h</code></td>
</tr>
<tr>
<td>Prototype:</td>
<td><code>unsigned char DataRdySPI( void );</code></td>
</tr>
<tr>
<td></td>
<td><code>unsigned char DataRdySPI1( void );</code></td>
</tr>
<tr>
<td></td>
<td><code>unsigned char DataRdySPI2( void );</code></td>
</tr>
<tr>
<td>Remarks:</td>
<td>This function determines if there is a byte to be read from the SSPBUF(x) register.</td>
</tr>
<tr>
<td>Return Value:</td>
<td>0 if there is no data in the SSPBUF(x) register</td>
</tr>
<tr>
<td></td>
<td>1 if there is data in the SSPBUF(x) register</td>
</tr>
<tr>
<td>File Name:</td>
<td><code>spi_dtrd.c</code></td>
</tr>
<tr>
<td></td>
<td><code>spi1dtrd.c</code></td>
</tr>
<tr>
<td></td>
<td><code>spi2dtrd.c</code></td>
</tr>
<tr>
<td>Code Example:</td>
<td><code>while (!DataRdySPI());</code></td>
</tr>
</tbody>
</table>

**getcSPI**
**getcSPI1**
**getcSPI2**

getcSPI\(x\) is defined as ReadSPI\(x\). *See ReadSPI\(x\).*
getsSPI
getsSPI1
getsSPI2

Function: Read a string from the SPIx bus.
Include: spi.h
Prototype:
void getsSPI( unsigned char *rdptr, unsigned char length );
void getsSPI1( unsigned char *rdptr, unsigned char length );
void getsSPI2( unsigned char *rdptr, unsigned char length );

Arguments: rdptr Pointer to location to store data read from SPIx device.
length Number of bytes to read from SPIx device.

Remarks: This function reads in a predetermined data string length from the SPIx bus.

File Name: spi_gets.c
spi1gets.c
spi2gets.c

Code Example:
unsigned char wrptr[10];
getsSPI(wrptr, 10);

OpenSPI
OpenSPI1
OpenSPI2

Function: Initialize the SSPx module.
Include: spi.h
Prototype:
void OpenSPI( unsigned char sync_mode, unsigned char bus_mode, unsigned char smp_phase);
void OpenSPI1( unsigned char sync_mode, unsigned char bus_mode, unsigned char smp_phase);
void OpenSPI2( unsigned char sync_mode, unsigned char bus_mode, unsigned char smp_phase);

Arguments: sync_mode One of the following values, defined in spi.h:
SPI_FOSC_4 SPI Master mode, clock = Fosc/4
SPI_FOSC_16 SPI Master mode, clock = Fosc/16
SPI_FOSC_64 SPI Master mode, clock = Fosc/64
SPI_FOSC_TMR2 SPI Master mode, clock = TMR2 output/2
SLV_SSON SPI Slave mode, /SS pin control enabled
SLV_SSOFF SPI Slave mode, /SS pin control disabled

bus_mode One of the following values, defined in spi.h:
MODE_00 Setting for SPI bus Mode 0,0
MODE_01 Setting for SPI bus Mode 0,1
MODE_10 Setting for SPI bus Mode 1,0
MODE_11 Setting for SPI bus Mode 1,1
OpenSPI
OpenSPI1
OpenSPI2 (Continued)

`smp_phase`

One of the following values, defined in `spi.h`:
- SMPEND: Input data sample at end of data out
- SMPMID: Input data sample at middle of data out

Remarks: This function sets up the SSPx module for use with a SPIx bus device.

File Name: `spi_open.c`
- `spi1open.c`
- `spi2open.c`

Code Example: `OpenSPI(SPI_FOSC_16, MODE_00, SMPEND);`

putcSPI
putcSPI1
putcSPI2

putcSPIx is defined as WriteSPIx. See WriteSPIx.

putsSPI
putsSPI1
putsSPI2

Function: Write a string to the SPIx bus.
Include: `spi.h`
Prototype:
```c
void putsSPI(unsigned char *wrptr);
void putsSPI1(unsigned char *wrptr);
void putsSPI2(unsigned char *wrptr);
```
Arguments: `wrptr`
Point to value that will be written to the SPIx bus.
Remarks: This function writes out a data string to the SPIx bus device. The routine is terminated by reading a null character in the data string (the null character is not written to the bus).

File Name: `spi_puts.c`
- `spi1puts.c`
- `spi2puts.c`

Code Example: `unsigned char wrptr[] = "Hello!"; putsSPI(wrptr);`
<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
<th>Include</th>
<th>Prototype</th>
<th>Remarks</th>
<th>Return Value</th>
<th>File Name</th>
<th>Code Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>ReadSPI</td>
<td>Read a byte from the SPIx bus.</td>
<td>spi.h</td>
<td>unsigned char ReadSPI( void );</td>
<td>This function initiates a SPIx bus cycle for the acquisition of a byte of data.</td>
<td>This function returns a byte of data read during a SPIx read cycle.</td>
<td>spi_read.c, spi1read.c, spi2read.c #define in spi.h #define in spi.h #define in spi.h</td>
<td>char x; x = ReadSPI();</td>
</tr>
<tr>
<td>Function</td>
<td>Description</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>-----------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WriteSPI</td>
<td>Write a byte to the SPIx bus.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WriteSPI1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WriteSPI2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>putcSPI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>putcSPI1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>putcSPI2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Include:** spi.h

**Prototype:**

```c
unsigned char WriteSPI(unsigned char data_out);
unsigned char WriteSPI1(unsigned char data_out);
unsigned char WriteSPI2(unsigned char data_out);
unsigned char putcSPI(unsigned char data_out);
unsigned char putcSPI1(unsigned char data_out);
unsigned char putcSPI2(unsigned char data_out);
```

**Arguments:**

`data_out`

Value to be written to the SPIx bus.

**Remarks:**

This function writes a single data byte out and then checks for a write collision. putcSPIx is defined to be WriteSPIx in spi.h.

**Return Value:**

- 0 if no write collision occurred
- -1 if a write collision occurred

**File Name:**

- spi_writ.c
- spilwrit.c
- spi2writ.c

- #define in spi.h
- #define in spi.h
- #define in spi.h

**Code Example:**

```c
WriteSPI('a');
```
2.8.2 Example of Use

The following example demonstrates the use of an SSP module to communicate with a Microchip 25C080 SPI EE memory device.

```c
#include <p18cxx.h>
#include <spi.h>

// FUNCTION Prototypes
void main(void);
void set_wren(void);
void busy_polling(void);
unsigned char status_read(void);
void status_write(unsigned char data);
void byte_write(unsigned char addhigh,
                 unsigned char addlow,
                 unsigned char data);
void page_write(unsigned char addhigh,
                 unsigned char addlow,
                 unsigned char *wrptr);
void array_read(unsigned char addhigh,
                unsigned char addlow,
                unsigned char *rdptr,
                unsigned char count);
unsigned char byte_read(unsigned char addhigh,
                        unsigned char addlow);

// VARIABLE Definitions
unsigned char arraywr[] = {1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,0};

//25C040/080/160 page write size
unsigned char arrayrd[16];
unsigned char var;

#define SPI_CS  LATCbits.LATC2

//*************************************************************
void main(void)
{
    TRISCbits.TRISC2 = 0;
    SPI_CS = 1;  // ensure SPI memory device
    // Chip Select is reset
    OpenSPI(SPI_FOSC_16, MODE_00, SMPEND);
    set_wren();
    status_write(0);

    busy_polling();
    set_wren();
    byte_write(0x00, 0x61, 'E');

    busy_polling();
    var = byte_read(0x00, 0x61);

    busy_polling();
    var = status_read();
    set_wren();
    page_write(0x00, 0x30, arraywr);
    busy_polling();

    array_read(0x00, 0x30, arrayrd, 16);
    var = status_read();
}
```

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CloseSPI();
while(1);
}

void set_wren(void)
{
    SPI_CS = 0;       //assert chip select
    var = putcSPI(SPI_WREN); //send write enable command
    SPI_CS = 1;       //negate chip select
}

void page_write (unsigned char addhigh,
 unsigned char addlow,
 unsigned char *wrptr)
{
    SPI_CS = 0;       //assert chip select
    var = putcSPI(SPI_WRITE); //send write command
    var = putcSPI(addhigh); //send high byte of address
    var = putcSPI(addlow); //send low byte of address
    putsSPI(wrptr); //send data byte
    SPI_CS = 1;       //negate chip select
}

void array_read (unsigned char addhigh,
 unsigned char addlow,
 unsigned char *rdptr,
 unsigned char count)
{
    SPI_CS = 0;       //assert chip select
    var = putcSPI(SPI_READ); //send read command
    var = putcSPI(addhigh); //send high byte of address
    var = putcSPI(addlow); //send low byte of address
    getsSPI(rdptr, count); //read multiple bytes
    SPI_CS = 1;
}

void byte_write (unsigned char addhigh,
 unsigned char addlow,
 unsigned char data)
{
    SPI_CS = 0;       //assert chip select
    var = putcSPI(SPI_WRITE); //send write command
    var = putcSPI(addhigh); //send high byte of address
    var = putcSPI(addlow); //send low byte of address
    var = putcSPI(data); //send data byte
    SPI_CS = 1;       //negate chip select
}

unsigned char byte_read (unsigned char addhigh,
 unsigned char addlow)
{
    SPI_CS = 0;       //assert chip select
    var = putcSPI(SPI_READ); //send read command
    var = putcSPI(addhigh); //send high byte of address
    var = putcSPI(addlow); //send low byte of address
    var = getcSPI(); //read single byte
    SPI_CS = 1;
    return (var);
}
unsigned char status_read (void)
{
    SPI_CS = 0;               //assert chip select
    var = putcSPI(SPI_RDSR);  //send read status command
    var = getcSPI();         //read data byte
    SPI_CS = 1;              //negate chip select
    return (var);
}

void status_write (unsigned char data)
{
    SPI_CS = 0;
    var = putcSPI(SPI_WRSR);  //write status command
    var = putcSPI(data);      //status byte to write
    SPI_CS = 1;              //negate chip select
}

void busy_polling (void)
{
do
{
    SPI_CS = 0;               //assert chip select
    var = putcSPI(SPI_RDSR);  //send read status command
    var = getcSPI();         //read data byte
    SPI_CS = 1;              //negate chip select
} while (var & 0x01);       //stay in loop until !busy
}
2.9 TIMER FUNCTIONS

The timer peripherals are supported with the following functions:

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CloseTimer</td>
<td>Disable timer x.</td>
</tr>
<tr>
<td>OpenTimer</td>
<td>Configure and enable timer x.</td>
</tr>
<tr>
<td>ReadTimer</td>
<td>Read the value of timer x.</td>
</tr>
<tr>
<td>WriteTimer</td>
<td>Write a value into timer x.</td>
</tr>
</tbody>
</table>

2.9.1 Function Descriptions

**CloseTimer0**
**CloseTimer1**
**CloseTimer2**
**CloseTimer3**
**CloseTimer4**

Function: Disable the specified timer.
Include: timers.h
Prototype: void CloseTimer0( void );
void CloseTimer1( void );
void CloseTimer2( void );
void CloseTimer3( void );
void CloseTimer4( void );
Remarks: This function disables the interrupt and the specified timer.
File Name: t0close.c
t1close.c
t2close.c
t3close.c
t4close.c
## OpenTimer0

**Function:** Configure and enable timer0.

**Include:**

```c
#include "timers.h"
```

**Prototype:**

```c
void OpenTimer0( unsigned char config );
```

**Arguments:**

```c
config
```

A bitmask that is created by performing a bitwise AND operation ('&') with a value from each of the categories listed below. These values are defined in the file `timers.h`.

**Enable Timer0 Interrupt:**

- `TIMER_INT_ON`  Interrupt enabled
- `TIMER_INT_OFF`  Interrupt disabled

**Timer Width:**

- `T0_8BIT`  8-bit mode
- `T0_16BIT`  16-bit mode

**Clock Source:**

- `T0_SOURCE_EXT`  External clock source (I/O pin)
- `T0_SOURCE_INT`  Internal clock source (TOSC)

**External Clock Trigger (for T0_SOURCE_EXT):**

- `T0_EDGE_FALL`  External clock on falling edge
- `T0_EDGE_RISE`  External clock on rising edge

**Prescale Value:**

- `T0_PS_1_1`  1:1 prescale
- `T0_PS_1_2`  1:2 prescale
- `T0_PS_1_4`  1:4 prescale
- `T0_PS_1_8`  1:8 prescale
- `T0_PS_1_16`  1:16 prescale
- `T0_PS_1_32`  1:32 prescale
- `T0_PS_1_64`  1:64 prescale
- `T0_PS_1_128`  1:128 prescale
- `T0_PS_1_256`  1:256 prescale

**Remarks:**

This function configures timer0 according to the options specified and then enables it.

**File Name:** `t0open.c`

**Code Example:**

```c
OpenTimer0( TIMER_INT_OFF &
            T0_8BIT &
            T0_SOURCE_INT &
            T0_PS_1_32 );
```
OpenTimer1

Function: Configure and enable timer1.
Include: timers.h
Prototype: void OpenTimer1( unsigned char config );
Arguments: config
A bitmask that is created by performing a bitwise AND operation ('&') with a value from each of the categories listed below. These values are defined in the file timers.h.

Enable Timer1 Interrupt:
- TIMER_INT_ON Interrupt enabled
- TIMER_INT_OFF Interrupt disabled

Timer Width:
- T1_8BIT_RW 8-bit mode
- T1_16BIT_RW 16-bit mode

Clock Source:
- T1_SOURCE_EXT External clock source (I/O pin)
- T1_SOURCE_INT Internal clock source (TOSC)

Prescaler:
- T1_PS_1_1 1:1 prescale
- T1_PS_1_2 1:2 prescale
- T1_PS_1_4 1:4 prescale
- T1_PS_1_8 1:8 prescale

Oscillator Use:
- T1_OSC1EN_ON Enable Timer1 oscillator
- T1_OSC1EN_OFF Disable Timer1 oscillator

Synchronize Clock Input:
- T1_SYNC_EXT_ON Sync external clock input
- T1_SYNC_EXT_OFF Don’t sync external clock input

Use With CCP:
For devices with 1 or 2 CCPs
- T3_SOURCE_CCP Timer3 source for both CCP’s
- T1_CCP1_T3_CCP2 Timer1 source for CCP1 and Timer3 source for CCP2
- T1_SOURCE_CCP Timer1 source for both CCP’s

For devices with more than 2 CCPs
- T34_SOURCE_CCP Timer3 and Timer4 are sources for all CCP’s
- T12_CCP12_T34_CCP345 Timer1 and Timer2 are sources for CCP1 and CCP2 and Timer3 and Timer4 are sources for CCP3 through CCP5
- T12_CCP1_T34_CCP2345 Timer1 and Timer2 are sources for CCP1 and Timer3 and Timer4 are sources for CCP2 through CCP5
- T12_SOURCE_CCP Timer1 and Timer2 are sources for all CCP’s

Remarks: This function configures timer1 according to the options specified and then enables it.

File Name: t1open.c
Code Example:
OpenTimer1( TIMER_INT_ON &
T1_8BIT_RW &
T1_SOURCE_EXT &
T1_PS_1_1 &
T1_OSC1EN_OFF &
T1_SYNC_EXT_OFF );
OpenTimer2

Function: Configure and enable timer2.
Include: timers.h
Prototype: void OpenTimer2( unsigned char config );
Arguments: config
A bitmask that is created by performing a bitwise AND operation ('&') with a value from each of the categories listed below. These values are defined in the file timers.h.

Enable Timer2 Interrupt:
  TIMER_INT_ON Interrupt enabled
  TIMER_INT_OFF Interrupt disabled

Prescale Value:
  T2_PS_1_1 1:1 prescale
  T2_PS_1_4 1:4 prescale
  T2_PS_1_16 1:16 prescale

Postscale Value:
  T2_POST_1_1 1:1 postscale
  T2_POST_1_2 1:2 postscale
  :           :
  T2_POST_1_15 1:15 postscale
  T2_POST_1_16 1:16 postscale

Use With CCP:
For devices with 1 or 2 CCPs
  T3_SOURCE_CCP Timer3 source for both CCP's
  T1_CCP1_T3_CCP2 Timer1 source for CCP1 and
                     Timer3 source for CCP2
  T1_SOURCE_CCP Timer1 source for both CCP's

For devices with more than 2 CCPs
  T34_SOURCE_CCP Timer3 and Timer4 are sources for all
                   CCP's
  T12_CCP12_T34_CCP345 Timer1 and Timer2 are sources for
                          CCP1 and CCP2 and Timer3 and
                          Timer4 are sources for CCP3
                          through CCP5
  T12_CCP1_T34_CCP2345 Timer1 and Timer2 are sources for
                          CCP1 and Timer3 and Timer4 are
                          sources for CCP2 through CCP5
  T12_SOURCE_CCP Timer1 and Timer2 are sources for all
                   CCP's

Remarks: This function configures timer2 according to the options specified and then enables it.

File Name: t2open.c
Code Example: OpenTimer2( TIMER_INT_OFF &
                           T2_PS_1_1 &
                           T2_POST_1_8 );
OpenTimer3

Function: Configure and enable timer3.
Include: timers.h
Prototype: void OpenTimer3( unsigned char config );
Arguments: config
A bitmask that is created by performing a bitwise AND operation (’&’) with a value from each of the categories listed below. These values are defined in the file timers.h.

Enable Timer3 Interrupt:
- TIMER_INT_ON Interrupt enabled
- TIMER_INT_OFF Interrupt disabled

Timer Width:
- T3_8BIT_RW 8-bit mode
- T3_16BIT_RW 16-bit mode

Clock Source:
- T3_SOURCE_EXT External clock source (I/O pin)
- T3_SOURCE_INT Internal clock source (TOSC)

Prescale Value:
- T3_PS_1_1 1:1 prescale
- T3_PS_1_2 1:2 prescale
- T3_PS_1_4 1:4 prescale
- T3_PS_1_8 1:8 prescale

Synchronize Clock Input:
- T3_SYNC_EXT_ON Sync external clock input
- T3_SYNC_EXT_OFF Don’t sync external clock input

Use With CCP:
For devices with 1 or 2 CCPs
- T3_SOURCE_CCP Timer3 source for both CCP’s
- T1_CCP1_T3_CCP2 Timer1 source for CCP1 and Timer3 source for CCP2
- T1_SOURCE_CCP Timer1 source for both CCP’s

For devices with more than 2 CCPs
- T34_SOURCE_CCP Timer3 and Timer4 are sources for all CCP’s
- T12_CCP12_T34_CCP345 Timer1 and Timer2 are sources for CCP1 and CCP2 and Timer3 and Timer4 are sources for CCP3 through CCP5
- T12_CCP1_T34_CCP2345 Timer1 and Timer2 are sources for CCP1 and Timer3 and Timer4 are sources for CCP2 through CCP5
- T12_SOURCE_CCP Timer1 and Timer2 are sources for all CCP’s

Remarks: This function configures timer3 according to the options specified and then enables it.

File Name: t3open.c
Code Example: OpenTimer3( TIMER_INT_ON &
- T3_8BIT_RW &
- T3_SOURCE_EXT &
- T3_PS_1_1 &
- T3_OSC1EN_OFF &
- T3_SYNC_EXT_OFF );
OpenTimer4

Function: Configure and enable timer4.
Include: timers.h
Prototype: void OpenTimer4( unsigned char config );
Arguments: config
A bitmask that is created by performing a bitwise AND operation ('&')
with a value from each of the categories listed below. These values are
defined in the file timers.h.

Enable Timer4 Interrupt:
  TIMER_INT_ON  Interrupt enabled
  TIMER_INT_OFF  Interrupt disabled

Prescale Value:
  T4_PS_1_1  1:1 prescale
  T4_PS_1_4  1:4 prescale
  T4_PS_1_16  1:16 prescale

Postscale Value:
  T4_POST_1_1  1:1 postscale
  T4_POST_1_2  1:2 postscale
  :             :
  T4_POST_1_15  1:15 postscale
  T4_POST_1_16  1:16 postscale

Remarks: This function configures timer4 according to the options specified and
then enables it.
File Name: t4open.c
Code Example: OpenTimer4( TIMER_INT_OFF &
                         T4_PS_1_1 &
                         T4_POST_1_8 );
Hardware Peripheral Functions

ReadTimer0
ReadTimer1
ReadTimer2
ReadTimer3
ReadTimer4

<table>
<thead>
<tr>
<th>Function:</th>
<th>Read the value of the specified timer.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Include:</td>
<td>timers.h</td>
</tr>
<tr>
<td>Prototype:</td>
<td></td>
</tr>
</tbody>
</table>
  unsigned int ReadTimer0( void );
  unsigned int ReadTimer1( void );
  unsigned char ReadTimer2( void );
  unsigned int ReadTimer3( void );
  unsigned char ReadTimer4( void ); |
| Remarks:  | These functions read the value of the respective timer register(s).
  Timer0:   TMR0L,TMR0H
  Timer1:   TMR1L,TMR1H
  Timer2:   TMR2
  Timer3:   TMR3L,TMR3H
  Timer4:   TMR4 |

Note: When using a timer in 8-bit mode that may be configured in 16-bit mode (e.g., timer0), the upper byte is not ensured to be zero. The user may wish to cast the result to a char for correct results. For example:

```c
// Example of reading a 16-bit result
// from a 16-bit timer operating in
// 8-bit mode:
unsigned int result;
result = (unsigned char) ReadTimer0();
```

<table>
<thead>
<tr>
<th>Return Value:</th>
<th>The current value of the timer.</th>
</tr>
</thead>
</table>
| File Name:    | t0read.c
t1read.c
t2read.c
t3read.c
t4read.c |
**WriteTimer0**

**WriteTimer1**

**WriteTimer2**

**WriteTimer3**

**WriteTimer4**

### Function:
Write a value into the specified timer.

### Include:
`timers.h`

### Prototype:
- `void WriteTimer0( unsigned int timer );`
- `void WriteTimer1( unsigned int timer );`
- `void WriteTimer2( unsigned char timer );`
- `void WriteTimer3( unsigned int timer );`
- `void WriteTimer4( unsigned char timer );`

### Arguments:
- `timer`
The value that will be loaded into the specified timer.

### Remarks:
These functions write a value to the respective timer register(s):
- **Timer0:** TMR0L, TMR0H
- **Timer1:** TMR1L, TMR1H
- **Timer2:** TMR2
- **Timer3:** TMR3L, TMR3H
- **Timer4:** TMR4

### File Name:
- `t0write.c`
- `t1write.c`
- `t2write.c`
- `t3write.c`
- `t4write.c`

### Code Example:
```c
WriteTimer0( 10000 );
```
2.9.2 Example of Use

```c
#include <p18C452.h>
#include <timers.h>
#include <usart.h>
#include <stdlib.h>

void main( void )
{
  int result;
  char str[7];

  // configure timer0
  OpenTimer0( TIMER_INT_OFF &
             T0_SOURCE_INT &
             T0_PS_1_32 );

  // configure USART
  OpenUSART( USART_TX_INT_OFF &
             USART_RX_INT_OFF &
             USART_ASYNCH_MODE &
             USART_EIGHT_BIT &
             USART_CONT_RX,
             25 );

  while( 1 )
  {
    while( ! PORTBbits.RB3 ); // wait for RB3 high
    result = ReadTimer0();    // read timer

    if( result > 0xc000 )     // exit loop if value
      break;                  //   is out of range

    WriteTimer0( 0 );         // restart timer

    ultoa( result, str );     // convert timer to string
    putsUSART( str );         // print string
  }

  CloseTimer0();              // close modules
  CloseUSART();
}
2.10 UART FUNCTIONS

The following routines are provided for devices with a single UART peripheral:

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BusyUSART</td>
<td>Is the UART transmitting?</td>
</tr>
<tr>
<td>CloseUSART</td>
<td>Disable the UART.</td>
</tr>
<tr>
<td>DataRdyUSART</td>
<td>Is data available in the UART read buffer?</td>
</tr>
<tr>
<td>getUSART</td>
<td>Read a byte from the UART.</td>
</tr>
<tr>
<td>getsUSART</td>
<td>Read a string from the UART.</td>
</tr>
<tr>
<td>OpenUSART</td>
<td>Configure the UART.</td>
</tr>
<tr>
<td>putcUSART</td>
<td>Write a byte to the UART.</td>
</tr>
<tr>
<td>putsUSART</td>
<td>Write a string from data memory to the UART.</td>
</tr>
<tr>
<td>putrsUSART</td>
<td>Write a string from program memory to the UART.</td>
</tr>
<tr>
<td>ReadUSART</td>
<td>Read a byte from the UART.</td>
</tr>
<tr>
<td>WriteUSART</td>
<td>Write a byte to the UART.</td>
</tr>
<tr>
<td>baudUSART</td>
<td>Set the baud rate configuration bits for enhanced UART.</td>
</tr>
</tbody>
</table>

The following routines are provided for devices with multiple UART peripherals:

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BusyUART</td>
<td>Is UART transmitting?</td>
</tr>
<tr>
<td>CloseUART</td>
<td>Disable UART x.</td>
</tr>
<tr>
<td>DataRdyUART</td>
<td>Is data available in the read buffer of UART x?</td>
</tr>
<tr>
<td>getUART x</td>
<td>Read a byte from UART x.</td>
</tr>
<tr>
<td>getsUART x</td>
<td>Read a string from UART x.</td>
</tr>
<tr>
<td>OpenUART x</td>
<td>Configure UART x.</td>
</tr>
<tr>
<td>putcUART x</td>
<td>Write a byte to UART x.</td>
</tr>
<tr>
<td>putsUART x</td>
<td>Write a string from data memory to UART x.</td>
</tr>
<tr>
<td>putrsUART x</td>
<td>Write a string from program memory to UART x.</td>
</tr>
<tr>
<td>ReadUART x</td>
<td>Read a byte from UART x.</td>
</tr>
<tr>
<td>WriteUART x</td>
<td>Write a byte to UART x.</td>
</tr>
<tr>
<td>baudUART x</td>
<td>Set the baud rate configuration bits for enhanced UART x.</td>
</tr>
</tbody>
</table>
2.10.1 Function Descriptions

**BusyUSART**
**Busy1USART**
**Busy2USART**

**Function:**
Is the USART transmitting?

**Include:**
`usart.h`

**Prototype:**
```c
char BusyUSART(  void );
char Busy1USART(  void );
char Busy2USART(  void );
```

**Remarks:**
Returns a value indicating if the USART transmitter is currently busy. This function should be used prior to commencing a new transmission. `BusyUSART` should be used on parts with a single USART peripheral. `Busy1USART` and `Busy2USART` should be used on parts with multiple USART peripherals.

**Return Value:**
0 if the USART transmitter is idle
1 if the USART transmitter is in use

**File Name:**
`ubusy.c`
`u1busy.c`
`u2busy.c`

**Code Example:**
```c
while (BusyUSART());
```

**CloseUSART**
**Close1USART**
**Close2USART**

**Function:**
Disable the specified USART.

**Include:**
`usart.h`

**Prototype:**
```c
void CloseUSART(  void );
void Close1USART(  void );
void Close2USART(  void );
```

**Remarks:**
This function disables the interrupts, transmitter and receiver for the specified USART. `CloseUSART` should be used on parts with a single USART peripheral. `Close1USART` and `Close2USART` should be used on parts with multiple USART peripherals.

**File Name:**
`uclose.c`
`u1close.c`
`u2close.c`
DataRdyUSART
DataRdy1USART
DataRdy2USART

Function: Is data available in the read buffer?
Include: `usart.h`
Prototype:
```c
char DataRdyUSART( void );
char DataRdy1USART( void );
char DataRdy2USART( void );
```
Remarks:
This function returns the status of the RCIF flag bit in the PIR register. DataRdyUSART should be used on parts with a single USART peripheral. DataRdy1USART and DataRdy2USART should be used on parts with multiple USART peripherals.

Return Value: 1 if data is available
0 if data is not available
File Name: `udrdy.c`
`u1drdy.c`
`u2drdy.c`

Code Example:
```c
while (!DataRdyUSART());
```

getcUSART
getc1USART
getc2USART

getcUSART is defined as ReadxUSART. See ReadUSART

getsUSART
gets1USART
gets2USART

Function: Read a fixed-length string of characters from the specified USART.
Include: `usart.h`
Prototype:
```c
void getsUSART ( char * buffer, unsigned char len );
void gets1USART ( char * buffer, unsigned char len );
void gets2USART ( char * buffer, unsigned char len );
```
Arguments: `buffer`
A pointer to the location where incoming characters are to be stored.
`len`
The number of characters to read from the USART.
Remarks:
This function only works in 8-bit transmit/receive mode. This function waits for and reads `len` number of characters out of the specified USART. There is no time out when waiting for characters to arrive. getsUSART should be used on parts with a single USART peripheral. gets1USART and gets2USART should be used on parts with multiple USART peripherals.

File Name: `ugets.c`
`u1gets.c`
`u2gets.c`

Code Example:
```c
char inputstr[10];
getsUSART( inputstr, 5 );
```
OpenUSART
Open1USART
Open2USART

Function: Configure the specified USART module.

Include: 

Prototype: 

    void OpenUSART( unsigned char config,
                    unsigned int spbrg);
    void Open1USART( unsigned char config,
                     unsigned int spbrg);
    void Open2USART( unsigned char config,
                     unsigned int spbrg);

Arguments: 

    config
    A bitmask that is created by performing a bitwise AND operation (‘&’) with a value from each of the categories listed below. These values are defined in the file usart.h.

    Interrupt on Transmission:
        USART_TX_INT_ON   Transmit interrupt ON
        USART_TX_INT_OFF  Transmit interrupt OFF

    Interrupt on Receipt:
        USART_RX_INT_ON   Receive interrupt ON
        USART_RX_INT_OFF  Receive interrupt OFF

    USART Mode:
        USART_ASYNCH_MODE Asynchronous Mode
        USART_SYNCH_MODE Synchronous Mode

    Transmission Width:
        USART_EIGHT_BIT   8-bit transmit/receive
        USART_NINE_BIT   9-bit transmit/receive

    Slave/Master Select*:
        USART_SYNC_SLAVE  Synchronous Slave mode
        USART_SYNC_MASTER Synchronous Master mode

    Reception mode:
        USART_SINGLE_RX  Single reception
        USART_CONT_RX    Continuous reception

    Baud rate:
        USART_BRGH_HIGH  High baud rate
        USART_BRGH_LOW   Low baud rate

* Applies to Synchronous mode only

    spbrg
    This is the value that is written to the baud rate generator register which determines the baud rate at which the UART operates. The formulas for baud rate are:

    Asynchronous mode, high speed:
        Fosc / (16 * (spbrg + 1))
    Asynchronous mode, low speed:
        Fosc / (64 * (spbrg + 1))
    Synchronous mode:
        Fosc / (4 * (spbrg + 1))

    Where Fosc is the oscillator frequency.

Remarks: This function configures the UART module according to the specified configuration options.

OpenUSART should be used on parts with a single UART peripheral.
Open1USART and Open2USART should be used on parts with multiple UART peripherals.

File Name: uopen.c
            u1open.c
            u2open.c
OpenUSART
Open1USART
Open2USART (Continued)

Code Example:

```c
OpenUSART1( USART_TX_INT_OFF &
            USART_RX_INT_OFF &
            USARTASYNCH_MODE &
            USART_EIGHT_BIT &
            USART_CONT_RX &
            USART_BRGH_HIGH,
            25 );
```

putcUSART
putc1USART
putc2USART

putcUSART is defined as WriteUSART. See WriteUSART

putsUSART
puts1USART
puts2USART
putrsUSART
putrs1USART
putrs2USART

Function: Writes a string of characters to the USART including the null character.

Include:

```
#include "usart.h"
```

Prototype:

```c
void putsUSART( char *data );
void puts1USART( char *data );
void puts2USART( char *data );
void putrsUSART( const rom char *data );
void putrs1USART( const rom char *data );
void putrs2USART( const rom char *data );
```

Arguments:

- `data` Pointer to a null-terminated string of data.

Remarks:

This function only works in 8-bit transmit/receive mode. This function writes a string of data to the USART including the null character. Strings located in data memory should be used with the "puts" versions of these functions. Strings located in program memory, including string literals, should be used with the "putrs" versions of these functions. putsUSART and putrsUSART should be used on parts with a single USART peripheral. The other functions should be used on parts with multiple USART peripherals.

File Name:

- uputs.c
- u1puts.c
- u2puts.c
- uputrs.c
- u1putrs.c
- u2putrs.c

Code Example:

```c
putrsUSART( "Hello World!" );
```
### Hardware Peripheral Functions

#### ReadUSART

**Function:** Read a byte (one character) out of the USART receive buffer, including the 9th bit if enabled.

**Include:** usart.h

**Prototype:**

```c
char ReadUSART(  void );
char Read1USART( void );
char Read2USART( void );
char getcUSART(  void );
char getc1USART( void );
char getc2USART( void );
```

**Remarks:** This function reads a byte out of the USART receive buffer. The Status bits and the 9th data bits are saved in a union with the following declaration:

```c
union USART
{
    unsigned char val;
    struct
    {
        unsigned RX_NINE:1;
        unsigned TX_NINE:1;
        unsigned FRAME_ERROR:1;
        unsigned OVERRUN_ERROR:1;
        unsigned fill:4;
    };
};
```

The 9th bit is read-only if 9-bit mode is enabled. The Status bits are always read.

On a part with a single USART peripheral, the `getcUSART` and `ReadUSART` functions should be used and the status information is read into a variable named `USART_Status` which is of the type `USART` described above.

On a part with multiple USART peripherals, the `getcUSART` and `ReadxUSART` functions should be used and the status information is read into a variable named `USARTx_Status` which is of the type `USART` described above.

**Return Value:** This function returns the next character in the USART receive buffer.

**File Name:** uread.c

```c
#define in usart.h
```

**Code Example:**

```c
int result;
result = ReadUSART();
result |= (unsigned int) USART_Status.RX_NINE << 8;
```
WriteUSART
Write1USART
Write2USART
putcUSART
putc1USART
putc2USART

Function: Write a byte (one character) to the USART transmit buffer, including the 9th bit if enabled.

Include: usart.h

Prototype:
void WriteUSART( char data);
void Write1USART( char data);
void Write2USART( char data);
void putcUSART( char data);
void putc1USART( char data);
void putc2USART( char data);

Arguments: data
The value to be written to the USART.

Remarks: This function writes a byte to the USART transmit buffer. If 9-bit mode is enabled, the 9th bit is written from the field TX_NINE, found in a variable of type USART:

union USART
{
    unsigned char val;
    struct
    {
        unsigned RX_NINE:1;
        unsigned TX_NINE:1;
        unsigned FRAME_ERROR:1;
        unsigned OVERRUN_ERROR:1;
        unsigned fill:4;
    };
};

On a part with a single USART peripheral, the putcUSART and WriteUSART functions should be used and the Status register is named USART_Status which is of the type USART described above. On a part with multiple USART peripherals, the putcxUSART and WritexUSART functions should be used and the status register is named USARTx_Status which is of the type USART described above.

File Name: uwrite.c
ulwrite.c
u2write.c
#define in usart.h
#define in usart.h
#define in usart.h

Code Example:
unsigned int outval;
USART1_Status.TX_NINE = (outval & 0x0100) >> 8;
Write1USART( (char) outval );
Hardware Peripheral Functions

baudUSART
baud1USART
baud2USART

Function: Set the baud rate configuration bits for enhanced USART operation.
Include: usbart.h
Prototype:
void baudUSART( unsigned char baudconfig );
void baud1USART( unsigned char baudconfig );
void baud2USART( unsigned char baudconfig );

Arguments:
baudconfig
A bitmask that is created by performing a bitwise AND ('&') operation with a value from each of the categories listed below. These values are defined in the file usbart.h:

Clock Idle State:
BAUD_IDLE_CLK_HIGH Clock idle state is a high level
BAUD_IDLE_CLK_LOW Clock idle state is a low level

Baud Rate Generation:
BAUD_16_BIT_RATE 16-bit baud generation rate
BAUD_8_BIT_RATE 8-bit baud generation rate

RX Pin Monitoring:
BAUD_WAKEUP_ON RX pin monitored
BAUD_WAKEUP_OFF RX pin not monitored

Baud Rate Measurement:
BAUD_AUTO_ON Auto baud rate measurement enabled
BAUD_AUTO_OFF Auto baud rate measurement disabled

Remarks:
These functions are only available for processors with enhanced USART capability.

File Name:
ubaud.c
ulbaud.c
u2baud.c

Code Example:
baudUSART (BAUD_IDLE_CLK_HIGH &
           BAUD_16_BIT_RATE &
           BAUD_WAKEUP_ON &
           BAUD_AUTO_ON);
2.10.2 Example of Use

```c
#include <p18C452.h>
#include <usart.h>

void main(void)
{
    // configure USART
    OpenUSART( USART_TX_INT_OFF &
               USART_RX_INT_OFF &
               USART_ASYNCH_MODE &
               USART_EIGHT_BIT &
               USART_CONT_RX &
               USART_BRGH_HIGH,
               25 );

    while(1)
    {
        while( ! PORTAbits.RA0 );  // wait for RA0 high

        WriteUSART( PORTD );       // write value of PORTD

        if(PORTD == 0x80)          // check for termination
            break;                   // value
    }

    CloseUSART();
}
```
Chapter 3. Software Peripheral Library

3.1 INTRODUCTION

This chapter documents software peripheral library functions. The source code for all of these functions is included with MPLAB C18 in the src\traditional\pmc and src\extended\pmc subdirectories of the compiler installation.

See the MPASM™ Assembler, MPLINK™ Object Linker, MPLIB™ Object Librarian User’s Guide (DS33014) for more information about building libraries.

The following peripherals are supported by MPLAB C18 library routines:

- External LCD Functions (Section 3.2 “External LCD Functions”)
- External CAN2510 Functions (Section 3.3 “External CAN2510 Functions”)
- Software I²C™ Functions (Section 3.4 “Software I²C Functions”)
- Software SPI™ Functions (Section 3.5 “Software SPI™ Functions”)
- Software UART Functions (Section 3.6 “Software UART Functions”)

3.2 EXTERNAL LCD FUNCTIONS

These functions are designed to allow the control of a Hitachi HD44780 LCD controller using I/O pins from a PIC18 microcontroller. The following functions are provided:

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BusyXLCD</td>
<td>Is the LCD controller busy?</td>
</tr>
<tr>
<td>OpenXLCD</td>
<td>Configure the I/O lines used for controlling the LCD and initialize the LCD.</td>
</tr>
<tr>
<td>putcXLCD</td>
<td>Write a byte to the LCD controller.</td>
</tr>
<tr>
<td>putsXLCD</td>
<td>Write a string from data memory to the LCD.</td>
</tr>
<tr>
<td>putrsXLCD</td>
<td>Write a string from program memory to the LCD.</td>
</tr>
<tr>
<td>ReadAddrXLCD</td>
<td>Read the address byte from the LCD controller.</td>
</tr>
<tr>
<td>ReadDataXLCD</td>
<td>Read a byte from the LCD controller.</td>
</tr>
<tr>
<td>SetCGRamAddr</td>
<td>Set the character generator address.</td>
</tr>
<tr>
<td>SetDDRamAddr</td>
<td>Set the display data address.</td>
</tr>
<tr>
<td>WriteCmdXLCD</td>
<td>Write a command to the LCD controller.</td>
</tr>
<tr>
<td>WriteDataXLCD</td>
<td>Write a byte to the LCD controller.</td>
</tr>
</tbody>
</table>

The precompiled versions of these functions use default pin assignments that can be changed by redefining the following macro assignments in the file xlcd.h, found in the h subdirectory of the compiler installation:
### TABLE 3-2: MACROS FOR SELECTING LCD PIN ASSIGNMENTS

<table>
<thead>
<tr>
<th>LCD Controller Line</th>
<th>Macros</th>
<th>Default Value</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>E Pin</td>
<td>E_PIN</td>
<td>PORTBbits.RB4</td>
<td>Pin used for the E line.</td>
</tr>
<tr>
<td></td>
<td>TRIS_E</td>
<td>DDRBbits.RB4</td>
<td>Bit that controls the direction of the pin associated with the E line.</td>
</tr>
<tr>
<td>RS Pin</td>
<td>RS_PIN</td>
<td>PORTBbits.RB5</td>
<td>Pin used for the RS line.</td>
</tr>
<tr>
<td></td>
<td>TRIS_RS</td>
<td>DDRBbits.RB5</td>
<td>Bit that controls the direction of the pin associated with the RS line.</td>
</tr>
<tr>
<td>RW Pin</td>
<td>RW_PIN</td>
<td>PORTBbits.RB6</td>
<td>Pin used for the RW line.</td>
</tr>
<tr>
<td></td>
<td>TRIS_RW</td>
<td>DDRBbits.RB6</td>
<td>Bit that controls the direction of the pin associated with the RW line.</td>
</tr>
<tr>
<td>Data Lines</td>
<td>DATA_PORT</td>
<td>PORTB</td>
<td>Pins used for DATA lines. These routines assume all pins are on a single port.</td>
</tr>
<tr>
<td></td>
<td>TRIS_DATA_PORT</td>
<td>DDRB</td>
<td>Data Direction register associated with the DATA lines.</td>
</tr>
</tbody>
</table>

The libraries that are provided can operate in either a 4-bit mode or 8-bit mode. When operating in 8-bit mode, all the lines of a single port are used. When operating in 4-bit mode, either the upper 4 bits or lower 4 bits of a single port are used. The table below lists the macros used for selecting between 4- or 8-bit mode and for selecting which bits of a port are used when operating in 4-bit mode.

### TABLE 3-3: MACROS FOR SELECTING 4- OR 8-BIT MODE

<table>
<thead>
<tr>
<th>Macro</th>
<th>Default Value</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIT8</td>
<td>not defined</td>
<td>If this value is defined when the library functions are built, they will operate in 8-bit Transfer mode. Otherwise, they will operate in 4-bit Transfer mode.</td>
</tr>
<tr>
<td>UPPER</td>
<td>not defined</td>
<td>When BIT8 is not defined, this value determines which nibble of the DATA_PORT is used for data transfer. If UPPER is defined, the upper 4 bits (4:7) of DATA_PORT are used. If UPPER is not defined, the lower 4 bits (0:3) of DATA_PORT are used.</td>
</tr>
</tbody>
</table>

After these definitions have been made, the user must recompile the XLCD routines and then include the updated files in the project. This can be accomplished by adding the XLCD source files into the project or by recompiling the library files using the provided batch files.
The XLCD libraries also require that the following functions be defined by the user to provide the appropriate delays:

### TABLE 3-4: XLCD DELAY FUNCTIONS

<table>
<thead>
<tr>
<th>Function</th>
<th>Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>DelayFor18TCY</td>
<td>Delay for 18 cycles.</td>
</tr>
<tr>
<td>DelayPORXLCD</td>
<td>Delay for 15 ms.</td>
</tr>
<tr>
<td>DelayXLCD</td>
<td>Delay for 5 ms.</td>
</tr>
</tbody>
</table>

#### 3.2.1 Function Descriptions

**BusyXLCD**

Function: Is the LCD controller busy?
Include: xlcd.h
Prototype: unsigned char BusyXLCD( void );
Remarks: This function returns the status of the busy flag of the Hitachi HD44780 LCD controller.
Return Value: 1 if the controller is busy
0 otherwise.
File Name: busyxlcd.c
Code Example: while( BusyXLCD() );

**OpenXLCD**

Function: Configure the PIC® I/O pins and initialize the LCD controller.
Include: xlcd.h
Prototype: void OpenXLCD( unsigned char lcdtype );
Arguments: lcdtype
A bitmask that is created by performing a bitwise AND operation ('&') with a value from each of the categories listed below. These values are defined in the file xlcd.h.
Data Interface:
- FOUR_BIT 4-bit Data Interface mode
- EIGHT_BIT 8-bit Data Interface mode

LCD Configuration:
- LINE_5X7 5x7 characters, single line display
- LINE_5X10 5x10 characters display
- LINES_5X7 5x7 characters, multiple line display

Remarks: This function configures the PIC18 I/O pins used to control the Hitachi HD44780 LCD controller. It also initializes this controller.
File Name: openxlcd.c
Code Example: OpenXLCD( EIGHT_BIT & LINES_5X7 );

**putcXLCD**

See WriteDataXLCD.
putsXLCD  
putrsXLCD  

Function:        Write a string to the Hitachi HD44780 LCD controller.
Include:         xlcd.h
Prototype:       void putsXLCD( char *buffer );
                   void putrsXLCD( const rom char *buffer );
Arguments:       buffer
Remarks:         This function writes a string of characters located in buffer to the Hitachi HD44780 LCD controller. It stops transmission when a null character is encountered. The null character is not transmitted. Strings located in data memory should be used with the “puts” versions of these functions. Strings located in program memory, including string literals, should be used with the “putrs” versions of these functions.
File Name:       putsxlcd.c
                   putrxlcd.c
Code Example:    char mybuff [20];
                   putrsXLCD( "Hello World" );
                   putsXLCD( mybuff );

ReadAddrXLCD

Function:        Read the address byte from the Hitachi HD44780 LCD controller.
Include:         xlcd.h
Prototype:       unsigned char ReadAddrXLCD( void );
Remarks:         This function reads the address byte from the Hitachi HD44780 LCD controller. The LCD controller should not be busy when this operation is performed – this can be verified using the BusyXLCD function. The address read from the controller is for the character generator RAM or the display data RAM depending on the previous Set??RamAddr function that was called.
Return Value:    This function returns an 8-bit quantity. The address is contained in the lower order 7 bits and the BUSY status flag in the Most Significant bit.
File Name:       readaddr.c
Code Example:    char addr;
                   while ( BusyXLCD() );
                   addr = ReadAddrXLCD();
ReadDataXLCD

Function: Read a data byte from the Hitachi HD44780 LCD controller.
Include: xlcd.h
Prototype: char ReadDataXLCD( void );
Remarks: This function reads a data byte from the Hitachi HD44780 LCD controller. The LCD controller should not be busy when this operation is performed – this can be verified using the BusyXLCD function. The data read from the controller is for the character generator RAM or the display data RAM depending on the previous Set??RamAddr function that was called.
Return Value: This function returns the 8-bit data value.
File Name: readdata.c
Code Example:
char data;
while ( BusyXLCD() );
data = ReadAddrXLCD();

SetCGRamAddr

Function: Set the character generator address.
Include: xlcd.h
Prototype: void SetCGRamAddr( unsigned char addr );
Arguments: 
addr Character generator address.
Remarks: This function sets the character generator address of the Hitachi HD44780 LCD controller. The LCD controller should not be busy when this operation is performed – this can be verified using the BusyXLCD function.
File Name: setcgram.c
Code Example:
char cgaddr = 0x1F;
while( BusyXLCD() );
SetCGRamAddr( cgaddr );

SetDDRamAddr

Function: Set the display data address.
Include: xlcd.h
Prototype: void SetDDRamAddr( unsigned char addr );
Arguments: 
addr Display data address.
Remarks: This function sets the display data address of the Hitachi HD44780 LCD controller. The LCD controller should not be busy when this operation is performed – this can be verified using the BusyXLCD function.
File Name: setddram.c
Code Example:
char ddaddr = 0x10;
while( BusyXLCD() );
SetDDRamAddr( ddaddr );
WriteCmdXLCD

Function: Write a command to the Hitachi HD44780 LCD controller.
Include: xlcd.h
Prototype: void WriteCmdXLCD( unsigned char cmd );
Arguments: 

Specifies the command to be performed. The command may be one of the following values defined in xlcd.h:

- DOFF: Turn display off
- CURSOR_OFF: Enable display with no cursor
- BLINK_ON: Enable display with blinking cursor
- BLINK_OFF: Enable display with unblinking cursor
- SHIFT_CUR_LEFT: Cursor shifts to the left
- SHIFT_CUR_RIGHT: Cursor shifts to the right
- SHIFT_DISP_LEFT: Display shifts to the left
- SHIFT_DISP_RIGHT: Display shifts to the right

Alternatively, the command may be a bitmask that is created by performing a bitwise AND operation ('&') with a value from each of the categories listed below. These values are defined in the file xlcd.h.

Data Transfer Mode:
- FOUR_BIT: 4-bit Data Interface mode
- EIGHT_BIT: 8-bit Data Interface mode

Display Type:
- LINE_5X7: 5x7 characters, single line
- LINE_5X10: 5x10 characters display
- LINES_5X7: 5x7 characters, multiple lines

Remarks: This function writes the command byte to the Hitachi HD44780 LCD controller. The LCD controller should not be busy when this operation is performed – this can be verified using the BusyXLCD function.

File Name: wcmdxlcd.c
Code Example:
while( BusyXLCD() );
WriteCmdXLCD( EIGHT_BIT & LINES_5X7 );
WriteCmdXLCD( BLINK_ON );
WriteCmdXLCD( SHIFT_DISP_LEFT );

putcXLCD

Function: Writes a byte to the Hitachi HD44780 LCD controller.
Include: xlcd.h
Prototype: void WriteDataXLCD( char data );
Arguments: 

data

The value of data can be any 8-bit value, but should correspond to the character RAM table of the HD44780 LCD controller.

Remarks: This function writes a data byte to the Hitachi HD44780 LCD controller. The LCD controller should not be busy when this operation is performed – this can be verified using the BusyXLCD function. The data read from the controller is for the character generator RAM or the display data RAM depending on the previous Set??RamAddr function that was called.

File Name: writdata.c
3.2.2 Example of Use

```c
#include <p18C452.h>
#include <xlcd.h>
#include <delays.h>
#include <usart.h>

void DelayFor18TCY( void )
{
    Nop();
    Nop();
    Nop();
    Nop();
    Nop();
    Nop();
    Nop();
    Nop();
    Nop();
    Nop();
    Nop();
    Nop();
    Nop();
    Nop();
    Nop();
    Nop();
    Nop();
}

void DelayPORXLCD (void)
{
    Delay1KTCYx(60); // Delay of 15ms
    // Cycles = (TimeDelay * Fosc) / 4
    // Cycles = (15ms * 16MHz) / 4
    // Cycles = 60,000
    return;
}

void DelayXLCD (void)
{
    Delay1KTCYx(20); // Delay of 5ms
    // Cycles = (TimeDelay * Fosc) / 4
    // Cycles = (5ms * 16MHz) / 4
    // Cycles = 20,000
    return;
}

void main( void )
{
    char data;

    // configure external LCD
    OpenXLCD( EIGHT_BIT & LINES_5X7 );

    // configure USART
    OpenUSART( USART_TX_INT_OFF  & USART_RX_INT_OFF &
               USART_ASYNCH_MODE & USART_EIGHT_BIT  &
               USART_CONT_RX, 25);

    while(1)
    {
        while(!DataRdyUSART()); //wait for data
        data = ReadUSART();     //read data
        WriteDataXLCD(data);    //write to LCD
        if(data=='Q')
            break;
    }

    CloseUSART();
}
```
3.3 EXTERNAL CAN2510 FUNCTIONS

This section documents the MCP2510 external peripheral library functions. The following functions are provided:

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN2510BitModify</td>
<td>Modifies the specified bits in a register to the new values.</td>
</tr>
<tr>
<td>CAN2510ByteRead</td>
<td>Reads the MCP2510 register specified by the address.</td>
</tr>
<tr>
<td>CAN2510ByteWrite</td>
<td>Writes a value to the MCP2510 register specified by the address.</td>
</tr>
<tr>
<td>CAN2510DataRead</td>
<td>Reads a message from the specified receive buffer.</td>
</tr>
<tr>
<td>CAN2510DataReady</td>
<td>Determines if data is waiting in the specified receive buffer.</td>
</tr>
<tr>
<td>CAN2510Disable</td>
<td>Drives the selected PIC18CXXX I/O pin high to disable the Chip Select of the MCP2510.</td>
</tr>
<tr>
<td>CAN2510Enable</td>
<td>Drives the selected PIC18CXXX I/O pin low to Chip Select the MCP2510.</td>
</tr>
<tr>
<td>CAN2510ErrorState</td>
<td>Reads the current Error State of the CAN bus.</td>
</tr>
<tr>
<td>CAN2510Init</td>
<td>Initialize the PIC18CXXX SPI port for communications to the MCP2510 and then configures the MCP2510 registers to interface with the CAN bus.</td>
</tr>
<tr>
<td>CAN2510InterruptEnable</td>
<td>Modifies the CAN2510 interrupt enable bits (CANINTE register) to the new values.</td>
</tr>
<tr>
<td>CAN2510InterruptStatus</td>
<td>Indicates the source of the CAN2510 interrupt.</td>
</tr>
<tr>
<td>CAN2510LoadBufferStd</td>
<td>Loads a Standard data frame into the specified transfer buffer.</td>
</tr>
<tr>
<td>CAN2510LoadBufferXtd</td>
<td>Loads an Extended data frame into the specified transfer buffer.</td>
</tr>
<tr>
<td>CAN2510LoadRTRStd</td>
<td>Loads a Standard remote frame into the specified transfer buffer.</td>
</tr>
<tr>
<td>CAN2510LoadRTRXtd</td>
<td>Loads an Extended remote frame into the specified transfer buffer.</td>
</tr>
<tr>
<td>CAN2510ReadMode</td>
<td>Reads the MCP2510 current mode of operation.</td>
</tr>
<tr>
<td>CAN2510ReadStatus</td>
<td>Reads the status of the MCP2510 Transmit and Receive Buffers.</td>
</tr>
<tr>
<td>CAN2510Reset</td>
<td>Resets the MCP2510.</td>
</tr>
<tr>
<td>CAN2510SendBuffer</td>
<td>Requests message transmission for the specified transmit buffer(s).</td>
</tr>
<tr>
<td>CAN2510SequentialRead</td>
<td>Reads the number of specified bytes in the MCP2510, starting at the specified address. These values will be stored in DataArray.</td>
</tr>
<tr>
<td>CAN2510SequentialWrite</td>
<td>Writes the number of specified bytes in the MCP2510, starting at the specified address. These values will be written from DataArray.</td>
</tr>
<tr>
<td>CAN2510SetBufferPriority</td>
<td>Loads the specified priority for the specified transmit buffer.</td>
</tr>
<tr>
<td>CAN2510SetMode</td>
<td>Configures the MCP2510 mode of operation.</td>
</tr>
<tr>
<td>CAN2510SetMsgFilterStd</td>
<td>Configures ALL of the filter and mask values of the specific receive buffer for a standard message.</td>
</tr>
</tbody>
</table>
### 3.3.1 Function Descriptions

#### CAN2510BitModify

**Function:** Modifies the specified bits in a register to the new values.

**Required CAN Mode(s):** All

**Include:** can2510.h

**Prototype:**

```c
void CAN2510BitModify(
    unsigned char addr,
    unsigned char mask,
    unsigned char data);
```

**Arguments:**

- `addr` The value of `addr` specifies the address of the MCP2510 register to modify.
- `mask` The value of `mask` specifies the bits that will be modified.
- `data` The value of `data` specifies the new state of the bits.

**Remarks:**

This function modifies the contents of the register specified by address, the mask specifies which bits are to be modified and the data specifies the new value to load into those bits. Only specific registers can be modified with the Bit Modify command.

**File Name:** canbmod.c

---

### TABLE 3-5: EXTERNAL CAN2510 FUNCTIONS (CONTINUED)

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN2510SetMsgFilterXtd</td>
<td>Configures ALL of the filter and mask values of the specific receive buffer for a extended message.</td>
</tr>
<tr>
<td>CAN2510SetSingleFilterStd</td>
<td>Configures the specified Receive filter with a filter value for a Standard (Std) message.</td>
</tr>
<tr>
<td>CAN2510SetSingleFilterXtd</td>
<td>Configures the specified Receive filter with a filter value for a Extended (Xtd) message.</td>
</tr>
<tr>
<td>CAN2510SetSingleMaskStd</td>
<td>Configures the specified Receive buffer mask with a mask value for a Standard (Std) format message.</td>
</tr>
<tr>
<td>CAN2510SetSingleMaskXtd</td>
<td>Configures the specified Receive buffer mask with a mask value for an Extended (Xtd) message.</td>
</tr>
<tr>
<td>CAN2510WriteBuffer</td>
<td>Initiates CAN message transmission of selected buffer.</td>
</tr>
<tr>
<td>CAN2510WriteStd</td>
<td>Writes a Standard format message out to the CAN bus using the first available transmit buffer.</td>
</tr>
<tr>
<td>CAN2510WriteXtd</td>
<td>Writes an Extended format message out to the CAN bus using the first available transmit buffer.</td>
</tr>
</tbody>
</table>

**Note 1:** The functions CAN2510Enable and CAN2510Disable will need to be recompiled if:
- the PICmicro® MCU assignment of the CS pin is modified from RC2
- the device header file needs to be changed

---
### CAN2510ByteRead

**Function:** Reads the MCP2510 register specified by the address.

**Required CAN Mode(s):** All

**Include:** can2510.h

**Prototype:**
```c
unsigned char CAN2510ByteRead(
    unsigned char address);
```

**Arguments:**
- `address`: The address of the MCP2510 that is to be read.

**Remarks:** This function reads a single byte from the MCP2510 at the specified address.

**Return Value:** The contents of the specified address.

**File Name:** readbyte.c

---

### CAN2510ByteWrite

**Function:** Writes a value to the MCP2510 register specified by the address.

**Required CAN Mode(s):** All

**Include:** can2510.h

**Prototype:**
```c
void CAN2510ByteWrite(
    unsigned char address,
    unsigned char value);
```

**Arguments:**
- `address`: The address of the MCP2510 that is to be written.
- `value`: The value that is to be written.

**Remarks:** This function writes a single byte from the MCP2510 at the specified address.

**File Name:** wrtbyte.c

---

### CAN2510DataRead

**Function:** Reads a message from the specified receive buffer.

**Required CAN Mode(s):** All (except Configuration mode)

**Include:** can2510.h

**Prototype:**
```c
unsigned char CAN2510DataRead(
    unsigned char bufferNum,
    unsigned long *msgId,
    unsigned char *numBytes,
    unsigned char *data);
```

**Arguments:**
- `bufferNum`: Receive buffer from which to read the message. One of the following values:
  - `CAN2510_RXB0` Read receive buffer 0
  - `CAN2510_RXB1` Read receive buffer 1
- `msgId`: Points to a location that will be modified by the function to contain the CAN standard message identifier.
numBytes
Points to a location that will be modified by the function to contain the number of bytes in this message.

data
Points to an array that will be modified by the function to contain the message data. This array should be at least 8 bytes long, since that is the maximum message data length.

Remarks:
This function determines if the message is a standard or extended message, decodes the ID and message length, and fills in the user-supplied locations with the appropriate information. The CAN2510DataReady function should be used to determine if a specified buffer has data to read.

Return Value:
Function returns one of the following values:
- CAN2510_XTDMMSG: Extended format message
- CAN2510_STDMMSG: Standard format message
- CAN2510_XTDRTR: Remote transmit request (XTD message)
- CAN2510_STDRTR: Remote transmit request (STD message)

File Name: canread.c

CAN2510DataReady

Function:
Determines if data is waiting in the specified receive buffer.

Required CAN Mode(s):
All (except Configuration mode)

Include:
can2510.h

Prototype:
unsigned char CAN2510DataReady( unsigned char bufferNum );

Arguments:
bufferNum
Receive buffer to check for waiting message. One of the following values:
- CAN2510_RXB0: Check Receive Buffer 0
- CAN2510_RXB1: Check Receive Buffer 1
- CAN2510_RXBX: Check Receive Buffer 0 and Receive Buffer 1

Remarks:
This function tests the appropriate RXnIF bit in the CANINTF register.

Return Value:
Returns zero if no message detected or a non-zero value if a message was detected.

1 = buffer0
2 = buffer1
3 = both

File Name: canready.c
CAN2510Disable

Function: Drives the selected PIC18CXXX I/O pin high to disable the Chip Select of the MCP2510.

Required CAN Mode(s): All

Include: canenabl.h

Note: This include file will need to be modified if the Chip Select signal is not associated with the RC2 pin of the PICmicro MCU.

Prototype: void CAN2510Disable( void );

Arguments: None

Remarks: This function requires that the user modifies the file to specify the PIC18CXXX I/O pin (and Port) that will be used to connect to the MCP2510 CS pin. The default pin is RC2.

Note: The source file that contains this function (and the CAN2510Enable function) must have the definitions modified to correctly specify the Port (A, B, C, ...) and Pin number (1, 2, 3, ...) that is used to control the MCP2510 CS pin. After the modification, the processor-specific library must be rebuilt. See Section 1.5.3 “Rebuilding” for information on rebuilding.

File Name: canenabl.c

CAN2510Enable

Function: Drives the selected PIC18CXXX I/O pin low to Chip Select the MCP2510.

Required CAN Mode(s): All

Include: canenabl.h

Note: This include file will need to be modified if the Chip Select signal is not associated with the RC2 pin of the PICmicro MCU.

Prototype: void CAN2510Enable( void );

Remarks: This function requires that the user modifies the file to specify the PIC18CXXX I/O pin (and Port) that will be used to connect to the MCP2510 CS pin. The default pin is RC2.

Note: The source file that contains this function (and the CAN2510Disable function) must have the definitions modified to correctly specify the Port (A, B, C, ...) and Pin number (1, 2, 3, ...) that is used to control the MCP2510 CS pin. After the modification, the processor-specific library must be rebuilt. See Section 1.5.3 “Rebuilding” for information on rebuilding.

File Name: canenabl.c
CAN2510ErrorState

Function: Reads the current Error State of the CAN bus.
Required CAN Mode(s): Normal mode, Loopback mode, Listen Only mode
(Error counters are reset in Configuration mode)
Include: can2510.h
Prototype: unsigned char CAN2510ErrorState( void );
Remarks: This function returns the Error State of the CAN bus. The Error State is dependent on the values in the TEC and REC registers.
Return Value: Function returns one of the following values:
   CAN2510_BUS_OFF TEC < 255
   CAN2510_ERROR_PASSIVE_TX TEC > 127
   CAN2510_ERROR_PASSIVE_RX REC > 127
   CAN2510_ERROR_ACTIVE_WITH_TXWARN TEC > 95
   CAN2510_ERROR_ACTIVE_WITH_RXWARN REC > 95
   CAN2510_ERROR_ACTIVE TEC ≤ 95 and REC ≤ 95
File Name: canerrst.c

CAN2510Init

Function: Initialize the PIC18CXXX SPI port for communications to the MCP2510 and then configures the MCP2510 registers to interface with the CAN bus.
Required CAN Mode(s): Configuration mode
Include: can2510.h
Prototype: unsigned char CAN2510Init( unsigned short long BufferConfig, unsigned short long BitTimeConfig, unsigned char interruptEnables, unsigned char SPI_syncMode, unsigned char SPI_busMode, unsigned char SPI_smpPhase );
Arguments: The values of the following parameters are defined in the include file can2510.h.
BufferConfig
The value of BufferConfig is constructed through the bitwise AND ('&') operation of the following options. Only one option per group function may be selected. The option in the bold font is the default value.

Reset MCP2510 Device
Specifies if the MCP2510 Reset command is to be sent. This does not correspond to a bit in the MCP2510 registers.
   CAN2510_NORESET Don't reset the MCP2510
   CAN2510_RESET Reset the MCP2510

Buffer 0 Filtering
Controlled by the RXB0M1:RXB0M0 bits (RXB0CTRL register)
   CAN2510_RXB0_USEFILT Receive all messages, Use filters
   CAN2510_RXB0_STDMSG Receive only Standard messages
   CAN2510_RXB0_XTDMMSG Receive only Extended messages
   CAN2510_RXB0_NOFILT Receive all messages, NO filters

Buffer 1 Filtering
Controlled by the RXB1M1:RXB1M0 bits (RXB1CTRL register)
   CAN2510_RXB1_USEFILT Receive all messages, Use filters
   CAN2510_RXB1_STDMSG Receive only Standard messages
   CAN2510_RXB1_XTDMMSG Receive only Extended messages
   CAN2510_RXB1_NOFILT Receive all messages, NO filters
## CAN2510Init (Continued)

### Receive Buffer 0 to Receive Buffer 1 Rollover
Controlled by the B0CTRL bit (RXB0CTRL register)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN2510_RXB0_ROLL</td>
<td>If receive buffer 0 is full, message goes to receive buffer 1</td>
</tr>
<tr>
<td>CAN2510_RXB0_NOROLL</td>
<td>Rollover Disabled</td>
</tr>
</tbody>
</table>

### RXBF Pin Setting
Controlled by the B1BFS:B1BFE:B1BFM bits (BFPCtrl register)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN2510_RXBF_OFF</td>
<td>RXBF pin is high-impedance</td>
</tr>
<tr>
<td>CAN2510_RXBF_INT</td>
<td>RXBF pin is an output which indicates Receive Buffer 1 was loaded. Can be used as an interrupt signal.</td>
</tr>
<tr>
<td>CAN2510_RXBF_GPOUTH</td>
<td>RXBF pin is a general purpose digital output. Output High</td>
</tr>
<tr>
<td>CAN2510_RXBF_GPOUTL</td>
<td>RXBF pin is a general purpose digital output. Output Low</td>
</tr>
</tbody>
</table>

### RX0BF Pin Setting
Controlled by the B0BFS:B0BFE:B0BFM bits (BFPCtrl register)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN2510_RX0BF_OFF</td>
<td>RX0BF pin is high-impedance</td>
</tr>
<tr>
<td>CAN2510_RX0BF_INT</td>
<td>RX0BF pin is an output which indicates Receive Buffer 0 was loaded. Can be used as an interrupt signal.</td>
</tr>
<tr>
<td>CAN2510_RX0BF_GPOUTH</td>
<td>RX0BF pin is a general purpose digital output. Output High</td>
</tr>
<tr>
<td>CAN2510_RX0BF_GPOUTL</td>
<td>RX0BF pin is a general purpose digital output. Output Low</td>
</tr>
</tbody>
</table>

### TX2 Pin Setting
Controlled by the B2RTSM bit (TXRTSCTRL register)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN2510_TX2_GPIN</td>
<td>TX2RTS pin is a digital input</td>
</tr>
<tr>
<td>CAN2510_TX2_RTS</td>
<td>TX2RTS pin is an input used to initiate a Request To Send frame from TXBUF2</td>
</tr>
</tbody>
</table>

### TX1 Pin Setting
Controlled by the B1RTSM bit (TXRTSCTRL register)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN2510_TX1_GPIN</td>
<td>TX1RTS pin is a digital input</td>
</tr>
<tr>
<td>CAN2510_TX1_RTS</td>
<td>TX1RTS pin is an input used to initiate a Request To Send frame from TXBUF1</td>
</tr>
</tbody>
</table>

### TX0 Pin Setting
Controlled by the B0RTSM bit (TXRTSCTRL register)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN2510_TX0_GPIN</td>
<td>TX0RTS pin is a digital input</td>
</tr>
<tr>
<td>CAN2510_TX0_RTS</td>
<td>TX0RTS pin is an input used to initiate a Request To Send frame from TXBUF0</td>
</tr>
</tbody>
</table>

### Request Mode of Operation
Controlled by the REQOP2:REQOP0 bits (CANCTRL register)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN2510_REQ_CONFIG</td>
<td>Configuration mode</td>
</tr>
<tr>
<td>CAN2510_REQ_NORMAL</td>
<td>Normal Operation mode</td>
</tr>
<tr>
<td>CAN2510_REQ_SLEEP</td>
<td>Sleep mode</td>
</tr>
<tr>
<td>CAN2510_REQ_LOOPBACK</td>
<td>Loop Back mode</td>
</tr>
<tr>
<td>CAN2510_REQ_LISTEN</td>
<td>Listen Only mode</td>
</tr>
</tbody>
</table>

### CLKOUT Pin Setting
Controlled by the CLKEN:CLKPRE1:CLKPRE0 bits (CANCTRL register)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN2510_CLKOUT_8</td>
<td>CLKOUT = Fosc / 8</td>
</tr>
<tr>
<td>CAN2510_CLKOUT_4</td>
<td>CLKOUT = Fosc / 4</td>
</tr>
<tr>
<td>CAN2510_CLKOUT_2</td>
<td>CLKOUT = Fosc / 2</td>
</tr>
<tr>
<td>CAN2510_CLKOUT_1</td>
<td>CLKOUT = Fosc</td>
</tr>
<tr>
<td>CAN2510_CLKOUT_OFF</td>
<td>CLKOUT is Disabled</td>
</tr>
</tbody>
</table>
**BitTimeConfig**
The value of BitTimeConfig is constructed through the bitwise AND (‘&’) operation of the following options. Only one option per group function may be selected. The option in the **bold font** is the default value.

**Baud Rate Prescaler (BRP)**
Controlled by the BRP5:BRP0 bits (CNF1 register)
- CAN2510_BRG_1X  
  \( T_Q = 1 \times (2T_{OSc}) \)
- CAN2510_BRG_64X  
  \( T_Q = 64 \times (2T_{OSc}) \)

**Synchronization Jump Width**
Controlled by the SJW1: SJW0 bits (CNF1 register)
- CAN2510_SJW_1TQ  
  SJW length = 1 Tq
- CAN2510_SJW_2TQ  
  SJW length = 2 Tq
- CAN2510_SJW_3TQ  
  SJW length = 3 Tq
- CAN2510_SJW_4TQ  
  SJW length = 4 Tq

**Phase 2 Segment Width**
Controlled by the PH2SEG2:PH2SEG0 bits (CNF3 register)
- CAN2510_PH2SEG_2TQ  
  Length = 2 Tq
- CAN2510_PH2SEG_3TQ  
  Length = 3 Tq
- CAN2510_PH2SEG_4TQ  
  Length = 4 Tq
- CAN2510_PH2SEG_5TQ  
  Length = 5 Tq
- CAN2510_PH2SEG_6TQ  
  Length = 6 Tq
- CAN2510_PH2SEG_7TQ  
  Length = 7 Tq
- CAN2510_PH2SEG_8TQ  
  Length = 8 Tq

**Phase 1 Segment Width**
Controlled by the PH1SEG2:PH1SEG0 bits (CNF2 register)
- CAN2510_PH1SEG_1TQ  
  Length = 1 Tq
- CAN2510_PH1SEG_2TQ  
  Length = 2 Tq
- CAN2510_PH1SEG_3TQ  
  Length = 3 Tq
- CAN2510_PH1SEG_4TQ  
  Length = 4 Tq
- CAN2510_PH1SEG_5TQ  
  Length = 5 Tq
- CAN2510_PH1SEG_6TQ  
  Length = 6 Tq
- CAN2510_PH1SEG_7TQ  
  Length = 7 Tq
- CAN2510_PH1SEG_8TQ  
  Length = 8 Tq

**Propagation Segment Width**
Controlled by the PRSEG2:PRSEG0 bits (CNF2 register)
- CAN2510_PROPSEG_1TQ  
  Length = 1 Tq
- CAN2510_PROPSEG_2TQ  
  Length = 2 Tq
- CAN2510_PROPSEG_3TQ  
  Length = 3 Tq
- CAN2510_PROPSEG_4TQ  
  Length = 4 Tq
- CAN2510_PROPSEG_5TQ  
  Length = 5 Tq
- CAN2510_PROPSEG_6TQ  
  Length = 6 Tq
- CAN2510_PROPSEG_7TQ  
  Length = 7 Tq
- CAN2510_PROPSEG_8TQ  
  Length = 8 Tq

**Phase 2 Source**
Controlled by the BTIMODE bit (CNF2 register). This determines if the Phase 2 length is determined by the PH2SEG2:PH2SEG0 bits or the greater length of PH1SEG2:PH1SEG0 bits and (2Tq).
- CAN2510_PH2SOURCE_PH2  
  Length = PH2SEG2:PH2SEG0
- CAN2510_PH2SOURCE_PH1  
  Length = greater of PH1SEG2:PH1SEG0 and 2Tq

**Bit Sample Point Frequency**
Controlled by the SAM bit (CNF2 register). This determines if the bit is sampled 1 or 3 times at the sample point.
- CAN2510_SAMPLE_1x  
  Bit is sampled once
- CAN2510_SAMPLE_3x  
  Bit is sampled three times
RX pin Noise Filter in Sleep Mode
Controlled by the WAKFIL bit (CNF3 register). This determines if the RX pin will use a filter to reject noise when the device is in Sleep mode.

<table>
<thead>
<tr>
<th>CAN2510_RX_FILTER</th>
<th>Filtering on RX pin when in Sleep mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN2510_RX_NOPFILTER</td>
<td>No filtering on RX pin when in Sleep mode</td>
</tr>
</tbody>
</table>

interruptEnables
The value of interruptEnables can be a combination of the following values, combined using a bitwise AND ('&') operation. The option in the bold font is the default value. Controlled by all bits in the CANINTE register.

<table>
<thead>
<tr>
<th>CAN2510_NONE_EN</th>
<th>No interrupts enabled</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN2510_MSGERR_EN</td>
<td>Interrupt on error during message reception or transmission</td>
</tr>
<tr>
<td>CAN2510_WAKEUP_EN</td>
<td>Interrupt on CAN bus activity</td>
</tr>
<tr>
<td>CAN2510_ERROR_EN</td>
<td>Interrupt on EFLG error condition change</td>
</tr>
<tr>
<td>CAN2510_TXB2_EN</td>
<td>Interrupt on transmission buffer 2 becoming empty</td>
</tr>
<tr>
<td>CAN2510_TXB1_EN</td>
<td>Interrupt on transmission buffer 1 becoming empty</td>
</tr>
<tr>
<td>CAN2510_TXB0_EN</td>
<td>Interrupt on transmission buffer 0 becoming empty</td>
</tr>
<tr>
<td>CAN2510_RXB1_EN</td>
<td>Interrupt when message received in receive buffer 1</td>
</tr>
<tr>
<td>CAN2510_RXB0_EN</td>
<td>Interrupt when message received in receive buffer 0</td>
</tr>
</tbody>
</table>

SPI_syncMode
Specifies the PIC18CXXX SPI synchronization frequency:

<table>
<thead>
<tr>
<th>CAN2510_SPI_FOSC4</th>
<th>Communicates at Fosc/4</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN2510_SPI_FOSC16</td>
<td>Communicates at Fosc/16</td>
</tr>
<tr>
<td>CAN2510_SPI_FOSC64</td>
<td>Communicates at Fosc/64</td>
</tr>
<tr>
<td>CAN2510_SPI_FOSCTMR2</td>
<td>Communicates at TMR2/2</td>
</tr>
</tbody>
</table>

SPI_busMode
Specifies the PIC18CXXX SPI bus mode:

<table>
<thead>
<tr>
<th>CAN2510_SPI_MODE00</th>
<th>Communicate using SPI mode 00</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN2510_SPI_MODE01</td>
<td>Communicate using SPI mode 01</td>
</tr>
</tbody>
</table>

SPI_smpPhase
Specifies the PIC18CXXX SPI sample point:

<table>
<thead>
<tr>
<th>CAN2510_SPI_SMPMID</th>
<th>Samples in middle of SPI bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN2510_SPI_SMPEND</td>
<td>Samples at end of SPI bit</td>
</tr>
</tbody>
</table>

Remarks:
This function initializes the PIC18CXXX SPI module, resets the MCP2510 device (if requested) and then configures the MCP2510 registers.

Note: When this function is completed, the MCP2510 is left in the Configuration mode.

Return Value: Indicates if the MCP2510 could be initialized.
0 if initialization completed
-1 if initialization did not complete

File Name: caninit.c
**CAN2510InterruptEnable**

**Function:** Modifies the CAN2510 interrupt enable bits (CANINTE register) to the new values.

**Required CAN Mode(s):** All

**Include:**
- can2510.h,
- spi_can.h

**Prototype:**
```c
void CAN2510InterruptEnable(
    unsigned char interruptEnables);
```

**Arguments:**
- `interruptEnables` The value of `interruptEnables` can be a combination of the following values, combined using a bitwise AND (`&`) operation. The option in the **bold font** is the default value. Controlled by all bits in the CANINTE register.

<table>
<thead>
<tr>
<th>CAN2510_NONE_EN</th>
<th>No interrupts enabled (00000000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN2510_MSGERR_EN</td>
<td>Interrupt on error during message reception or transmission (10000000)</td>
</tr>
<tr>
<td>CAN2510_WAKEUP_EN</td>
<td>Interrupt on CAN bus activity (01000000)</td>
</tr>
<tr>
<td>CAN2510_ERROR_EN</td>
<td>Interrupt on EFLG error condition change (00100000)</td>
</tr>
<tr>
<td>CAN2510_TXB2_EN</td>
<td>Interrupt on transmission buffer 2 becoming empty (00010000)</td>
</tr>
<tr>
<td>CAN2510_TXB1_EN</td>
<td>Interrupt on transmission buffer 1 becoming empty (00001000)</td>
</tr>
<tr>
<td>CAN2510_TXB0_EN</td>
<td>Interrupt on transmission buffer 0 becoming empty (00000100)</td>
</tr>
<tr>
<td>CAN2510_RXB1_EN</td>
<td>Interrupt when message received in receive buffer 1 (00000010)</td>
</tr>
<tr>
<td>CAN2510_RXB0_EN</td>
<td>Interrupt when message received in receive buffer 0 (00000001)</td>
</tr>
</tbody>
</table>

**Remarks:** This function updates the CANINTE register with the value that is determined by ANDing the desired interrupt sources.

**File Name:** caninte.c
### CAN2510InterruptStatus

**Function:**
Indicates the source of the CAN2510 interrupt.

**Required CAN Mode(s):**
All

**Include:**
can2510.h,
spi_can.h

**Prototype:**
```c
unsigned char CAN2510InterruptStatus(
    void );
```

**Remarks:**
This function reads the CANSTAT register and specifies a code depending on the state of the ICCODE2:ICODE0 bits.

**Return Value:**
Function returns one of the following values:
- CAN2510_NO_INTS: No interrupts occurred
- CAN2510_WAKEUP_INT: Interrupt on CAN bus activity
- CAN2510_ERROR_INT: Interrupt on EFLG error condition change
- CAN2510_TXB2_INT: Interrupt on transmission buffer 2 becoming empty
- CAN2510_TXB1_INT: Interrupt on transmission buffer 1 becoming empty
- CAN2510_TXB0_INT: Interrupt on transmission buffer 0 becoming empty
- CAN2510_RXB1_INT: Interrupt when message received in receive buffer 1
- CAN2510_RXB0_INT: Interrupt when message received in receive buffer 0

**File Name:**
canints.c

---

### CAN2510LoadBufferStd

**Function:**
Loads a Standard data frame into the specified transfer buffer.

**Required CAN Mode(s):**
All

**Include:**
can2510.h

**Prototype:**
```c
void CAN2510LoadBufferStd(
    unsigned char bufferNum,
    unsigned int msgId,
    unsigned char numBytes,
    unsigned char *data );
```

**Arguments:**
- *bufferNum*
  Specifies the buffer to load the message into. One of the following values:
  - CAN2510_TXB0: Transmit buffer 0
  - CAN2510_TXB1: Transmit buffer 1
  - CAN2510_TXB2: Transmit buffer 2

- *msgId*
  CAN message identifier, up to 11 bits for a standard message.

- *numBytes*
  Number of bytes of data to transmit, from 0 to 8. If value is greater than 8, only the first 8 bytes of data will be stored.

- *data*
  Array of data values to be loaded. The array must be at least as large as the value specified in *numBytes*. 
### CAN2510LoadBufferStd (Continued)

**Remarks:** This function loads the message information, but does not transmit the message. Use the CAN2510WriteBuffer() function to write the message onto the CAN bus. This function does not set the priority of the buffer. Use the CAN2510SetBufferPriority() function to set buffer priority.

**File Name:** canloads.c

### CAN2510LoadBufferXtd

**Function:** Loads an Extended data frame into the specified transfer buffer.

**Required CAN Mode(s):** All

**Include:** can2510.h

**Prototype:**

```c
void CAN2510LoadBufferXtd(
    unsigned char bufferNum,
    unsigned long msgId,
    unsigned char numBytes,
    unsigned char *data );
```

**Arguments:**

- `bufferNum` Specifies the buffer to load the message into. One of the following values:
  - CAN2510_TXB0 Transmit buffer 0
  - CAN2510_TXB1 Transmit buffer 1
  - CAN2510_TXB2 Transmit buffer 2

- `msgId` CAN message identifier, up to 29 bits for a extended message.

- `numBytes` Number of bytes of data to transmit, from 0 to 8. If value is greater than 8, only the first 8 bytes of data will be stored.

- `data` Array of data values to be loaded. The array must be at least as large as the value specified in `numBytes`.

**Remarks:** This function loads the message information, but does not transmit the message. Use the CAN2510WriteBuffer() function to write the message onto the CAN bus. This function does not set the priority of the buffer. Use the CAN2510SetBufferPriority() function to set buffer priority.

**File Name:** canloadx.c
### CAN2510LoadRTRStd

**Function:**
Loads a Standard remote frame into the specified transfer buffer.

**Required CAN Mode(s):**
All

**Include:**
can2510.h

**Prototype:**
```c
void CAN2510LoadBufferStd(
    unsigned char bufferNum,
    unsigned int msgId,
    unsigned char numBytes);
```

**Arguments:**
- **bufferNum**
  Specifies the buffer to load the message into. One of the following values:
  - CAN2510_TXB0  Transmit buffer 0
  - CAN2510_TXB1  Transmit buffer 1
  - CAN2510_TXB2  Transmit buffer 2

- **msgId**
  CAN message identifier, up to 11 bits for a standard message.

- **numBytes**
  Number of bytes of data to transmit, from 0 to 8. If value is greater than 8, only the first 8 bytes of data will be stored.

**Remarks:**
This function loads the message information, but does not transmit the message. Use the CAN2510WriteBuffer() function to write the message onto the CAN bus.

This function does not set the priority of the buffer. Use the CAN2510SetBufferPriority() function to set buffer priority.

**File Name:**
canlrtrs.c

### CAN2510LoadRTRXtd

**Function:**
 Loads an Extended remote frame into the specified transfer buffer.

**Required CAN Mode(s):**
All

**Include:**
can2510.h

**Prototype:**
```c
void CAN2510LoadBufferXtd(
    unsigned char bufferNum,
    unsigned long msgId,
    unsigned char numBytes);
```

**Arguments:**
- **bufferNum**
  Specifies the buffer to load the message into. One of the following values:
  - CAN2510_TXB0  Transmit buffer 0
  - CAN2510_TXB1  Transmit buffer 1
  - CAN2510_TXB2  Transmit buffer 2

- **msgId**
  CAN message identifier, up to 29 bits for a extended message.

- **numBytes**
  Number of bytes of data to transmit, from 0 to 8. If value is greater than 8, only the first 8 bytes of data will be stored.

**Remarks:**
This function loads the message information, but does not transmit the message. Use the CAN2510WriteBuffer() function to write the message onto the CAN bus.

This function does not set the priority of the buffer. Use the CAN2510SetBufferPriority() function to set buffer priority.

**File Name:**
canlrtrx.c
CAN2510ReadMode

**Function:** Reads the MCP2510 current mode of operation.

**Required CAN Mode(s):** All

**Include:** can2510.h

**Prototype:**

```c
unsigned char CAN2510ReadMode( void );
```

**Remarks:** This function reads the current operating mode. The mode may have a pending request for a new mode.

**Return Value:**

- `mode`

  The value of `mode` can be one of the following values (defined in can2510.h). Specified by the OPMODE2:OPMODE0 bits (CANSTAT register). One of the following values:

  - CAN2510_MODE_CONFIG: Configuration registers can be modified
  - CAN2510_MODE_NORMAL: Normal (send and receive messages)
  - CAN2510_MODE_SLEEP: Wait for interrupt
  - CAN2510_MODE_LISTEN: Listen only, don’t send
  - CAN2510_MODE_LOOPBACK: Used for testing, messages stay internal

**File Name:** canmoder.c

---

CAN2510ReadStatus

**Function:** Reads the status of the MCP2510 Transmit and Receive Buffers.

**Required CAN Mode(s):** All

**Include:** can2510.h

**Prototype:**

```c
unsigned char CAN2510ReadStatus( void );
```

**Remarks:** This function reads the current status of the transmit and receive buffers.

**Return Value:**

- `status`

  The value of `status` (an unsigned byte) has the following format:

  - bit 7: TXB2IF
  - bit 6: TXB2REQ
  - bit 5: TXB1IF
  - bit 4: TXB1REQ
  - bit 3: TXB0IF
  - bit 2: TXB0REQ
  - bit 1: RXB1IF
  - bit 0: RXB0IF

**File Name:** canstats.c
### CAN2510Reset

**Function:** Resets the MCP2510.

**Required CAN Mode(s):** All

**Include:**
- can2510.h
- spi_can.h
- spi.h

**Prototype:**
```c
void CAN2510Reset( void );
```

**Remarks:** This function resets the MCP2510.

**File Name:** canreset.c

### CAN2510SendBuffer

**Function:** Requests message transmission for the specified transmit buffer(s).

**Required CAN Mode(s):** Normal mode

**Include:**
- can2510.h

**Prototype:**
```c
void CAN2510WriteBuffer( unsigned char bufferNum );
```

**Arguments:**
- `bufferNum` Specifies the buffer to request transmission of. One of the following values:
  - `CAN2510_TXB0` Transmit buffer 0
  - `CAN2510_TXB1` Transmit buffer 1
  - `CAN2510_TXB2` Transmit buffer 2
  - `CAN2510_TXB0_B1` Transmit buffer 0 and buffer 1
  - `CAN2510_TXB0_B2` Transmit buffer 0 and buffer 2
  - `CAN2510_TXB1_B2` Transmit buffer 1 and buffer 2
  - `CAN2510_TXB0_B1_B2` Transmit buffer 0, buffer 1 and buffer 2

**Remarks:** This function requests transmission of a previously loaded message stored in the specified buffer(s). To load a message, use the `CAN2510LoadBufferStd()` or `CAN2510LoadBufferXtd()` routines.

**File Name:** cansend.c

### CAN2510SequentialRead

**Function:** Reads the number of specified bytes in the MCP2510, starting at the specified address. These values will be stored in `DataArray`.

**Required CAN Mode(s):** All

**Include:**
- can2510.h

**Prototype:**
```c
void CAN2510SequentialRead( unsigned char *DataArray, unsigned char CAN2510addr, unsigned char numbytes );
```

**Arguments:**
- `DataArray` The start address of the data array that stores the sequential read data.
- `CAN2510addr` The address of the MCP2510 where the sequential reads start from.
- `numbytes` The number of bytes to sequentially read.
CAN2510SequentialRead (Continued)

Remarks: This function reads sequential bytes from the MCP2510 starting at the specified address. These values are loaded starting at the first address of the array that is specified.

File Name: readseq.c

CAN2510SequentialWrite

Function: Writes the number of specified bytes in the MCP2510, starting at the specified address. These values will be written from DataArray.

Required CAN Mode(s): All

Include: can2510.h

Prototype:
void CAN2510SequentialWrite(
    unsigned char *DataArray,
    unsigned char CAN2510addr,
    unsigned char numbytes);

Arguments: DataArray
The start address of the data array that contains the sequential write data.

CAN2510addr
The address of the MCP2510 where the sequential writes start from.

numbytes
The number of bytes to sequentially write.

Remarks: This function writes sequential bytes to the MCP2510 starting at the specified address. These values are contained starting at the first address of the array that is specified.

File Name: wrtseq.c

CAN2510SetBufferPriority

Function: Loads the specified priority for the specified transmit buffer.

Required CAN Mode(s): All

Include: can2510.h

Prototype:
void CAN2510SetBufferPriority(
    unsigned char bufferNum,
    unsigned char bufferPriority);

Arguments: bufferNum
Specifies the buffer to configure the priority of. One of the following values:
CAN2510_TXB0 Transmit buffer 0
CAN2510_TXB1 Transmit buffer 1
CAN2510_TXB2 Transmit buffer 2

bufferPriority
Priority of buffer. One of the following values:
CAN2510_PRI_HIGHEST Highest message priority
CAN2510_PRI_HIGH High message priority
CAN2510_PRI_LOW Low message priority
CAN2510_PRI_LOWEST Lowest message priority

Remarks: This function loads the specified priority of an individual buffer.

File Name: cansetpr.c
**CAN2510SetMode**

**Function:** Configures the MCP2510 mode of operation.

**Required CAN Mode(s):** All

**Include:** can2510.h

**Prototype:**
```c
void CAN2510SetMode( unsigned char mode );
```

**Arguments:**

- **mode**
  
  The value of `mode` can be one of the following values (defined in `can2510.h`). Controlled by the REQOP2:REQOP0 bits (CANCTRL register). One of the following values:

  - **CAN2510_MODE_CONFIG**  
    Configuration registers can be modified
  - **CAN2510_MODE_NORMAL**  
    Normal (send and receive messages)
  - **CAN2510_MODE_SLEEP**  
    Wait for interrupt
  - **CAN2510_MODE_LISTEN**  
    Listen only, don’t send
  - **CAN2510_MODE_LOOPBACK**  
    Used for testing, messages stay internal

**Remarks:**

This function configures the specified mode. The mode will not change until all pending message transmissions are complete.

**File Name:** canmodes.c

---

**CAN2510SetMsgFilterStd**

**Function:** Configures ALL of the filter and mask values of the specific receive buffer for a standard message.

**Required CAN Mode(s):** All

**Include:** can2510.h

**Prototype:**
```c
unsigned char CAN2510SetMsgFilterStd( unsigned char bufferNum, unsigned int mask, unsigned int *filters );
```

**Arguments:**

- **bufferNum**
  
  Specifies the receive buffer to configure the mask and filters for. One of the following values:

  - **CAN2510_RXB0**  
    Configure RXM0, RXF0 and RXF1
  - **CAN2510_RXB1**  
    Configure RXM1, RXF2, RXF3, RXF4 and RXF5

- **mask**
  
  Value to store in the corresponding mask

- **filters**
  
  Array of filter values.

  For Buffer 0
  
  Standard-length messages: Array of 2 unsigned integers
  
  For Buffer 1
  
  Standard-length messages: Array of 4 unsigned integers

**Remarks:**

This function configures the MCP2510 into Configuration mode, then writes the mask and filter values out to the appropriate registers. Before returning, it configures the MCP2510 to the original mode.

**Return Value:**

Indicates if the MCP2510 modes could be modified properly.

0 if initialization and restoration of Operating mode completed

-1 if initialization and restoration of Operating mode did not complete

**File Name:** canfms.c
CAN2510SetMsgFilterXtd

Function: Configures ALL of the filter and mask values of the specific receive buffer for a extended message.

Required CAN Mode(s): All

Include: can2510.h

Prototype:

```c
unsigned char CAN2510SetMsgFilterXtd(
    unsigned char bufferNum,
    unsigned long mask,
    unsigned long *filters);
```

Arguments:

- **bufferNum**
  Specifies the receive buffer to configure the mask and filters for one of the following values:
  - CAN2510_RXB0: Configure RXM0, RXF0 and RXF1
  - CAN2510_RXB1: Configure RXM1, RXF2, RXF3, RXF4 and RXF5

- **mask**
  Value to store in the corresponding mask

- **filters**
  Array of filter values.
  For Buffer 0
  - Extended-length messages: Array of 2 unsigned long integers
  For Buffer 1
  - Extended-length messages: Array of 4 unsigned long integers

Remarks: This function configures the MCP2510 into Configuration mode, then writes the mask and filter values out to the appropriate registers. Before returning, it configures the MCP2510 to the original mode.

Return Value: Indicates if the MCP2510 modes could be modified properly:
- 0 if Initialization and restoration of Operating mode completed
- -1 if initialization and restoration of Operating mode did not complete

File Name: canfmx.c
CAN2510SetSingleFilterStd

**Function:**
Configures the specified Receive filter with a filter value for a Standard (Std) message.

**Required CAN Mode(s):**
Configuration mode

**Include:**
can2510.h

**Prototype:**
```c
void CAN2510SetSingleFilterStd(
    unsigned char filterNum,
    unsigned int filter);
```

**Arguments:**
- **filterNum**
  Specifies the acceptance filter to configure. One of the following values:
  - CAN2510_RXF0  Configure RXF0  (for RXB0)
  - CAN2510_RXF1  Configure RXF1  (for RXB0)
  - CAN2510_RXF2  Configure RXF2  (for RXB1)
  - CAN2510_RXF3  Configure RXF3  (for RXB1)
  - CAN2510_RXF4  Configure RXF4  (for RXB1)
  - CAN2510_RXF5  Configure RXF5  (for RXB1)

- **filter**
  Value to store in the corresponding filter

**Remarks:**
This function writes the filter value to the appropriate registers. The MCP2510 must be in Configuration mode before executing this function.

**File Name:**
canfilts.c

CAN2510SetSingleFilterXtd

**Function:**
Configures the specified Receive filter with a filter value for a Extended (Xtd) message.

**Required CAN Mode(s):**
Configuration mode

**Include:**
can2510.h

**Prototype:**
```c
void CAN2510SetSingleFilterXtd(
    unsigned char filterNum,
    unsigned long filter);
```

**Arguments:**
- **filterNum**
  Specifies the acceptance filter to configure. One of the following values:
  - CAN2510_RXF0  Configure RXF0  (for RXB0)
  - CAN2510_RXF1  Configure RXF1  (for RXB0)
  - CAN2510_RXF2  Configure RXF2  (for RXB1)
  - CAN2510_RXF3  Configure RXF3  (for RXB1)
  - CAN2510_RXF4  Configure RXF4  (for RXB1)
  - CAN2510_RXF5  Configure RXF5  (for RXB1)

- **filter**
  Value to store in the corresponding filter

**Remarks:**
This function writes the filter value to the appropriate registers. The MCP2510 must be in Configuration mode before executing this function.

**File Name:**
canfiltx.c
CAN2510SetSingleMaskStd

Function: Configures the specified Receive buffer mask with a mask value for a Standard (Std) format message.

Required CAN Mode(s): Configuration mode

Include: can2510.h

Prototype:

```c
unsigned char CAN2510SetSingleMaskStd(
    unsigned char maskNum,
    unsigned int mask
);
```

Arguments:

- `maskNum` Specifies the acceptance mask to configure. One of the following values:
  - CAN2510_RXM0 Configure RXM0 (for RXB0)
  - CAN2510_RXM1 Configure RXM1 (for RXB1)

- `mask` Value to store in the corresponding mask

Remarks: This function writes the mask value to the appropriate registers. The MCP2510 must be in Configuration mode before executing this function.

File Name: canmasks.c

CAN2510SetSingleMaskXtd

Function: Configures the specified Receive buffer mask with a mask value for an Extended (Xtd) format message.

Required CAN Mode(s): Configuration mode

Include: can2510.h

Prototype:

```c
unsigned char CAN2510SetSingleMaskXtd(
    unsigned char maskNum,
    unsigned long mask
);
```

Arguments:

- `maskNum` Specifies the acceptance mask to configure. One of the following values:
  - CAN2510_RXM0 Configure RXM0 (for RXB0)
  - CAN2510_RXM1 Configure RXM1 (for RXB1)

- `mask` Value to store in the corresponding mask

Remarks: This function writes the mask value to the appropriate registers. The MCP2510 must be in Configuration mode before executing this function.

File Name: canmaskx.c
## CAN2510WriteBuffer

**Function:** Initiates CAN message transmission of selected buffer.

**Required CAN Mode(s):** All

**Include:** can2510.h

**Prototype:**
```c
unsigned char CAN2510WriteBuffer(
    unsigned char bufferNum
)
```

**Arguments:**
- **bufferNum**
  Specifies the buffer to load the message into. One of the following values:
  - CAN2510_TXB0: Transmit buffer 0
  - CAN2510_TXB1: Transmit buffer 1
  - CAN2510_TXB2: Transmit buffer 2

**Remarks:** This function initiates transmission of the selected transmit buffer.

**File Name:** canwrbuf.c
### CAN2510WriteStd

**Function:**
Writes a Standard format message out to the CAN bus using the first available transmit buffer.

**Required CAN Mode(s):**
Normal mode

**Include:**
can2510.h

**Prototype:**
```c
unsigned char CAN2510WriteStd(
    unsigned int msgId,
    unsigned char msgPriority,
    unsigned char numBytes,
    unsigned char *data );
```

**Arguments:**

- **msgId**
  CAN message identifier, 11 bits for a standard message. This 11-bit identifier is stored in the lower 11 bits of msgId (an unsigned integer).

- **msgPriority**
  Priority of buffer. One of the following values:
  - CAN2510_PRI_HIGHEST  Highest message priority
  - CAN2510_PRI_HIGH    High intermediate message priority
  - CAN2510_PRI_LOW     Low intermediate message priority
  - CAN2510_PRI_LOWEST  Lowest message priority

- **numBytes**
  Number of bytes of data to transmit, from 0 to 8. If value is greater than 8, only the first 8 bytes of data will be sent.

- **data**
  Array of data values to be written. Must be at least as large as the value specified in numBytes.

**Remarks:**
This function will query each transmit buffer for a pending message, and will post the specified message into the first available buffer.

**Return Value:**
Value indicates which buffer was used to transmit the message (0, 1 or 2).
-1 indicates that no message was sent.

**File Name:**
canwrits.c
## CAN2510WriteXtd

**Function:**
Writes an Extended format message out to the CAN bus using the first available transmit buffer.

**Required CAN Mode(s):**
Normal mode

**Include:**
can2510.h

**Prototype:**
```c
unsigned char CAN2510WriteXtd(
    unsigned long msgId,
    unsigned char msgPriority,
    unsigned char numBytes,
    unsigned char *data );
```

**Arguments:**
- **msgId**
  CAN message identifier, 29 bits for an extended message. This 29-bit identifier is stored in the lower 29 bits of msgId (an unsigned long).
- **msgPriority**
  Priority of buffer. One of the following values:
  - CAN2510_PRI_HIGHEST: Highest message priority
  - CAN2510_PRI_HIGH: High intermediate message priority
  - CAN2510_PRI_LOW: Low intermediate message priority
  - CAN2510_PRI_LOWEST: Lowest message priority
- **numBytes**
  Number of bytes of data to transmit, from 0 to 8. If value is greater than 8, only the first 8 bytes of data will be sent.
- **data**
  Array of data values to be written. Must be at least as large as the value specified in `numBytes`.

**Remarks:**
This function will query each transmit buffer for a pending message, and will post the specified message into the first available buffer.

**Return Value:**
Value indicates which buffer was used to transmit the message (0, 1 or 2).
-1 indicates that no message was sent.

**File Name:**
canwritx.c
3.4 SOFTWARE I²C FUNCTIONS

These functions are designed to allow the implementation of an I²C bus using I/O pins from a PIC18 microcontroller. The following functions are provided:

**TABLE 3-6: I²C™ SOFTWARE FUNCTIONS**

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clock_test</td>
<td>Generate a delay for slave clock stretching.</td>
</tr>
<tr>
<td>SWAckI2C</td>
<td>Generate an I²C™ bus Acknowledge condition.</td>
</tr>
<tr>
<td>SWGetcI2C</td>
<td>Read a byte from the I²C bus.</td>
</tr>
<tr>
<td>SWGetsI2C</td>
<td>Read a data string.</td>
</tr>
<tr>
<td>SWNotAckI2C</td>
<td>Generate an I²C bus Not Acknowledge condition.</td>
</tr>
<tr>
<td>SWPutcI2C</td>
<td>Write a single byte to the I²C bus.</td>
</tr>
<tr>
<td>SWPutsI2C</td>
<td>Write a string to the I²C bus.</td>
</tr>
<tr>
<td>SWReadI2C</td>
<td>Read a byte from the I²C bus.</td>
</tr>
<tr>
<td>SWRestartI2C</td>
<td>Generate an I²C bus Restart condition.</td>
</tr>
<tr>
<td>SWStartI2C</td>
<td>Generate an I²C bus Start condition.</td>
</tr>
<tr>
<td>SWStopI2C</td>
<td>Generate an I²C bus Stop condition.</td>
</tr>
<tr>
<td>SWWriteI2C</td>
<td>Write a single byte to the I²C bus.</td>
</tr>
</tbody>
</table>

The precompiled versions of these functions use default pin assignments that can be changed by redefining the macro assignments in the file `sw_i2c.h`, found in the h subdirectory of the compiler installation:

**TABLE 3-7: MACROS FOR SELECTING I²C™ PIN ASSIGNMENTS**

<table>
<thead>
<tr>
<th>I²C Line</th>
<th>Macros</th>
<th>Default Value</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATA Pin</td>
<td>DATA_PIN</td>
<td>PORTBbits.RB4</td>
<td>Pin used for the DATA line.</td>
</tr>
<tr>
<td></td>
<td>DATA_LAT</td>
<td>LATBbits.RB4</td>
<td>Latch associated with DATA pin.</td>
</tr>
<tr>
<td></td>
<td>DATA_LOW</td>
<td>TRISBbits.TRISB4 = 0;</td>
<td>Statement to configure the DATA pin as an output.</td>
</tr>
<tr>
<td></td>
<td>DATA_HI</td>
<td>TRISBbits.TRISB4 = 1;</td>
<td>Statement to configure the DATA pin as an input.</td>
</tr>
<tr>
<td>CLOCK Pin</td>
<td>SCLK_PIN</td>
<td>PORTBbits.RB3</td>
<td>Pin used for the CLOCK line.</td>
</tr>
<tr>
<td></td>
<td>SCLK_LAT</td>
<td>LATBbits.LATB3</td>
<td>Latch associated with the CLOCK pin.</td>
</tr>
<tr>
<td></td>
<td>CLOCK_LOW</td>
<td>TRISBbits.TRISB3 = 0;</td>
<td>Statement to configure the CLOCK pin as an output.</td>
</tr>
<tr>
<td></td>
<td>CLOCK_HI</td>
<td>TRISBbits.TRISB3 = 1;</td>
<td>Statement to configure the CLOCK pin as an input.</td>
</tr>
</tbody>
</table>

After these definitions have been made, the user must recompile the I²C routines and then use the updated files in the project. This can be accomplished by adding the library source files into the project or by recompiling the library files using the provided batch files.
3.4.1 Function Descriptions

**Clock_test**

Function: Generate a delay for slave clock stretching.

Include: `sw_i2c.h`

Prototype: `char Clock_test( void );`

Remarks: This function is called to allow for slave clock stretching. The delay time may need to be adjusted per application requirements. If at the end of the delay period the clock line is low, a value is returned indicating clock error.

Return Value: 0 is returned if no clock error occurred
-2 is returned if a clock error occurred

File Name: `swckti2c.c`

**SWAckI2C, SWNotAckI2C**

Function: Generate an \(^2\)C bus Acknowledge/Not Acknowledge condition.

Include: `sw_i2c.h`

Prototype: `char SWAckI2C( void );`
`char SWNotAckI2C( void );`

Remarks: This function is called to generate an \(^2\)C bus Acknowledge sequence.

Return Value: 0 if the slave Acknowledges
-1 if the slave does not Acknowledge

File Name: `swacki2c.c`

**SWGetcI2C**

See `SWReadI2C`.

**SWGetsI2C**

Function: Read a string from the \(^2\)C bus.

Include: `sw_i2c.h`

Prototype: `char SWGetsI2C( unsigned char *rdptr, unsigned char *length );`

Arguments: `rdptr` Location to store the data read from the \(^2\)C bus. `length` Number of bytes to read.

Remarks: This function reads in a string of predetermined length.

Return Value: -1 if the master generated a NOT ACK bus condition before all bytes have been received
0 otherwise

File Name: `swgtsi2c.c`

Code Example: `char x[10]; SWGetsI2C( x, 5 );`
SWNotAckI2C

See SWAckI2C.

SWPutcI2C

See SWWriteI2C.

SWPutsI2C

Function: Write a string to the I2C bus.
Include: sw_i2c.h
Prototype: char SWPutsI2C(
          unsigned char *wrdptr );
Arguments: wrdptr Pointer to data to be written to the I2C bus.
Remarks: This function writes out a data string up to (but not including) a null character.
Return Value: -1 if there was an error writing to the I2C bus
              0 otherwise
File Name: swptsi2c.c
Code Example: char mybuff [] = "Hello";
              SWPutsI2C(mybuff);

SWReadI2C
SWGetcI2C

Function: Read a byte from the I2C bus.
Include: sw_i2c.h
Prototype: char SWReadI2C( void );
Remarks: This function reads in a single data byte by generating the appropriate signals on the predefined I2C clock line.
Return Value: This function returns the acquired I2C data byte.
              -1 if there was an error in this function.
File Name: swgtci2c.c

SWRestartI2C

Function: Generate an I2C Restart bus condition.
Include: sw_i2c.h
Prototype: void SWRestartI2C( void );
Remarks: This function is called to generate an I2C bus restart condition.
File Name: swrsti2c.c
**SWStartI2C**

**Function:** Generate an I²C bus *Start* condition.

**Include:** sw_i2c.h

**Prototype:**

```
void SWStartI2C( void );
```

**Remarks:** This function is called to generate an I²C bus Start condition.

**File Name:** swstri2c.c

---

**SWStopI2C**

**Function:** Generate an I²C bus *Stop* condition.

**Include:** sw_i2c.h

**Prototype:**

```
void SWStopI2C( void );
```

**Remarks:** This function is called to generate an I²C bus Stop condition.

**File Name:** swstpi2c.c

---

**SWWriteI2C**

**Function:** Write a byte to the I²C bus.

**Include:** sw_i2c.h

**Prototype:**

```
char SWWriteI2C( unsigned char data_out );
```

**Arguments:**

- `data_out`: Single data byte to be written to the I²C bus.

**Remarks:** This function writes out a single data byte to the predefined data pin.

**Return Value:**

- 0 if write is successful
- -1 if there was an error condition

**File Name:** swptci2c.c

**Code Example**

```
if(SWWriteI2C(0x80))
{
    errorHandler();
}
```
3.4.2 Example of Use

The following is a simple code example illustrating a software I²C implementation communicating with a Microchip 24LC01B I²C EE memory device.

```c
#include <p18cxxx.h>
#include <sw_i2c.h>
#include <delays.h>

// FUNCTION Prototype
void main(void);
void byte_write(void);
void page_write(void);
void current_address(void);
void random_read(void);
void sequential_read(void);
void ack_poll(void);
unsigned char warr[] = {8,7,6,5,4,3,2,1,0};
unsigned char rarr[15];
unsigned char far *rdptr = rarr;
unsigned char far *wrptr = warr;
unsigned char var;

#define W_CS PORTA.2

void main( void )
{
    byte_write();
    ack_poll();
    page_write();
    ack_poll();
    Nop();
    sequential_read();
    Nop();
    while (1);  // Loop indefinitely
}

void byte_write( void )
{
    SWStartI2C();
    var = SWPutcI2C(0xA0); // control byte
    SWAckI2C();
    var = SWPutcI2C(0x10); // word address
    SWAckI2C();
    var = SWPutsI2C(wrptr); // data
    SWAckI2C();
    SWStopI2C();
}

void page_write( void )
{
    SWStartI2C();
    var = SWPutcI2C(0xA0); // control byte
    SWAckI2C();
    var = SWPutcI2C(0x10); // word address
    SWAckI2C();
    var = SWPutsI2C(wrptr); // data
    SWAckI2C();
    SWStopI2C();
}
```

void sequential_read( void )
{
    SWStartI2C();
    var = SWPutcI2C( 0xA0 ); // control byte
    SWAckI2C();
    var = SWPutcI2C( 0x00 ); // address to read from
    SWAckI2C();
    SWRestartI2C();
    var = SWPutcI2C( 0xA1 );
    SWAckI2C();
    var = SWGetsI2C( rdptr, 9 );
    SWStopI2C();
}

void current_address( void )
{
    SWStartI2C();
    SWPutcI2C( 0xA1 ); // control byte
    SWAckI2C();
    SWGetcI2C(); // word address
    SWNotAckI2C();
    SWStopI2C();
}

void ack_poll( void )
{
    SWStartI2C();
    var = SWPutcI2C( 0xA0 ); // control byte
    while( SWAckI2C() )
    {
        SWRestartI2C();
        var = SWPutcI2C(0xA0); // data
    }
    SWStopI2C();
}
3.5 SOFTWARE SPI™ FUNCTIONS

These functions are designed to allow the implementation of an SPI using I/O pins from a PIC18 microcontroller. The following functions are provided:

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ClearCSSWSPI</td>
<td>Clear the Chip Select (CS) pin.</td>
</tr>
<tr>
<td>OpenSWSPI</td>
<td>Configure the I/O pins for use as an SPI™.</td>
</tr>
<tr>
<td>putcSWSPI</td>
<td>Write a byte of data to the software SPI.</td>
</tr>
<tr>
<td>SetCSSWSPI</td>
<td>Set the Chip Select (CS) pin.</td>
</tr>
<tr>
<td>WriteSWSPI</td>
<td>Write a byte of data to the software SPI bus.</td>
</tr>
</tbody>
</table>

The precompiled versions of these functions use default pin assignments that can be changed by redefining the macro assignments in the file `sw_spi.h`, found in the `h` subdirectory of the compiler installation:

<table>
<thead>
<tr>
<th>LCD Controller Line</th>
<th>Macros</th>
<th>Default Value</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS Pin</td>
<td>SW_CS_PIN</td>
<td>PORTBbits.RB2</td>
<td>Pin used for the Chip Select (CS) line.</td>
</tr>
<tr>
<td></td>
<td>TRIS_SW_CS_PIN</td>
<td>TRISBbits.TRISB2</td>
<td>Bit that controls the direction of the pin associated with the CS line.</td>
</tr>
<tr>
<td>DIN Pin</td>
<td>SW_DIN_PIN</td>
<td>PORTBbits.RB3</td>
<td>Pin used for the DIN line.</td>
</tr>
<tr>
<td></td>
<td>TRIS_SW_DIN_PIN</td>
<td>TRISBbits.TRISB3</td>
<td>Bit that controls the direction of the pin associated with the DIN line.</td>
</tr>
<tr>
<td>DOUT Pin</td>
<td>SW_DOUT_PIN</td>
<td>PORTBbits.RB7</td>
<td>Pin used for the DOUT line.</td>
</tr>
<tr>
<td></td>
<td>TRIS_SW_DOUT_PIN</td>
<td>TRISBbits.TRISB7</td>
<td>Bit that controls the direction of the pin associated with the DOUT line.</td>
</tr>
<tr>
<td>SCK Pin</td>
<td>SW_SCK_PIN</td>
<td>PORTBbits.RB6</td>
<td>Pin used for the SCK line.</td>
</tr>
<tr>
<td></td>
<td>TRIS_SW_SCK_PIN</td>
<td>TRISBbits.TRISB6</td>
<td>Bit that controls the direction of the pin associated with the SCK line.</td>
</tr>
</tbody>
</table>
The libraries that are provided can operate in one of four modes. The table below lists the macros used for selecting between these modes. Exactly one of these must be defined when rebuilding the software SPI libraries.

**TABLE 3-10: MACROS FOR SELECTING MODES**

<table>
<thead>
<tr>
<th>Macro</th>
<th>Default Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODE0</td>
<td>defined</td>
<td>CKP = 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CKE = 0</td>
</tr>
<tr>
<td>MODE1</td>
<td>not defined</td>
<td>CKP = 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CKE = 0</td>
</tr>
<tr>
<td>MODE2</td>
<td>not defined</td>
<td>CKP = 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CKE = 1</td>
</tr>
<tr>
<td>MODE3</td>
<td>not defined</td>
<td>CKP = 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CKE = 1</td>
</tr>
</tbody>
</table>

After these definitions have been made, the user must recompile the software SPI routines and then include the updated files in the project. This can be accomplished by adding the software SPI source files into the project or by recompiling the library files using the provided batch files.

### 3.5.1 Function Descriptions

**ClearCSSWSPi**

**Function:** Clear the Chip Select (CS) pin that is specified in the sw_spi.h header file.

**Include:** sw_spi.h

**Prototype:** void ClearCSSWSPi( void );

**Remarks:** This function clears the I/O pin that is specified in sw_spi.h to be the Chip Select (CS) pin for the software SPI.

**File Name:** clrcssspi.c

**OpenSSWSPi**

**Function:** Configure the I/O pins for the software SPI.

**Include:** sw_spi.h

**Prototype:** void OpenSSWSPi( void );

**Remarks:** This function configures the I/O pins used for the software SPI to the correct input or output state and logic level.

**File Name:** opensspi.c

**putcSSWSPi**

*See* WriteSSWSPi.
3.5.2 Example of Use

```c
#include <p18C452.h>
#include <sw_spi.h>
#include <delays.h>

void main( void )
{
    char address;

    // configure software SPI
    OpenSWSPI();

    for( address=0; address<0x10; address++ )
    {
        ClearCSSWSPI();        //clear CS pin
        WriteSWSPI( 0x02 );    //send write cmd
        WriteSWSPI( address ); //send address hi
        WriteSWSPI( address ); //send address low
        SetCSSWSPI();          //set CS pin
        Delay10KTCYx( 50 );    //wait 5000,000TCY
    }
}
```

---

**SetCSSWSPI**

**Function:** Set the Chip Select (CS) pin that is specified in the `sw_spi.h` header file.

**Include:** `sw_spi.h`

**Prototype:**
```c
void SetCSSWSPI( void );
```

**Remarks:** This function sets the I/O pin that is specified in `sw_spi.h` to be the Chip Select (CS) pin for the software SPI.

**File Name:** `setcsspi.c`

---

**WriteSWSPI**

**Function:** Write a byte to the software SPI.

**Include:** `sw_spi.h`

**Prototype:**
```c
char WriteSWSPI( char data );
```

**Arguments:**
```c
data
```

**Data to be written to the software SPI.**

**Remarks:** This function writes the specified byte of data out the software SPI and returns the byte of data that was read. This function does not provide any control of the Chip Select pin (CS).

**Return Value:** This function returns the byte of data that was read from the data in (DIN) pin of the software SPI.

**File Name:** `wrtsspi.c`

**Code Example:**
```c
char addr = 0x10;
char result;
result = WriteSWSPI( addr );
```
3.6 SOFTWARE UART FUNCTIONS

These functions are designed to allow the implementation of a UART using I/O pins from a PIC18 microcontroller. The following functions are provided:

TABLE 3-11: SOFTWARE UART FUNCTIONS

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>getcUART</td>
<td>Read a byte from the software UART.</td>
</tr>
<tr>
<td>getsUART</td>
<td>Read a string from the software UART.</td>
</tr>
<tr>
<td>OpenUART</td>
<td>Configure I/O pins for use as a UART.</td>
</tr>
<tr>
<td>putcUART</td>
<td>Write a byte to the software UART.</td>
</tr>
<tr>
<td>putsUART</td>
<td>Write a string to the software UART.</td>
</tr>
<tr>
<td>ReadUART</td>
<td>Read a byte from the software UART.</td>
</tr>
<tr>
<td>WriteUART</td>
<td>Write a byte to the software UART.</td>
</tr>
</tbody>
</table>

The precompiled versions of these functions use default pin assignments that can be changed by redefining the equate (equ) statements in the files writuart.asm, readuart.asm and openuart.asm, found in the src/traditional/pmc/sw_uart or scr/extended/pmc/sw_uart subdirectory of the compiler installation:

TABLE 3-12: MACROS FOR SELECTING UART PIN ASSIGNMENTS

<table>
<thead>
<tr>
<th>LCD Controller Line</th>
<th>Definition</th>
<th>Default Value</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>TX Pin</td>
<td>SWTXD</td>
<td>PORTB</td>
<td>Port used for the transmit line.</td>
</tr>
<tr>
<td></td>
<td>SWTXDpin</td>
<td>4</td>
<td>Bit in the SWTXD port used for the TX line.</td>
</tr>
<tr>
<td></td>
<td>TRIS_SWTXD</td>
<td>TRISB</td>
<td>Data Direction register associated with the port used for the TX line.</td>
</tr>
<tr>
<td>RX Pin</td>
<td>SWRXD</td>
<td>PORTB</td>
<td>Port used for the receive line.</td>
</tr>
<tr>
<td></td>
<td>SWRXDpin</td>
<td>5</td>
<td>Bit in the SWRXD port used for the RX line.</td>
</tr>
<tr>
<td></td>
<td>TRIS_SWRXD</td>
<td>TRISB</td>
<td>Data Direction register associated with the port used for the RX line.</td>
</tr>
</tbody>
</table>

If changes to these definitions are made, the user must recompile the software UART routines and then include the updated files in the project. This can be accomplished by adding the software UART source files into the project or by recompiling the library files using the batch files provided with the MPLAB C18 compiler installation.

The UART libraries also require that the following functions be defined by the user to provide the appropriate delays:

TABLE 3-13: SOFTWARE UART DELAY FUNCTIONS

<table>
<thead>
<tr>
<th>Function</th>
<th>Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>DelayTXBitUART</td>
<td>Delay for: (((2<em>Fosc) / (4</em>baud)) + 1) / 2) - 12 cycles</td>
</tr>
<tr>
<td>DelayRXHalfBitUART</td>
<td>Delay for: (((2<em>Fosc) / (8</em>baud)) + 1) / 2) - 9 cycles</td>
</tr>
<tr>
<td>DelayRXBitUART</td>
<td>Delay for: (((2<em>Fosc) / (4</em>baud)) + 1) / 2) - 14 cycles</td>
</tr>
</tbody>
</table>
3.6.1 Function Descriptions

getcUART
See ReadUART.

getsUART
Function: Read a string from the software UART.
Include: sw_uart.h
Prototype: void getsUART( char * buffer,
                     unsigned char len);
Arguments: buffer Pointer to the string of characters read from the software UART.
len Number of characters to be read from the software UART.
Remarks: This function reads len characters from the software UART and places them in buffer.
File Name: getsuart.c
Code Example: char x[10];
             getsUART( x, 5 );

OpenUART
Function: Configure the I/O pins for the software UART.
Include: sw_uart.h
Prototype: void OpenUART( void );
Remarks: This function configures the I/O pins used for the software UART to the correct input or output state and logic level.
File Name: openuart.asm
Code Example: OpenUART();

putcUART
See WriteUART.

putsUART
Function: Write a string to the software UART.
Include: sw_uart.h
Prototype: void putsUART( char * buffer );
Arguments: buffer String to be written to the software UART.
Remarks: This function writes a string of characters to the software UART. The entire string including the null is sent to the UART.
File Name: putsuart.c
Code Example: char mybuff [] = "Hello";
              putsUART( mybuff );
### ReadUART

**getcUART**

**Function:** Read a byte from the software UART.

**Include:** `sw_uart.h`

**Prototype:**

```c
char ReadUART( void );
```

**Remarks:** This function reads a byte of data out the software UART.

**Return Value:** Returns the byte of data that was read from the receive data (RXD) pin of the software UART.

**File Name:** `readuart.asm`

**Code Example:**

```asm
char x;
    x = ReadUART();
```

### WriteUART

**putcUART**

**Function:** Write a byte to the software UART.

**Include:** `sw_uart.h`

**Prototype:**

```c
void WriteUART( char data );
```

**Arguments:**

- **data**
  - Byte of data to be written to software UART.

**Remarks:** This function writes the specified byte of data out the software UART.

**File Name:** `writuart.asm`

**Code Example:**

```asm
char x = 'H';
    WriteUART( x );
```

#### 3.6.2 Example of Use

```c
#include <p18C452.h>
#include <sw_uart.h>

void main( void )
{
    char data;

    // configure software UART
    OpenUART();

    while( 1 )
    {
        data = ReadUART();  //read a byte
        WriteUART( data );  //bounce it back
    }
}
```
4.1 INTRODUCTION

This chapter documents general software library functions found in the precompiled standard C library file. The source code for all of these functions is included with MPLAB C18 in the following subdirectories of the compiler installation:

- src\traditional\stdlib
- src\extended\stdlib
- src\traditional\delays
- src\extended\delays

The following categories of routines are supported by the MPLAB C18 library:

- Character Classification Functions
- Data Conversion Functions
- Memory and String Manipulation Functions
- Delay Functions
- Reset Functions
- Character Output Functions

4.2 CHARACTER CLASSIFICATION FUNCTIONS

These functions are consistent with the ANSI 1989 standard C library functions of the same name. The following functions are provided:

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>isalnum</td>
<td>Determine if a character is alphanumeric.</td>
</tr>
<tr>
<td>isalpha</td>
<td>Determine if a character is alphabetic.</td>
</tr>
<tr>
<td>iscntrl</td>
<td>Determine if a character is a control character.</td>
</tr>
<tr>
<td>isdigit</td>
<td>Determine if a character is a decimal digit.</td>
</tr>
<tr>
<td>isgraph</td>
<td>Determine if a character is a graphical character.</td>
</tr>
<tr>
<td>islower</td>
<td>Determine if a character is a lowercase alphabetic character.</td>
</tr>
<tr>
<td>isprint</td>
<td>Determine if a character is a printable character.</td>
</tr>
<tr>
<td>ispunct</td>
<td>Determine if a character is a punctuation character.</td>
</tr>
<tr>
<td>isspace</td>
<td>Determine if a character is a white space character.</td>
</tr>
<tr>
<td>isupper</td>
<td>Determine if a character is an uppercase alphabetic character.</td>
</tr>
<tr>
<td>isxdigit</td>
<td>Determine if a character is a hexadecimal digit.</td>
</tr>
</tbody>
</table>
### 4.2.1 Function Descriptions

#### isalnum

<table>
<thead>
<tr>
<th>Function</th>
<th>Determine if a character is alphanumeric.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Include</td>
<td><code>ctype.h</code></td>
</tr>
<tr>
<td>Prototype</td>
<td><code>unsigned char isalnum( unsigned char ch );</code></td>
</tr>
<tr>
<td>Arguments</td>
<td><code>ch</code> Character to be checked.</td>
</tr>
<tr>
<td>Remarks</td>
<td>A character is considered to be alphanumeric if it is in the range of 'A' to 'Z', 'a' to 'z' or '0' to '9'.</td>
</tr>
</tbody>
</table>
| Return Value | Non-zero if the character is alphanumeric  
Zero otherwise |
| File Name | `isalnum.c` |

#### isalpha

<table>
<thead>
<tr>
<th>Function</th>
<th>Determine if a character is alphabetic.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Include</td>
<td><code>ctype.h</code></td>
</tr>
<tr>
<td>Prototype</td>
<td><code>unsigned char isalpha( unsigned char ch );</code></td>
</tr>
<tr>
<td>Arguments</td>
<td><code>ch</code> Character to be checked.</td>
</tr>
<tr>
<td>Remarks</td>
<td>A character is considered to be alphabetic if it is in the range of 'A' to 'Z' or 'a' to 'z'.</td>
</tr>
</tbody>
</table>
| Return Value | Non-zero if the character is alphabetic  
Zero otherwise |
| File Name | `isalpha.c` |

#### iscntrl

<table>
<thead>
<tr>
<th>Function</th>
<th>Determine if a character is a control character.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Include</td>
<td><code>ctype.h</code></td>
</tr>
<tr>
<td>Prototype</td>
<td><code>unsigned char iscntrl( unsigned char ch );</code></td>
</tr>
<tr>
<td>Arguments</td>
<td><code>ch</code> Character to be checked.</td>
</tr>
<tr>
<td>Remarks</td>
<td>A character is considered to be a control character if it is not a printable character as defined by <code>isprint()</code>.</td>
</tr>
</tbody>
</table>
| Return Value | Non-zero if the character is a control character  
Zero otherwise |
| File Name | `iscntrl.c` |
isdigit
Function: Determine if a character is a decimal digit.
Include: ctype.h
Prototype: unsigned char isdigit( unsigned char ch );
Arguments: ch Character to be checked.
Remarks: A character is considered to be a digit character if it is in the range of ‘0’ to ‘9’.
Return Value: Non-zero if the character is a digit character
Zero otherwise
File Name: isdigit.c

isgraph
Function: Determine if a character is a graphical character.
Include: ctype.h
Prototype: unsigned char isgraph( unsigned char ch );
Arguments: ch Character to be checked.
Remarks: A character is considered to be a graphical case alphabetic character if it is any printable character except space.
Return Value: Non-zero if the character is a graphical character
Zero otherwise
File Name: isgraph.c

islower
Function: Determine if a character is a lowercase alphabetic character.
Include: ctype.h
Prototype: unsigned char islower( unsigned char ch );
Arguments: ch Character to be checked.
Remarks: A character is considered to be a lowercase alphabetic character if it is in the range of ‘a’ to ‘z’.
Return Value: Non-zero if the character is a lowercase alphabetic character
Zero otherwise
File Name: islower.c
### isprint

**Function:** Determine if a character is a printable character.

**Include:** `ctype.h`

**Prototype:**

```c
unsigned char isprint( unsigned char ch );
```

**Arguments:**

- `ch`: Character to be checked.

**Remarks:** A character is considered to be a printable character if it is in the range 0x20 to 0x7e, inclusive.

**Return Value:** Non-zero if the character is a printable character, zero otherwise.

**File Name:** `isprint.c`

### ispunct

**Function:** Determine if a character is a punctuation character.

**Include:** `ctype.h`

**Prototype:**

```c
unsigned char ispunct( unsigned char ch );
```

**Arguments:**

- `ch`: Character to be checked.

**Remarks:** A character is considered to be a punctuation character if it is a printable character which is neither a space nor an alphanumeric character.

**Return Value:** Non-zero if the character is a punctuation character, zero otherwise.

**File Name:** `ispunct.c`

### isspace

**Function:** Determine if a character is a white space character.

**Include:** `ctype.h`

**Prototype:**

```c
unsigned char isspace (unsigned char ch);
```

**Arguments:**

- `ch`: Character to be checked.

**Remarks:** A character is considered to be a white space character if it is one of the following: space (' '), tab('	'), carriage return ('r'), new line ('n'), form feed ('f') or vertical tab ('v').

**Return Value:** Non-zero if the character is a white space character, zero otherwise.

**File Name:** `isspace.c`
isupper

Function: Determine if a character is an uppercase alphabetic character.
Include:  <ctype.h>
Prototype: unsigned char isupper (unsigned char ch);
Arguments: ch
Character to be checked.
Remarks: A character is considered to be an uppercase alphabetic character if it is in the range of ‘A’ to ‘Z’.
Return Value: Non-zero if the character is an uppercase alphabetic character
Zero otherwise
File Name: isupper.c

isxdigit

Function: Determine if a character is a hexadecimal digit.
Include:  <ctype.h>
Prototype: unsigned char isxdigit( unsigned char ch );
Arguments: ch
Character to be checked.
Remarks: A character is considered to be a hexadecimal digit character if it is in the range of ‘0’ to ‘9’, ‘a’ to ‘f’ or ‘A’ to ‘F’.
Return Value: Non-zero if the character is a hexadecimal digit character
Zero otherwise
File Name: isxdig.c
4.3 DATA CONVERSION FUNCTIONS

Except as noted in the function descriptions, these functions are consistent with the ANSI 1989 standard C library functions of the same name. The functions provided are:

### TABLE 4-2: DATA CONVERSION FUNCTIONS

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>atob</td>
<td>Convert a string to an 8-bit signed byte.</td>
</tr>
<tr>
<td>atof</td>
<td>Convert a string into a floating point value.</td>
</tr>
<tr>
<td>atoi</td>
<td>Convert a string to a 16-bit signed integer.</td>
</tr>
<tr>
<td>atol</td>
<td>Convert a string into a long integer representation.</td>
</tr>
<tr>
<td>btoa</td>
<td>Convert an 8-bit signed byte to a string.</td>
</tr>
<tr>
<td>itoa</td>
<td>Convert a 16-bit signed integer to a string.</td>
</tr>
<tr>
<td>ltoa</td>
<td>Convert a signed long integer to a string.</td>
</tr>
<tr>
<td>rand</td>
<td>Generate a pseudo-random integer.</td>
</tr>
<tr>
<td>srand</td>
<td>Set the starting seed for the pseudo-random number generator.</td>
</tr>
<tr>
<td>tolower</td>
<td>Convert a character to a lowercase alphabetical ASCII character.</td>
</tr>
<tr>
<td>toupper</td>
<td>Convert a character to an uppercase alphabetical ASCII character.</td>
</tr>
<tr>
<td>ultoa</td>
<td>Convert an unsigned long integer to a string.</td>
</tr>
</tbody>
</table>

#### 4.3.1 Function Descriptions

**atob**

**Function:** Convert a string to an 8-bit signed byte.

**Include:** stdlib.h

**Prototype:**

```c
signed char atob( const char * s );
```

**Arguments:**

- `s` Pointer to ASCII string to be converted.

**Remarks:**

This function converts the ASCII string `s` into an 8-bit signed byte (-128 to 127). The input string must be in base 10 (decimal radix) and can begin with a character indicating sign (`+` or `-`). Overflow results are undefined. This function is an MPLAB C18 extension to the ANSI standard libraries.

**Return Value:**

8-bit signed byte for all strings in the range (-128 to 127).

**File Name:** atob.asm

**atof**

**Function:** Convert a string into a floating point value.

**Include:** stdlib.h

**Prototype:**

```c
double atof ( const char * s );
```

**Arguments:**

- `s` Pointer to ASCII string to be converted.

**Remarks:**

This function converts the ASCII string `s` into a floating point value. Examples of floating point strings that are recognized are:

- `-3.1415`
- `1.0E2`
- `1.0E+2`
- `1.0E-2`

**Return Value:**

The function returns the converted value.

**File Name:** atof.c
### atoi

**Function:** Convert a string to a 16-bit signed integer.

**Include:** `stdlib.h`

**Prototype:**
```
int atoi( const char * s );
```

**Arguments:**
- `s` Pointer to ASCII string to be converted.

**Remarks:** This function converts the ASCII string `s` into an 16-bit signed integer (-32768 to 32767). The input string must be in base 10 (decimal radix) and can begin with a character indicating sign (`+` or `-`). Overflow results are undefined. This function is an MPLAB C18 extension to the ANSI standard libraries.

**Return Value:** 16-bit signed integer for all strings in the range (-32768 to 32767).

**File Name:** `atoi.asm`

### atol

**Function:** Convert a string into a long integer representation.

**Include:** `stdlib.h`

**Prototype:**
```
long atol( const char * s );
```

**Arguments:**
- `s` Pointer to ASCII string to be converted.

**Remarks:** This function converts the ASCII string `s` into a long value. The input string must be in base 10 (decimal radix) and can begin with a character indicating sign (`+` or `-`). Overflow results are undefined. This function is an MPLAB C18 extension to the ANSI standard libraries.

**Return Value:** The function returns the converted value.

**File Name:** `atol.asm`

### btoa

**Function:** Convert an 8-bit signed byte to a string.

**Include:** `stdlib.h`

**Prototype:**
```
char * btoa( signed char value, char * string );
```

**Arguments:**
- `value` An 8-bit signed byte.
- `string` Pointer to ASCII string that will hold the result. `string` must be long enough to hold the ASCII representation, including the sign character for negative values and a trailing null character.

**Remarks:** This function converts the 8-bit signed byte in the argument `value` to a ASCII string representation. This function is an MPLAB C18 extension of the ANSI required libraries.

**Return Value:** Pointer to the result `string`.

**File Name:** `btoa.asm`
### itoa

**Function:** Convert a 16-bit signed integer to a string.

**Include:** `stdlib.h`

**Prototype:**
```c
char * itoa( int value, char * string );
```

**Arguments:**
- `value` A 16-bit signed integer.
- `string` Pointer to ASCII string that will hold the result. `string` must be long enough to hold the ASCII representation, including the sign character for negative values and a trailing null character.

**Remarks:**
This function converts the 16-bit signed integer in the argument `value` to a ASCII string representation.

This function is an MPLAB C18 extension of the ANSI required libraries.

**Return Value:** Pointer to the result `string`.

**File Name:** `itoa.asm`

### ltoa

**Function:** Convert a signed long integer to a string.

**Include:** `stdlib.h`

**Prototype:**
```c
char * ltoa( long value, char * string );
```

**Arguments:**
- `value` A signed long integer to be converted.
- `string` Pointer to ASCII string that will hold the result.

**Remarks:**
This function converts the signed long integer in the argument `value` to a ASCII string representation. `string` must be long enough to hold the ASCII representation, including the sign character for negative values and a trailing null character. This function is an MPLAB C18 extension to the ANSI required libraries.

**Return Value:** Pointer to the result `string`.

**File Name:** `ltoa.asm`

### rand

**Function:** Generate a pseudo-random integer.

**Include:** `stdlib.h`

**Prototype:**
```c
int rand( void );
```

**Remarks:**
Calls to this function return pseudo-random integer values in the range [0,32767]. To use this function effectively, you must seed the random number generator using the `srand()` function. This function will always return the same sequence of integers when identical seed values are used.

**Return Value:** A pseudo-random integer value.

**File Name:** `rand.asm`
**srand**

**Function:** Set the starting seed for the pseudo-random number sequence.

**Include:** `stdlib.h`

**Prototype:**

```c
void srand( unsigned int seed );
```

**Arguments:**

`seed`

The starting value for the pseudo-random number sequence.

**Remarks:**

This function sets the starting seed for the pseudo-random number sequence generated by the `rand()` function. The `rand()` function will always return the same sequence of integers when identical seed values are used. If `rand()` is called without `srand()` having first been called, the sequence of numbers generated will be the same as if `srand()` had been called with a seed value of 1.

**File Name:** `rand.asm`

---

**tolower**

**Function:** Convert a character to a lowercase alphabetical ASCII character.

**Include:** `ctype.h`

**Prototype:**

```c
char tolower( char ch );
```

**Arguments:**

`ch`

Character to be converted.

**Remarks:**

This function converts `ch` to a lowercase alphabetical ASCII character provided that the argument is a valid uppercase alphabetical character.

**Return Value:**

This function returns a lowercase character if the argument was uppercase to begin with; otherwise the original character is returned.

**File Name:** `tolower.c`

---

**toupper**

**Function:** Convert a character to an uppercase alphabetical ASCII character.

**Include:** `ctype.h`

**Prototype:**

```c
char toupper( char ch );
```

**Arguments:**

`ch`

Character to be converted.

**Remarks:**

This function converts `ch` to a uppercase alphabetical ASCII character provided that the argument is a valid lowercase alphabetical character.

**Return Value:**

This function returns an uppercase character if the argument was lowercase to begin with; otherwise the original character is returned.

**File Name:** `toupper.c`
4.4 MEMORY AND STRING MANIPULATION FUNCTIONS

Except as noted in the function descriptions, these functions are consistent with the ANSI (1989) standard C library functions of the same name. The following functions are provided:

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>memchr</td>
<td>Search for a value in a specified memory region.</td>
</tr>
<tr>
<td>memchrpgm</td>
<td></td>
</tr>
<tr>
<td>memcpy</td>
<td>Copy a buffer.</td>
</tr>
<tr>
<td>memcpypgm</td>
<td></td>
</tr>
<tr>
<td>memcpypgm2ram</td>
<td></td>
</tr>
<tr>
<td>memcmppgm2ram</td>
<td></td>
</tr>
<tr>
<td>memcmppgm2pgm</td>
<td></td>
</tr>
<tr>
<td>memcmpram2pgm</td>
<td></td>
</tr>
<tr>
<td>memmove</td>
<td>Copy a buffer, where the source and destination may overlap.</td>
</tr>
<tr>
<td>memmovepgm</td>
<td></td>
</tr>
<tr>
<td>memmovepgm2ram</td>
<td></td>
</tr>
<tr>
<td>memmoveram2pgm</td>
<td></td>
</tr>
<tr>
<td>memset</td>
<td>Initialize an array with a single repeated value.</td>
</tr>
<tr>
<td>memsetpgm</td>
<td></td>
</tr>
<tr>
<td>strcat</td>
<td>Append a copy of the source string to the end of the destination string.</td>
</tr>
<tr>
<td>strcatpgm</td>
<td></td>
</tr>
<tr>
<td>strcatpgm2ram</td>
<td></td>
</tr>
<tr>
<td>strcatram2pgm</td>
<td></td>
</tr>
<tr>
<td>strchr</td>
<td>Locate the first occurrence of a value in a string.</td>
</tr>
<tr>
<td>strchrpgm</td>
<td></td>
</tr>
<tr>
<td>strcmp</td>
<td>Compare two strings.</td>
</tr>
<tr>
<td>strcmp</td>
<td></td>
</tr>
<tr>
<td>strcmppgm</td>
<td></td>
</tr>
<tr>
<td>strcmppgm2ram</td>
<td></td>
</tr>
<tr>
<td>strcmpram2pgm</td>
<td></td>
</tr>
<tr>
<td>strcpy</td>
<td>Copy a string from data or program memory into data memory.</td>
</tr>
<tr>
<td>strcpypgm</td>
<td></td>
</tr>
<tr>
<td>strcpypgm2ram</td>
<td></td>
</tr>
<tr>
<td>strcpypgm2pgm</td>
<td></td>
</tr>
<tr>
<td>strcpyram2pgm</td>
<td></td>
</tr>
</tbody>
</table>

uloa
Function: Convert an unsigned long integer to a string.
Include: stdlib.h
Prototype: char * ultoa( unsigned long value,
                  char * string);
Arguments: value
An unsigned long integer to be converted.
string
Pointer to ASCII string that will hold the result.
Remarks: This function converts the unsigned long integer in the argument value to an ASCII string representation. string must be long enough to hold the ASCII representation, including a trailing null character. This function is an MPLAB C18 extension to the ANSI required libraries.
Return Value: Pointer to the result string.
File Name: ultoa.asm
### TABLE 4-3: MEMORY AND STRING MANIPULATION FUNCTIONS (CONTINUED)

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>strcspn</code></td>
<td>Calculate the number of consecutive characters at the beginning of a string that are not contained in a set of characters.</td>
</tr>
<tr>
<td><code>strlen</code></td>
<td>Determine the length of a string.</td>
</tr>
<tr>
<td><code>strlwr</code></td>
<td>Convert all uppercase characters in a string to lowercase.</td>
</tr>
<tr>
<td><code>strncat</code></td>
<td>Append a specified number of characters from the source string to the end of the destination string.</td>
</tr>
<tr>
<td><code>strncpy</code></td>
<td>Copy characters from the source string into the destination string, up to the specified number of characters.</td>
</tr>
<tr>
<td><code>strpbrk</code></td>
<td>Search a string for the first occurrence of a character from a set of characters.</td>
</tr>
<tr>
<td><code>strrchr</code></td>
<td>Locate the last occurrence of a specified character in a string.</td>
</tr>
<tr>
<td><code>strspn</code></td>
<td>Calculate the number of consecutive characters at the beginning of a string that are contained in a set of characters.</td>
</tr>
<tr>
<td><code>strstr</code></td>
<td>Locate the first occurrence of a string inside another string.</td>
</tr>
<tr>
<td><code>strtok</code></td>
<td>Break a string into substrings or tokens, by inserting null characters in place of specified delimiters.</td>
</tr>
<tr>
<td><code>strupr</code></td>
<td>Convert all lowercase characters in a string to uppercase.</td>
</tr>
</tbody>
</table>
4.4.1 Function Descriptions

memchr
memchrpgm

Function: Locate the first occurrence of a byte value in a specified memory region.

Include: string.h

Prototype: void * memchr( const void *mem, unsigned char c, size_t n );
rom char * memchrpgm( const rom char *mem, const unsigned char c, sizerom_t n );

Arguments:

mem Pointer to a memory region.
c Byte value to find.
n Maximum number of bytes to search.

Remarks: This function searches up to n bytes of the region mem to find the first occurrence of c.
This function differs from the ANSI specified function in that c is defined as an unsigned char parameter rather than an int parameter.

Return Value: If c appears in the first n bytes of mem, this function returns a pointer to the character in mem. Otherwise, it returns a null pointer.

File Names: memchr.asm
mchrpgm.asm

memcmp
memcmppgm
memcmppgm2ram
memcmpram2pgm

Function: Compare the contents of two arrays of bytes.

Include: string.h

Prototype:
signed char memcmp( const void *buf1, const void *buf2, size_t memsize );
signed char memcmppgm( const rom void *buf1, const rom void *buf2, sizerom_t memsize );
signed char memcmppgm2ram( const void *buf1, const rom void *buf2, sizeram_t memsize );
signed char memcmpram2pgm( const rom void *buf1, const void *buf2, sizeram_t memsize );
Arguments:  

(buf1) Pointer to first array.
(buf2) Pointer to second array.
(memsize) Number of elements to be compared in arrays.

Remarks: This function compares the first memsize number of bytes in buf1 to the first memsize number of bytes in buf2 and returns a value indicating whether the buffers are less than, equal to or greater than each other.

Return Value: Returns a value that is:
  <0 if buf1 is less than buf2
  ==0 if buf1 is the same as buf2
  >0 if buf1 is greater than buf2

File Names: memcmp.asm
memcmpp2p.asm
memcmpp2r.asm
memcmpr2p.asm

### memcpy

**Function:** Copy the contents of the source buffer into the destination buffer.

**Include:** string.h

**Prototype:**
```c
void * memcpy(
    void * dest,
    const void * src,
    size_t memsize);
```

```c
rom void * memcpypgm(
    rom void * dest,
    const rom void * src,
    sizerom_t memsize);
```

```c
void * memcpypgm2ram(
    void * dest,
    const rom void * src,
    sizerom_t memsize);
```

```c
rom void * memcpyram2pgm(
    rom void * dest,
    const void * src,
    sizerom_t memsize);
```

Arguments:  

(dest) Pointer to destination array.
(src) Pointer to source array.
(memsize) Number of bytes of src array to copy into dest.

Remarks: This function copies the first memsize number of bytes of src to the array dest. If src and dest overlap, the behavior is undefined.
memcpy
memcpypgm
memcpypgm2ram
memcpyram2pgm (Continued)

Return Value: This function returns the value of dest.
File Names:  
memcpy.asm
memcpyp2p.asm
memcpyp2r.asm
memcpyr2p.asm

memmove
memcpypgm
memcpypgm2ram
memcpyram2pgm

Function: Copy the contents of the source buffer into the destination buffer, even if the regions overlap.
Include: string.h
Prototype: 
void * memmove( void * dest,  
const void * src,  
size_t memsize );

rom void * memmovepgm(  
void * dest,  
const void * src,  
sizerom_t memsize );

void * memmovepgm2ram(  
void * dest,  
const rom void * src,  
sizerom_t memsize );

rom void * memmovepgm2ram(  
void * dest,  
const rom void * src,  
sizerom_t memsize );

Return Value: This function returns the value of dest.
File Names:  
memcpy.asm
memcpyp2p.asm
memcpyp2r.asm
memcpyr2p.asm

Arguments:
dest  
Pointer to destination array.
src  
Pointer to source array.
memsize  
Number of bytes of src array to copy into dest.

Remarks: This function copies the first memsize number of bytes in src to the array dest. This function performs correctly even if src and dest overlap.
## memset

### Function:
Copy the specified character into the destination array.

### Include:
`string.h`

### Prototype:
```
void * memset( void * dest, unsigned char value, size_t memsize );
rom void * memsetpgm( rom void * dest, unsigned char value, sizerom_t memsize );
```

### Arguments:
- **dest**
  Pointer to destination array.
- **value**
  Character value to be copied.
- **memsize**
  Number of bytes of `dest` into which `value` is copied.

### Remarks:
This function copies the character `value` into the first `memsize` bytes of the array `dest`. This functions differs from the ANSI specified function in that `value` is defined as an `unsigned char` rather than as an `int` parameter.

### Return Value:
This function returns the value of `dest`.

### File Name:
- `memset.asm`
- `memsetpgm.asm`

---

## strcat

### Function:
Append a copy of the source string to the end of the destination string.

### Include:
`string.h`

### Prototype:
```
char * strcat( char * dest, const char * src );
rom char * strcatpgm( rom char * dest, const rom char * src );
char * strcatpgm2ram( char * dest, const rom char * src );
rom char * strcatram2pgm( rom char * dest, const char * src );
```

### Arguments:
- **dest**
  Pointer to destination array.
- **src**
  Pointer to source array.

### Remarks:
This function copies the string in `src` to the end of the string in `dest`. The `src` string starts at the null in `dest`. A null character is added to the end of the resulting string in `dest`. If `src` and `dest` overlap, the behavior is undefined.

### Return Value:
This function returns the value of `dest`. 
File Names:  strcat.asm
catp2p.asm
catp2r.asm
catp2p.asm

strchr
strchrpgm

Function:  Locate the first occurrence of a specified character in a string.
Include:  string.h
Prototype:  char * strchr( const char * str,
              unsigned char c );
            rom char * strchrpgm(
              const rom char * str,
              unsigned char c );
Arguments:  str
            Pointer to a string to be searched.
            c
            Character to find.
Remarks:  This function searches the string str to find the first occurrence of
            character c.
            This function differs from the ANSI specified function in that c is defined
            as an unsigned char parameter rather than an int parameter.
Return Value:  If c appears in str, this function returns a pointer to the character in
            str. Otherwise, it returns a null pointer.
File Names:  strchr.asm
            schrpgm.asm

str cmp
str cmppgm
str cmppgm2ram
str cmpram2pgm

Function:  Compare two strings.
Include:  string.h
Prototype:  signed char strcmp(
            const char * strl,
            const char * str2 );
signed char strcmppgm(
            const rom char * strl,
            const rom char * str2 );
signed char strcmppgm2ram(
            const char * strl,
            const rom char * str2 );
signed char strcmpram2pgm(
            const char * strl,
            const char * str2 );
**strcmp**

Arguments:
- `str1`: Pointer to first string.
- `str2`: Pointer to second string.

Remarks: This function compares the string in `str1` to the string in `str2` and returns a value indicating if `str1` is less than, equal to or greater than `str2`.

Return Value: Returns a value that is:
- `<0` if `str1` is less than `str2`
- `==0` if `str1` is the same as `str2`
- `>0` if `str1` is greater than `str2`

File Name: `strcmp.asm`
- `scmpp2p.asm`
- `scmpp2r.asm`
- `scmpr2p.asm`

---

**strcpy**

Function: Copy the source string into the destination string.

Include: `string.h`

Prototype:
```c
char * strcpy( char * dest, const char * src );
rom char * strcpypgm( char * dest, const rom char * src );
char * strcpypgm2ram( char * dest, const rom char * src );
rom char * strcpyram2pgm( char * dest, const char * src );
```

Arguments:
- `dest`: Pointer to destination string.
- `src`: Pointer to source string.

Remarks: This function copies the string in `src` to `dest`. Characters in `src` are copied up to, and including, the terminating null character in `src`. If `src` and `dest` overlap, the behavior is undefined.

Return Value: This function returns the value of `dest`.

File Name: `strcpy.asm`
- `scpyp2p.asm`
- `scpyp2r.asm`
- `scpyp2r.asm`
strcspn
strcspnpgm
strcspnpgrm
strcspnrampgm

Function: Calculate the number of consecutive characters at the beginning of a string that are not contained in a set of characters.

Include:

```
string.h
```

Prototype:

```
size_t strcspn( const char * str1,
    const char * str2 );
sizerom_t strcspnpgm( const rom char * str1,     
    const rom char * str2 );
sizerom_t strcspnpgrm( const rom char * str1,     
    const char * str2 );
sizeram_t strcspnrampgm( const char * str1,     
    const rom char * str2 );
```

Arguments:

- `str1`: Pointer to a string to be searched.
- `str2`: Pointer to a string that is treated as a set of characters.

Remarks: This function will determine the number of consecutive characters from the beginning of `str1` that are not contained in `str2`. For example:

<table>
<thead>
<tr>
<th><code>str1</code></th>
<th><code>str2</code></th>
<th><code>result</code></th>
</tr>
</thead>
<tbody>
<tr>
<td>“hello”</td>
<td>“aeiou”</td>
<td>1</td>
</tr>
<tr>
<td>“antelope”</td>
<td>“aeiou”</td>
<td>0</td>
</tr>
<tr>
<td>“antelope”</td>
<td>“xyz”</td>
<td>8</td>
</tr>
</tbody>
</table>

Return Value: This function returns the number of consecutive characters from the beginning of `str1` that are not contained in `str2`, as shown in the examples above.

File Names:

- `strcspn.asm`
- `scspnp.asm`
- `scspnpr.asm`
- `scspnrp.asm`

strlen
strlenpgm

Function: Return the length of the string.

Include:

```
string.h
```

Prototype:

```
size_t strlen( const char * str );
sizerom_t strlenpgm( const rom char * str );
```

Arguments:

- `str`: Pointer to string.

Remarks: This function determines the length of the string, not including the terminating null character.

Return Value: This function returns the length of the string.

File Name:

- `strlen.asm`
- `slenpgm.asm`
### strlwr

**Function:** Convert all uppercase characters in a string to lowercase.

**Include:** `<string.h>`

**Prototype:**

```c
char * strlwr(char * str);
rom char * strlwrpgm(rom char * str);
```

**Arguments:**
- `str` Pointer to string.

**Remarks:** This function converts all uppercase characters in `str` to lowercase characters. All characters that are not uppercase (A to Z) are not affected.

**Return Value:** This function returns the value of `str`.

**File Name:**
- `strlwr.asm`
- `strlwrpgm.asm`

### strncat

**Function:** Append a specified number of characters from the source string to the destination string.

**Include:** `<string.h>`

**Prototype:**

```c
char * strncat(char * dest, const char * src, size_t n);
rom char * strncatpgm(rom char * dest, const rom char * src, sizerom_t n);
char * strncatpgm2ram(rom char * dest, const rom char * src, sizerom_t n);
rom char * strncatram2pgm(rom char * dest, const char * src, sizeram_t n);
```

**Arguments:**
- `dest` Pointer to destination array.
- `src` Pointer to source array.
- `n` Number of characters to append.

**Remarks:** This function appends exactly `n` characters from the string in `src` to the end of the string in `dest`. If a null character is copied before `n` characters have been copied, null characters will be appended to `dest` until exactly `n` characters have been appended. If `src` and `dest` overlap, the behavior is undefined. If a null character is not encountered, then a null character is not appended.

**Return Value:** This function returns the value of `dest`. 
File Names:

strncat.asm
sncatp2p.asm
sncatp2r.asm
sncatr2p.asm

strncmp
strncmppgm
strncmppgm2ram
strncmpram2pgm

Function: Compare two strings, up to a specified number of characters.

Include: string.h

Prototype:

signed char strncmp( const char * str1,
const char * str2,
size_t n );

signed char strncmppgm(
const rom char * str1,
const rom char * str2,
sizerom_t n );

signed char strncmppgm2ram(
const char * str1,
const rom char * str2,
sizerom_t n );

signed char strncmpram2pgm(
const rom char * str1,
const char * str2,
sizeram_t n );

Arguments:

str1
Pointer to first string.
str2
Pointer to second string.
n
Maximum number of characters to compare.

Remarks: This function compares the string in str1 to the string in str2 and returns a value indicating if str1 is less than, equal to or greater than str2. If n characters are compared and no differences are found, this function will return a value indicating that the strings are equivalent.

Return Value: Returns a value based on the first character that differs between str1 and str2. It returns:
<0 if str1 is less than str2
==0 if str1 is the same as str2
>0 if str1 is greater than str2

File Name:

strncmp.asm
sncmpp2p.asm
sncmpp2r.asm
sncmpr2p.asm
Function: Copy characters from the source string into the destination string, up to the specified number of characters.

Include:

```
#include <string.h>
```

Prototype:

```
char * strncpy( char * dest, const char * src, size_t n);
rom char * strncpypgm(  
    rom char * dest, const rom char * src, sizerom_t n );
char * strncpypgm2ram(  
    char * dest, const rom char * src, sizeram_t n );
rom char * strncpyram2pgm(  
    rom char * dest, const char * src, sizeram_t n );
```

Arguments:

- **dest**: Pointer to destination string.
- **src**: Pointer to source string.
- **n**: Maximum number of characters to copy.

Remarks: This function copies the string in **src** to **dest**. Characters in **src** are copied into **dest** until the terminating null character or **n** characters have been copied. If **n** characters were copied and no null character was found then **dest** will not be null-terminated.

If copying takes place between objects that overlap, the behavior is undefined.

Return Value: This function returns the value of **dest**.

File Name: `strncpy.asm`  
`sncpypgm.asm`  
`sncpypgm2ram.asm`  
`sncpyram2pgm.asm`
strpbrk
strpbrkpgm
strpbrkpgmram
strpbrkrampgm

Function: Search a string for the first occurrence of a character from a specified set of characters.

Include: string.h

Prototype: char * strpbrk( const char * str1, const char * str2 );
rom char * strpbrkpgm(
    const rom char * str1,
    const rom char * str2 );
rom char * strpbrkpgmram(
    const rom char * str1,
    const char * str2 );
char * strpbrkrampgm(
    const char * str1,
    const rom char * str2 );

Arguments: str1
    Pointer to a string to be searched.
str2
    Pointer to a string that is treated as a set of characters.

Remarks: This function will search str1 for the first occurrence of a character contained in str2.

Return Value: If a character in str2 is found, a pointer to that character in str1 is returned. If no character from str2 is found in str1, a null pointer is returned.

File Names: strpbrk.asm
spbrkp.asm
spbrkprr.asm
spbrkrp.asm

strrchr

Function: Locate the last occurrence of a specified character in a string.

Include: string.h

Prototype: char * strrchr( const char * str, const char c );

Arguments: str
    Pointer to a string to be searched.
c
    Character to find.

Remarks: This function searches the string str, including the terminating null character, to find the last occurrence of character c. This function differs from the ANSI specified function in that c is defined as an unsigned char parameter rather than an int parameter.

Return Value: If c appears in str, this function returns a pointer to the character in str. Otherwise, it returns a null pointer.

File Names: strrchr.asm
strspn
strspnpgm
strspnpgmram
strspnrampgm

Function: Calculate the number of consecutive characters at the beginning of a string that are contained in a set of characters.

Include: string.h

Prototype:
size_t strspn( const char * str1, const char * str2 );
sizerom_t strspnpgm( const rom char * str1, const rom char * str2 );
sizerom_t strspnpgmram( const rom char * str1, const char * str2 );
sizeram_t strspnrampgm( const char * str1, const rom char * str2 );

Arguments:
str1 Pointer to a string to be searched.
str2 Pointer to a string that is treated as a set of characters.

Remarks: This function will determine the number of consecutive characters from the beginning of str1 that are contained in str2. For example:

<table>
<thead>
<tr>
<th>str1</th>
<th>str2</th>
<th>result</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;banana&quot;</td>
<td>&quot;ab&quot;</td>
<td>2</td>
</tr>
<tr>
<td>&quot;banana&quot;</td>
<td>&quot;abn&quot;</td>
<td>6</td>
</tr>
<tr>
<td>&quot;banana&quot;</td>
<td>&quot;an&quot;</td>
<td>0</td>
</tr>
</tbody>
</table>

Return Value: This function returns the number of consecutive characters from the beginning of str1 that are contained in str2, as shown in the examples above.

File Names:
strspn.asm
sspnpp.asm
sspnpr.asm
sspnrp.asm
**strstr**
**strstrpgm**
**strstrpgmram**
**strstrrampgm**

**Function:** Locate the first occurrence of a string inside another string.
**Include:** `string.h`
**Prototype:**
```c
char * strstr( const char * str,
               const char * substr );
rom char * strstrpgm(
               const rom char * str,
               const rom char * substr );
rom char * strstrpgmram(
               const rom char * str,
               const char * substr );
char * strstrrampgm(
               const char * str,
               const rom char * substr );
```

**Arguments:**
- `str` Pointer to a string to be searched.
- `substr` Pointer to a string pattern for which to search.

**Remarks:** This function will find the first occurrence of the string `substr` (excluding the null terminator) within string `str`.

**Return Value:** If the string is located, a pointer to that string in `str` will be returned. Otherwise a null pointer is returned.

**File Names:**
- `strstr.asm`
- `sstrpp.asm`
- `sstrpr.asm`
- `sstrrp.asm`

**strtok**
**strtokpgm**
**strtokpgmram**
**strtokrampgm**

**Function:** Break a string into substrings or tokens, by inserting null characters in place of specified delimiters.
**Include:** `string.h`
**Prototype:**
```c
char * strtok( char * str,
               const char * delim );
rom char * strtokpgm(
               rom char * str,
               const rom char * delim );
char * strtokpgmram(  
               char * str,
               const rom char * delim );
rom char * strtokrampgm(  
               rom char * str,
               const char * delim );
```

**Arguments:**
- `str` Pointer to a string to be searched.
- `delim` Pointer to a set of characters that indicate the end of a token.
strtok
strtokpgm
strtokpgmram
strtokrampgm (Continued)

Remarks: This function can be used to split up a string into substrings by replacing specified characters with null characters. The first time this function is invoked on a particular string, that string should be passed in str. After the first time, this function can continue parsing the string from the last delimiter by invoking it with a null value passed in str. When strtok is invoked with a non-null parameter for str, it starts searching str from the beginning. It skips all leading characters that appear in the string delim, then skips all characters not appearing in delim, then sets the next character to null. When strtok is invoked with a null parameter for str, it searches the string that was most recently examined, beginning with the character after the one that was set to null during the previous call. It skips all characters not appearing in delim, then sets the next character to null. If strtok finds the end of the string before it finds a delimiter, it does not modify the string. The set of characters that is passed in delim need not be the same for each call to strtok.

Return Value: If a delimiter was found, this function returns a pointer into str to the first character that was searched that did not appear in the set of characters delim. This character represents the first character of a token that was created by the call. If no delimiter was found prior to the terminating null character, a null pointer is returned from the function.

File Names:  strtok.asm
stokpgm.asm
stokpr.asm
stokrp.asm

strupr
struprpgm

Function: Convert all lowercase characters in a string to uppercase.
Include: string.h
Prototype: char * strupr( char * str );
rom char * struprpgm( rom char * str );
Arguments: str
Pointer to string.
Remarks: This function converts all lowercase characters in str to uppercase characters. All characters that are not lowercase (a to z) are not affected.
Return Value: This function returns the value of str.
File Name: strupr.asm
struprpgm.asm
4.5 DELAY FUNCTIONS

The delay functions execute code for a specific number of processor instruction cycles. For time based delays, the processor operating frequency must be taken into account. The following routines are provided:

<table>
<thead>
<tr>
<th>TABLE 4-4: DELAY FUNCTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
</tr>
<tr>
<td>Delay1TCY</td>
</tr>
<tr>
<td>Delay10TCYx</td>
</tr>
<tr>
<td>Delay100TCYx</td>
</tr>
<tr>
<td>Delay1KTCYx</td>
</tr>
<tr>
<td>Delay10KTCYx</td>
</tr>
</tbody>
</table>

4.5.1 Function Descriptions

**Delay1TCY**

Function: Delay 1 instruction cycle (TCY).
Include: delays.h
Prototype: void Delay1TCY( void );
Remarks: This function is actually a #define for the NOP instruction. When encountered in the source code, the compiler simply inserts a NOP.
File Name: #define in delays.h

**Delay10TCYx**

Function: Delay in multiples of 10 instruction cycles (TCY).
Include: delays.h
Prototype: void Delay10TCYx( unsigned char unit );
Arguments: unit
Remarks: This function creates a delay in multiples of 10 instruction cycles.
File Name: d10tcyx.asm

**Delay100TCYx**

Function: Delay in multiples of 100 instruction cycles (TCY).
Include: delays.h
Prototype: void Delay100TCYx( unsigned char unit );
Arguments: unit
Remarks: This function creates a delay in multiples of 10 instruction cycles.
File Name: d10tcyx.asm
## Delay100TCYx (Continued)

**Remarks:** This function creates a delay in multiples of 100 instruction cycles. This function uses the globally allocated variable, DelayCounter1. If this function is used in both interrupt and mainline code, the variable DelayCounter1 should be saved and restored in the interrupt handler. Refer to the `save=` clause of the `#pragma interrupt` or `#pragma interruptlow` directives for more information. Note that other delay functions also use the globally allocated DelayCounter1 variable.

**File Name:** d100tcyx.asm

## Delay1KTCYx

**Function:** Delay in multiples of 1,000 instruction cycles (TCY).

**Include:** delays.h

**Prototype:**
```c
void Delay1KTCYx( unsigned char unit );
```

**Arguments:**
- `unit`
  The value of `unit` can be any 8-bit value. A value in the range [1,255] will delay (`unit` * 1000) cycles. A value of 0 causes a delay of 256,000 cycles.

**Remarks:** This function creates a delay in multiples of 1,000 instruction cycles. This function uses the globally allocated variables, DelayCounter1 and DelayCounter2. If this function is used in both interrupt and mainline code, these variables, DelayCounter1 and DelayCounter2, should be saved and restored in the interrupt handler. Refer to the `save=` clause of the `#pragma interrupt` and `#pragma interruptlow` directives for more information. Note that other delay functions also use the globally allocated DelayCounter1 variable.

**File Name:** d1ktcyx.asm

## Delay10KTCYx

**Function:** Delay in multiples of 10,000 instruction cycles (TCY).

**Include:** delays.h

**Prototype:**
```c
void Delay10KTCYx( unsigned char unit );
```

**Arguments:**
- `unit`
  The value of `unit` can be any 8-bit value. A value in the range [1,255] will delay (`unit` * 10000) cycles. A value of 0 causes a delay of 2,560,000 cycles.

**Remarks:** This function creates a delay in multiples of 10,000 instruction cycles. This function uses the globally allocated variable, DelayCounter1. If this function is used in both interrupt and mainline code, the variable DelayCounter1 should be saved and restored in the interrupt handler. Refer to the `save=` clause of the `#pragma interrupt` or `#pragma interruptlow` directives for more information. Note that other delay functions also use the globally allocated DelayCounter1 variable.

**File Name:** d10ktcyx.asm
4.6  RESET FUNCTIONS

The Reset functions may be used to help determine the source of a Reset or wake-up event and for reconfiguring the processor status following a Reset. The following routines are provided:

TABLE 4-5:  RESET FUNCTIONS

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>isBOR</td>
<td>Determine if the cause of a Reset was the Brown-out Reset circuit.</td>
</tr>
<tr>
<td>isLVD</td>
<td>Determine if the cause of a Reset was a low voltage detect condition.</td>
</tr>
<tr>
<td>isMCLR</td>
<td>Determine if the cause of a Reset was the MCLR pin.</td>
</tr>
<tr>
<td>isPOR</td>
<td>Detect a Power-on Reset condition.</td>
</tr>
<tr>
<td>isWDTTO</td>
<td>Determine if the cause of a Reset was a Watchdog timer time-out.</td>
</tr>
<tr>
<td>isWDTWU</td>
<td>Determine if the cause of a wake-up was the Watchdog timer.</td>
</tr>
<tr>
<td>isWU</td>
<td>Detects if the microcontroller was just waken up from Sleep from the MCLR pin or an interrupt.</td>
</tr>
<tr>
<td>StatusReset</td>
<td>Set the POR and BOR bits.</td>
</tr>
</tbody>
</table>

Note: If you are using Brown-out Reset (BOR) or the Watchdog Timer (WDT), then you must define the enable macros (#define BOR_ENABLED and #define WDT_ENABLED, respectively) in the header file reset.h and recompile the source code. If the device is configured to reset on stack overflow/underflow, then you must define the enable macro (#define STVR_ENABLED) in the header file reset.h and recompile the source code.

4.6.1  Function Descriptions

**isBOR**

Function: Determine if the cause of a Reset was the Brown-out Reset circuit.

Include: reset.h

Prototype: char isBOR( void );

Remarks: This function detects if the microcontroller was reset due to the Brown-out Reset circuit. This condition is indicated by the following Status bits:

<table>
<thead>
<tr>
<th>POR</th>
<th>BOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Return Value: 1 if the Reset was due to the Brown-out Reset circuit

0 otherwise

File Name: isbor.c

**isLVD**

Function: Determine if the cause of a Reset was a low voltage detect condition.

Include: reset.h

Prototype: char isLVD( void );

Remarks: This function detects if the voltage of the device has become lower than the value specified in the LVDCON register (LVDL3:LVDL0 bits.)

Return Value: 1 if a Reset was due to LVD during normal operation

0 otherwise

File Name: islvd.c
isMCLR

**Function:** Determine if the cause of a Reset was the MCLR pin.

**Include:** reset.h

**Prototype:**
char isMCLR( void );

**Remarks:** This function detects if the microcontroller was reset via the MCLR pin while in normal operation. This situation is indicated by the following Status bits:
- POR = 1
- If Brown-out is enabled, BOR = 1
- If WDT is enabled, TO = 1
- PD = 1
- If stack overflow/underflow reset is enabled, then the stack overflow and underflow flag bits will be cleared in the STKPTR register.

**Return Value:**
- 1 if the Reset was due to MCLR during normal operation
- 0 otherwise

**File Name:** ismclr.c

isPOR

**Function:** Detect a Power-on Reset condition.

**Include:** reset.h

**Prototype:**
char isPOR( void );

**Remarks:** This function detects if the microcontroller just left a Power-on Reset. This condition is indicated by the following Status bits:
- POR = 0
- BOR = 0
- TO = 1
- PD = 1
- This condition also can occur for MCLR during normal operation and when the CLRWDT instruction is executed.
- After isPOR is called, StatusReset should be called to set the POR and BOR bits.

**Return Value:**
- 1 if the device just left a Power-on Reset
- 0 otherwise

**File Name:** ispor.c

isWDTTO

**Function:** Determine if the cause of a Reset was a Watchdog Timer (WDT) time out.

**Include:** reset.h

**Prototype:**
char isWDTTO( void );

**Remarks:** This function detects if the microcontroller was reset due to the WDT during normal operation. This condition is indicated by the following Status bits:
- POR = 1
- BOR = 1
- TO = 0
- PD = 1

**Return Value:**
- 1 if the Reset was due to the WDT during normal operation
- 0 otherwise

**File Name:** iswdtto.c
### isWDTWU

**Function:** Determine if the cause of a wake-up was the Watchdog Timer (WDT).

**Include:** reset.h

**Prototype:**
```
char isWDTWU( void );
```

**Remarks:**
This function detects if the microcontroller was brought out of Sleep by the WDT. This condition is indicated by the following Status bits:
- **POR** = 1
- **BOR** = 1
- **TO** = 0
- **PD** = 0

**Return Value:**
- 1 if device was brought out of Sleep by the WDT
- 0 otherwise

**File Name:** iswDTwu.c

### isWU

**Function:** Detects if the microcontroller was just waken up from Sleep via the MCLR pin or interrupt.

**Include:** reset.h

**Prototype:**
```
char isWU( void );
```

**Remarks:**
This function detects if the microcontroller was brought out of Sleep by the MCLR pin or an interrupt. This condition is indicated by the following Status bits:
- **POR** = 1
- **BOR** = 1
- **TO** = 1
- **PD** = 0

**Return Value:**
- 1 if the device was brought out of Sleep by the MCLR pin or an interrupt
- 0 otherwise

**File Name:** iswu.c

### StatusReset

**Function:** Set the **POR** and **BOR** bits in the CPUSTA register.

**Include:** reset.h

**Prototype:**
```
void StatusReset( void );
```

**Remarks:**
This function sets the **POR** and **BOR** bits in the CPUSTA register. These bits must be set in software after a Power-on Reset has occurred.

**File Name:** statrst.c
4.7 CHARACTER OUTPUT FUNCTIONS

The character output functions provide a central family of functions for processing output to peripherals, memory buffers and other consumers of character data.

When processing a call to \texttt{fprintf}, \texttt{printf}, \texttt{sprintf}, \texttt{vfprintf}, \texttt{vprintf} or \texttt{vsprintf}, MPLAB C18 will always process the variable length portion of the argument list with integer promotions enabled (see the “Integer Promotions” section of the \textit{MPLAB® C18 C Compiler User’s Guide} (DS51288) for more information). This allows the standard library to interface with the compiler cleanly and with consistent behavior for the formatting of the output as would normally be expected from those functions.

4.7.1 Output Streams

Output is based on the use of a destination stream. A stream can be a peripheral, memory buffer, or any other consumer of data and is denoted by a pointer to an object of \texttt{FILE} type. MPLAB C18 defines two streams in the standard library:

- \texttt{_H_USER} output via the user-defined output function \texttt{_user_putc}.
- \texttt{_H_USART} output via the library output function \texttt{_usart_putc}.

The current version of the library supports only these two output streams. Both streams are always considered to be open and do not require use of functions such as \texttt{fopen}, \texttt{fclose}, etc.

The global variables \texttt{stdout} and \texttt{stderr} are defined by the library and have default value of \texttt{_H_USART}. To change the destination to be \texttt{_H_USER}, assign that value to the variable. For example, to change standard output to use the user defined output function:

\begin{verbatim}
stdout = _H_USER;
\end{verbatim}

\begin{table}[h]
\centering
\caption{CHARACTER OUTPUT FUNCTIONS}
\begin{tabular}{|l|l|}
\hline
Function & Description \\
\hline
\texttt{fprintf} & Formatted string output to a stream. \\
\texttt{fputs} & String output to a stream. \\
\texttt{printf} & Formatted string output to \texttt{stdout}. \\
\texttt{putc} & Character output to a stream \\
\texttt{puts} & String output to \texttt{stdout}. \\
\texttt{sprintf} & Formatted string output to a data memory buffer. \\
\texttt{vfprintf} & Formatted string output to a stream with the arguments for processing the format string supplied via the \texttt{stdarg} facility. \\
\texttt{vprintf} & Formatted string output to \texttt{stdout} with the arguments for processing the format string supplied via the \texttt{stdarg} facility. \\
\texttt{vsprintf} & Formatted string output to a data memory buffer with the arguments for processing the format string supplied via the \texttt{stdarg} facility. \\
\texttt{_usart_putc} & Single character output to the USART (USART1 for devices which have more than one USART). \\
\texttt{_user_putc} & Single character output in an application defined manner. \\
\hline
\end{tabular}
\end{table}
4.7.2 Function Descriptions

<table>
<thead>
<tr>
<th>Function</th>
<th>Prototype</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>fprintf</td>
<td>int fprintf (FILE *f, const rom char *fmt, ...);</td>
<td>The <code>fprintf</code> function formats output, passing the characters to the specified stream via the <code>putc</code> function. The format string is processed one character at a time and the characters are output as they appear in the format string, except for format specifiers. A format specifier is indicated in the format string by a percent sign, <code>%</code>; following that, a well-formed format specifier has the following components. Except for the conversion operation, all format specifiers are optional:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Flag characters (order does not matter), where a flag character is one of <code>#</code>, <code>-</code>, <code>+</code>, <code>0</code> or <code>space</code>.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. A field width, which is a decimal integer constant value an asterisk, <code>*</code>.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. A field precision, which is a period (<code>.</code>), optionally followed by a decimal integer or an asterisk, <code>*</code>.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. A size specification, which is one of the specifiers <code>h</code>, <code>H</code>, <code>hh</code>, <code>j</code>, <code>z</code>, <code>t</code>, <code>T</code> or <code>l</code>.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. A conversion operation, which is one of <code>c</code>, <code>b</code>, <code>B</code>, <code>d</code>, <code>i</code>, <code>n</code>, <code>o</code>, <code>p</code>, <code>P</code>, <code>s</code>, <code>S</code>, <code>u</code>, <code>x</code>, <code>X</code> or <code>%</code>.</td>
</tr>
</tbody>
</table>

¹Not all components are valid for all conversion operations. Details are provided in the descriptions of the conversion operators.
### Flag Characters

- `#` - The alternate form of the result will be presented. For the `o` conversion, the alternate form is as if the precision were increased such that the first digit of the result is forced to be a zero. For the `x` conversion, a non-zero result will have a `0x` prefix added to it. For the `X` conversion, a non-zero result will have a `0X` prefix added to it. For the `b` conversion, a non-zero result will have a `0b` prefix added to it. For the `B` conversion, a non-zero result will have a `0B` prefix added to it. For other conversions, the flag is ignored.

- `-` - The result will be left justified. If this flag is not specified, the result will be right justified.

- `+` - For a signed conversion, the result will always begin with a `+` or a `-` sign. By default, a sign character is only added to the result if the result is negative. For other conversions, the flag is ignored.

- `space` - For a signed conversion, if the result is non-negative or has no characters, a space will be prefixed to the result. If the `space` and `+` flags are both specified, the `space` flag will be ignored. For other conversions, the flag is ignored.

- `0` - For the integer conversions (`d`, `i`, `o`, `u`, `b`, `x`, `X`), leading zeroes are prefixed to the result (after any sign and/or base indicators) such that the result fills the field width. No space padding is performed. If the `-` flag is also specified, the `0` flag will be ignored. If a precision is specified, the `0` flag will be ignored. For other conversions, the flag is ignored.

### Field Width

The field width specifies the minimum number of characters for the converted value. If the converted value is shorter than the field width, then the value is padded to have the number of characters be equal to the field width. By default, leading spaces are used for padding; the flag characters are used to alter the pad character and the justification of the value.

If the field width is an asterisk character, `*`, an `int` argument is read to specify the field width. If the value is negative, it is as if the `-` flag were specified, followed by a positive field width.

### Field Precision

The field precision specifies the minimum number of digits which will be present in the converted value for a `d`, `i`, `o`, `u`, `b`, `x` or `X` conversion, or the maximum number of characters in the converted value for an `s` conversion.

If the field width is an asterisk character, `*`, an `int` argument is read to specify the field width. If the value is negative, it is as if the precision were unspecified.

For the `d`, `i`, `o`, `u`, `b`, `x` or `X` conversion operators, the default precision is `1`. For all other conversion operators the behavior when the precision is unspecified is described below.
Size Specifications
The size specification character applies to the integer conversion specifiers, d, i, o, u, b, B, x or X, and the pointer conversion specifiers, p and P. If present for any other conversion operator, it is ignored.

hh For integer conversion specifiers, the argument to be converted is a signed char or unsigned char argument.2 For an n conversion specifier, the specifier denotes a pointer to a signed char argument.

h For integer conversion specifiers, the argument to be converted is a short int or unsigned short int. For an n conversion specifier, the specifier denotes a pointer to a short int argument. As a plain int is the same size as a short int for MPLAB C18, this option has no actual effect and is present for compatibility purposes only. For pointer conversion specifiers, the argument to be converted is a 16-bit pointer.

H For integer conversion specifiers, the argument to be converted is a short long int or unsigned short long int. For an n conversion specifier, the specifier denotes a pointer to a short long int argument. For pointer conversion specifiers, the argument to be converted is a 24-bit pointer.3 For example, when outputting a far rom char *, the size specifier H should be used (%HS).

j For integer conversion specifiers, the argument to be converted is an intmax_t or uintmax_t argument. For an n conversion specifier, the specifier denotes a pointer to an intmax_t argument. For MPLAB C18, this is equivalent to the l size specifier.

l For integer conversion specifiers, the argument to be converted is a long int or unsigned long int. For an n conversion specifier, the specifier denotes a pointer to a long int argument. For pointer conversion specifiers, the size specifier is ignored.

t For integer conversion specifiers, the argument to be converted is an ptrdiff_t argument. For an n conversion specifier, the specifier denotes a pointer to a signed integer type corresponding to ptrdiff_t argument. For MPLAB C18, this is equivalent to the h size specifier.

T For integer conversion specifiers, the argument to be converted is an ptrdifffrom_t argument. For an n conversion specifier, the specifier denotes a pointer to a signed integer type corresponding to ptrdifffrom_t argument. For MPLAB C18, this is equivalent to the H size specifier.4

z For integer conversion specifiers, the argument to be converted is an size_t argument. For an n conversion specifier, the specifier denotes a pointer to a signed integer type corresponding to size_t argument. For MPLAB C18, this is equivalent to the h size specifier.

Z For integer conversion specifiers, the argument to be converted is an sizerom_t argument. For an n conversion specifier, the specifier denotes a pointer to a signed integer type corresponding to sizerom_t argument. For MPLAB C18, this is equivalent to the H size specifier.5

2Note that the integer promotions will still apply when the argument is passed. This specifier causes the argument to be cast back to 8 bits in size prior to the value being used.

3The H size specifier is an MPLAB C18 specific extension to ANSI C.

4The T size specifier is an MPLAB C18 specific extension to ANSI C.

5The Z size specifier is an MPLAB C18 specific extension to ANSI C.
Conversion Operators

- **c**: The `int` argument is converted to an `unsigned char` value and the character represented by that value is written.
- **d**: The `int` argument is formatted as signed decimal with the precision indicating the minimum number of digits to be written. If the converted value has fewer digits, it is prepended with zeros. If the converted value is zero and the precision is zero, no characters will be written.
- **o**: The `unsigned int` argument is converted to unsigned octal with the precision indicating the minimum number of digits to be written. If the converted value has fewer digits, it is prepended with leading zeros. If the converted value is zero and the precision is zero, no characters will be written.
- **u**: The `unsigned int` argument is formatted as unsigned decimal with the precision indicating the minimum number of digits to be written. If the converted value has fewer digits, it is prepended with zeros. If the converted value is zero and the precision is zero, no characters will be written.
- **b**: The `unsigned int` argument is formatted as unsigned binary with the precision indicating the minimum number of digits to be written. If the converted value has fewer digits, it is prepended with zeros. If the converted value is zero and the precision is zero, no characters will be written.
- **X**: The `unsigned int` argument is formatted as unsigned hexadecimal with the precision indicating the minimum number of digits to be written. The characters ABCDEF are used for the representation of the decimal numbers 10 through 15. If the converted value has fewer digits, it is prepended with zeros. If the converted value is zero and the precision is zero, no characters will be written.

Characters from the data memory array of char argument are written until either a terminating `\0` character is seen (the `\0` character is not written) or the number of characters written is equal to the specified precision. If the precision is specified to be greater than the size of the array or is unspecified, the array must contain a terminating `\0` character.

Characters from the program memory array of char argument are written until either a terminating `\0` character is seen (the `\0` character is not written) or the number of characters written is equal to the specified precision. If the precision is specified to be greater than the size of the array or is unspecified, the array must contain a terminating `\0` character.

The `b` conversion operator is an MPLAB C 18 specific extension to ANSI C.

The `B` conversion operator is an MPLAB C 18 specific extension to ANSI C.

The `S` conversion operator is an MPLAB C 18 specific extension to ANSI C.
The pointer to void (data or program memory) argument is converted to an equivalent size unsigned integer type and that value is processed as if the \texttt{x} conversion operator had been specified. If the \texttt{H} size specifier is present, the pointer is a 24-bit pointer, else it is a 16-bit pointer.

The pointer to void (data or program memory) argument is converted to an equivalent size unsigned integer type and that value is processed as if the \texttt{x} conversion operator had been specified. If the \texttt{H} size specifier is present, the pointer is a 24-bit pointer, else it is a 16-bit pointer.\footnote{The \texttt{P} conversion operator is an MPLAB C18 specific extension to ANSI C.}

The number of characters written so far shall be stored in the location referenced by the argument, which is a pointer to an integer type in data memory. The size of the integer type is determined by the size specifier present for the conversion, or a plain 16-bit integer if no size specifier is present.

A literal \texttt{%} character is written. The conversion specification shall be \texttt{%%} only, no flags or other specifiers may be present.

If a conversion specifier is invalid (e.g., a flag character is present for the \texttt{%%} conversion specifier), the behavior is undefined.

Return Value: \texttt{fprintf} returns \texttt{EOF} if an error occurs, otherwise returns the number of characters output.

Filename: \texttt{fprintf.c}

Code Example: 
\begin{verbatim}
#include <stdio.h>

void main (void)
{
   far rom char * S = "Hello, World!";
   int n = 0x1234;
   fprintf (_H_USART, "test output to USART\n");
   fprintf (_H_USER, "test output to application" 
      "defined function\n");
   fprintf (stdout, "hex output: %#x", n);
   fprintf (stderr, "%HS\n", S);
}
\end{verbatim}

\footnote{The \texttt{P} conversion operator is an MPLAB C18 specific extension to ANSI C.}

\begin{tabular}{|p{0.5\textwidth}|}
\hline
\textbf{fputs} \\
\hline
\textbf{Function:} & String output to a stream. \\
\textbf{Include:} & stdio.h \\
\textbf{Prototype:} & int fputs (const rom char *s, FILE *f); \\
\textbf{Remarks:} & fputs outputs a null terminated string to the specified output stream, one character at a time via putc. A newline character is appended to the output. The terminating null is not output. \\
\textbf{Return Value:} & fputs returns EOF if an error occurs, otherwise returns a non-negative value. \\
\textbf{Filename:} & fputs.c \\
\hline
\end{tabular}
### printf

**Function:** Formatted string output to stdout.

**Include:**

```c
#include <stdio.h>
```

**Prototype:**

```c
int printf (const rom char *fmt, ...);
```

**Remarks:**

The `printf` function formats output, passing the characters to stdout via the `putc` function. The format string is processed as described for the `fprintf` function.

**Return Value:**

`printf` returns EOF if an error occurs, otherwise returns the number of characters output.

**Filename:**

`printf.c`

**Code Example:**

```c
#include <stdio.h>

void main (void)
{
    /* will output via stdout (_H_USART by default) */
    printf("Hello, World!\n");
}
```

### putc

**Function:** Character output to a stream.

**Include:**

```c
#include <stdio.h>
```

**Prototype:**

```c
int putc (char c, FILE *f);
```

**Remarks:**

`putc` outputs a single character to the specified output stream.

**Return Value:**

`putc` returns EOF if an error occurs, otherwise returns the character which was output.

**Filename:**

`putc.c`

### puts

**Function:** String output to stdout.

**Include:**

```c
#include <stdio.h>
```

**Prototype:**

```c
int puts (const rom char *s);
```

**Remarks:**

`puts` outputs a null terminated string to stdout one character at a time via `putc`. A newline character is appended to the output. The terminating null is not output.

**Return Value:**

`puts` returns EOF if an error occurs, otherwise returns a non-negative value.

**Filename:**

`puts.c`

**Code Example:**

```c
#include <stdio.h>

void main (void)
{
    puts("test message");
}
```
**sprintf**

**Function:** Formatted string output to a data memory buffer.

**Include:** `stdio.h`

**Prototype:**

```c
int sprintf (char *buf, const rom char *fmt, ...);
```

**Remarks:**

The `sprintf` function formats output, storing the characters to the destination data memory buffer, `buf`. The format string, `fmt`, is processed as described for the `fprintf` function.

**Return Value:** `sprintf` returns `EOF` if an error occurs, otherwise the number of characters output is returned.

**Filename:** `sprintf.c`

**Code Example:**

```c
#include <stdio.h>

void main (void)
{
    int i = 0xA12;
    char buf[20];
    sprintf (buf, "%#010x", i);
    /* buf will contain the string "0x00000a12" */
}
```

---

**vfprintf**

**Function:** Formatted string output to a stream with the arguments for processing the format string supplied via the `stdarg` facility.

**Include:** `stdio.h`

**Prototype:**

```c
int vfprintf (FILE *f, const rom char *fmt, va_list ap);
```

**Remarks:**

The `vfprintf` function formats output, passing the characters to the specified output stream, `f`, via the `putc` function. The format string, `fmt`, is processed as described for the `fprintf` function except that the arguments consumed when processing the format string are retrieved via the `stdarg` variable length argument facility.

**Return Value:** `vfprintf` returns `EOF` if an error occurs, otherwise the number of characters output is returned.

**Filename:** `vfprintf.c`

---

**vprintf**

**Function:** Formatted string output to `stdout` with the arguments for processing the format string supplied via the `stdarg` facility.

**Include:** `stdio.h`

**Prototype:**

```c
int vprintf (const rom char *fmt, va_list ap);
```

**Remarks:**

The `vprintf` function formats output, passing the characters to `stdout` via the `putc` function. The format string, `fmt`, is processed as described for the `fprintf` function except that the arguments consumed when processing the format string are retrieved via the `stdarg` variable length argument facility.

**Return Value:** `vprintf` returns `EOF` if an error occurs, otherwise the number of characters output is returned.

**Filename:** `vprintf.c`
vsprintf

Function: Formatted string output to a data memory buffer with the arguments for processing the format string supplied via the `stdarg` facility.

Include: `stdio.h`

Prototype: `int vsprintf (char *buf, const rom char *fmt, va_list ap);`

Remarks: The `vsprintf` function formats output, storing the characters to the destination data memory buffer, `buf`. The format string, `fmt`, is processed as described for the `fprintf` function except that the arguments consumed when processing the format string are retrieved via the `stdarg` variable-length-argument facility.

Return Value: `vsprintf` returns `EOF` if an error occurs, otherwise the number of characters output is returned.

Filename: `vsprintf.c`

__usart_putchar

Function: Single character output to the USART (USART1 for devices which have more than one USART).

Include: `stdio.h`

Prototype: `int _usart_putchar (char c);`

Remarks: `_usart_putchar` is the library output function invoked by `putc` when `_H_USART` is the destination stream. The character to be output is assigned to the transmit register (TXREG) when the USART is ready for output (TRMT is set).

If the USART is not enabled when _usart_putchar is called (TXSTA bit TXEN is clear), the USART will be enabled (TXEN and SPEN will be set) and set to maximum baud rate output (SPBRG will be assigned a value of zero). This configuration allows the character output library functions to be used with the MPLAB IDE support for USART debug output without explicit peripheral configuration.

Return Value: `_usart_putchar` returns the value of the character which was output.

Filename: `_usart_putchar.c`

__user_putchar

Function: Single character output in an application defined manner.

Include: `stdio.h`

Prototype: `int _user_putchar (char c);`

Remarks: `_user_putchar` is an application defined function. It will be called by the character output functions for each character to be output when the destination stream is _H_USER.

Return Value: `_user_putchar` returns the value of the character which was output.
Chapter 5. Math Libraries

5.1 INTRODUCTION

This chapter documents math library functions. It includes two sections:

- 32-Bit Floating Point Math Library
- The C Standard Library Math Functions

5.2 32-BIT FLOATING POINT MATH LIBRARY

The basic floating point operations—add, subtract, multiply, divide and conversions between floats and integers—comply with the IEEE 754 standard for single precision floats with two exceptions. The exceptions will be discussed under Subnormals (Section 5.2.1.2 “Subnormals”) and Rounding (Section 5.2.2 “Rounding”). The extended mode and traditional mode use the same float representations and the results of float operations are the same.

The IEEE standard for binary floating-point arithmetic published in 1985 became known officially as ANSI/IEEE Std 754-1985 [IEEE85]. The standard has three important requirements:

- consistent representation of floating-point numbers by all machines adopting the standard;
- correctly rounded floating-point operations, using various rounding modes;
- consistent treatment of exceptional situations such as division by zero.

5.2.1 Floating-Point Representation

The C18 floating point number representation follows the single precision IEEE 754 standard. A floating-point number consists of four parts:

1. A sign
2. A significand
3. A base
4. An exponent

These components are of the form

\[ x = \pm d_0.d_1.d_2.d_3 \cdots d_{23} \times 2^E \]

where ± is the sign, \( d_0.d_1.d_2.d_3 \cdots d_{23} \) is the significand, and \( E \) is the exponent to which the base 2 is raised. Each \( d_i \) is a digit (0 or 1). The exponent \( E \) is an integer in the range \( E_{\text{min}} \) to \( E_{\text{max}} \) where \( E_{\text{min}} = -126 \) and \( E_{\text{max}} = 127 \).

Single-format numbers use a 32-bit word organized as a 1-bit sign, an 8-bit biased exponent \( e = E + 127 \), and a 23-bit fraction, which is the fractional part of the significand.

The most-significant bit of the significand \( d_0 \) is not stored. This is possible because its value can be inferred from the exponent value: if the biased exponent value is 0, then \( d_0 = 0 \), otherwise \( d_0 = 1 \). Using this convention allows 24 bits of precision to be stored in 23 physical bits.
In the C18 implementation, the $d_0 = 0$ numbers are not used (see Section 5.2.1.2 “Subnormals”).

5.2.1.1 NORMALS

All the lines in Table 5-1 except the first and last refer to normalized numbers. The exponent bit string $e_7e_6e_5\ldots e_0$ uses a biased representation; the bit string is stored as the binary representation of $E+127$, where $E$ is the unbiased exponent. The number 127, which is added to the exponent $E$, is called the exponent bias. For example, the number $1=(1.000\ldots 0)2^0$ is stored as

Here the exponent bit string is the binary representation for $0+127$ and the fraction bit string is the binary representation for 0 (the fractional part of 1.0).

The range of exponent field bit strings for normalized numbers is 00000001 to 11111110 (the decimal numbers 1 through 254), representing actual exponents from $E_{\text{min}} = -126$ to $E_{\text{max}} = 127$.

The smallest positive, non-zero normalized number that can be stored is represented by

and this is denoted by

$N_{\text{min}} = (1.000\ldots 0)2^{-126} = 2^{-126} - 1.2 \times 10^{38}$

The constant $N_{\text{min}}$ is accessible to C programmers using the manifest constant FLT_MIN defined in <float.h>.

The largest normalized number (equivalently, the largest finite number) is represented by

and this is denoted by

$N_{\text{max}} = (1.111\ldots 1)2^{127} = (2 - 2^{-23}) \times 2^{127} - 2^{128} - 3.4 \times 10^{38}$

The constant $N_{\text{max}}$ is accessible to C programmers using the manifest constant FLT_MAX defined in <float.h>.
5.2.1.2 SUBNORMALS

The smallest normalized number that can be represented is $2^{-126}$. The IEEE 754 standard uses the combination of a zero biased exponent $e$ and a nonzero fraction $f$ to represent smaller numbers called subnormal numbers. The structure of subnormal numbers is shown on line 1 of Table 5-1. In the C18 float implementation, subnormal numbers are always converted to signed zero.

IEEE 754 uses two different zero representations: +0 and -0. The +0 is represented by all zero bits. The -0 is represented by all zero bits except for the sign bit.

If the result of a float operation is less than the smallest normalized number, the result is set to a signed zero before it is returned. Since, in the C18 implementation, no float operation can create a subnormal, a subnormal will appear only if it is constructed explicitly as a literal, or is generated in some way other than by standard float operations. If a subnormal value is used in a float operation, it is converted automatically to a signed zero before it is used in the operation.

5.2.1.3 NaNs

In addition to supporting signed infinities, signed zeroes and signed non-zero finite numbers, the IEEE floating-point format specifies an encoding for error patterns. These patterns are not numbers but a recording of the fact that an invalid operation has been attempted. Any such pattern is an error indicator, not a floating-point number and so is referred to as Not a Number, or NaN. Invalid operations are defined by the IEEE standard to include:
- Magnitude subtraction of infinities, such as $(+\infty) + (-\infty)$
- Multiplication of a zero by an infinity, such as $(0) \times (+\infty)$
- Division of a zero or infinity by zero or infinity, respectively, such as $(+\infty)/(-\infty)$ or $(+\infty)/(+\infty)$

NaNs have a biased exponent of 255, which is also the exponent used to encode infinities. The interpretation when the biased exponent is 255 is: if the fraction is zero, the encoding represents an infinity; if the fraction is not zero, the encoding represents NaN (not a number). Ignoring the sign bit, which the standard does not interpret for NaNs, there are therefore $2^{23} - 1$ possible NaNs. The C18 implementation returns the NaN pattern 7FFF FFFF$_{16}$ in response to an invalid operation. That is, the sign bit is 0, the exponent is 255, and the fraction bits are all 1s.

5.2.2 Rounding

The IEEE-754 standard requires that operations be correctly rounded. The standard defines the correctly rounded value of $x$, which is denoted by $\text{round}(x)$, as follows: If $x$ is a floating-point number, then $\text{round}(x) = x$. Otherwise, the correctly-rounded value depends on which of four rounding modes is in effect. The C18 float implementation uses the Round to Nearest mode with a slight modification to the IEEE 754 standard. The threshold for rounding up is about 0.502 instead of exactly 0.5. This gives a slight bias toward rounding toward zero. This modification results in a significant savings in code space and execution time with virtually no consequences for real-world calculations.
5.3 THE C STANDARD LIBRARY MATH FUNCTIONS

All the math functions of the standard C Library will return NaN if one or more of its arguments:

- is NaN.
- is outside the range of values for which the function has a defined real value, for example the square root of a negative number.

Table 5-2 lists the math functions.

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>acos</td>
<td>Compute the inverse cosine (arccosine).</td>
</tr>
<tr>
<td>asin</td>
<td>Compute the inverse sine (arcsine).</td>
</tr>
<tr>
<td>atan</td>
<td>Compute the inverse tangent (arctangent).</td>
</tr>
<tr>
<td>atan2</td>
<td>Compute the inverse tangent (arctangent) of a ratio.</td>
</tr>
<tr>
<td>ceil</td>
<td>Compute the ceiling (least integer).</td>
</tr>
<tr>
<td>cos</td>
<td>Compute the cosine.</td>
</tr>
<tr>
<td>cosh</td>
<td>Compute the hyperbolic cosine.</td>
</tr>
<tr>
<td>exp</td>
<td>Compute the exponential $e^x$.</td>
</tr>
<tr>
<td>fabs</td>
<td>Compute the absolute value.</td>
</tr>
<tr>
<td>floor</td>
<td>Compute the floor (greatest integer).</td>
</tr>
<tr>
<td>fmod</td>
<td>Compute the remainder.</td>
</tr>
<tr>
<td>frexp</td>
<td>Split into fraction and exponent.</td>
</tr>
<tr>
<td>ieee2mchp</td>
<td>Convert an IEEE-754 format 32-bit floating point value into the Microchip 32-bit floating point format.</td>
</tr>
<tr>
<td>ldexp</td>
<td>Load exponent – compute $x \times 2^n$.</td>
</tr>
<tr>
<td>log</td>
<td>Compute the natural logarithm.</td>
</tr>
<tr>
<td>log10</td>
<td>Compute the common (base 10) logarithm.</td>
</tr>
<tr>
<td>mchp2ieee</td>
<td>Convert a Microchip format 32-bit floating point value into the IEEE-754 32-bit floating point format.</td>
</tr>
<tr>
<td>modf</td>
<td>Compute the modulus.</td>
</tr>
<tr>
<td>pow</td>
<td>Compute the exponential $x^y$.</td>
</tr>
<tr>
<td>sin</td>
<td>Compute the sine.</td>
</tr>
<tr>
<td>sinh</td>
<td>Compute the hyperbolic sine.</td>
</tr>
<tr>
<td>sqrt</td>
<td>Compute the square root.</td>
</tr>
<tr>
<td>tan</td>
<td>Compute the tangent.</td>
</tr>
<tr>
<td>tanh</td>
<td>Compute the hyperbolic tangent.</td>
</tr>
</tbody>
</table>
5.3.1 Function Descriptions

acos

Function: Compute the inverse cosine (arccosine)
Include: math.h
Prototype: float acos( float x );
Remarks: This function computes the inverse cosine (arccosine) of the argument x, which must be between –1 and +1. Arguments outside the permitted range produce domain errors and the result is NaN.
Return Value: The returned value is the arccosine in radians, and is between 0 and π.
File Name: acos.c

asin

Function: Compute the inverse sine (arcsine).
Include: math.h
Prototype: float asin( float x );
Remarks: This function computes the inverse sine (arcsine) of the argument x, which must be between –1 and +1. Arguments outside the permitted range produce domain errors and the result is NaN.
Return Value: The returned value is the arcsine in radians, and is between –π/2 and π/2.
File Name: asin.c

atan

Function: Compute the inverse tangent (arctangent).
Include: math.h
Prototype: float atan( float x );
Remarks: This function computes the inverse tangent (arctangent) of the argument x. If x is a NaN, a domain error occurs and the value returned is NaN.
Return Value: The returned value is in radians, and between –π/2 and π/2.
File Name: atan.c

atan2

Function: Compute the inverse tangent (arctangent) of a ratio.
Include: math.h
Prototype: float atan2( float y, float x );
Remarks: This function computes the inverse tangent (arctangent) of y/x. If x or y is NaN, a domain occurs and the value returned is NaN. If x is a NaN, or if x = y = 0, or if x = y = ∞, a domain error occurs and the value returned is NaN.
Return Value: The returned value is in radians, and between –π and π.
File Name: atan2.c
### ceil

**Function:** Compute the ceiling (least integer).

**Include:** `math.h`

**Prototype:**
```
float ceil ( float x );
```

**Remarks:** None.

**Return Value:** The smallest integer greater than or equal to \( x \).

**File Name:** `ceil.c`

### cos

**Function:** Compute the cosine.

**Include:** `math.h`

**Prototype:**
```
float cos ( float x );
```

**Remarks:** Computes the cosine of \( x \) (in radians). A domain error results from an argument that is infinite or NaN. Both cases return NaN.

**Return Value:** The cosine of argument \( x \).

**File Name:** `cos.c`

### cosh

**Function:** Compute the hyperbolic cosine.

**Include:** `math.h`

**Prototype:**
```
float cosh ( float x );
```

**Remarks:** None.

**Return Value:** The hyperbolic cosine of argument \( x \).

**File Name:** `cosh.c`

### exp

**Function:** Compute the exponential \( e^x \).

**Include:** `math.h`

**Prototype:**
```
float exp ( float x );
```

**Remarks:** A range error occurs if the magnitude of \( x \) is too large. The range of this function is limited to values for the exponent of between approximately -103.2789 and 88.722283. The minimum value of the result is \( 2^{-149} \) and the maximum is \( 2^{127} \).

**Return Value:** The value of the exponential \( e^x \).

**File Name:** `exp.c`

### fabs

**Function:** Compute the absolute value.

**Include:** `math.h`

**Prototype:**
```
float fabs ( float x );
```

**Remarks:** For floating point arguments that are zeroes and infinities, the return value is the argument with the sign bit cleared.

**Return Value:** The absolute value of \( x \).

**File Name:** `fabs.c`
floor

Function: Compute the floor (greatest integer).
Include: math.h
Prototype: float floor( float x );
Remarks: None.
Return Value: The largest integer less than or equal to \( x \).
File Name: floor.c

fmod

Function: Compute the remainder.
Include: math.h
Prototype: float fmod( float x, float y );
Remarks: None.
Return Value: The remainder for \( x \) modulo \( y \).
File Name: fmod.c

frexp

Function: Split into fraction and exponent.
Include: math.h
Prototype: float frexp( float x, int *pexp );
Remarks: Separates the argument \( x \) into two parts that fit this formula:
\[ x = \text{frexp}(x, *\text{pexp}) \times 2^{\text{pexp}} \]
The integer value, which is stored at location \( \text{pexp} \), is chosen so that the fractional portion of the result is between \( \frac{1}{2} \) and 1.
Return Value: Fractional result that satisfies the conditions listed above.
File Name: frexp.c

ieeetomchp

Function: Convert an IEEE-754 format 32-bit floating point value into the Microchip 32-bit floating point format.
Include: math.h
Prototype: unsigned long ieeetomchp( float v );
Remarks: This function adjusts the sign bit of the floating point representation to be located as required by the Microchip format:

<table>
<thead>
<tr>
<th></th>
<th>( s )</th>
<th>( e )</th>
<th>( f_0 )</th>
<th>( f_1 )</th>
<th>( f_2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{IEEE-754 32-bit} )</td>
<td>seee eeee</td>
<td>exxx xxxx</td>
<td>xxxx xxxx</td>
<td>xxxx xxxx</td>
<td></td>
</tr>
<tr>
<td>( \text{Microchip 32-bit} )</td>
<td>eeee eeee</td>
<td>sxxx xxxx</td>
<td>xxxx xxxx</td>
<td>xxxx xxxx</td>
<td></td>
</tr>
</tbody>
</table>

Return Value: The converted 32-bit value.
File Name: ieeetomchp.c
ldexp
Function: Load exponent – compute x * 2^n.
Include: math.h
Prototype: float ldexp( float x, int n );
Remarks: None.
Return Value: Returns the value of x * 2^n.
File Name: ldexp.c

log
Function: Compute the natural logarithm.
Include: math.h
Prototype: float log( float x );
Remarks: A domain error occurs if the argument is not in the interval [0, +∞].
Return Value: Natural logarithm of x.
File Name: log.c

log10
Function: Compute the common (base 10) logarithm.
Include: math.h
Prototype: float log10( float x );
Remarks: A domain error occurs if the argument is not in the interval [0, +∞].
Return Value: log10x.
File Name: log10.c

mchptoieee
Function: Convert a Microchip format 32-bit floating point value into the IEEE-754 32-bit floating point format.
Include: math.h
Prototype: float ieeetomchp( unsigned long v );
Remarks: This function adjusts the sign bit of the floating point representation to be located as required by the IEEE format:

<table>
<thead>
<tr>
<th>Format</th>
<th>eb</th>
<th>f0</th>
<th>f1</th>
<th>f2</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEEE-754 32-bit</td>
<td>seee</td>
<td>xxxx</td>
<td>xxxx</td>
<td>xxxx</td>
</tr>
<tr>
<td>Microchip 32-bit</td>
<td>eeee</td>
<td>xxxx</td>
<td>xxxx</td>
<td>xxxx</td>
</tr>
</tbody>
</table>

s=sign bit  e=exponent  x=significand
Return Value: The converted floating point value.
File Name: mchptoieee.c
**modf**

**Function:** Compute the modulus.

**Include:** `math.h`

**Prototype:**
```
float modf( float x, float *ipart );
```

**Remarks:** This function separates the argument `x` into integer and fractional parts. The fractional part is returned, and the integer part is stored at location `ipart`. If the argument is NaN, the results for both the fractional and integer part will be NaN as well.

**Return Value:** Fractional portion of `x`.

**File Name:** `modf.c`

---

**pow**

**Function:** Compute the exponential $x^y$.

**Include:** `math.h`

**Prototype:**
```
float pow( float x, float y );
```

**Remarks:** Domain errors occur if $x$ is finite and negative, and $y$ is finite and not an integer; also if $x$ is zero and $y$ is less than or equal to zero. A range error occurs if $x^y$ is too large or too small to be represented. In such a case, a correctly signed infinity or zero is returned and a range error is signaled.

**Return Value:** $x^y$.

**File Name:** `pow.c`

---

**sin**

**Function:** Compute the sine.

**Include:** `math.h`

**Prototype:**
```
float sin( float x );
```

**Remarks:** Computes the sine of $x$ (in radians). A domain error results from an argument that is infinite or NaN. Both cases return NaN.

**Return Value:** The sine of $x$.

**File Name:** `sin.c`

---

**sinh**

**Function:** Compute the hyperbolic sine.

**Include:** `math.h`

**Prototype:**
```
float sinh( float x );
```

**Remarks:** None.

**Return Value:** The hyperbolic sine of argument $x$.

**File Name:** `sinh.c`
sqrt

Function: Compute the square root.
Include: math.h
Prototype: float sqrt( float x );
Remarks: A domain error occurs if the argument x is strictly negative. The principal square root exists and is computable for every non-negative floating point number x.
Return Value: The square root of x.
File Name: sqrt.c

tan

Function: Compute the tangent.
Include: math.h
Prototype: float tan( float x );
Remarks: Computes the tangent of x (in radians). A domain error occurs if the argument is infinite or NaN. Both cases return NaN.
Return Value: The tangent of x.
File Name: tan.c

tanh

Function: Compute the hyperbolic tangent.
Include: math.h
Prototype: float tanh( float x );
Remarks: If the argument is NaN, the return value is NaN.
Return Value: The hyperbolic tangent of x.
File Name: tanh.c
A

Absolute Section
A section with a fixed address that cannot be changed by the linker.

Access Memory
Special General Purpose Registers (GPR) on the PIC18 PICmicro microcontrollers that allow access regardless of the setting of the Bank Select Register (BSR).

Address
The code that identifies where a piece of information is stored in memory.

Anonymous Structure
An unnamed object.

ANSI
American National Standards Institute

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

Assembly
A symbolic language that describes the binary machine code in a readable form.

Assigned Section
A section that has been assigned to a target memory block in the linker command file.

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

B

Binary
The base two numbering system that uses the digits 0-1. The right-most digit counts ones, the next counts multiples of 2, then $2^2 = 4$, etc.

C

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

Compiler
A program that translates a source file written in a high-level language into machine code.
Conditional Compilation
The act of compiling a program fragment only if a certain constant expression, specified by a preprocessor directive, is true.

CPU
Central Processing Unit

E
Endianness
The ordering of bytes in a multi-byte object.

Error File
A file containing the diagnostics generated by the MPLAB C18 compiler.

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

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

Frame Pointer
A pointer that references the location on the stack that separates the stack-based arguments from the stack-based local variables.

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

H
Hexadecimal
The base 16 numbering system that uses the digits 0-9 plus the letters A-F (or a-f). The digits A-F represent decimal values of 10 to 15. The right-most digit counts ones, the next counts multiples of 16, then \(16^2 = 256\), etc.

High-level Language
A language for writing programs that is further removed from the processor than assembly.

I
ICD
In-Circuit Debugger

ICE
In-Circuit Emulator

IDE
Integrated Development Environment
IEEE
Institute of Electrical and Electronics Engineers

Interrupt
A signal to the CPU that suspends the execution of a running application and transfers control to an ISR so that the event may be processed. Upon completion of the ISR, normal execution of the application resumes.

Interrupt Service Routine
A function that handles an interrupt.

ISO
International Organization for Standardization

ISR
Interrupt Service Routine

L
Latency
The time between when an event occurs and the response to it.

Librarian
A program that creates and manipulates libraries.

Library
A collection of relocatable object modules.

Linker
A program that combines object files and libraries to create executable code.

Little Endian
Within a given object, the Least Significant Byte is stored at lower addresses.

M
Memory Model
A description that specifies the size of pointers that point to program memory.

Microcontroller
A highly integrated chip that contains a CPU, RAM, some form of ROM, I/O ports and timers.

MPASM Assembler
Microchip Technology’s relocatable macro assembler for PICmicro microcontroller families.

MPLIB Object Librarian
Microchip Technology’s librarian for PICmicro microcontroller families.

MPLINK Object Linker
Microchip Technology’s linker for PICmicro microcontroller families.

N
Non-extended Mode
In Non-extended mode, the compiler will not utilize the extended instructions nor the indexed with literal offset addressing.
O
Object File
A file containing object code. It may be immediately executable or it may require linking with other object code files (e.g., libraries) to produce a complete executable program.

Object Code
The machine code generated by an assembler or compiler.

Octal
The base 8 number system that only uses the digits 0-7. The right-most digit counts ones, the next digit counts multiples of 8, then \(8^2 = 64\), etc.

P
Pragma
A directive that has meaning to a specific compiler.

R
RAM
Random Access Memory

Random Access Memory
A memory device in which information can be accessed in any order.

Read Only Memory
Memory hardware that allows fast access to permanently stored data but prevents addition to or modification of the data.

ROM
Read Only Memory

Recursive
Self-referential (e.g., a function that calls itself).

Reentrant
A function that may have multiple, simultaneously active instances. This may happen due to either direct or indirect recursion or through execution during interrupt processing.

Relocatable
An object whose address has not been assigned to a fixed memory location.

Runtime Model
Set of assumptions under which the compiler operates.

S
Section
A portion of an application located at a specific address of memory.

Section Attribute
A characteristic ascribed to a section (e.g., an access section).

Special Function Register
Registers that control I/O processor functions, I/O status, timers or other modes or peripherals.
Storage Class
Determines the lifetime of the memory associated with the identified object.

Storage Qualifier
Indicates special properties of the objects being declared (e.g., const).

V
Vector
The memory locations that an application will jump to when either a Reset or interrupt occurs.
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