



**BoostC C Compiler**  
for PICmicro  
**Reference Manual**

# Index

<b>BoostC compiler</b> .....	<b>9</b>
<b>Introduction</b> .....	<b>9</b>
<b>BoostC Compiler specification</b> .....	<b>9</b>
Base Data types .....	9
Special Data types .....	9
Special Language Features .....	9
Code Production and Optimization Features .....	9
Debugging features .....	10
Full MPLAB integration .....	10
Librarian.....	10
Code Analysis.....	10
<b>Installation</b> .....	<b>11</b>
<b>Compilation model and toolchain</b> .....	<b>13</b>
Preprocessor.....	13
Compiler.....	13
Linker.....	14
Librarian.....	14
Differences with C2C compilation model.....	14
<b>MPLAB integration</b> .....	<b>15</b>
Features.....	15
Setting the MPLAB Language Tool Locations.....	15
Creating a project under MPLAB IDE.....	17
Using ICD2.....	21
<b>Command line options</b> .....	<b>22</b>
BoostC command line.....	22
Optimization.....	22
BoostLink command line.....	23
- <i>rb</i> .....	23
- <i>swcs s1 s2 s3</i> .....	24
- <i>isrnoshadow</i> .....	24
- <i>isrnocontext</i> .....	24
- <i>icd2</i> .....	25
- <i>hexela</i> .....	25
<i>libc Library</i> .....	25
Code entry points.....	25
<b>SourceBoost IDE</b> .....	<b>25</b>
<b>Preprocessor</b> .....	<b>26</b>
<b>Predefined macros</b> .....	<b>26</b>
<b>Directives</b> .....	<b>26</b>
# <i>include</i> .....	27
# <i>define</i> .....	28
# <i>undef</i> .....	29
# <i>if</i> , # <i>else</i> , # <i>endif</i> .....	30
# <i>ifdef</i> .....	31
# <i>ifndef</i> .....	32
# <i>error</i> .....	33
# <i>warning</i> .....	34
<b>Pragma directives</b> .....	<b>34</b>
# <i>pragma DATA</i> .....	35
# <i>pragma CLOCK_FREQ</i> .....	36
# <i>pragma OPTIMIZE</i> .....	37
<b>Setting Device Configuration Options</b> .....	<b>38</b>
<b>Initialization of EEPROM Data</b> .....	<b>39</b>

<b>C language</b>	<b>40</b>
<b>Program structure</b>	<b>40</b>
<b>Data types</b>	<b>40</b>
<i>Base data types</i>	40
<i>Structures and unions</i>	41
<i>Typedef</i>	41
<i>Enum</i>	41
<i>Code size vs Data Types</i>	41
<i>Rom</i>	43
<i>Volatile</i>	43
<i>Static</i>	44
<i>Constants</i>	44
<b>Strings</b>	<b>44</b>
<b>Variables</b>	<b>45</b>
<i>Register mapped variables</i>	45
<i>Bit access</i>	45
<b>Arrays</b>	<b>45</b>
<b>Pointers</b>	<b>45</b>
<i>Strings as function arguments</i>	46
<b>Operators</b>	<b>46</b>
<i>Arithmetic</i>	46
<i>Arithmetic Operator Examples</i>	46
<i>Assignment</i>	48
<i>Assignment Operator Examples</i>	48
<i>Comparison</i>	51
<i>Comparison Operator Examples</i>	51
<i>Logical</i>	54
<i>Logical Operator Examples</i>	54
<i>Bitwise</i>	55
<i>Bitwise Operator Examples</i>	55
<i>Conditionals</i>	57
<i>Conditional Examples</i>	57
<b>Program Flow</b>	<b>59</b>
<i>Program Flow Examples</i>	59
<b>Inline assembly</b>	<b>61</b>
<i>asm</i>	61
<i>asm</i>	61
<i>Variable Referencing in asm</i>	62
<i>Constants in asm</i>	62
<i>Inline assembly example 1</i>	62
<i>Inline assembly example 2</i>	63
<i>Inline assembly example 3</i>	63
<i>User Data</i>	63
<b>Functions</b>	<b>64</b>
<i>Inline functions</i>	64
<i>Special functions</i>	64
<i>General functions and interrupts</i>	64
<i>Functions pointers</i>	65
<i>Memory mapped functions</i>	66
<b>Dynamic memory management</b>	<b>66</b>
<b>C language superset</b>	<b>68</b>
<b>References as function arguments</b>	<b>68</b>
<i>Notes on using references as function arguments</i>	68
<b>Function overloading</b>	<b>68</b>
<b>Function templates</b>	<b>69</b>
<b>Parametric timing functions</b>	<b>70</b>
<i>void delay_us( unsigned char t )</i>	70
<i>void delay_10us( unsigned char t )</i>	70
<i>void delay_100us( unsigned char t )</i>	70
<i>void delay_ms( unsigned char t )</i>	70

<code>void delay_s( unsigned char t )</code> .....	70
<b>System Libraries</b> .....	<b>71</b>
<b>General purpose functions</b> .....	<b>71</b>
<code>clear_bit( var, num )</code> .....	71
<code>set_bit( var, num )</code> .....	71
<code>test_bit( var, num )</code> .....	71
<code>MAKESHORT( dst, lobyte, hobyte )</code> .....	71
<code>LOBYTE( dst, src )</code> .....	71
<code>HIBYTE( dst, src )</code> .....	71
<code>void nop( void )</code> .....	71
<code>void clear_wdt( void )</code> .....	72
<code>void sleep( void )</code> .....	72
<code>void reset( void )</code> .....	72
<b>String and Character Functions</b> .....	<b>72</b>
<code>void strcpy( char *dst, const char *src )</code> .....	72
<code>void strcpy( char *dst, rom char *src )</code> .....	72
<code>void strncpy( char *dst, const char *src, unsigned char len )</code> .....	72
<code>void strncpy( char *dst, rom char *src, unsigned char len )</code> .....	72
<code>unsigned char strlen( const char *src )</code> .....	72
<code>unsigned char strlen( rom char *src )</code> .....	72
<code>signed char strcmp( const char *src1, const char *src2 )</code> .....	72
<code>signed char strcmp( rom char *src1, const char *src2 )</code> .....	72
<code>signed char strcmp( const char *src1, rom char *src2 )</code> .....	72
<code>signed char strcmp( rom char *src1, rom char *src2 )</code> .....	72
<code>signed char strcmp( const char *src1, const char *src2 )</code> .....	72
<code>signed char strcmp( rom char *src1, const char *src2 )</code> .....	72
<code>signed char strcmp( const char *src1, rom char *src2 )</code> .....	72
<code>signed char strcmp( rom char *src1, rom char *src2 )</code> .....	72
<code>signed char strncmp( char *src1, char *src2, unsigned char len )</code> .....	72
<code>signed char strncmp( rom char *src1, char *src2, unsigned char len )</code> .....	72
<code>signed char strncmp( char *src1, rom char *src2, unsigned char len )</code> .....	72
<code>signed char strncmp( rom char *src1, rom char *src2, unsigned char len )</code> .....	73
<code>signed char strnicmp( char *src1, char *src2, unsigned char len )</code> .....	73
<code>signed char strnicmp( rom char *src1, char *src2, unsigned char len )</code> .....	73
<code>signed char strnicmp( char *src1, rom char *src2, unsigned char len )</code> .....	73
<code>signed char strnicmp( rom char *src1, rom char *src2, unsigned char len )</code> .....	73
<code>void strcat( char *dst, const char *src )</code> .....	73
<code>void strcat( char *dst, rom char *src )</code> .....	73
<code>void strncat( char *dst, const char *src, unsigned char len )</code> .....	73
<code>void strncat( char *dst, rom char *src, unsigned char len )</code> .....	73
<code>char* strpbrk( const char *ptr1, const char *ptr2 )</code> .....	73
<code>char* strpbrk( const char *src, rom char *src )</code> .....	73
<code>unsigned char strcspn( const char *src1, const char *src2 )</code> .....	73
<code>unsigned char strcspn( rom char *src1, const char *src2 )</code> .....	73
<code>unsigned char strcspn( const char *src1, rom char *src2 )</code> .....	73
<code>unsigned char strcspn( rom char *src1, rom char *src2 )</code> .....	73
<code>unsigned char strspn( const char *src1, const char *src2 )</code> .....	73
<code>unsigned char strspn( rom char *src1, const char *src2 )</code> .....	73
<code>unsigned char strspn( const char *src1, rom char *src2 )</code> .....	73
<code>unsigned char strspn( rom char *src1, rom char *src2 )</code> .....	73
<code>char* strtok( const char *ptr1, const char *ptr2 )</code> .....	73
<code>char* strtok( const char *src, rom char *src )</code> .....	73
<code>char* strchr( const char *src, char ch )</code> .....	74
<code>char* strchr( const char *src, char ch )</code> .....	74
<code>char* strstr( const char *ptr1, const char *ptr2 )</code> .....	74
<code>char* strstr( const char *src, rom char *src )</code> .....	74
<b>Conversion Functions</b> .....	<b>74</b>
<code>unsigned char sprintf( char* buffer, const char *format, unsigned int val )</code> .....	74
<i>Left justifies the field, the default is right justification</i> .....	74
<i>Examples</i> .....	75
<code>unsigned char sprintf32( char* buffer, const char *format, unsigned long val )</code> .....	76
<code>int strtol( const char* buffer, char** endPtr, unsigned char radix )</code> .....	76

<a href="#"><u>long strtol( const char* buffer, char** endPtr, unsigned char radix );</u></a>	<a href="#">76</a>
<a href="#"><u>int atoi( const char* buffer )</u></a>	<a href="#">76</a>
<a href="#"><u>long atol( const char* buffer )</u></a>	<a href="#">77</a>
<a href="#"><u>char* itoa( int val, char* buffer, unsigned char radix )</u></a>	<a href="#">77</a>
<a href="#"><u>char* ltoa( long val, char* buffer, unsigned char radix )</u></a>	<a href="#">77</a>
<a href="#"><u>unsigned char sqrt( unsigned short val )</u></a>	<a href="#">77</a>
<b>Lightweight Conversion Functions</b>	<b>77</b>
<a href="#"><u>void uitoa_hex( char* buffer, unsigned int val, unsigned char digits )</u></a>	<a href="#">77</a>
<a href="#"><u>void uitoa_bin( char* buffer, unsigned int val, unsigned char digits )</u></a>	<a href="#">77</a>
<a href="#"><u>void uitoa_dec( char* buffer, unsigned int val, unsigned char digits )</u></a>	<a href="#">77</a>
<a href="#"><u>unsigned int atoui_hex( const char* buffer )</u></a>	<a href="#">78</a>
<a href="#"><u>unsigned int atoui_bin( const char* buffer )</u></a>	<a href="#">78</a>
<a href="#"><u>unsigned int atoui_dec( const char* buffer )</u></a>	<a href="#">78</a>
<a href="#"><u>unsigned char sqrt1( unsigned short val )</u></a>	<a href="#">78</a>
<b>Character</b>	<b>78</b>
<a href="#"><u>char toupper( char ch )</u></a>	<a href="#">78</a>
<a href="#"><u>char tolower( char ch )</u></a>	<a href="#">78</a>
<a href="#"><u>char isdigit( char ch )</u></a>	<a href="#">78</a>
<a href="#"><u>char isalpha( char ch )</u></a>	<a href="#">78</a>
<a href="#"><u>char isalnum( char ch )</u></a>	<a href="#">78</a>
<a href="#"><u>char isblank( char ch )</u></a>	<a href="#">78</a>
<a href="#"><u>char iscntrl( char ch )</u></a>	<a href="#">78</a>
<a href="#"><u>char isgraph( char ch )</u></a>	<a href="#">79</a>
<a href="#"><u>char islower( char ch )</u></a>	<a href="#">79</a>
<a href="#"><u>char isprint( char ch )</u></a>	<a href="#">79</a>
<a href="#"><u>char ispunct( char ch )</u></a>	<a href="#">79</a>
<a href="#"><u>char isspace( char ch )</u></a>	<a href="#">79</a>
<a href="#"><u>char isupper( char ch )</u></a>	<a href="#">79</a>
<a href="#"><u>char isxdigit( char ch )</u></a>	<a href="#">79</a>
<a href="#"><u>void* memchr( const void *ptr, char ch, unsigned char len )</u></a>	<a href="#">79</a>
<a href="#"><u>signed char memcmp( const void *ptr1, const void *ptr2, unsigned char len )</u></a>	<a href="#">80</a>
<a href="#"><u>void* memcpy( void *dst, const void *src, unsigned char len )</u></a>	<a href="#">80</a>
<a href="#"><u>void* memmove( void *dst, const void *src, unsigned char len )</u></a>	<a href="#">80</a>
<a href="#"><u>void* memset( void *ptr, char ch, unsigned char len )</u></a>	<a href="#">80</a>
<b>Miscellaneous Functions</b>	<b>80</b>
<a href="#"><u>unsigned short rand( void )</u></a>	<a href="#">80</a>
<a href="#"><u>void srand( unsigned short seed )</u></a>	<a href="#">80</a>
<a href="#"><u>max( a, b )</u></a>	<a href="#">80</a>
<a href="#"><u>min( a, b )</u></a>	<a href="#">80</a>
<a href="#"><u>abs( a )</u></a>	<a href="#">80</a>
<b>I2C functions</b>	<b>81</b>
<a href="#"><u>i2c_init, i2c_start, i2c_restart, i2c_stop, i2c_read, i2c_write</u></a> <a href="#"><u>(for more information look into i2c_driver.h and i2c_test.c files)</u></a>	<a href="#">81</a>
<b>RS232 functions</b>	<b>81</b>
<a href="#"><u>uart_init, kbhit, getch, getch, putc, putchar</u></a> <a href="#"><u>(for more information look into serial_driver.h and serial_test.c files)</u></a>	<a href="#">81</a>
<b>LCD functions</b>	<b>81</b>
<a href="#"><u>lcd_setup, lprintf, lcd_clear, lcd_write, lcd_funcmode, lcd_datamode</u></a> <a href="#"><u>(for more information look into lcd_driver.h and lcd.c files)</u></a>	<a href="#">81</a>
<b>Flash functions</b>	<b>81</b>
<a href="#"><u>unsigned short flash_read(unsigned short addr) (PIC16 only)</u></a>	<a href="#">81</a>
<a href="#"><u>void flash_loadbuffer(unsigned short data) (PIC16 only)</u></a>	<a href="#">81</a>
<a href="#"><u>void flash_write(unsigned short addr) (PIC16 only)</u></a>	<a href="#">81</a>
<a href="#"><u>void flash_erase(unsigned long addr) (PIC18 only)</u></a>	<a href="#">81</a>
<a href="#"><u>void flash_read(unsigned long addr, unsigned char * buf) (PIC18 only)</u></a>	<a href="#">81</a>
<a href="#"><u>unsigned short flash_read(unsigned long addr) (PIC18 only)</u></a>	<a href="#">81</a>
<a href="#"><u>void flash_write(unsigned long addr, const unsigned char * buf) (PIC18 only)</u></a>	<a href="#">82</a>
<a href="#"><u>unsigned char flash_verify(unsigned long addr, const unsigned char * buf) (PIC18 only)</u></a>	<a href="#">82</a>
<b>EEPROM functions</b>	<b>82</b>
<a href="#"><u>unsigned char eeprom_read(unsigned char addr) (PIC16)</u></a>	<a href="#">82</a>
<a href="#"><u>unsigned char eeprom_read(unsigned short addr) (PIC18)</u></a>	<a href="#">82</a>
<a href="#"><u>void eeprom_write(unsigned char addr, unsigned char data) (PIC16)</u></a>	<a href="#">82</a>

<i>void eeprom_write(unsigned short addr, unsigned char data) (PIC18)</i> .....	82
<b>ADC functions</b> .....	<b>83</b>
<i>short adc_measure(char ch)</i> .....	83
<b>One wire bus functions</b> .....	<b>83</b>
<i>char oo_busreset()</i> .....	83
<i>short oo_get_data()</i> .....	84
<i>char oo_read_scratchpad()</i> .....	84
<i>void oo_start_conversion()</i> .....	84
<i>char oo_conversion_busy()</i> .....	84
<i>char oo_wait_for_completion()</i> .....	85
<b>PC System Requirements</b> .....	<b>86</b>
<b>Technical support</b> .....	<b>87</b>
<b>BoostC Support Subscription</b> .....	<b>87</b>
<b>Licensing Issues</b> .....	<b>87</b>
<b>General Support</b> .....	<b>87</b>
<b>Legal Information</b> .....	<b>89</b>

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# BoostC compiler

## Introduction

Thank you for choosing BoostC. **BoostC** is our next generation C compiler that works with PIC16, PIC18 and some PIC12 processors.

This ANSI C compatible compiler supports features like source level symbolic debugging, signed data types, structures/unions and pointers.

The **BoostC** compiler can be used within our **SourceBoost IDE** (Integrated Development Environment), or it can be integrated into Microchip MPLAB.

## BoostC Compiler specification

### Base Data types

Size	Type name	Specification
<b>1 bit</b>	<i>bit, bool</i>	boolean
<b>8 bit</b>	<i>char</i>	signed, unsigned
<b>16 bit</b>	<i>short, int</i>	signed, unsigned
<b>32 bit</b>	<i>long</i>	signed, unsigned

### Special Data types

- **Single bit** - single bit data type for efficient flag storage.
- **Fixed address** - fixed address data types allow easy access to target device registers.
- **Read only** - code memory based constants.

### Special Language Features

- References as function arguments.
- Function overloading.
- Function templates.

### Code Production and Optimization Features

- **ANSI 'C' compatible** - Makes code highly portable.
- Produces optimized code for both PIC16 (14bit core) and PIC18 (16bit core) targets.
- **Support for Data Structures and Unions** - Data structures and arrays can be comprised of base data types or other data structures. Arrays of base data types or data structures can be created.
- **Support for pointers** - pointers can be used in "all the usual ways".
- **Inline Assembly** - Inline assembly allows hand crafted assembly code to be used when necessary.
- **Inline Functions** - Inline functions allows a section of code to be written as a function, but when a reference is made to it the inline function code is inserted instead of a function call. This speeds up code execution.

- **Eliminates unreachable (or dead) code** - reduces code memory usage.
- **Removal of Orphan (uncalled) functions** - reduces code memory usage.
- **Minimal Code Page switching** - code where necessary for targets with multiple code pages.
- **Automatic Banks Switching for Variables** - allows carefree use of variables.
- **Efficient RAM usage** - local variables in different code sections can share memory. The linker analyzes the program to prevent any clashes.
- **Dynamic memory management.**

## Debugging features

- **Source Level and Instruction Level Debugger** - linker Generates COF file output for source level debugging under SourceBoost Debugger.
- **Step into, Step over, Step out and Step Back** – these functions operate both at source level and instruction level.
- **Multiple Execution Views** - see where the execution of the code is at source level and assembly level at the same time.
- **Monitoring variables** - variables can be added to the watch windows to allow their values to be examined and modified. There is no need to know where a variable is stored.

## Full MPLAB integration

- Use of the MPLAB Project Manager within MPLAB IDE.
- Creation and Editing of source code from within MPLAB IDE.
- Build a project without leaving MPLAB IDE environment.
- Source level debugging and variable monitoring using:
  - **MPLAB simulator;**
  - **MPLAB ICD2;**
  - **MPLAB ICE2000.**

## Librarian

- Allows generation of **library files** - this simplifies management and control of regularly used, shared code.
- Reduce compilation time - using library files reduces compilation time.

## Code Analysis

- **Call tree view** - **SourceBoost IDE** can display the function call tree.
- **Target Code Usage** - From the complete program, down to Function level the code space usage can be viewed in SourceBoost IDE.
- **Target RAM Usage** - From the complete program, down to Function level the RAM usage can be examined and reviewed in SourceBoost IDE.

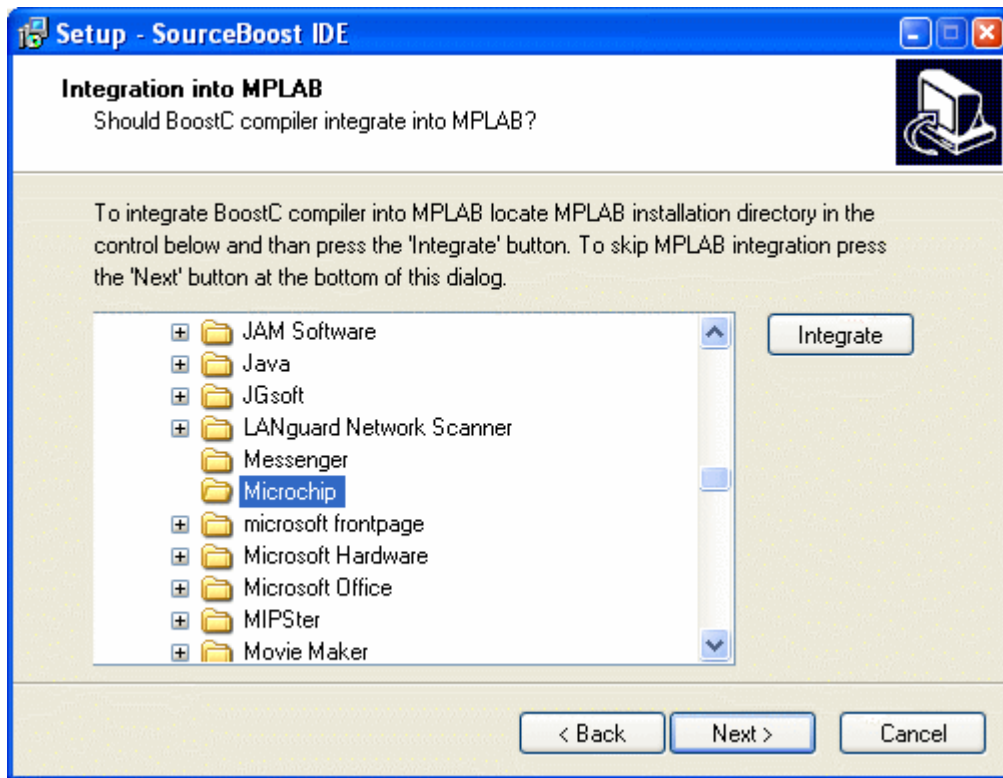
## Installation

The BoostC compiler cannot be downloaded or installed on its own. BoostC is part of the SourceBoost software package that includes the SourceBoost IDE and other Language Suites. It is available for download from our site <http://www.sourceboost.com>

When you buy a license, you will activation code(s) and detailed instructions on how to activate the compiler and other tools you have licensed.

To install SourceBoost IDE and BoostC on your system, please follow these simple steps:

- Execute the installer sourceboost.exe and follow on-screen directions.
- Please pay attention to the integration dialog:

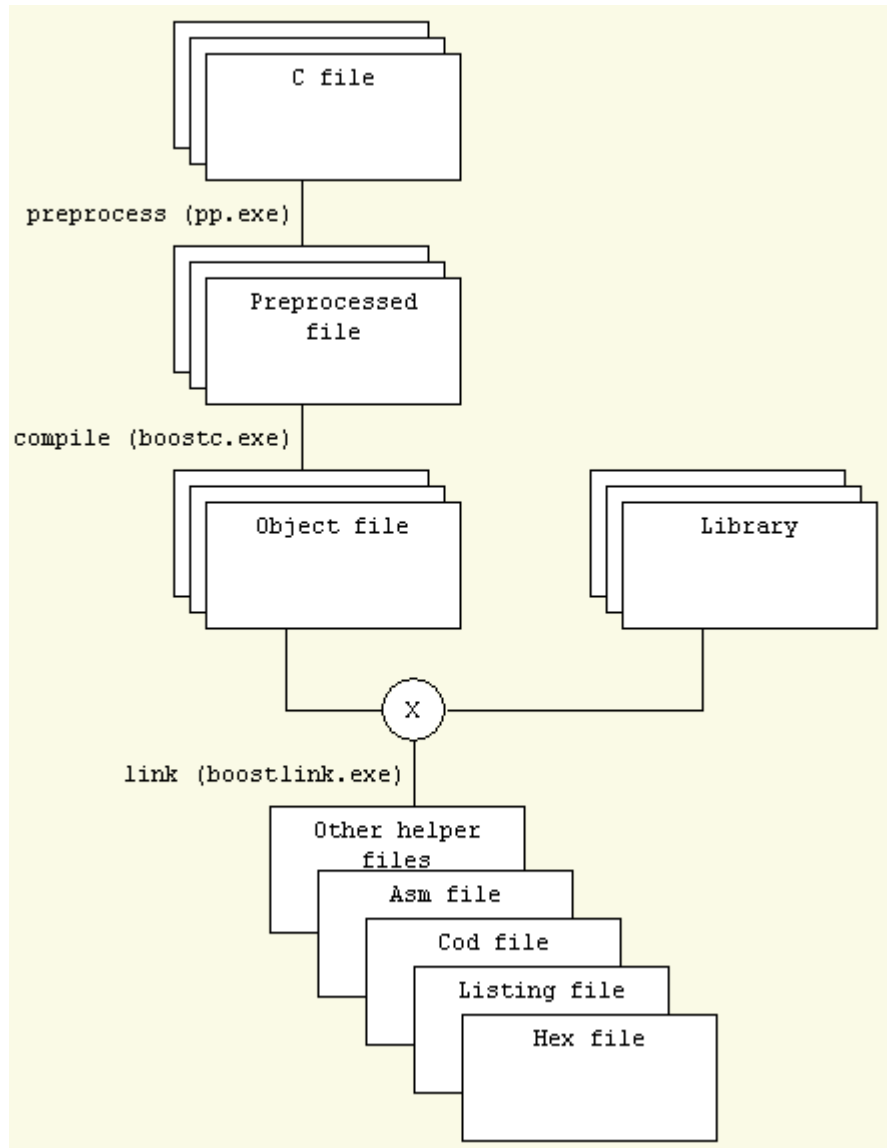


To integrate BoostC with MPLAB, choose the correct Microchip installation directory, then click on "Integrate" before stepping to the next installation wizard dialog.

- The rest of the installation process is straightforward. At the end, SourceBoost IDE is ready to be used on your system. Should any difficulty arise, please double check your system configuration and mail all details to [support@sourceboost.com](mailto:support@sourceboost.com)

- **Please note:** if the installation step “MPLAB Integration” is skipped, the necessary MPLAB integration files will be installed to the \mplab subdirectory of the chosen SourceBoost installation directory. These files can always be manually copied to the correct location – please see the “MPLAB Integration” section later in this manual.

## Compilation model and toolchain



### Preprocessor

The preprocessor **pp.exe** is automatically invoked by the compiler.

### Compiler

There are actually two separate compilers: one for pic16 and one for pic18 targets. When you work under SourceBoost IDE, there is no need to specify which one to use: the IDE picks the correct compiler based on the selected target.

The output of the compiler is one or more **.obj** files, that are further processed by **librarian** or **linker**, in order to get a **.lib** or **.hex** file.

## Linker

**BoostLink** Optimizing Linker links **.obj** files generated by compiler into a **.hex** file that is ready to send to target. It also generates some auxiliary files used for debugging and code analysis.

## Librarian

Librarian is built into **BoostLink** linker executable and gets activated by `-lib` command line argument. There is a dedicated box in the Option dialog inside **SourceBoost IDE** that changes project target to library instead of hex file.

To create a target independent library, include *boostc.h* instead of *system.h* into the library sources. This way no target specific information (like target dependent constants or variables mapped to target specific registers) is included into the library. Note that this is the only case in which *system.h* does not be included into the code.

## Differences with C2C compilation model

The main difference between **BoostC** and our previous generation **C2C** compiler is that the latter had a built-in linker and created an **.asm** file needing to be assembled using an external assembler (like MPASM), while the **BoostC** toolsuite doesn't need any external tools and directly generates the target **.hex** file.

Another difference is in how compilers handle read-only variables located in code memory. **BoostC** uses the special data type specifier '*rom*', while **C2C** placed any variable defined as '*const*' into code memory.

## MPLAB integration

**BoostC C** compiler can be integrated into Microchips MPLAB integrated development environment (IDE). The MPLAB integration option should be selected during the SourceBoost software package installation.

**Please note:** To use BoostC under MPLAB the MPLAB integration button must be pressed during the SourceBoost package installation. This copies some files and sets the required registry keys required for integration to work.

In case the installation step "MPLAB Integration" failed, the files in the <SourceBoost>\mplab directory can be manually copied into

<MPLAB IDE>\MPLAB IDE\Core\MTC Suites for **MPLAB 8.x**, or

<MPLAB IDE>\Third Party\MTC Suites for **MPLAB 7.x**, or

<MPLAB IDE>\LegacyLanguageSuites for **MPLAB 6.x**.

In the above examples, <MPLAB IDE> refers to the MPLAB installation directory and <SourceBoost> refers to the SourceBoost IDE and compilers installation directory.

## Features

When **BoostC** is integrated into MPLAB IDE it allows the following:

- Use of the MPLAB Project Manager within MPLAB IDE.
- Creation and Editing of source code from within MPLAB IDE.
- Build a project without leaving MPLAB IDE.
- Source level debugging and variable monitoring using: MPLAB simulator, MPLAB ICD2, MPLAB ICE2000.

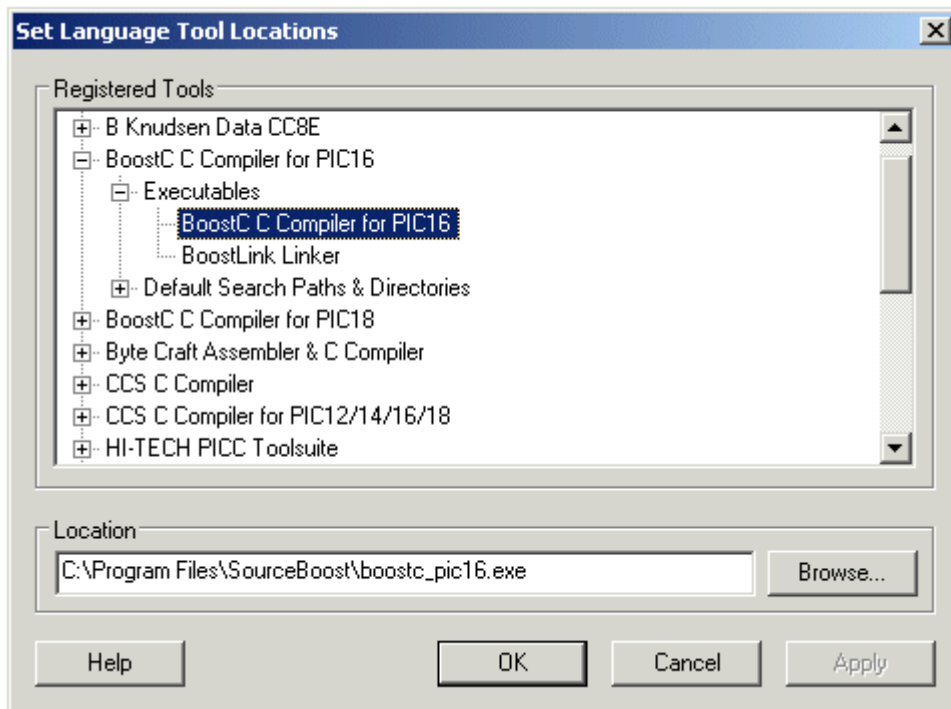
## Setting the MPLAB Language Tool Locations

Note: this process only needs to be performed once.

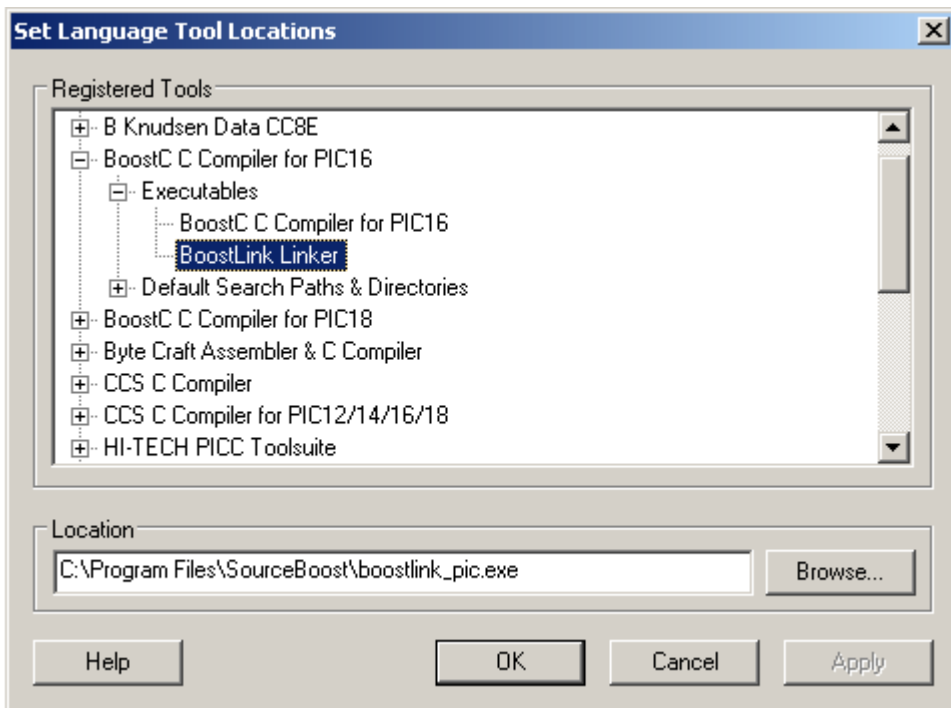
The procedure below specifies paths assuming the default installation folder has been used for the SourceBoost software package.

1. Start MPLAB IDE.
2. Menu **Project** ➔ **Set Language Tool Locations**.  
Note: if BoostC C compiler does not appear in the Registered Tools list, then the integration process during the SourceBoost installation was not performed or was unsuccessful.

3. Set **BoostC C** compiler for PIC16 location:

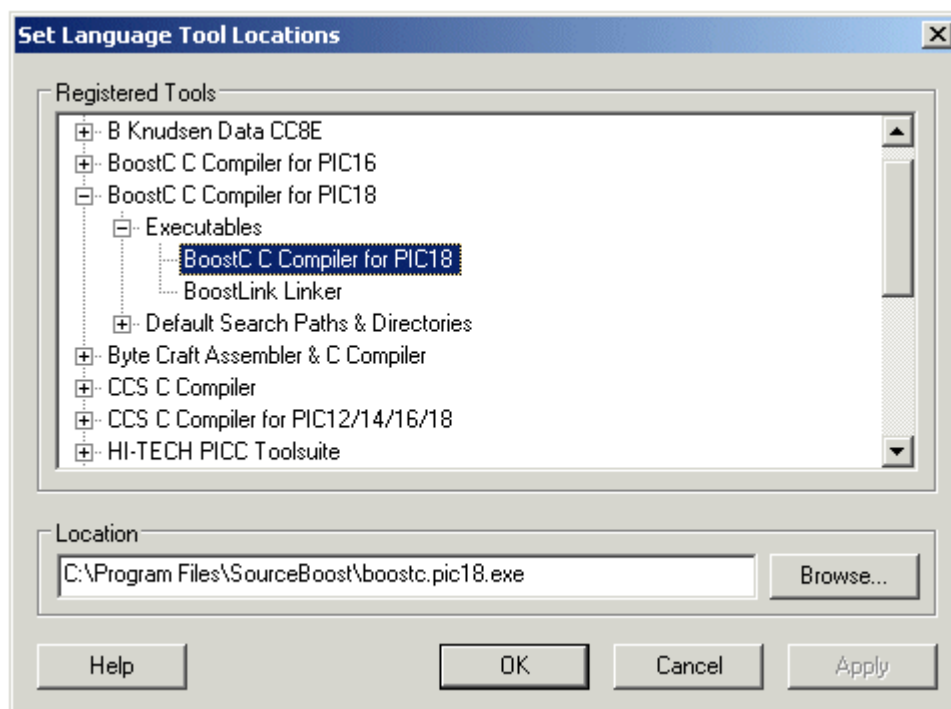


4. Now set **BoostLink** Linker location:

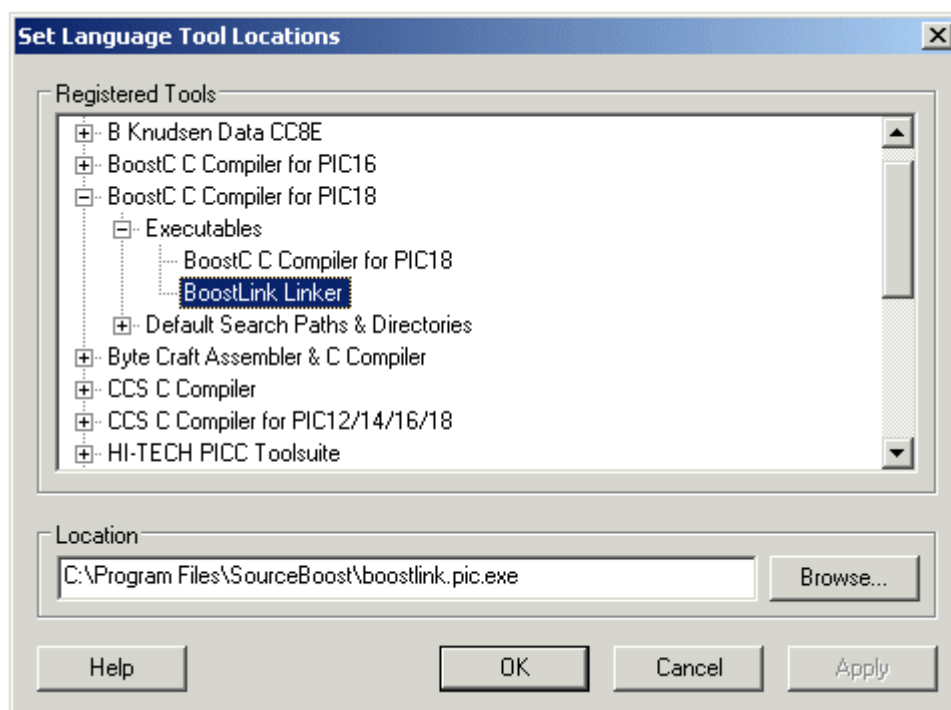




5. Set **BoostC C** compiler for PIC18 location:



6. Eventually, set **BoostLink** Linker location in the PIC18 tree:

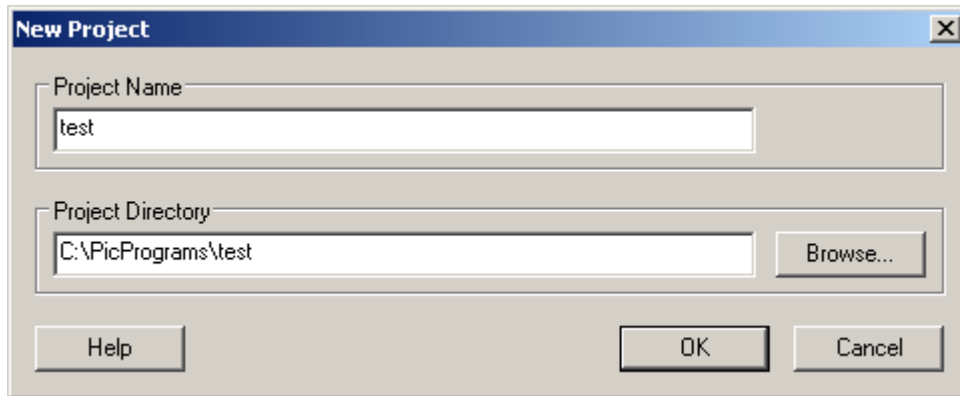


## Creating a project under MPLAB IDE

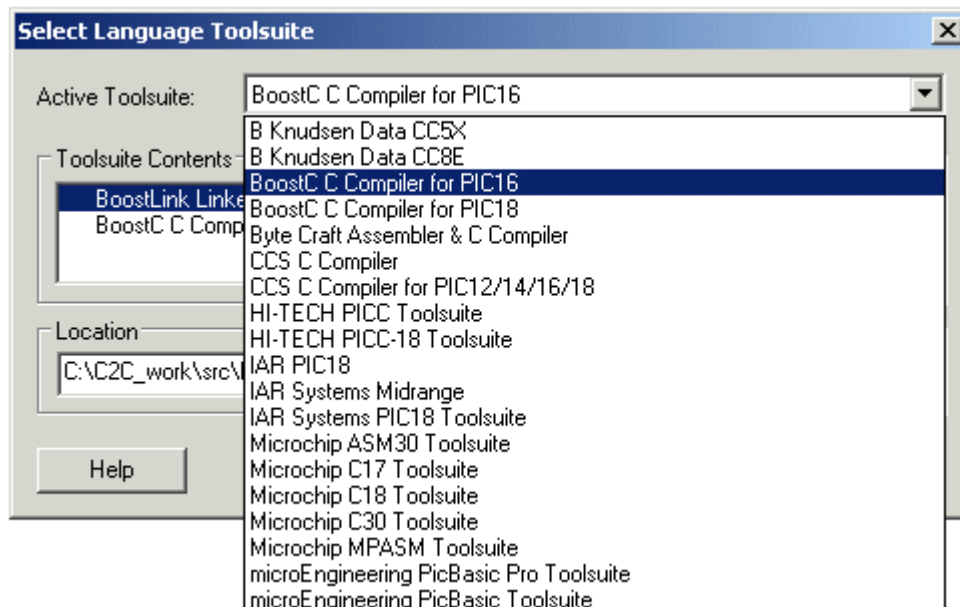
Before attempting to do this, please ensure that the “**Setting the MPLAB language tool locations**” process illustrated in the above section has been successfully performed.

The following steps will help you create a project under MPLAB IDE, that will be built using the BoostC C compiler, compiling for a PIC16 Target. The project name is test and the project and source code will be located in folder C:\PicPrograms\test

1. Menu **Project** ➔ **New**. Enter a project name and directory.  
Note: this can be an existing directory containing a SourceBoost IDE project.

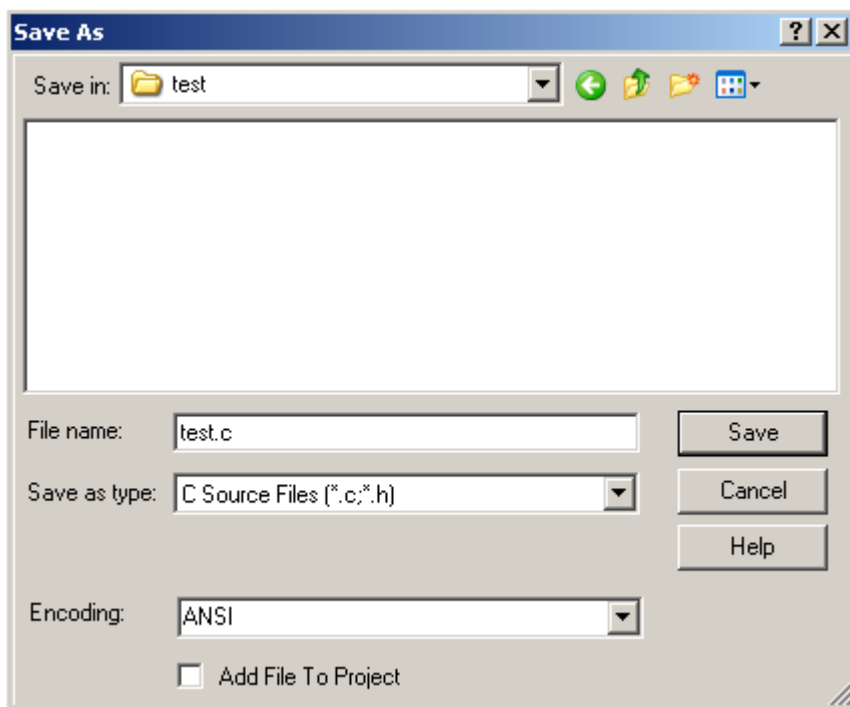


2. Menu **Project** ➔ **Select Language Toolsuite**. Select the **BoostC C Compiler for PIC16**.

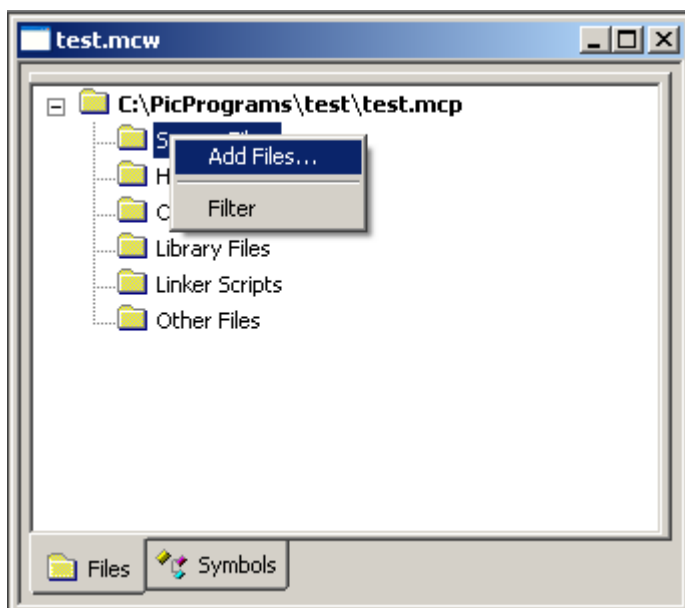


3. Menu **File** ➔ **New**. Type code into the Untitled window.  
Note: If you already have Source Files, this step and steps 4 can be skipped.

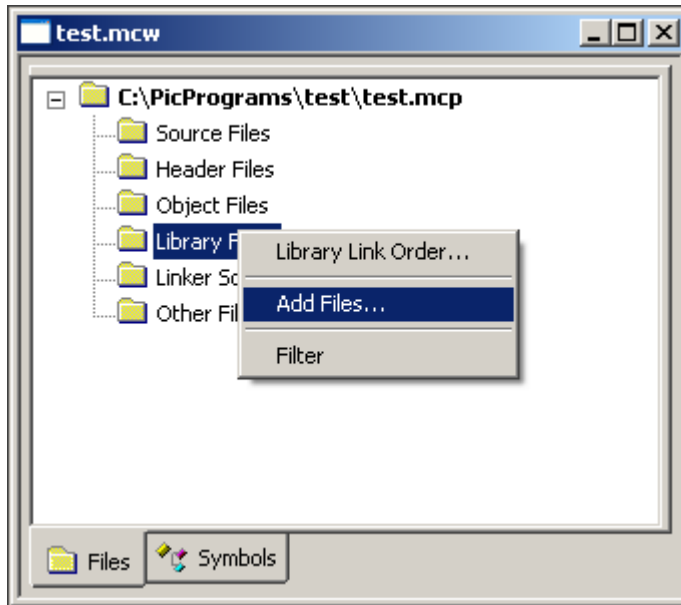
4. Menu **File** ➔ **Save As**. Locate the project folder using the Save As dialog box.



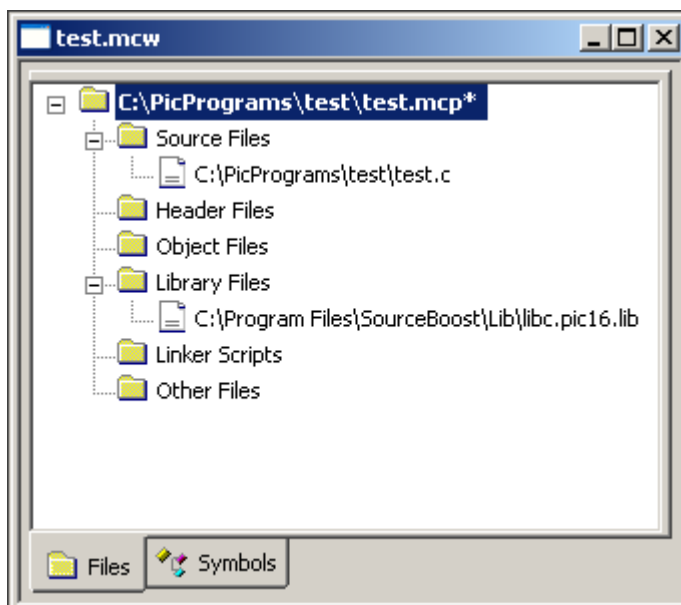
5. Add the test.c source file to the project by right clicking on Source Files in the project tree – as shown below.



6. Add the libc.pic16.lib file (found in the C:\Program Files\SourceBoost\Lib folder) to the project by right clicking on Library Files in the project tree.



7. Check the final project. It should look as below:



8. Menu **Project** ➔ **Build** (or press the build button on the tool bar). The code should then be built.

You can now use the MPLAB simulator, ICD2 or ICE to run the code, or a programmer to program a device. Please refer to the "Using ICD2" section of this document before using ICD2 to avoid potential problems.

For ease of project browsing, you can also add the project header files to the project tree in the same way as the source files where added.

## Using ICD2

There are a few things to be aware of when using or planning using ICD2:

1. **RAM usage:** ICD2 uses some of the target device's RAM, leaving less room for the actual application.

In order to reserve the RAM required by ICD2, and prevent Boost Linker from using it, the *icd2.h* header file must be included into **one** file in the source code, eg:

```
#include <system.h>
#include <icd2.h>           // allocates RAM used by ICD2

void main()
{
    while(1);
}
```

2. **SFR usage:** ICD2 uses some Special Function Registers. This prevents the use of some peripheral devices when using ICD2 to debug code.

**Important:** It is down to the user to ensure that the ICD2 special function registers are not accessed. On some targets these registers reside at the same address as other peripheral device special function registers. Please check the documentation provided in the MPLAB IDE help for ICD2 resource usage in order to prevent problems.

3. **Break point overrun:** Due to timing skew in the target device (caused by instruction prefetch), execution will pass the instruction address where a breakpoint is set before it stops.
4. **NOP at ROM address 0:** See the BoostLink command line option `-icd2` to add a NOP at ROM address 0.

## Command line options

To get full list of BoostC compiler and BoostLink linker command line options run compiler or linker from command line.

### BoostC command line

BoostC Optimizing C Compiler Version x.xx  
http://www.sourceboost.com  
Copyright(C) 2004-2009 Pavel Baranov  
Copyright(C) 2004-2009 David Hobday

Licensed to <license info>

Usage: boostc\_pic16.exe [options] files

Options:

-t name target processor (default name=PIC16F648A)  
-T name configuration (.tdf) file directory  
-On optimization level (default n=2)  
n=0 - optimization turned off  
n=1 - optimization turned on  
n=2 - global optimization turned on  
n=a - aggressive optimization turned on  
n=p - 32 bit long promotion turned on  
-Wn warning level (default n=1)  
n=0 - no warnings  
n=1 - some warnings  
n=2 - all warnings  
-werr treat warnings as errors (default off)  
-i debug inline code (default off)  
-Su disable initialization of uninitialized static variables  
-d name define 'name'  
-m generate dependencies file (default off)  
-16x use PIC16 extended instructions (PIC16F193x and alike, default off) *--PIC16 compiler only--*  
-idx num index size in bytes (default num=1) *--PIC18 7.00+ compiler only--*  
-obj path object file output directory  
-o name specify name for generated object file  
-v verbose mode turned on (default off)  
-I path1;path2 additional include directories  
-beep issue sound at the end of compilation (default off)

### Optimization

Code optimization is controlled by -O command line option and *#pragma*.

Optimize flags:

- O0** no or very minimal optimization
- O1** regular optimization
- O2** global optimization (this option is recommended for most applications)
- Oa** aggressive optimization (produces shorter code and optimizes out some variables - this can make debugging more difficult!)
- Op** promotes results of some 16 bit operations to 32 bits (can result in more efficient code in some cases).

## BoostLink command line

BoostLink Optimizing Linker Version x.xx  
http://www.sourceboost.com  
Copyright(C) 2004-2009 Pavel Baranov  
Copyright(C) 2004-2009 David Hobday

Licensed to <license info>

Usage: boostlink\_pic.exe [options] files

Options:

-t name target processor  
-On optimization level 0-1 (default n=1)  
n=0 - no optimization  
n=1 - pattern matching and bank switching optimize on  
-v verbose mode  
-d path directory for project output  
-p name project (output) name for multiple .obj file linking  
-ld path directory for library search  
-rb address ROM base (start) address to use  
-rt address ROM top (end) address to use  
-swcs s1 s2 s3 Use software call stack. Hardware stack is allocated by  
specifying stack depths s1,s2,s3 (optional)  
s1 = main and task routines hardware stack allocation  
s2 = ISR hardware stack allocation  
s3 = PIC18 low priority ISR hardware stack allocation  
-isrnoshadow ISR No use of Shadow registers  
-isrnocontext ISR No context Save/restore is added to ISR(PIC18 only)  
-icd2 Add NOP at first ROM address for correct ICD2 operation  
-hexela Always add extended linear address record to .hex file  
-beep Issue sound at the end of link (default off)

Switches for making libraries:

-lib make library file from supplied .obj and .lib files  
-p name project (library output file) name

### **-rb**

This command line option causes the code generated by the linker to start at the address specified. Boot loaders often reside in the low area of ROM.

### **Example**

-rb 0x0800

### ***-swcs s1 s2 s3***

This command line option to the linker tells it to use a software call stack in addition to the hardware call stack. This allows subroutine calls deeper than the call hardware call stack of the PIC. A function call that is made on the software call stack uses an extra byte of RAM to hold the return point number. This option must be used when using **Novo RTOS**. Where possible the hardware stack is used for efficiency. By specifying the depth of hardware stack to use for main (and Novo tasks) **s1**, ISR (interrupt service routine) **s2** and low priority ISR (PIC18 only) **s3**, provides control over when the software call stack is used instead of the hardware call stack. The software call stack is applied to functions higher up in the call tree, so calls lower down the call tree still use the hardware call stack. If no hardware stack depths are specified, then the software stack is only used in functions that contain or call functions that contain a **Novo RTOS** Sys\_Yield() function.

#### **Example:**

```
-swcs 6 2
```

Main routine will use hardware call stack up to a depth of 6 and then start using software call stack. Interrupt routine will use hardware call stack up to a depth of 2 and start using software call stack. An ISR uses hardware call stack depth of 1 to save the address of the point where the code was interrupted, so in this example it only leaves a hardware call stack depth 1 for subsequent calls within the ISR.

### ***-isrnoshadow***

This command line switch tells the linker not to use the PIC18 shadow registers for interrupt service routine (ISR) context saving. This option is required as a work around for silicon bugs in some PIC18's.

### ***-isrnocontext***

This option only works with PIC18's. When use this prevents the linker adding extra code for context saving. This allow the programmer to generate their own minimal ISR context saving code, or have none at all.

#### **Example:**

```
// Context saving example
// Assumes that the ISR code will only modify w and and bsr

// create context saving buffer at fixed address
char context[ 2 ]@0x0000;

void interrupt()
{
    asm movff _bsr, _context
    asm movwf _context+1
    . . . .
    asm movwf _context+1
    asm movff _bsr, _context
}
```



### **-icd2**

Use this command line switch to add a NOP instruction at the first ROM address used (usually address 0). This is required on some devices for correct operation of Microchip ICD2 (In Circuit Debugger).

### **-hexela**

Always add extended linear address record to .hex file. Without this switch an extended linear address record is only added to the .hex file if required by addresses included in the .hex file.

### **libc Library**

When a project is being linked, **SourceBoost IDE** adds *libc.pic16.lib* or *libc.pic18.lib* to the linker command line, if it can find this library in its default location.

The *libc* library contains necessary code for multiplication, division and dynamic memory allocation. It also includes code for string operations.

## **Code entry points**

Entry points depend on the code address range using by the BoostLink linker. By default, the linker uses all available code space, but it's also possible to specify code start and end addresses that linker should use through linker command line options.

For PIC16:

Reset (main) entry point	<code start> + 0x00
Interrupt entry point	<code start> + 0x04

For PIC18:

Reset (main) entry point	<code start> + 0x00
Interrupt entry point	<code start> + 0x08
Low priority ISR entry point	<code start> + 0x18

## **SourceBoost IDE**

The **SourceBoost IDE** is thoroughly covered in a separate manual.

## Preprocessor

The **pp.exe** preprocessor is automatically invoked by the compiler. It executes a series of parametrized text substitutions and replacement (macro processing), besides evaluating special directives.

All preprocessor directives start with a '#'. Non standard directives are always contained in statements with a leading ANSI keyword *#pragma*, so to avoid potential conflicts when porting code to other compilers and/or with advanced source analysis tools (lint, static checkers, code formatters, flow analyzers and so on).

## Predefined macros

<b>_BOOSTC</b>	always defined
<b>_PIC16</b>	defined for all supported PIC12 and PIC16 targets
<b>_PIC16x</b>	defined if PIC16 extended instruction set is used (PIC16F193x and alike)
<b>_PIC18</b>	defined for all supported PIC18 targets

## Directives

The following directives are supported by **pp**:

**#include**

**#define**

**#undef**

**#if**

**#else**

**#endif**

**#ifdef**

**#ifndef**

**#error**

**#warning**

These directives are individually explained in the following pages.

## #include

**Syntax:** `#include <filename.h>`  
or  
`#include "filename.h"`

**Elements:** **filename** is any valid PC filename. It may include standard drive and path information.

In the event no path is given, the following applies:

a) If filename appears between "", the directory of the projects is searched first.

b) If the delimiters <> are used, only the IDE *include path list* is searched for filename.

If the file is not found, an error will be issued and compilation shall stop.

**Purpose:** Text from the include file **filename.h** is inserted at the point of the source where this directive appears, at compile time.

**Examples:** `#include <system.h>`

## #define

**Syntax:** `#define id statement`

or

`#define id(a, b...) statement`

**Elements:** **id** is any valid preprocessor identifier.

**statement** is any valid text.

**a, b** and so on are local preprocessor identifiers, that in the given form model a function's formal parameters, separated by commas.

**Purpose:** Both forms produce a basic string replacement of **id** with the given **text**. Replacement will take place from the point where the `#define` statement appears in the program, and below.

The second form represents a preprocessor pseudo-function. The local identifiers are positionally matched up with the original text, and are replaced with the text passed to the macro wherever it is used.

**Examples:**

```
#define LEN 16
#define LOWNIBBLE(x) ((x) & 0x0F)
...
a = 69;
le = a + LEN;           // becomes le = a + 16;
b = LOWNIBBLE(a);      // same as b = a & 0x0F;
```

## #undef

**Syntax:** `#undef id`

**Elements:** **id** is any valid preprocessor identifier previously defined via `#define`.

**Purpose:** Starting with the line where this directive appears, **id** will no more have meaning for the preprocessor, i.e. a subsequent `#ifdef id` shall evaluate to logical FALSE.

Please note that **id** can then be reused and assigned a different value.

**Examples:**

```
#define LEN 16
#define LOWNIBBLE(x) ((x) & 0x0F)
...
a = 69;
le = a + LEN;           // becomes le = a + 16;
#undef LEN              // LEN is not recognized anymore by pp
...

#define LEN 24          /* This is now valid and does not cause
"double definition attempt" errors. */
```

## #if, #else, #endif

**Syntax:**     *#if* **expr**  
                  *code*  
          *#else*  
                  *code*  
          *#endif*

**Elements:**   **expr** is any valid expression using constants, standard operators and preprocessor identifiers.  
              **code** is one or more valid C source code line.

**Purpose:**      The preprocessor evaluates the constant expression **expr** and, if it is non-zero, will process the lines up to the optional *#else* or the *#endif*. Otherwise the optional *#else* branch code will be processed, if present.

The latter two preprocessor directives are also used with specialized forms of the *#if* directive (see *#ifdef*, *#ifndef*).

NOTE: **expr** cannot contain C variables ! Only constant expressions and operators can be used.

**Examples:**    // Conditionally initialize a RAM variable  
*#if* STARTDELAY > 20  
          slow = 1;  
*#else*  
          slow = 0;  
*#endif*

## #ifdef

**Syntax:**        `#ifdef id`  
                  `code`  
                  `#endif`

**Elements:**     **id** is any valid preprocessor identifier.  
**code** is one or more lines of valid C source code.

**Purpose:**        When the preprocessor encounters this directive, it evaluates whether the identifier **id** is in its symbol table (eg previously specified within a *#define* statement).  
In case **id** is defined, the lines of **code** between *#ifdef* and *#endif* (or an optional *#else*, if present) will be processed.  
In the opposite case, **code** statements between *#ifdef* and *#endif* will be ignored by the compiler.

NOTE: **id** can not be a C variable ! Only preprocessor identifiers created via *#define* can be used.

**Examples:**     `#define DEBUG`  
                  `...`  
                  `#ifdef DEBUG`  
                  `printf("Reached test point #1");`  
                  `#endif`

## #ifndef

**Syntax:**        *ifndef id*  
                      *code*  
                      *endif*

**Elements:**     **id** is any valid preprocessor identifier.  
                      **code** is one or more lines of valid C source code.

**Purpose:**        When the preprocessor encounters this directive, it evaluates whether the identifier **id** is in its symbol table (eg previously specified within a *define* statement).

In case **id** is **not** defined, the lines of **code** between *ifndef* and *endif* (or an optional *else*, if present) will be processed.

In the opposite case, **code** statements between *ifndef* and *endif* will be ignored by the compiler.

NOTE: **id** can not be a C variable ! Only preprocessor identifiers created via *define* can be used.

**Examples:**     *ifndef* DEBUG  
                      printf("Debug disabled !");  
                      *else*  
                      printf("Reached test point #1");  
                      *endif*



## **#error**

**Syntax:** `#error text`

**Elements:** **text** is any valid text.

**Purpose:** When the preprocessor encounters this directive, it stops compilation and issues an error. The user supplied **text** is printed as an informational message.

This directive is useful when coupled with the expression checking features of the preprocessor, to validate the coherence of configuration choices and defines made elsewhere in the sources and include files (or on the command line).

**Examples:**

```
#ifndef PWM_DEFAULT
#error "MUST define a default value for speed !"
#endif
```

## **#warning**

**Syntax:** `#warning text`

**Elements:** **text** is any valid text.

**Purpose:** When the preprocessor encounters this directive, it forces the compiler to issue a warning. The user supplied **text** is printed as an informational message.

This directive is useful when coupled with the expression checking features of the preprocessor, to validate the coherence of configuration choices and defines made elsewhere in the sources and include files (or on the command line).

**Examples:**

```
#ifndef NODEADDR
#warning "ADDR not defined, will enter dynamic mode."
#endif
```

## **Pragma directives**

Specific BoostC preprocessor directives all follow the ANSI keyword *#pragma*, so to avoid potential conflicts when porting code to other compilers and/or with advanced source analysis tools (lint, static checkers, code formatters, flow analyzers and so on).

The following directives are supported by **pp**:

**#pragma DATA**

**#pragma CLOCK\_FREQ**

**#pragma OPTIMIZE**

These directives are individually explained in the following pages.

## #pragma DATA

**Syntax:** `#pragma DATA addr, d1, d2, ...`

or

`#pragma DATA addr, "abcdefg1", "abcdefg2", ...`

**Elements:** **addr** is any valid code memory address.

**d1, d2...** are 8-bit integer constants.

**"abcdefgX"** is a character string, the ASCII values of the characters will be stored as 8 bit value.

**Purpose:** User data can be placed at a specific location using this construct. In particular, this can be used to specify target configuration word or to set some calibration/configuration data into on-chip eeprom.

**Examples:**

```
#pragma DATA 0x200, 0xA, 0xB, "test"  
//Set PIC16 configuration word  
#pragma DATA 0x2007, _HS_OSC & _WDT_OFF & _LVP_OFF  
//Put some data into eeprom  
#pragma DATA 0x2100, 0x12, 0x34, 0x56, 0x78, "ABCD"
```

## **#pragma CLOCK\_FREQ**

**Syntax:** `#pragma CLOCK_FREQ Frequency_in_Hz`

**Elements:** **Frequency\_in\_Hz** is the processor's clock speed.

**Purpose:** The CLOCK\_FREQ directive tells the compiler under what clock frequency the code is expected to run.

Note: delay code generated by the linker is based on this figure.

**Examples:** `//Set 20 MHz clock frequency  
#pragma CLOCK_FREQ 20000000`

## **#pragma OPTIMIZE**

**Syntax:** `#pragma OPTIMIZE "Flags"`

**Elements:** **Flags** are the optimization flags also used on the command line.

**Purpose:** This directive sets new optimization, at function level. It must be used in the global scope and applies to the function that follows this pragma.

The pragma argument should be enclosed into quotes and is same as argument of the -O compiler command line options.

Empty quotes reset the optimization level previously set by this pragma.

This is the current list of valid optimization flags:

- 0** no or very minimal optimization
- 1** regular optimization (recommended)
- a** aggressive optimization
- p** promotes results of some 16 bit operations to 32 bits

**Examples:**

```
//Use aggressive optimization for function 'foo'
#pragma OPTIMIZE "a"

void foo()
{
    ...
}
```

## Setting Device Configuration Options

In order for a program to be able to run on a target device the device configuration options need to be correctly set. For example having the wrong oscillator configuration setting may mean that the device has no clock, making it impossible for any code to be executed. Configuration data is set using the pragma directive: `#pragma DATA`.

Configuration options typically control:

- Oscillator configuration
- Brown out reset
- Power up reset timer
- Watchdog configuration
- Peripheral configurations
- Pin configurations
- Low voltage programming
- Memory protection
- Table read protection
- Stack overflow handling

The exact configuration options available depend on exactly which device is being used. The PIC18 devices have many more configuration options than the PIC16/PIC12 devices.

### Configuration Example 1:

```
// Configuration for PIC16F874A
#pragma DATA _CONFIG, _CP_OFF & _PWRTE_OFF & _WDT_OFF & _HS_OSC & _LVP_OFF
```

### Configuration Example 2:

```
// Configuration for PIC18F452
#pragma DATA _CONFIG1H, _OSCS_OFF_1H & _HS_OSC_1H
#pragma DATA _CONFIG2L, _BOR_ON_2L & _BORV_20_2L & _PWRT_OFF_2L
#pragma DATA _CONFIG2H, _WDT_OFF_2H & _WDTPS_128_2H
#pragma DATA _CONFIG3H, _CCP2MX_ON_3H
#pragma DATA _CONFIG4L, _STVR_ON_4L & _LVP_OFF_4L & _DEBUG_OFF_4L
#pragma DATA _CONFIG5L, _CP0_OFF_5L & _CP1_OFF_5L & _CP2_OFF_5L & _CP3_OFF_5L
#pragma DATA _CONFIG5H, _CPB_OFF_5H & _CPD_OFF_5H
#pragma DATA _CONFIG6L, _WRT0_OFF_6L & _WRT1_OFF_6L & _WRT2_OFF_6L & _WRT3_OFF_6L
#pragma DATA _CONFIG6H, _WRTC_OFF_6H & _WRTB_OFF_6H & _WRWD_OFF_6H
#pragma DATA _CONFIG7L, _EBTR0_OFF_7L & _EBTR1_OFF_7L & _EBTR2_OFF_7L & _EBTR3_OFF_7L
#pragma DATA _CONFIG7H, _EBTRB_OFF_7H
```

You can find the defined configuration options for a given device by looking in the target devices BoostC header file (PIC18XXXX.h and PIC16XXXX.h) which can be found in the installation directory (typically "C:\Program File\SourceBoost\include"). Its also worth looking at relevant Microchip data sheet to find the exact function of each option.

## ***Initialization of EEPROM Data***

It is often desirable to program the PIC on board EEPROM with initial data as part of the programming process. This initial data can be included in the source code. EEPROM initialization data is set using the pragma directive: *#pragma DATA*.

### **Example:**

```
// Initializes EEPROM with data: 0C 22 38 48 45 4C 4C 4F 00 FE 99  
#pragma DATA _EEPROM, 12, 34, 56, "HELLO", 0xFE, 0b10011001
```

## C language

This section of the manual contains a condensed list of BoostC C compiler features. It is in no way intended to replace a complete C language manual or ANSI/ISO specification. It is targeted, instead, at the already expert C programmer that needs a quick reference of BoostC and its peculiarities due to the specific PIC target platform.

### *Program structure*

Every source file should include the general system header file, that in turn includes target specific header (containing register mapped variables specific for this target), some internal functions prototypes needed for code generation and string manipulation function prototypes:

```
#include <system.h>
//Rest of the source code goes here, after the system include
```

The only exception to this rule is a project that outputs a library. Library sources should not include any system headers to avoid duplicate variable declaration error.

## Data types

### *Base data types*

Size	Type
<b>1 bit</b>	bit, bool
<b>8 bits</b>	char, unsigned char, signed char
<b>16 bits</b>	short, unsigned short, signed short
<b>16 bits</b>	int, unsigned int, signed int
<b>32 bits</b>	long, unsigned long, signed long

The difference between **bit** and **bool** data types is in the way how an expression (longer than 1 bit) is assigned to a bit or bool operands.

- **bit** operands receive the least significant bit of the right side expression;
- **bool** operands receive the value of the right side expression casted to bool.

For example:



```

bool a;
bit b;
char x;
...
a = x & 2; // 'a' will be 'true' if the bit #1 in 'x' is set
           // and 'false' otherwise
b = x & 1; // 'b' will always be false, because bit #0
           // (the least significant bit) in the expression
           // result is zero - regardless of the value of 'x'

```

## Structures and unions

Both struct and union keywords are supported.

## Typedef

New names for data types can be defined using typedef operation:

```
typedef unsigned char uchar;
```

## Enum

Enumerated data types are an handy type of automatically defined constant series. The declaration assigns a value of zero to the first symbolic constant of the list, and the assigns subsequent values (automatically incremented) to the following constants.

The user can, as well, arbitrarily assign numerical (signed) values at the beginning as well as in the middle of the series. Values following an explicit assignment use that value as a base and keep on incrementing from that point.

The data type for an enum type or typedef variable is, as per ANSI definition, *the smaller type that can contain the absolute maximum value of the constant series.*

```

enum ETypes { E_NONE=0, E_RED, E_GREEN, E_BLUE };

// Same as :
// #define E_NONE 0
// #define E_RED 1
// #define E_GREEN 2
// #define E_BLUE 3

```

## Code size vs Data Types

Be sure to always use the smallest data types possible. The rule is simple: the bigger data types are used, the bigger code will be generated.

Thus, always follow these rules of thumb:

- Use `char` (8-bit or **byte**) as the default, everywhere;
- Use `short` or `int` (16-bit or **word**) for common arithmetic, counters and to hold ADC conversion results on advanced cores (with 10-bit or more internal ADC).
- Only as a as last resort, and only where absolutely necessary, use `long` (32-bit, **dword**) variables.

Another rule that also affects the size of produced code, though in a much smaller degree, is about sign.

Use **unsigned data types** wherever you can, and signed only when necessary. Unsigned math always generates smaller (and typically faster) code than signed.

## Rom

Strings or arrays of data can be placed into program memory.

Such variables are declared using regular data types and `rom` storage specifier.

Such `rom` variables must be initialized within declaration:

```
rom char *text = "Test string"; // text with trailing zero
rom char *ptr = "\x64\x11\x12"; // 4 bytes: 0x64, 0x0B, 0x0C, 0x00
rom char *data = { 0x64, 11, 12 }; // 3 data bytes: 0x64, 0x0B, 0x0C
```

Please keep in mind that the `rom` storage specifier has several limitations:

- `rom` can be used with `char` data types only;
- there is no implicit cast between `rom` and regular data types. Though BoostC will not generate an explicit error for such a cast, it is expected that the operand should be casted back to its original type. If this is not done, the resulting code will behave unpredictably.
- a `rom` pointer is internally limited to 8-bits: the constant array size is thus limited to 256 elements. This is coherent with smaller cores constraints;
- access to `rom` elements has to be done exclusively through the `[]` operators and they **cannot be referenced with substring pointer initialized at runtime**. Please keep in mind that `rom` variables must always and exclusively be initialized within declaration;

Example of wrong referencing with a runtime initialized pointer:

```
/*
Part of the following code is WRONG and will FAIL because BoostC cannot
dynamically create the pointer to mystr[OFFSET] when the mystr array is
located in ROM.
*/
rom char *mystr = "Str_one \0 Str_two \0";
/* WRONG: a rom pointer must be initialized in declaration */
rom char *substr;

    substr = &mystr[OFFSET]; //** WRONG **
    cc = substr[0]; //** WRONG **

    cc = mystr[OFFSET]; // Correct
```

## Volatile

The *volatile* type specifier should be used with variables that:

- a) Can be changed outside the normal program flow, and
- b) Should **not** receive intermediate values within expressions.

For example, if a bit variable is mapped to a port pin, it is a good programming practice to declare such variable as *volatile*.

Code generated for expressions with *volatile* variables is a little longer when compared to 'regular' code:

```
volatile bit pinB1@0x6.1; //declare bit variable mapped to pin 1, port B
```

Currently compiler generates different code only for expressions that assign values to volatile bit variables. Also volatile variables are not checked for being initialized.

### **Static**

Both global and local variables can be declared as static. This limits their scope to the current module.

### **Constants**

Constants can be expressed in binary, octal, decimal and hexadecimal forms:

`0bXXXX` binary number, where X is either 1 or 0  
or  
`XXXXb`  
`0XXXX` octal number, where X is a number between 0 and 7  
`XXXX` decimal number, where X is a number between 0 and 9  
`0xXXXX` hexadecimal number, where X is a number between 0 and 9 or A and F

### **Strings**

Besides regular characters, strings can include escape sequences:

`\nn` ASCII character, value nn is decimal  
`\xnn` ASCII character, value nn is hexadecimal  
`\a` ASCII character 0x07 (ALERT)  
`\b` ASCII character 0x08 (Backspace)  
`\t` ASCII character 0x09 (Horizontal Tab)  
`\r` ASCII character 0x0D (CR, Carriage Return)  
`\v` ASCII character 0x0B (Vertical Tab)  
`\f` ASCII character 0x0C (Form Feed)  
`\n` ASCII character 0x0A (LF, Line Feed)  
`\\` ASCII character 0x5C (the «\» character)  
`\'` ASCII character 0x27 (the «'» character)  
`\"` ASCII character 0x22 (the «"» character)  
`\?` ASCII character 0x3F (the «?» character)

## Variables

Variables can be declared and used in the standard ANSI C way.

The linker will place variables at specific addresses. BoostLink analyzes the call and scope trees, so that it can re-use the same pool of RAM memory locations for variables that don't collide with each other, being used disjointly by unrelated routines active at different times.

This is a very effective way to minimize data memory usage.

### **Register mapped variables**

Variables can be forced to be placed at certain addresses. Syntax is the same as in the legacy C2C compiler:

```
char var@<addr>;
```

where <addr> is an hex or decimal address.

This technique is used to access target specific registers from code.

Please note that system header files already contain all target specific registers, so there is no need to define them again in the user's code.

Bit variables can also have fixed addresses. Their address includes bit position and can be made in 2 forms:

```
bit b; //variable will be placed by linker at arbitrary position
bit b1@0x40.1; // dotted: access bit 1 of register 0x40
bit b2@0x202; // bit offset: access bit 2 of register 0x40 (0x40*8 + 2)
```

### **Bit access**

Besides 'bit' variables, individual bits of every variable can be accessed using the '.' operator:

```
char var;
var.2 = 1; //set bit 2 of variable 'var'
```

## Arrays

Arrays can have any number of dimensions. The only constraint is that an array must fit into a single RAM bank.

## Pointers

Pointers can be used in the standard general way, the only exception being variables declared with the **rom** storage specifiers, that can only be accessed through the [] operators.

## Strings as function arguments

If a function has one or more `char*` arguments, it can be called with a constant string passed as an argument.

The compiler will reuse the same RAM memory allocated for such arguments when several similar calls are made within same code block.

For example, the code below will use the same memory block to temporarily store the strings "Date" and "Time":

```
...  
foo( "Date" );  
foo( "Time" );  
...
```

## Operators

If an operation result is not explicitly casted, it is promoted by default to 16 bit precision. For example, given the following expression:

```
long l = a * 100 / b; // 'a' and 'b' are 16 bit long variables
```

the result of the multiplication will be stored in a 16-bit long (**word**) temporary variable, that will be then divided by **b**. This 16-bit long result will eventually be stored in **l**. This is the ANSI 'C' standard behavior.

This behavior can be changed using the `-Op` compiler command line option or a local `#pragma OPTIMIZE` directive.

When this optimization is applied to the given expression, the multiplication result will be promoted to 32-bit long (**dword**) temporary variable, that will then be divided by **b**: the result, that is now 32 bit long, will eventually be stored in **l**.

## Arithmetic

+ - \* / % ++ --

## Arithmetic Operator Examples

```
// + is a binary operator. It is used to add or produce  
// the arithmetic sum of two operands.  
// Example:  
//      c = a + b;  
//      or  
//      c = 5 + 7; // After the operation c = 12
```

```
// - is a binary operator. It is used to subtract or produce
// the difference of two operands. In other words, the second
// operand is subtracted from the first operand.
```

```
// Example:
```

```
    c = a - b;
// or
    c = 18 - 12; // After the operation c = 6
```

```
// * is a binary operator. It is used to multiply or produce
// the arithmetic product of two operands.
```

```
// Example:
```

```
    c = a * b;
// or
    c = 5 * 7; // After the operation c = 35
```

```
// / is a binary operator. It is used to divide or produce
// the quotient of two operands. In other words, the first
// operand is divided by the second operand.
```

```
// Example:
```

```
    c = a / b;
// or
    c = 24 / 8; // After the operation c = 3
```

```
// % is a binary operator. It is used to produce the modulus
// or remainder when two operands are divided.
```

```
// Examples:
```

```
    c = a % b;
// or
    c = 25 % 8; // After the operation c = 1
    c = 17 % 3; // 17 % 3 = 5 with a remainder of 2
                // After the operation c = 2
    c = 17 % 4; // 17 % 4 = 1 with a remainder of 1
                // After the operation c = 1
```

```
// ++ is a unary operator. It is used for pre-incrementing
// or post-incrementing an operand.
```

```
// Examples:
```

```
    x = 10;
    c = x++; // Post-increment.
             // After the operation x = 11, c = 10

    x = 10;
    c = ++x; // Pre-increment.
             // After the operation x = 11, c = 11
```

```
// -- is a unary operator. It is used for pre-decrementing
// or post-decrementing an operand.
// Examples:
x = 10;
c = x--; // Post-decrement.
// After the operation x = 9, c = 10

x = 10;
c = --x; // Pre-decrement.
// After the operation x = 9, c = 9
```

## Assignment

= += -= \*= /= %= &= |= ^= <<= >>=

## Assignment Operator Examples

```
// = is the ASSIGN operator. The value of the variable or
// expression on the right side of the equal is assigned
// to the variable on the left side of the equal.
// Examples:
x = 3; // whatever was in the variable x
// has been replaced with 3.

x = 2 + 4; // whatever was in the variable x
// has been replaced with 6.

c = x + y; // If x has a value of 12 and y has a value of 16.
// whatever was in the variable c will
// be replaced with 28.
```

```
// += is the combined ADD and ASSIGN operator. The variable
// on the left side of the operator will be added to the
// variable or expression on the right side. The result is
// then assigned to the variable on the left side of the
// operator.
```

```
// Examples:
x += 2; // If x has an initial value of 14. After
// the operation x will be 16.

c += x + y; // If c has an initial value of 10 and x has
// the value 12 and y has the value 16.
// After the operation c will be 38.
```

```
// -= is the combined SUBTRACT and ASSIGN operator. The variable
```



```
// or expression on the right side of the operator will be
// subtracted from the variable on the left side. The result
// is then assigned to the variable on the left side of the
// operator.
```

```
// Examples:
```

```
x -= 2; // If x has an initial value of 14. After
// the operation x will be 12.

c -= x + y; // If c has an initial value of 38 and x has
// the value 12 and y has the value 16.
// After the operation c will be 10.
```

```
// *= is the combined MULTIPLY and ASSIGN operator. The variable
// on the left side of the operator will be multiplied by the
// variable or expression on the right side. The result is
// then assigned to the variable on the left side of the
// operator.
```

```
// Examples:
```

```
x *= 2; // If x has an initial value of 14. After
// the operation x will be 28.

c *= x + y; // If c has an initial value of 10 and x has
// the value 12 and y has the value 16.
// After the operation c will be 280.
```

```
// /= is the combined DIVIDE and ASSIGN operator. The variable
// on the left side of the operator will be divided by the
// variable or expression on the right side. The result
// is then assigned to the variable on the left side of
// the operator.
```

```
// Examples:
```

```
x /= 2; // If x has an initial value of 14. After
// the operation x will be 7.

c /= x + y; // If c has an initial value of 280 and x has
// the value 12 and y has the value 16.
// After the operation c will be 10.
```

```
// %= is the combined MODULUS and ASSIGN operator. The variable
// on the left side of the operator will be divided by the
// variable or expression on the right side. The result,
// which is a remainder only, is then assigned to the
// variable on the left side of the operator.
```

```
// Examples:
```

```
x %= 2; // If x has an initial value of 15. After
// the operation x will be 1.

y %= 7; // If y has an initial value of 17. After
// the operation y will be 3.

c %= x + y; // If c has an initial value of 19 and x has
```

```
// the value 4 and y has the value 3.  
// After the operation c will be 5.
```

```
// &= is the combined BITWISE-AND and ASSIGN operator. The variable  
// on the left side of the operator will be ANDed on a bit-by-bit  
// basis with the variable or constant on the right side. The  
// result is then assigned to the variable on the left side of  
// the operator.
```

```
// Examples:
```

```
x &= y; // If x has an initial value of 14 and y has the  
// value 5. After the operation x will be 4.
```

```
c &= 0x07; // If c has an initial value of 0x0E. After  
// the operation c will be 0x06.
```

```
y &= 0b11110001; // If y has an initial value of 0b10001111.  
// After the operation y will  
// be 0b10000001.
```

```
// |= is the combined BITWISE-OR and ASSIGN operator. The variable  
// on the left side of the operator will be ORed on a bit-by-bit  
// basis with the variable or constant on the right side. The  
// result is then assigned to the variable on the left side of  
// the operator.
```

```
// Examples:
```

```
x |= y; // If x has an initial value of 14 and y has the  
// value 5. After the operation x will be 15.
```

```
c |= 0x07; // If c has an initial value of 0x0E. After  
// the operation c will be 0x0F.
```

```
y |= 0b11110000; // If y has an initial value of 0b10001110.  
// After the operation y will  
// be 0b11111110.
```

```
// ^= is the combined BITWISE-XOR and ASSIGN operator. The variable  
// on the left side of the operator will be XORed on a bit-by-bit  
// basis with the variable or constant on the right side. The  
// result is then assigned to the variable on the left side of  
// the operator.
```

```
// Examples:
```

```
x ^= y; // If x has an initial value of 14 and y has the  
// value 5. After the operation x will be 11.
```

```
c ^= 0x07; // If c has a value of 0x0E. After the  
// operation c will be 0x09.
```

```
y ^= 0b11111000; // If y has an initial value of 0b00011110.  
// After the operation y will  
// be 0b11100110.
```

```
// <<= is the combined SHIFT-LEFT and ASSIGN operator. The variable
```

```
// on the left side of the operator will be shifted left by the
// number of places indicated by the variable or constant on
// the right. The result is then assigned to the variable on
// the left side of the operator.
```

```
// Examples:
```

```
x <<= y;    // If x has an initial value of 14 and y has the
            // value 2. After the operation x will be 56.

c <<= 0x01;  // If c has an initial value of 0x0E. After the
            // operation c will be 0x1C.

y <<= 0b00000010; // If y has an initial value of 0b00011110.
                // After the operation y will
                // be 0b01111000.
```

```
// >>= is the combined SHIFT-RIGHT and ASSIGN operator. The
// variable on the left side of the operator will be shifted
// right by the number of places indicated by the variable
// or constant on the right. The result is then assigned to
// the variable on the left side of the operator.
```

```
// Examples:
```

```
x >>= y;    // If x has an initial value of 14 and y has the
            // value 2. After the operation x will be 3.

c >>= 0x01;  // If c has an initial value of 0x0E. After the
            // operation c will be 0x07.

y >>= 0b00000010; // If y has an initial value of 0b00011110.
                // After the operation y will
                // be 0b00000111.
```

## Comparison

== != < <= > >=

## Comparison Operator Examples

```
// == is a binary operator. It is used to see if one operand
// IS equal to another operand.
```

```
// Example1:
```

```
if( x == y ) // If c has an initial value of 0, and
{           // x has the value 8 and y has the value 8.
    c = x + y; // The final value for c will be 16.
}
```

```
// Example2:
```

```
if( x == y ) // If c has an initial value of 0, and
{           // x has the value 8 and y has the value 5.
    c = x + y; // The final value for c will be 0.
}
```

```
// != is a binary operator. It is used to see if one operand
// is NOT equal to another operand.
```

```
// Example1:
```

```
if( x != y ) // If c has an initial value of 0, and
{ // x has the value 8 and y has the value 5.
    c = x * y; // The final value for c will be 40.
}
```

```
// Example2:
```

```
if( x != y ) // If c has an initial value of 0, and
{ // x has the value 8 and y has the value 8.
    c = x * y; // The final value for c will be 0.
}
```

```
// < is a binary operator. It is used to see if one operand
// is LESS than another operand.
```

```
// Example1:
```

```
if( x < y ) // If c has an initial value of 0, and
{ // x has the value 40 and y has the value 65.
    c = y - x; // The final value for c will be 25.
}
```

```
// Example2:
```

```
if( x < y ) // If c has an initial value of 0, and
{ // x has the value 65 and y has the value 40.
    c = y - x; // The final value for c will be 0.
}
```

```
// <= is a binary operator. It is used to see if one operand
// is LESS than or EQUAL to another operand.
```

```
// Example1:
```

```
if( x <= y ) // If x has a value of 22 and y has a value of 33.
    set_bit( PORTA, LED_bit ); // Turn LED ON
else
    clear_bit( PORTA, LED_bit ); // Turn LED OFF
```

```
// In this example the LED will be turned ON.
```

```
// Example2:
```

```
if( x <= y ) // If x has a value of 15 and y has a value of 8.
    set_bit( PORTA, LED_bit ); // Turn LED ON
else
    clear_bit( PORTA, LED_bit ); // Turn LED OFF
```

```
// In this example the LED will be turned OFF.
```

```
// Example3:
```

```
if( x <= y ) // If x has a value of 46 and y has a value of 46.
    set_bit( PORTA, LED_bit ); // Turn LED ON
```

```
else
    clear_bit( PORTA, LED_bit ); // Turn LED OFF
// In this example the LED will be turned ON.
```

```
// > is a binary operator. It is used to see if one operand
// is GREATER than another operand.
```

```
// Example1:
```

```
if( x > y ) // If c has an initial value of 0, and
{ // x has the value 28 and y has the value 14.
    c = x / y; // The final value for c will be 2.
}
```

```
// Example2:
```

```
if( x > y ) // If c has an initial value of 0, and
{ // x has the value 14 and y has the value 28.
    c = x / y; // The final value for c will be 0.
}
```

```
// >= is a binary operator. It is used to see if one operand
// is GREATER than or EQUAL to another operand.
```

```
// Example1:
```

```
if( x >= y ) // If x has a value of 25 and y has a value of 10.
    set_bit( PORTA, LED_bit ); // Turn LED ON
else
    clear_bit( PORTA, LED_bit ); // Turn LED OFF
```

```
// In this example the LED will be turned ON.
```

```
// Example2:
```

```
if( x >= y ) // If x has a value of 8 and y has a value of 15.
    set_bit( PORTA, LED_bit ); // Turn LED ON
else
    clear_bit( PORTA, LED_bit ); // Turn LED OFF
```

```
// In this example the LED will be turned OFF.
```

```
// Example3:
```

```
if( x >= y ) // If x has a value of 34 and y has a value of 34.
    set_bit( PORTA, LED_bit ); // Turn LED ON
else
    clear_bit( PORTA, LED_bit ); // Turn LED OFF
```

```
// In this example the LED will be turned ON.
```

## Logical

&& || !

### Logical Operator Examples

```
// && is a binary operator. It is used to determine if both operands
// are true. The operands are expressions that evaluate to true
// or false.
```

```
// Example1:
```

```
if( ( temp > 50 ) && ( temp < 100 ) )
    clear_bit( PORTA, ALARM_bit ); // Turn alarm OFF
else
    set_bit( PORTA, ALARM_bit ); // Turn alarm ON
```

```
// If temp has a value of 70 the alarm will be turned OFF.
```

```
// Example2:
```

```
if( ( temp > 50 ) && ( temp < 100 ) )
    clear_bit( PORTA, ALARM_bit ); // Turn alarm OFF
else
    set_bit( PORTA, ALARM_bit ); // Turn alarm ON
```

```
// If temp has a value of 105 the alarm will be turned ON.
```

```
// Example3:
```

```
if( ( temp > 50 ) && ( temp < 100 ) )
    clear_bit( PORTA, ALARM_bit ); // Turn alarm OFF
else
    set_bit( PORTA, ALARM_bit ); // Turn alarm ON
```

```
// If temp has a value of 25 the alarm will be turned ON.
```

```
// || is a binary operator. It is used to determine if either
// operand is true. The operands are expressions that evaluate
// to true or false.
```

```
// Example1:
```

```
if( ( volt > 7 ) || ( volt < 5 ) )
    set_bit( PORTA, LED_bit ); // Turn LED ON
else
    clear_bit( PORTA, LED_bit ); // Turn LED OFF
```

```
// If volt has a value of 8 the LED will be turned ON.
```

```
// Example2:
```

```
if( ( volt > 7 ) || ( volt < 5 ) )
    set_bit( PORTA, LED_bit ); // Turn LED ON
else
    clear_bit( PORTA, LED_bit ); // Turn LED OFF
```

```
// If volt has a value of 6 the LED will be turned OFF.
```

```
// Example3:
    if( ( volt > 7 ) || ( volt < 5 ) )
        set_bit( PORTA, LED_bit );      // Turn LED ON
    else
        clear_bit( PORTA, LED_bit ); // Turn LED OFF
// If volt has a value of 4 the LED will be turned ON.
```

```
// ! is a unary operator. It is used to complement an evaluated
// operand. The operand is an expression that evaluates to
// true or false.
```

```
// Example1:
    if( !( pressure > 120 ) )
        clear_bit( PORTA, ALARM_bit ); // Turn alarm OFF
    else
        set_bit( PORTA, ALARM_bit ); // Turn alarm ON
// If pressure has a value of 75 the alarm will be turned OFF.
```

```
// Example2:
    if( !( pressure > 120 ) )
        clear_bit( PORTA, ALARM_bit ); // Turn alarm OFF
    else
        set_bit( PORTA, ALARM_bit ); // Turn alarm ON
// If pressure has a value of 125 the alarm will be turned ON.
```

## Bitwise

& | ^ ~ << >>

## Bitwise Operator Examples

```
// & is a binary operator. It is used to produce the logical product
// of two operands. The individual bits of two operands are ANDed
// together to produce the final results.
```

```
// Examples:
```

```
c = x & y; // If x has a value of 14 and y has a value
           // of 5. After the operation c will be 4.
```

```
x = y & 0x07; // If y has a value of 0x0E. After the
              // operation x will be 0x06.
```

```
x = y & 0b11110001; // If y has a value of 0b10001111.
                   // After the operation x will
                   // be 0b10000001.
```

```
// | is a binary operator. It is used to produce the logical sum of
// two operands. The individual bits of two operands are OREd
// together to produce the final results.
```

```
// Examples:
```

```
c = x | y; // If x has a value of 14 and y has a value
// of 5. After the operation c will be 15.
```

```
x = y | 0x07; // If y has a value of 0x0E. After the
// operation x will be 0x0F.
```

```
x = y | 0b11110000; // If y has a value of 0b10001110.
// After the operation x will
// be 0b11111110.
```

```
// ^ is a binary operator. It is used to produce the logical
// difference of two operands. The individual bits of two operands
// are XORed together to produce the final results.
```

```
// Examples:
```

```
x = y ^ 0x07; // If y has a value of 0x0E. After the
// operation x will be 0x09.
```

```
x = y ^ 0b11111000; // If y has a value of 0b00011110.
// After the operation x will
// be 0b11100110.
```

```
// ~ is a unary operator. It is used to produce the complement of an
// operand. The individual bits of the operand are complemented.
// The ones become zeros and the zeros become ones.
```

```
// Examples:
```

```
x = ~y; // If y has a value of 0x0E. After the
// operation x will be 0xF1.
```

```
x = ~0b01010111; // After the operation x will
// be 0b10101000.
```

```
// << is a binary operator. The operand on the left side of the
// operator will be shifted left by the number of places
// indicated by the operand on the right.
```

```
// Examples:
```

```
c = x << y; // If x has a value of 14 and y has a value
// of 2. After the operation c will be 56.
```

```
x = y << 0x01; // If y has a value of 0x0E. After the
// operation x will be 0x1C.
```

```
x = y << 0b00000010; // If y has a value of 0b00011110.
// After the operation x will
// be 0b01111000.
```

```
// >> is a binary operator. The operand on the left side of the
```



```

//      operator will be shifted right by the number of places
//      indicated by the operand on the right.
// Examples:
c = x >> y;    // If x has a value of 14 and y has a value of 2.
               // After the operation c will be 3.
x = y >> 0x01; // If y has a value of 0x0E. After the operation
               // x will be 0x07.
x = y >> 0b00000010; // If y has a value of 0b00011110.
                    // After the operation x will
                    // be 0b00000111.

```

## Conditionals

if / else statement  
 switch statement  
 ? : ternary operator

## Conditional Examples

```

// if / else is a two-way decision making statement. If the
// expression evaluates to true, the first statement
// will be executed. If it evaluates to false the
// second statement will be executed.
// Example1:
if( x > y ) // If x has a value of 25 and y has a value of 10.
  set_bit( PORTA, LED_bit ); // Turn LED ON
else
  clear_bit( PORTA, LED_bit ); // Turn LED OFF
// In this example the LED will be turned ON.
// Example2:
if( x > y ) // If x has a value of 8 and y has a value of 15.
  set_bit( PORTA, LED_bit ); // Turn LED ON
else
  clear_bit( PORTA, LED_bit ); // Turn LED OFF
// In this example the LED will be turned OFF.

```

```

// switch is a multi-way decision making statement. The variable is
// compared with the different cases. The case that matches
// will have its statements executed.
// Example1:

```

```

switch( weight )
{
    case 5:
        set_bit( PORTA, red_LED );    // Turn red LED ON
        clear_bit( PORTA, green_LED ); // Turn green LED OFF
        break;
    case 10:
        set_bit( PORTA, green_LED );  // Turn green LED ON
        clear_bit( PORTA, red_LED );  // Turn red LED OFF
        break;
    default:
        clear_bit( PORTA, green_LED ); // Turn green LED OFF
        clear_bit( PORTA, red_LED );  // Turn red LED OFF
}
// If the 'weight' variable has a value of 5 the red LED will
// be turned ON and the green LED will be turned OFF.

```

// Example2:

```

switch( weight )
{
    case 5:
        set_bit( PORTA, red_LED );    // Turn red LED ON
        clear_bit( PORTA, green_LED ); // Turn green LED OFF
        break;
    case 10:
        set_bit( PORTA, green_LED );  // Turn green LED ON
        clear_bit( PORTA, red_LED );  // Turn red LED OFF
        break;
    default:
        clear_bit( PORTA, green_LED ); // Turn green LED OFF
        clear_bit( PORTA, red_LED );  // Turn red LED OFF
}
// If the 'weight' variable has a value of 10 the green LED will
// be turned ON and the red LED will be turned OFF.

```

// Example3:

```

switch( weight )
{
    case 5:
        set_bit( PORTA, red_LED );    // Turn red LED ON
        clear_bit( PORTA, green_LED ); // Turn green LED OFF
        break;
    case 10:
        set_bit( PORTA, green_LED );  // Turn green LED ON
        clear_bit( PORTA, red_LED );  // Turn red LED OFF
        break;
    default:
        clear_bit( PORTA, green_LED ); // Turn green LED OFF
        clear_bit( PORTA, red_LED );  // Turn red LED OFF
}
// If the 'weight' variable has any value other than 5 or 10,
// both the green and red LEDs will be turned OFF.

```

```

// ? : is an if/else operator. This operator can be used inside an
// expression to determine if a part of it is true or false.

```

```

// Example1:          turn the LED ON          turn the LED OFF

```

```

        (volts > 5) ? set_bit(PORTA, LED_bit) : clear_bit(PORTA, LED_bit);
// If 'volts' has a value of 7 turn the LED ON.

// Example2:                turn the LED ON                turn the LED OFF
        (volts > 5) ? set_bit(PORTA, LED_bit) : clear_bit(PORTA, LED_bit);
// If 'volts' has a value of 3 turn the LED OFF.

```

## Program Flow

```

while
do / while
for
break
continue

```

### Program Flow Examples

```

// while is a loop control construct. It controls the execution of
// a block of statements for as long as an expression evaluates
// to true. The expression is evaluated first and if true,
// executes the block. If it evaluates to false, stop the
// execution.

// Example1:
    while( number > 0 )
    {
        factorial *= number;    // 'factorial' is initialized to 1
        --number;              // before entering the loop.
    }

// If 'number' has a value of 3 'factorial' will become 6.
// factorial = 3 x 2 x 1 ;

// Example2:
    while( number > 0 )
    {
        factorial *= number;    // 'factorial' is initialized to 1
        --number;              // before entering the loop.
    }

// If 'number' has a value of 0, 'factorial' will stay
// equal to 1 because the loop was never entered.

```

```

// do / while is a loop control construct. It controls the execution
// of a block of statements for as long as an expression
// evaluates to true. The block is executed at least once
// before the expression is evaluated. If it evaluates to
// false, stop the execution. If it evaluates to true,

```

```
//          continue the execution.
// Example1:
do
{
    factorial *= number;    // 'factorial' is initialized to 1
    --number;              // before entering the loop.
} while( number > 0 );
// If 'number' has a value of 4 'factorial' will become 24.
// factorial = 4 x 3 x 2 x 1 ;
// Example2:
do
{
    factorial *= number;    // 'factorial' is initialized to 1
    --number;              // before entering the loop.
} while( number > 0 );
// If 'number' has a value of 0, 'factorial' will become 0 because
// the loop was entered, before the expression was evaluated.
```

```
// for is a loop control construct. It controls the number of times
// a block of statements is executed. The construct has an
// initial value, a final value, and a loop-count value that is
// incremented each time after the block is executed.
// Example1:
for( volts = 0; volts < 7; volts++ )
{
    sum += volts;          // 'sum' is initialized to 0
}                          // before entering the loop.
// Upon exiting the loop 'sum' will have a value of 21.
```

```
// break is an option that can be used to exit out of a for-loop,
// based upon the evaluation of an expression.
// Example1:
for( volts = 0; volts < 7; volts++ )
{
    if( volts == 5 )
        break;
    sum += volts;          // 'sum' is initialized to 0
}                          // before entering the loop.
// Upon exiting the loop 'sum' will have a value of only 10.
```

```
// continue is an option used to redirect a for-loop based upon the
// evaluation of an expression. If the expression evaluates
// to true, the block of statements will not be executed.
// Example1:
```

```

for( volts = 0; volts < 7; volts++ )
{
    if( volts == 5 )
        continue;

    sum += volts;    // 'sum' is initialized to 0
                    // before entering the loop.
}

// Upon exiting the loop 'sum' will have a value of only 16.
// 'sum' will only have the values 0, 1, 2, 3, 4, & 6 added together.

```

## Goto

In the vast majority of programming books, the usage of 'goto' is heavily deprecated. This is true for BoostC and PIC C coding as well: it should normally be avoided.

There are, anyway, some very specific circumstances where it may still be useful: to optimize early exit cases within complex nested control structures or to simplify local error handling (it can somehow mimic try/catch exception handling syntax).

```

while( ... )
{
    while(...)
    {
        while(...)
        {
            goto exit;
        }
    }
}
exit:

```

## Inline assembly

Use the [asm](#) or [\\_asm](#) operators to embed assembly into C code.

Bank switching and code page switching code should NOT be added to inline assembly code. The linker will add the appropriate Bank switching and code page switching code.

### ***asm***

Code will be affected as follows:

- Bank switching added automatically.
- Code page switching added automatically.

### ***\_asm***

Code will be affected as follows:

- Bank switching added automatically.
- Code page switching added automatically.
- Other optimizations applied (including dead code removal).

Assembly operators can be used in single line or multi line modes. Single line mode operates on one assembly instruction that follows the `asm` or `_asm` operators on the same line:

```
asm nop
```

In multi line mode assembly instructions are enclosed into curly braces that should be placed on different than assembly code lines:

```
asm
{
    nop
    nop
    nop
}
```

### ***Variable Referencing in asm***

To refer to a C variable from inline assembly, simply prefix its name with an underscore `'_'`. If a C variable name is used with the `'movlw'` instruction, the address of this variable is copied into W.

Labels are identified with a trailing semicolon `':'` after the label name.

### ***Constants in asm***

Inline assembly supports decimal and hexadecimal constants only:

- `XXXX` decimal number, where X is a number between 0 and 9
- `0xXXXX` hexadecimal number, where X is a number between 0 and 9 or A and F
- `0bXXXX` binary number, where X is a number between 0 and 1

### ***Inline assembly example 1***

```
// Example showing use of bit tests and labels in inline assembly
#include <system.h>

void foo()
{
    unsigned char i, b;
    i = 0;
    b = 12;
    asm
    {
        start:
        btfsc _i, 4
        goto end
        btfss _b, 0
        goto iter

        iter:
        movlw 0
        movwf _b
        end:
    }
}
```

```
}
```

### ***Inline assembly example 2***

```
// Example for PIC18F8720 target showing how to access bytes of
// integer arguments
#include <system.h>

int GetTmr1Val()
{
    int x;
    asm
    {
        movf _tmr1h, W
        movwf _x+1 ; write to high byte of variable x
        movf _tmr1l, W
        movwf _x ; write to low byte of variable x
    }

    return x;
}
```

### ***Inline assembly example 3***

```
// Example of how to access structure members from inline assembly.
//
// Note: This code may not work as expected if the data structure
// is modified causing member count2 to have a different offset.

struct Stats
{
    unsigned int count0; // stored in bytes 0 & 1
    unsigned char count1; // stored in byte 2
    unsigned int count2; // stored in bytes 3 & 4
};

struct Stats myStats;

void AddCount2()
{
    int x;
    asm
    {
        movf _myStats+3, W
        addlw 0x01
        movwf _myStats+3
        btfsc _status, C
        incf _myStats+4, F
    }
}
```

### ***User Data***

User data can be placed at the current location using the 'data' assembly instruction followed by comma separated numbers or strings.

Example:

```
// Code below will place bytes 10,11,116,101,115,116,0
// at current code location
asm data 0xA, 0xB, "test"
```

## Functions

### *Inline functions*

Functions declared as inline are repeatedly embedded into the code for each occurrence. When a function is defined as inline, its body must be defined before it gets called for the first time.

Though any function can be declared as inline, procedures (functions with no return value and a possibly empty argument list) are best suited to be used as inline. An exception to this rule are inline functions with reference arguments. Such functions will not overload variables passed as arguments but will operate directly on them:

```
inline void foo( char &port )
{
    port = 0xFF; // set all pins of a port
}
```

**An heavy usage of inline functions obviously augments code size.**

### *Special functions*

```
void main(void)
```

Program entry point. This function is mandatory for every C program.

```
void interrupt(void)
```

Interrupt handler function. Is linked to high priority interrupts for PIC18 parts.

```
void interrupt_low(void)
```

Low priority interrupt handler, can be used only on the PIC18 family.

### *General functions and interrupts*

Standard user functions are not *thread-safe*: their local variables are **not** saved when function execution gets interrupted by an interrupt. This can lead to very hard to trace errors.

To help prevent this pitfall, the linker generates a serious warning when a function is called from both main() and interrupt threads.



If you really need to use same function in both threads, you need to duplicate its code and assign a different name to the second copy, or ensure that interrupts are appropriately disabled when the function is called from non-interrupt code so that its execution cannot be interrupted.

```
//This function gets called from main thread
void foo()
{
    ...
}

//Copy of 'foo' that will be called from interrupt thread
void foo_interrupt()
{
    ...
}

//Interrupt thread
void interrupt( void )
{
    foo_interrupt();
    ...
}

//Main thread
void main( void )
{
    foo();
    ...
}
```

### ***Functions pointers***

Function pointers are supported with the following limitations:

- arrays of function pointers are not supported.

```
void foo1()
{
    ...
}

void foo2()
{
    ...
}

//Pointer to a function
void (*foo)();

//Program entry point
void main( void )
{
```

```
...
foo = foo1;
foo(); //foo1 is called
foo = foo2;
foo(); //foo2 is called
...
}
```

### **Memory mapped functions**

Functions just as variables can be forced to be placed at certain addresses. Syntax is the same as in the legacy C2C compiler:

```
void foo() @ <addr>;
```

where <addr> is an hex or decimal address.

```
//This function placed at address 0x100
void foo1() @ 0x100
{
...
}
```

In most cases there is no need to use memory mapped functions as linker will analyze the code and optimize function allocation. Only very special occasions require this feature.

## **Dynamic memory management**

Dynamic memory management is used to dynamically create and destroy objects at run time.

For example, this functionality may be needed when a program needs to keep several data packets. Memory for this packets can also be allocated at compile time, but this way the memory may not be available for other variables even if it's not used.

The solution is to use dynamic memory allocation. Objects to store data are created as soon as they are needed and destroyed after data gets processed.

This way all available target data memory is used most efficiently.

The amount of possible objects that can be allocated depends on the specific PIC part at hand, and on the application.

When the application is built, the linker uses RAM memory left after allocation of global and local variables as a heap. When some memory gets allocated at run time by the 'alloc' call, it gets allocated from this heap. The bigger the heap, the more run time objects can exist at any given time.

```
void* alloc(unsigned char size)
```

Dynamically allocate memory 'size' bytes long. Max size is 127 bytes. Returns NULL if memory can't be allocated.

```
void free(void *ptr)
```

Free memory previously allocated by 'alloc'. Passing any other pointer will lead to unpredictable results.

## ***C language superset***

The BoostC compiler has some advanced features "borrowed" from C++ language. These features allow development of more flexible and powerful code, but their use is merely optional.

### **References as function arguments**

Function arguments can be references to other variables.

When such argument changes inside a function the original variable used in function call changes too.

This is a very powerful way to alter the data flow without blowing up the generated code:

```
void foo(char &n)           //'n' is a reference
{
    n = 100;
}

void main(void)
{
    char a = 0;
    foo( a );               //upon return 'a' will have value of 100
    ...
}
```

### ***Notes on using references as function arguments***

For general efficiency, the mechanism used to pass a variable by reference is that of taking a copy of the variable data when the function is called, and by copying the data back to the original variable after the function has been exited.

Passing a large structure by reference will generate a large amount of code to copy the data back and fourth. Passing volatile variables (those declared using the volatile type specifier) may result in not the behavior you would expect, despite being a volatile variable its value will only get updated on exit of the function.

General guidelines:

- Don't pass large data structures by reference.
- Don't pass volatile data by reference.

### **Function overloading**

There can be more than one function in the same application having a given name. Such functions must anyway differ by the number and type of their arguments:

```

void foo( void )           //'foo' number 1
{
...
}

void foo( char *ptr )     //'foo' number 2
{
...
}

void foo( char a, char b )  //'foo' number 3
{
...
}

void main( void )
{
    foo();           //'foo' number 1 gets called
    foo( "test" );  //'foo' number 2 gets called
    foo( 10, 20 );  //'foo' number 3 gets called
    ...
}

```

The compiler will generate internal references to the functions so that no ambiguity is possible (*name mangling*), and will select which function will be invoked for each call analyzing how many parameters are passed, as well as their type.

## Function templates

Functions can be declared and defined using data type placeholders. This feature allows writing very general code (for example, linked lists handling) that is not tied to a particular data type and, what may be more important, allows the user to create template libraries contained in header files:

```

template <class T>
void foo( T *t )
{
...
}

void main( void )
{
    short s;
    foo<char>( "test" );    //'foo( char* )' gets called
    foo<short>( &s );      //'foo( short* )' gets called
    ...
}

```

## ***Parametric timing functions***

Most of software based timing functions are strictly dependent on clock speed. As this parameter is usually well known at linking time, depending only on hardware design and implementation, such functions can be dynamically generated, once the clock frequency is correctly assigned with the `CLOCK_FREQ` pragma.

These functions can be used in the standard way when writing any program for BoostC.

### ***void delay\_us( unsigned char t )***

(generated function) Delays execution for 't' micro seconds. Declared in `boostc.h` This function gets generated every time a project is linked and is controlled by the `CLOCK_FREQ` pragma. In some cases when clock frequency is too low it's not physically possible to generate this function. If that's the case linker will issue a warning.

### ***void delay\_10us( unsigned char t )***

(generated function) Delays execution for 't\*10' micro seconds. Declared in `boostc.h` This function gets generated every time a project is linked and is controlled by the `CLOCK_FREQ` pragma. In some cases, when clock frequency is too low, it's not physically possible to generate this function. If that's the case, the linker will issue a warning.

### ***void delay\_100us( unsigned char t )***

(generated function) Delays execution for 't\*100' micro seconds. Declared in `boostc.h` This function gets generated every time a project is linked and is controlled by the `CLOCK_FREQ` pragma. In some cases, when clock frequency is too low, it's not physically possible to generate this function. If that's the case, the linker will issue a warning.

### ***void delay\_ms( unsigned char t )***

(generated function) Delays execution for 't' milli seconds. Declared in `boostc.h` This function gets generated every time a project is linked and is controlled by the `CLOCK_FREQ` pragma.

### ***void delay\_s( unsigned char t )***

(generated function) Delays execution for 't' seconds. Declared in `boostc.h` This function gets generated every time a project is linked and is controlled by the `CLOCK_FREQ` pragma.

**Notes about delays:** The delays provided are ***at least*** the value specified, the delays will be longer rather than shorter. The delays produced may be larger than expected if the delay routine is interrupted by an interrupt.

When the clock frequency is such that the delay becomes highly inaccurate then the delay overhead, unit delay and delay resolution of the delay are displayed during the linking process.

**Delay Overhead** – The delay created in calling, setting up and returning from the delay function.

**Unit Delay** – The amount of additional delay generated for a delay value increase of 1.

**Delay Resolution** – The amount the delay value has to be increased before an actual increase in the delay occurs. A delay resolution of 4 would mean that the delay value may need to be increased by a value of up to 4 in order to see an increase in the delay.

## **System Libraries**

A number of standard functions are included into BoostC installations. The number of such functions isn't static. It increases from release to release as new features are added. Most of these functions are declared in boostc.h (It's not recommended to include boostc.h directly into your code. Instead include system.h which in turn included boostc.h)

### **General purpose functions**

#### ***clear\_bit( var, num )***

(macro) Clears bit 'num' in variable 'var'. Declared in boostc.h

#### ***set\_bit( var, num )***

(macro) Sets bit 'num' in variable 'var'. Declared in boostc.h

#### ***test\_bit( var, num )***

(macro) Tests if bit 'num' in variable 'var' is set. Declared in boostc.h

#### ***MAKESHORT( dst, lobyte, hibyte )***

(macro) Makes a 16 bit long value (stored in 'dst') from two 8-bit long values (low byte 'lobyte' and high byte 'hibyte'). 'dst' must be a 16-bit long variable. Declared in boostc.h

```
unsigned short res;  
MAKESHORT( res, adres1, adresh ); //make 16 bit value from adresh:adres1  
registers and write it into variable 'res'
```

#### ***LOBYTE( dst, src )***

(macro) Gets low byte from 'src' and writes it into 'dst'. Declared in boostc.h

#### ***HIBYTE( dst, src )***

(macro) Gets high byte from 'src' and writes it into 'dst'. 'src' must be a 16-bit long variable. Declared in boostc.h

#### ***void nop( void )***

(inline function) Generates one 'nop' instruction. Declared in boostc.h

***void clear\_wdt( void )***

(inline function) Generates one 'clrwdt' instruction. Declared in boostc.h

***void sleep( void )***

(inline function) Generates one 'sleep' instruction. Declared in boostc.h

***void reset( void )***

(inline function) "Soft" resets the CPU. Please note that "soft" reset may differ from hardware reset in the way how SFRs get initialised. Declared in boostc.h

**String and Character Functions*****void strcpy( char \*dst, const char \*src )******void strcpy( char \*dst, rom char \*src )******void strncpy( char \*dst, const char \*src, unsigned char len )******void strncpy( char \*dst, rom char \*src, unsigned char len )***

(function) Copies zero terminated string 'src' into destination buffer 'dst'. Destination buffer must be big enough for string to fit. Declared in string.h

***unsigned char strlen( const char \*src )******unsigned char strlen( rom char \*src )***

(function) Returns length of a string. Declared in string.h

***signed char strcmp( const char \*src1, const char \*src2 )******signed char strcmp( rom char \*src1, const char \*src2 )******signed char strcmp( const char \*src1, rom char \*src2 )******signed char strcmp( rom char \*src1, rom char \*src2 )******signed char stricmp( const char \*src1, const char \*src2 )******signed char stricmp( rom char \*src1, const char \*src2 )******signed char stricmp( const char \*src1, rom char \*src2 )******signed char stricmp( rom char \*src1, rom char \*src2 )***

(function) Compares two strings. Returns -1 if string #1 is less than string #2, 1 if string #1 is greater than string #2 or 0 if string #1 is same as string #2. Declared in string.h



***signed char strncmp( char \*src1, char \*src2, unsigned char len )***  
***signed char strncmp( rom char \*src1, char \*src2, unsigned char len )***  
***signed char strncmp( char \*src1, rom char \*src2, unsigned char len )***  
***signed char strncmp( rom char \*src1, rom char \*src2, unsigned char len )***

***signed char strnicmp( char \*src1, char \*src2, unsigned char len )***  
***signed char strnicmp( rom char \*src1, char \*src2, unsigned char len )***  
***signed char strnicmp( char \*src1, rom char \*src2, unsigned char len )***  
***signed char strnicmp( rom char \*src1, rom char \*src2, unsigned char len )***

(function) Compares first 'len' characters of two strings. Returns -1 if string #1 is less than string #2, 1 if string #1 is greater than string #2 or 0 if string #1 is same as string #2. Declared in string.h

***void strcat( char \*dst, const char \*src )***  
***void strcat( char \*dst, rom char \*src )***

***void strncat( char \*dst, const char \*src, unsigned char len )***  
***void strncat( char \*dst, rom char \*src, unsigned char len )***

(function) Appends zero terminated string 'src' to destination string 'dst'. Destination buffer must be big enough for string to fit. Declared in string.h

***char\* strpbrk( const char \*ptr1, const char \*ptr2 )***  
***char\* strpbrk( const char \*src, rom char \*src )***

***unsigned char strcspn( const char \*src1, const char \*src2 )***  
***unsigned char strcspn( rom char \*src1, const char \*src2 )***  
***unsigned char strcspn( const char \*src1, rom char \*src2 )***  
***unsigned char strcspn( rom char \*src1, rom char \*src2 )***

(function) Locates the first occurrence of a character in the string that doesn't match any character in the search string. Declared in string.h

***unsigned char strspn( const char \*src1, const char \*src2 )***  
***unsigned char strspn( rom char \*src1, const char \*src2 )***  
***unsigned char strspn( const char \*src1, rom char \*src2 )***  
***unsigned char strspn( rom char \*src1, rom char \*src2 )***

(function) Locates the first occurrence of a character in the string. Declared in string.h

***char\* strtok( const char \*ptr1, const char \*ptr2 )***  
***char\* strtok( const char \*src, rom char \*src )***

(function) Breaks string pointed into a sequence of tokens, each of which is delimited by a character from delimiter string. Declared in string.h

***char\* strchr( const char \*src, char ch )***

(function) Locates the first occurrence of a character in the string. Declared in string.h

***char\* strrchr( const char \*src, char ch )***

(function) Locates the last occurrence of a character in the string. Declared in string.h

***char\* strstr( const char \*ptr1, const char \*ptr2 )***

***char\* strstr( const char \*src, rom char \*src )***

(function) Locates the first occurrence of a sub-string in the string. Declared in string.h

## Conversion Functions

**Note:** When using conversion functions that store the ASCII result in a buffer, be sure to provide a buffer of sufficient size or other memory may get overwritten. The buffer needs to be enough to store the resulting characters and a null terminator.

***unsigned char sprintf( char\* buffer, const char \*format, unsigned int val )***

Outputs a numerical value to a string in the specified format. The buffer must be long enough to hold the result. Only one numerical value can be output at a time. Declared in stdio.h.

Format specified in the format string with the following format:

**%[Flags][Width][Radix specifier]**

### Flags

Flag	Description
-	<i>Left justifies the field, the default is right justification.</i>
+	Causes the output to be prefixed with a sign, either + or negative. space
space	Prefixes positive numbers with a space (where the sign would go), and negative numbers with a '-'. space
0	Pads numerical values with leading zeroes' to make the specified width

### width

Implementation of field width is non standard - If a justification width is specified the width will be padded **or truncated** to the width value specified. The most significant digits and sign maybe truncated. This is done to prevent unexpected buffer overrun which can occur in standard implementations.

### Radix Specifier

Radix	Description
-------	-------------

Specifier	
o	Radix is octal (base 8), value is unsigned
d	Radix is decimal (base 10), values is signed.
u	Radix is decimal (base 10), value is unsigned
X	Radix is hexadecimal (base 16), value is unsigned
b	Radix is binary (base 2), value is unsigned

### Examples

Radix Specifying	Example output	Description
"%d"	"-120"	decimal signed integer
"%u"	"150"	decimal unsigned integer
"%o"	"773"	octal unsigned integer
"%X"	"ABF1"	hex unsigned integer
"%b"	"101101"	binary unsigned integer

Justification	Example output	Description
"%8d"	" 231"	right justified, padded to 8 characters length
"%016u"	"0000000000045102"	right justified, padded with zeroes to 16 characters length
"%-8b"	"10 "	left justified, padded 8 characters length

Display of sign	Example output	Description
"%+8d"	" +972"	right justified, padded 8 characters length, signed always displayed
"% 8d"	" 765"	right justified, padded 8 characters length, positive signed displayed as ' '

Display of sign only applies to signed decimal radix. Radix and field width added just to show complete format specification

***unsigned char sprintf32( char\* buffer, const char \*format, unsigned long val )***

Outputs a numerical value to a string in the specified format. The buffer must be long enough to hold the result. Only one numerical value can be output at a time. Declared in stdio.h.

This function operates as sprintf, but it handles a 32bit value. It also supports the "%l" radix specifier, which is handled the same as "%d".

***int strtol( const char\* buffer, char\*\* endPtr, unsigned char radix )***

(Function) String to integer. A function that converts the numerical character string supplied into a signed integer (16 bit) value using the radix specified. Radix valid range 2 to 26.

**buffer:** Pointer to a numerical string.

**endPtr:** Address of a pointer. This is filled by the function with the address where string scan has ended. Allows determination of where there is the first non-numerical character in the string. Passing a NULL is valid and causes the end scan address not to be saved.

**radix:** The radix (number base) to use for the conversion, typical values: 2 (binary), 8 (octal), 10 (decimal), 16 (hexadecimal).

**Return:** The converted value.

***long strtoll( const char\* buffer, char\*\* endPtr, unsigned char radix );***

(Function) String to long integer. A function that converts the numerical character string supplied into a signed long integer (32 bit) value using the radix specified. Radix valid range 2 to 26.

**buffer:** Pointer to a numerical string

**endPtr:** Address of a pointer. This is filled by the function with the address where string scan has ended. Allows determination of where there is the first non-numerical character in the string. Passing a NULL is valid and causes the end scan address not to be saved.

**radix:** The radix (number base) to use for the conversion, typical values: 2 (binary), 8 (octal), 10 (decimal), 16 (hexadecimal).

**Return:** The converted value.

***int atoi( const char\* buffer )***

(Macro) ASCII to integer. A macro that converts the numerical character string supplied into a signed integer (16 bit) value using a radix of 10.

**buffer:** Pointer to a numerical string.

**Return:** The converted value.

Note: Macro implemented as: #define atoi( buffer ) strtol( buffer, NULL, 10 )

### ***long atol( const char\* buffer )***

(Macro) ASCII to long integer. A macro that converts the numerical character string supplied into a signed long integer (32 bit) value using a radix of 10.

**buffer:** Pointer to a numerical string.

**Return:** The converted value.

Note: Macro implemented as: `#define atoi( buffer ) strtol( buffer, NULL, 10 )`

### ***char\* itoa( int val, char\* buffer, unsigned char radix )***

(Function) Integer to ASCII. Function that converts an integer (16 bit) value into a character string.

### ***char\* ltoa( long val, char\* buffer, unsigned char radix )***

(Function) Long integer to ASCII. Function that converts an long integer (32 bit) value into a character string.

### ***unsigned char sqrt( unsigned short val )***

(Function) Integer square root. Function that returns square root from an unsigned 16 bit integer.

## **Lightweight Conversion Functions**

The standard conversion functions offer a lot of flexibility at the cost of ROM, RAM and execution time. For application that are short of RAM and ROM, or require shorter execution time, it maybe desirable to use the following lightweight functions.

### ***void uitoa\_hex( char\* buffer, unsigned int val, unsigned char digits )***

(Function) Unsigned integer to ASCII, hexadecimal representation. This function converts a 16 bit unsigned integer into a hex value with leading zeros. The number of digits is specified using by the *digits* parameter.

### ***void uitoa\_bin( char\* buffer, unsigned int val, unsigned char digits )***

(Function) Unsigned integer to ASCII, binary representation. This function converts a 16 bit unsigned integer into a binary value with leading zeros. The number of digits is specified using by the *digits* parameter.

### ***void uitoa\_dec( char\* buffer, unsigned int val, unsigned char digits )***

(Function) Unsigned integer to ASCII, decimal representation. This function converts and 16 bit unsigned integer into a decimal value with leading zeros. The number of digits is specified using by the *digits* parameter.

### ***unsigned int atoui\_hex( const char\* buffer )***

(Function) ASCII to unsigned integer, hexadecimal representation. This function converts a hexadecimal string value into 16 bit unsigned integer.

### ***unsigned int atoui\_bin( const char\* buffer )***

(Function) ASCII to unsigned integer, binary representation. This function converts a binary string value into 16 bit unsigned integer.

### ***unsigned int atoui\_dec( const char\* buffer )***

(Function) ASCII to unsigned integer, decimal representation. This function converts a decimal string value into 16 bit unsigned integer.

### ***unsigned char sqrt1( unsigned short val )***

(Function) Integer square root. Function that returns square root from an unsigned 16 bit integer. Unlike sqrt this function is far shorter but its execution time may be longer than sqrt.

## **Character**

### ***char toupper( char ch )***

(function) Converts lowercase character to uppercase. Declared in ctype.h

### ***char tolower( char ch )***

(function) Converts uppercase character to lowercase. Declared in ctype.h

### ***char isdigit( char ch )***

(function) Checks if character 'ch' is a digit. Returns non zero if this is a digit. Declared in ctype.h

### ***char isalpha( char ch )***

(function) Checks if character 'ch' is a letter. Returns non zero if this is a letter. Declared in ctype.h

### ***char isalnum( char ch )***

(function) Checks if character 'ch' is a letter or a digit. Returns non zero if this is a letter or a digit. Declared in ctype.h

### ***char isblank( char ch )***

(function) Returns a 1 if the argument is a standard blank character. All other inputs will return a 0. The following are the standard blank characters:

' ' (space) or '\t' (horizontal tab). Declared in ctype.h

### ***char iscntrl( char ch )***

(function) Returns a 1 if the argument is a valid control character. All other inputs will return a 0. Declared in ctype.h

### ***char isgraph( char ch )***

(function) Returns a 1 if the argument is a valid displayable ASCII character. All other inputs will return a 0. Declared in ctype.h

### ***char islower( char ch )***

(function) Returns a 1 if the argument is a valid lower-case ASCII letter. All other inputs will return a 0. Declared in ctype.h

### ***char isprint( char ch )***

(function) Returns a 1 if the argument is a valid printable ASCII character. All other inputs will return a 0. Declared in ctype.h

### ***char ispunct( char ch )***

(function) Returns a 1 if the argument is a valid punctuation character. All other inputs will return a 0. The following are the implemented punctuation characters:  
! " # \$ % & ' ( ) \* + , - . / : ; < = > ? @ [ \ ] ^ \_ ` { | } ~

### ***char isspace( char ch )***

(function) Returns a 1 if the argument is a standard white-space character. All other inputs will return a 0. Declared in ctype.h. The following are the standard white-space characters:

Character Description	Character ASCII code	Character Escape sequence
space	0x20	' '
horizontal tab	0x09	'\t'
vertical tab	0x0B	'\v'
newline	0x0A	'\n'
carriage return	0x0D	'\r'
form feed	0x0C	'\f'

### ***char isupper( char ch )***

(function) Returns a 1 if the argument is a valid upper-case ASCII letter. All other inputs will return a 0. Declared in ctype.h

### ***char isxdigit( char ch )***

(function) Returns a 1 if the argument is a valid hexadecimal character. All other inputs will return a 0. Declared in ctype.h

### ***void\* memchr( const void \*ptr, char ch, unsigned char len )***

(function) Locates the first character in memory. Declared in memory.h

***signed char memcmp( const void \*ptr1, const void \*ptr2, unsigned char len )***

(function) Compares memory. Declared in memory.h

***void\* memcpy( void \*dst, const void \*src, unsigned char len )***

(function) Copies memory. Declared in memory.h

***void\* memmove( void \*dst, const void \*src, unsigned char len )***

(function) Moves memory. Declared in memory.h

***void\* memset( void \*ptr, char ch, unsigned char len )***

(function) sets memory. Declared in memory.h

## **Miscellaneous Functions**

***unsigned short rand( void )***

(function) Generates pseudo random number. Declared in rand.h Defined in rand.lib

***void srand( unsigned short seed )***

(function) Sets seed for pseudo random number generator. Declared in rand.h Defined in rand.lib

***max( a, b )***

(Macro) Returns the value of the argument with the largest value.

***min( a, b )***

(Macro) Returns the value of the argument with the smallest value.

***abs( a )***

(Macro) Returns absolute value of the argument.



## I2C functions

*i2c\_init, i2c\_start, i2c\_restart, i2c\_stop, i2c\_read, i2c\_write*  
(for more information look into *i2c\_driver.h* and *i2c\_test.c* files)

## RS232 functions

*uart\_init, kbhit, getc, getch, putc, putchar*  
(for more information look into *serial\_driver.h* and *serial\_test.c* files)

## LCD functions

*lcd\_setup, lprintf, lcd\_clear, lcd\_write, lcd\_funcmode, lcd\_datamode*  
(for more information look into *lcd\_driver.h* and *lcd.c* files)

## Flash functions

***unsigned short flash\_read(unsigned short addr)*** (PIC16 only)

(function) Reads flash content from address 'addr'. Works with PIC16 devices. Declared in flash.h Defined in flash.pic16.lib

***void flash\_loadbuffer(unsigned short data)*** (PIC16 only)

(function) Stores 'data' in an internal buffer of 4 shorts long. Must be called four times to fill the internal buffer. Data in this buffer is used by [flash\\_write](#) to store data in flash. Works with PIC16 devices. Declared in flash.h Defined in flash.pic16.lib

***void flash\_write(unsigned short addr)*** (PIC16 only)

(function) Writes data from an internal buffer into flash at address 'addr'. The internal buffer that is 4 shorts long must be filled using 4 calls to [flash\\_loadbuffer](#). Works with PIC16 devices. Declared in flash.h Defined in flash.pic16.lib

***void flash\_erase(unsigned long addr)*** (PIC18 only)

(function) Erases a block of code memory of 64 bytes starting from address 'addr'. The address must be 64 bytes aligned. Works with PIC18 devices. Declared in flash.h Defined in flash.pic18.lib

***void flash\_read(unsigned long addr, unsigned char \* buf)*** (PIC18 only)

(function) Reads a block of 64 bytes of code memory starting from address 'addr' into provided buffer 'buf'. The address must be 64 bytes aligned. The buffer must be big enough to hold 64 bytes. Works with PIC18 devices. Declared in flash.h Defined in flash.pic18.lib

***unsigned short flash\_read(unsigned long addr)*** (PIC18 only)

(function) Reads 2 bytes from code memory starting from address 'addr'. The address must be 2 bytes aligned. Works with PIC18 devices. Declared in flash.h Defined in flash.pic18.lib

***void flash\_write(unsigned long addr, const unsigned char \* buf)*** (PIC18 only)

(function) Writes a block of 64 bytes from buffer 'buf' into code memory starting from address 'addr'. The address must be 64 bytes aligned. The buffer must be big enough to hold 64 bytes. Works with PIC18 devices. Declared in flash.h Defined in flash.pic18.lib

Notes: Before write started the value of global interrupt enable bit (GIE) is remembered and interrupts are disabled. After write GIE is restored to its original value.

This function does not monitor completion of the write operation and does not clear the EEIF flag. It's up to the calling code to make sure that the operation is complete before another write operation and clear the EEIF flag if necessary. For example such code may look like:

```
//Include Flash header
#include <flash.h>
...
//Declare buffer 64 bytes long to work with flash blocks
unsigned char buf[BLOCK_SIZE];
...
flash_write( 0x12000, buf ); //write into code memory at address 0x12000
pir2.EEIF = 0; //clear the flash write complete interrupt flag
```

***unsigned char flash\_verify(unsigned long addr, const unsigned char \* buf)***  
(PIC18 only)

(function) Verifies if a 64 bytes long block of code memory starting from address 'addr' matches the data in buffer 'buf'. Returns true if they match and false otherwise. The address must be 64 bytes aligned. The buffer must be big enough to hold 64 bytes. Works with PIC18 devices. Declared in flash.h Defined in flash.pic18.lib

## **EEPROM functions**

***unsigned char eeprom\_read(unsigned char addr)*** (PIC16)

***unsigned char eeprom\_read(unsigned short addr)*** (PIC18)

(function) Reads eeprom content from address 'addr'. Works with PIC16 and PIC18 devices. Declared in eeprom.h Defined in eeprom.pic16.lib and eeprom.pic18.lib

***void eeprom\_write(unsigned char addr, unsigned char data)*** (PIC16)

***void eeprom\_write(unsigned short addr, unsigned char data)*** (PIC18)

(function) Writes 'data' into eeprom at address 'addr'. Works with PIC16 and PIC18 devices. Declared in eeprom.h Defined in eeprom.pic16.lib and eeprom.pic18.lib

Notes: Before write started the value of global interrupt enable bit (GIE) is remembered and interrupts are disabled. After write GIE is restored to its original value.

This function does not monitor completion of the write operation and does not clear the EEIF flag. It's up to the calling code to make sure that the operation is complete before another write operation and clear the EEIF flag if necessary. For example such code may look like:

```
//Include EEPROM header
#include <eeprom.h>
...
//Test write into eeprom location 0xD0
eeprom_write(0xD0, 0xA5); //write 0xA5 into EEPROM location 0xD0
pir2.EEIF = 0; //clear the eeprom write complete interrupt flag
val = eeprom_read(0xD0); //read EEPROM location 0xD0
if( 0xA5 != val ) //check if read matches write
    error();
```

## ADC functions

### *short adc\_measure(char ch)*

(function) Reads ADC channel 'ch'. ADC must be initialized before using this function. Works with PIC16F devices that have ADC units. Declared in adc.h Defined in adc.pic16.lib

A sample ADC initialization can look like:

```
volatile bit adc_on @ ADCON0 . ADON; //AC activate flag

set_bit(adcon1, ADFM); // AD result needs to be right justified
set_bit(adcon1, PCFG0); // all analog inputs
set_bit(adcon1, PCFG1); // Vref+ = Vdd
set_bit(adcon1, PCFG2); // Vref- = Vss

set_bit(adcon0, ADCS1); // Select Tad = 32 * Tosc (this depends on the X-
tal here 10 MHz, should work up to 20 MHz)
clear_bit(adcon0, CHS0); // Channel 0
clear_bit(adcon0, CHS1); //
clear_bit(adcon0, CHS2); //
adc_on = 1; // Activate AD module
```

## One wire bus functions

### *char oo\_busreset()*

(function) Resets the one wire bus. Declared in oo.h Defined in oo.pic16.lib and oo.pic18.lib

Here is a typical scenario how to use the one wire library:

```

// To be able to use the one wire library two global bit variables need to
// be declared in the code.
// These are the variables that control port pin used for one wire
// communication. For example
// if the one wire interface is connected to pin 6 of port B the
// declaration will look like this:

#define OO_PORT PORTB
#define OO_TRIS TRISB
#define OO_PIN 6

volatile bit oo_bus @ OO_PORT . OO_PIN;
volatile bit oo_bus_tris @ OO_TRIS . OO_PIN;

...

// Reset the one wire bus
oo_busreset();

// Start the conversion (non-blocking function)
oo_start_conversion();

// wait for completion, you could do other stuff here
// But make sure that this function returns zero before
// reading the scratchpad
if( oo_wait_for_completion() )
{
    //handle conversion time out
}

// Read the scratchpad
if( oo_read_scratchpad() )
{
    //handle conversion error
}

// And extract the temperature information
short data = oo_get_data();

```

### ***short oo\_get\_data()***

(function) Reads data from one wire bus. Declared in oo.h Defined in oo.pic16.lib and oo.pic18.lib

### ***char oo\_read\_scratchpad()***

(function) Reads scratchpad. Declared in oo.h Defined in oo.pic16.lib and oo.pic18.lib

### ***void oo\_start\_conversion()***

(function) Starts conversion. Declared in oo.h Defined in oo.pic16.lib and oo.pic18.lib

### ***char oo\_conversion\_busy()***

(function) Checks if conversion is in progress. Returns 0 if no conversion is active. Declared in oo.h Defined in oo.pic16.lib and oo.pic18.lib

***char oo\_wait\_for\_completion()***

(function) Waits for a conversion to complete. Returns 0 if conversion completed within 1 sec. Declared in oo.h Defined in oo.pic16.lib and oo.pic18.lib

## PC System Requirements

In order to install and run the Compiler/SourceBoost Integrated Development Environment, a PC with the following specification is required:

<b><i>Minimum System Specification</i></b>
Microsoft Windows 98/ME/NT/2000/XP, Adobe Reader and a web browser (to allow access to help files and manuals). Pentium Processor or equivalent, 128MB of RAM, CD ROM Drive, 80MB of disk space, 16Bit Color display Adapter at 800x600 Resolution.

<b><i>Recommended System Specification</i></b>
As the Minimum System Specification, plus: 2.0GHz (or faster) Processor, 512MByte (or more) RAM, 16Bit Color display Adapter at 1024x768 Resolution (or higher).

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