



CrossWorks for MSP430 Reference Manual

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Introduction

This guide is divided into a number of sections:

Introduction

Covers installing CrossWorks on your machine and verifying that it operates correctly, followed by a brief guide to the operation of the CrossStudio integrated development environment, debugger, and other software supplied in the product.

CrossStudio Tutorial

Describes how to get started with CrossStudio and runs through all the steps from creating a project to debugging it on hardware.

CrossStudio User Guide

Contains information on how to use the CrossStudio development environment to manage your projects, build, and debug your applications.

C Compiler User Guide

Contains documentation for the C compiler, including syntax and usage details and a description of extensions provided by CrossWorks.

C Library User Guide

Contains documentation for the functions in the standard C library supplied in CrossWorks.

Assembler User Guide

Contains detailed documentation covering how to use the assembler, the assembler notation, macros, and other assembler features.

What is CrossWorks?

CrossWorks for MSP430 is a complete C development system for Texas Instruments MSP430 microcontrollers that runs on Windows, Mac OS and Linux.

C compiler

CrossWorks C is a faithful implementation of the ANSI and ISO standards for the programming language C. We have added some extensions that enhance usability in a microcontroller environment.

CrossWorks C Library

CrossWorks for MSP430 has its own royalty-free ANSI and ISO C compliant C library that has been specifically designed for use within embedded systems.

CrossStudio IDE

CrossStudio for MSP430 is a streamlined integrated development environment for building, testing, and deploying your applications. CrossStudio provides:

- *Source Code Editor:* A powerful source code editor with multi-level undo and redo, makes editing your code a breeze.
- *Project System:* A complete project system organizes your source code and build rules.
- *Build System:* With a single key press you can build all your applications in a solution, ready for them to be loaded onto a target microcontroller.
- *Debugger and Flash Programming:* You can download your programs directly into Flash and debug them seamlessly from within the IDE using a wide range of target interfaces.
- *Help system:* The built-in help system provides context-sensitive help and a complete reference to the CrossStudio IDE and tools.
- *Core Simulator:* As well as providing cross-compilation technology, CrossWorks provides a PC-based fully functional simulation of the target microcontroller core so you can debug parts of your application without waiting for hardware.

CrossWorks Tools

CrossWorks for MSP430 supplies command line tools that enable you to build your application on the command line and flash it to the target board using the same project file that the IDE uses.

What we don't tell you

This documentation does not attempt to teach the C or assembly language programming; rather, you should seek out one of the many introductory texts available. And similarly the documentation doesn't cover the MSP430 architecture or microcontroller application development in any great depth.

We also assume that you're fairly familiar with the operating system of the host computer being used.

C programming guides

These are must-have books for any C programmer:

- Kernighan, B.W. and Ritchie, D.M., *The C Programming Language* (2nd edition, 1988). Prentice-Hall, Englewood Cliffs, NJ, USA. ISBN 0-13-110362-8.
The original C bible, updated to cover the essentials of ANSI C (1990 version).
- Harbison, S.P. and Steele, G.L., *C: A Reference Manual* (second edition, 1987). Prentice-Hall, Englewood Cliffs, NJ, USA. ISBN 0-13-109802-0.
A nice reference guide to C, including a useful amount of information on ANSI C. Co-authored by Guy Steele, a noted language expert.

ANSI C reference

If you're serious about C programming, you may want to have the ISO standard on hand:

- ISO/IEC 9899:1990, C Standard and ISO/IEC 9899:1999, C Standard. The standard is available from your national standards body or directly from ISO at <http://www.iso.ch/>.

Activating your product

Each copy of CrossWorks must be licensed and registered before it can be used. Each time you purchase a CrossWorks license, you, as a single user, can use CrossWorks on the computers you need to develop and deploy your application. This covers the usual scenario of using both a laptop and desktop and, optionally, a laboratory computer.

Evaluating CrossWorks

If you are evaluating CrossWorks on your computer, you must activate it. To activate your software for evaluation, follow these instructions:

- Install CrossWorks on your computer using the CrossWorks installer and accept the license agreement.
- Run the CrossStudio application.
- Choose **Tools > License Manager**.
- Click "Evaluate CrossWorks". If you have a default mailer, click the **By Mail** button.
- Using e-mail, send the registration key to the e-mail address license@rowley.co.uk.
- If you don't have a default mailer, select the text underneath "Activation request".
- Send the registration key to the e-mail address license@rowley.co.uk.

By return you will receive an **activation key**. To activate CrossWorks for evaluation, do the following:

- Run the CrossStudio application.
- Choose **Tools > License Manager**.
- Click **Activate CrossWorks**.
- Type in or paste the returned activation key into the dialog and click **Install License**.

If you need more time to evaluate CrossWorks, simply request a new evaluation key when the issued one expires or is about to expire.

After purchasing CrossWorks

When you purchase CrossStudio, either directly from ourselves or through a distributor, you will be issued a Product Key which uniquely identifies your purchase

To permanently activate your software:

- Install CrossWorks on your computer using the CrossWorks installer and accept the license agreement.
- Run the CrossStudio application.
- Choose **Tools > License Manager**.
- Click "Request Activation After Purchasing". If you have a default mailer, click the **By Mail** button.

- Using e-mail, send the registration key to the e-mail address license@rowley.co.uk.
- If you don't have a default mailer, select the text underneath "Activation request".
- Send the registration key to the e-mail address license@rowley.co.uk.

By return you will receive an **activation key**. Then, complete the activation process:

- Run the CrossStudio application.
- Choose **Tools > License Manager**.
- Click **Activate CrossWorks**.
- Type in or paste the returned activation key into the dialog and click **Install License**.

As CrossWorks is licensed per developer, you can install the software on any computer that you use such as a desktop, laptop, and laboratory computer, but on each of these you must go through activation using your issued product key.

Text conventions

Menus and user interface elements

When this document refers to any user interface element, it will do so in **bold font**. For instance, you will often see reference to the **Project Explorer**, which is taken to mean the project explorer window. Similarly, you'll see references to the **Standard** toolbar which is positioned at the top of the CrossStudio window, just below the menu bar on Windows and Linux.

When you are directed to select an item from a menu in CrossStudio, we use the form *menu-name* > *item-name*. For instance, **File** > **Save** means that you need to click the **File** menu in the menu bar and then select the **Save** item. This form extends to items in sub-menus, so **File** > **Open With Binary Editor** has the obvious meaning.

Keyboard accelerators

Frequently-used commands are assigned keyboard *accelerators* to speed up common tasks. CrossStudio uses standard Windows and Mac OS keyboard accelerators wherever possible.

Windows and Linux have three key modifiers which are **Ctrl**, **Alt**, and **Shift**. For instance, **Ctrl+Alt+P** means that you should hold down the **Ctrl** and **Alt** buttons whilst pressing the **P** key; and **Shift+F5** means that you should hold down the **Shift** key whilst pressing **F5**.

Mac OS has four key modifiers which are ? (command), ? (option), ? (control), and ? (shift). Generally there is a one-to-one correspondence between the Windows modifiers and the Mac OS modifiers: **Ctrl** is ?, **Alt** is ?, and **Shift** is ?. CrossStudio on Mac OS has its own set of unique key sequences using ? (control) that have no direct Windows equivalent.

CrossStudio on Windows and Linux also uses *key chords* to expand the set of accelerators. Key chords are key sequences composed of two or more key presses. For instance, the key chord **Ctrl+T, D** means that you should type **Ctrl+T** followed by **D**; and **Ctrl+K, Ctrl+Z** means that you should type **Ctrl+T** followed by **Ctrl+Z**. Mac OS does not support accelerator key chords.

Code examples and human interaction

Throughout the documentation, text printed in **this typeface** represents verbatim communication with the computer: for example, pieces of C text, commands to the operating system, or responses from the computer. In examples, text printed in *this typeface* is not to be used verbatim: it represents a class of items, one of which should be used. For example, this is the format of one kind of compilation command:

hcl *source-file*

This means that the command consists of:

- The word **hcl**, typed exactly like that.
- A *source-file*: not the text **source-file**, but an item of the *source-file* class, for example **myprog.c**.

Whenever commands to and responses from the computer are mixed in the same example, the commands (i.e. the items which you enter) will be presented in this typeface. For example, here is a dialog with the computer using the format of the compilation command given above:

```
c:\code\examples>hcl -v myprog.c
```

The user types the text **hcl -v myprog.c** and then presses the enter key (which is assumed and is not shown); the computer responds with the rest.

Additional resources

With software as complex as CrossWorks, it's almost inevitable that you will need assistance at some point. Along with the documentation that comes with CrossWorks for MSP430, there are a variety of other resources you can use to find out more.

CrossWorks for MSP430 website

- <http://www.rowley.co.uk/msp430/index.htm>

Support

If you need some help working with CrossWorks, or if something you consider a bug, go to:

- <http://rowley.zendesk.com/>

You can subscribe to our RSS newsfeed here:

- <http://www.rowley.co.uk/rss.xml>

Suggestions

If you have any comments or suggestions regarding the software or documentation, you can make suggestions on our suggestion forum:

- <https://rowley.zendesk.com/forums/171704-Suggestions>

Finding your way around

CrossStudio is a complex program in many ways, but we have tried to simplify it so that it's easy to use. It's very easy to get started and CrossStudio scales well to complex multi-programmer projects that need to manage large code bases and the inevitable software variants.

In the tutorial you were presented with a whistle-stop tour of CrossStudio to get you up and running. Here we dig deeper into the corners of CrossStudio so you can get the best from it.

Highlights

The development of CrossWorks 3 has taken longer than we ever expected. During that period, we visited each part of the software to evaluate, polish, improve, and perhaps completely rewrite it. The changes in CrossStudio range from subtle (changing a few icons here and there, improving performance) to extensive (threaded source indexer, parallel build system, slick source control, new trace support). Here are some of the highlights in CrossWorks 3...

Parallel and Unity Building

Quad core processor are now standard in desktops and laptops, and CrossStudio can take full advantage of multi-core processors when building your applications by scheduling projects to build in parallel. To partner parallel building, CrossStudio also introduces support for *unity builds* where a set of source files are compiled as a single unit.

To illustrate the advantages of these new features, here are the build times for rebuilding the example HTTP server included in many CrossWorks board support packages, with the exception that all projects are source code rather than object code libraries:

Cores	Unity?	Time	Speedup	Comments
1	No	21s	1x	Baseline
2	No	15s	1.4x	
4	No	10s	2.1x	
8	No	9.4s	2.2x	Hyperthreading doesn't really help
1	Yes	6.3s	3.3x	
2	Yes	4.5s	4.6x	
4	Yes	3.1s	6.8x	
8	Yes	3.2s	6.5x	Hyperthreading isn't an advantage

And, building a set of sensor example projects, again in many board support packages, in a single solution:

Cores	Unity?	Time	Speedup	Comments
1	No	65s	1x	Baseline
2	No	41s	1.6x	
4	No	24s	2.7x	
8	No	20s	3.3x	Hyperthreading does help
1	Yes	39s	1.6x	
2	Yes	23s	2.8x	

4	Yes	14s	4.6x	
8	Yes	11s	5.9x	Hyperthreading does help

These timings were taken on Windows 7 running under Parallels 9 on a Retina MacBook Pro with a 4-core 2.3 GHz Intel Core i7 and 8 GB of memory allocated to the virtual machine. The effect of parallel building will depend upon the way you structure your project and the performance of your hardware.

Source indexer

The source indexer is completely reworked to be much more precise. Indexing takes place in the background, using threads to index your code quickly. You can change the number of threads launched to index your project, choosing between performance and responsiveness when indexing.

Hand in hand with the indexer, the code editor is improved with *code completion* where appropriate suggestions pop up as you type. Because the indexer is very accurate, code completion is also accurate, increasing your productivity as a programmer.

To complement the indexer, CrossStudio adds a **Find References** capability that fill search your application for references to items. As you would expect, Find References runs in parallel, is configurable, and is a great way to find the uses of functions, variables, types, and members.

Source control

Source-control integration is now significantly faster in CrossStudio 3. We've added source-control annotations to the project explorer, but kept the ability to show the source-control column from CrossStudio 2.

We've changed the source-control model that CrossStudio 3 uses from the check-out/lock/check-in model (as used by Visual Source Safe and RCS) to the widely used update/merge/commit model (as used by CVS and Subversion).

In addition, we've added the popular **Pending Changes** window that succinctly shows you the changes you've made and the overall state of the items in your project. We've also added a source-control state filter to the project explorer, if you're more comfortable working in that window.

Source-control state updates progress in the background and much more efficient than the CrossStudio 2 implementation, making CrossStudio a real pleasure to use.

Release notes

Version 3.1.0

Build

- Fixed build log job counting on folder and file builds.
- Fixed memory leak in project explorer.
- Fix crash if F4 is held down during a large build.
- Added #pragma isrseg to hcc.
- Implemented "Standard Libraries Directory" project property.
- All library projects that an executable project is dependent on are now added to the link.
- Fixed dynamic folder path attribute only expanding macros if macro is right at the start of the string.
- Fixed dynamic folder exclude attribute matching on a sub-string.
- Added missing C99 float and double precision math functions to C library.
- Files within projects now build in parallel when multi-threaded building is enabled.
- Supplied ascii only version of ctype functions in ctype_no_wchar.c in the \$(StudioDir)/source directory.
- Supplied non threaded version errno in errno_no_thread.c in the \$(StudioDir)/source directory.
- Fixed setting errno to EDOM with invalid arguments to acos(f), asin(f) and fmod(f).
- Fixed setting errno to ERANGE when overflow occurs with ldexp(f).
- Added "Optimize Sections" project property.
- Added option to linker and IDE to rename input sections.
- C library is now compiled into sections that are named **LIBC_**.
- Fixed crash caused by clearing build log whilst building.
- Fixed build for project Link and unity folder Compile.

Debug

- Hardware breakpoints now cleared after using **Target > Download File** options.
- Stopped unnecessary USB enumeration at startup when the **Target > Background Scan for Debug Pod Presence** environment option is enabled.
- Fixed the context menu displayed in the disassembly window.
- Editing in the memory window now selects the next column for edit.
- Implemented a new memory window editor providing 'one click' editing.
- Text view can now be edited in memory window.
- Added automatic size and column modes to memory window.
- Enhanced memory window data/text viewing options.
- Added automatic refresh function to memory window.
- Mouse, scroll wheel and keyboard can now be used to navigate memory in the memory window.
- Added Unicode text viewing and editing when memory window is set to 16 or 32 bit widths.

- Removed "Register Definition Macros" project property.
- Added drag and drop support to project explorer.
- Added range selection to memory window.
- Added save selection functions to memory window.
- Added data tips to memory window.
- The memory window's columns field now scales when changing width field.
- The memory window now adds extra space between column 8 and 9 in 16 column mode.
- Added "Thread Maximum" project property to limit the number of entries in the threads window.
- Threads window now updates based on the "Startup Completion Point" status.
- Threads window now selects threads.js script only from the active project.
- Added "Start From Entry Point Symbol" project property.
- Watch windows have optional columns to display address, size and type.
- Watch windows can now contain sub-expressions of existing watched expressions.
- Added environment option "Show Data Tips In Text Editor".
- Total warning count now displayed on build completion.
- Debugger now sets the initial and startup completion breakpoints before the user breakpoints are set.
- Fixed memory leak in watch windows.
- Fixed crash while using memory window when not connected to target.
- Removed "Debugger Initial Breakpoint" environment options.
- Can now optionally specify the main load file to download using the "Load File" project property.
- Added "Go To Disassembly" to code editor context menu when debugging.
- Added "Export As Text" to variable display windows.
- Variable display windows now display char * as null terminated strings by default.
- Fixed display of array and struct variables.
- Added "Auto Refresh" to the context menu of the execution count window.
- Fixed set breakpoint on variable from text editor.
- Fixed modifying breakpoint properties.
- Fixed memory window always evaluating address expression when auto size is selected.
- Fixed memory window switching to auto size mode if size is less than display width.
- Fixed watch window not storing the filename and linenumber context in which to evaluate the expression.

IDE

- Fixed "File Exists" error when pasting cut/copied file in project explorer.
- Fixed "Folder Name in use" error when creating folders with the same name as the parent folder.
- Added **Goto Declaration**.
- Fixed saving of read-only files when using **Find References**.
- Added Code Formatting capability to text editor.
- Property dialog group selection now shows only the selected group.
- Fixed computing the filepath when pasting files between projects.

- Misc improvements to new project wizard.
- Properties positioning in project explorer context menu now controlled by an environment property.
- Project file is now saved prior to showing properties editor dialog.
- Auto reload of project file when edited using the text editor.
- Fixed file naming when file extension supplied to new file dialog.
- Added c++11 keywords to code editor syntax coloring.
- Added SEGGER style to code formatter choices.
- Added support for Windows 10.
- Assumes .S files are assembly code files.
- Fixed code editor undo after saving with the **Text Editor > Save Options > Delete Trailing Space On Save** environment option enabled.
- Added **Text Editor > Programmer Assistance > Template Characters To Match** option.
- Changed implementation of code completion and source navigation to use external program index.
- Fixed auto-recovery when file has been edited within IDE and also with an external editor.
- Go To Definition (and other source code operations) work without Source Navigator assistance.
- Go To Definition (and other source code operations) fixed when files contain c++ constructors/destructors/operators.
- Filenames in session files are now stored relative to the session file.
- Fixed **Find Extras > Find In** editor context menu options not working on OS X.
- Fixed layout of windows when using monitors with a resolution of 4K and above.
- Fixed usage of clang and libclang (e.g. goto definition) on Windows 10.
- Fixed smart indentation when previous line is empty.
- Fixed problem causing available packages list download to fail.
- IDE is now brought to the foreground when a file is opened from an external application.
- Fixed code completion leaving PCH files in temporary directory.
- Added **Window > Zoom** and **Window > Minimize** menu options (*OS X only*).
- Fixed creating folders of the same name as the parent folder.
- Fixed crash using "Find References" on newly created project.
- Fixed project property dialog forgetting previously modified properties on cancel.
- Project property dialog now optionally prompts on cancel if properties have been modified.
- JavaScript project properties now have a multi-line editor.
- Fixed reading of XML files with a UTF-8 byte order mark.
- Register descriptions may now contain UTF-8 characters.
- Fixed **Spaces In Square Brackets** and **Spaces In Parentheses** text editor code formatting options.
- Code formatter tool can now run on header files in project.
- Fixed code formatting of a selection.
- Fixed code formatting of a modified file.
- Fixed disassembly window's font not updating until restart.
- Fixed **Text Editor > Mouse Options > Alt+Left Click** and **Text Editor > Mouse Options > Ctrl+Left Click** environment options.
- Fixed copying to clipboard in text editor resetting scaled font size.

- Changed **Import Package Files** to also import files referenced via \$(StudioDir).
- Fixed index.exe holding open header file handles after code completion and goto definition.
- Fixed goto definition usage of Source Navigator.
- The **Space Before Parentheses** text editor code formatting option is now taken into account when generating code completion suggestions.
- Fixed crash when dragging a project folder onto itself.
- Fixed display of string properties that contain line feeds.
- The "Project Type" property can now be set on a per configuration basis.
- Fixed reload project not working correctly when the project has been opened from the Recent Projects window.
- Project properties editor dialog is now modal.
- Memory window address field now expands to fill available space.
- Fixed blank filenames in **Open File From Solution** dialog.
- Fixed binary editor cursor display and mouse tracking.
- Fixed crash when right clicking in empty area of build configuration dialog.
- Fixed crash when changing configuration with a property editor focused in properties dialog.
- Changed the way modified and inherited properties are shown in the properties dialog/window.
- Code editor no longer displays file modified warning if file has been externally deleted.
- Properties dialog, removed "All" group, deselecting the group/page will show all properties.
- Properties dialog, changed the graphic to indicate that a project property has been modified or is set in another node or configuration.
- Properties dialog, removed the build macros and added a means to display the set of macros on individual property editors.
- Project explorer, added "Exclude From Build" option to folders.
- Properties dialog, added option to show modified properties only.
- Fixed drag and drop in project explorer only working on a new folder after project has been reloaded.
- File path property editor now applies change when enter key is pressed.
- The **Application Monospace Font** property editor will now only allow monospace fonts to be selected.
- Parallel building of files in projects now shows a progress bar and ETA, both of these can be disabled using new environment options.
- Removed project property "Build Dependents in Parallel", replaced it with "Project Can Build In Parallel".
- Improved appearance of build log's memory usage summary when there are many memory segments.
- Fixed code completion on files with paths containing UNICODE characters.
- Fixed goto definition and find references on files with paths containing UNICODE characters.
- Fixed close solution not stopping when the saving of a modified file has failed.
- Fixed crash when dragging a project folder onto one of its own sub folders.
- Register window bitfield entries now use monospace font.
- Ctrl+C and Ctrl+A now work in project property dialog's description field.
- Fixed drag not working in project explorer on new files or folders until project has been reloaded.
- Cannot close solution while Source Navigator and References window are active.
- Added stop button to Source Navigator window.

- Added environment option "Parallel Project Building" to enable dependent project (and solution) builds to be done in parallel.

Licensing

- Sentinel shared license dongle now supported on Mac OS X.

Release 3.0.0

What's New

CrossStudio

- Source code editor now has code completion capability.
- **Source Navigator** has a new core that is precise and can run multiple indexing threads in parallel.
- **Find References** (Alt+R or Ctrl+Alt+F) quickly finds references to a symbol or preprocessor definition.
- **Find References** can run multiple indexing threads in parallel.
- **Find Symbol** (Alt+Y) uses new **Source Navigator** core to quickly access project-wide symbols.
- **Search** menu simplified and shortened by splitting into **Search** and **Navigate** menus to work better on small laptop screens.
- **Search Build Configuration** (Ctrl+Shift+B) provides a way to directly select a build configuration.
- **Search Project** (Ctrl+Shift+J) provides a way to directly select a project in a loaded solution.
- **Search Targets** (Ctrl+Shift+T) provides a way to directly connect a target interface.
- **Search Includes** (Ctrl+Shift+M) will open include files referenced in the focused source file.
- **Project Explorer** has a **Filter Project** (Ctrl+;) capability to show matching filenames.
- **Project Explorer** has accelerators for **Collapse to Projects** (Ctrl+P, J), **Collapse to Folders** (Ctrl+P, F), **Collapse to Solutions** (Ctrl+P, S), **Collapse All** (Ctrl+P, -), and **Expand All** (Ctrl+P, =).
- **Project Explorer** will highlight files using stars, above all other files, if the filename matches any wildcard in the list **Tools > Options > Windows > Project Explorer Options > Starred File Names**.
- Shift double-clicking a file in the **Project Explorer** will open the file with the external editor set in **Tools > Options > Windows > Project Explorer Options > External Editor**.
- **Project Explorer** will highlight dynamic folders, and their child items, using a red shortcut arrow.
- **File > Open**'s accelerator, Ctrl+O, will open a file in the solution. Pressing Ctrl+O a second time opens a dialog to select a file from the solution.
- **Search > Find**'s accelerator, Ctrl+F, will open an incremental find. Pressing Ctrl+F a second time opens a standard Find dialog.
- **Move Opposite** (Alt+O) moves the focused source file to the opposite window; this streamlines putting files side by side for reference or comparison.
- All mouse click actions are configurable through **Tools > Options > Text Editor > Mouse Options**.
- All property dialogs along with **Build Configuration** and **Project Dependencies** refreshed.

- Properties can be made favorites. A favorite property appears in the **(Favorites)** group in the **Properties Window** and appears on the **Project Explorer** right-click menu
- Target interfaces can be made favorites. Favorite target interface are shown above non-favorite interfaces in **Search Targets** and the **Targets** window.
- Memory map files are presented in datasheet form in the **Preview** pane of the **Code Outline** window.
- Added column tidy option to editor.
- Added codec support to editor.
- Added option to generate support information.
- The **Registers** window now has search capability and has been reworked for smoother operation
- Help contents load much more rapidly than before.
- Progress shows in Transcript when loading lengthy projects.
- Attributes in project files fit on a single line if less than 75 characters long; if longer, attributes wrap one per line which allows comfortable editing with a text editor.
- Added VCS support for subversion, git and mercurial.

Build

- Added support for Thread Local Storage.
- Project macros can now be used in filenames in the project system.

Debug

- Added support for MSP-FET.

Library

- Locales and 16-bit `wchar_t` implemented.

What's Gone

CrossStudio

- Removed Disassemble, Open As Text and Open As Binary options - replaced with File | Open With.
- Removed Replace In Files - this is now supported in the Find And Replace window.
- Removed VCS support for VisualSourceSafe and SourceOffSite.

Debug

- Removed support for MSP-FET430PIF parallel port target interface.

Library

- Added `debugio.h` header file. Use this rather than `__cross_studio_io.h` or `cross_studio_io.h` to access `debugIO` functions.
- Removed debug/target IO libraries - use `__debug_stdio.h` if you want debug IO by default.

- Removed CTL from distribution. CTL is now supplied as a CrossWorks Technology Library package which you will need to install if you are using it. Projects that reference the old CTL directories will be upgraded by CrossStudio when they are loaded.



CrossStudio Tutorial

In this tutorial, we will take you through activating your copy of CrossWorks; installing support packages; and creating, compiling, and debugging a simple application using the built-in simulator.

Note

If you're viewing this tutorial from within the CrossStudio help **Browser** window, you may find it more convenient to view using an external web browser so you can still see the entire CrossStudio window. To do so, simply right-click on the help content in the CrossStudio **Browser** and choose **Open With External Browser**.

In this section

[Activating CrossWorks](#)

Describes how to activate your copy of CrossWorks by obtaining and installing an activation key for evaluation.

[Managing support packages](#)

Describes how to download, install, and view CPU-support and board-support packages.

[Creating a project](#)

Describes how to start a project, select your target processor, and other common options.

[Managing files in a project](#)

Describes how to add existing and new files to a project and how to remove items from a project.

[Setting project options](#)

Describes how to set options on project items and how inheritance works for project settings.

Building projects

Describes how to build a project, correct compilation and linkage errors, and find out how big your applications are.

Exploring projects

Describes how to use the **Project Explorer** and **Symbol Browser** to learn how much memory your project takes and how to navigate among the files that make up the project.

Using the debugger

Describes the debugger and how to find and fix problems at a high level when executing your application.

Low-level debugging

Describes how to use debugger features to debug your program at the machine level by watching registers and tracing instructions.

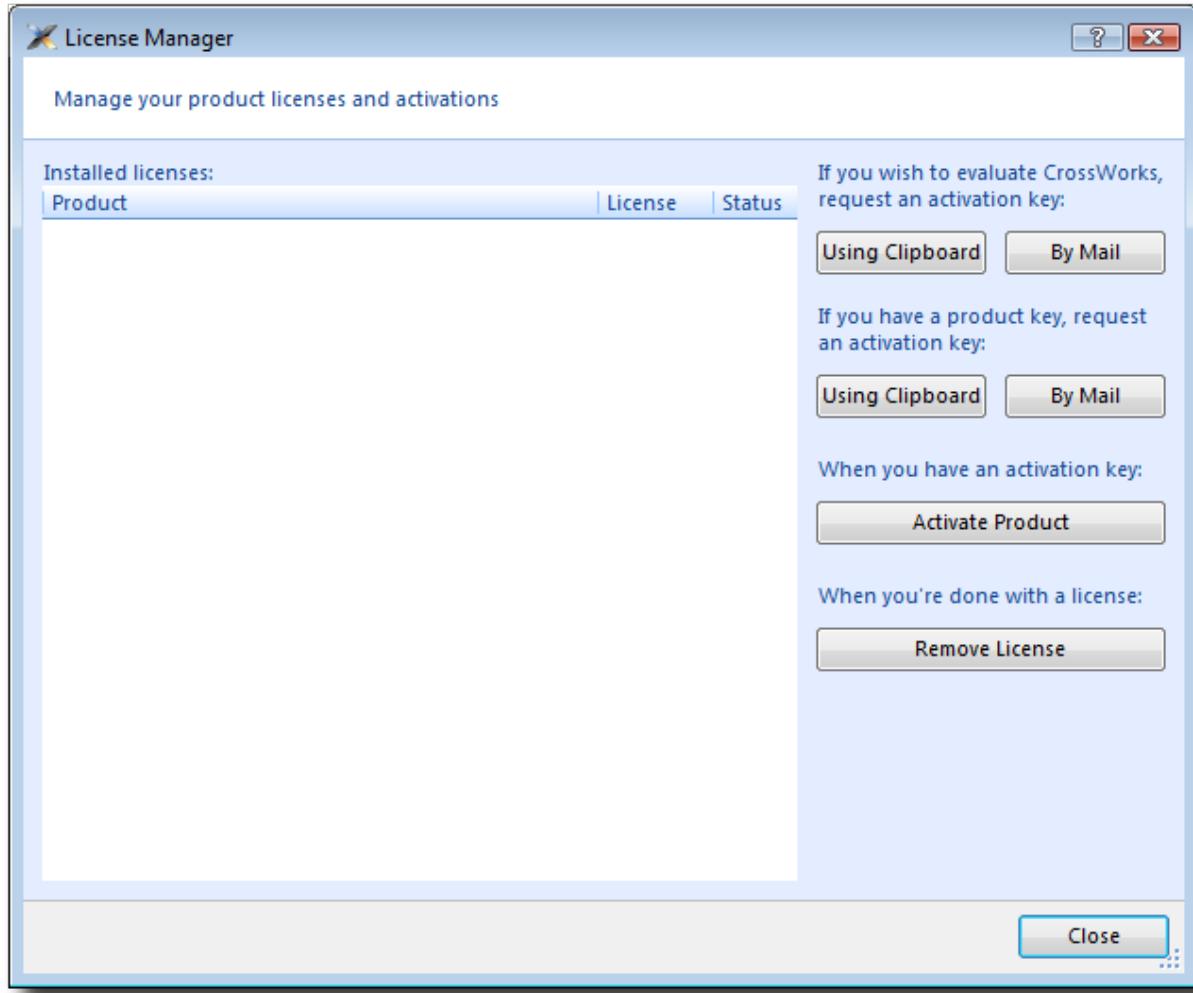
Debugging externally built applications

Describes how to use the debugger to debug externally built applications.

Activating CrossWorks

Each copy of CrossWorks must be registered and activated before it will build projects or download and debug applications. In this tutorial, we are going to use CrossWorks's **License Manager** dialog to request an evaluation activation key and, after the key is received, to activate CrossWorks.

If you have already activated your copy of CrossWorks, you can skip this page.



Requesting an evaluation activation key (with a default e-mail client)

To receive an evaluation activation key that is valid for 30 days:

- Choose **Tools > License Manager**.
- Click the **Evaluate CrossWorks** option.
- Choose whether to lock the license to your computer's MAC address or to your system's primary disk.

- Send the e-mail containing the registration key to **license@rowley.co.uk**. If your development system does not have a default e-mail client, copy the activation request and paste it into an e-mail to this address.

Choosing which hardware to lock to is a matter of personal choice. If you lock to your primary disk and then replace that disk drive, reformat it, or upgrade the operating system, CrossWorks may need to be reactivated. If you lock to a network adapter and the network adapter fails and is replaced, then CrossWorks will require reactivation.

When we receive your registration key we will send an activation key back to your e-mail's reply address. You then will use the activation key to unlock and activate CrossWorks.

Activating CrossWorks

When you receive your activation key from us, you can activate CrossWorks as follows:

- Choose **Tools > License Manager**.
- Click the **Activate CrossWorks** option.
- Enter the activation key you have received from us.
- Click **Install License**.
- The new activation should now be visible in the list of **Installed licenses**. Click **Close** to close the **License Manager** window.

Note

If you request an activation key outside office hours, there may be a delay processing the registration. If this is the case, you can continue the tutorial until you reach the **Building projects** section—you will need to activate CrossWorks before you can build.

Managing support packages

Before a project can be created, a CPU-support or board-support package suitable for the device you are targeting must be installed. A support package is a single, compressed file that can contain project templates, system files, example projects, and documentation for a particular target.

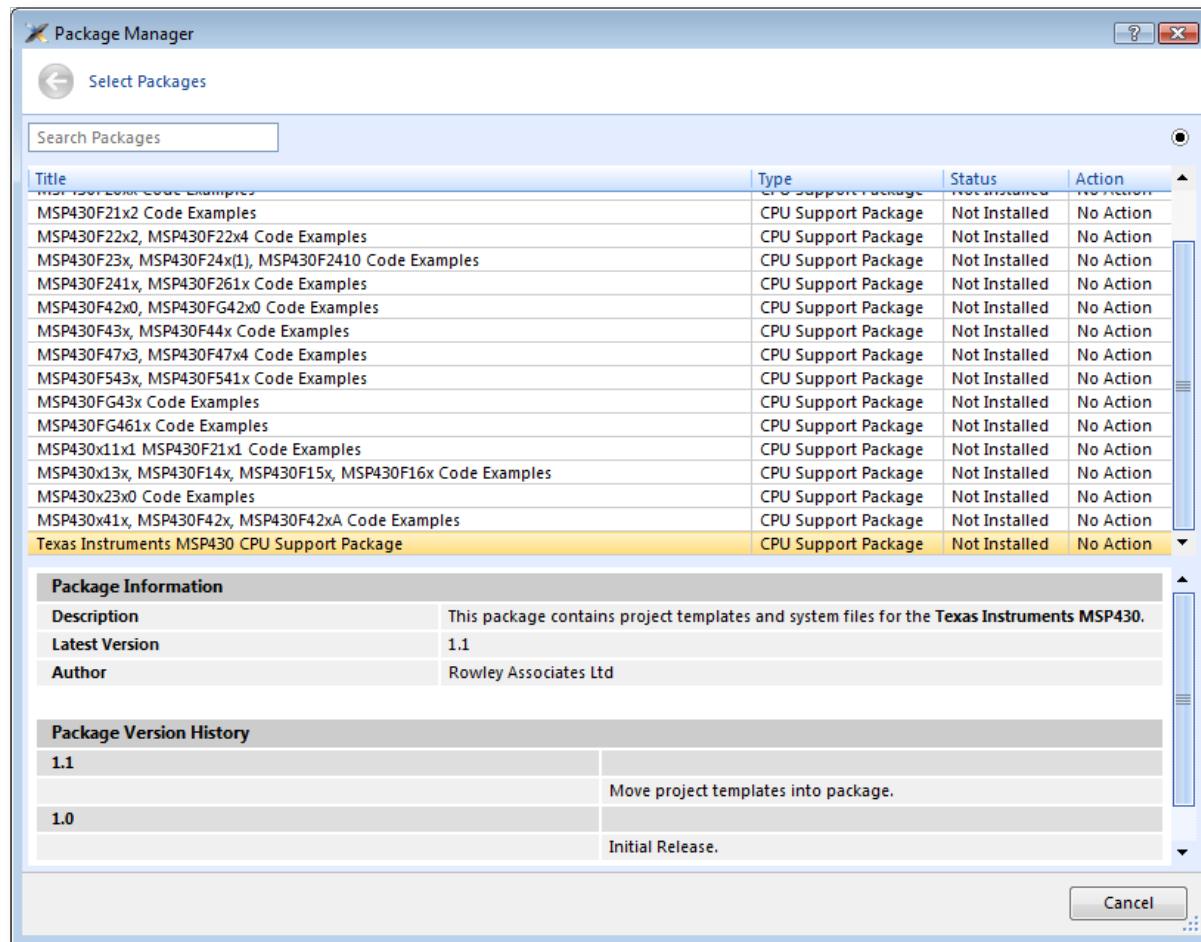
In this tutorial, we are going to use CrossWorks's **Package Manager** to download, install, and use the Texas Instruments MSP430 CPU Support Package.

If you have already installed this support package, you can skip this page.

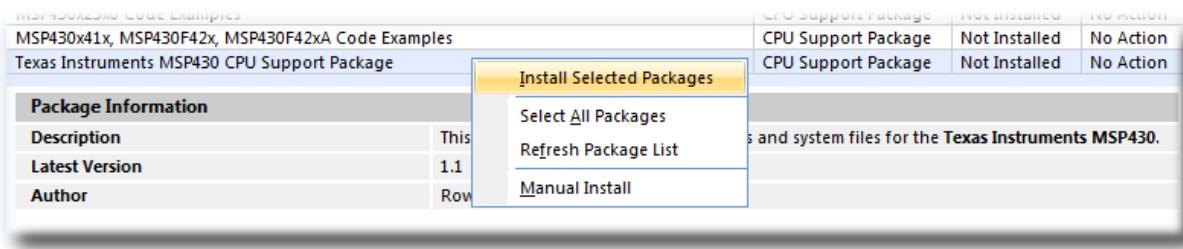
Downloading and installing a support package

To download and install a support package:

- Choose **Tools > Manage Packages**.
- Select the Texas Instruments MSP430 CPU Support Package entry.
- (To select more packages to download and install at the same time, you can control-click the additional packages.)



- Right-click the selected package and choose to **Install Selected Packages**.



- Click the **Next** button and you will be presented with a list of actions the package manager is going to carry out.
- Click **Next** again to download and install the support package.
- Upon successful completion, you will see a list of the newly installed packages. Click **Finish**.

Viewing installed support packages

To view the installed support packages:

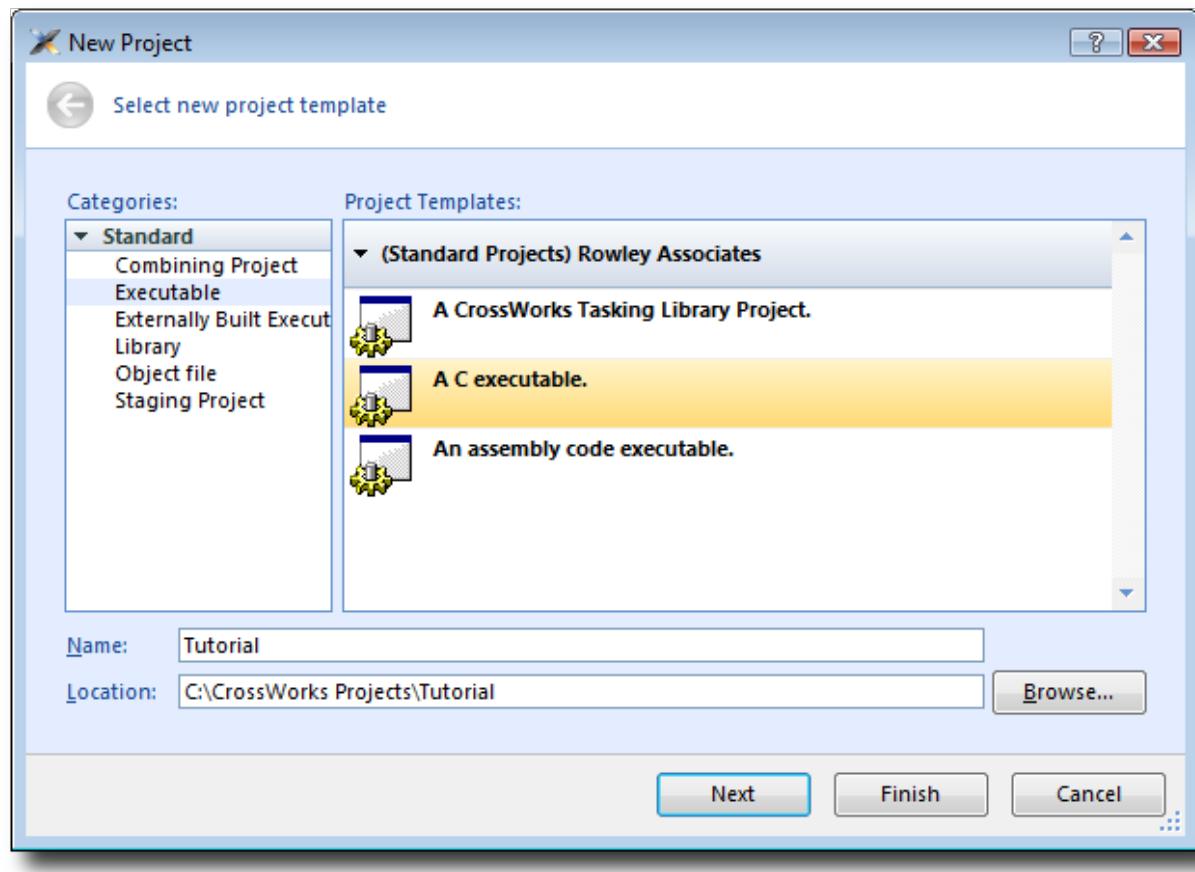
- Choose **Tools > Show Installed Packages** to list the support packages you have installed on your system. You should see the name of the **Texas Instruments MSP430 CPU Support Package** you just installed.
- Click **Texas Instruments MSP430 CPU Support Package** to view the support package page in the CrossWorks **Browser** window. This page provides more information about the support package and links to any documentation, example projects, and system files that may be included in the package.

Creating a project

To start developing an application, first create a new project. To create a new project:

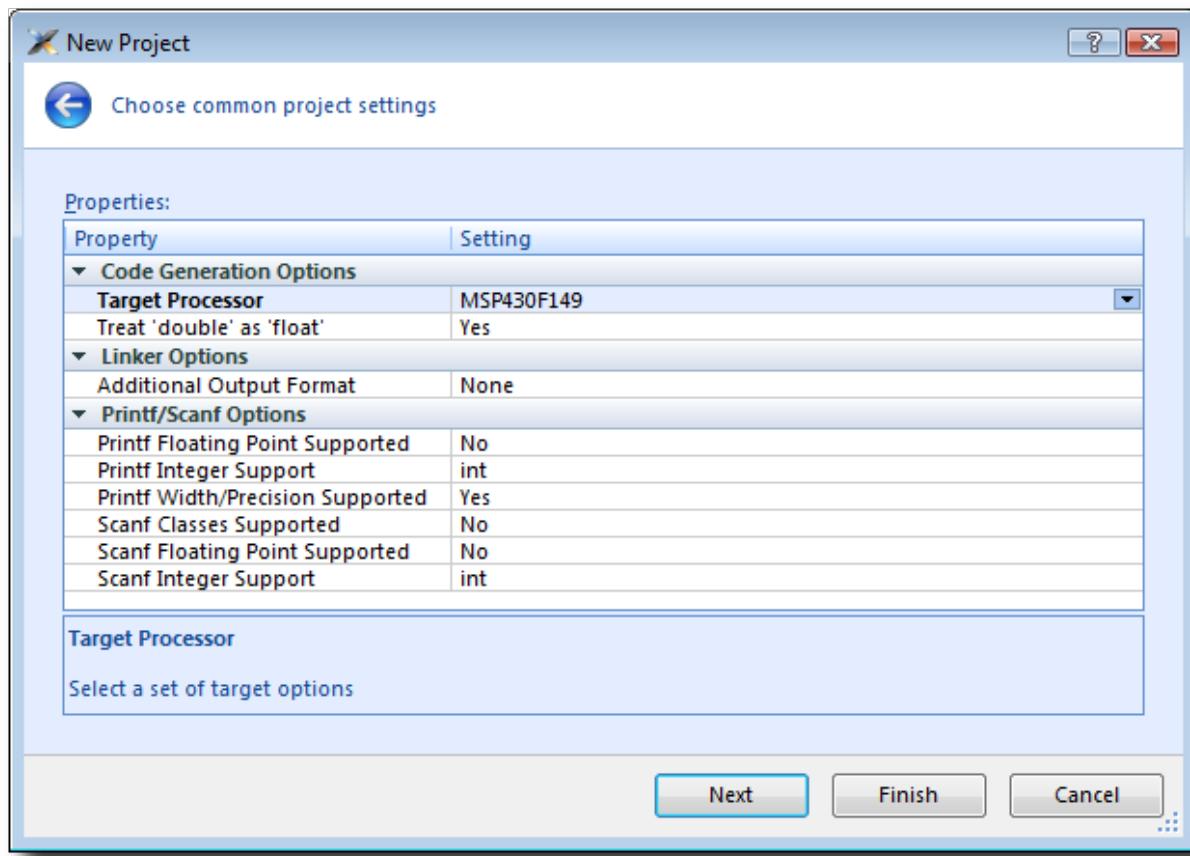
- Choose **File > New Project** or press **Ctrl+Shift+N**

The **New Project** dialog appears. This dialog displays the set of project types (**Categories**) and project templates.



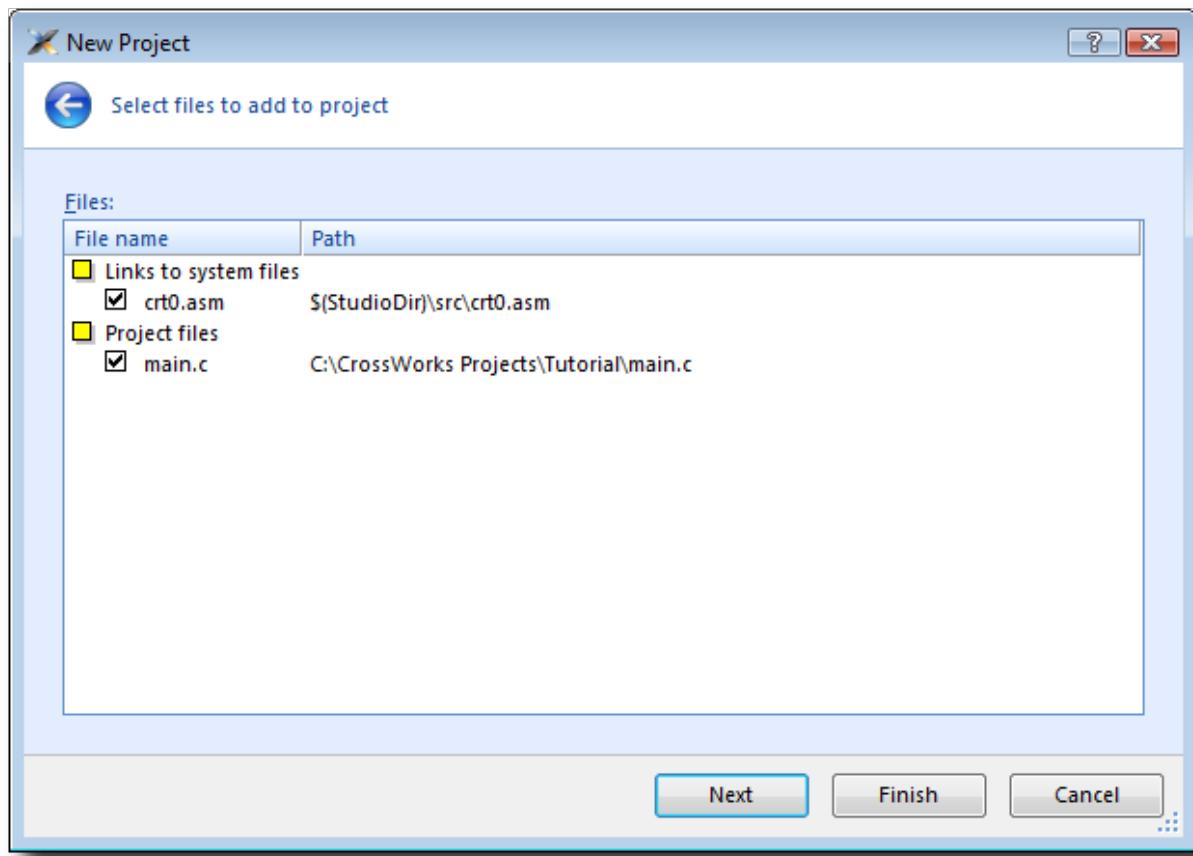
We'll create a project to develop our application in C:

1. In the **Categories** pane, select the **Standard > Executable**
2. From the list in the **Project Templates** pane, select the **A C executable**
3. In the **Name** text field, type **Tutorial** to assign that as the new project's name.
4. You can use the **Location** text field or the **Browse** button to locate where you want to save the project in your local file system.
5. Click **Next**.



Here you can customize the project by altering a number of common project properties, such as an additional file format to be output when the application is linked and what library support to include if you use `printf` and `scanf`. After the project is created, you can change these settings in the Project Explorer as needed.

1. You can double-click a project property or its value to display either a drop-down menu of potential, valid values or a text field in which you can type arbitrary values. For our tutorial, the default values are fine.
2. Click **Next** to display a list of the files CrossWorks will add to this project by default. You can uncheck any file you plan to add manually or that you know will not be needed.

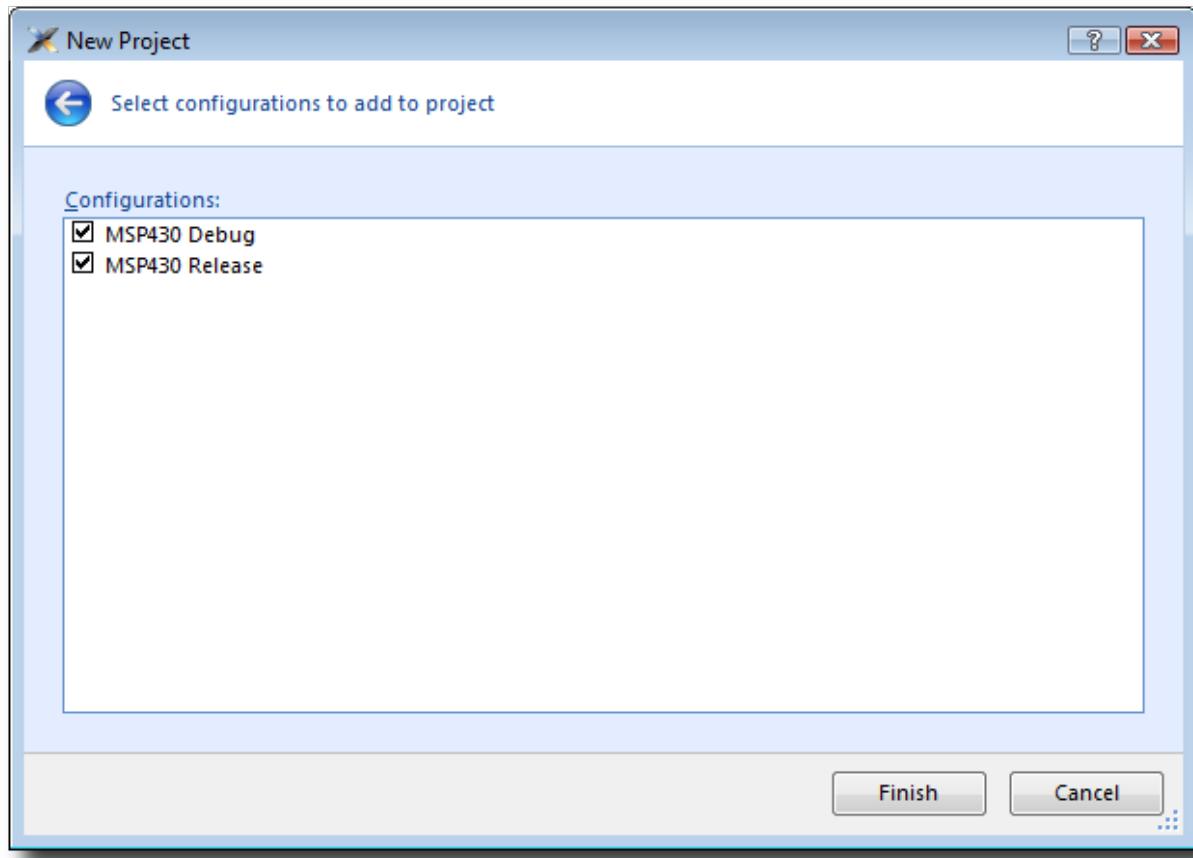


The **Links to system files** group shows the links to CrossWorks system files that will be created in the project. Because these files are links, the default behavior is that they will be shared with other projects—so modifying one will affect all projects containing similar links. To prevent accidental modification, these files are created as read-only. Should you wish to modify a shared file without affecting other projects, first import it into the project. (Importing a shared file will be demonstrated later in this tutorial.) See [Creating and managing projects](#) for more information on project links.

The **Project files** pane shows the files that will be copied into the project. Because these files are *copied* to the project directory, they can be modified without affecting any other project.

If you uncheck an item, that file is not linked to, or created in, the project. We will leave all items checked for the moment.

1. Click **Next** to view the default configurations that will be added to the project. Again, you can uncheck any you know will not be needed but, for this tutorial, we will leave the defaults unchanged.



Here you can specify the default configurations that will be added to the project. See [Creating and managing projects](#) for more information on project configurations.

1. Click **Finish** to complete the new project's creation.

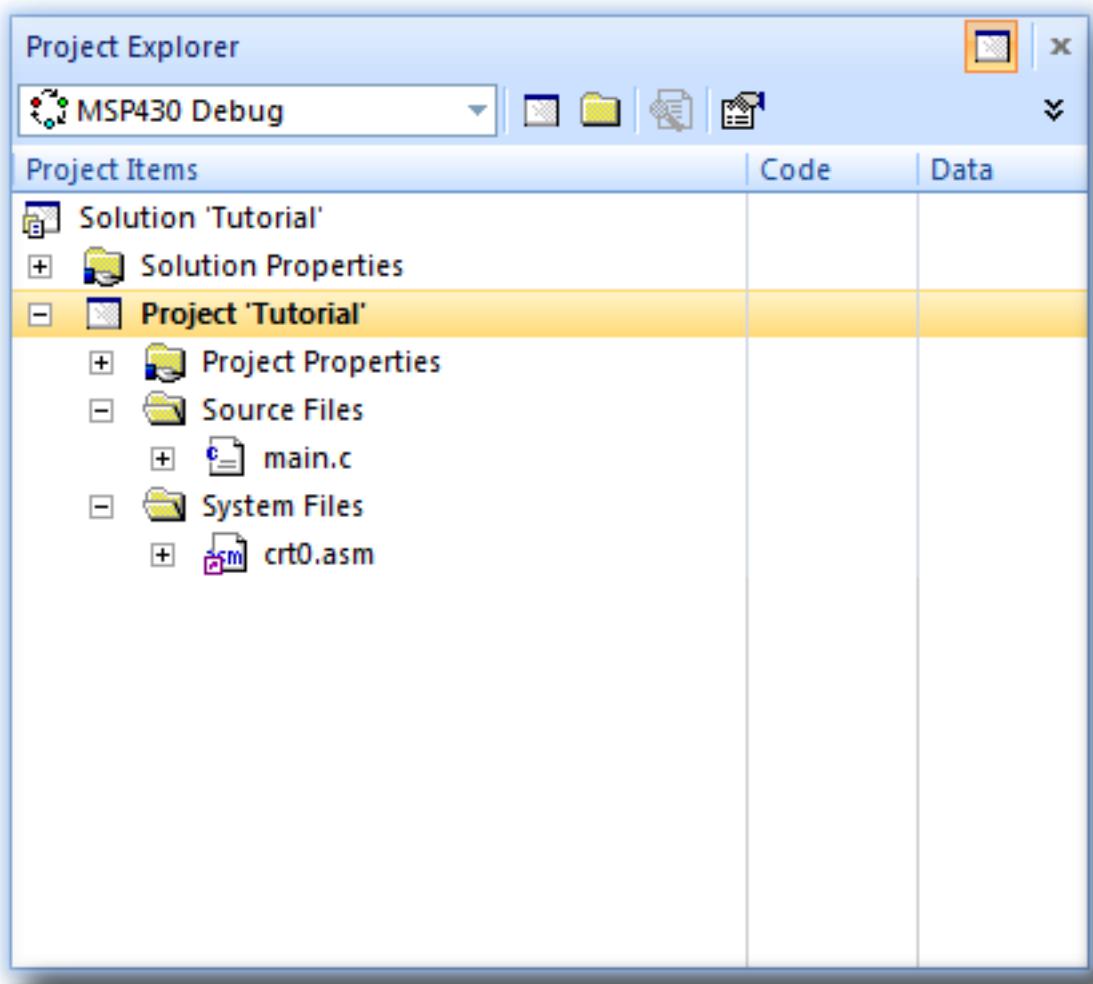
The **Project Explorer** shows the overall structure of your project. To invoke it, do one of the following:

- Choose **View > Project Explorer**.

—or—

- Type **Ctrl+Alt+P**.

This is what our project looks like in the **Project Explorer**:



The project name is shown in bold to indicate it is the active project (and, in our case, the only project). If you have more than one project, you can set the active project by using the drop-down box on the **Build** tool bar or by right-clicking the desired project's name in the **Project Explorer** to display the shortcut menu with the **Set as Active Project** command.

The files are arranged into two groups; click the + symbol next to the project name to reveal them:

- **Source Files** contains the main source files for your application, typically header files, C files, and assembly code files. You may want to add files with other extensions or documentation files in HTML format, for instance.
- **System Files** contains links to source files that are not part of the project but are required when the project is built and run. In this case, the system files are: `crt0.asm` — the C run-time startup, written in assembly code

Files stored outside the project's home directory (with a small purple shortcut indicator at the bottom left of the icon, as above).

These folders have nothing to do with directories on disk, they are simply a means to group related files in the **Project Explorer**. You can create new folders and specify filters for them based on the project files' extensions; thereafter, when you add a new file to the project, it will be shown in the **Project Explorer** folder whose filter matches the new file's extension.

Managing files in a project

We'll now set up the example project with some files that demonstrate features of the CrossWorks IDE. For this, we will add one pre-prepared file and one new file to the project.

Adding an existing file to a project

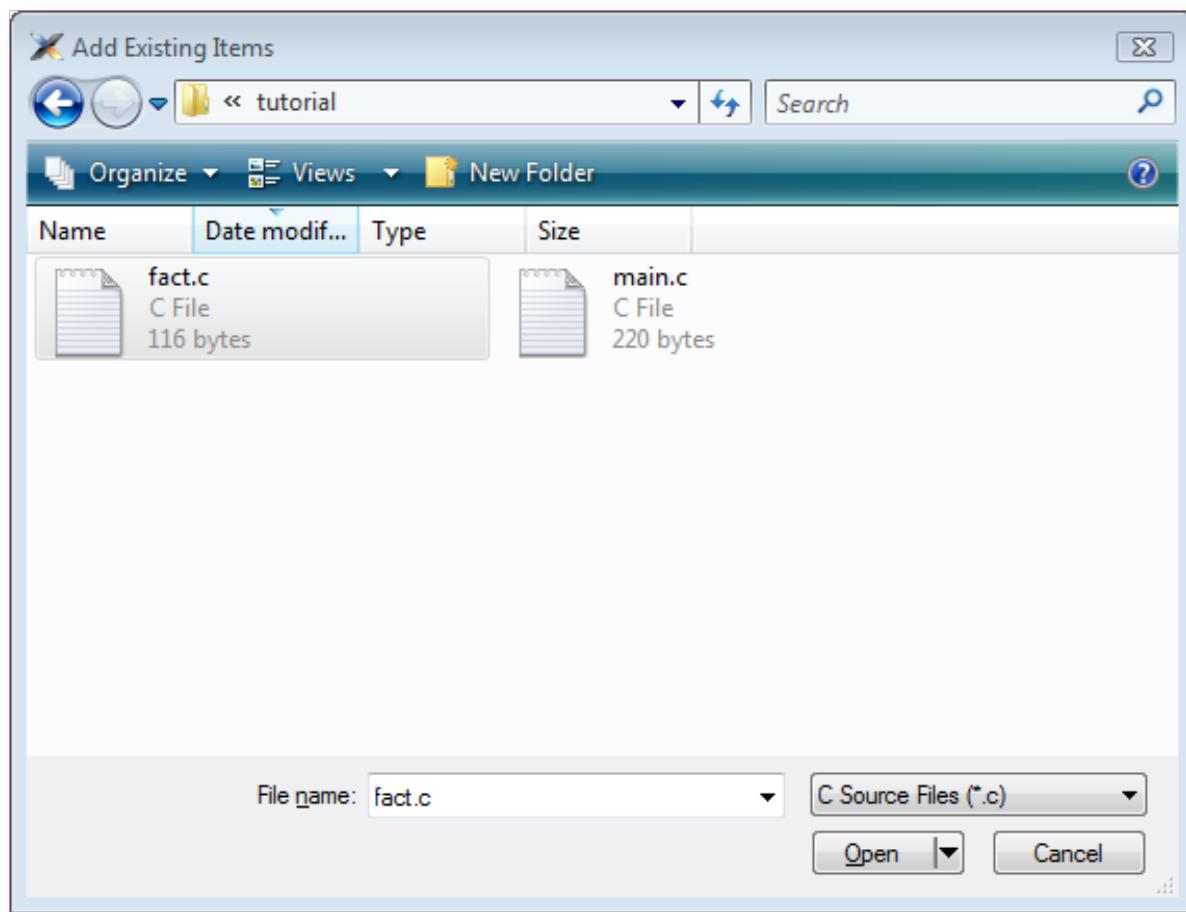
To add one of the existing tutorial files to the project:

- Choose **Project > Add Existing File** or press **Ctrl+P, A**.

—or—

- In the **Project Explorer**, right-click the Tutorial project node.
- Choose **Add Existing File** from the shortcut menu.

In response, CrossWorks displays a standard file-locator dialog. Use it to navigate to the CrossWorks installation directory, then to the `tutorial` folder, where you should select the `fact.c` file.

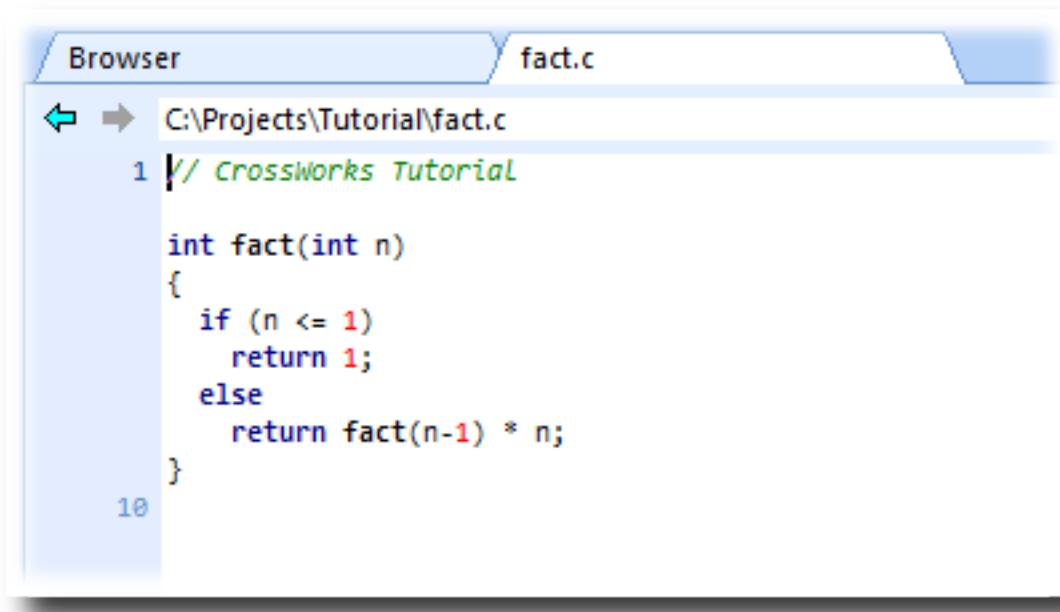


Click **Open** to add the file to the project. The **Project Explorer** will list `fact.c` in the **Project Items' Source Files** folder, with a shortcut arrow because the file is not in the project's home directory. Rather than edit the file in the tutorial directory, we'll put a copy of it into the project's home directory:

- In the **Project Explorer**, right-click the `fact.c` node.
- From the pop-up menu, click **Import**.

The shortcut arrow disappears from the `fact.c` node, indicating that our working version of that file is now in our Tutorial project's home directory.

We can open a file for editing by double-clicking the node in the **Project Explorer**. For example, double-clicking `fact.c` opens it in the code editor:



```
Browser fact.c
C:\Projects\Tutorial\fact.c
1 // CrossWorks Tutorial

int fact(int n)
{
    if (n <= 1)
        return 1;
    else
        return fact(n-1) * n;
}
```

Removing a file from a project

We don't need the `main.c` file that was added to the project by the new-project wizard, so we will remove it.

Do one of the following:

- Select `main.c` in the **Project Explorer**.
- Choose **Edit > Delete** or press **Del**.

—or—

- In the **Project Explorer**, right-click `main.c`.
- From the shortcut menu, click **Remove**.

Adding a new file to a project

Our project isn't complete, because `fact.c` is only part of an application. To our project we'll add a new C file that will contain the `main()` function. To add a new file to the project, do the following:

- Choose **File > New** to open the **New File** dialog.

—or—

- On the **Project Explorer** tool bar, click the **Add New File** button.

—or—

- In the **Project Explorer**, right-click the Tutorial node.
- Choose **Add New File** from the shortcut menu.

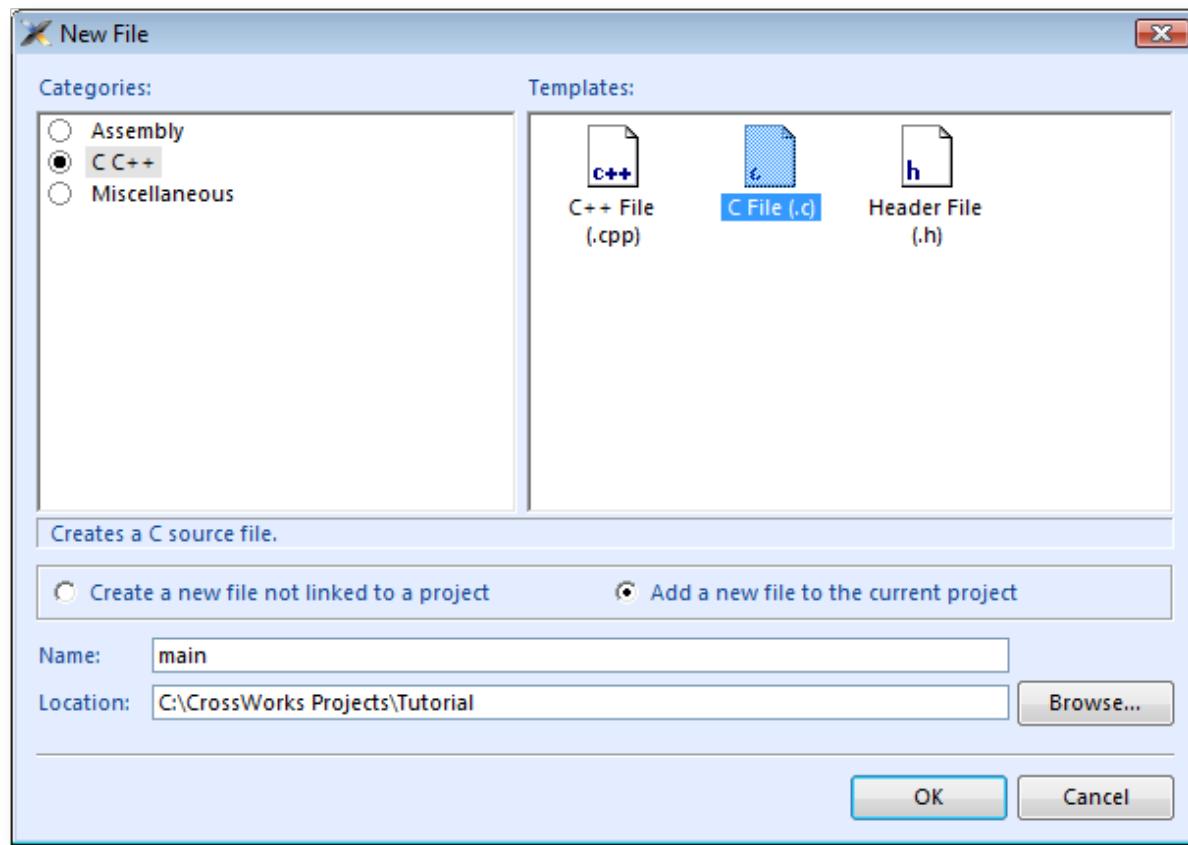
—or—

- Type **Ctrl+N**.

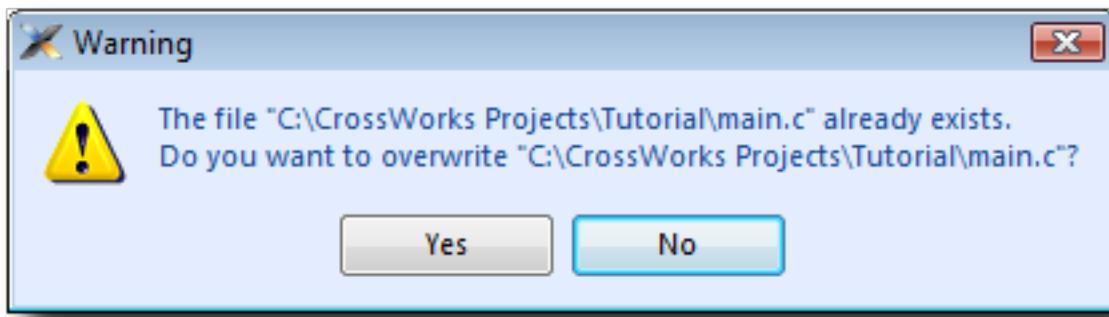
The **New File** dialog appears.

- In the **Categories** pane, select **C C++** to indicate the general type of file.
- In the **Templates** pane, select the **C File (.c)** option to further specify the kind of file we will be adding.
- In the **Name** edit box, type `main`.

The dialog box will now look like this:



Click **OK** to add the new file. Because `main.c` already exists on disk, you will be asked whether you wish to overwrite the file:



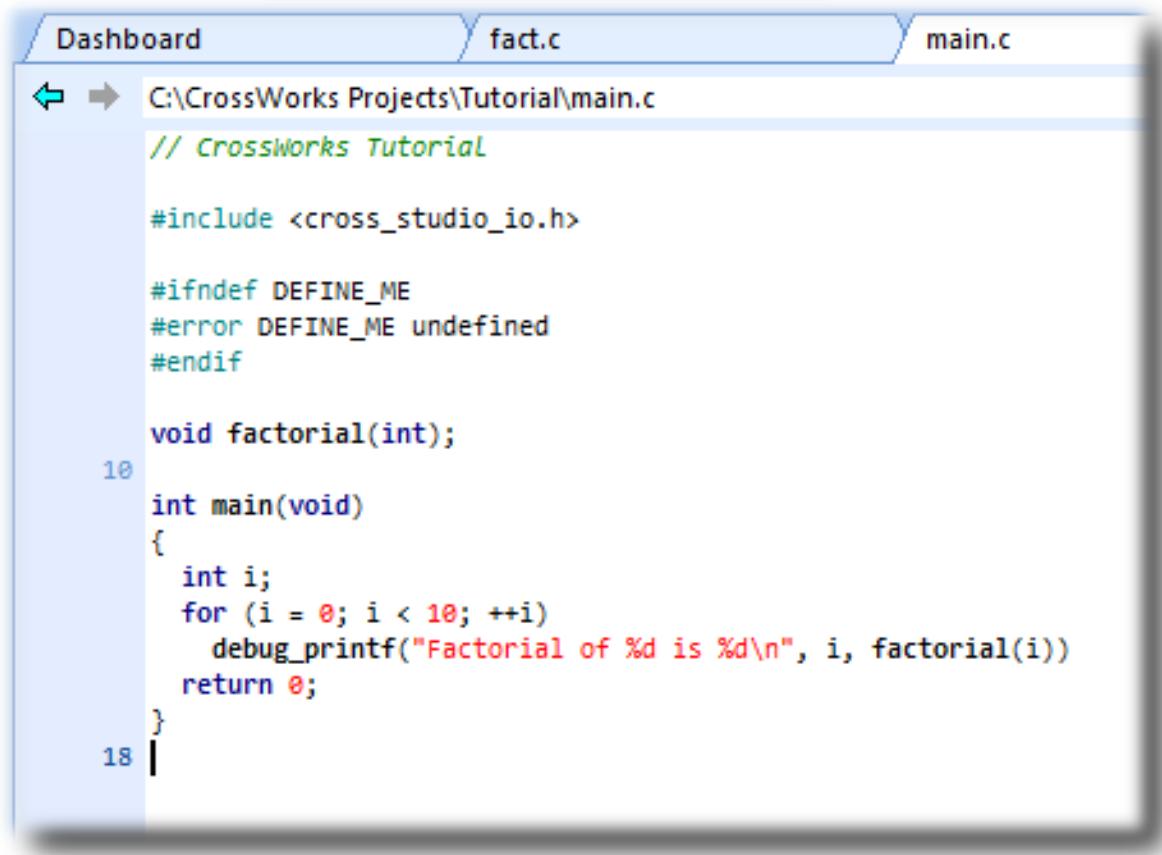
Click **Yes** to overwrite the file and continue with the tutorial.

CrossWorks opens the new file in the code editor. Rather than type the program from scratch, we'll add it from a file stored on disk. With the new, empty `main.c` in the foreground:

- Choose **Edit > Others > Insert File** or press **Ctrl+K, Ctrl+I**.
- Using the file-selection dialog, navigate to the `tutorial` directory.

- Select the `main.c` file.
- Click **OK**.

Your `main.c` file should now look like this:



The screenshot shows the CrossStudio IDE interface with the main.c file open. The title bar displays "Dashboard fact.c main.c". The code editor shows the following C code:

```
// CrossWorks Tutorial

#include <cross_studio_io.h>

#ifndef DEFINE_ME
#error DEFINE_ME undefined
#endif

void factorial(int);
10
int main(void)
{
    int i;
    for (i = 0; i < 10; ++i)
        debug_printf("Factorial of %d is %d\n", i, factorial(i))
    return 0;
}
18
```

Next, we'll set up some project options.

Setting project options

Up to this point, you have created a simple project. In this section, we will set some options for that project.

You can set project options on any node of a solution. That is, you can set options on a solution-wide basis, on a project-wide basis, on a project-group basis, or on an individual-file basis. For instance, options you set on a solution are inherited by all projects in that solution, by all groups in each of those projects, and by all files in each of those groups. If you set an option further down in the hierarchy, that setting will be inherited by nodes that are children of (or grandchildren of, etc.) that node. This provides a powerful way to customize and manage your projects.

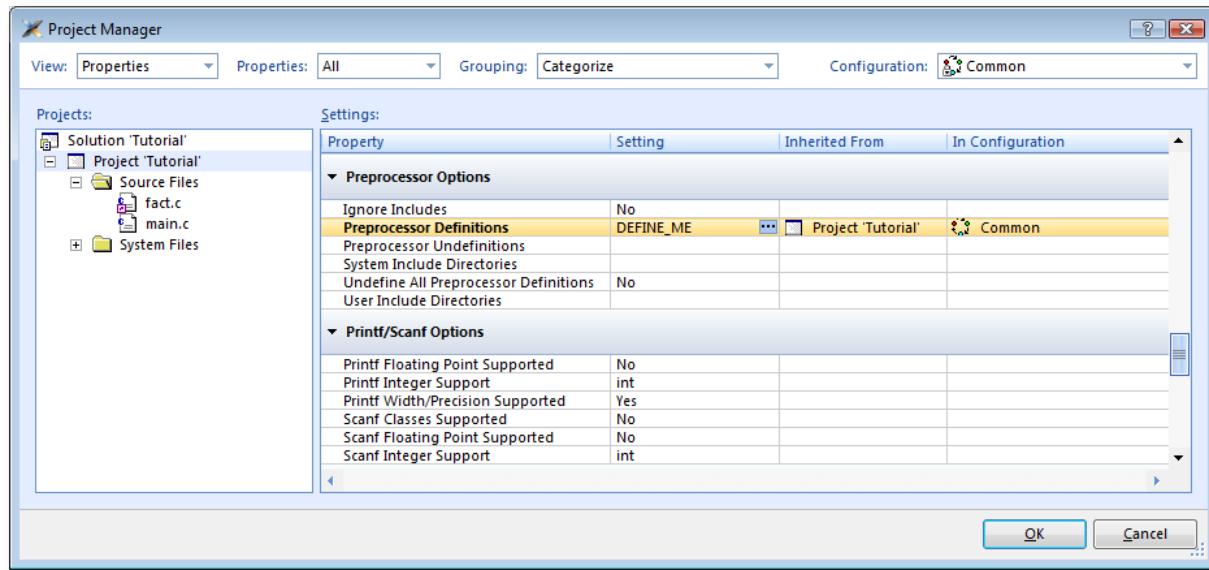
Adding a C preprocessor definition

In this instance, we will define a C preprocessor definition that will apply to the entire Tutorial *project*. This means every file in the project will inherit our new definition. If, however, we were to later add other projects to the solution, they would not inherit the definition; if we wanted that, we could set the property on the solution node rather than the project node.

To set a C preprocessor definition on the project node:

- Right-click the Tutorial project in the **Project Explorer** and select **Properties** from the menu—the **Project Manager** dialog appears.
- Click the **Configuration** drop-down and change to the **Common** configuration (it is one of the "Private Configurations").
- Scroll down the list as necessary to click the **Preprocessor Options > Preprocessor Definitions** property. Double-click the property name or value field, or click the . . . symbol to display the empty **Preprocessor Definitions** window, and in that window type the definition `DEFINE_ME`.

The dialog box will now look like this:



Notice that, when you change between **Debug** and **Release** configurations, the code generation options change. This dialog shows the options used when building a project (or anything in a project) in a given configuration. Because we put the above, new definition in the **Common** configuration, both **Debug** and **Release** configurations will use this setting. We could, however, set the definition to be different in **Debug** and **Release** configurations if we wanted to pass different definitions into debug and release builds.

Now click **OK** to accept the changes made to the project.

Using the Properties Window

If you click on the project node, the **Properties Window** will show the properties of the project—all were inherited from the solution. If you modify a property when the project node is selected, you'll find that its value is highlighted because you have overridden the property value inherited from the solution. To restore the inherited value of a property that was changed, right-click the property and select **Use Inherited Value**.

Next, we'll build the project.

Building projects

Now that the project is created and set up, it's time to build it. There are some deliberate errors in the program that we need to correct; doing that is the next step in this tutorial.

Setting the build configuration

The first thing to do is set the active build configuration you want to use:

- Select **MSP430 Debug** from the Active Configuration .

This means we are going to use a build configuration that generates code with debug information and no optimization, so it can be debugged. If we wanted to produce production code with no debug information and optimization enabled, we could use the **MSP430 Release** configuration. However, because we are going to use the debugger, we shall use the **MSP430 Debug** configuration.

Building the project

To build the project:

- Choose **Build > Build Tutorial**.

—or—

- On the **Build** tool bar, click the **Build Active Project** button.

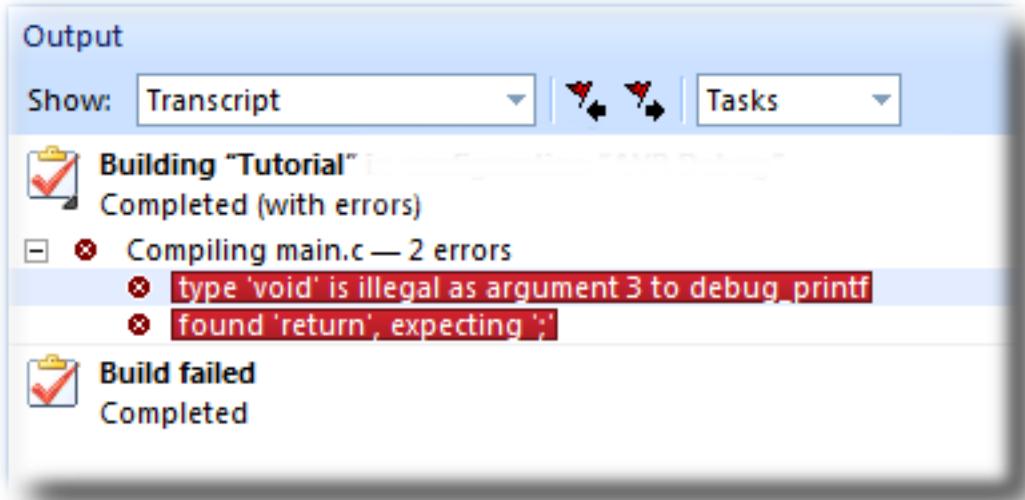
—or—

- Type **F7**.

Alternatively, to build the Tutorial project using a shortcut menu:

- In the **Project Explorer**, right-click the Tutorial project node.
- Select **Build** from the shortcut menu.

CrossWorks starts compiling the project files, but stops after detecting an error. The **Output** window shows the Transcript, which contains the errors found in the project:



Correcting compilation and linkage errors

The file `main.c` contains two errors. After compilation, CrossWorks moves the cursor to the line containing the first reported error and displays an error message in the **Output** window. (You can change this behavior by modifying the **Text Editor > Editing Options > Enable Popup Diagnostics** environment option using the **Tools > Options** dialog.)

```

int main(void)
{
    int i;
    for (i = 1; i <= 5; i++)
        debug_printf("Factorial of %d is %d\n", i, factorial(i));
    return 0;
}

```

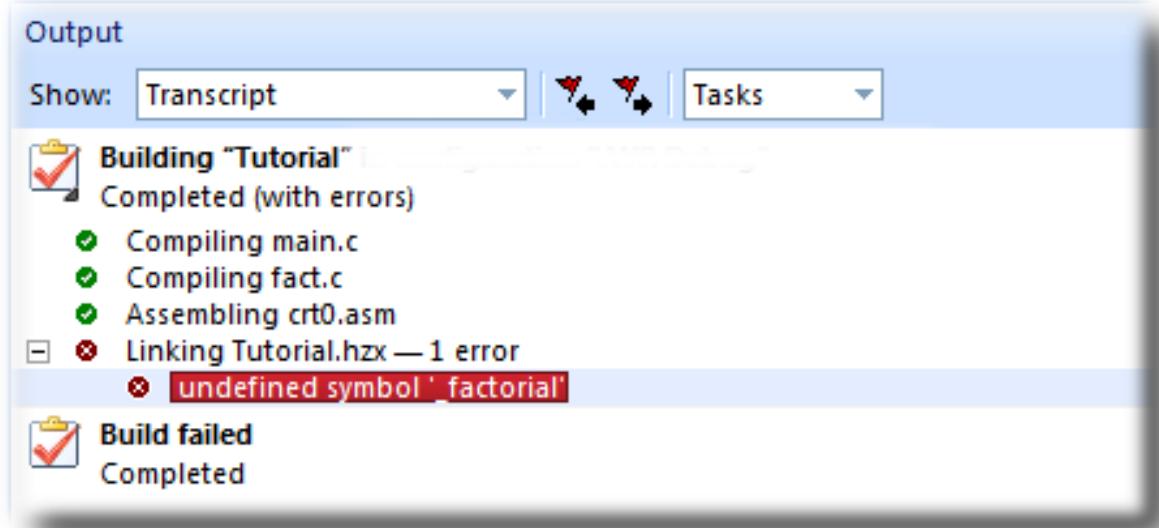
The code editor shows the following errors:

- Line 15: `debug_printf("Factorial of %d is %d\n", i, factorial(i));` - Error: type 'void' is illegal as argument 3 to debug_printf
- Line 15: `return 0;` - Error: found 'return', expecting ':' (highlighted in red)

To correct the error, change the return type of `factorial` from `void` to `int` in its prototype.

To move the cursor to the line containing the next error, type **F4** or choose **Search > Next Location**. The cursor is now positioned at the `debug_printf` statement, which is missing a terminating semicolon—add the semicolon to the end of the line. Using **F4** again reveals that we have corrected all errors.

Pressing **F4** again wraps around and moves the cursor to the first error, and you can use **Shift+F4** or **Search > Previous Location** to move back through errors. Now that the errors are corrected, build the project again by pressing **F7**. The Transcript shows there still is a problem.



The remaining error is a linkage error. Double-click `fact.c` in the **Project Explorer** to open it for editing and change the two occurrences of `fact` to `factorial`. Rebuild the project—this time, the project compiles correctly:



A summary of the memory used by the project is displayed at the end of the build log. The results for your application may be different, so don't worry if they don't match.

In the next sections, we'll explore the characteristics of the newly built project.

Exploring projects

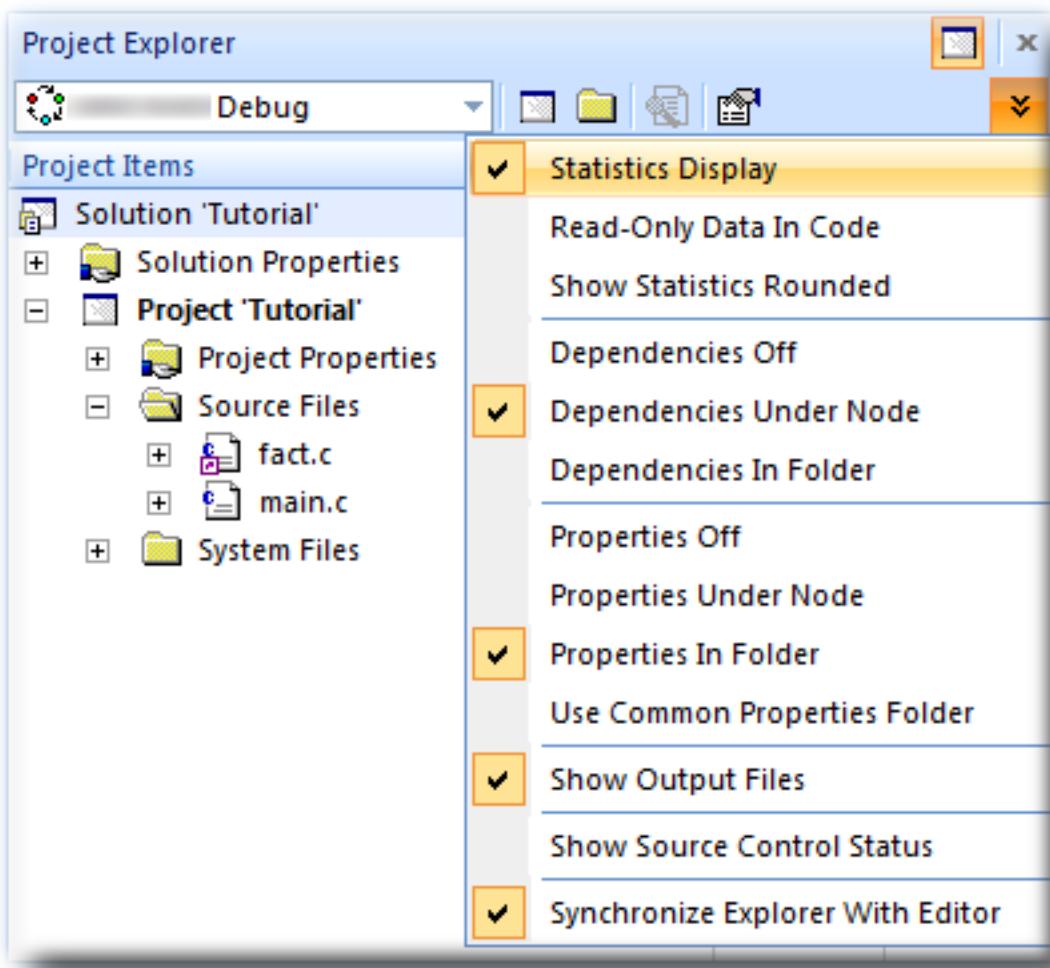
Now that the project has no errors and builds correctly, we can turn our attention to uncovering exactly how our application fits in memory and how to navigate around it.

Using Project Explorer features

The **Project Explorer** is the central focus for arranging your source code into projects, and it's a good place to show ancillary information gathered when CrossWorks builds your applications. This section will cover features the **Project Explorer** offers to give you an overview of your project.

Project code and data sizes

Developers are always interested in how much memory their applications use, especially when they are working with small, embedded microcontrollers. The **Project Explorer** can display the code and data sizes for each project and individual source file that successfully compiled. To view this information, use the **Options** pop-up menu on the **Project Explorer** tool bar to ensure that **Statistics Column** is checked.



When the **Statistics Column** option is checked, the **Project Explorer** displays two additional columns, **Code** and **Data**.

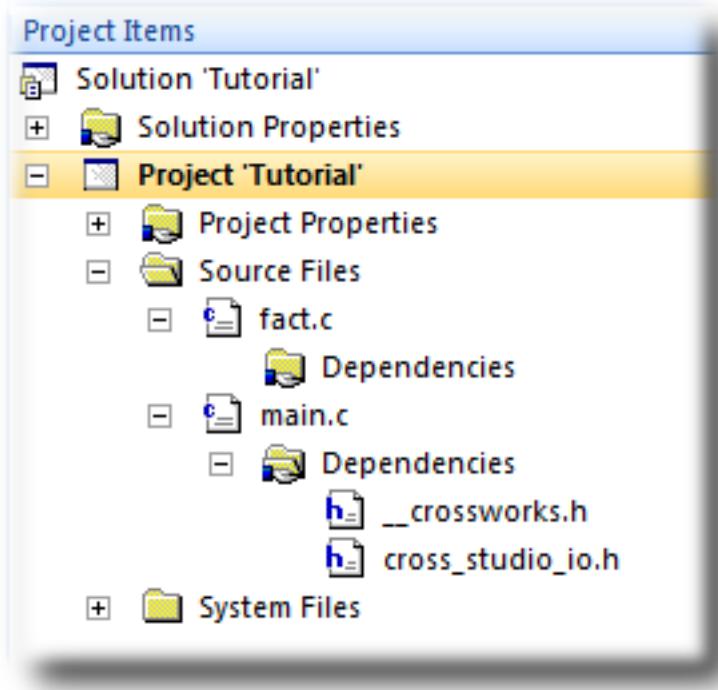
Project Items	Code	Data
Solution 'Tutorial'		
Solution Properties		
Project 'Tutorial'	2,148	28
Project Properties		
Source Files		
fact.c	80	
main.c	100	24
System Files		

The **Code** column displays the total code space required for the project. The **Data** column displays the total data space required. The code and data sizes shown for each C and assembly source file are *estimates*, but good ones. Because the linker removes any unreferenced code and data, and performs a number of optimizations, the sizes for the linked project may not be the sum of the sizes of each individual file. The code and data sizes for the project, however, *are* accurate. As already mentioned, your numbers may not match these exactly.

Dependencies

The **Project Explorer** is very versatile: not only can you display the code and data sizes for each element of a project and for the project as a whole, you can also configure it to show the *dependencies* for a file. As part of the compilation process, CrossWorks finds and records the relationships between files—that is, it finds which files depend upon other files. CrossWorks uses these known relationships when it builds the project again, to minimize the amount of work required to bring the project up to date.

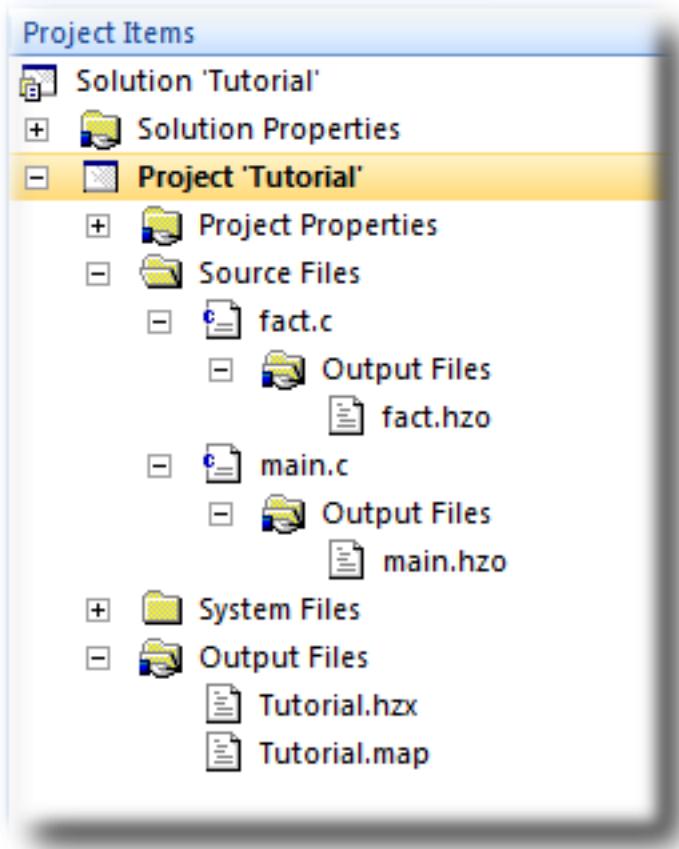
To show the dependencies for a project, use the **Options** button on the **Project Explorer** tool bar to ensure that either **Dependencies Under Node** or **Dependencies In Folder** is checked. Once checked, dependent files are shown as sub-nodes of the file that depends on them.



In this case, `main.c` is dependent upon `cross_studio_io.h` because it includes it with an `#include` directive. It is also dependent on `__crossworks.h` because that is included by `cross_studio_io.h`. You can open the files in an editor by double-clicking them, so having dependencies turned on is an effective way of navigating to and summarizing the files a source file includes.

Output files

It is useful to know the output files when compiling and linking the application, and CrossWorks can display this information, too. To turn on output-file display, click the **Project Explorer** tool bar's **Options** button and verify that **Output Files Folder** option is checked in the menu. Once checked, output files are shown in an **Output Files** folder under the node that generates them. Click that folder's + symbol to expand the view of the output files.



In the above figure, we see that the object files `fact.hzo` and `main.hzo` are object files produced by compiling their corresponding source files; the map file `Tutorial.map` and the linked executable `Tutorial.hzx` are produced by the linker. As a convenience, double-clicking an object file or a linked executable file in the **Project Explorer** will open an editor showing the disassembled contents of the file.

Disassembling a project or file

You can disassemble a project either by double-clicking the corresponding file in the **Project Explorer**, as described above, or by using the **Disassemble** tool.

To disassemble a project or file:

- Right-click the appropriate project or file in the **Project Explorer**.
- From the shortcut menu, choose **Disassemble**.

CrossWorks then opens a new read-only editor showing the disassembled listing. If you change your project and rebuild it, thereby causing a change in the object or executable file, the disassembly updates to keep the display's contents synchronized with the file on disk.

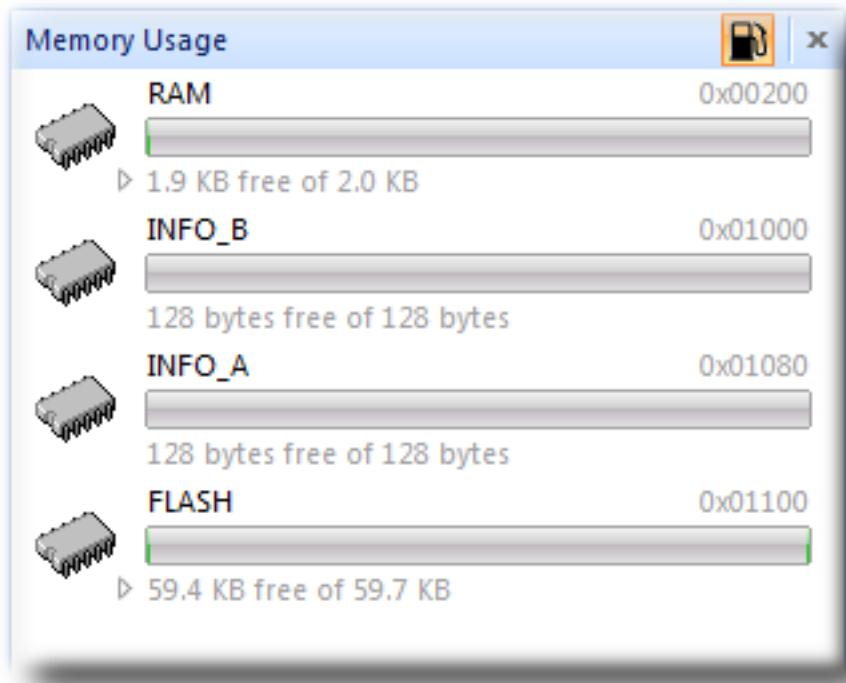
Using Memory Usage Window features

The **Memory Usage** window can be used to view a graphical summary of how memory was used in each memory segment of a linked application.

To display the memory usage:

- Choose **View > Memory Usage** or press **Ctrl+Alt+Z**.

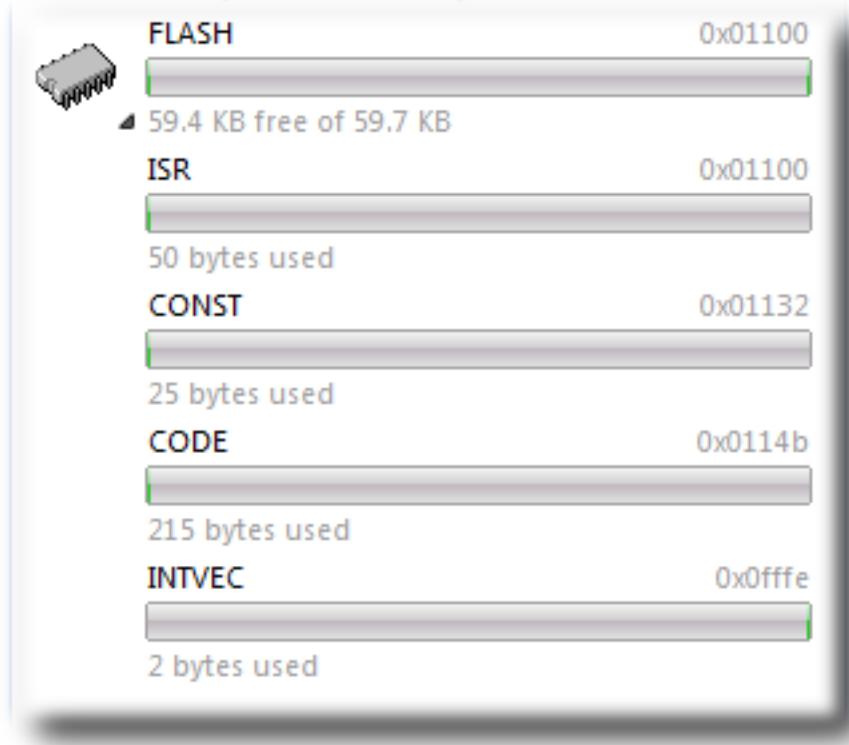
For the Tutorial project, the **Memory Usage** window shows this:



From this, you can see:

- The **RAM** segment is located at 0200, is 2 KB in length, and has 1.9 KB of unused memory.
- The **FLASH** segment is located at 1110, is 59.7 KB in length, and has 59.4 KB of unused memory.

If you expand the **FLASH** segment, CrossWorks will display the program sections contained within the segment:



From this, you can see that the the **CODE** section is located at 114B and is 215 bytes in length.

Using Symbol Browser features

For a more-detailed view of how your application is laid out in memory than the **Memory Usage** window provides, you can use the **Symbol Browser**. It allows you to navigate your application, see which data objects and functions have been linked into your application, what their sizes are, which section they are in, and where they are placed in memory.

To activate the Symbol Browser:

- Choose **Navigate > Symbol Browser** or press **Ctrl+Alt+Y**.

Drilling down into the application

The Tutorial project shows this in the **Symbol Browser**:

The screenshot shows the 'Symbol Browser' window with the title bar 'Symbol Browser'. Below the title bar is a toolbar with icons for search, refresh, and other functions. A search bar labeled 'Search Symbols' is present. The main area is a table with three columns: 'Name', 'Range', and 'Size'. The table lists the following memory sections:

Name	Range	Size
(No section)		
CODE	0114b-01221	215
CONST	01132-0114a	25
IDATA0	00200-00201	2
INTVEC	0ffffe-0fffff	2
ISR	01100-01131	50
UDATA0	00202-00203	2

From this, you can see that the **CODE** section is 215 bytes in size and is placed in memory between address 114B and 1221, inclusive. Similarly, the zeroed data section **UDATA0** is 2 bytes in size and is placed between 0202 and 0203. The **CONST** section that holds string constants and read-only data is 25 bytes in size, and is located between 1132 and 114A. To sort the sections by address, click on the column's **Range** header, or click **Size** to sort them by their sizes.

To drill down, open the **CODE** node by double-clicking it: CrossWorks displays the individual functions that have been placed in memory and their sizes:

Name	Range	Size
[+] [No section]		
- [CODE]	0114b-01221	215
[_debug_printf]	01200-0121d	30
[_factorial]	0116e-0118b	30
[_main]	0114c	
[_main]	0114c-0116d	34
[_memcpy]	011a0	
[_memcpy]	011a0-011af	16
[_memset]	011b0	
[_memset]	011b0-011bf	16
[__debug_io_lock]	0121e-0121f	2
[__debug_io_unlock]	01220-01221	2
[_do_debug_operation]	011c0	
[_do_debug_operation]	011c0-011ff	64
[__int16_mul]	0118c-0119f	20

Here, we can see that **main** is 34 bytes in size and is placed in memory between addresses 114C and 116D, inclusive, and that **factorial** is 30 bytes and occupies addresses 116E through 118B. Just as in the **Project Explorer**, if you double-click a function, CrossWorks moves the cursor to the line containing the definition of that function, so you can easily use the **Symbol Browser** to navigate around your application.

Printing Symbol Browser contents

You can print the contents of the **Symbol Browser** by selecting its window and choosing **Print** from the **File** menu, or **Print Preview** if you want to see what it will look like before printing. CrossWorks prints only the columns you have selected for display, and prints items in the order displayed in the **Symbol Browser**, so you can choose which columns to print and how to print symbols by configuring the **Symbol Browser** display.

We have touched on only some of the features the **Symbol Browser** offers; to learn more, refer to [Symbol Browser](#), where it is described in detail.

Using the debugger

Our sample application, which we have just compiled and linked, is now built and ready to run. In this section, we'll concentrate on downloading and debugging this application, and on using the features of CrossWorks to see how it performs.

Getting set up

Before running your application, you need to select the target to run it on. Choose **Target > Targets** to list in the **Targets** window each target interface that is defined. You will use these to connect CrossWorks to a target. For this tutorial, you'll be debugging on the simulator, not hardware, to simplify matters.

To connect to the simulator:

- Choose **Target > Connect > MSP430 Core Simulator**.
- or—
- Choose **View > Targets** to activate the **Targets** window.
 - In the **Targets** window, double-click **MSP430 Core Simulator**.

After connecting, the MSP430 Core Simulator target is shown in the status bar:



The color of the target-status LED in the status bar changes according to what CrossWorks and the target are doing:

- **White** — No target is connected.
- **Yellow** — Target is connected.
- **Solid green** — Target is free running, not under control of CrossWorks or the debugger.
- **Flashing green** — Target is running under control of the debugger.
- **Solid red** — Target is stopped at a breakpoint or because execution is paused.
- **Flashing red** — CrossWorks is programming the application into the target.

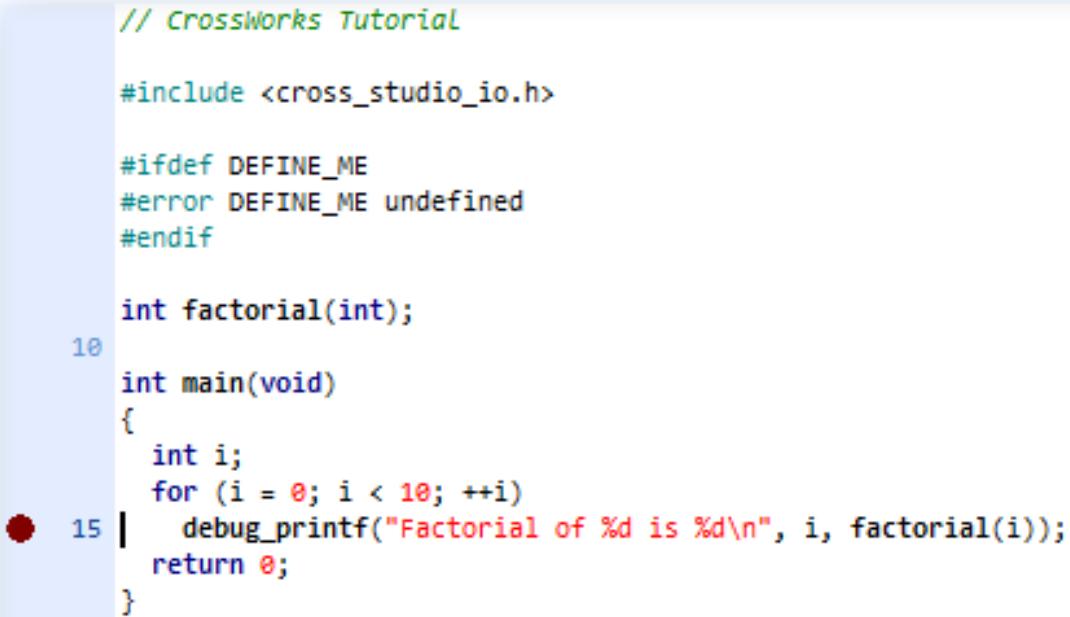
Double-clicking the **Target Status** will show the **Targets** window, if it is not already visible.

The core simulator target can accurately count the cycles spent executing your application, so the status bar shows a cycle counter. If you connect a target that cannot provide performance information, the cycle counter panel is hidden. Double-clicking the **Cycle Counter** panel will reset the cycle counter to zero.

Setting a breakpoint

CrossWorks will run a program until it hits a breakpoint. We'll place a breakpoint on the call to `debug_printf` in `main.c`. To set the breakpoint, move the cursor to the line containing `debug_printf` and choose **Debug > Toggle Breakpoint** or press **F9**.

Alternately, you can set a breakpoint without changing the cursor's position by clicking in the gutter of the line to set the breakpoint on.



```
// CrossWorks Tutorial

#include <cross_studio_io.h>

#ifndef DEFINE_ME
#error DEFINE_ME undefined
#endif

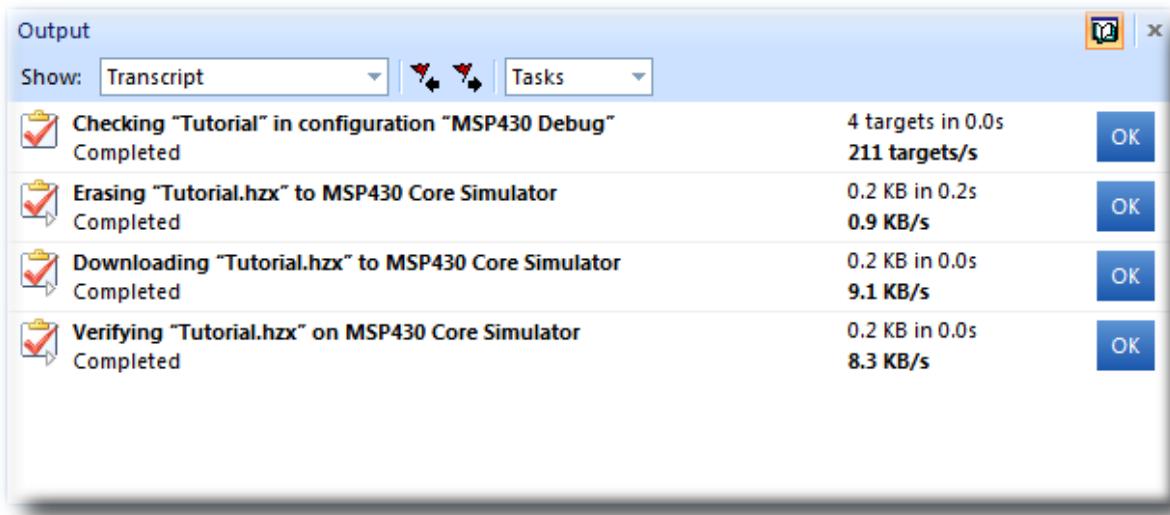
int factorial(int);
10
int main(void)
{
    int i;
    for (i = 0; i < 10; ++i)
● 15 |     debug_printf("Factorial of %d is %d\n", i, factorial(i));
    return 0;
}
```

The gutter displays an icon on lines where breakpoints are set. The **Breakpoints** window updates to show where each breakpoint is set and whether it's set, disabled, or invalid—you can find more detailed information in the [Breakpoints window](#) section. The breakpoints you set are stored in a session file associated with the project, so your breakpoints are remembered if you exit and re-run CrossWorks.

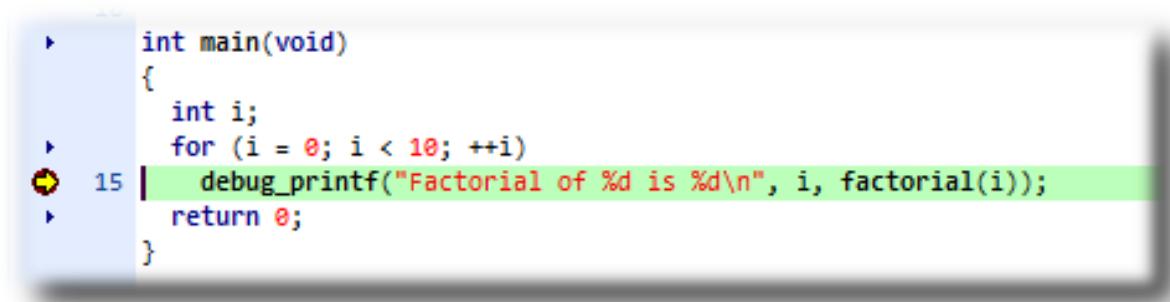
Starting the application

To start the application, choose **Debug > Start** or press **F5**.

The workspace will change from the standard Editing workspace to the Debugging workspace. You can choose which windows to display in each of these workspaces and manage them independently. CrossWorks loads the active project into the target and places the breakpoints you have set. During loading, the **Target Log** in the **Output Window** shows its progress and any problems:



The program stops at our breakpoint and a yellow arrow in the gutter indicates where the program is paused.



Step into the `factorial` function by selecting **Debug > Step Into**, by typing **F11**, or by clicking the **Step Into** button on the **Debug** tool bar.

Now step to the first statement in the function by selecting **Debug > Step Over**, by typing **F10**, or by clicking the **Step Over** button on the **Debug** tool bar.

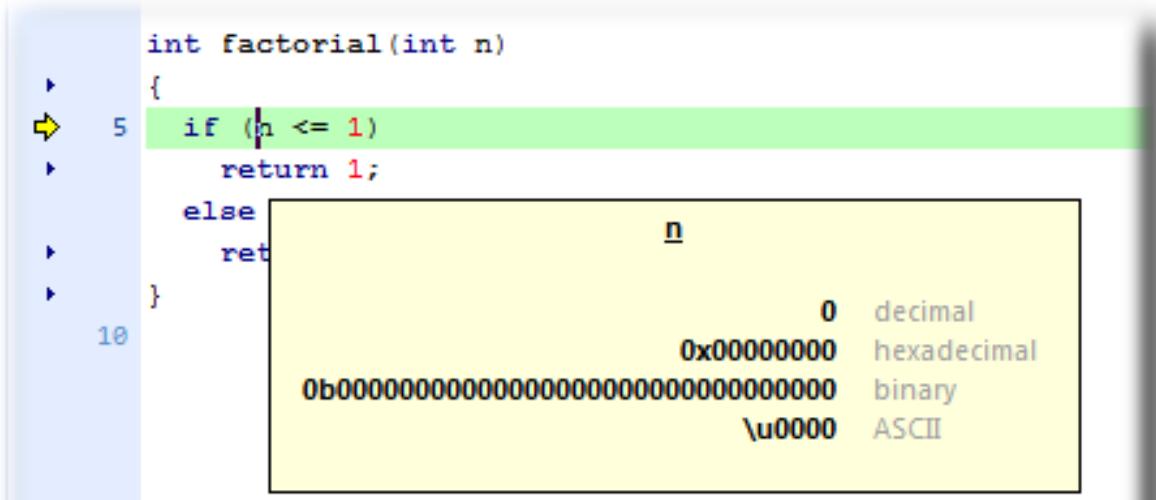
```
int factorial(int n)
{
    if (n <= 1)
        return 1;
    else
        return factorial(n-1) * n;
}
```

You can step out of a function by choosing **Debug > Step Out**, by typing **Shift+F11**, or by clicking the **Step Out** button on the **Debug** tool bar. You can also step to a specific statement by choosing **Debug > Run To Cursor**. To allow your application to run to the next breakpoint, choose **Debug > Go**.

Note that, when single-stepping, you may step into a function whose source code the debugger cannot locate. In such cases, the debugger will display the instructions of the application; you can step out to get back to source code or continue to debug at the instruction-code level. There may be cases in which the debugger cannot display the instructions; in such cases, you will be informed of this with a dialog and you should step out.

Inspecting data

Being able to control execution isn't very helpful if you can't look at the values of variables, registers, and peripherals. Hovering the mouse cursor over a variable will show its value as a *data tip*:

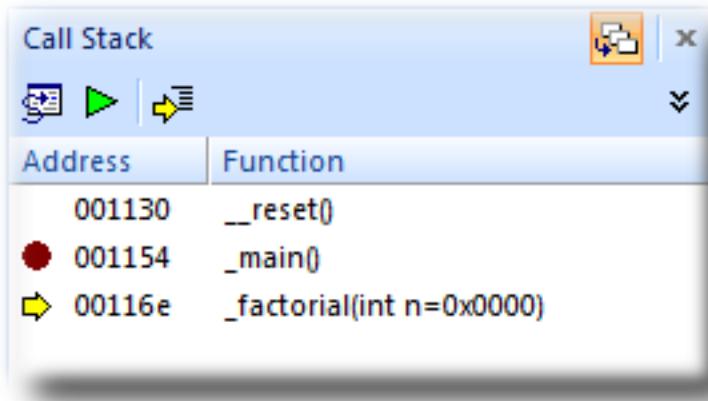


You can configure CrossWorks to display data tips in a variety of formats at the same time using the **Environment Options** dialog. You can also use the **Autos**, **Locals**, **Globals**, **Watch**, and **Memory** windows to view variables and memory. These windows are described in [CrossStudio User Guide](#).

The **Call Stack** window shows the function calls that have been made but have not yet finished executing, that is the list of active functions.

To display the call stack:

- Choose **Debug > Call Stack** or press **Ctrl+Alt+S**.



You can learn more about this in the [Call Stack window](#) section.

Program output

The Tutorial application uses the function `debug_printf` to output a string to the **Debug Terminal** in the **Output** window. The **Debug Terminal** appears automatically whenever something is written to it—press **F5** to continue program execution and you will notice that the **Debug Terminal** appears. In fact, the program runs forever, writing the same messages over and over again. To pause the program, select **Debug > Break** or type **Ctrl+.** (control-period).

In the next section, we'll cover low-level debugging at the machine level.

Low-level debugging

This section describes how to debug your application at the register and instruction level. Debugging at a high level is fine, but sometimes you need to look more closely into the way your program executes to track down the causes of difficult-to-find bugs. CrossWorks provides the tools you need to do so.

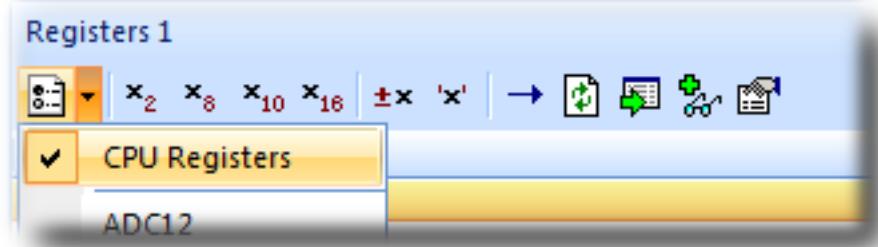
Setting up again

Next, we'll run the sample application again and look at how it executes at the machine level. If you haven't done so already, stop the program executing by typing **Shift+F5**, by selecting **Debug > Stop**, or by clicking the **Stop Debugging** button on the **Debug** tool bar. Now, run the program until it stops at the first breakpoint again.

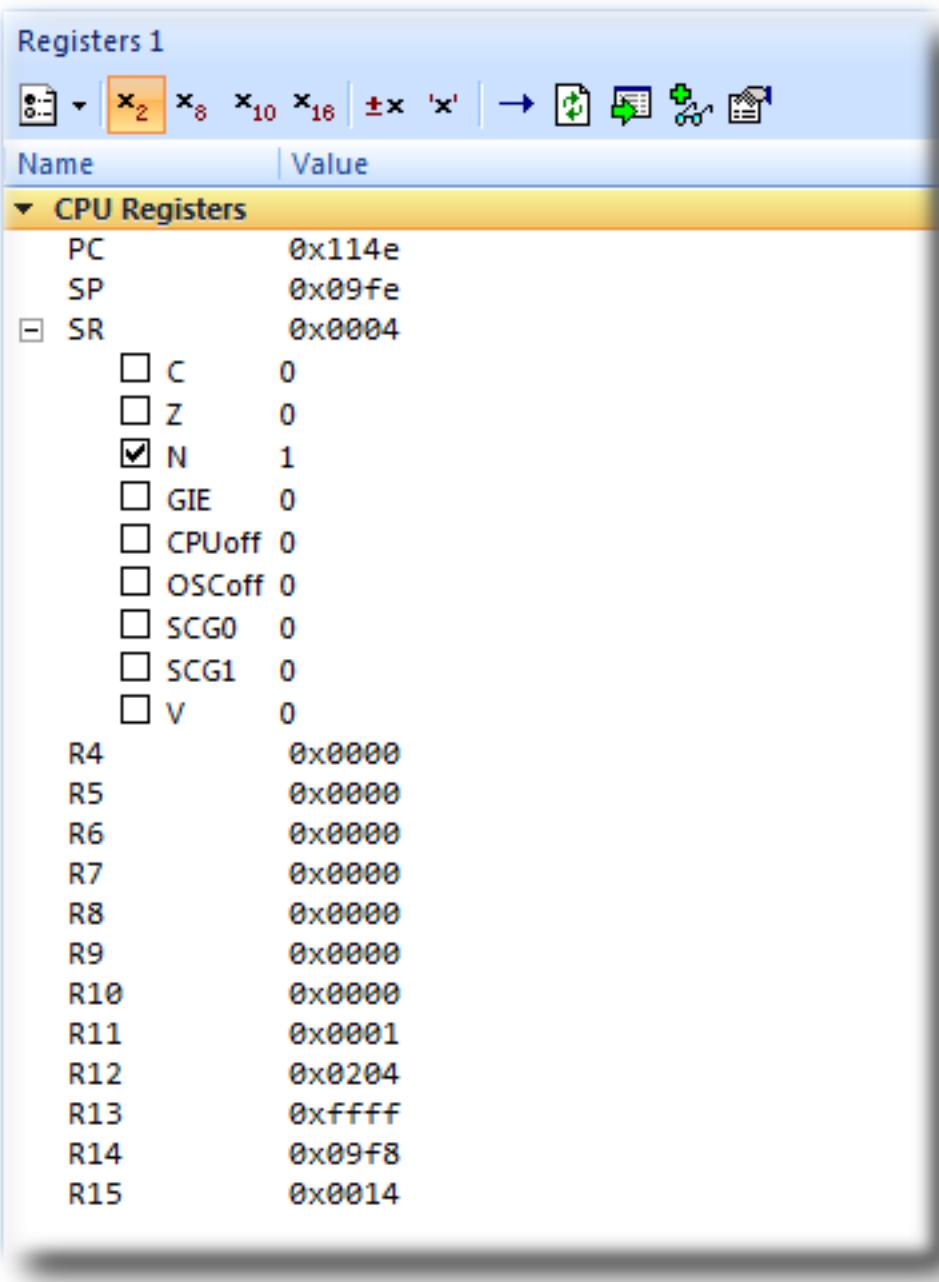
You can see the current processor state in the **Register** windows. To show the first **Registers** window:

- Choose **Debug > Other Windows > Registers > Registers 1** or press **Ctrl+T, R, 1**.

The **Registers** window can be used to view CPU and peripheral registers. First we shall look at just the CPU registers. To do this, use the **Registers 1** window's **Register Groups** menu to select **CPU Registers**.



Your registers window will look something like this:



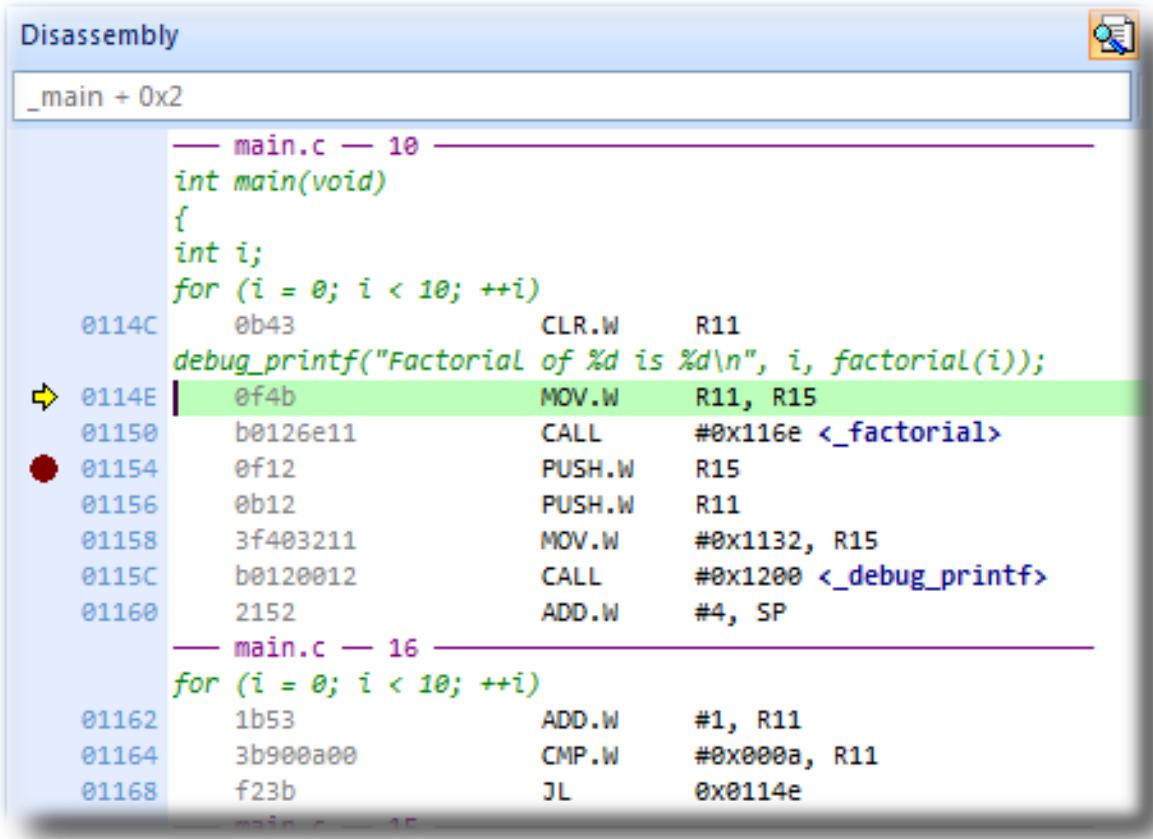
You can also use the registers window to display peripheral registers. To display the state of the target's hardware multiplier registers, select **Multiplier** from the **Register Groups** menu.

Registers 1	
Name	Value
CPU Register:	
PC	0x114e
SP	0x09fe
+ SR	0x0004
R4	0x0000
R5	0x0000
R6	0x0000
R7	0x0000
R8	0x0000
R9	0x0000
R10	0x0000
R11	0x0001
R12	0x0204
R13	0xffff
R14	0x09f8
R15	0x0014
Multiplier	
MPY	0x0006
MPYS	0x0006
MAC	0x0006
MACS	0x0006
OP2	0x0078
RESLO	0x02d0
RESHI	0x0000
SUMEXT	0x0000

There are four register windows, so you can open and display four sets of CPU and peripheral registers at the same time. You can configure which registers and peripherals to display in the **Registers** windows individually. As you single-step the program, the contents of the **Registers** window updates and any change in a register value is highlighted in red.

Disassembly

The **Disassembly** window can be used to debug your program at the instruction level. It displays a disassembly of the instructions around the currently located instruction, interleaved with the source code of the program, if the source is available. When the **Disassembly** window has focus, all single-stepping is done one instruction at a time. This window also allows you to set breakpoints by clicking in the gutter of lines containing instructions on which you want to set a breakpoint.



The screenshot shows the Disassembly window with the title bar "Disassembly". The window displays assembly code for the function `_main + 0x2`. The code is interleaved with C source code from `main.c`. A yellow arrow points to the instruction at address `0114E`, which is highlighted in green. A red dot marks a breakpoint at address `01154`. The assembly code includes instructions like `CLR.W R11`, `MOV.W R11, R15`, and `JL 0x0114e`.

```

Disassembly
_main + 0x2

--- main.c — 10 ---
int main(void)
{
    int i;
    for (i = 0; i < 10; ++i)
        0b43          CLR.W   R11
    debug_printf("Factorial of %d is %d\n", i, factorial(i));
    ➤ 0114E  0f4b      MOV.W   R11, R15
    01150  b0126e11    CALL    #0x116e <_factorial>
● 01154  0f12      PUSH.W  R15
    01156  0b12      PUSH.W  R11
    01158  3f403211    MOV.W   #0x1132, R15
    0115C  b0120012    CALL    #0x1200 <_debug_printf>
    01160  2152      ADD.W   #4, SP
--- main.c — 16 ---
    for (i = 0; i < 10; ++i)
    01162  1b53      ADD.W   #1, R11
    01164  3b900a00    CMP.W   #0x000a, R11
    01168  f23b      JL     0x0114e
main.c — 15

```

Stopping and starting debugging

- You can stop debugging using **Debug > Stop** or **Shift+F5**.
- To restart debugging without reloading the program, you can use **Debug > Debug From Reset**. Note that, when you debug from reset, no loading takes place; it is expected that your program resets any data values as necessary as part of its startup.
- You can attach the debugger to a running target, other than a simulator, using **Target > Attach Debugger**.

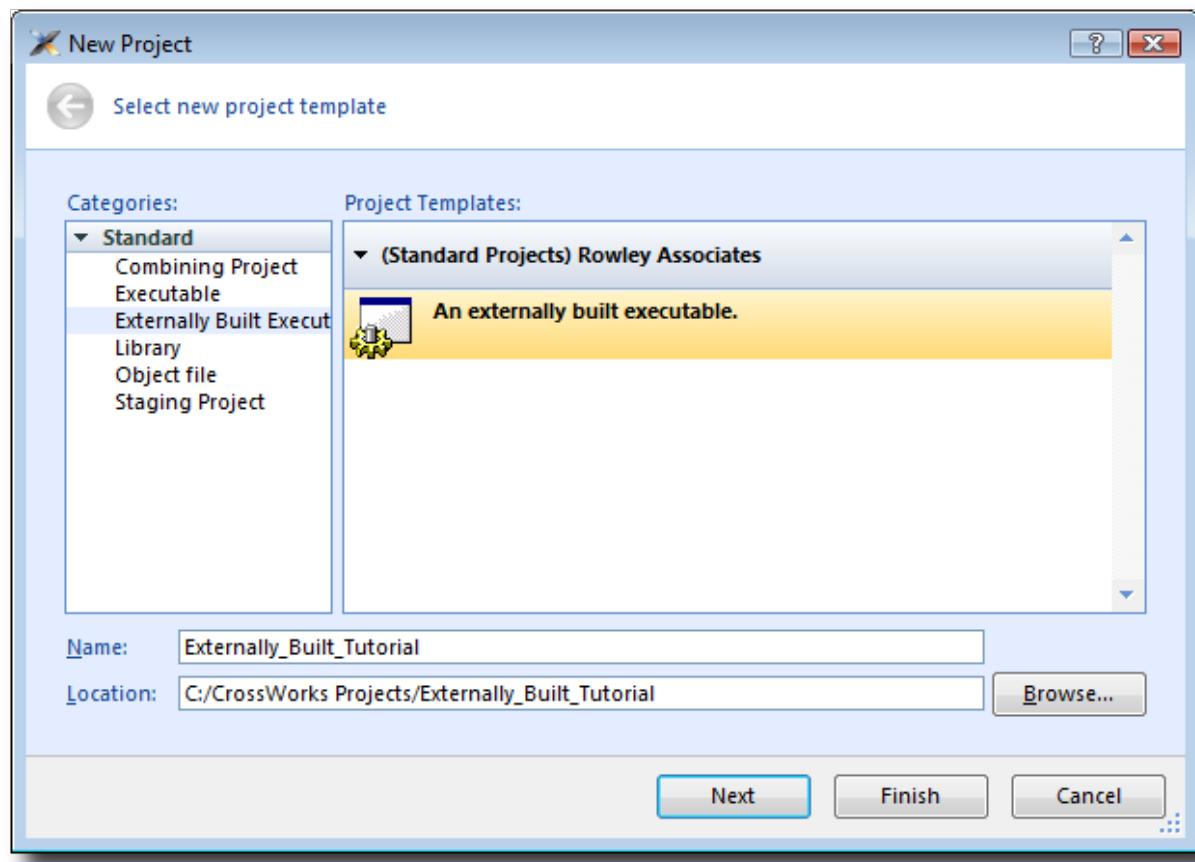
Debugging externally built applications

This section describes how to debug applications that were not built by CrossWorks. To keep things simple, we shall use the application we just built as our externally built application.

Start by creating a new, externally built executable project:

- Choose **File > New Project** or press **Ctrl+Shift+N**.

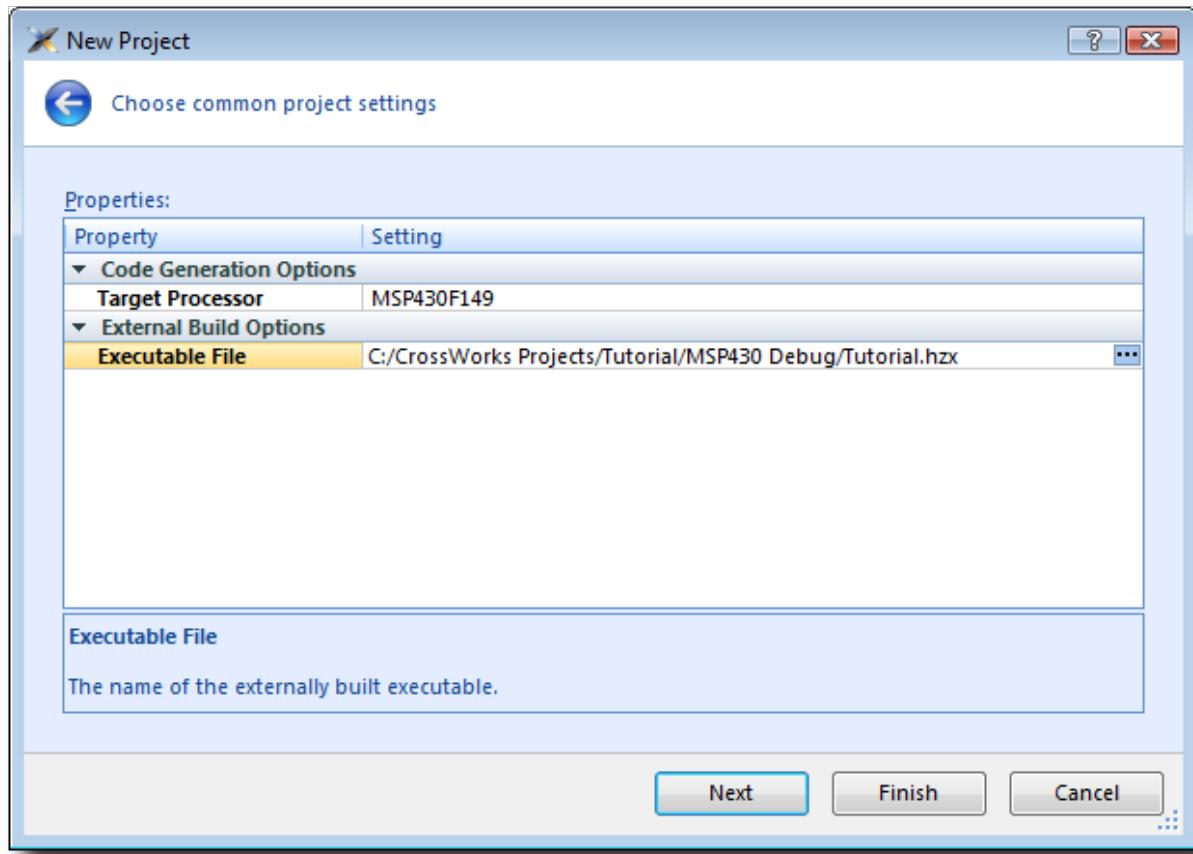
The **New Project** dialog appears. It displays the set of project types and project templates.



We'll create an externally built executable project:

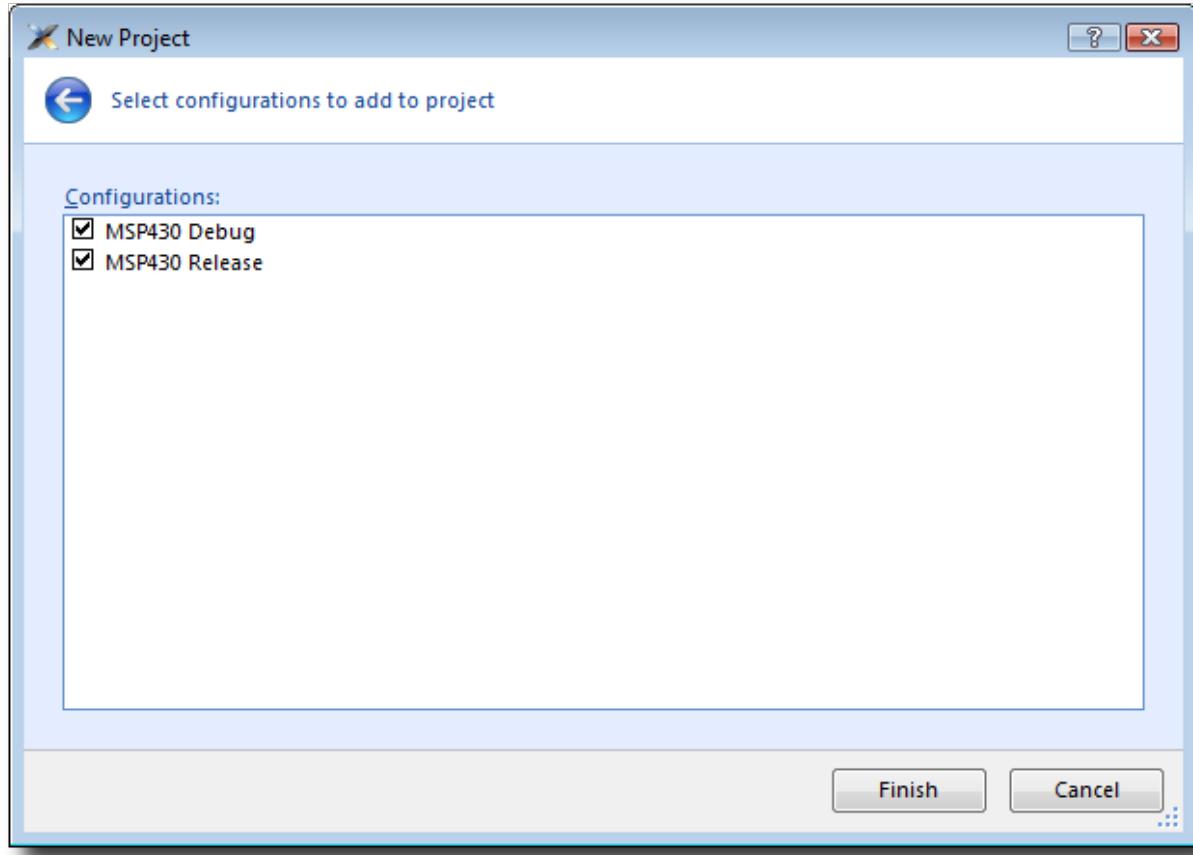
- In the **Categories** pane, select the **Standard > Externally Built Executable** project type.
- In the **Project Templates** pane, select the **An externally built executable** icon, which selects the type of project to add.
- Type **Externally_Built_Tutorial** in the **Name** field, which names the project.
- You can use the **Location** field or the **Browse** button to locate where you want the project to be created.
- Click **OK**.

Once created, the project-setup wizard prompts you for the executable file you want to use.



In the **Executable File** field, type the path to the `Tutorial.hzx` executable file we generated earlier. For example, if the project was created in the `C:/CrossWorks Projects/Tutorial` directory and was built using the **MSP430 Debug** configuration, the path to the executable file will be `C:/CrossWorks Projects/Tutorial/MSP430 Debug/Tutorial.hzx`.

Clicking **Next** displays the configurations that will be added to the project.



Complete the project creation by clicking **Finish**.

You will be prompted as to whether you want to overwrite the existing memory map and target script. Click **No** to keep the existing files.

Now you have created the externally built executable project. You should be able to use the debugger just as we did earlier in the tutorial.



CrossStudio User Guide

This is the user guide for the CrossStudio integrated development environment (IDE). The CrossStudio IDE consists of:

- a project system to organize your source files
- a build system to build your applications
- programmer aids to navigate and work effectively
- a target programmer to download applications into RAM or flash
- a debugger to pinpoint bugs

CrossStudio standard layout

CrossStudio's main window is divided into the following areas:

- *Title bar*: Displays the name of the current solution.
- *Menu bar*: Menus for editing, building, and debugging your program.
- *Toolbars*: Frequently used actions are quickly accessible on toolbars below the menu bar.
- *Editing area*: A tabbed view of any open editor windows and the HTML viewer.
- *Docked windows*: CrossStudio has many windows that dock to the left, right, or below the editing area.
You can configure which windows will be visible, and their placement, when editing and debugging.
- *Status bar*: At the bottom of the main window, the status bar contains useful information about the current editor, build status, and debugging environment.

Menu bar

The menu bar contains menus for editing, building, and debugging your program. You can navigate menus using the keyboard or the mouse.

Navigating menus using the mouse

To navigate menus using the mouse:

1. Click a menu title in the menu bar to show the related menu.
2. Click the desired command in the menu to execute that command.

—or—

1. Click and hold the mouse on a menu title in the menu bar to show the related menu.
2. Drag the mouse to the desired command in the menu.
3. Release the mouse while it is over the command to execute that command.

Navigating menus with the keyboard

To navigate menus using the keyboard:

1. Tap the **Alt** key activate the menu bar.
2. Tap **Return** to display the menu.
3. Use the **Left** and **Right** keys to select the required menu.
4. Use the **Up** or **Down** key to select the required command or submenu.
5. Press **Enter** to execute the selected command.
6. Press **Alt** or **Esc** at any time to cancel menu selection.

After you press the **Alt** key once, each menu on the menu bar has one letter underlined—its shortcut key. So, to activate a menu using the keyboard:

- While holding down the **Alt** key, type the desired menu's shortcut key.

After the menu appears, you can navigate it using the cursor keys:

- Use **Up** and **Down** to move up and down the list of menu items.
- Use **Esc** to cancel a menu.
- Use **Right** or **Enter** to open a submenu.
- Use **Left** or **Esc** to close a submenu and return to the parent menu.
- Type the underlined letter in a command's name to execute that command.

Title bar

The first item shown in the title bar is CrossStudio's name. Because CrossStudio can be used to target different processors, the name of the target processor family is also shown, to help you distinguish between instances of CrossStudio when debugging multi-processor or multi-core systems.

The filename of the active editor follows CrossStudio's name; you can configure the presentation of this filename as described below.

After the filename, the title bar displays status information on CrossStudio's state:

- **[building]** — CrossStudio is building a solution, building a project, or compiling a file.
- **[run]** — An application is running under control of CrossStudio's debugger.
- **[break]** — The debugger is stopped at a breakpoint.
- **[autostep]** — The debugger is single stepping the application without user interaction (*autostepping*).

Status bar

At the bottom of the window, the status bar contains useful information about the current editor, build status, and debugging environment. The status bar is divided into two regions: one contains a set of fixed panels and the other is used for messages.

The message area

The leftmost part of the status bar is a message area used for things such as status tips, progress information, warnings, errors, and other notifications.

Status bar panels

You can show or hide the following panels on the status bar:

Panel	Description
Target device status	Displays the connected target interface. When connected, this panel contains the selected target interface's name and, if applicable, the processor to which the target interface is connected. The LED icon flashes green when a program is running, is solid red when stopped at a breakpoint, and is yellow when connected to a target but not running a program. Double-clicking this panel displays the Targets pane, and right-clicking it invokes the Target shortcut menu.
Cycle count panel	Displays the number of processor cycles used by the executing program. This panel is only visible if the connected target supports performance counters that can report the total number of cycles executed. Double-clicking this panel resets the cycle counter to zero, and right-clicking it brings up the Cycle Count shortcut menu.
Insert/overwrite status	Indicates whether the current editor is in insert or overwrite mode. In overwrite mode, the panel displays "OVR"; in insert mode, the panel displays "INS".
Read-only status	Indicates whether the editor is in read-only mode. If the editor is editing a read-only file or is in read-only mode, the panel display "R/O"; if the editor is in read-write mode, the panel displays "R/W".
Build status	Indicates the success or failure of the last build. If the last build completed without errors or warnings, the build status pane contains Built OK ; otherwise, it contains the number of errors and warnings reported. If there were errors, double-clicking this panel displays the Build Log in the Output pane.

Caret position	Indicates the insertion position position in the editor window. For text files, the caret position pane displays the line number and column number of the insertion point in the active window; when editing binary files, it displays the address being edited.
Time panel	Displays the current time.

Configuring the status bar panels

To configure which panels are shown on the status bar:

- Choose **View > Status Bar**.
- From the status bar menu, select the panels to display and deselect the ones you want hidden.

—or—

- Right-click the status bar.
- From the status bar menu, select the panels to display and deselect the ones you want to hide.

To show or hide the status bar:

- Choose **View > Status Bar**.
- From the status bar menu, select or deselect the **Status Bar** item.

You can choose to hide or display the *size grip* when CrossStudio's main window is not maximized. (The size grip is never shown in full-screen mode or when maximized.)

To show or hide the size grip

- Choose **View > Status Bar**.
- From the status bar menu, select or deselect the **Size Grip** item.

Editing workspace

The main area of CrossStudio is the editing workspace. It contains any files being edited, the on-line help system's HTML browser, and the Dashboard.

Docking windows

CrossStudio has a flexible docking system you can use to position windows as you like them. You can dock windows in the CrossStudio window or in the four *head-up display* windows. CrossStudio will remember the position of the windows when you leave the IDE and will restore them when you return.

Window groups

You can organize CrossStudio windows into *window groups*. A window group has multiple windows docked in it, only one of which is *active* at a time. The window group displays the active window's title for each of the windows docked in the group.

Clicking on the window icons in the window group's header changes the active window. Hovering over a docked window's icon in the header will display that window's title in a *tooltip*.

To dock a window to a different window group:

- Press and hold the left mouse button over the title of the window you wish to move.
- As you start dragging, all window groups, including hidden window groups, become visible.
- Drag the window over the window group to dock in.
- Release the mouse button.

Holding **Ctrl** when moving the window will prevent the window from being docked. If you do not dock a window on a window group, the window will float in a new window group.

Perspectives

CrossStudio remembers the dock position and visibility of each window in each *perspective*. The most common use for this is to lay your windows out in the **Standard** perspective, which is the perspective used when you are editing and not debugging. When CrossStudio starts to debug a program, it switches to the **Debug** perspective. You can now lay out your windows in this perspective and CrossStudio will remember how you laid them them out. When you stop debugging, CrossStudio will revert to the **Standard** perspective and that window layout for editing; when you return to **Debug** perspective on the next debug session, the windows will be restored to how you laid them out in that for debugging.

CrossStudio remembers the layout of windows, in all perspectives, such that they can be restored when you run CrossStudio again. However, you may wish to revert back to the standard docking positions; to do this:

- Choose **Window > Reset Window Layout**.

Some customers are accustomed to having the **Project Explorer** on the left or the right, depending upon which version of Microsoft Visual Studio they commonly use. To quickly switch the CrossStudio layout to match your preferred Visual Studio setup:

- Choose **Window > Reverse Workspace Layout**.

Dashboard

When CrossStudio starts, it presents the **Dashboard**, a collection of panels that provide useful information, one-click loading of recent projects, and at-a-glance summaries of activity relevant to you.

Tasks

The **Tasks** panel indicates tasks you need to carry out before CrossWorks is fully functional—for instance, whether you need to activate CrossWorks, install packages, and so on.

Updates

The **Updates** panel indicates whether any packages you have installed are now out of date because a newer version is available. You can install each new package individually by clicking the **Install** button under each notification, or install all packages by clicking the **Install all updates** link at the bottom of the panel.

Projects

The **Projects** panel contains links to projects you have worked on recently. You can load a project by clicking the appropriate link, or clear the project history by clicking the **Clear List** button. To manage the contents of the list, click the **Manage Projects** link and edit the list of projects in the **Recent Projects** window.

News

The **News** panel summarizes the activity of any RSS and Atom feeds you have subscribed to. Clicking a link will display the published article in an external web browser. You can manage your feed subscriptions to by clicking the **Manage Feeds** link at the end of the **News** panel and *pinning* the feeds in the **Favorites** window—you are only subscribed to the pinned feeds.

Links

The **Links** panel is a handy set of links to your favorite websites. If you pin a link in the **Favorites** window, it appears in the **Links** panel.

CrossStudio help and assistance

CrossStudio provides context-sensitive help in increasing detail:

Tooltips

When you position the pointer over a button and keep it still, a small window displays a brief description of the button and its keyboard shortcut, if it has one.

Status tips

In addition to tooltips, CrossStudio provides a longer description in the status bar when you hover over a button or menu item.

Online manual

CrossStudio has links from all windows to the online help system.

The browser

Documentation pages are shown in the **Browser**.

Help using CrossStudio

CrossStudio provides an extensive, HTML-based help system that is available at all times.

To view the help text for a particular window or other user-interface element:

- Click to select the item with which you want assistance.
- Choose **Help > Help** or press **F1**.

Help within the text editor

The text editor is linked to the help system in a special way. If you place the insertion point within a word and press **F1**, the help-system page most likely to be useful is displayed in the HTML browser. This is a great way to quickly find the help text for functions provided in the library.

Browsing the documentation

The **Contents** window lists all the topics in the CrossWorks documentation and gives a way to search through them.

The highlighted entry indicates the current help topic. When you click a topic, the corresponding page appears in the **Browser** window.

The **Next Topic** and **Previous Topic** items in the **Help** menu, or the buttons on the **Contents** window toolbar, help navigate through topics.

To search the online documentation, type a search phrase into the **Search** box on the **Contents** window toolbar.

To search the online documentation:

- Choose **Help > Search**.
- Enter your search phrase in the **Search** box and press **Enter** (or **Return** on Macs).

The search commences and the table of contents is replaced by links to pages matching your query, listed in order of relevance. To clear the search and return to the table of contents, click the clear icon in the **Search** box.

Creating and managing projects

A CrossStudio *project* is a container for everything required to build your applications. It contains all the assorted resources and maintains the relationships between them.

A project is a convenient place to find every file and piece of information associated with your work. You place projects into a *solution*, which can contain one or more projects.

This chapter introduces the various parts of a project, shows how to create projects, and describes how to organize the contents of a project. It describes how to use the **Project Explorer** and **Project Manager** for project-management tasks.

Solutions and projects

To develop a product using CrossStudio, you must understand the concepts of *projects* and *solutions*.

- A *project* contains and organizes everything you need to create a single application or a library.
- A *solution* is a collection of projects and configurations.

Organizing your projects into a solution allows you to build all the projects in a solution with a single keystroke, and to load them onto the target ready for debugging.

In your CrossWorks project, you...

- ...organize build-system inputs for building a product.
- ...add information about items in the project, and their relationships, to assist you in the development process.

Projects in a solution can reside in the same or different directories. Project directories are always relative to the directory of the solution file, which enables you to more-easily move or share project-file hierarchies.

The **Project Explorer** organizes your projects and files, and provides quick access to the commands that operate on them. A toolbar at the top of the window offers quick access to commonly used commands.

Solutions

When you have created a solution, it is stored in a project file. Project files are text files, with the file extension **hzp**, that contain an XML description of your project. See [Project file format](#) for a description of the project-file format.

Projects

The projects you create within a solution have a *project type* CrossStudio uses to determine how to build the project. The project type is selected when you use the **New Project** dialog. The available project types depend on the CrossWorks variant you are using, but the following are present in most CrossWorks variants:

- *Executable*: — a program that can be loaded and executed.
- *Externally Built Executable*: — an executable that is not built by the CrossWorks internal build process.
- *Library*: — a group of object files collected into a single file (sometimes called an *archive*).
- *Externally Built Library*: — a library that is not built by the CrossWorks internal build process.
- *Object File*: — the result of a single compilation.
- *Staging*: — a project that will apply a user-defined command to each file in a project.
- *Combining*: — a project that can be used to apply a user-defined command when any files in a project have changed.

Properties and configurations

Properties are attached to project nodes. They are usually used in the build process, for example, to define C preprocessor symbols. You can assign different values to the same property, based on a configuration: for example, you can assign one value to a C preprocessor symbol for release and a different value for a debug build.

Folders

Projects can contain *folders*, which are used to group related files. Automated grouping uses the files' extensions to, for example, put all .c files in one folder, etc. Grouping also can be done manually by explicitly creating a file within a folder. Note that these project folders do not map onto directories in the file system, they are used solely to structure the display of content shown in the **Project Explorer**.

Source files

Source files are all the files used to build a product. These include source code files and also section-placement files, memory-map files, and script files. All the source files you use for a particular product, or for a suite of related products, are managed in a CrossStudio project. A project can also contain files that are not directly used by CrossStudio to build a product but contain information you use during development, such as documentation. You edit source files during development using CrossStudio's built-in text editor, and you organize files into a target (described next) to define the build-system inputs for creating the product.

The source files of your project can be placed in folders or directly in the project. Ideally, the paths to files placed in a project should be relative to the project directory, but at times you might want to refer to a file in an absolute location and this is supported by the project system.

When you add a file to a project, the project system detects whether the file is in the project directory. If a file is not in the project directory, the project system tries to make a relative path from the file to the project directory. If the file isn't relative to the project directory, the project system detects whether the file is relative to the `$(StudioDir)` directory; if so, the filename is defined using `$(StudioDir)`. If a file is not relative to the project directory or to `$(StudioDir)`, the full, absolute pathname is used.

The project system will allow (with a warning) duplicate files to be put into a project.

The project system uses a file's extension to determine the appropriate build action to perform on the file:

- A file with the extension `.c` will be compiled by a C compiler.
- A file with the extension `.s` or `.asm` will be compiled by an assembler.
- A file with the object-file extension `.hzo` will be linked.
- A file with the library-file extension `.hza` will be linked.
- A file with the extension `.xml` will be opened and its file type determined by the XML document type.
- Files with other file extensions will not be compiled or linked.

You can modify this behavior by setting a file's **File Type** property with the **Common** configuration selected in the **Properties** window, which enables files with non-standard extensions to be compiled by the project system.

Externally Built Executables

You can use an external build process for **Externally Built Executable** project types by setting the **Build Command** project property, for example to **make target**. Alternatively you can set command lines for specific build steps to compile/assemble and link. When you create an **Externally Built Executable** project type configurations will be created that create command lines for a variety of external tool chains.

Solution links

You can create links to existing project files from a solution, which enables you to create hierarchical builds. For example, you could have a solution that builds a library together with a stub test driver executable. You can link to that solution from your current solution by right-clicking the solution node of the **Project Explorer** and selecting **Add Existing Project**. Your current solution can then use the library built by the other project.

Session files

When you exit CrossWorks, details of your current session are stored in a *session file*. Session files are text files, with the file extension **hzs**, that contain details such as which files you have opened in the editor and what breakpoints you have set in the **Breakpoint** window.

Creating a project

You can create a new solution for each project or place multiple projects in an existing solution.

To create a new project in an existing solution:

1. Choose **Project > Add New Project**.
2. In the **New Project** wizard, select the type of project you wish to create and specify where it will be placed.
3. Ensure that **Add the project to current solution** is checked.
4. Click **OK** to go to next stage or **Cancel** to cancel the project's creation.

The project name must be unique to the solution and, ideally, the project directory should be relative to the solution directory. The project system will use the project directory as the *current directory* when it builds your project. Once complete, the **Project Explorer** displays the new solution, project, and files contained in the project. To add another project to the solution, repeat the above steps.

To create a new project in a new solution:

1. Choose **File > New Project** or press **Ctrl+Shift+N**.
2. Select the type of project you wish to create and where it will be placed.
3. Click **OK**.

Adding existing files to a project

You can add existing files to a project in a number of ways.

To add existing files to the active project:

- Choose **Project > Add Existing File** or press **Ctrl+P, A**.

Using the **Open File** dialog, navigate to the directory containing the files and select the ones you wish to add to the project.

- Click **OK**.

The selected files are added to the folders whose filter matches the extension of each of the files. If no filter matches a file's extension, the file is placed underneath the project node.

To add existing files to a specific project:

1. In the **Project Explorer**, right-click the project to which you wish to add a new file.
2. Choose **Add Existing File**.

To add existing files to a specific folder:

1. In the **Project Explorer**, right-click the folder to which you wish to add a new file.
2. Choose **Add Existing File**.

The files are added to the specified folder without using filter matching.

Adding new files to a project

You can add new files to a project in a number of ways.

To add new files to the active project:

- Choose **Project > Add New File** or press **Ctrl+N**.

To add a new file to a project:

1. In the **Project Explorer**, right-click the project to which you wish to add a new file.
2. Choose **Add New File**.

When adding a new file, CrossStudio displays the **New File** dialog, from which you can choose the type of file to add, its filename, and where it will be stored. Once created, the new file is added to the folder whose filter matches the extension of the newly added file. If no filter matches the newly added file extension, the new file is placed underneath the project node.

To add new files to a folder:

1. In the **Project Explorer**, right-click the folder to which you wish to add a new file.
2. Choose **Add New File**.

The new file is added to the folder without using filter matching.

Removing a file, folder, project, or project link

You can remove whole projects, folders, or files from a project, or you can remove a project from a solution, using the **Remove** button on the **Project Explorer** toolbar. Note that removing a source file from a project does not remove it from disk.

To remove an item from the solution:

1. In the **Project Explorer**, select the item to remove.
2. Choose **Edit > Delete** or press **Del**.

—or—

1. In the **Project Explorer**, right-click the item to remove.
2. Choose **Remove**.

Project macros

You can use macros to modify the way the project system refers to files.

Macros are divided into four classes:

- *System macros* defined by CrossStudio relay information about the environment, such as paths to common directories.
- *Global macros* are saved in the environment and are shared across all solutions and projects. Typically, you would set up paths to libraries and any external items here.
- *Project macros* are saved as project properties in the project file and can define values specific to the solution or project in which they are defined.
- *Build macros* are generated by the project system when you build your project.

System macros

System macros are defined by CrossStudio itself and as such are read-only. System macros can be used in project properties, environment settings and to refer to files. See [System macros list](#) for the list of System macros.

Global macros

To define a global macro:

1. Choose **Project > Macros**.
2. Select the **Global** tab.
3. Set the macro using the syntax *name = replacement text*.

Project macros

To define a project macro:

1. Choose **Project > Macros**.
2. Select the **Project** tab.
3. Select the solution or project to which the macro should apply.
4. Set the macro using the syntax *name = replacement text*.

Alternatively, you can set the project macros from the **Properties** window:

1. Select the appropriate solution/project in the **Project Explorer**.
2. In the **Properties** window's **General Options** group, select the **Macros** property.
3. Click the ellipsis button on the right.
4. Set the macro using the syntax *name = replacement text*.

Build macros

Build macros are defined by the project system for a build of a given project node. See [Build macros list](#) for the list of build macros.

Using macros

You can use a macro for a project property or environment setting by using the \$(macro) syntax. For example, the **Object File Name** property has a default value of \$(IntDir)/\$(InputName)\$(OBJ).

You can also specify a default value for a macro if it is undefined using the \$(macro:default) syntax. For example, \$(MyMacro : 0) would expand to 0 if the macro MyMacro has not been defined.

Building your application

CrossStudio builds your application using the resources and build rules it finds in your solution.

When CrossStudio builds your application, it tries to avoid building files that have not changed since they were last built. It does this by comparing the modification dates of the generated files with the modification dates of the dependent files together with the modification dates of the properties that pertain to the build. But if you are copying files, sometimes the modification dates may not be updated when the file is copied—in this instance, it is wise to use the **Rebuild** command rather than the **Build** command.

You can see the build rationale CrossStudio currently is using by setting the **Environment Properties > Build Settings > Show Build Information** property. To see the build commands themselves, set the **Environment Properties > Build Settings Echo Build Command** property.

You may have a solution that contains several interdependent projects. Typically, you might have several executable projects and some library projects. The **Project Dependencies** dialog specifies the dependencies between projects and to see the effect of those dependencies on the solution build order. Note that dependencies can be set on a per-configuration basis, but the default is for dependencies to be defined in the **Common** configuration.

You will also notice that a new folder titled **Dependencies** has appeared in the **Project Explorer**. This folder contains the list of newly generated files and the files from which they were generated. To see if one of files can be decoded and displayed in the editor, right-click the file to see if the **View** command is available on the shortcut menu.

If you have the **Symbols** window open, it will be updated with the symbol and section information of all executable files built in the solution.

When CrossStudio builds projects, it uses the values set in the **Properties** window. To generalize your builds, you can define macro values that are substituted when the project properties are used. These macro values can be defined globally at the solution and project level, and can be defined on a per-configuration basis. You can view and update the macro values using **Project > Macros**.

The combination of configurations, properties with inheritance, dependencies, and macros provides a very powerful build-management system. However, such systems can become complicated. To understand the implications of changing build settings, right-click a node in the **Project Explorer** and select **Properties** to view a dialog that shows which macros and build steps apply to that project node.

To build all projects in the solution:

1. Choose **Build > Build Solution** or press **Shift+F7**.

—or—

1. Right-click the solution in the **Project Explorer** window.
2. Choose **Build** from the shortcut menu.

To build a single project:

1. Select the required project in the **Project Explorer**.
2. Choose **Build > Build** or press **F7**.

—or—

1. Right-click the project in the **Project Explorer**.
2. Choose **Build**.

To compile a single file:

1. In the **Project Explorer**, click to select the source file to compile.
2. Choose **Build > Compile** or press **Ctrl+F7**.

—or—

1. In the **Project Explorer**, right-click the source file to compile.
2. Choose **Compile** from the shortcut menu.

Correcting errors after building

The results of a build are recorded in a **Build Log** that is displayed in the **Output** window. Errors are highlighted in red, warnings are highlighted in yellow. Double-clicking an error, warning, or note will move the insertion point to the line of source code that triggered that log entry.

You can move forward and backward through errors using **Search > Next Location** and **Search > Previous Location**.

When you build a single project in a single configuration, the **Transcript** will display the memory used by the application and a summary for each memory area.

Creating variants using configurations

CrossStudio provides a facility to build projects in various configurations. Project configurations are used to create different software builds for your projects.

A configuration defines a set of project property values. For example, the output of a compilation can be put into different directories, dependent upon the configuration. When you create a solution, some default project configurations are created.

Build configurations and their uses

Configurations are typically used to differentiate debug builds from release builds. For example, the compiler options for debug builds will differ from those of a release build: a debug build will set options so the project can be debugged easily, whereas a release build will enable optimization to reduce program size or to increase its speed. Configurations have other uses; for example, you can use configurations to produce variants of software, such as custom libraries for several different hardware variants.

Configurations inherit properties from other configurations. This provides a single point of change for definitions common to several configurations. A particular property can be overridden in a particular configuration to provide configuration-specific settings.

When a solution is created, two configurations are generated — **Debug** and **Release** — and you can create additional configurations by choosing **Build > Build Configurations**. Before you build, ensure that the appropriate configuration is set using **Build > Set Active Build Configuration** or, alternatively, the **Active Configuration** combo box in the **Project Explorer**. You should also ensure that the appropriate build properties are set in the **Properties** window.

Selecting a configuration

To set the configuration that affects your building and debugging, use the combo box in the **Project Explorer** or select **Build > Set Active Build Configuration**

Creating a configuration

To create your own configurations, select **Build > Build Configurations** to invoke the **Configurations** dialog. The **New** button will produce a dialog allowing you to name your configuration. You can now specify the existing configurations from which your new configuration will inherit values.

Deleting a configuration

You can delete a configuration by selecting it and clicking the **Remove** button. This deletion cannot be undone or canceled, so beware.

Private configurations

Some configurations are defined purely for inheriting and, as such, should not appear in the **Build** combo box. When you select a configuration in the **Configuration** dialog, you can choose to hide that configuration.

Project properties

For solutions, projects, folders, and files, properties can be defined that are used by the project system in the build process. These property values can be viewed and modified by using the **Properties** window in conjunction with the **Project Explorer**. As you select items in the **Project Explorer**, the **Properties** window will list the set of relevant properties.

Some properties are only applicable to a given item type. For example, linker properties are only applicable to a project that builds an executable file. However, other properties can be applied either at the file, project, or solution project node. For example, a compiler property can be applied to a solution, project, or individual file. By setting a property at the solution level, you enable all files of the solution to use that property's value.

Unique properties

A unique property has *one* value. When a build is done, the value of a unique property is the first one defined in the project hierarchy. For example, the **Treat Warnings As Errors** property could be set to **Yes** at the solution level, which would then be applicable to every file in the solution that is compiled, assembled, and linked. You can then selectively define property values for other project items. For example, a particular source file may have warnings you decide are allowable, so you set the **Treat Warnings As Errors** to **No** for that particular file.

Note that, when the **Properties** window displays a project property, it will be shown in bold if it has been defined for unique properties. The inherited or default value will be shown if it hasn't been defined.

```
solution - Treat Warnings As Errors = Yes
project1 - Treat Warnings As Errors = Yes
    file1 - Treat Warnings As Errors = Yes
    file2 - Treat Warnings As Errors = No
project2 - Treat Warnings As Errors = No
    file1 - Treat Warnings As Errors = No
    file2 - Treat Warnings As Errors = Yes
```

In the above example, the files will be compiled with these values for **Treat Warnings As Errors**:

project1/file1	Yes
project1/file2	No
project2/file1	No
project2/file2	Yes

Aggregate properties

An aggregating property collects all the values defined for it in the project hierarchy. For example, when a C file is compiled, the **Preprocessor Definitions** property will take all the values defined at the file, project, and solution levels. Note that the **Properties** window *will not* show the inherited values of an aggregating property.

```
solution - Preprocessor Definitions = SolutionDef
    project1 - Preprocessor Definitions =
        file1 - Preprocessor Definitions =
        file2 - Preprocessor Definitions = File1Def
    project2 - Preprocessor Definitions = ProjectDef
        file1 - Preprocessor Definitions =
        file2 - Preprocessor Definitions = File2Def
```

In the above example, the files will be compiled with these preprocessor definitions:

project1/file1	SolutionDef
project1/file2	SolutionDef, File1Def
project2/file1	SolutionDef, ProjectDef
project2/file2	SolutionDef, ProjectDef, File2Def

Configurations and property values

Property values are defined for a configuration so you can have different values for a property for different builds. A given configuration can inherit the property values of other configurations. When the project system requires a property value, it checks for the existence of the property value in current configuration and then in the set of inherited configurations. You can specify the set of inherited configurations using the **Configurations** dialog.

A special configuration named **Common** is always inherited by a configuration. The **Common** configuration allows you to set property values that will apply to all configurations you create. You can select the **Common** configuration using the **Configurations** combo box of the properties window. If you are modifying a property value of your project, you almost certainly want each configuration to inherit it, so ensure that the **Common** configuration is selected.

If the property is unique, the build system will use the one defined for the particular configuration. If the property isn't defined for this configuration, the build system uses an arbitrary one from the set of inherited configurations.

If the property is still undefined, the build system uses the value for the **Common** configuration. If it is still undefined, the build system tries to find the value in the next higher level of the project hierarchy.

```
solution [Common] - Preprocessor Definitions = CommonSolutionDef

solution [Debug] - Preprocessor Definitions = DebugSolutionDef

solution [Release] - Preprocessor Definitions = ReleaseSolutionDef

project1 - Preprocessor Definitions =
    file1 - Preprocessor Definitions =
        file2 [Common] - Preprocessor Definitions = CommonFile1Def
        file2 [Debug] - Preprocessor Definitions = DebugFile1Def
    project2 [Common] - Preprocessor Definitions = ProjectDef
        file1 - Preprocessor Definitions =
            file2 [Common] - Preprocessor Definitions = File2Def
```

In the above example, the files will be compiled with these preprocessor definitions when in **Debug** configuration...

File	Setting
project1/file1	CommonSolutionDef, DebugSolutionDef
project1/file2	CommonSolutionDef, DebugSolutionDef, CommonFile1Def, DebugFile1Def
project2/file1	CommonSolutionDef, DebugSolutionDef, ProjectDef

project2/file2	ComonSolutionDef, DebugSolutionDef, ProjectDef, File2Def
----------------	----------------------------------------------------------

...and the files will be compiled with these **Preprocessor Definitions** when in **Release** configuration:

File	Setting
project1/file1	CommonSolutionDef, ReleaseSolutionDef
project1/file2	CommonSolutionDef, ReleaseSolutionDef, CommonFile1Def
project2/file1	CommonSolutionDef, ReleaseSolutionDef, ProjectDef
project2/file2	ComonSolutionDef, ReleaseSolutionDef, ProjectDef, File2Def

Dependencies and build order

You can set up dependency relationships between projects using the **Project Dependencies** dialog. Project dependencies make it possible to build solutions in the correct order and, where the target permits, to load and delete applications and libraries in the correct order. A typical usage of project dependencies is to make an executable project dependent upon a library executable. When you elect to build the executable, the build system will ensure that the library it depends upon is up to date. In the case of a dependent library, the output file of the library build is supplied as an input to the executable build, so you don't have to worry about it.

Project dependencies are stored as project properties and, as such, can be defined differently based upon the selected configuration. You almost always want project dependencies to be independent of the configuration, so the **Project Dependencies** dialog selects the **Common** configuration by default.

To make one project dependent upon another:

1. Choose **Project > Project Dependencies**.
2. From the **Project** dropdown, select the target project that depends upon other projects.
3. In the **Depends Upon** list box, select the projects the target project depends upon and deselect the projects it does not depend upon.

Some items in the **Depends Upon** list box may be dimmed, indicating that a circular dependency would result if any of those projects were selected. In this way, CrossStudio prevents you from constructing circular dependencies using the **Project Dependencies** dialog.

If your target supports loading multiple projects, the **Build Order** also reflects the order in which projects are loaded onto the target. Projects will load, in order, from top to bottom. Generally, libraries need to be loaded before the applications that use them, and you can ensure this happens by making the application dependent upon the library. With this dependency set, the library gets built and loaded before the application does.

Applications are deleted from a target in reverse of their build order; in this way, applications are removed before the libraries on which they depend.

Linking and section placement

Executable programs consist of a number of sections. Typically, there are program sections for code, initialized data, and zeroed data. There is often more than one code section and they must be placed at specific addresses in memory.

To describe how the program sections of your program are positioned in memory, the CrossWorks project system uses *memory-map* files and *section-placement* files. These XML-formatted files are described in [Memory Map file format](#) and [Section Placement file format](#). They can be edited with the CrossWorks text editor. The memory-map file specifies the start address and size of target memory segments. The section-placement file specifies where to place program sections in the target's memory segments. Separating the memory map from the section-placement scheme enables a single hardware description to be shared across projects and also enables a project to be built for a variety of hardware descriptions.

For example, a memory-map file representing a device with two memory segments called **FLASH** and **SRAM** could look something like this in the memory-map editor.

```
<Root name="Device1">
  <MemorySegment name="FLASH" start="0x10000000" size="0x10000" />
  <MemorySegment name="SRAM" start="0x20000000" size="0x1000" />
```

A corresponding section-placement file will refer to the memory segments of the memory-map file and will list the sections to be placed in those segments. This is done by using a memory-segment name in the section-placement file that matches the corresponding memory-segment name in the memory-map file.

For example, a section-placement file that places a section called **.stack** in the **SRAM** segment and the **.vectors** and **.text** sections in the **FLASH** segment would look like this:

```
<Root name="Flash Section Placement">
  <MemorySegment name="FLASH" >
    <ProgramSection name=".vectors" load="Yes" />
    <ProgramSection name=".text" load="Yes" />
  </MemorySegment>
  <MemorySegment name="SRAM" >
    <ProgramSection name=".stack" load="No" />
  </MemorySegment>
</Root>
```

Note that the order of section placement within a segment is top down; in this example **.vectors** is placed at lower addresses than **.text**.

The memory-map file and section-placement file to use for linkage can be included as a part of the project or, alternatively, they can be specified in the project's [linker properties](#).

You can create a new program section using either the assembler or the compiler. For the C compiler, this can be achieved using one of the **#pragma** directives. For example:

```
#pragma codeseg( ".foo" )
void foobar(void);
```

```
#pragma codeseq(default)
```

This will allocate **foobar** in the section called **.foo**. Alternatively, you can specify the names for the code, constant, data, and zeroed-data sections of an entire compilation unit by using the **Section Options** properties.

You can now place the section into the section placement file using the editor so that it will be located after the vectors sections as follows:

```
<Root name="Flash Section Placement">
  <MemorySegment name="FLASH">
    <ProgramSection name=".vectors" load="Yes" />
    <ProgramSection name=".foo" load="Yes" />
    <ProgramSection name=".text" load="Yes" />
  </MemorySegment>
  <MemorySegment name="SRAM">
    <ProgramSection name=".stack" load="No" />
  </MemorySegment>
</Root>
```

If you are modifying a section-placement file that is supplied in the CrossWorks distribution, you will need to import it into your project using the **Project Explorer**.

Sections containing code and constant data should have their **load** property set to **Yes**. Some sections don't require any loading, such as stack sections and zeroed-data sections; such sections should have their **load** property set to **No**.

You can specify that initialization data is stored in the default program section using the **INIT** directive, and you can refer to the start and end of the section using the **SFE** and **SFB** directives. If, for example, you create a new data section called **IDATA2**, you can store this in the program by putting the following into the startup code:

```
_data2_init_begin::
  INIT "IDATA2"
_data2_init_end::
```

You can then use these symbols to copy the stored section information into the data section using (an assembly-coded version of):

```
/* Section image located in flash */
extern const unsigned char data2_init_begin[];
extern const unsigned char data2_init_end[];

memcpy(SFB(IDATA2), data2_init_begin, data2_init_end-data2_init_end)
```

Using source control

Source control is an essential tool for individuals or development teams. CrossStudio integrates with several popular source-control systems to provide this feature for files in your CrossWorks projects.

Source-control capability is implemented by a number of third-party providers, but the set of functions provided by CrossWorks aims to be provider independent.

Source control capabilities

The source-control integration capability provides:

- Connecting to the source-control *repository* and mapping files in the CrossWorks project to those in source control.
- Showing the source-control status of files in the project.
- Adding files in the project to source control.
- Fetching files in the project from source control.
- Optionally locking and unlocking files in the project for editing.
- Comparing a file in the project with the latest version in source control.
- Updating a file in the project by merging changes from the latest version in source control.
- Committing changes made to project files into source control.

Configuring source-control providers

CrossStudio supports Subversion, Git, and Mercurial as source-control systems. To enable CrossStudio to utilize source-control features, you need to install, on your operating system, the appropriate command line client for the source-control systems that you will use.

Once you have installed the command line client, you must configure CrossStudio to use it.

To configure Subversion:

1. Choose **Tools > Options** or press **Alt+,,**.
2. Select the **Source Control** category in the options dialog.
3. Set the **Executable** property of the **Subversion Options** group to point to Subversion `svn` command. On Windows operating systems, the Subversion command is `svn . exe`.

To configure Git:

1. Choose **Tools > Options** or press **Alt+,,**.
2. Select the **Source Control** category in the options dialog.
3. Set the **Executable** property of the **Git Options** group to point to Git `git` command. On Windows operating systems, the Git command is `git . exe`.

To configure Mercurial:

1. Choose **Tools > Options** or press **Alt+,,**.
2. Select the **Source Control** category in the options dialog.
3. Set the **Executable** property of the **Mercurial Options** group to point to Git `hg` command. On Windows operating systems, the Git command is `hg . exe`.

Connecting to the source-control system

When CrossStudio loads a project, it examines the file system folder that contains the project to determine the source-control system the project uses. If CrossStudio cannot determine, from the file system, the source-control system in use, it disables source-control integration.

That is, if you have not set up the paths to the source-control command line clients, even if a working copy exists and the appropriate command line client is installed, CrossStudio cannot establish source-control integration for the project.

User credentials

You can set the credentials that the source-control system uses, for commands that require credentials, using **VCS > Options > Configure**. From here you can set the user name and password. These details are saved to the session file (the password is encrypted) so you won't need to specify this information each time the project is loaded.

Note

CrossStudio has no facility to create repositories from scratch, nor to clone, pull, or checkout repositories to a working copy: it is your responsibility to create a working copy outside of CrossStudio using your selected command-line client or Windows Explorer extension.

The "Tortoise" products are a popular set of tools to provide source-control facilities in the Windows shell. Use Google to find **TortoiseSVN**, **TortoiseGit**, and **TortoiseHG** and see if you like them.

File source-control status

Determining the source-control status of a file can be expensive for large repositories, so CrossWorks updates the source-control status in the background. Priority is given to items that are displayed.

A file will be in one of the following states:

- *Clean*: The file is in source control and matches the tip revision.
- *Not Controlled*: The file is not in source control.
- *Conflicted*: The file is in conflict with changes made to the repository.
- *Locked*: The file is locked.
- *Update Available*: The file is older than the most-recent version in source control.
- *Added*: The file is scheduled to be added to the repository.
- *Removed*: The file is scheduled to be removed from the repository.

If the file has been modified, its status is displayed in red in the **Project Explorer**. Note that if a file is not under the local root, it will not have a source-control status.

You can reset any stored source-control file status by choosing **VCS > Refresh**.

Source-control operations

Source-control operations can be performed on single files or recursively on multiple files in the **Project Explorer** hierarchy. Single-file operations are available on the **Source Control** toolbar and on the text editor's shortcut menu. All operations are available using the **VCS** menu. The operations are described in terms of the **Project Explorer** shortcut menu.

Adding files to source control

To add files to the source-control system:

1. In the **Project Explorer**, select the file to add. If you select a folder, project, or solution, any eligible child items will also be added to source control.
2. choose **Source Control > Add** or press **Ctrl+R, A**.
3. The dialog will list the files that can be added.
4. In that dialog, you can deselect any files you don't want to add to source control.
5. Click **Add**.

Note

Files are scheduled to be added to source control and will only be committed to source control (and seen by others) when you commit the file.

Enabling the **VCS > Options > Add Immediately** option will bypass the dialog and immediately add (but not commit) the files.

Updating files

To update files from source control:

1. In the **Project Explorer**, select the file to update. If you select a folder, project, or solution, any eligible child items will also be updated from source control.
2. choose **Source Control > Update** or press **Ctrl+R, U**.
3. The dialog will list the files that can be updated.
4. In that dialog, you can deselect any files you don't want to update from source control.
5. Click **Update**.

Note

Enabling the **VCS > Options > Update Immediately** option will bypass the dialog and immediately update the files.

Committing files

To commit files:

1. In the **Project Explorer**, select the file to commit. If you select a folder, project, or solution, any eligible child items will also be committed.
2. Choose **Source Control > Commit** or press **Ctrl+R, C**.
3. The dialog will list the files that can be committed.
4. In that dialog, you can deselect any files you don't want to commit and enter an optional comment.
5. Click **Commit**.

Note

Enabling the **VCS > Options > Commit Immediately** option will bypass the dialog and immediately commit the files without a comment.

Reverting files

To revert files:

1. In the **Project Explorer**, select the file to revert. If you select a folder, project, or solution, any eligible child items will also be reverted.
2. Choose **Source Control > Revert** or press **Ctrl+R, V**.
3. The dialog will list the files that can be reverted.
4. In that dialog, you can deselect any files you don't want to revert.
5. Click **Revert**.

Note

Enabling the **VCS > Options > Revert Immediately** option will bypass the dialog and immediately revert files.

Locking files

To lock files:

1. In the **Project Explorer**, select the file to lock. If you select a folder, project, or solution, any eligible child items will also be locked.
2. Choose **Source Control > Lock** or press **Ctrl+R, L**.
3. The dialog will list the files that can be locked.
4. In that dialog, you can deselect any files you don't want to lock and enter an optional comment.
5. Click **Lock**.

Note

Enabling the **VCS > Options > Lock Immediately** option will bypass the dialog and immediately lock files without a comment.

Unlocking files

To unlock files:

1. In the **Project Explorer**, select the file to lock. If you select a folder, project, or solution, any eligible child items will also be unlocked.
2. Choose **Source Control > Unlock** or press **Ctrl+R, N**.
3. The dialog will list the files that can be unlocked.
4. In that dialog, you can deselect any files you don't want to unlock.
5. Click **Unlock**.

Note

Enabling the **VCS > Options > Unlock Immediately** option will bypass the dialog and immediately unlock files.

Removing files from source control

To remove files from source control:

1. In the **Project Explorer**, select the file to remove. If you select a folder, project, or solution, any eligible child items will also be removed.
2. choose **Source Control > Remove** or press **Ctrl+R, R**.
3. The dialog will list the files that can be removed.
4. In that dialog, you can deselect any files you don't want to remove.
5. Click **Remove**.

Note

Files are scheduled to be removed from source control and will still be and seen by others, giving you the opportunity to revert the removal. When you commit the file, the file is removed from source control.

Enabling the **VCS > Options > Remove Immediately** option will bypass the dialog and immediately remove (but not commit) files.

Showing differences between files

To show the differences between the file in the project and the version checked into source control, do the following:

1. In the **Project Explorer**, right-click the file.
2. From the shortcut menu, choose **Source Control > Show Differences**.

You can use an external diff tool in preference to the built-in CrossWorks diff tool. To define the diff command line CrossWorks generates, choose **Tools > Options > Source Control > Diff Command Line**. The command line is defined as a list of strings to avoid problems with spaces in arguments. The diff command line can contain the following macros:

- `$(localfile)`: The filename of the file in the project.
- `$(remotefile)`: The filename of the latest version of the file in source control.
- `$(localname)`: A display name for `$(localfile)`.
- `$(remotename)`: A display name for `$(remotefile)`.

Source-control properties

When a file in the project is in source control, the **Properties** window shows the following properties in the **Source Control Options** group:

Property	Description
CrossStudio Status	The source-control status of working copy as viewed by CrossStudio.
Last Author	The author of the file's head revision.
Path: Relative	The item's path relative to the repository root.
Path: Repository	The pathname of the file in the source-control system, typically a URL.
Path: Working Copy	The pathname of the file in the working copy.
Provider	The name of the source-control system managing this file.
Provider Status	The status of the file as reported by the source-control provider.
Revision: Local	The revision number/name of the local file.
Revision: Remote	The revision number/name of the most-recent version in source control.
Status: In Conflict?	If Yes , updates merged into the file using Update conflict with the changes you made locally; if No , the file is not locked. When conflicted, must resolve the conflicts and mark them Resolved before committing the file.
Status: Locked?	If Yes , the file is lock by you; if No , the file is not locked.
Status: Modified?	If Yes , the checked-out file differs from the version in the source control system; if No , they are identical.
Status: Update Available?	If Yes , the file in the project location is an old version compared to the latest version in the source-control system—use Update to merge in the latest changes.

Subversion provider

The Subversion source-control provider has been tested with SVN 1.4.3.

Provider-specific options

The following environment options are supported:

Property	Description
Executable	The path to the svn executable.
Lock Supported	If Yes, check out and undo check out operations are supported. Check out will issue the <code>svn lock</code> command; check in and undo check out will issue the <code>svn unlock</code> command.
Authentication	Selects whether authentication (user name and password) is sent with every command.
Show Updates	Selects whether the update (-u flag) is sent with status requests in order to show that new versions are available in the repository. Note that this requires a live connection to the repository: if you are working without a network connection to your repository, you can disable this switch and continue to enjoy source control status information in the Project Explorer and Pending Changes windows.

Connecting to the source-control system

When connecting to source control, the provider checks if the local root is in SVN control. If this is the case, the local and remote root will be set accordingly. If the local root is not in SVN control after you have set the remote root, a `svn checkout -N` command will be issued to make the local root SVN controlled. This command will also copy any files in the remote root to the local root.

The user name and password you enter will be supplied with each svn command the provider issues.

Source control operations

The CrossWorks source-control operations are implemented using Subversion commands. Mapping CrossWorks source-control operations to Subversion source-control operations is straightforward:

Operation	Command
Commit	<code>svn commit</code> for the file, with optional comment.
Update	<code>svn update</code> for each file.
Revert	<code>svn revert</code> for each file.

Resolved	<code>svn resolved</code> for each file.
Lock	<code>svn lock</code> for each file, with optional comment.
Unlock	<code>svn unlock</code> for each file.
Add	<code>svn add</code> for each file.
Remove	<code>svn remove</code> for each file.
Source Control Explorer	<code>svn list</code> with a remote root. <code>svn mkdir</code> to create directories in the repository.

CVS provider

The CVS source-control provider has been tested with CVSNT 2.5.03. The CVS source-control provider uses the `cvs rls` command to browse the repository—this command is implemented in CVS 1.12 but usage of '' as the root of the module name is not supported.

Provider-specific options

The following environment options are supported:

Property	Description
CVSROOT	The CVSROOT value to access the repository.
Edit/Unedit Supported	If Yes, Check Out and Undo Check Out commands are supported. Any check-out operation will issue the <code>cvs edit</code> command; any check-in or undo-check-out operation will issue the <code>cvs unedit</code> command; the status operation will issue the <code>cvs ss</code> command.
Executable	The path to the <code>cvs</code> executable.
Login/Logout Required	If Yes, Connect will issue the <code>cvs login</code> command.

Connecting to the source-control system

When connecting to source control, the provider checks if the local root is in CVS control. If this is the case, the local and remote root will be set accordingly. If the local root is not in CVS control after you have set the remote root, a `cvs checkout -l -d` command will be issued to make the local root CVS controlled. This command will also copy any files in the remote root to the local root.

Source-control operations

The CrossWorks source-control operations have been implemented using CVS commands. There are no multiple-file operations, each operation is done on a single file and committed as part of the operation.

Operation	Command
Get Status	<code>cvs status</code> and optional <code>cvs editors</code> for local directories in CVS control. <code>cvs rls -e</code> for directories in the repository.
Add To Source Control	<code>cvs add</code> for each directory not in CVS control. <code>cvs add</code> for the file. <code>cvs commit</code> for the file and directories.
Get Latest	<code>cvs update -l -d</code> for each directory not in CVS control. <code>cvs update</code> to merge the local file. <code>cvs update -C</code> to overwrite the local file.

Check Out	Optional <code>cvs update -C</code> to get the latest version. <code>cvs edit</code> to lock the file.
Undo Check Out	<code>cvs unedit</code> to unlock the file. Optional <code>cvs update</code> to get the latest version.
Check In	<code>cvs commit</code> for the file.
Source Control Explorer	<code>cvs rls -e</code> with a remote root starting with '..'. <code>cvs import</code> to create directories in the repository.

Package management

Additional target-support functions can be added to, and removed from, CrossWorks with *packages*.

A CrossWorks package is an archive file containing a collection of target-support files. Installing a package involves copying the files it contains to an appropriate destination directory and registering the package with CrossWorks's package system. Keeping target-support files separate from the main CrossWorks installation allows us to support new hardware and issue bug fixes for existing hardware-support files between CrossWorks releases, and it allows third parties to develop their own support packages.

Installing packages

Use the **Package Manager** to automate the download, installation, upgrade and removal of packages.

To activate the Package Manager:

- Choose **Tools > Manage Packages**.

In some situations, such as using CrossWorks on a computer without Internet access or when you want to install packages that are not on the website, you cannot use the **Package Manager** to install packages and it will be necessary to manually install them.

To manually install a package:

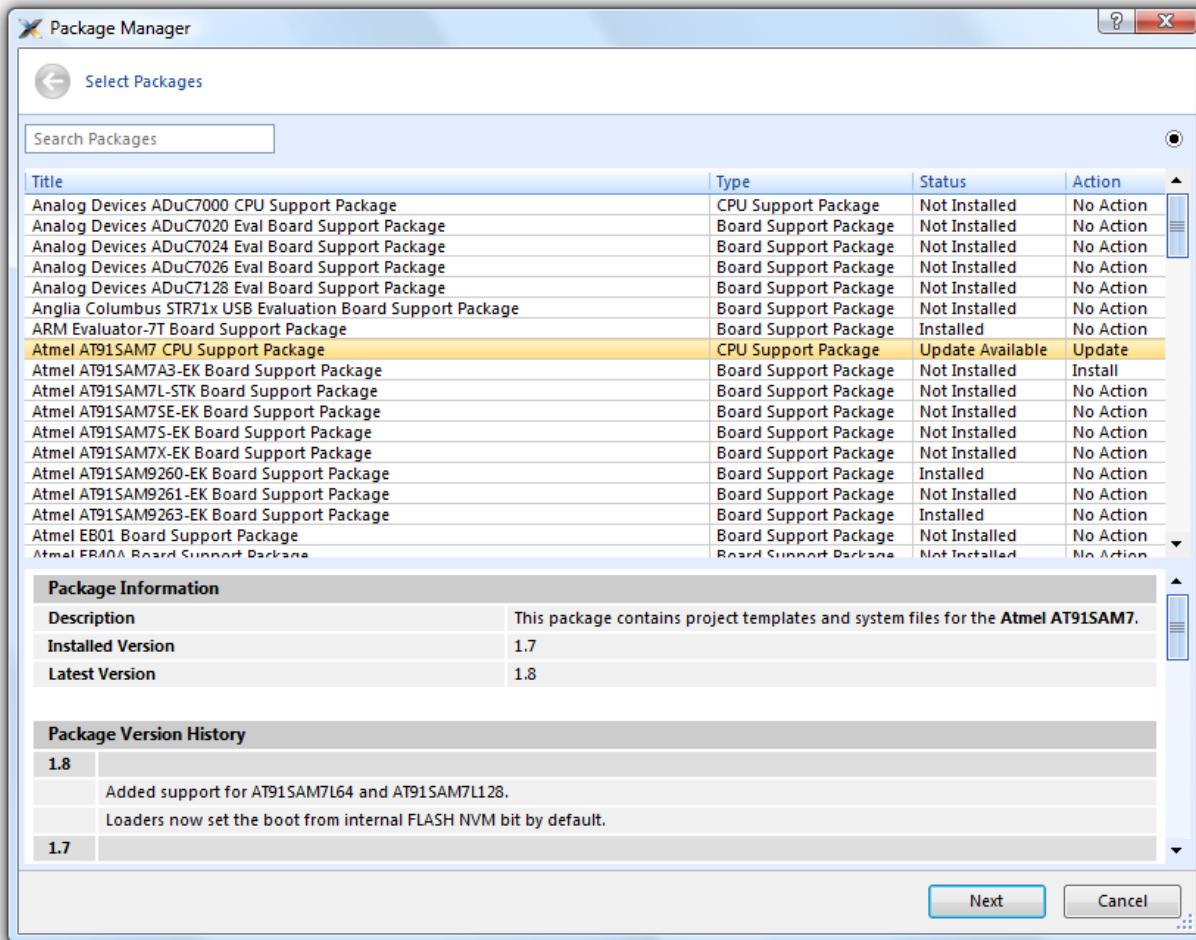
1. Choose **Tools > Packages > Manually Install Packages**.
2. Select one or more package files you want to install.
3. Click **Open** to install the packages.

Choose **Tools > Show Installed Packages** to see more information on the installed packages.

The **Package Manager** window will remove manually installed packages.

The package manager

The **Package Manager** manages the support packages installed on your system. It lists the available packages, shows the installed packages, and allows you to install, update, reinstall, and remove them.



To activate the Package Manager:

- Choose Tools > Manage Packages.

Filtering the package list

By default, the **Package Manager** lists all available and installed packages. You can filter the displayed packages in a number of ways.

To filter by package status:

- Click on the disclosure icon near the top-right corner of the dialog.
- Use the pop-up menu to choose how to filter the list of packages.

The list-filter choices are:

- Display All** — Show all packages irrespective of their status.
- Display Not Installed** — Show packages that are available but are not currently installed.

- **Display Installed** — Only show packages that are installed.
- **Display Updates** — Only show packages that are installed but are not up-to-date because a newer version is available.

You can also filter the list of packages by the text in the package's title and documentation.

To filter packages by keyword:

- Type the keyword into the **Search Packages** box at the top-left corner of the dialog.

Installing a package

The package-installation operation downloads a package to **\$(PackagesDir)/downloads**, if it has not been downloaded already, and unpacks the files contained within the package to their destination directory.

To install a package:

1. Choose **Tools > Packages > Install Packages** (this is equivalent to choosing **Tools > Manage Packages** and setting the status filter to **Display Not Installed**).
2. Select the package or packages you wish to install.
3. Right-click the selected packages and choose **Install Selected Packages** from the shortcut menu.
4. Click **Next**; you will see the actions the **Package Manager** is about to carry out.
5. Click **Next** and the **Package Manager** will install the selected packages.
6. When installation is complete, click **Finish** to close the **Package Manager**.

Updating a package

The package-update operation first removes existing package files, then it downloads the updated package to **\$(PackagesDir)/downloads** and unpacks the files contained within the package to their destination directory.

To update a package:

1. Choose **Tools > Packages > Update Packages** (this is equivalent to clicking **Tools > Package Manager** and setting the status filter to **Display Updates**).
2. Select the package or packages you wish to update.
3. Right-click the selected packages and choose **Update Selected Packages** from the shortcut menu.
4. Click **Next**; you will see the actions the **Package Manager** is about to carry out.
5. Click **Next** and the **Package Manager** will update the package(s).
6. When the update is complete, click **Finish** to close the **Package Manager**.

Removing a package

The package-remove operation removes all the files that were extracted when the package was installed.

To remove a package:

1. Choose **Tools > Packages > Remove Packages** (this is equivalent to choosing **Tools > Package Manager** and setting the status filter to **Display Installed**).
2. Select the package or packages you wish to remove.
3. Right-click the selected packages and choose **Remove Selected Packages** from the shortcut menu.
4. Click **Next**; you will see the actions the **Package Manager** is about to carry out.
5. Click **Next** and the **Package Manager** will remove the package(s).
6. When the operation is complete, click **Finish** to close the **Package Manager**.

Reinstalling a package

The package-reinstall operation carries out a package-remove operation followed by a package-install operation.

To reinstall a package:

1. Choose **Tools > Packages > Reinstall Packages** (this is equivalent to choosing **Tools > Package Manager** and setting the status filter to **Display Installed**).
2. Select the package or packages you wish to reinstall.
3. Right-click the packages to reinstall and choose **Reinstall Selected Packages** from the shortcut menu.
4. Click **Next**; you will see the actions the **Package Manager** is about to carry out.
5. Click **Next** and the **Package Manager** will reinstall the packages.
6. When the operation is complete, click **Finish** to close the **Package Manager**.

Exploring your application

In this section, we discuss the CrossStudio tools that help you examine how your application is built.

Project explorer

The **Project Explorer** is the user interface of the CrossWorks project system. It organizes your projects and files and provides access to the commands that operate on them. A toolbar at the top of the window offers quick access to commonly used commands for the selected project node or the active project. Right-click to reveal a shortcut menu with a larger set of commands that will work on the selected project node, ignoring the active project.

The selected project node determines what operations you can perform. For example, the **Compile** operation will compile a single file if a file project node is selected; if a folder project node is selected, each of the files in the folder are compiled.

You can select project nodes by clicking them in the **Project Explorer**. Additionally, as you switch between files in the editor, the selection in the **Project Explorer** changes to highlight the file you're editing.

To activate the Project Explorer:

- Choose **View > Project Explorer** or press **Ctrl+Alt+P**.

Left-click operations

The following operations are available in the **Project Explorer** with a left-click of the mouse:

Action	Description
Single click	Select the node. If the node is already selected and is a solution, project, or folder node, a rename editor appears.
Double click	Double-clicking a solution node or folder node will reveal or hide the node's children. Double-clicking a project node selects it as the active project. Double-clicking a file opens the file with the default editor for that file's type.

Toolbar commands

The following buttons are on the toolbar:

Button	Description
	Add a new file to the active project using the New File dialog.
	Add existing files to the active project.

	Remove files, folders, projects, and links from the project.
	Create a new folder in the active project.
	Menu of build operations.
	Disassemble the active project.
	Menu of Project Explorer options.
	Display the properties dialog for the selected item.

Shortcut menu commands

The shortcut menu, displayed by right-clicking, contains the commands listed below.

For solutions:

Item	Description
Build and Batch Build	Build all projects under the solution in the current or batch build configuration.
Rebuild and Batch Rebuild	Rebuild all projects under the solution in the current or batch build configuration.
Clean and Batch Clean	Remove all output and intermediate build files for the projects under the solution in the current or batch build configuration.
Export Build and Batch Export Build	Create an editor with the build commands for the projects under the solution in the current or batch build configuration.
Add New Project	Add a new project to the solution.
Add Existing Project	Create a link from an existing solution to this solution.
Paste	Paste a copied project into the solution.
Remove	Remove the link to another solution from the solution.
Rename	Rename the solution node.
Source Control Operations	Source-control operations on the project file and recursive operations on all files in the solution.
Edit Solution As Text	Create an editor containing the project file.
Save Solution As	Change the filename of the project file—note that the saved project file is not reloaded.
Properties	Show the Properties dialog with the solution node selected.

For projects:

Item	Description
Build and Batch Build	Build the project in the current or batch build configuration.
Rebuild and Batch Rebuild	Rebuild the project in the current or batch build configuration.
Clean and Batch Clean	Remove all output and intermediate build files for the project in the current or batch build configuration.
Export Build and Batch Export Build	Create an editor with the build commands for the project in the current or batch build configuration.
Link	Perform the project node build operation: link for an Executable project type, archive for a Library project type, and the combine command for a Combining project type.
Set As Active Project	Set the project to be the active project.
Debugging Commands	For Executable and Externally Built Executable project types, the following debugging operations are available on the project node: Start Debugging , Step Into Debugging , Reset And Debug , Start Without Debugging , Attach Debugger , and Verify .
Memory-Map Commands	For Executable project types that don't have memory-map files in the project and have the memory-map file project property set, there are commands to view the memory-map file and to import it into the project.
Section-Placement Commands	For Executable project types that don't have section-placement files in the project but have the section-placement file project property set, there are commands to view the section-placement file and to import it into the project.
Target Processor	For Executable and Externally Built Executable project types that have a Target Processor property group, the selected target can be changed.
Add New File	Add a new file to the project.
Add Existing File	Add an existing file to the project.
New Folder	Create a new folder in the project.
Cut	Cut the project from the solution.
Copy	Copy the project from the solution.
Paste	Paste a copied folder or file into the project.
Remove	Remove the project from the solution.
Rename	Rename the project.

Source Control Operations	Source-control, recursive operations on all files in the project.
Find in Project Files	Run Find in Files in the project directory.
Properties	Show the Project Manager dialog and select the project node.

For folders:

Item	Description
Add New File	Add a new file to the folder.
Add Existing File	Add an existing file to the folder.
New Folder	Create a new folder in the folder.
Cut	Cut the folder from the project or folder.
Copy	Copy the folder from the project or folder.
Paste	Paste a copied folder or file into the folder.
Remove	Remove the folder from the project or folder.
Rename	Rename the folder.
Source Control Operations	Source-control recursive operations on all files in the folder.
Compile	Compile each file in the folder.
Properties	Show the properties dialog with the folder node selected.

For files:

Item	Description
Open	Edit the file with the default editor for the file's type.
Open With	Edit the file with a selected editor. You can choose from the Binary Editor , Text Editor , and Web Browser .
Select in File Explorer	Create a operating system file system window with the file selected.
Compile	Compile the file.
Export Build	Create an editor window containing the commands to compile the file in the active build configuration.
Exclude From Build	Set the Exclude From Build property to Yes for this project node in the active build configuration.
Disassemble	Disassemble the output file of the compile into an editor window.
Preprocess	Run the C preprocessor on the file and show the output in an editor window.
Cut	Cut the file from the project or folder.

Copy	Copy the file from the project or folder.
Remove	Remove the file from the project or folder.
Import	Import the file into the project.
Source Control Operations	Source-control operations on the file.
Properties	Show the properties dialog with the file node selected.

Source navigator window

One of the best ways to find your way around your source code is using the **Source Navigator**. It parses the active project's source code and organizes classes, functions, and variables in various ways.

To activate the Source Navigator:

- Choose **Navigate > Source Navigator** or press **Ctrl+Alt+N**.

The main part of the **Source Navigator** window provides an overview of your application's functions, classes, and variables.

CrossStudio displays these icons to the left of each object:

Icon	Description
{ }	A C or C++ structure or a C++ namespace.
	A C++ class.
	A C++ member function declared <code>private</code> or a function declared with <code>static</code> linkage.
	A C++ member function declared <code>protected</code> .
	A C++ member function declared <code>public</code> or a function declared with <code>extern</code> linkage.
	A C++ member variable declared <code>private</code> or a variable declared with <code>static</code> linkage.
	A C++ member variable declared <code>protected</code> .
	A C++ member variable declared <code>public</code> or a variable declared with <code>extern</code> linkage.

Re-parsing after editing

The **Source Navigator** does not update automatically, only when you ask it to. To parse source files manually, click the **Refresh** button on the **Source Navigator** toolbar.

CrossStudio re-parses all files in the active project, and any dependent project, and updates the **Source Navigator** with the changes. Parsing progress is shown as a progress bar in the **Source Navigator** window. Errors and warnings detected during parsing are sent to the **Source Navigator Log** in the **Output** window—you can show the log quickly by clicking the **Show Source Navigator Log** tool button on the **Source Navigator** toolbar.

Setting indexing threads

You can configure how many threads CrossStudio launches to index your project.

To set the number of threads launched when indexing a project:

- Choose **Navigate > Source Navigator** or press **Ctrl+Alt+N**.
- Click the **Options** dropdown button at the right of the toolbar.
- Move the slider to select the number of threads to launch.

Increasing the number of threads will complete indexing faster, but may reduce the responsiveness of CrossStudio when editing, for example. You should choose a setting that you are comfortable with for your PC. By default, CrossStudio launches 16 threads to index the project and is a good compromise for a desktop quad-core PC.

Sorting and grouping

You can group objects by their type; that is, whether they are classes, functions, namespaces, structures, or variables. Each object is placed into a folder according to its type.

To group objects by type:

1. On the **Source Navigator** toolbar, click the arrow to the right of the **Cycle Grouping** button.
2. Choose **Group By Type**

References window

The **References** window shows the results of the last **Find References** operation. The **Find References** facility is closely related to the **Source Navigator** in that it indexes your project and searches for references within the active source code regions.

To activate the References window:

If you have hidden the **References** window and want to see it again:

- Choose **Navigate > References** or press **Ctrl+Alt+R**.

To find all references in a project:

1. Open a source file that is part of the active project, or one of its dependent projects.
2. In the editor, move the insertion point within the name of the function, variable, method, or macro to find.
3. Choose **Search > Find References** or press **Alt+R**.
4. CrossStudio shows the **References** window, without moving focus, and searches your project in the background.

You can also find references directly from the text editor's context menu: right-click the item to find and choose **Find References**. As a convenience, CrossStudio is configured to also run **Find References** when you Alt+Right-click in the text editor—see [Mouse-click accelerators](#).

To search within the results:

- Type the text to search for in the Reference window's search box. As you type, the search results are narrowed.
- Click the close button to clear the search text and show all references.

To set the number of threads launched when finding references:

- Choose **Navigate > References** or press **Ctrl+Alt+R**.
- Click the **Options** dropdown button at the right of the toolbar.
- Move the slider to select the number of threads to launch.

Increasing the number of threads will complete searches faster, but may reduce the responsiveness of CrossStudio when editing, for example. You should choose a setting that you are comfortable with for your PC. By default, CrossStudio launches 16 threads to search the project and is a good compromise for a desktop quad-core PC.

Symbol browser window

The **Symbol Browser** shows useful information about your linked application and complements the information displayed in the **Project Explorer** window. You can select different ways to filter and group the information in the **Symbol Browser** to provide an at-a-glance overview of your application. You can use the **Symbol Browser** to *drill down* to see the size and location of each part of your program. The way symbols are sorted and grouped is saved between runs; so, when you rebuild an application, CrossStudio automatically updates the **Symbol Browser** so you can see the effect of your changes on the memory layout of your program.

User interface

Button	Description
{ 	Group symbols by source filename.
{ 	Group symbols by symbol type (equates, functions, labels, sections, and variables).
{ 	Group symbols by the section where they are defined.
+ 	Move the insertion point to the statement that defined the symbol.
	Select columns to display.

The main part of the **Symbol Browser** displays each symbol (both external and static) that is linked into an application. CrossStudio displays the following icons to the left of each symbol:

Icon	Description
	<i>Private Equate</i> A private symbol not defined relative to a section.
	<i>Public Equate</i> A public symbol that is not defined relative to a section.
	<i>Private Function</i> A private function symbol.
	<i>Public Function</i> A public function symbol.
	<i>Private Label</i> A private data symbol, defined relative to a section.
	<i>Public Label</i> A public data symbol, defined relative to a section.
	<i>Section</i> A program section.

Choosing what to show

To activate the Symbol Browser window:

- Choose **Navigate > Symbol Browser** or press **Ctrl+Alt+Y**.

You can choose to display the following fields for each symbol:

- Value:** The value of the symbol. For labels, code, and data symbols, this will be the address of the symbol. For absolute or symbolic equates, this will be the value of the symbol.
- Range:** The range of addresses the code or data item covers. For code symbols that correspond to high-level functions, the range is the range of addresses used for that function's code. For data addresses that correspond to high-level **static** or **extern** variables, the range is the range of addresses used to store that data item. These ranges are only available if the corresponding source file was compiled with debugging information turned on: if no debugging information is available, the range will simply be the first address of the function or data item.
- Size:** The size, in bytes, of the code or data item. The **Size** column is derived from the **Range** of the symbol: if the symbol corresponds to a high-level code or data item and has a range, **Size** is calculated as the difference between the start and end addresses of the range. If a symbol has no range, the size column is blank.
- Section:** The section in which the symbol is defined. If the symbol is not defined within a section, the **Section** column is blank.
- Type:** The high-level type for the data or code item. If the source file that defines the symbol is compiled with debugging information turned off, type information is not available and the **Type** column is blank.

Initially the **Range** and **Size** columns are shown in the **Symbol Browser**. To select which columns to display, use the **Field Chooser** button on the **Symbol Browser** toolbar.

To select the fields to display:

- Click the **Field Chooser** button on the **Symbol Browser** toolbar.
- Select the fields you wish to display and deselect the fields you wish to hide.

Organizing and sorting symbols

When you group symbols by section, each symbol is grouped underneath the section in which it is defined. Symbols that are absolute or are not defined within a section are grouped beneath '(No Section)'.

To group symbols by section:

- On the **Symbol Browser** toolbar, click the arrow next to the **Cycle Grouping** button.
- From the pop-up menu, choose **Group By Section**.

The **Cycle Grouping** icon will change to indicate that the **Symbol Browser** is grouping symbols by section.

When you group symbols by type, each symbol is classified as one of the following:

- An *Equate* has an absolute value and is not defined as relative to, or inside, a section.
- A *Function* is defined by a high-level code sequence.
- A *Variable* is defined by a high-level data declaration.
- A *Label* is defined by an assembly language module. *Label* is also used when high-level modules are compiled with debugging information turned off.

When you group symbols by source file, each symbol is grouped underneath the source file in which it is defined. Symbols that are absolute, are not defined within a source file, or are compiled without debugging information, are grouped beneath '(Unknown)'.

To group symbols by type:

1. On the **Symbol Browser** toolbar, click the arrow next to the **Cycle Grouping** button.
2. Choose **Group By Type** from the pop-up menu.

The **Cycle Grouping** icon will change to indicate that the **Symbol Browser** is grouping symbols by type.

To group symbols by source file:

1. On the **Symbol Browser** toolbar, click the arrow next to the **Cycle Grouping** button.
2. Choose **Group By Source File**.

The **Cycle Grouping** icon will change to indicate that the **Symbol Browser** is grouping symbols by source file.

When you sort symbols alphabetically, all symbols are displayed in a single list in alphabetical order.

To list symbols alphabetically:

1. On the **Symbol Browser** toolbar, click the arrow next to the **Cycle Grouping** button.
2. Choose **Sort Alphabetically**.

The **Cycle Grouping** icon will change to indicate that the **Symbol Browser** is grouping symbols alphabetically.

Filtering and finding symbols

When you're dealing with big projects with hundreds, or even thousands, of symbols, a way to filter those symbols in order to isolate just the ones you need is very useful. The **Symbol Browser**'s toolbar provides an editable combobox} you can use to specify the symbols you'd like displayed. You can type '*' to match a sequence of zero or more characters and '?' to match exactly one character.

The symbols are filtered and redisplayed as you type into the combo box. Typing the first few characters of a symbol name is usually enough to narrow the display to the symbol you need. Note: the C compiler prefixes all

high-level language symbols with an underscore character, so the variable `extern int u` or the function `void fn(void)` have low-level symbol names `_u` and `_fn`. The **Symbol Browser** uses the low-level symbol name when displaying and filtering, so you must type the leading underscore to match high-level symbols.

To display symbols that start with a common prefix:

- Type the desired prefix text into the combo box, optionally followed by a `"*"`.

For instance, to display all symbols that start with `"i2c_"`, type `"i2c_"` and all matching symbols are displayed—you don't need to add a trailing `"*"` in this case, because it is implied.

To display symbols that end with a common suffix:

- Type `"*"` into the combo box, followed by the required suffix.

For instance, to display all symbols that end in `'_data'`, type `*_data'` and all matching symbols are displayed—in this case, the leading `"*"` is required.

When you have found the symbol you're interested in and your source files have been compiled with debugging information turned on, you can jump to a symbol's definition using the **Go To Definition** button.

To jump to the definition of a symbol:

1. Select the symbol from the list of symbols.
2. On the **Symbol Browser** toolbar, click **Go To Definition**.

—or—

1. Right-click the symbol in the list of symbols.
2. Choose **Go To Definition** from the shortcut menu.

Watching symbols

If a symbol's range and type is known, you can add it to the most recently opened **Watch** window or **Memory** window.

To add a symbol to the Watch window:

1. In the **Symbol Browser**, right-click the symbol you wish to add to the **Watch** window.
2. On the shortcut menu, choose **Add To Watch**.

To add a symbol to the Memory window:

1. In the **Symbol Browser**, right-click the symbol you wish to add to the **Memory** window.

2. Choose **Locate Memory** from the shortcut menu.

Using size information

Here are a few common ways to use the **Symbol Browser**:

What function uses the most code space? What requires the most data space?

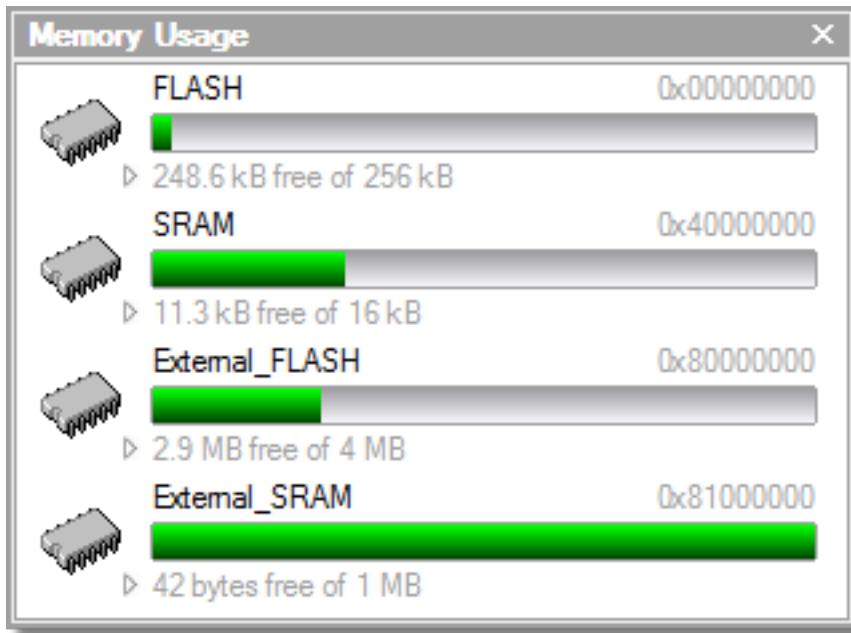
1. Choose **Navigate > Symbol Browser** or press **Ctrl+Alt+Y**.
2. In the **Grouping** button menu on the **Symbol Browser** toolbar, select **Group By Type**.
3. Ensure the **Size** field is checked in the **Field Chooser** button's menu.
4. Ensure that the filter on the **Symbol Browser** toolbar is empty.
5. Click on the **Size** field in the header to sort by data size.
6. The sizes of variables and of functions are shown in separate lists.

What's the overall size of my application?

1. Choose **Navigate > Symbol Browser** or press **Ctrl+Alt+Y**.
2. In the **Grouping** button menu on the **Symbol Browser** toolbar, select **Group By Section**.
3. Ensure the **Range** and **Size** fields are checked in the **Field Chooser** button's menu.
4. Read the section sizes and ranges of each section in the application.

Memory usage window

The **Memory Usage** window displays a graphical summary of how memory has been used in each memory segment of a linked application.



Each bar represents an entire memory segment. Green represents the area of the segment that contains code or data.

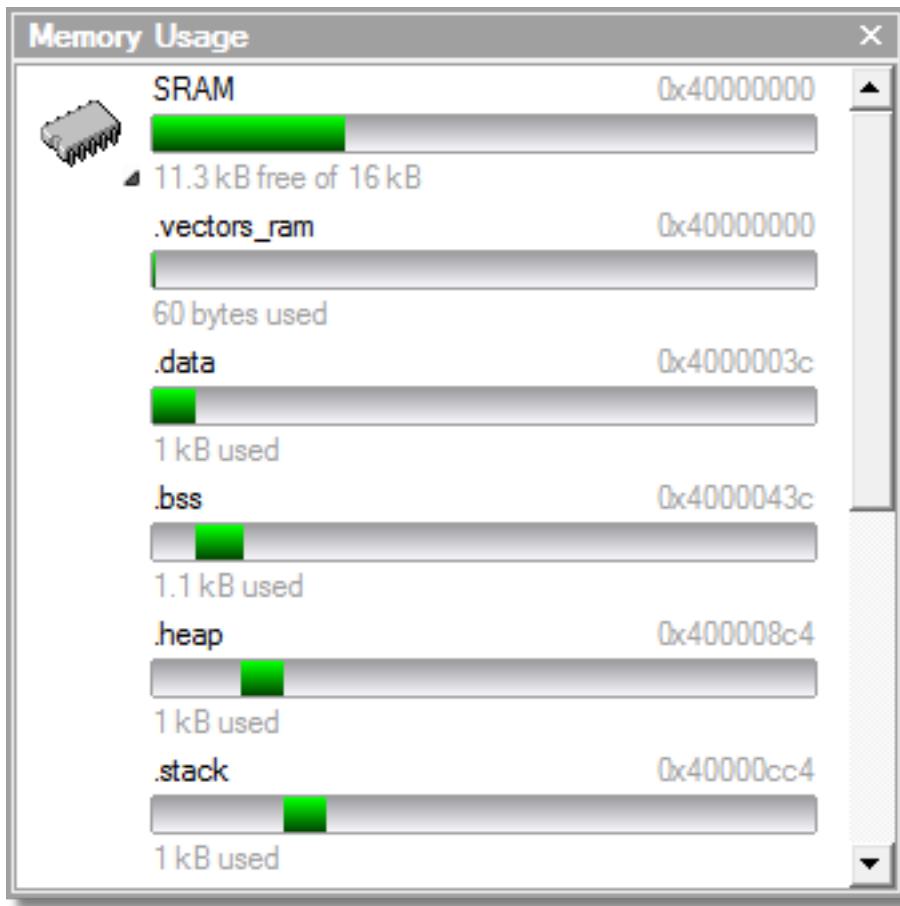
To activate the Memory Usage window:

- Choose **View > Memory Usage** or press **Ctrl+Alt+Z**.

The memory-usage graph will only be visible if your active project's target is an executable file and the file exists. If the executable file has not been linked by CrossStudio, memory-usage information may not be available.

Displaying section information

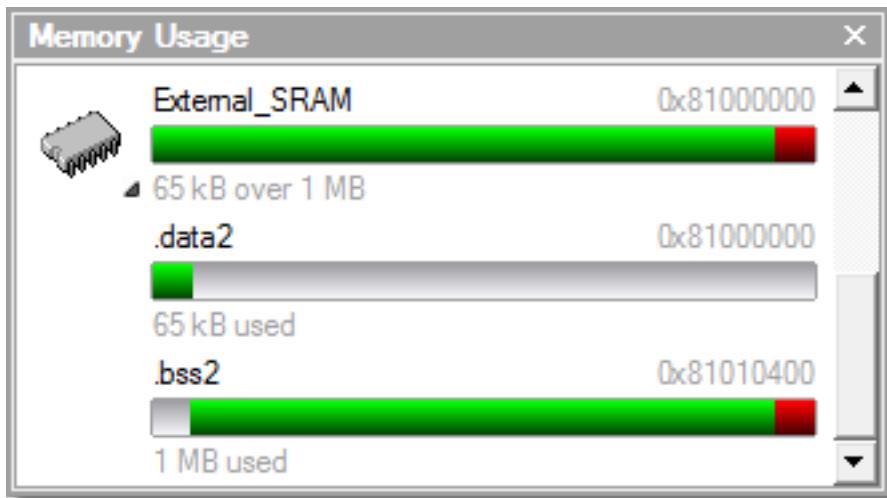
The **Memory Usage** window can also be used to visualize how program sections have been placed in memory. To display the program sections, simply click the memory segment to expand it; or, alternatively, right-click and choose **Show Memory Sections** from the shortcut menu.



Each bar represents an entire memory segment. Green represents the area of the segment that contains the program section.

Displaying segment overflow

The **Memory Usage** window also displays segment overflows when the total size of the program sections placed in a segment is larger than the segment size. When this happens, the segment and section bars represent the total memory used, green areas represent the code or data within the segment, and red areas represent code or data placed outside the segment.



Getting more-detailed information

If you require more-detailed information than that provided by the **Memory Usage** window, such as the location of specific objects within memory, use the [Symbol browser window](#).

Bookmarks window

The **Bookmarks** window contains a list of bookmarks that are set in the project. The bookmarks are stored in the session file associated with the project and persist across runs of CrossStudio—if you remove the session file, the bookmarks associated with the project are lost.

User interface

Button	Description
	Toggle a bookmark at the insertion point in the active editor. Equivalent to choosing Edit > Bookmarks > Toggle Bookmark or pressing Ctrl+F2 .
	Go to the previous bookmark in the bookmark list. Equivalent to choosing Edit > Bookmarks > Previous Bookmark or pressing Alt+Shift+F2 .
	Go to the next next bookmark in the bookmark list. Equivalent to choosing Edit > Bookmarks > Next Bookmark or pressing Alt+F2 .
	Clear all bookmarks—you confirm the action using a dialog. Equivalent to choosing Edit > Bookmarks > Clear All Bookmarks or pressing Ctrl+K, Alt+F2 .
	Selects the fill color for newly created bookmarks.

Double-clicking a bookmark in the bookmark list moves focus to the the bookmark.

You can set bookmarks with the mouse or using keystrokes—see [Using bookmarks](#).

Editing your code

CrossStudio has a built-in editor that allows you to edit text, but some features make it particularly well suited to editing code.

You can open multiple code editors to browse or edit project source code, and you can copy and paste among them. The **Windows** menu contains a list of all open code editors.

The code editor supports the language of the source file it is editing, showing code with syntax highlighting and offering smart indenting.

You can open a code editor in several ways, some of which are:

- By double-clicking a file in the **Project Explorer** or by right-clicking a file and selecting **Open** from the shortcut menu.
- Using the **File > New File** or **File > Open** commands.

Elements of the code editor

The code editor is composed of several elements, which are described here.

- *Code pane*: The area where you edit code. You can set options that affect the code pane's text indents, tabs, drag-and-drop behavior, and so forth.
- *Margin gutter*: A gray area on the left side of the code editor where margin indicators such as breakpoints, bookmarks, and shortcuts are displayed. Clicking this area sets a breakpoint on the corresponding line of code.
- *Horizontal and vertical scroll bars*: You can scroll the code pane horizontally and vertically to view code that extends beyond the edges of the pane.

Basic editing

This section is a whirlwind tour of the basic editing features CrossStudio's code editor provides.

Whether you are editing code, HTML, or plain text, the code editor is just like many other text editors or word processors. For code that is part of a project, the project's programming language support provides syntax highlighting (colorization), indentation, and so on.

This section *is not* a reference for everything the code editor provides; for that, look in the following sections.

Moving the insertion point

The most common way to navigate through text is to use the mouse or the keyboard's cursor keys.

Using the mouse

You can move the insertion point within a document by clicking the mouse inside the editor window.

Using the keyboard

The keystrokes most commonly used to navigate through a document are:

Keystroke	Description
Up	Move the insertion point up one line
Down	Move the insertion point down one line
Left	Move the insertion point left one character
Right	Move the insertion point right one character
Home	Move the insertion point to the first non-whitespace character on the line — pressing Home a second time moves the insertion point to the leftmost column
End	Move the insertion point to the end of the line
PageUp	Move the insertion point up one page
PageDown	Move the insertion point down one page
Ctrl+Home	Move the insertion point to the start of the document
Ctrl+End	Move the insertion point to the end of the document
Ctrl+Left	Move the insertion point left one word
Ctrl+Right	Move the insertion point right one word

CrossStudio offers additional movement keystrokes, though most users are more comfortable using repeated simple keystrokes to accomplish the same thing:

Keystroke	Description
Alt+Up	Move the insertion point up five lines
Alt+Down	Move the insertion point down five lines
Alt+Home	Move the insertion point to the top of the window
Alt+End	Move the insertion point to the bottom of the window
Ctrl+Up	Scroll the document up one line in the window without moving the insertion point

Ctrl+Down	Scroll the document down one line in the window without moving the insertion point
------------------	------------------------------------------------------------------------------------

If you are editing source code, there are source-related keystrokes too:

Keystroke	Description
Ctrl+PgUp	Move the insertion point backwards to the previous function or method.
Ctrl+PgDn	Move the insertion point forwards to the next function or method.

Adding text

The editor has two text-input modes:

- *Insertion mode*: As you type on the keyboard, text is entered at the insertion point and any text to the right of the insertion point is shifted along. A visual indication of insertion mode is that the cursor is a flashing line.
- *Overstrike mode*: As you type on the keyboard, text at the insertion point is replaced with your typing. A visual indication of insertion mode is that the cursor is a flashing block.

Insert and overstrike modes are common to *all* editors: if one editor is in insert mode, *all* editors are in insert mode. To configure the cursor appearance, choose **Tools > Options**.

To toggle between insertion and overstrike mode:

- Click **Insert**.

When overstrike mode is enabled, the mode indicator changes from **INS** to **OVR** and the cursor will change to the overstrike cursor.

To add or insert text:

1. Move the insertion point to the place text is to be inserted.
2. Enter the text using the keyboard.

To overwrite characters in an existing line, press the **Insert** key to place the editor into overstrike mode.

Deleting text

The text editor supports the following common editing keystrokes:

Keystroke	Description
Backspace	Delete the character before the insertion point
Delete	Delete the character after the insertion point
Ctrl+Backspace	Delete one word before the insertion point
Ctrl+Delete	Delete one word after the insertion point

To delete characters or words:

1. Place the insertion point before the word or letter you want to delete.
2. Press **Delete** as many times as needed.

—or—

1. Place the insertion point after the letter or word you want to delete.
2. Press **Backspace** as many times as needed.

To delete text that spans more than a few characters:

1. Select the text you want to delete.
2. Press **Delete** or **Backspace** to delete it.

Using the clipboard

You can select text by using the keyboard or the mouse.

To select text with the keyboard:

- Hold down the **Shift** key while using the cursor keys.

To select text with the mouse:

1. Click the start of the selection.
2. Drag the mouse to mark the selection.
3. Release the mouse to end selecting.

To copy selected text to the clipboard:

- Choose **Edit > Copy** or press **Ctrl+C**.

The standard Windows key sequence **Ctrl+Ins** also copies text to the clipboard.

To cut selected text to the clipboard:

- Choose **Edit > Cut** or press **Ctrl+X**.

The standard Windows key sequence **Shift+Del** also cuts text to the clipboard.

To insert the clipboard content at the insertion point:

- Choose **Edit > Paste** or press **Ctrl+V**.

The standard Windows key sequence **Shift+Ins** also inserts the clipboard content at the insertion point.

Undo and redo

The editor has an *undo* facility to undo previous editing actions. The *redo* feature can be used to re-apply previously undone actions.

To undo one editing action:

- Choose **Edit > Undo** or press **Ctrl+Z**.

The standard Windows key sequence **Alt+Backspace** also undoes an edit.

To undo multiple editing actions:

1. On the **Standard** toolbar, click the arrow next to the **Undo** button.
2. Select the editing operations to undo.

To undo all edits:

- Choose **Edit > Others > Undo All** or press **Ctrl+K, Ctrl+Z**.

To redo one editing action:

- Choose **Edit > Redo** or press **Ctrl+Y**.

The standard Windows key sequence **Alt+Shift+Backspace** also redoes an edit.

To redo multiple editing actions:

1. On the **Standard** toolbar, click the arrow next to the **Redo** tool button.
2. From the pop-up menu, select the editing operations to redo.

To redo all edits:

- Choose **Edit > Others > Redo All** or press **Ctrl+K, Ctrl+Y**.

Drag and drop

You can select text, then drag it to another location. You can drop the text at a different location in the same window or in another one.

To drag and drop text:

1. Select the text you want to move.
2. Press and hold the mouse button to drag the selected text to where you want to place it.
3. Release the mouse button to drop the text.

Dragging text *moves* it to the new location. To *copy* it to a new location, hold down the **Ctrl** key while dragging the text: the mouse pointer changes to indicate a copy operation. Press the **Esc** key while dragging text to cancel the drag-and-drop edit.

By default, drag-and drop-editing is *disabled* and you must enable it if you want to use it.

To enable or disable drag-and-drop editing:

1. Choose **Tools > Options** or press **Alt+,,**.
2. Click **Text Editor**.
3. Set **Allow Drag and Drop Editing** to **Yes** to enable or to **No** to disable drag-and-drop editing.

Searching

To find text in the current file:

1. Press **Ctrl+F**.
2. Enter the string to search for.

As you type, the editor searches the file for a match. The pop-up shows how many matches are in the current file.

To move through the matches while the **Find** box is still active, press **Tab** or **F3** to move to the next match and **Shift+Tab** or **Shift+F3** to move to the previous match.

If you press **Ctrl+F** a second time, CrossStudio pops up the standard **Find** dialog to search the file. If you wish to bring up the **Find** dialog without pressing **Ctrl+F** twice, choose **Search > Find**.

Advanced editing

You can do anything using its basic code-editing features, but the CrossStudio text editor has a host of labor-saving features that make editing programs a snap.

This section describes the code-editor features intended to make editing source code easier.

Indenting source code

The editor uses the **Tab** key to increase or decrease the indentation level of the selected text.

To increase indentation:

- Select the text to indent.
- Choose **Selection > Increase Line Indent** or press **Tab**.

To decrease indentation:

- Select the text to indent.
- Choose **Selection > Decrease Line Indent** or press **Shift+Tab**.

The indentation size can be changed in the **Language Properties** pane of the editor's **Properties** window, as can all the indent-related features listed below.

To change indentation size:

- Choose **Tools > Options** or press **Alt+,**.
- Select the **Languages** page.
- Set the **Indent Size** property for the required language.

You can choose to use spaces or tab tab characters to fill whitespace when indenting.

To set tab or space fill when indenting:

- Choose **Tools > Options** or press **Alt+,**.
- Select the **Languages** page.
- Set the **Use Tabs** property for the required language. *Note:* changing this setting does not add or remove existing tabs from files, the change will only affect new indents.

The editor can assist with source code indentation while inserting text. There are three levels of indentation assistance:

- *None:* The indentation of the source code is left to the user.
- *Indent:* This is the default. The editor maintains the current indentation level. When you press **Return** or **Enter**, the editor moves the insertion point down one line and indented to the same level as the now-previous line.
- *Smart:* The editor analyzes the source code to compute the appropriate indentation level for each line. You can change how many lines before the insertion point will be analyzed for context. The smart-indent mode can be configured to indent either open and closing braces or the lines following the braces.

Changing indentation options:

To change the indentation mode:

- Set the **Indent Mode** property for the required language.

To change whether opening braces are indented in smart-indent mode:

- Set the **Indent Opening Brace** property for the required language.

To change whether closing braces are indented in smart-indent mode:

- Set the **Indent Closing Brace** property for the required language.

To change the number of previous lines used for context in smart-indent mode:

- Set the **Indent Context Lines** property for the required language.

Commenting out sections of code

To comment selected text:

- Choose **Selection > Comment** or press **Ctrl+/-**.

To uncomment selected text:

- Choose **Selection > Uncomment** or press **Ctrl+Shift+/-**.

You can also toggle the commenting of a selection by typing **/**. This has no menu equivalent.

Adjusting letter case

The editor can change the case of the current word or the selection. The editor will change the case of the selection, if there is a selection, otherwise it will change the case of word at the insertion point.

To change text to uppercase:

- Choose **Selection > Make Uppercase** or press **Ctrl+Shift+U**.

This changes, for instance, 'Hello' to 'HELLO'.

To change text to lowercase:

- Choose **Selection > Make Lowercase** or press **Ctrl+U**.

This changes, for instance, 'Hello' to 'hello.'

To switch between uppercase and lowercase:

- Choose **Selection > Switch Case**.

This changes, for instance, 'Hello' to 'hELLO.'

With large software teams or imported source code, sometimes identifiers don't conform to your local coding style. To assist in conversion between two common coding styles for identifiers, CrossStudio's editor offers the following two shortcuts:

To change from split case to camel case:

- Choose **Selection > Camel Case** or press **Ctrl+K, Ctrl+Shift+U**.

This changes, for instance, 'this_is_wrong' to 'thisIsWrong.'

To change from camel case to split case:

- Choose **Selection > Split Case** or press **Ctrl+K, Ctrl+U**.

This changes, for instance, 'thisIsWrong' to 'this_is_wrong.'

Using bookmarks

To edit a document elsewhere and then return to your current location, add a bookmark. The **Bookmarks** window maintains a list of the bookmarks set in source files — see [Bookmarks window](#).

To place a bookmark:

1. Move the insertion point to the line you wish to bookmark.
2. Choose **Edit > Bookmarks > Toggle Bookmark** or press **Ctrl+F2**.

A bookmark symbol appears next to the line in the indicator margin to show the bookmark is set.

To place a bookmark using the mouse:

1. Right-click the margin gutter where the bookmark should be set.
2. Choose **Toggle Bookmark**.

The default color to use for new bookmarks is configured in the **Bookmarks** window. You can choose a specific color for the bookmark as follows:

1. Press and hold the **Alt** key.
2. Click the margin gutter where the bookmark should be set.
3. From the palette, click the bookmark color to use for the bookmark.

To navigate forward through bookmarks:

1. Choose **Edit > Bookmarks > Next Bookmark In Document** or press **F2**.
2. The editor moves the insertion point to the next bookmark in the document.

If there is no following bookmark, the insertion point moves to the first bookmark in the document.

To navigate backward through bookmarks:

1. Choose **Edit > Bookmarks > Previous Bookmark In Document** or press **Shift+F2**.
2. The editor moves the insertion point to the previous bookmark in the document.

If there is no previous bookmark, the insertion point moves to the last bookmark in the document.

To remove a bookmark:

1. Move the insertion point to the line containing the bookmark.
2. Choose **Edit > Bookmarks > Toggle Bookmark** or press **Ctrl+F2**.

The bookmark symbol disappears, indicating the bookmark is no longer set.

To remove all bookmarks in a document:

- Choose **Edit > Bookmarks > Clear Bookmarks In Document** or press **Ctrl+K, F2**.

Quick reference for bookmark operations

Keystroke	Menu	Description
Ctrl+F2	Edit > Bookmarks > Toggle Bookmark	Toggle a bookmark at the insertion point.
Ctrl+K, 0		Clear the bookmark at the insertion point.
F2	Edit > Bookmarks > Next Bookmark In Document	Move the insertion point to next bookmark in the document.
Shift+F2	Edit > Bookmarks > Previous Bookmark In Document	Move the insertion point to previous bookmark in the document.
Ctrl+Q, F2	Edit > Bookmarks > First Bookmark In Document	Move the insertion point to the first bookmark in the document.
Ctrl+Q, Shift+F2	Edit > Bookmarks > Last Bookmark In Document	Move the insertion point to the last bookmark in the document.
Ctrl+K, F2	Edit > Bookmarks > Clear Bookmarks In Document	Clear all bookmarks in the document.
Alt+F2	Edit > Bookmarks > Next Bookmark	Move the insertion point to the next bookmark in the Bookmarks list.
Alt+Shift+F2	Edit > Bookmarks > Previous Bookmark	Move the insertion point to the previous bookmark in the Bookmarks list.
Ctrl+Q, Alt+F2	Edit > Bookmarks > First Bookmark	Move the insertion point to the first bookmark in the Bookmarks list.
Ctrl+Q, Alt+Shift+F2	Edit > Bookmarks > Last Bookmark	Move the insertion point to the last bookmark in the Bookmarks list.
Ctrl+K, Alt+F2	Edit > Bookmarks > Clear All Bookmarks	Clear all bookmarks in all documents.

Find and Replace window

The **Find and Replace** window allows you to search for and replace text in the current document or in a range of specified files.

To activate the Find and Replace window:

- Choose **Search > Find And Replace** or press **Ctrl+Alt+F**.

To find text in a single file:

- Select **Current Document** in the context combo box.
- Enter the string to be found in the text edit input.
- If the search will be case sensitive, set the **Match case** option.
- If the search will be for a whole word—i.e., there will be whitespace, such as spaces or the beginning or end of the line, on both sides of the string being searched for—set the **Whole word** option.
- If the search string is a regular expression, set the **Use regexp** option.
- Click the **Find** button to find all occurrences of the string in the current document.

To find and replace text in a single file:

- Click the **Replace** button on the toolbar.
- Enter the string to search for into the **Find what** input.
- Enter the replacement string into the **Replace with** input. If the search string is a regular expression, the *n* back-reference can be used in the replacement string to reference captured text.
- If the search will be case sensitive, set the **Match case** option.
- If the search will be for a whole word—i.e., there will be whitespace, such as spaces or the beginning or end of the line, on both sides of the string being searched for—set the **Match whole word** option.
- If the search string is a regular expression, set the **Use regular expression** option.
- Click the **Find Next** button to find next occurrence of the string, then click the **Replace** button to replace the found string with the replacement string; or click **Replace All** to replace all occurrences of the search string without prompting.

To find text in multiple files:

- Click the **Find In Files** button on the toolbar.
- Enter the string to search for into the **Find what** input.
- Select the appropriate option in the **Look in** input to select whether to carry out the search in all open documents, all documents in the current project, all documents in the current solution, or all files in a specified folder.
- If you have specified that you want to search in a folder, select the folder you want to search by entering its path in the **Folder** input and use the **Look in files matching** input to specify the type of files you want to search.

- If the search will be case sensitive, set the **Match case** option.
- If the search will be for a whole word—i.e., there will be whitespace, such as spaces or the beginning or end of the line, on both sides of the string being searched for—set the **Match whole word** option.
- If the search string is a regular expression, set the **Use regular expression** option.
- Click the **Find All** button to find all occurrences of the string in the specified files, or click the **Bookmark All** button to bookmark all the occurrences of the string in the specified files.

To replace text in multiple files:

- Click the **Replace In Files** button on the toolbar.
- Enter the string to search for into the **Find what** input.
- Enter the replacement string into the **Replace with** input. If the search string is a regular expression, the *n* back-reference can be used in the replacement string to reference captured text.
- Select the appropriate option in the **Look in** input to select whether you want to carry out the search and replace in all open documents, all documents contained in the current project, all documents in the current solution, or all files in a specified folder.
- If you have specified that you want to search in a folder, select the folder you want to search by entering its path in the **Folder** input and use the **Look in files matching** input to specify the type of files you want to search.
- If the search will be case sensitive, set the **Match case** option.
- If the search will be for a whole word—i.e., there will be whitespace, such as spaces or the beginning or end of the line, on both sides of the string being searched for—set the **Match whole word** option.
- If the search string is a regular expression, set the **Use regular expression** option.
- Click the **Replace All** button to replace all occurrences of the string in the specified files.

Clipboard Ring window

The code editor captures all cut and copy operations, and stores the cut or copied item on the *clipboard ring*. The clipboard ring stores the last 20 cut or copied text items, but you can configure the maximum number by using the environment options dialog. The clipboard ring is an excellent place to store scraps of text when you're working with many documents and need to cut and paste between them.

To activate the clipboard ring:

- Choose **Edit > Clipboard Ring > Clipboard Ring** or press **Ctrl+Alt+C**.

To paste from the clipboard ring:

1. Cut or copy some text from your code. The last item you cut or copy into the clipboard ring is the current item for pasting.
2. Press **Ctrl+Shift+V** to paste the clipboard ring's current item into the current document.
3. Repeatedly press **Ctrl+Shift+V** to cycle through the entries in the clipboard ring until you get to the one you want to permanently paste into the document. Each time you press **Ctrl+Shift+V**, the editor replaces the last entry you pasted from the clipboard ring, so you end up with just the last one you selected. The item you stop on then becomes the current item.
4. Move to another location or cancel the selection. You can use **Ctrl+Shift+V** to paste the current item again or to cycle the clipboard ring to a new item.

Clicking an item in the clipboard ring makes it the current item.

To paste a specific item from the clipboard ring:

1. Move the insertion point to the position to paste the item in the document.
2. Click the arrow at the right of the item to paste.
3. Choose **Paste** from the pop-up menu.

—or—

1. Click the item to paste to make it the current item.
2. Move the insertion point to the position to paste the item in the document.
3. Press **Ctrl+Shift+V**.

To paste all items into a document:

To paste all items on the clipboard ring into the current document, move the insertion point to where you want to paste the items and do one of the following:

- Choose **Edit > Clipboard Ring > Paste All**.

—or—

- On the **Clipboard Ring** toolbar, click the **Paste All** button.

To remove an item from the clipboard ring:

1. Click the arrow at the right of the item to remove.
2. Choose **Delete** from the pop-up menu.

To remove all items from the clipboard ring:

- Choose **Edit > Clipboard Ring > Clear Clipboard Ring**.

—or—

- On the **Clipboard Ring** toolbar, click the **Clear Clipboard Ring** button.

To configure the clipboard ring:

1. Choose **Tools > Options** or press **Alt+,**.
2. Click the **Windows** category to show the **Clipboard Ring Options** group.
3. Select **Preserve Contents Between Runs** to save the content of the clipboard ring between runs, or deselect it to start with an empty clipboard ring.
4. Change **Maximum Items Held In Ring** to configure the maximum number of items stored on the clipboard ring.

Mouse-click accelerators

CrossStudio provides a number of mouse-click accelerators in the editor that speed access to commonly used functions. The mouse-click accelerators are user configurable using **Tools > Options**.

Default mouse-click assignments

Click	Default
Left	Not configurable — start selection.
Shift+Left	Not configurable — extend selection.
Ctrl+Left	Select word.
Alt+Left	Execute Go To Definition .
Middle	No action.
Shift+Middle	Display Go To Include menu.
Ctrl+Middle	No action.
Alt+Middle	Display Go To Method menu.
Right	Not configurable — show context menu.
Shift+Right	No action.
Ctrl+Right	No action.
Alt+Right	Execute Find References .

Each accelerator can be assigned one of the following actions:

- **Default:** The system default for that click.
- **Go To Definition:** Go to the definition of the item clicked, equivalent to choosing **Navigate > Go To Definition** or pressing **Alt+G**.
- **Find References:** Find references to the item clicked, equivalent to choosing **Search > Find References** or pressing **Alt+R**.
- **Find in Solution:** Textually find the item clicked in all the files in the solution, equivalent to choosing **Search > Find Extras > Find in Solution** or pressing **Alt+U**.
- **Find Help:** Use F1-help on the item clicked, equivalent to choosing **Help > Help** or pressing **F1**.
- **Go To Method:** Display the **Go To Method** menu, equivalent to choosing **Navigate > Find Method** or pressing **Ctrl+M**.
- **Go To Include:** Display the **Go To Include** menu, equivalent to choosing **Navigate > Find Include** or pressing **Ctrl+Shift+M**.
- **Paste:** Paste the clipboard at the position clicked, equivalent to choosing **Edit > Paste** or pressing **Ctrl+V**.

Configuring Mac OS X

On Mac OS X you must configure the mouse to pass middle clicks and right clicks to the application if you wish to use mouse-click accelerators in CrossStudio. Configure the mouse preferences in the **Mouse** control panel in Mac OS X **System Preferences** to the following:

- Right mouse button set to **Secondary Button**.
- Middle mouse button set to **Button 3**.

Regular expressions

The editor can search and replace text using *regular expressions*. A regular expression is a string that uses special characters to describe and reference patterns of text. The regular expression system used by the editor is modeled on Perl's regexp language. For more information on regular expressions, see *Mastering Regular Expressions*, Jeffrey E F Freidl, ISBN 0596002890.

Summary of special characters

The following table summarizes the special characters the CrossStudio editor supports

Pattern	Description
\d	Match a numeric character.
\D	Match a non-numeric character.
\s	Match a whitespace character.
\S	Match a non-whitespace character.
\w	Match a word character.
\W	Match a non-word character.
[c]	Match set of characters; e.g., [ch] matches characters c or h. A range can be specified using the '-' character; e.g., '[0-27-9]' matches if the character is 0, 1, 2, 7 8, or 9. A range can be negated using the '^' character; e.g., '[^a-z]' matches if the character is anything other than a lowercase alphabetic character.
\c	Match the literal character c. For example, you would use '*' to match the character '*'.
\a	Match ASCII bell character (ASCII code 7).
\f	Match ASCII form feed character (ASCII code 12).
\n	Match ASCII line feed character (ASCII code 10).
\r	Match ASCII carriage return character (ASCII code 13).
\t	Match ASCII horizontal tab character (ASCII code 9).
\v	Match ASCII vertical tab character.
\xhhhh	Match Unicode character specified by hexadecimal number hhhh.
.	Match any character.
*	Match zero or more occurrences of the preceding expression.
+	Match one or more occurrences of the preceding expression.

?	Match zero or one occurrences of the preceding expression.
{n}	Match <i>n</i> occurrences of the preceding expression.
{n,}	Match at least <i>n</i> occurrences of the preceding expression.
{m}	Match at most <i>m</i> occurrences of the preceding expression.
{n,m}	Match at least <i>n</i> and at most <i>m</i> occurrences of the preceding expression.
^	Beginning of line.
\$	End of line.
\b	Word boundary.
\B	Non-word boundary.
(e)	Capture expression <i>e</i> .
\n	Back-reference to <i>n</i> th captured text.

Examples

The following regular expressions can be used with the editor's search-and-replace operations. To use the regular expression mode, the **Use regular expression** checkbox must be set in the search-and-replace dialog. Once enabled, regular expressions can be used in the **Find what** search string. The **Replace With** strings can use the "*n*" back-reference string to reference any captured strings.

"Find what"	"Replace With"	Description
u\w.d		Search for any-length string containing one or more word characters beginning with the character 'u' and ending in the character 'd'.
^.*;\$		Search for any lines ending in a semicolon.
(typedef.+\\s+)(\\S+);	\1TEST_\2;	Find C type definition and insert the string 'TEST' onto the beginning of the type name.

Locals window

The **Locals** window displays a list of all variables that are in scope of the selected stack frame in the **Call Stack**.

The **Locals** window has a toolbar and a main data display.

Button	Description
	Display the selected item in binary.
	Display the selected item in octal.
	Display the selected item in decimal.
	Display the selected item in hexadecimal.
	Display the selected item as a signed decimal.
	Display the selected item as a character or Unicode character.
	Set the range displayed in the active Memory window to span the memory allocated to the selected item.
	Sort variables alphabetically by name.
	Sort variables numerically by address or register number (default).

Using the Locals window

The **Locals** window shows the local variables of the active function when the debugger is stopped. The contents of the **Locals** window changes when you use the **Debug Location** toolbar items or select a new frame in the **Call Stack** window. When the program stops at a breakpoint, or is stepped, the **Locals** window updates to show the active stack frame. Items that have changed since they were previously displayed are highlighted in red.

To activate the Locals window:

- Choose **Debug > Locals** or press **Ctrl+Alt+L**.

When you select a variable in the main part of the display, the display-format button highlighted on the **Locals** window toolbar changes to show the selected item's display format.

To change the display format of a local variable:

- Right-click the item to change.
- From the shortcut menu, choose the desired display format.

—or—

- Click the item to change.
- On the **Locals** window toolbar, select the desired display format.

To modify the value of a local variable:

- Click the value of the local variable to modify.
- Enter the new value for the local variable. Prefix hexadecimal numbers with **0x**, binary numbers with **0b**, and octal numbers with **0**.

—or—

- Right-click the value of the local variable to modify.
- From the shortcut menu, select one of the commands to modify the local variable's value.

Globals window

The **Globals** window displays a list of all variables that are global to the program. The operations available on the entries in this window are the same as the **Watch** window, except you cannot add or delete variables from the **Globals** window.

Globals window user interface

The **Globals** window consists of a toolbar and main data display.

Globals toolbar

Button	Description
	Display the selected item in binary.
	Display the selected item in octal.
	Display the selected item in decimal.
	Display the selected item in hexadecimal.
	Display the selected item as a signed decimal.
	Display the selected item as a character or Unicode character.
	Set the range displayed in the active Memory window to span the memory allocated to the selected item.
	Sort variables alphabetically by name.
	Sort variables numerically by address or register number (default).

Using the Globals window

The **Globals** window shows the global variables of the application when the debugger is stopped. When the program stops at a breakpoint, or is stepped, the **Globals** window updates to show the active stack frame and new variable values. Items that have changed since they were previously displayed are highlighted in red.

To activate the Globals window:

- Choose **Debug > Other Windows > Globals** or press **Ctrl+Alt+G**.

Changing the display format

When you select a variable in the main part of the display, the display-format button highlighted on the **Globals** window toolbar changes to show the item's display format.

To change the display format of a global variable:

- Right-click the item to change.
- From the shortcut menu, choose the desired display format.

—or—

- Click the item to change.
- On the **Globals** window toolbar, select the desired display format.

To modify the value of a global variable:

- Click the value of the global variable to modify.
- Enter the new value for the global variable. Prefix hexadecimal numbers with **0x**, binary numbers with **0b**, and octal numbers with **0**.

Watch window

The **Watch** window provides a means to evaluate expressions and to display the results of those expressions. Typically, expressions are just the name of a variable to be displayed, but they can be considerably more complex; see [Debug expressions](#). Note: expressions are always evaluated when your program stops, so the expression you are watching is the one that is in scope of the stopped program position.

The **Watch** window is divided into a toolbar and the main data display.

Button	Description
	Display the selected item in binary.
	Display the selected item in octal.
	Display the selected item in decimal.
	Display the selected item in hexadecimal.
	Display the selected item as a signed decimal.
	Display the selected item as a character or Unicode character.
	Set the range displayed in the active Memory window to span the memory allocated to the selected item.
	Sort the watch items alphabetically by name.
	Sort the watch items numerically by address or register number (default).
	Remove the selected watch item.
	Remove all the watches.

Right-clicking a watch item shows a shortcut menu with commands that are not available from the toolbar.

Button	Description
	View pointer or array as a null-terminated string.
	View pointer or array as an array.
	View pointer value.
	Set watch value to zero.
	Set watch value to one.

	Increment watched variable by one.
	Decrement watched variable by one.
	Negated watched variable.
	Invert watched variable.
	View the properties of the watch value.

You can view details of the watched item using the **Properties** window.

Filename

The filename context of the watch item.

Line number

The line number context of the watch item.

(Name)

The name of the watch item.

Address

The address or register of the watch item.

Expression

The debug expression of the watch item.

Previous Value

The previous watch value.

Size In Bytes

The size of the watch item in bytes.

Type

The type of the watch item.

Value

The value of the watch item.

Using the Watch window

Each expression appears as a row in the display. Each row contains the expression and its value. If the value of an expression is structured (for example, an array), you can open the structure to see its contents.

The display updates each time the debugger locates to source code. So it will update each time your program stops on a breakpoint, or single steps, and whenever you traverse the call stack. Items that have changed since they were previously displayed are highlighted in red.

To activate the Watch window:

- Choose **Debug > Other Windows > Watch > Watch 1** or press **Ctrl+T, W, 1**.

You can show other **Watch** windows similarly.

You can add a new expression to be watched by clicking and typing into the last entry in the **Watch** window.

You can change an expression by clicking its entry and editing its contents.

When you select a variable in the main part of the display, the display format button highlighted on the **Watch** window toolbar changes to show the item's display format.

To change the display format of an expression:

- Right-click the item to change.
- From the shortcut menu, choose the desired display format.

—or—

- Click the item to change.
- On the **Watch** window toolbar, select the desired display format.

The selected display format will then be used for all subsequent displays and will be preserved after the debug session stops.

For C programs, the interpretation of pointer types can be changed by right-clicking and selecting from the shortcut menu. A pointer can be interpreted as:

- a null-terminated ASCII string
- an array
- an integer
- dereferenced

To modify the value of an expression:

- Click the value of the local variable to modify.
- Enter the new value of the local variable. Prefix hexadecimal numbers with **0x**, binary numbers with **0b**, and octal numbers with **0**.

—or—

- Right-click the value of the local variable to modify.
- From the shortcut menu, choose one of the commands to modify the variable's value.

Register window

The **Register** windows show the values of both CPU registers and the processor's special function or peripheral registers. Because microcontrollers are becoming very highly integrated, it's not unusual for them to have hundreds of special function registers or peripheral registers, so CrossStudio provides four register windows. You can configure each register window to display one or more register groups for the processor being debugged.

A **Register** window has a toolbar and a main data display.

Button	Description
	Display the CPU, special function register, and peripheral register groups.
	Display the CPU registers.
	Hide the CPU registers.
	Force-read a register, ignoring the access property of the register.
	Update the selected register group.
	Set the active memory window to the address and size of the selected register group.

Using the registers window

Both CPU registers and special function registers are shown in the main part of the **Registers** window. When the program stops at a breakpoint, or is stepped, the **Registers** windows update to show the current values of the registers. Items that have changed since they were previously displayed are highlighted in red.

To activate the first register window:

- Choose **Debug > Other Windows > Registers > Registers 1** or press **Ctrl+T, R, 1**.

Other register windows can be similarly activated.

Displaying CPU registers

The values of the CPU registers displayed in the **Registers** window depend up upon the selected context. The selected context can be:

- The register state the CPU stopped in.
- The register state when a function call occurred using the Call Stack window.
- The register state of the currently selected thread using the the **Threads** window.

- The register state you supplied with the **Debug > Locate** operation.

To display a group of CPU registers:

- On the **Registers** window toolbar, click the **Groups** button.
- From the pop-up menu, select the register groups to display and deselect the ones to hide.

You can deselect all CPU register groups to allow more space in the display for special function registers or peripheral registers. So, for instance, you can have one register window showing the CPU registers and other register windows showing different peripheral registers.

Displaying special function or peripheral registers

The **Registers** window shows the set of register groups defined in the memory-map file the application was built with. If there is no memory-map file associated with a project, the **Registers** window will show only the CPU registers.

To display a special function or peripheral register:

- On the **Registers** toolbar, click the **Groups** button.
- From the pop-up menu, select the register groups to display and deselect the ones to hide.

Changing display format

When you select a register in the main part of the display, the display-format button highlighted on the **Registers** window toolbar changes to show the item's display format.

To change the display format of a register:

- Right-click the item to change.
- From the shortcut menu, choose the desired display format.

—or—

- Click the item to change.
- On the **Registers** window toolbar, select the desired display format.

Modifying register values

To modify the value of a register:

- Click the value of the register to modify.

- Enter the new value for the register. Prefix hexadecimal numbers with **0x**, binary numbers with **0b**, and octal numbers with **0**.

—or—

- Right-click the value of the register to modify.
- From the shortcut menu, choose one of the commands to modify the register value.

Modifying the saved register value of a function or thread may not be supported.

Memory window

The **Memory** window shows the contents of the connected target's memory areas and allows the memory to be edited. CrossStudio provides four memory windows, you can configure each memory window to display different memory ranges.

The **Memory** window has a toolbar and a data display/edit area

Field/Button	Description
<i>Address</i>	Address to display. This can be a numeric value or a debug expression.
<i>Size</i>	Number of bytes to display. This can be a number or a debug expression. If unspecified, the number of bytes required to fill the window will be automatically calculated.
<i>Columns</i>	Number of columns to display. If unspecified, the number of columns required to fill the window will be automatically calculated.
 ₂	Select binary display.
 ₈	Select octal display.
 ₁₀	Select unsigned decimal display.
 ₁₀ ⁺	Select signed decimal display.
 ₁₆	Select hexadecimal display (<i>default</i>).
 ₈	Select byte display (<i>default</i>).
 ₁₆	Select 2-byte display.
 ₃₂	Select 4-byte display.
	Display both data and text (<i>default</i>).
	Display data only.
	Display text only.
	Display an incrementing address range that starts from the selected address (<i>default</i>).
	Display a decrementing address range that starts from the selected address.

	Display an incrementing address range that ends at the selected address.
	Display a decrementing address range that ends at the selected address.
	Evaluate the address and size expressions, and update the Memory window.

Using the memory window

The memory window does not show the complete address space of the target, instead you must enter both the address and the number of bytes to display. You can specify the address and size using numeric values or [debug expressions](#) which enable you to position the memory display at the address of a variable or at the value of a register. You can also specify whether you want the expressions to be evaluated each time the memory window is updated, or you can re-evaluate them yourself with the press of a button. Memory windows update each time your program stops on a breakpoint, after a single step and whenever you traverse the call stack. If any values that were previously displayed have changed, they are highlighted in red.

To activate the first Memory window:

- Choose **Debug > Other Windows > Memory > Memory 1** or press **Ctrl+T, M, 1**.

Other register windows can be similarly activated.

Using the mouse

You can move the memory window's edit cursor by clicking on a data or text entry.

The vertical scroll bar can be used to modify the address being viewed by clicking the up and down buttons, the page up and down areas or using the vertical scroll wheel when the scroll bar is at it's furthest extent.

Using the keyboard

Keystroke	Description
Up	Move the cursor up one line, or if the cursor is on the first line, move the address up one line.
Down	Move the cursor down one line, or if the cursor is on the last line, move the address down one line.
Left	Move the cursor left one character.
Right	Move the cursor right one character.
Home	Move the cursor to the first entry.
End	Move the cursor to the last entry.
PageUp	Move the cursor up one page, or if the cursor is on first page, move the address up one page.

PageDown	Move the cursor down one page, or if the cursor is on the last page, move the address down one page.
Ctrl+E	Toggle the cursor between data and text editing.

Editing memory

To edit memory, simply move the cursor to the data or text entry you want to modify and start typing. The memory entry will be written and read back as you type.

Shortcut menu commands

The shortcut menu contains the following commands:

Action	Description
Access Memory By Display Width	Access memory in terms of the display width.
Address Order	Specify whether the address range shown uses Address as the start or end address and whether addresses should increment or decrement.
Auto Evaluate	Re-evaluate Address and Size each time the Memory window is updated.
Auto Refresh	Specify how frequently the memory window should automatically refresh.
Export To Binary Editor	Create a binary editor with the current Memory window contents.
Save As	Save the current Memory window contents to a file. Supported file formats are Binary File , Motorola S-Record File , Intel Hex File , TI Hex File , and Hex File .
Load From	Load the current Memory window from a file. Supported file formats are Binary File , Motorola S-Record File , Intel Hex File , TI Hex File , and Hex File .

Display formats

You can set the **Memory** window to display 8-bit, 16-bit, and 32-bit values that are formatted as hexadecimal, decimal, unsigned decimal, octal, or binary. You can also specify how many columns to display.

Saving memory contents

You can save the displayed contents of the memory window to a file in various formats. Alternatively, you can export the contents to a binary editor to work on them.

You can save the displayed memory values as a binary file, Motorola S-record file, Intel hex file, or a Texas Instruments TXT file.

To save the current state of memory to a file:

- Select the start address and number of bytes to save by editing the **Start Address** and **Size** fields in the **Memory** window toolbar.
- Right-click the main memory display.
- From the shortcut menu, select **Save As**, then choose the format from the submenu.

To export the current state of memory to a binary editor:

- Select the start address and number of bytes to save by editing the **Start Address** and **Size** fields in the **Memory** window toolbar.
- Right-click the main memory display.
- Choose **Export to Binary Editor** from the shortcut menu.

Note that subsequent modifications in the binary editor will not modify memory in the target.

Breakpoints window

The **Breakpoints** window manages the list of currently set breakpoints on the solution. Using the **Breakpoints** window, you can:

- Enable, disable, and delete existing breakpoints.
- Add new breakpoints.
- Show the status of existing breakpoints.

Breakpoints are stored in the session file, so they will be remembered each time you work on a particular project. When running in the debugger, you can set breakpoints on assembly code addresses. These low-level breakpoints appear in the **Breakpoints** window for the duration of the debug run but are not saved when you stop debugging.

When a breakpoint is reached, the matching breakpoint is highlighted in the **Breakpoints** window.

Breakpoints window layout

The **Breakpoints** window has a toolbar and a main breakpoint display.

Button	Description
	Create a new breakpoint using the New Breakpoint dialog.
	Toggle the selected breakpoint between enabled and disabled states.
	Remove the selected breakpoint.
	Move the insertion point to the statement where the selected breakpoint is set.
	Delete all breakpoints.
	Disable all breakpoints.
	Enable all breakpoints.
	Create a new breakpoint group and makes it active.

The main part of the **Breakpoints** window shows what breakpoints are set and the state they are in. You can organize breakpoints into folders, called *breakpoint groups*.

CrossStudio displays these icons to the left of each breakpoint:

Icon	Description
------	-------------

	Enabled breakpoint An enabled breakpoint will stop your program running when the breakpoint condition is met.
	Disabled breakpoint A disabled breakpoint will not stop the program when execution passes through it.
	Invalid breakpoint An invalid breakpoint is one where the breakpoint cannot be set; for example, no executable code is associated with the source code line where the breakpoint is set or the processor does not have enough hardware breakpoints.

Showing the Breakpoints window

To activate the Breakpoints window:

- Choose **Breakpoints > Breakpoints** or press **Ctrl+Alt+B**.

Managing single breakpoints

You can manage breakpoints in the **Breakpoint** window.

To delete a breakpoint:

- In the **Breakpoints** window, click the breakpoint to delete.
- From the **Breakpoints** window toolbar, click the **Delete Breakpoint** button.

To edit the properties of a breakpoint:

- In the **Breakpoints** window, right-click the breakpoint to edit.
- Choose **Edit Breakpoint** from the shortcut menu.
- Edit the breakpoint in the **New Breakpoint** dialog.
- To toggle the enabled state of a breakpoint:
 - In the **Breakpoints** window, right-click the breakpoint to enable or disable.
 - Choose **Enable/Disable Breakpoint** from the shortcut menu.

—or—

- In the **Breakpoints** window, click the breakpoint to enable or disable.
- Press **Ctrl+F9**.

Breakpoint groups

Breakpoints are divided into *breakpoint groups*. You can use breakpoint groups to specify sets of breakpoints that are applicable to a particular project in the solution or for a particular debug scenario. Initially, there is a single breakpoint group, named *Default*, to which all new breakpoints are added.

To create a new breakpoint group:

- From the **Breakpoints** window toolbar, click the **New Breakpoint Group** button.

—or—

- From the **Debug** menu, choose **Breakpoints** then **New Breakpoint Group**.

—or—

- Right-click anywhere in the **Breakpoints** window.
- Choose **New Breakpoint Group** from the shortcut menu.

In the **New Breakpoint Group** dialog, enter the name of the breakpoint group.

When you create a breakpoint, it is added to the active breakpoint group.

To make a group the active group:

- In the **Breakpoints** window, right-click the breakpoint group to make active.
- Choose **Set as Active Group** from the shortcut menu.

To delete a breakpoint group:

- In the **Breakpoints** window, right-click the breakpoint group to delete.
- Choose **Delete Breakpoint Group** from the shortcut menu.

You can enable all breakpoints within a group at once.

To enable all breakpoints in a group:

- In the **Breakpoints** window, right-click the breakpoint group to enable.
- Choose **Enable Breakpoint Group** from the shortcut menu.

You can disable all breakpoints within a group at once.

To disable all breakpoints in a group:

- In the **Breakpoints** window, right-click the breakpoint group to disable.
- Choose **Disable Breakpoint Group** from the shortcut menu.

Managing all breakpoints

You can delete, enable, or disable all breakpoints at once.

To delete all breakpoints:

- Choose **Breakpoints > Clear All Breakpoints** or press **Ctrl+Shift+F9**.

—or—

- On the **Breakpoints** window toolbar, click the **Delete All Breakpoints** button.

To enable all breakpoints:

- Choose **Breakpoints > Enable All Breakpoints** or press **Ctrl+B, N**.

—or—

- On the **Breakpoints** window toolbar, click the **Enable All Breakpoints** button.

To disable all breakpoints:

- Choose **Breakpoints > Disable All Breakpoints** or press **Ctrl+B, X**.

—or—

- On the **Breakpoints** window toolbar, click the **Disable All Breakpoints** button.

Call Stack window

The **Call Stack** window displays the list of function calls (stack frames) that were active when program execution halted. When execution halts, CrossStudio populates the call-stack window from the active (currently executing) task. For simple, single-threaded applications not using the CrossWorks tasking library, there is only a single task; but for multi-tasking programs that use the CrossWorks Tasking Library, there may be any number of tasks. CrossStudio updates the **Call Stack** window when you change the active task in the **Threads** window.

The **Call Stack** window has a toolbar and a main call-stack display.

Button	Description
	Move the insertion point to where the call was made to the selected frame.
	Set the debugger context to the selected stack frame.
	Move the debugger context down one stack to the called function.
	Move the debugger context up one stack to the calling function.
	Select the fields to display for each entry in the call stack.
	Set the debugger context to the most recent stack frame and move the insertion point to the currently executing statement.

The main part of the **Call Stack** window displays each unfinished function call (active stack frame) at the point when program execution halted. The most recent stack frame is displayed at the bottom of the list and the oldest is displayed at the top of the list.

CrossStudio displays these icons to the left of each function name:

Icon	Description
	Indicates the stack frame of the current task.
	Indicates the stack frame selected for the debugger context.
	Indicates that a breakpoint is active and when the function returns to its caller.

These icons can be overlaid to show, for instance, the debugger context and a breakpoint on the same stack frame.

Showing the call-stack window

To activate the Call Stack window:

- Choose **Debug > Call Stack** or press **Ctrl+Alt+S**.

Configuring the call-stack window

Each entry in the **Call Stack** window displays the function name and, additionally, parameter names, types, and values. You can configure the **Call Stack** window to show varying amounts of information for each stack frame. By default, CrossStudio displays all information.

To show or hide a field:

1. On the **Call Stack** toolbar, click the **Options** button on the far right.
2. Select the fields to show, and deselect the ones that should be hidden.

Changing the debugger context

You can select the stack frame for the debugger context from the **Call Stack** window.

To move the debugger context to a specific stack frame:

- In the **Call Stack** window, double-click the stack frame to move to.
—or—
 - In the **Call Stack** window, select the stack frame to move to.
 - On the **Call Stack** window's toolbar, click the **Switch To Frame** button.
—or—
 - In the **Call Stack** window, right-click the stack frame to move to.
 - Choose **Switch To Frame** from the shortcut menu.

The debugger moves the insertion point to the statement where the call was made. If there is no debug information for the statement at the call location, CrossStudio opens a disassembly window at the instruction.

To move the debugger context up one stack frame:

- On the **Call Stack** window's toolbar, click the **Up One Stack Frame** button.
—or—

- On the **Debug Location** toolbar, click the **Up One Stack Frame** button.

—or—

- Press **Alt+-**.

The debugger moves the insertion point to the statement where the call was made. If there is no debug information for the statement at the call location, CrossStudio opens a disassembly window at the instruction.

To move the debugger context down one stack frame:

- On the **Call Stack** window's toolbar, click the **Down One Stack Frame** button.

—or—

- On the **Debug Location** toolbar, click the **Down One Stack Frame** button.

—or—

- Press **Alt++**.

The debugger moves the insertion point to the statement where the call was made. If there is no debug information for the statement at the call location, CrossStudio opens a disassembly window at the instruction.

Setting a breakpoint on a return to a function

To set a breakpoint on return to a function:

- In the **Call Stack** window, click the stack frame on the function to stop at on return.
- On the **Build** toolbar, click the **Toggle Breakpoint** button.

—or—

- In the **Call Stack** window, click the stack frame on the function to stop at on return.
- Press **F9**.

—or—

- In the **Call Stack** window, right-click the function to stop at on return.
- Choose **Toggle Breakpoint** from the shortcut menu.

Threads window

The **Threads** window displays the set of executing contexts on the target processor structured as a set of queues.

To activate the Threads window:

- Choose **Debug > Threads** or press **Ctrl+Alt+H**.

The window is populated using the threads script, which is a JavaScript program store in a file whose file-type property is "Threads Script" (or is called `threads.js`) and is in the project that is being debugged.

When debugging starts, the threads script is loaded and the **function init()** is called to determine which columns are displayed in the **Threads** window.

When the application stops on a breakpoint, the function **update()** is called to create entries in the **Threads** window corresponding to the columns that have been created together with the saved execution context (register state) of the thread. By double-clicking one of the entries, the debugger displays its saved execution context—to put the debugger back into the default execution context, use **Show Next Statement**.

Writing the threads script

The threads script controls the **Threads** window with the **Threads** object.

The methods **Threads.setColumns** and **Threads.setSortByNumber** can be called from the **function init()**.

```
function init()
{
    Threads.setColumns("Name", "Priority", "State", "Time");
    Threads.setSortByNumber("Time");
}
```

The above example creates the named columns **Name**, **Priority**, **State**, and **Time** in the **Threads** window, with the **Time** column sorted numerically rather than alphabetically.

If you don't supply the **function init()** in the threads script, the **Threads** window will create the default columns **Name**, **Priority**, and **State**.

The methods **Threads.clear()**, **Threads.newqueue()**, and **Threads.add()** can be called from the **function update()**.

The **Threads.clear()** method clears the **Threads** window.

The **Threads.newqueue()** function takes a string argument and creates a new, top-level entry in the **Threads** window. Subsequent entries added to this window will go under this entry. If you don't call this, new entries will all be at the top level of the **Threads** window.

The **Threads.add()** function takes a variable number of string arguments, which should correspond to the number of columns displayed by the **Threads** window. The last argument to the **Threads.add()** function should be an array (possibly empty) containing the registers of the thread or, alternatively, a handle that can be supplied a call to the threads script **function getregs(handle)**, which will return an array when the thread is selected in the **Threads** window. The array containing the registers should have elements in the same order in which they are displayed in the CPU **Registers** display—typically this will be in register-number order, e.g., **r0, r1**, and so on.

```
function update()
{
    Threads.clear();
    Threads.newqueue("My Tasks");
    Threads.add("Task1", "0", "Executing", "1000", [0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16]);
    Threads.add("Task2", "1", "Waiting", "2000", [0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16]);
}
```

The above example will create a fixed output on the **Threads** window and is here to demonstrate how to call the methods.

To get real thread state, you need to access the debugger from the threads script. To do this, you can use the JavaScript method **Debug.evaluate("expression")**, which will evaluate the string argument as a debug expression and return the result. The returned result will be an object if you evaluate an expression that denotes a structure or an array. If the expression denotes a structure, each field can be accessed by using its field name.

So, if you have structs in the application as follows...

```
struct task {
    char *name;
    unsigned char priority;
    char *state;
    unsigned time;
    struct task *next;
    unsigned registers[17];
    unsigned thread_local_storage[4];
};

struct task task2 =
{
    "Task2",
    1,
    "Waiting",
    2000,
    0,
    { 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16 },
    { 0,1,2,3 }
};

struct task task1 =
{
    "Task1",
    0,
    "Executing",
    1000,
    &task2,
    { 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16 },
};
```

```
{ 0,1,2,3 }
};
```

...you can **update()** the **Threads** window using the following:

```
task1 = Debug.evaluate("task1");
Threads.add(task1.name, task1.priority, task1.state, task1.time, task1.registers);
```

You can use pointers and C-style cast to enable linked-list traversal.

```
var next = Debug.evaluate("&task1");
while (next)
{
    var xt = Debug.evaluate("*(struct task*)"+next);
    Threads.add(xt.name, xt.priority, xt.state, xt.time, xt.registers);
    next = xt.next;
}
```

Note that, if the threads script goes into an endless loop, the debugger—and consequently CrossStudio—will become unresponsive and you will need to kill CrossStudio using a task manager. Therefore, the above loop is better coded as follows:

```
var next = Debug.evaluate("&task1");
var count = 0;
while (next && count < 10)
{
    var xt = Debug.evaluate("*(struct task*)"+next);
    Threads.add(xt.name, xt.priority, xt.state, xt.time, xt.registers);
    next = xt.next;
    count++;
}
```

You can speed up the **Threads** window update by not supplying the registers of the thread to the **Threads.add()** function. To do this, you should supply a handle/pointer to the thread as the last argument to the **Threads.add()** function. For example:

```
var next = Debug.evaluate("&task1");
var count = 0;
while (next && count < 10)
{
    var xt = Debug.evaluate("*(struct task*)"+next);
    Threads.add(xt.name, xt.priority, xt.state, xt.time, next);
    next=xt.next;
    count++;
}
```

When the thread is selected, the **Threads** window will call **getregs(x)** in the threads script. That function should return the array of registers, for example:

```
function getregs(x)
{
    return Debug.evaluate("((struct task*)"+x+")->registers");
}
```

If you use thread local storage, implementing the **gettls(x)** function enables you to return an expression for the debugger to evaluate when the base address of the thread local storage is accessed, for example:

```
function gettls(x)
{
    return "((struct task*)"+x+"->thread_local_storage";
```

The debugger may require the name of a thread which you can provide by implementing the **getname(x)** function, for example:

```
function getname(x)
{
    return Debug.evaluate("((struct task*)"+x+"->name");
```

Execution Profile window

The **Execution Profile** window shows a list of source locations and the number of times those source locations have been executed. This window is only available for targets that support the collection of jump trace information.

To activate the Execution Profile window:

- Choose **Debug > Other Windows > Execution Profile** or press **Ctrl+T, P.**

The count value displayed is the number of times the first instruction of the source code location has been executed. The source locations displayed are target dependent: they could represent each statement of the program or each jump target of the program. If however the debugger is in intermixed or disassembly mode then the count values will be displayed on a per instruction basis.

The execution counts window is updated each time your program stops and the window is visible so if you have this window displayed then single stepping may be slower than usual.

Execution Trace window

The trace window displays historical information on the instructions executed by the target.

To activate the Trace window:

- Choose **Debug > Other Windows > Execution Trace** or press **Ctrl+T, T**.

The type and number of the trace entries depends upon the target that is connected when gathering trace information. Some targets may trace all instructions, others may trace jump instructions, and some may trace modifications to variables. You'll find the trace capabilities of your target on the shortcut menu.

Each entry in the trace window has a unique number, and the lower the number the earlier the trace. You can click on the header to show earliest to latest or the latest to earliest trace entries. If a trace entry can have source code located to it then double-clicking the trace entry will show the appropriate source display.

Some targets may provide timing information which will be displayed in the ticks column.

The trace window is updated each time the debugger stops when it is visible so single stepping is likely to be slower if you have this window displayed.

Debug file search editor

When a program is built with debugging enabled, the debugging information contains the paths and filenames of all the source files for the program in order to allow the debugger to find them. If a program or library linked into the program is on a different machine than the one on which it was compiled, or if the source files were moved after the program was compiled, the debugger will not be able to find the source files.

In this situation, the simplest way to help CrossStudio find the source files is to add the directory containing the source files to one of its source-file search paths. Alternatively, if CrossStudio cannot find a source file, it will prompt you for its location and will record its new location in the source-file map.

Debug source-file search paths

Debug's source-file search paths can be used to help the debugger locate source files that are no longer located where they were at compile time. When a source file cannot be found, the search-path directories will be checked, in turn, to see if they contain the source file. CrossStudio maintains two debug source-file search paths:

- *Project-session search path:* This path is for the current project session and does not apply to all projects.
- *The global search path:* This system-wide path applies to all projects.

The project-session search path is checked before the global search path.

To edit the debug search paths:

- Choose **Debug > Options > Search Paths**.

Debug source file map

If a source file cannot be found while debugging and the debugger has to prompt the user for its location, the results are stored in the debug source file map. The debug source file map simply correlates, or *maps*, the original pathnames to the new locations. When a file cannot be found at its original location or in the debug search paths, the debug source file map is checked to see if a new location has been recorded for the file or if the user has specified that the file does not exist. Each project session maintains its own source file map, the map is not shared by all projects.

To view the debug source file map:

- Choose **Debug > Options > Search Paths**.

To remove individual entries from the debug source file map:

- Choose **Debug > Options > Search Paths**.

- Right-click the mapping to delete.
- Choose **Delete Mapping** from the shortcut menu.

To remove all entries from the debug source file map:

- Choose **Debug > Options > Search Paths**.
- Right-click any mapping.
- Choose **Delete All Mappings** from the shortcut menu.

Breakpoint expressions

The debugger can set breakpoints by evaluating simple C-like expressions. Note that the exact capabilities offered by the hardware to assist in data breakpointing will vary from target to target; please refer to the particular target interface you are using and the capabilities of your target silicon for exact details. The simplest expression supported is a symbol name. If the symbol name is a function, a breakpoint occurs when the first instruction of the symbol is about to be executed. If the symbol name is a variable, a breakpoint occurs when the symbol has been accessed; this is termed a *data breakpoint*. For example, the expression `x` will breakpoint when `x` is accessed. You can use a debug expression (see [Debug expressions](#)) as a breakpoint expression. For example, `x[4]` will breakpoint when element 4 of array `x` is accessed, and `@sp` will breakpoint when the `sp` register is accessed.

Data breakpoints can be specified, using the `==` operator, to occur when a symbol is accessed with a specific value. The expression `x == 4` will breakpoint when `x` is accessed and its value is 4. The operators `<`, `>=`, `>`, `<=`, and `!=` can be used similarly. For example, `@sp <= 0x1000` will breakpoint when register `sp` is accessed and its value is less than or equal to `0x1000`.

You can use the operator `'&'` to mask the value you wish to break on. For example, `(x & 1) == 1` will breakpoint when `x` is accessed and has an odd value.

You can use the operator `'&&'` to combine comparisons. For example...

```
(x >= 2) && (x <= 14)
```

...will breakpoint when `x` is accessed and its value is between 2 and 14.

You can specify an arbitrary memory range using an array cast expression. For example, `(char[256])(0x1000)` will breakpoint when the memory region `0x1000–0x10FF` is accessed.

You can specify an inverse memory range using the `!` operator. For example `!(char[256])(0x1000)` will breakpoint when memory outside the range `0x1000–0x10FF` is accessed.

Debug expressions

The debugger can evaluate simple expressions that can be displayed in the **Watch** window or as a tool-tip in the code editor.

The simplest expression is an identifier the debugger tries to interpret in the following order:

- an identifier that exists in the scope of the current context.
- the name of a global identifier in the program of the current context.

Numbers can be used in expressions. Hexadecimal numbers must be prefixed with 0x.

Registers can be referenced by prefixing the register name with @.

The standard C and C++ operators !, ~, *, /, %, +, -, >>, <<, <, <=, >, >=, ==, |, &, ^, &&, and || are supported on numeric types.

The standard assignment operators =, +=, -=, *=, /=, %=, >>=, >>=, <<=, &=, |=, ^= are supported on numeric types.

The array subscript operator '[' is supported on array and pointer types.

The structure access operator '.' is supported on structured types (this also works on pointers to structures), and -> works similarly.

The dereference operator (prefix '*') is supported on pointers, the address-of (prefix '&') and **sizeof** operators are supported.

The **addressof** (*filename*, *linenumber*) operator will return the address of the specified source code line number.

Function calling with parameters and return results.

Casting to basic pointer types is supported. For example, (unsigned char *)0x300 can be used to display the memory at a given location.

Casting to basic array types is supported. For example, (unsigned char[256])0x100 can be used to reference a memory region.

Operators have the precedence and associativity one expects of a C-like programming language.

Output window

The **Output** window contains logs and transcripts from various systems within CrossStudio. Most notably, it contains the *Transcript* and *Source Navigator Log*.

Transcript

The Transcript contains the results of the last build or target operation. It is cleared on each build. Errors detected by CrossStudio are shown in red and warnings are shown in yellow. Double-clicking an error or warning in the build log will open the offending file at the error position. The commands used for the build can be echoed to the build log by setting the **Echo Build Command Lines** environment option. The transcript also shows a trace of the high-level loading and debug operations carried out on the target. For downloading, uploading, and verification operations, it displays the time it took to carry out each operation. The log is cleared for each new download or debug session.

Navigator Log

The Source Navigator Log displays a list of files the Source Navigator has parsed and the time it took to parse each file.

To activate the Output window:

- Choose **View > Output** or press **Ctrl+Alt+O**.

To show a specific log:

- On the **Output** window toolbar, click the log combo box.
- From the list, click the log to display.

—or—

- Choose **View > Logs** and select the log to display.

Properties window

The **Properties** window displays properties of the current CrossStudio object. Using the **Properties** window, you can set the build properties of your project, modify the editor defaults, and change target settings.

To activate the Properties window:

- Choose **View > Properties Window** or press **Ctrl+Alt+Enter**.

The **Properties** window is organized as a set of key-value pairs. As you select one of the keys, help text explains the purpose of the property. Because properties are numerous and can be specific to a particular product build, consider this help to be the definitive help on the property.

You can divide the properties display into categories or, alternatively, display it as a flat list that is sorted alphabetically.

A combo-box enables you to change the properties and explains which properties you are looking at.

Some properties have actions associated with them—you can find these by right-clicking the property key. Most properties that represent filenames can be opened this way.

When the **Properties** window is displaying project properties, you'll find some properties displayed in bold. This means the property value hasn't been inherited. If you wish to inherit rather than define such a property, right-click the property and select **Inherit** from the shortcut menu.

Targets window

The **Targets** window (and its associated menu) displays the set of target interfaces you can connect to in order to download and debug your programs. Using the **Targets** window in conjunction with the **Properties** window enables you to define new targets based on the specific target types supported by the particular CrossStudio release.

To activate the Targets window:

- Choose **View > Targets** or press **Ctrl+Alt+T**.

You can connect, disconnect, and reconnect to a target system. You can also use the **Targets** window to reset and load programs.

Targets window layout

Button	Description
	Connect the target interface selected in the Targets window.
	Disconnect the connected target interface.
	Reconnect the connected target interface.
	Reset the connected target interface.
	Display the properties of the selected target interface.

Managing connections to target devices

To connect a target:

- In the **Targets** window, double-click the target to connect.

—or—

- Choose **Target > Connect** and click the target to connect.

—or—

- In the **Targets** window, click the target to connect.
- On the **Targets** window toolbar, click the **Connect** button

—or—

- In the **Targets** window, right-click the target to connect.
- Choose **Connect**.

To disconnect a target:

- Choose **Target > Disconnect** or press **Ctrl+T, D.**
- or—
 - On the **Targets** window toolbar, click the **Disconnect** button.
- or—
 1. Right-click the connected target in the **Targets** window.
 2. Choose **Disconnect** from the shortcut menu.

Alternatively, connecting a different target will disconnect the current target connection.

You can disconnect and reconnect a target in a single operation using the reconnect feature. This may be useful if the target board has been power cycled, or reset manually, because it forces CrossStudio to resynchronize with the target.

To reconnect a target:

- Choose **Target > Reconnect** or press **Ctrl+T, E.**
- or—
 - On the **Targets** window toolbar, click the **Reconnect** button.
- or—
 1. In the **Targets** window, right-click the target to reconnect.
 2. Choose **Reconnect** from the shortcut menu.

Automatic target connection

You can configure CrossStudio to automatically connect to the last-used target interface when loading a solution.

To enable or disable automatic target connection:

1. Choose **View > Targets** or press **Ctrl+Alt+T.**
2. Click the disclosure arrow on the **Targets** window toolbar.
3. Select or deselect Unknown property Target/Auto Connect.

Resetting the target

Reset of the target is typically handled by the system when you start debugging. However, you can manually reset the target from the **Targets** window.

To reset the connected target:

- Choose **Project > Reset And Debug** or press **Ctrl+Alt+F5.**

—or—

- On the **Targets** window toolbar, click the **Reset** button.

Creating a new target interface

To create a new target interface:

1. From the **Targets** window shortcut menu, click **New Target Interface**. A menu will display the types of target interface that can be created.
2. Select the type of target interface to create.

Setting target interface properties

All target interfaces have a set of properties. Some properties are read-only and provide information about the target, but others are modifiable and allow the target interface to be configured. Target interface properties can be viewed and edited using CrossStudio's property system.

To view or edit target properties:

- Select a target.
- Select the **Properties** option from the target's shortcut menu.

The **Targets** window provides the facility to restore the target definitions to the default set. Restoring the default target definitions will undo any of the changes you have made to the targets and their properties, therefore it should be used with care.

To restore the default target definitions:

1. Select **Restore Default Targets** from the **Targets** window shortcut menu.
2. Click **Yes** when the system asks whether you want to restore the default targets.

Importing and exporting target definitions

You can import and export your target-interface definitions. This may be useful if you make a change to the default set of target definitions and want to share it with another user or use it on another machine.

To export the current set of target-interface definitions:

- Choose **Export Target Definitions To XML** from the **Targets** window shortcut menu.
- Specify the location and name of the file to which you want to save the target definitions and click **Save**.

To import an existing set of target-interface definitions:

- Select **Import Target Definitions From XML** from the **Targets** window shortcut menu.
- Select the file from which you want to load the target definitions and click **Open**.

Downloading programs

Program download is handled automatically by CrossStudio when you start debugging. However, you can download arbitrary programs to a target using the **Targets** window.

To download a program to the currently selected target:

- In the **Targets** window, right-click the selected target.
- Choose **Download File**.
- From the **Download File** menu, select the type of file to download.
- In the **Open File** dialog, select the executable file to download and click **Open** to download the file.

CrossStudio supports the following file formats when downloading a program:

- Binary
- Intel Hex
- Motorola S-record
- CrossWorks native object file
- Texas Instruments text file

Verifying downloaded programs

You can verify a target's contents against arbitrary programs on disk using the **Targets** window.

To verify a target's contents against a program:

1. In the **Targets** window, right-click the selected target.
2. Choose **Verify File**.
3. From the **Verify File** menu, select the type of file to verify.
4. In the **Open File** dialog, select the executable file to verify and click **Open** to verify the file.

CrossStudio supports the same file types for verification as for downloading.

Erasing target memory

Usually, erasing target memory is done when CrossStudio downloads a program, but you can erase a target's memory manually.

To erase all target memory:

1. In the **Targets** window, right-click the target to erase.
2. Choose **Erase All** from the shortcut menu.

To erase part of target memory:

1. In the **Targets** window, right-click the target to erase.
2. Choose **Erase Range** from the shortcut menu.

Terminal emulator window

The **Terminal Emulator** window contains a basic serial-terminal emulator that allows you to receive and transmit data over a serial interface.

To activate the Terminal Emulator window:

- Choose **Tools > Terminal Emulator > Terminal Emulator** or press **Ctrl+Alt+M**.

To use the terminal emulator:

- Set the required terminal emulator properties.
- Connect the terminal emulator to the communications port by clicking the button on the toolbar or by selecting **Connect** from the shortcut menu.

Once connected, any input in the **Terminal Emulator** window is sent to the communications port and any data received from the communications port is displayed on the terminal.

Connection may be refused if the communication port is in use by another application or if the port doesn't exist.

To disconnect the terminal emulator:

- Disconnect the communications port by clicking the **Disconnect** icon on the toolbar or by right-clicking to select **Disconnect** from the shortcut menu.

This will release the communications port for use in other applications.

Supported control codes

The terminal supports a limited set of control codes:

Control code	Description
<BS>	Backspace
<CR>	Carriage return
<LF>	Linefeed
<ESC>[{attr1};...;{attrn}m	Set display attributes. The attributes 2-Dim, 5-Blink, 7-Reverse, and 8-Hidden are not supported.

Script Console window

The **Script Console** window provides interactive access to the JavaScript interpreter and JavaScript classes that are built into CrossStudio. The interpreter is an implementation of the 3rd edition of the ECMAScript standard. The interpreter has an additional function property of the global object that enable files to be loaded into the interpreter.

The JavaScript method **load(*filepath*)** loads and executes the JavaScript contained in *filepath* returns a Boolean indicating success.

To activate the Script Console window:

- Choose **View > Script Console** or press **Ctrl+Alt+J**.

Debug Immediate window

The **Debug Immediate** window allows you to type in debug expressions and display the results. All results are displayed in the format specified by the **Default Display Mode** property found in the **Debugging** group in the **Environment Options** dialog.

To activate the Environment Options dialog:

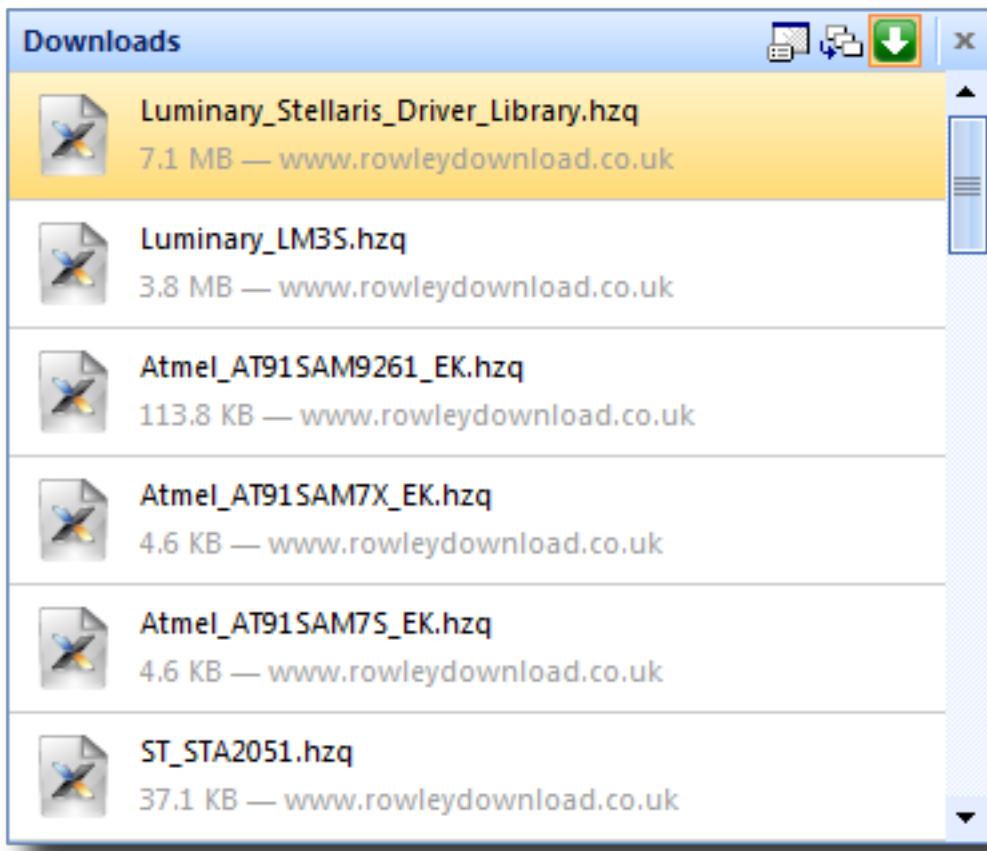
- Choose **Tools > Options** or press **Alt+,,**.

To activate the Debug Immediate window:

- Choose **Debug > Other Windows > Debug Immediate.**

Downloads window

The **Downloads Window** displays a historical list of files downloaded over the Internet by CrossStudio.

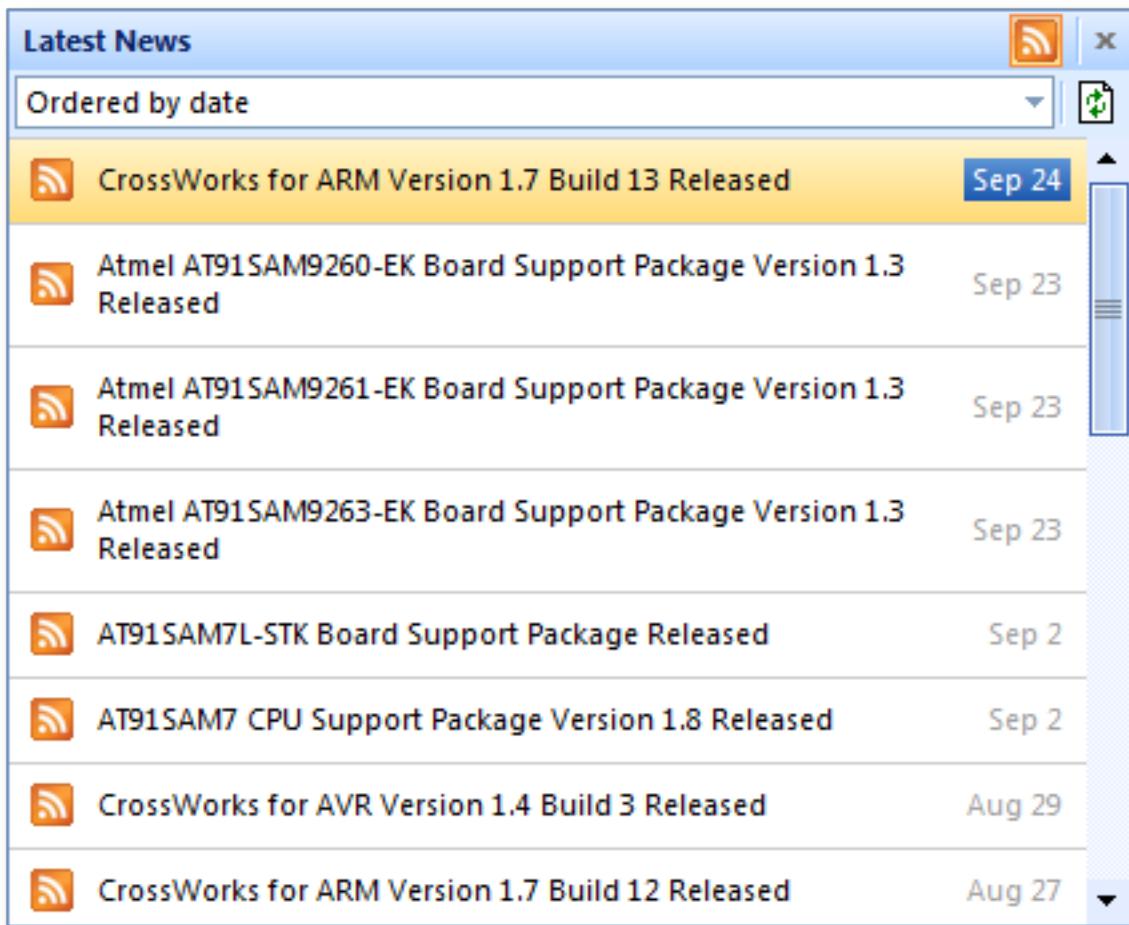


To activate the **Downloads window**:

- Choose **Tools > Downloads Window**.

Latest News window

The Latest News window displays a historical list of news articles from the Rowley Associates website.



To activate the Latest News window:

- Choose Help > Latest News.

Environment options dialog

The **Environment Options** dialog enables you to modify settings that apply to all uses of a CrossWorks installation.

Building Environment Options

Build

Property	Description
Automatically Build Before Debug Environment/Build/Build Before Debug – Boolean	Enables auto-building of a project before downloading if it is out of date.
Build Macros Environment/Macros/Global Macros – StringList	Build macros that are shared across all solutions and projects e.g. paths to library files.
Confirm Debugger Stop Environment/Build/Confirm Debugger Stop – Boolean	Present a warning when you start to build that requires the debugger to stop.
Display ETA Environment/Build/Display ETA – Boolean	Selects whether to attempt to compute and display the ETA on building.
Display Progress Bar Environment/Build/Display Progress Bar – Boolean	Selects whether to display progress bar on building.
Echo Build Command Lines Environment/Build>Show Command Lines – Boolean	Selects whether build command lines are written to the build log.
Echo Raw Error/Warning Output Environment/Build>Show Unparsed Error Output – Boolean	Selects whether the unprocessed error and warning output from tools is displayed in the build log.
Find Error After Building Environment/Build/Find Error After Build – Boolean	Moves the cursor to the first diagnostic after a build completes with errors.
Keep Going On Error Environment/Build/Keep Going On Error – Boolean	Build doesn't stop on error.
Save Project File Before Building Environment/Build/Save Project File On Build – Boolean	Selects whether to save the project file prior to build.
Show Build Information Environment/Build>Show Build Information – Boolean	Show build information.
Toolchain Root Directory Environment/Build/Tool Chain Root Directory – String	Specifies where to find the toolchain (compilers etc).

Build Acceleration

Property	Description
Disable Unity Build Environment/Build/Disable Unity Build - Boolean	Ignore Unity Build project properties and always build individual project components.
Parallel Building Threads Environment/Build/Building Threads - IntegerRange	The number of threads to launch when building.
Parallel Project Building Environment/Build/Parallel Project Building - Boolean	Selects whether to build projects or files within projects in parallel.

Window

Property	Description
Show Build Log On Build Environment/Show Transcript On Build - Boolean	Show the build log when a build starts.

Debugging Environment Options

Breakpoint

Property	Description
Clear Disassembly Breakpoints On Debug Stop Environment/Debugger/Clear_Disassembly_Breakpoint – Boolean	Clear Disassembly Breakpoints On Debug Stop

Display

Property	Description
Close Disassembly On Mode Switch Environment/Debugger/Close_Disassembly_On_Mode_Switch – Boolean	Close Disassembly On Mode Switch
Data Tips Display a Maximum Of Environment/Debugger/Maximum_Array_Elements_Displayed – IntegerRange	Selects the maximum number of array elements displayed in a datatip.
Default Display Mode Environment/Debugger/Default_Variable_Display_Mode – Enumeration	Selects the format that data values are shown in.
Display Floating Point Number In Environment/Debugger/Floating_Point_Format_Display – Custom	The printf format directive used to display floating point numbers.
Maximum Backtrace Calls Environment/Debugger/Maximum_Backtrace_Calls – IntegerRange	Selects the maximum number of calls when backtracing.
Prompt To Display If More Than Environment/Debugger/Array_Elements_Prompt_Size – IntegerRange	The array size to display with prompt.
Show Data Tips In Text Editor Environment/Debugger/Show_Data_Tips – Boolean	Show Data Tips In Text Editor
Show Labels In Disassembly Environment/Debugger/Disassembly_Show_Labels – Boolean	Show Labels In Disassembly
Show Source In Disassembly Environment/Debugger/Disassembly_Show_Source – Boolean	Show Source In Disassembly

Show char * As Null Terminated String Environment/Debugger/Display Char Ptr As String – Boolean	Display char * as null terminated string.
Source Path Environment/Debugger/Source Path – StringList	Global search path to find source files.

Extended Data Tips

Property	Description
ASCII Environment/Debugger/Extended Tooltip Display Mode/ASCII – Boolean	Selects ASCII extended datatips.
Binary Environment/Debugger/Extended Tooltip Display Mode/Binary – Boolean	Selects Binary extended datatips.
Decimal Environment/Debugger/Extended Tooltip Display Mode/Decimal – Boolean	Selects Decimal extended datatips.
Hexadecimal Environment/Debugger/Extended Tooltip Display Mode/Hexadecimal – Boolean	Selects Hexadecimal extended datatips.
Octal Environment/Debugger/Extended Tooltip Display Mode/Octal – Boolean	Selects Octal extended datatips.
Unsigned Decimal Environment/Debugger/Extended Tooltip Display Mode/Unsigned Decimal – Boolean	Selects Unsigned Decimal extended datatips.

Target

Property	Description
Step Using Hardware Step Environment/Debugger/Step Using Hardware Step – Boolean	Step using hardware single stepping rather than setting breakpoints

Window

Property	Description
Clear Debug Terminal On Run Environment/Clear Debug Terminal On Run – Boolean	Clear the debug terminal automatically when a program is run.

Hide Output Window On Successful Load Debugging/Hide Transcript On Successful Load – Boolean	Hide the Output window when a load completes without error.
Show Target Log On Load Debugging>Show Transcript On Load – Boolean	Show the target log when a load starts.

IDE Environment Options

Browser

Property	Description
Text Size Environment/Browser/Text Size – Enumeration	Sets the text size of the integrated HTML and help browser.
Underline Hyperlinks In Browser Environment/Browser/Underline Web Links – Boolean	Enables underlining of hypertext links in the integrated HTML and help browser.

File Search

Property	Description
Files To Search Find In Files/File Type – StringList	The wildcard used to match files in Find In Files searches.
Find History Find In Files/Find History – StringList	The list of strings recently used in searches.
Folder History Find In Files/Folder History – StringList	The set of folders recently used in file searches.
Match Case Find In Files/Match Case – Boolean	Whether the case of letters must match exactly when searching.
Match Whole Word Find In Files/Match Whole Word – Boolean	Whether the whole word must match when searching.
Replace History Find In Files/Replace History – StringList	The list of strings recently used in searches.
Search Dependencies Find In Files/Search Dependencies – Boolean	Controls searching of dependent files.
Search In Find In Files/Context – Enumeration	Where to look to find files.
Use Regular Expressions Find In Files/Use RegExp – Boolean	Whether to use a regular expression or plain text search.

Internet

Property	Description
Automatically Check For Packages Environment/Internet/Check Packages – Boolean	Specifies whether to enable downloading of the list of available packages.

Automatically Check For Updates Environment/Internet/Check Updates – Boolean	Specifies whether to enable checking for software updates.
Check For Latest News Environment/Internet/RSS Update – Boolean	Specifies whether to enable downloading of the Latest News RSS feeds.
Enable Connection Debugging Environment/Internet/Enable Debugging – Boolean	Controls debugging traces of internet connections and downloads.
External Web Browser Environment/External Web Browser – FileName	The path to the external web browser to use when accessing non-local files.
HTTP Proxy Host Environment/Internet/HTTP Proxy Server – String	Specifies the IP address or hostname of the HTTP proxy server. If empty, no HTTP proxy server will be used.
HTTP Proxy Port Environment/Internet/HTTP Proxy Port – IntegerRange	Specifies the HTTP proxy server's port number.
Maximum Download History Items Environment/Internet/Max Download History Items – IntegerRange	The maximum amount of download history kept in the downloads window.
Use Content Delivery Network Environment/Package/Use Content Delivery Network – Boolean	Specifies whether to use content delivery network to deliver packages.

Launcher

Property	Description
Launch Latest Installations Only Environment/Launcher Use Latest Installations Only – Boolean	Specifies whether the CrossStudio launcher should only consider the latest installations when deciding which one to use.
Launcher Enabled Environment/Launcher Enabled – Boolean	Specifies whether the CrossStudio launcher should be used when the operating system or an external application requests a file to be opened.

Package Manager

Property	Description
Check Solution Package Dependencies Environment/Package/Check Solution Package Dependencies – Boolean	Specifies whether to check package dependencies when a solution is loaded.

Package Directory Environment/Package/Destination Directory – String	Specifies the directory packages are installed to.
Show Logos Environment/Package/Show Logos – Enumeration	Specifies whether the package manager should display company logos.

Print

Property	Description
Bottom Margin Environment/Printing/Bottom Margin – IntegerRange	The page's bottom margin in millimetres.
Left Margin Environment/Printing/Left Margin – IntegerRange	The page's left margin in millimetres.
Page Orientation Environment/Printing/ Orientation – Enumeration	The page's orientation.
Page Size Environment/Printing/Page Size – Enumeration	The page's size.
Right Margin Environment/Printing/Right Margin – IntegerRange	The page's right margin in millimetres.
Top Margin Environment/Printing/Top Margin – IntegerRange	The page's top margin in millimetres.

Startup

Property	Description
Allow Multiple CrossStudios Environment/Permit Multiple Studio Instances – Boolean	Allow more than one CrossStudio to run at the same time.
Load Last Project On Startup Environment/Load Last Project On Startup – Boolean	Specifies whether to load the last project the next time CrossStudio runs.
New Project Directory Environment/General/Solution Directory – String	The directory where projects are created.
Splash Screen Environment/Splash Screen – Enumeration	How to display the splash screen on startup.

Status Bar

Property	Description
(Visible) Environment/Status Bar - Boolean	Show or hide the status bar.
Show Build Status Pane Environment/General/Status Bar/Show Build Status - Boolean	Show or hide the Build pane in the status bar.
Show Caret Position Pane Environment/General/Status Bar/Show Caret Pos - Boolean	Show or hide the Caret Position pane in the status bar.
Show Insert/Overwrite Status Pane Environment/General/Status Bar/Show Insert Mode - Boolean	Show or hide the Insert/Overwrite pane in the status bar.
Show Read-Only Status Pane Environment/General/Status Bar/Show Read Only - Boolean	Show or hide the Read Only pane in the status bar.
Show Size Grip Environment/General/Status Bar/Show Size Grip - Boolean	Show or hide the status bar size grip.
Show Target Pane Environment/General/Status Bar/Show Target - Boolean	Show or hide the Target pane in the status bar.
Show Time Pane Environment/General/Status Bar/Show Time - Boolean	Show or hide the Time pane in the status bar.

User Interface

Property	Description
Application Main Font Environment/Application Main Font - Font	The font to use for the user interface as a whole.
Application Monospace Font Environment/Application Monospace Font - FixedPitchFont	The fixed-size font to use for the user interface as a whole.
Error Display Timeout Environment/Error Display Timeout - IntegerRange	The minimum time, in seconds, that errors are shown for in the status bar.
Errors Are Displayed Environment/Error Display Mode - Enumeration	How errors are reported in CrossStudio.

File Size Display Units Environment/Size Display Unit – Enumeration	How to display sizes of items in the user interface. SI defines 1kB=1000 bytes, IEC defines 1kiB=1024 bytes, Alternate SI defines 1kB=1024 bytes.
Number File Names in Menus Environment/Number Menus – Boolean	Number the first nine file names in menus for quick keyboard access.
Show Large Icons In Toolbars Environment/General/Large Icons – Boolean	Show large or small icons on toolbars.
Show Ribbon Environment/General/Ribbon/Show – Boolean	Show or hide the ribbon.
Show Window Selector On Ctrl+Tab Environment/Show Selector – Boolean	Present the Window Selector on Next Window and Previous Window commands activated from the keyboard.
User Interface Theme Environment/General/Skin – Enumeration	The theme that CrossStudio uses.
Window Menu Contains At Most Environment/Max Window Menu Items – IntegerRange	The maximum number of windows appearing in the Windows menu.

Programming Language Environment Options

Assembly Language

Property	Description
Column Guide Columns Text Editor/Indent/Assembly Language/Column Guides – String	The columns that guides are drawn for.
Indent Closing Brace Text Editor/Indent/Assembly Language/Close Brace – Boolean	Indent the closing brace of compound statements.
Indent Context Text Editor/Indent/Assembly Language/Context Lines – IntegerRange	The number of lines to use for context when indenting.
Indent Mode Text Editor/Indent/Assembly Language/Indent Mode – Enumeration	How to indent when a new line is inserted.
Indent Opening Brace Text Editor/Indent/Assembly Language/Open Brace – Boolean	Indent the opening brace of compound statements.
Indent Size Text Editor/Indent/Assembly Language/Size – IntegerRange	The number of columns to indent a code block.
Tab Size Text Editor/Indent/Assembly Language/Tab Size – IntegerRange	The number of columns between tabstops.
Use Tabs Text Editor/Indent/Assembly Language/Use Tabs – Boolean	Insert tabs when indenting.
User-Defined Keywords Text Editor/Indent/Assembly Language/Keywords – StringList	Additional identifiers to highlight as keywords.

C and C++

Property	Description
Column Guide Columns Text Editor/Indent/C and C++/Column Guides – String	The columns that guides are drawn for.

Indent Closing Brace Text Editor/Indent/C and C++/Close Brace – Boolean	Indent the closing brace of compound statements.
Indent Context Text Editor/Indent/C and C++/Context Lines – IntegerRange	The number of lines to use for context when indenting.
Indent Mode Text Editor/Indent/C and C++/Indent Mode – Enumeration	How to indent when a new line is inserted.
Indent Opening Brace Text Editor/Indent/C and C++/Open Brace – Boolean	Indent the opening brace of compound statements.
Indent Size Text Editor/Indent/C and C++/Size – IntegerRange	The number of columns to indent a code block.
Tab Size Text Editor/Indent/C and C++/Tab Size – IntegerRange	The number of columns between tabstops.
Use Tabs Text Editor/Indent/C and C++/Use Tabs – Boolean	Insert tabs when indenting.
User-Defined Keywords Text Editor/Indent/C and C++/Keywords – StringList	Additional identifiers to highlight as keywords.

Default

Property	Description
Column Guide Columns Text Editor/Indent/Default/Column Guides – String	The columns that guides are drawn for.
Indent Closing Brace Text Editor/Indent/Default/Close Brace – Boolean	Indent the closing brace of compound statements.
Indent Context Text Editor/Indent/Default/Context Lines – IntegerRange	The number of lines to use for context when indenting.
Indent Mode Text Editor/Indent/Default/Indent Mode – Enumeration	How to indent when a new line is inserted.

Indent Opening Brace Text Editor/Indent/Default/Open Brace – Boolean	Indent the opening brace of compound statements.
Indent Size Text Editor/Indent/Default/Size – IntegerRange	The number of columns to indent a code block.
Tab Size Text Editor/Indent/Default/Tab Size – IntegerRange	The number of columns between tabstops.
Use Tabs Text Editor/Indent/Default/Use Tabs – Boolean	Insert tabs when indenting.
User-Defined Keywords Text Editor/Indent/Default/Keywords – StringList	Additional identifiers to highlight as keywords.

Java

Property	Description
Column Guide Columns Text Editor/Indent/Java/Column Guides – String	The columns that guides are drawn for.
Indent Closing Brace Text Editor/Indent/Java/Close Brace – Boolean	Indent the closing brace of compound statements.
Indent Context Text Editor/Indent/Java/Context Lines – IntegerRange	The number of lines to use for context when indenting.
Indent Mode Text Editor/Indent/Java/Indent Mode – Enumeration	How to indent when a new line is inserted.
Indent Opening Brace Text Editor/Indent/Java/Open Brace – Boolean	Indent the opening brace of compound statements.
Indent Size Text Editor/Indent/Java/Size – IntegerRange	The number of columns to indent a code block.
Tab Size Text Editor/Indent/Java/Tab Size – IntegerRange	The number of columns between tabstops.
Use Tabs Text Editor/Indent/Java/Use Tabs – Boolean	Insert tabs when indenting.

User-Defined Keywords

Text Editor/Indent/Java/Keywords – StringList

Additional identifiers to highlight as keywords.

Source Control Environment Options

External Tools

Property	Description
Diff Command Line Environment/Source Code Control/ DiffCommand – StringList	The diff command line
Merge Command Line Environment/Source Code Control/ MergeCommand – StringList	The merge command line

Preference

Property	Description
Add Immediately Environment/Source Code Control/Immediate Add – Boolean	Bypasses the confirmation dialog and immediately adds items to source control.
Commit Immediately Environment/Source Code Control/Immediate Commit – Boolean	Bypasses the confirmation dialog and immediately commits items.
Lock Immediately Environment/Source Code Control/Immediate Lock – Boolean	Bypasses the confirmation dialog and immediately locks items.
Remove Immediately Environment/Source Code Control/Immediate Remove – Boolean	Bypasses the confirmation dialog and immediately removes items source control.
Resolved Immediately Environment/Source Code Control/Immediate Resolved – Boolean	Bypasses the confirmation dialog and immediately mark items resolved.
Revert Immediately Environment/Source Code Control/Immediate Revert – Boolean	Bypasses the confirmation dialog and immediately revert items.
Unlock Immediately Environment/Source Code Control/Immediate Unlock – Boolean	Bypasses the confirmation dialog and immediately unlocks items.
Update Immediately Environment/Source Code Control/Immediate Update – Boolean	Bypasses the confirmation dialog and immediately updates items.

Text Editor Environment Options

Auto Recovery

Property	Description
Auto Recovery Backup Time Text Editor/Auto Recovery Backup Time – IntegerRange	The time in minutes between saving of auto recovery backups files or 0 to disable generation of backup files.
Auto Recovery Keep Time Text Editor/Auto Recovery Keep Time – IntegerRange	The time in days to keep unrecovered backup files or 0 to disable deletion of unrecovered backup files.

Cursor Fence

Property	Description
Bottom Margin Text Editor/Margins/Bottom – IntegerRange	The number of lines in the bottom margin.
Keep Cursor Within Fence Text Editor/Margins/Enabled – Boolean	Enable margins to fence and scroll around the cursor.
Left Margin Text Editor/Margins/Left – IntegerRange	The number of characters in the left margin.
Right Margin Text Editor/Margins/Right – IntegerRange	The number of characters in the right margin.
Top Margin Text Editor/Margins/Top – IntegerRange	The number of lines in the right margin.

Editing

Property	Description
Allow Drag and Drop Editing Text Editor/Drag Drop Editing – Boolean	Enables dragging and dropping of selections in the text editor.
Bold Popup Diagnostic Messages Text Editor/Bold Popup Diagnostics – Boolean	Displays popup diagnostic messages in bold for easier reading.
Column-mode Tab Text Editor/Column Mode Tab – Boolean	Tab key moves to the next textual column using the line above.
Confirm Modified File Reload Text Editor/Confirm Modified File Reload – Boolean	Display a confirmation prompt before reloading a file that has been modified on disk.

Copy Action When Nothing Selected Text Editor/Copy Action – Enumeration	What Copy copies when nothing is selected.
Cut Action When Nothing Selected Text Editor/Cut Action – Enumeration	What Cut cuts when nothing is selected.
Cut Single Blank Line Text Editor/Cut Blank Lines – Boolean	Selects whether to place text on the clipboard when a single blank line is cut. When set to
Diagnostic Cycle Mode Text Editor/Diagnostic Cycle Mode – Enumeration	Iterates through diagnostics either from most severe to least severe or in reported order.
Edit Read-Only Files Text Editor/Edit Read Only – Boolean	Allow editing of read-only files.
Enable Virtual Space Text Editor/Enable Virtual Space – Boolean	Permit the cursor to move into locations that do not currently contain text.
Numeric Keypad Editing Text Editor/Numeric Keypad Enabled – Boolean	Selects whether the numeric keypad plus and minus buttons copy and cut text.
Undo And Redo Behavior Text Editor/Undo Mode – Enumeration	How Undo and Redo group your typing when it is undone and redone.

Find And Replace

Property	Description
Case Sensitive Matching Text Editor/Find/Match Case – Boolean	Enables or disables the case sensitivity of letters when searching.
Find History Text Editor/Find/History – StringList	The list of strings recently used in searches.
Regular Expression Matching Text Editor/Find/Use RegExp – Boolean	Enables regular expression matching rather than plain text matching.
Replace History Text Editor/Replace/History – StringList	The list of strings recently used in replaces.
Whole Word Matching Text Editor/Find/Match Whole Word – Boolean	Enables or disables whole word matching when searching.

Formatting

Property	Description
Access Modifier Offset Text Editor/Formatting/AccessModifierOffset – Integer	The extra indent or outdent of access modifiers, e.g. public::

Align After Open Bracket Text Editor/Formatting/ AlignAfterOpenBracket – Boolean	If enabled, horizontally aligns arguments after an open bracket.
Align Escaped Newlines Left Text Editor/Formatting/ AlignEscapedNewlinesLeft – Boolean	If enabled, aligns escaped newlines as far left as possible otherwise puts them into the right-most column.
Align Operands Text Editor/Formatting/ AlignOperands – Boolean	If enabled, horizontally align operands of binary and ternary expressions.
Align Trailing Comments Text Editor/Formatting/ AlignTrailingComments – Boolean	If enabled, aligns trailing comments.
Allow All Parameters Of Declaration On Next Line Text Editor/Formatting/ AllowAllParametersOfDeclarationOnNextLine – Boolean	Allow putting all parameters of a function declaration onto the next line even if Bin-pack Parameters is disabled.
Allow Short 'if' Statements On A Single Line Text Editor/Formatting/ AllowShortIfStatementsOnASingleLine – Boolean	If enabled, short 'if' statements are put on a single line.
Allow Short Blocks On A Single Line Text Editor/Formatting/ AllowShortBlocksOnASingleLine – Boolean	If enabled, allows contracting simple braced statements to a single line.
Allow Short Case Labels On A Single Line Text Editor/Formatting/ AllowShortCaseLabelsOnASingleLine – Boolean	If enabled, short case labels will be contracted to a single line.
Allow Short Functions On A Single Line Text Editor/Formatting/ AllowShortFunctionsOnASingleLine – Enumeration	Optionally compress small functions to a single line.
Allow Short Loop Statements On A Single Line Text Editor/Formatting/ AllowShortLoopsOnASingleLine – Boolean	If enabled, short loop statements are put on a single line.
Always Break Before Multiline Strings Text Editor/Formatting/ AlwaysBreakAfterDefinitionReturnType – Boolean	If enabled, always break after function definition return types.
Always Break Before Multiline Strings Text Editor/Formatting/ AlwaysBreakBeforeMultilineStrings – Boolean	If enabled, always break before multiline strings.
Always Break Template Declarations Text Editor/Formatting/ AlwaysBreakTemplateDeclarations – Boolean	If enabled, always break after the 'template<...>' of a template declaration.
Bin-Pack Arguments Text Editor/Formatting/ BinPackArguments – Boolean	If disabled, a function call? s arguments will either be all on the same line or will have one line each.

Bin-Pack Parameters Text Editor/Formatting/ BinPackParameters – Boolean	If disabled, a function call's or function definition's parameters will either all be on the same line or will have one line each.
Break Before Binary Operators Text Editor/Formatting/ BreakBeforeBinaryOperators – Boolean	The way to wrap binary operators.
Break Before Braces Text Editor/Formatting/ BreakBeforeBraces – Enumeration	The brace breaking style to use.
Break Before Ternary Operators Text Editor/Formatting/ BreakBeforeTernaryOperators – Boolean	If enabled, ternary operators will be placed after line breaks.
Break Constructor Initializers Before Comma Text Editor/Formatting/ BreakConstructorInitializersBeforeComma – Boolean	If enabled, always break constructor initializers before commas and align the commas with the colon.
C++11 Braced List Style Text Editor/Formatting/ Cpp11BracedListStyle – Boolean	If enabled, format braced lists as best suited for C++11 braced lists.
Column Limit Text Editor/Formatting/ColumnLimit – Integer	The column limit which limits the width of formatted lines.
Comment Pragmas Text Editor/Formatting/ CommentPragmas – String	A regular expression that describes comments with special meaning, which should not be split into lines or otherwise changed.
Constructor Initializer All On One Line Or One Per Line Text Editor/Formatting/ ConstructorInitializerAllOnOneLineOrOnePer	If enabled and the constructor initializers don't fit on a line, put each initializer on its own line.
Constructor Initializer Indent Width Text Editor/Formatting/ ConstructorInitializerIndentWidth – Integer	The number of characters to use for indentation of constructor initializer lists.
Continuation Indent Width Text Editor/Formatting/ ContinuationIndentWidth – Integer	Indent width for line continuations.
For-Each Macros Text Editor/Formatting/ ForEachMacros – StringList	A list of macros that should be interpreted as foreach loops rather than function calls.
Formatting Style Text Editor/FormattingStyle – Enumeration	Select a set formatting options based on a named standard.
Indent Case Labels Text Editor/Formatting/ IndentCaseLabels – Boolean	If enabled, indent case labels one level from the switch statement.
Indent Width Text Editor/Formatting/IndentWidth – Integer	The number of columns to use for indentation.

Indent Wrappend Function Names Text Editor/Formatting/ IndentWrappedFunctionNames – Boolean	If enabled, Indent if a function definition or declaration is wrapped after the type.
Keep Empty Lines At The Start Of Blocks Text Editor/Formatting/ KeepEmptyLinesAtTheStartOfBlocks – Boolean	If enabled, empty lines at the start of blocks are kept.
Maximum Empty Lines To Keep Text Editor/Formatting/ MaxEmptyLinesToKeep – Integer	The maximum number of consecutive empty lines to keep.
Namespace Indentation Text Editor/Formatting/ NamespaceIndentation – Enumeration	The indentation used for namespaces.
Penalty Break Before First Call Parameter Text Editor/Formatting/ PenaltyBreakBeforeFirstCallParameter – Integer	The penalty for breaking a function call after 'call('.
Penalty Break Before First Less-Less Text Editor/Formatting/ PenaltyBreakFirstLessLess – IntegerRange	The penalty for breaking before the first less-less.
Penalty Break Comment Text Editor/Formatting/ PenaltyBreakComment – IntegerRange	The penalty for each line break introduced inside a comment.
Penalty Break String Text Editor/Formatting/ PenaltyBreakString – IntegerRange	The penalty for each line break introduced inside a string literal.
Penalty Excess Character Text Editor/Formatting/ PenaltyExcessCharacter – IntegerRange	The penalty for each character outside of the column limit.
Penalty Return Type On Its Own Line Text Editor/Formatting/ PenaltyReturnTypeOnItsOwnLine – IntegerRange	Penalty for putting the return type of a function onto its own line.
Pointer Alignment Text Editor/Formatting/ PointerAlignment – Enumeration	Pointer and reference alignment style.
Space After C Style Cast Text Editor/Formatting/ SpaceAfterCStyleCast – Boolean	If enabled, a space may be inserted after C style casts.
Space Before Assignment Operators Text Editor/Formatting/ SpaceBeforeAssignmentOperators – Boolean	If disabled spaces will be removed before assignment operators.
Space Before Parentheses Text Editor/Formatting/ SpaceBeforeParens – Enumeration	Defines in which cases to put a space before opening parentheses.

Space In Empty Parentheses Text Editor/Formatting/ SpaceInEmptyParentheses - Boolean	If enabled, spaces may be inserted into ')'.
Spaces Before Trailing Comments Text Editor/Formatting/ SpacesBeforeTrailingComments - IntegerRange	The number of spaces before trailing line comments.
Spaces In Angles Text Editor/Formatting/ SpacesInAngles - Boolean	If enabled, spaces will be inserted around the angle brackets in template argument lists.
Spaces In C-style Cast Parentheses Text Editor/Formatting/ SpacesInCStyleCastParentheses - Boolean	If enabled, spaces may be inserted into C style casts.
Spaces In Container Literals Text Editor/Formatting/ SpacesInContainerLiterals - Boolean	If enabled, spaces are inserted inside container literals.
Spaces In Parentheses Text Editor/Formatting/ SpacesInParentheses - Boolean	If true, spaces will be inserted after '(' and before ')'.
Spaces In Square Brackets Text Editor/Formatting/ SpacesInSquareBrackets - Boolean	If true, spaces will be inserted after '[' and before ']'.
Standard Text Editor/Formatting/ Standard - Enumeration	Format compatible with this standard
Tab Style Text Editor/Formatting/UseTab - Enumeration	The way to use hard tab characters in the resulting file.
Tab Width Text Editor/Formatting/ TabWidth - IntegerRange	The number of columns used for tab stops.

International

Property	Description
Default Text File Encoding Text Editor/Default Codec - Enumeration	The encoding to use if not overridden by a project property or file is not in a known format.

Mouse

Property	Description
----------	-------------

Alt+Left Click Action Environment/Project Explorer/Alt+Left Click Action - Enumeration	The action the editor performs on Alt+Left Click
Alt+Middle Click Action Environment/Project Explorer/Alt+Middle Click Action - Enumeration	The action the editor performs on Alt+Middle Click
Alt+Right Click Action Environment/Project Explorer/Alt+Right Click Action - Enumeration	The action the editor performs on Alt+Right Click
Copy On Mouse Select Text Editor/Copy On Mouse Select - Boolean	Automatically copy text to clipboard when marking a selection with the mouse.
Ctrl+Left Click Action Environment/Project Explorer/Ctrl+Left Click Action - Enumeration	The action the editor performs on Ctrl+Left Click
Ctrl+Middle Click Action Environment/Project Explorer/Ctrl+Middle Click Action - Enumeration	The action the editor performs on Ctrl+Middle Click
Ctrl+Right Click Action Environment/Project Explorer/Ctrl+Right Click Action - Enumeration	The action the editor performs on Ctrl+Right Click
Middle Click Action Environment/Project Explorer/Middle Click Action - Enumeration	The action the editor performs on Middle Click
Mouse Wheel Adjusts Font Size Text Editor/Mouse Wheel Adjusts Font Size - Boolean	Enable or disable resizing of font by mouse wheel when CTRL key pressed.
Shift+Middle Click Action Environment/Project Explorer/Shift+Middle Click Action - Enumeration	The action the editor performs on Shift+Middle Click
Shift+Right Click Action Environment/Project Explorer/Shift+Right Click Action - Enumeration	The action the editor performs on Shift+Right Click

Programmer Assistance

Property	Description
ATTENTION Tag List Text Editor/ATTENTION Tags - StringList	Set the tags to display as ATTENTION comments.
Ask For Index Text Editor/Ask For Index - Boolean	Ask to index the project if goto symbol fails in current editor context.

Auto-Comment Text Text Editor/Auto Comment – Boolean	Enable or disable automatically swapping commenting on source lines by typing '/' with an active selection.
Auto-Surround Text Text Editor/Auto Surround – Boolean	Enable or disable automatically surrounding selected text when typing triangular brackets, quotation marks, parentheses, brackets, or braces.
Check Spelling Text Editor/Spell Checking – Boolean	Enable spell checking in comments.
Display Code Completion Suggestions While Typing Text Editor/Suggest Completion While Typing – Boolean	Enable code completion as you type without needing to use the show suggestions key (Ctrl+J).
Enable Popup Diagnostics Text Editor/Enable Popup Diagnostics – Boolean	Enables on-screen diagnostics in the text editor.
FIXME Tag List Text Editor/FIXME Tags – StringList	Set the tags to display as FIXME comments.
Include Preprocessor Definitions in Suggestions Text Editor/Preprocessor Definition Suggestions – Boolean	Include or exclude preprocessor definitions in code completion suggestions.
Include Templates in Suggestions Text Editor/Template Suggestions – Boolean	Include or exclude templates in code completion suggestions.
Lint Tag List Text Editor/LINT Tags – StringList	Set the tags to display as Lint directives.
Template Characters To Match Text Editor/Template Suggestions Characters – IntegerRange	The number of characters to match before suggesting a template.

Save

Property	Description
Backup File History Depth Text Editor/Backup File Depth – IntegerRange	The number of backup files to keep when saving an existing file.
Delete Trailing Space On Save Text Editor/Delete Trailing Space On Save – Boolean	Deletes trailing whitespace from each line when a file is saved.
Tab Cleanup On Save Text Editor/Cleanup Tabs On Save – Enumeration	Cleans up tabs when a file is saved.

Visual Appearance

Property	Description
Font Text Editor/Font – FixedPitchFont	The font to use for text editors.
Font Smoothing Threshold Text Editor/Antialias Threshold – IntegerRange	The minimum size for font smoothing: font sizes smaller than this will have antialiasing turned off.
Hide Cursor When Typing Text Editor/Hide Cursor When Typing – Boolean	Hide or show the I-beam cursor when you start to type.
Highlight Cursor Line Text Editor/Highlight Cursor Line – Boolean	Enable or disable visually highlighting the cursor line.
Horizontal Scroll Bar Text Editor/HScroll Bar – Enumeration	Show or hide the horizontal scroll bar.
Insert Caret Style Text Editor/Insert Caret Style – Enumeration	How the caret is displayed with the editor in insert mode.
Line Numbers Text Editor/Line Number Mode – Enumeration	How often line numbers are displayed in the margin.
Mate Matching Mode Text Editor/Mate Matching Mode – Enumeration	Controls when braces, brackets, and parentheses are matched.
Overwrite Caret Style Text Editor/Overwrite Caret Style – Enumeration	How the caret is displayed with the editor in overwrite mode.
Show Diagnostic Icons In Gutter Text Editor/Diagnostic Icons – Boolean	Enables display of diagnostic icons in the icon gutter.
Show Icon Gutter Text Editor/Icon Gutter – Boolean	Show or hide the left-hand gutter containing breakpoint, bookmark, and optional diagnostic icons.
Show Mini Toolbar Text Editor/Mini Toolbar – Boolean	Show the mini toolbar when selecting text with the mouse.
Use I-beam Cursor Text Editor/Ibeam cursor – Boolean	Show an I-beam or arrow cursor in the text editor.
Vertical Scroll Bar Text Editor/VScroll Bar – Enumeration	Show or hide the vertical scroll bar.

Windows Environment Options

Call Stack

Property	Description
Execution Frame at Top Environment/Call Stack/Most Recent At Top – Boolean	Controls whether the most recent call is at the top or the bottom of the list.
Show Call Address Environment/Call Stack/Show Call Address – Boolean	Enables the display of the call address in the call stack.
Show Call Source Location Environment/Call Stack/Show Call Location – Boolean	Enables the display of the call source location in the call stack.
Show Frame Size Environment/Call Stack/Show Stack Usage – Boolean	Enables the display of the amount of stack used by the call.
Show Frame Size In Bytes Environment/Call Stack/Show Stack Usage In Bytes – Boolean	Display the stack usage in bytes rather than words.
Show Parameter Names Environment/Call Stack/Show Parameter Names – Boolean	Enables the display of parameter names in the call stack.
Show Parameter Types Environment/Call Stack/Show Parameter Types – Boolean	Enables the display of parameter types in the call stack.
Show Parameter Values Environment/Call Stack/Show Parameter Values – Boolean	Enables the display of parameter values in the call stack.
Show Stack Pointer Environment/Call Stack/Show Stack Pointer – Boolean	Enables the display of the stack pointer in the call stack.
Show Stack Usage Environment/Call Stack/Show Cumulative Stack Usage – Boolean	Enables the display of the amount of stack used.
Show Stack Usage In Bytes Environment/Call Stack/Show Cumulative Stack Usage In Bytes – Boolean	Display the stack usage in bytes rather than words.

Clipboard Ring

Property	Description
Maximum Items Held In Ring Environment/Clipboard Ring/Max Entries - IntegerRange	The maximum number of items held on the clipboard ring before they are recycled.
Preserve Contents Between Runs Environment/Clipboard Ring/Save - Boolean	Save the clipboard ring across CrossStudio runs.

Outline Window

Property	Description
Group #define Directives Windows/Outline/Group Defines - Boolean	Group consecutive #define and #undef preprocessor directives.
Group #if Directives Windows/Outline/Group Ifs - Boolean	Group lines contained between #if, #else, and #endif preprocessor directives.
Group #include Directives Windows/Outline/Group Includes - Boolean	Group consecutive #include preprocessor directives.
Group Top-Level Declarations Windows/Outline/Group Top Level Items - Boolean	Group consecutive top-level variable and type declarations.
Group Visibility Windows/Outline/Group Visibility - Boolean	Group class members by public, protected, and private visibility.
Hide #region Prefix Windows/Outline/Hide Region Prefix - Boolean	Hides the '#region' prefix from groups and shows only the group name.
Refresh Outline and Preview Windows/Outline/Preview Refresh Mode - Enumeration	How the Preview pane refreshes its contexts.

Project Explorer

Property	Description
Add Filename Replace Macros Environment/Project Explorer/Filename Replace Macros - StringList	Macros (system and global) used to replace the start of a filename on project file addition.
Color Project Nodes Environment/Project Explorer/Color Nodes - Boolean	Show the project nodes colored for identification in the Project Explorer.

Confirm Configuration Folder Delete Project Explorer/Confirm Configuration Folder Delete - Boolean	Display a confirmation prompt before deleting a configuration folder containing properties.
Confirm Forget Modified Properties Project Explorer/Confirm Reject Property Changes - Boolean	Display a confirmation prompt before forgetting property modifications.
Edit Properties At Top Environment/Project Explorer/Context Menu Properties Position - Boolean	Controls where edit properties is displayed by the Project Explorer's context menu.
External Editor Environment/Project Explorer/External Editor - FileName	The file name of the application to use as the external text editor
Favorite Properties Environment/Project Explorer/Favorite Properties - StringList	The favorite list of properties that are displayed starred and before other properties in the Project Explorer.
Favorite Properties Uses Common Folder Environment/Project Explorer/Context Menu Common Folder - Boolean	Controls how favorite common properties are displayed by the Project Explorer's context menu.
Highlight Dynamic Items Environment/Project Explorer/Show Dynamic Overlay - Boolean	Show an overlay on an item if it is populated from a dynamic folder.
Highlight External Items Environment/Project Explorer/Show Non-Local Overlay - Boolean	Show an overlay on an item if it is not held within the project directory.
Output Files Folder Environment/Project Explorer/Show Output Files - Boolean	Show the build output files in an Output Files folder in the project explorer.
Read-Only Data In Code Environment/Project Explorer/Statistics Read-Only Data Handling - Boolean	Configures whether read-only data contributes to the Code or Data statistic.
Show Dependencies Environment/Project Explorer/Dependencies Display - Enumeration	Controls how the dependencies are displayed.
Show Favorite Properties Environment/Project Explorer/Context Menu Show Favorites - Boolean	Controls if favorite properties are displayed by the Project Explorer's context menu.
Show File Count on Folder Environment/Project Explorer/Count Files - Boolean	Show the number of files contained in a folder as a badge in the Project Explorer.
Show Modified Properties on Folder/File Environment/Project Explorer/Show Modified Properties - Boolean	Show if a folder or file has modified properties as a badge in the Project Explorer.

Show Project Count on Solution Environment/Project Explorer/Count Projects - Boolean	Show the number of projects contained in a solution as a badge in the Project Explorer.
Show Properties Environment/Project Explorer/Properties Display - Enumeration	Controls how the properties are displayed.
Show Source Control Annotation Environment/Project Explorer/Show Source Control Annotation - Boolean	Annotate items in the project explorer with their source control status.
Show Statistics Rounded Environment/Project Explorer/Statistics Format - Boolean	Show exact or rounded sizes in the project explorer.
Source Control Status Column Environment/Project Explorer/Show Source Control Column - Boolean	Show the source control status column in the project explorer.
Starred Files Names Environment/Project Explorer/Starred File Names - StringList	The list of wildcard-matched file names that are highlighted with stars, to bring attention to themselves, in the Project Explorer.
Statistics Column Environment/Project Explorer/Statistics Display - Boolean	Show the code and data size columns in the Project Explorer.
Synchronize Explorer With Editor Environment/Project Explorer/Sync Editor - Boolean	Synchronizes the Project Explorer with the document being edited.
Use Common Properties Folder Environment/Project Explorer/Common Properties Display - Boolean	Controls how common properties are displayed.

Properties Window

Property	Description
Enable Favorites Group Environment/Properties Windows/Favorites Grouped - Enumeration	Assign favorites to their own group.
Properties Displayed Environment/Properties Windows/Property Display Format - Enumeration	Set how the properties are displayed.
Public Setting Check Environment/Properties Windows/Public Setting Check - Enumeration	Warn when setting property in public configuration.

Show Property Details Environment/Properties Windows/Show Details - Boolean	Show or hide the property description.
--------------------------------------------------------------------------------	----------------------------------------

Variable Window

Property	Description
Show Variable Address Column Environment/Variable Window/Show Address Column - Boolean	Controls whether the variable address column is displayed.
Show Variable Size Column Environment/Variable Window/Show Size Column - Boolean	Controls whether the variable size column is displayed.
Show Variable Type Column Environment/Variable Window/Show Type Column - Boolean	Controls whether the variable type column is displayed.

Windows Window

Property	Description
Buffer Grouping Environment/Windows/Grouping - Enumeration	How the files are grouped or listed in the Windows window.
Show File Path as Tooltip Environment/Windows/Show Filename Tooltips - Boolean	Show the full file name as a tooltip when hovering over files in the Windows window.
Show Line Count and File Size Environment/Windows/Show Sizes - Boolean	Show the number of lines and size of each file in the windows list.

Command-line options

This section describes the command-line options accepted by CrossStudio.

Usage

```
crossstudio [options...] [files...]
```

-D (Define macro)

Syntax

`-D macro=value`

Description

Define a CrossWorks macro value.

-noclang (Disable Clang support)

Syntax

-noclang

Description

Disable Clang support.

-packagesdir (Specify packages directory)

Syntax

`-packagesdir dir`

Description

Override the default value of the `$(PackagesDir)` macro.

-permit-multiple-studio-instances (Permit multiple studio instances)

Syntax

-permit-multiple-studio-instances

Description

Allow multiple instances of CrossStudio to run at the same time. This behaviour can also be enabled using the **Environment > Startup Options > Allow Multiple CrossStudios** environment option.

-rootuserdir (Set the root user data directory)

Syntax

-rootuserdir *dir*

Description

Set the CrossWorks root user data directory.

-save-settings-off (Disable saving of environment settings)

Syntax

-save-settings-off

Description

Disable the saving of modified environment settings.

-set-setting (Set environment setting)

Syntax

-set-setting *environment_setting*=*value*

Description

Sets an environment setting to a specified value. For example:

```
-set-setting "Environment/Build/Show Command Lines=Yes"
```

-templatesfile (Set project templates path)

Syntax

`-templatesfile path`

Description

Sets the search path for finding project template files.

Uninstalling CrossWorks for MSP430

This section describes how to completely uninstall CrossWorks for MSP430 for each supported operating system:

- [Uninstalling CrossWorks for MSP430 from Windows](#)
- [Uninstalling CrossWorks for MSP430 from Mac OS X](#)
- [Uninstalling CrossWorks for MSP430 from Linux](#)

Uninstalling CrossWorks for MSP430 from Windows

Removing user data and settings

The uninstaller does not remove any user data such as settings or installed packages. To completely remove the user data you will need to carry out the following operations for each user that has used CrossWorks for MSP430 on your system.

To remove user data using CrossStudio:

1. Start CrossStudio.
2. Click **Tools > Admin > Remove All User Data...**

Alternatively, if CrossWorks for MSP430 has already been uninstalled you can manually remove the user data as follows:

1. Click the Windows Start button.
2. Type `%LOCALAPPDATA%` in the search field and press enter to open the local application data folder.
3. Open the *Rowley Associates Limited* folder.
4. Open the *CrossWorks for MSP430* folder.
5. Delete the *v3* folder.
6. If you want to delete user data for all versions of the software, delete the *CrossWorks for MSP430* folder as well.

Uninstalling CrossWorks for MSP430

To uninstall CrossWorks for MSP430:

1. If CrossStudio is running, click **File > Exit** to shut it down.
2. Click the Start Menu and select Control Panel. The Control Panel window will open.
3. In the Control Panel window, click the **Uninstall a program** link under the Programs section.
4. From the list of currently installed programs, select **CrossWorks for MSP430 3.1**.
5. To begin the uninstall, click the **Uninstall** button at the top of the list.

Uninstalling CrossWorks for MSP430 from Mac OS X

Removing user data and settings

Uninstalling does not remove any user data such as settings or installed packages. To completely remove the user data you will need to carry out the following operations for each user that has used CrossWorks for MSP430 on your system.

To remove user data using CrossStudio:

1. Start CrossStudio.
2. Click Tools > Admin > Remove All User Data...

Alternatively, if CrossWorks for MSP430 has already been uninstalled you can manually remove the user data as follows:

1. Open Finder.
2. Go to the *\$HOME/Library/Rowley Associates Limited/CrossWorks for MSP430* directory.
3. Drag the *v3* folder to the Trash.
4. If you want to delete user data for all versions of the software, drag the *CrossWorks for MSP430* folder to the Trash as well.

Uninstalling CrossWorks for MSP430

To uninstall CrossWorks for MSP430:

1. If CrossStudio is running, shut it down.
2. Open the *Applications* folder in Finder.
3. Drag the *CrossWorks for MSP430 3.1* folder to the Trash.

Uninstalling CrossWorks for MSP430 from Linux

Removing user data and settings

The uninstaller does not remove any user data such as settings or installed packages. To completely remove the user data you will need to carry out the following operations for each user that has used CrossWorks for MSP430 on your system.

To remove user data using CrossStudio:

1. Start CrossStudio.

2. Click Tools > Admin > Remove All User Data...

Alternatively, if CrossWorks for MSP430 has already been uninstalled you can manually remove the user data as follows:

1. Open a terminal window or file browser.
2. Go to the `$HOME/.rowley_associates_limited/CrossWorks for MSP430` directory.
3. Delete the `v3` directory.
4. If you want to delete user data for all versions of the software, delete the `CrossWorks for MSP430` directory as well.

Uninstalling CrossWorks for MSP430

To uninstall CrossWorks for MSP430:

1. If CrossStudio is running, click **File > Exit** to shut it down.
2. Open a terminal window.
3. Go to the CrossWorks for MSP430 bin directory (this is `/usr/share/crossworks_for_msp430_3.1/bin` by default).
4. Run `sudo ./uninstall` to start the uninstaller.

Target interfaces

A target interface is a mechanism for communicating with, and controlling, a target. A target can be either a physical hardware device or a software simulation of a device. CrossStudio has a **Targets** window for viewing and manipulating target interfaces. For more information, see [Targets window](#).

Before you can use a target interface, you must *connect* to it. You can only connect to one target interface at a time. For more information, see [Connecting to a target](#).

All target interfaces have a set of properties. The properties provide information on the connected target and allow the target interface to be configured. For more information, see [Viewing and editing target properties](#).

MSP430 Debug Capabilities

The debug capabilities provided by CrossWorks for MSP430 are implemented using the MSP430 Enhanced Emulation Module (EEM). At the time of this writing, [SLAA393](#) is the only publicly available document that details the capabilities of the EEM. Refer to this document to learn about the debug capabilities of a particular device.

Software breakpoints

If the project property **Implement Software Breakpoints** is set to **Yes** when the target is connected then the opcode 0x4343 (`mov .b r3, r3`) is treated as a software-breakpoint instruction and, as such, when you set a code breakpoint, this opcode is written to the address at which you want execution to break. Using this feature provides an unlimited number of code breakpoints but will use one hardware breakpoint (EEM combination trigger) to implement the software breakpoint.

EEM triggers

CrossWorks for MSP430 implements breakpoint expressions (see [Breakpoint expressions](#)) using EEM triggers. Breakpoint expressions provide a simple interface for setting complex breakpoints. Additionally, using the breakpoint dialogs and breakpoint property window with CrossWorks for MSP430, you can specify...

- ...the EEM trigger type, by using **Breakpoint Trigger Type**.
- ...the EEM reaction (Stop, Trace, or Sequencer), by using **Action**.
- ...the EEM combination trigger number, by using **Use Hardware Breakpoint**. You should only need to use this if you are using the Trigger Sequencer or the MSP430F5xx variable-watch capability.

EEM state storage

The **Debug > Control > State Storage Control** dialog allows you to configure the state-storage block of the EEM, and the **Debug > Debug Windows > EEM State Storage** window allows you to see the contents of the EEM-

state-storage block. You can specify that breakpoints are to be used for state-storage control and are stored into the storage block by setting their breakpoint property **Action** to **Trace**. To implement a real-time trace on a variable, you can set a data breakpoint on a variable with the breakpoint property **Action** set to **Trace**, and set the state storage control to **Store Mode: Triggers**. You can refresh the **EEM State Storage** window without stopping the processor by right-clicking the window and choosing **Refresh** from the shortcut menu.

Variable watch (MSP430F5xx only)

On MSP430F5xx devices, you can configure the state-storage block to store variable values to fixed EEM storage locations and do instruction tracing with the remaining storage locations. For example, you can set state-storage locations 0 and 1 to contain the data-watch values corresponding to the EEM combination triggers 0 and 1. If you want to do this, you need to assign the appropriate EEM trigger combination number to the data breakpoint. Note that the EEM combination trigger number 0 is used to implement software breakpoints so, if you want to use this feature, you should disable software breakpoints.

EEM trigger sequencer

The EEM trigger sequencer enables EEM combination triggers 4–7 to be used as inputs to the trigger sequencer and, optionally, the EEM combination trigger 3 to be used to reset the trigger sequencer. The breakpoints you want as inputs to the sequencer should have the EEM combination trigger numbers 4–7 assigned to them and should have the breakpoint property **Action** set to **Sequencer**. You can set up the trigger sequencer using the **Debug > Control > Sequencer Control** dialog, and you can use the **Debug > Debug Windows > EEM Trigger Sequencer** window to see the current state of the trigger sequencer. The trigger sequencer starts in **State0** and executes the specified action when it enters **State3**. On each state, there can be two transitions (A and B) to any of the other states.

Clock control

When you are connected to a target, you can use the **ClockControl** dialog—from the **Debug > Control > Clock Control** menu—to specify the clock behavior when the CPU stops on a breakpoint. The desired clock-control settings are programmed when you start debugging, they cannot be changed while you are debugging. The settings reported by the **Clock Control** dialog are specific to a particular device.

Examples from SLAA393

See [SLAA393](#) on the TI website.

Break on write to address

Using the **New Data Breakpoint** dialog, the breakpoint expression **wLoopCounter==50** will break when **wLoopCounter** is written with the value **50**.

Break on Write to Register

Using the **New Data Breakpoint** dialog, the breakpoint expression `@sp\<=0x09A0` will break when the stack pointer is written with a value less than `0x09A0`.

Break on Write to Flash

Using the **New Data Breakpoint** dialog, entering the breakpoint expression `(char[0xF000])0x1000` and setting the "Breakpoint Trigger Type" to "Write" will break when a write is made to flash memory.

Break on Access of Invalid Memory

Using the **New Data Breakpoint** dialog, entering the breakpoint expression `(char[0x400])0x0C00` and setting the "Breakpoint Trigger Type" to "No IFetch" will break when an access is made to BSL memory.

Break if Fetch is Out of Allowed Area

Using the **New Data Breakpoint** dialog, entering the breakpoint expression `!(char[0xF000])0x1000` and setting the "Breakpoint Trigger Type" to "IFetch" will break when a fetch is made from outside flash memory.

CrossConnect for MSP430

Describes the Rowley CrossConnect for MSP430 target interface. This target interface is applicable to CrossConnect for ARM when used with a suitable ARM 20-pin to MSP430 14-pin JTAG converter. The converter should map the ARM nTRST signal to the MSP430 TEST signal, and the ARM nSRST, TDI, TMS, TCK, TDO, VCC, and GND signals map to the equivalent MSP430 signals.

TI MSP430 DLL Interface

Describes the MSP430 DLL interface, which is used to connect to a variety of devices, including the TI MSP-FET430UIF and Olimex MSP430-JTAG-TINY.

MSP430 core simulator

Describes the core simulator provided by CrossStudio, which you can use to develop software without access to hardware.

CrossConnect Target Interface

Connection

Property	Description
Enable Regulator enableRegulator – Boolean	Specifies whether the regulator is enabled when the target is connected.

Current

Property	Description
Operating Voltage operatingVoltage – String	Returns the operating voltage of the target.
Serial Number connectedSerialNumber – String	The serial number of the currently connected CrossConnect.
Version firmwareVersion – String	The firmware revision of the currently connected CrossConnect.

Loader

Property	Description
Enable Fast Flashing fast_flash_writes – Boolean	Enable block-mode fast flashing for devices that support it.

Target

Property	Description
Device Type – String	The detected type of the currently connected target device.
Host Connection Connection – Enumeration	(null)

MSP430 DLL Target Interface

Connection

Property	Description
Interface Type interfaceType – Enumeration	The target interface type to use.
Is USB Device isUsb – Boolean	The device is connected by USB.
Target Driver DLL Path targetDllPath – FileName	Specifies the path to use to load the MSP430 target driver DLL.
Vcc vcc – Integer	Set the desired supply voltage (specified in millivolts).
Version version – String	MSP430 target driver DLL version number.

Target

Property	Description
Device Type – String	The detected type of the currently connected target device.
Host Connection Connection – Enumeration	(null)

MSP430 Core Simulator Target Interface

Target

Property	Description
Device Type – String	The detected type of the currently connected target device.



C Compiler User Guide

CrossWorks C is a faithful implementation of the ANSI and ISO standards for the programming language C. This manual describes the C language as implemented by the CrossWorks C compiler.

Command line options

This section describes the command line options accepted by the CrossWorks C compiler.

-ansi (Warn about potential ANSI problems)

Syntax

`-ansi`

Description

Warn about potential problems that conflict with the relevant ANSI or ISO standard for the files that are compiled.

Project property

Compiler Options > Enforce ANSI Checking

-D (Define macro symbol)

Syntax

`-Dname`
`-Dname=value`

Description

You can define preprocessor macros using the `-D` option. The macro definitions are passed on to the respective language compiler which is responsible for interpreting the definitions and providing them to the programmer within the language.

The first form above defines the macro *name* but without an associated replacement value, and the second defines the same macro with the replacement value *value*.

Project property

[Preprocessor Options > Preprocessor Definitions](#)

Example

The following defines two macros, **SUPPORT_FLOAT** with a value of 1 and **LITTLE_ENDIAN** with no replacement value.

```
-DSUPPORT_FLOAT=1 -DLITTLE_ENDIAN
```

-g (Generate debugging information)

Syntax

`-g`

Description

The `-g` option instructs the compiler to generate debugging information (line numbers and data type information) for the debugger to use.

Project property

[Build Options > Include Debug Information](#)

-I (Define user include directories)

Syntax

`-Idirectory`

Description

In order to find include files the compiler driver arranges for the compilers to search a number of standard directories. You can add directories to the search path using the -I switch which is passed on to each of the language processors.

Project property

Preprocessor Options > User Include Directories

You can specify more than one include directory by separating each directory component with either a comma or semicolon.

-J (Define system include directories)

Syntax

-J*directory*

Description

The -J option adds *directory* to the end of the list of directories to search for source files included (using triangular brackets) by the #include preprocessor command.

Project property

Preprocessor Options > System Include Directories

You can specify more than one include directory by separating each directory component with either a comma or semicolon in the property

-m (Set MSP430 code memory size)

Syntax

`-m64k`
`-m1m`

Description

This option instructs the compiler to generate code for an MSP430 with with 64 kilobytes of code memory (a compact model) or up to 1 megabyte of code memory (a large model). If you generate code for a standard MSP430 processor that cannot support a large address space, this option is ignored.

For some processors, such as the CC430, although they have an MSP430X core, they do not have code memory that extends beyond the first 64 kilobytes of the address space. In this case it is beneficial, in terms of code space, data space, and execution time, to use the compact memory model which limits the total address space to 64 kilobytes.

-mcpux (Enable MSP430X processor)

Syntax

-mcpux

Description

This option instructs the compiler to generate code for the 20-bit MSP430X CPU core rather than a 16-bit MSP430 core. Note that it is not possible, in general, to mix code generated for the MSP430X with code generated for the MSP430.

By default the compiler selects large model when compiling code for an MSP430X. If your target processor has an MSP430X core with a total memory space of less than 64K, you will use less code and data space, and decrease execution time, if you select the compact memory model with the **-m64k** switch.

Project property

The correct CPU type is selected when you select or change your project's target processor. You can override this but we strongly discourage you from doing this.

-mmpy (Enable hardware multiplier)

Syntax

`-mmpy`

Description

This option instructs the compiler to generate code that can use the MSP430 hardware multiplier. By default, the hardware multiplier is not used and all integer and floating-point multiplications are carried out by software loops.

When using the hardware multiplier, the compiler ensures that no interrupts occur during the time the multiplier is in use. Global interrupts are disabled during a multiplication to prevent, for instance, an interrupt being taken immediately after the multiplication is complete but before the result has been loaded which could possibly corrupt the result of the multiplication. Because interrupts are disabled during hardware-assisted multiplication, interrupt latency is increased—if you wish to have the lowest possible interrupt latency, then do not enable the hardware multiplier and use soft multiplication instead.

The CrossWorks compiler generates inline code to use the hardware multiplier for 16-bit multiplications and calls out-of-line subroutines for all other multiplications. The runtime library also uses the hardware multiplier to accelerate multiplication of floating-point values.

Project property

Compiler Options > Use Hardware Multiplier

It is not possible to set this option on a per-file basis.

Note

There is no means to prevent a non-maskable interrupt from occurring, so you must be very careful not to use the hardware multiplier in an NMI interrupt service routine.

-msd (Treat double as float)

Syntax

`-msd`

Description

This option directs the compiler to treat **double** as **float** and not to support 64-bit floating point arithmetic.

Project property

Compiler Options > Treat 'double' as 'float'

It is not possible to set this option on a per-file basis.

-o (Set output file name)

Syntax

`-o filename`

Description

The `-o` option instructs the compiler to write its object file to *filename*.

-O (Optimize code generation)

Syntax

`-Olevel`

Description

Optimize at level *level* which must be between -9 and +9. Negative values of *level* optimize code space at the expense of speed, whereas positive values of *level* optimize for speed at the expense of code space. The '+' sign for positive optimization levels is accepted but not required.

The exact strategies used by the compiler to perform the optimization will vary from release to release and are not described here.

Project property

[Code Generation Options > Optimization Strategy](#)

-Or (Optimize register allocation)

Syntax

`-Or{g | l | -}`

Description

This selects the way that registers are allocated:

- `-Org` enables allocation of local variables and addresses of global variables and functions to processor registers for the lifetime of a function. This form of register allocation will always reduce code size but may reduce execution speed for some paths through the function.
- `-Orl` enables allocation of local variables (but not addresses of global variables and functions) to processor registers for the lifetime of a function. Register allocation of locals to processor registers will always reduce code size and increase execution speed.
- `-Or-` disables all allocation of values and addresses to processor registers.

Project property

[Code Generation Options > Register Allocation](#)

-Rc (Set default code section name)

Syntax

`-Rc,name`

Description

The -Rc command line option sets the name of the section that the compiler emits code into. If no other options are given, the default name for the section is **CODE**.

You can control the name of the code section used by the compiler within a source file using the [#pragma codeseg](#) or by using CrossStudio to set the **Code Section Name** property of the file or project.

Project property

Section Options > Code Section Name

-Rd (Set default initialized data section name)

Syntax

`-Rd,name`

Description

The **-Rd** command line option sets the name of the section that the compiler emits code into. If no other options are given, the default name for the section is **IDATA0**.

You can control the name of the code section used by the compiler within a source file using the [**#pragma dataseg**](#) or by using CrossStudio to set the **Data Section Name** property of the file or project.

Project property

Section Options > Data Section Name

-Ri (Set default ISR section name)

Syntax

`-Ri,name`

Description

The `-Ri` command line option sets the name of the section that the compiler emits interrupt service routine (ISR) code into. If no other options are given, the default name for the section is **ISR**.

You can control the name of the code section used by the compiler within a source file using the [`#pragma isrseg`](#) or by using CrossStudio to set the **ISR Section Name** property of the file or project.

Project property

Section Options > ISR Section Name

-Rk (Set default read-only section name)

Syntax

`-Rk,name`

Description

The `-Rk` command line option sets the name of the section that the compiler emits read-only data into. If no other options are given, the default name for the section is **CONST**.

You can control the name of the code section used by the compiler within a source file using the [`#pragma constseg`](#) or by using CrossStudio to set the **Constant Section Name** property of the file or project.

Project property

Section Options > Constant Section Name

-Rv (Set default vector section name)

Syntax

`-Rv,name`

Description

The `-Rv` command line option sets the name of the section that the compiler emits interrupt vectors into. If no other options are given, the default name for the section is **INTVEC**.

You can control the name of the code section used by the compiler within a source file using the [`#pragma vectorseg`](#) or by using CrossStudio to set the **Vector Section Name** property of the file or project.

Project property

Section Options > Vector Section Name

-Rz (Set default zeroed section name)

Syntax

`-Rz,name`

Description

The `-Rz` command line option sets the name of the section that the compiler emits zero-initialized data into. If no other options are given, the default name for the section is **UDATA0**.

You can control the name of the code section used by the compiler within a source file using the [`#pragma zeroedseg`](#) or by using CrossStudio to set the **Zeroed Section Name** property of the file or project.

Project property

Section Options > Zeroed Section Name

-V (Version information)

Syntax

-V

Description

The -V switch instructs the compiler to display its version information.

-w (Suppress warnings)

Syntax

-w

Description

This option instructs the compiler not to issue any warnings.

Project property

Build Options > Suppress Warnings

-we (Treat warnings as errors)

Syntax

`-we`

Description

This option directs the compiler to treat all warnings as errors.

Project property

Build Options > Treat Warnings as Errors

Preprocessor predefined symbols

Standard pre-processor symbols

The C preprocessor defines the following macro names:

DATE

The date of translation of the program unit. This expands to a string constant of the form "Mmm dd yy".

FILE

The name of the current source file. FILE expands to a string constant.

LINE

The line number of the current source line in the current source file. LINE expands to an integer constant.

STDC

The integer constant 1 as CrossWorks C conforms to the ISO/IEC 9899 standard. The integer constant 0 denotes that the implementation does not conform to the relevant standard.

STDC_HOSTED

The integer constant 0 as CrossWorks C is not a hosted implementation. The integer constant 1 denotes that the implementation is a hosted implementation.

STDC_VERSION

The integer constant 199409L as CrossWorks C conforms to ISO/IEC 9899:1990 with the changes required by ISO/IEC 9899/AMD1:1995. For standard C compilers conforming to ISO/IEC 9899:1999, this constant is 199901L.

TIME

The time of translation of the program unit. This expands to a string constant of the form "hh:mm:ss".

The following macro names are *not* defined by CrossWorks C as the implementation is still in the process of being upgraded to the 1999 standard.

- STDC_IEC_599
- STDC_IEC_599_COMPLEX
- STDC_ISO_10646

Architecture-dependent pre-processor symbols

The following symbols are set by the compiler (and, in fact, the assembler also) so that you can conditionally-compile your code.

-m64k only

- `__MSP430_CPUX` undefined.
- `__MSP430_CODE_ADDRESS_BITS` defined as 16

-mcpx and -m1m

- `__MSP430_CPUX` defined.
- `__MSP430_CODE_ADDRESS_BITS` defined as 20

-m64k and**-mcpx**

- `__MSP430_CPUX` defined.
- `__MSP430_CODE_ADDRESS_BITS` defined as 16

Pragmas

The C **#pragma** mechanism allows vendors to provide additional capabilities that extend or enhance the C standard. CrossWorks offers a number of pragmas to control section placement and compatibility with other products.

#pragma codeseg

Set the section name used for code.

#pragma database

Set the section name used for initialized data.

#pragma constseg

Set the section name used for read-only data.

#pragma zeroedseg

Set the section name used for uninitialized, zeroed data.

#pragma vectorseg

Set the section name used for interrupt vector tables.

#pragma isrseg

Set the section name used for interrupt service routine code.

#pragma vector

Define a vector for an interrupt function.

#pragma codeseg

Synopsis

```
#pragma codeseg("name" | default)
```

Description

The **codeseg** pragma sets the name of the section that the compiler emits code into. If the argument to the **codeseg** pragma is a string, a section of that name is created and the compiler emits code for all function definitions following the pragma into that section. If the argument to **codeseg** is the reserved word **default**, the compiler selects the default code section name.

The default code section name, if no other directives have been given, is **CODE**. You can change the default code section name for the whole compilation unit by using the [-Rc \(Set default code section name\)](#) command-line option or by setting the **Code Section Name** property of the file or project.

#pragma dataseg

Synopsis

```
#pragma dataseg("name" | default)
```

Description

The **dataseg** pragma sets the name of the section that the compiler emits initialized data into. If the argument to the **dataseg** pragma is a string, a section of that name is created and the compiler emits initialized data for all following initialized statics or externals following the pragma into that section. If the argument to **dataseg** is the reserved word **default**, the compiler selects the default data section name.

The default data section name, if no other directives have been given, is `IDATA0`. You can change the default data section name for the whole compilation unit by using the [-Rd \(Set default initialized data section name\)](#) command-line option or by setting the **Data Section Name** property of the file or project.

#pragma constseg

Synopsis

```
#pragma constseg("name" | default)
```

Description

The **constseg** pragma sets the name of the section that the compiler emits read-only data into. If the argument to the **constseg** pragma is a string, a section of that name is created and the compiler emits all following read-only data into that section. If the argument to **constseg** is the reserved word **default**, the compiler selects the default read-only section name.

The default read-only data section name, if no other directives have been given, is CONST. You can change the default read-only data section name for the whole compilation unit by using the [-Rk \(Set default read-only section name\)](#) command-line option or by setting the **Const Section Name** property of the file or project.

#pragma zeroedseg

Synopsis

```
#pragma zeroedseg("name" | default)
```

Description

The **zeroedseg** pragma sets the name of the section that the compiler emits zero-initialized data into. If the argument to the **zeroedseg** pragma is a string, a section of that name is created and the compiler emits zero-initialized data for all uninitialized statics or externals following the pragma into that section. If the argument to **zeroedseg** is the reserved word **default**, the compiler selects the default zeroed data section name.

The default zeroed data section name, if no other directives have been given, is UDATA0. You can change the default zeroed data section name for the whole compilation unit by using the [-Rz \(Set default zeroed section name\)](#) command-line option or by setting the **Zeroed Section Name** property of the file or project.

#pragma vectorseg

Synopsis

```
#pragma vectorseg("name" | default)
```

Description

The **zeroedseg** pragma sets the name of the section that the compiler emits interrupt vector tables into. If the argument to the **vectorseg** pragma is a string, a section of that name is created and the compiler emits interrupt vector tables for all following interrupt functions into that section. If the argument to **vectorseg** is the reserved word **default**, the compiler selects the default interrupt vector table section name.

The default interrupt vector table section name, if no other directives have been given, is `INTVEC`. You can change the default interrupt vector tables section name for the whole compilation unit by using the [-Rv \(Set default vector section name\)](#) command-line option or by setting the **Vector Section Name** property of the file or project.

#pragma isrseg

Synopsis

```
#pragma isrseg("name" | default)
```

Description

The **isrseg** pragma sets the name of the section that the compiler emits interrupt service routine code into. If the argument to the **isrseg** pragma is a string, a section of that name is created and the compiler emits code for all interrupt functions following the pragma into that section. If the argument to **isrseg** is the reserved word **default**, the compiler selects the default code section name.

The default ISR code section name, if no other directives have been given, is **ISR**. You can change the default interrupt code section name for the whole compilation unit by using the [-Ri \(Set default ISR section name\)](#) command-line option or by setting the **ISR Section Name** property of the file or project.

#pragma vector

Synopsis

```
#pragma vector=expr
```

Description

The **vector** pragma sets the interrupt service routine vector for the following function definition, if that function is an interrupt function.

Example

```
#pragma vector=14*2
void isr(void) __interrupt
{
    // Interrupt service routine code
}
```

This form of providing an interrupt vector makes CrossWorks C compatible with IAR's C compiler and the vast range of example code written for that compiler.

Section control

The CrossWorks C compiler separates generated code and data into sections so that they can be individually placed by the linker. It's the linker's job to combine, and make contiguous, sections of the same name from multiple object files.

You can change the sections that the compiler uses for individual data objects or functions using appropriate pragmas. The default section names and their use by the compiler are:

- `CODE` contains code generated for functions. See [-Rc \(Set default code section name\)](#).
- `ISR` contains code generated for interrupt service routines that may need special placement. See [-Ri \(Set default ISR section name\)](#).
- `IDATA0` contains static initialized data. See [-Rd \(Set default initialized data section name\)](#).
- `UDATA0` contains static zeroed (uninitialized) data. See [-Rz \(Set default zeroed section name\)](#).
- `CONST` contains read-only constant data. See [-Rk \(Set default read-only section name\)](#).
- `INTVEC` contains interrupt vector tables data. See [-Rv \(Set default vector section name\)](#).

Section overrides

The pragmas that allow you to change the default section names may well be a little cumbersome for some uses. The CrossWorks C compiler allows you to specify the section name to use for both data items and functions using the `_at` keyword.

Placing data objects in sections

To define the variable `config` and place it in the section **CONFIGVARS**, you would use:

```
int config __at "CONFIGVARS";
```

This will allocate space for the variable `config` in the **CONFIGVARS** section.

Placing functions in sections

To define the function `startup` and place it in section **BOOTSTRAP**, you would use:

```
void startup(void) __at "BOOTSTRAP"
{
    // Bootstrap code
}
```

Absolute data object placement

In addition to placing data into sections, the CrossWorks C compiler allows you to specify an absolute address for a variable using `__at`:

```
int version __at 0x200;
```

Note that this form of declaration *does not allocate space for the variable*. That is, the variable is not passed to the linker for placement and data will not flow around the variable using the linker's intelligent placement schemes. This syntax is provided only as a way to make code more readable and is somewhat equivalent to...

```
#define version (*(int *)0x200)
```

...but without using the C preprocessor.

Type-based enumerations

CrossWorks offers *type-based enumerations*, an extension to the ISO standard to set the size of enumeration types. You can use type-based enumerations to select the base type for your enumeration. Using type-based enumeration you can reduce the size of your application by using enumerations that match the size of the underlying data rather than using the default **int**-based enumeration.

Syntax

```
enum [base-type]
```

Where *base-type* is either a plain, **signed**, or **unsigned** variant of **char**, **int**, **long**, or **long long**.

Example

Use an 8-bit unsigned character to define an enumeration that maps onto a single byte and map that onto a byte at location 000₁₆:

```
enum unsigned char T0CN_t {
    M0      = 1<<0,
    M1      = 1<<1,
    CT      = 1<<2,
    GATE    = 1<<3,
    TR0     = 1<<4,
    TF0     = 1<<5,
    T0M     = 1<<6,
    ET0     = 1<<7
};

enum T0CN_t T0CN __at 0x100;
```

Special functions

This section describes the way in which code is generated and the models that the CrossWorks compiler uses.

Interrupt functions

It's common for embedded systems to be *real time systems* which need to process information as it arrives and take some action immediately. Processors provide *interrupts* specifically for this, where normal program execution is suspended whilst an interrupt service routine is executed, finally returning to normal program execution when the interrupt is finished.

Interrupt sources are chip-specific and you can find the exact interrupt sources from each processor's data sheet.

You define an interrupt function just like a standard C function, but in addition you tell the compiler that it is an interrupt function and optionally which vectors to use. The compiler generates the correct return sequence for the interrupt and saves any registers that are used by the function. Note that the name of the interrupt function is not significant in any way.

Initializing a single interrupt vector

This constructs an interrupt function called **handle_timer_interrupt** and initializes **TIMER_VECTOR** in the processor's interrupt vector table to point to **handle_timer_interrupt**.

```
void handle_timer_interrupt(void) __interrupt[TIMER_VECTOR]
{
    /* Handle interrupt here */
}
```

Initializing multiple interrupt vectors

This constructs an interrupt function called **handle_spurious_interrupt** and initializes the three vectors **UART0_RX_VECTOR**, **UART0_TX_VECTOR**, and **ACCVIO_VECTOR** in the processor's interrupt vector table to point to **handle_spurious_interrupt**.

```
void
handle_spurious_interrupt(void) __interrupt[UART0_RX_VECTOR,
                                             UART0_TX_VECTOR,
                                             ACCVIO_VECTOR]
{
    /* Handle interrupt here */
}
```

A plain interrupt handler

This constructs an interrupt function called **handle_pluggable_interrupt** but does not initialize the interrupt vector table. This style of interrupt function is useful when you plug different interrupt routines into a RAM-based table to dynamically change interrupt handlers when the application runs.

```
void handle_pluggable_interrupt(void) __interrupt
{
    /* Handle interrupt here */
}
```

Alternative form

The CrossWorks C compiler provides an alternative form to specify interrupt vectors; see [#pragma vector](#).

Monitor functions

In embedded systems it's common for access to critical system structures to be protected by disabling and then enabling interrupts so that interrupt service routines are not executed during the update. You can write your own code to do this using the `__disable_interrupt` and `__set_interrupt` intrinsic functions like this:

```
void update_critical_resource(void)
{
    // Disable interrupts and save previous interrupt enable state
    unsigned state = __disable_interrupt();

    // Update your critical resource here...
    task_list = task_list->next; // just an example

    // Restore interrupt state on entry
    __set_interrupt(state);
}
```

If you disabled and enabled interrupts using `__disable_interrupt` and `__enable_interrupt`, rather than using `__disable_interrupt` and `__set_interrupt` as above, calling the function with interrupts disabled would re-enable interrupts on return which is usually not what you want. If you write your code in the same fashion as above you can call the function and be sure that it's run with interrupts disabled and that on return the interrupt enable state is as it was before the call.

Because this type of function is so common, CrossWorks provides the `__monitor` keyword. Using `__monitor` the example above becomes:

```
void update_critical_resource(void) __monitor
{
    // Update your critical resource here...
    task_list = task_list->next; // just an example
}
```

Top-level functions

Usually the compiler saves and restores registers in a function according to the calling convention and, in almost all cases, this is exactly what you want. However, there are some cases where it's just not necessary to save registers on entry to a function as it is a *top-level function* and will not be called directly from code. The compiler can't easily detect these cases so you can point them out using the `__toplevel` attribute.

The most common function, `main`, is a good example of a top-level function: it's only called by the runtime startup code, runs, and usually never terminates in an embedded system. As such, CrossWorks automatically marks `main` as a top-level function which instructs the code generator not to save and restore registers on entry and exit because their values are not required.

Another good example is top-level task functions when you're using the CrossWorks tasking library; in this case, you can safely declare all your task functions with the `toplevel` attribute because none of their registers are unimportant on entry and exit. Using the `toplevel` attribute in this way will reduce the stack requirement of the task.

Example

```
void task1(void *p) __toplevel
{
    // task code
}

void task2(void *p) __toplevel
{
    // task code
}

void main(void)
{
    ctl_task_run(&task1Task, 1, task1, 0, "task1", sizeof(task1Stack)/sizeof(unsigned),
    task1Stack);
    ctl_task_run(&task2Task, 1, task2, 0, "task2", sizeof(task2Stack)/sizeof(unsigned),
    task2Stack);
}
```

External naming convention

CrossWorks makes a distinction between the low-level symbol names used for C objects and the names of the C objects themselves. The CrossWorks compiler always prepends an underscore character '_' to the name of any externally visible C function or variable when constructing its low-level symbol name.

For example, an external variable declared at the C level 'extern int x' will be accessible at the assembly level using the name '_x'.

Data representation

All data items are held in the native byte order of the MSP430 processor. The plain character type is signed by default. The floating-point types **float** and **double** are implemented as 32-bit and 64-bit IEEE floating-point.

Data Type	Size in bytes	Alignment in bytes
char, signed char, and unsigned char	1	1
int and unsigned int	2	2
short and unsigned short	2	2
long and unsigned long	4	2
long long and unsigned long long	8	2
float and double (compiled with -msd)	4	2
double and long double	8	2
type * (pointer)	2	2
enum (enumeration)	2	2

When compiling for the MSP430X in the 1MB addressing mode using **-m1m**, function pointers are still represented in a 16-bit pointer but are ‘thunked’. That is, the compiler uses an indirect call through the 16-bit address to anywhere in the 20-bit address range.

As a C programmer this has no impact on the way that you write your code, but if you are passing function pointers to assembly code or are dealing with function pointers at a low-level, such as porting an RTOS, then you need to be aware that function pointers are not held as 20-bit addresses.

Register use

The compiler partitions the MSP430 general purpose registers into two sets.

The registers in the first set, **R12** through **R15**, are used for parameter passing and returning function results and are not preserved across functions calls.

The registers in the second set, **R4** through **R11**, are used for register-allocated variables, working storage, and temporary results and must be preserved across function calls.

Parameter passing

The compiler uses the scratch registers to pass values to the called routine for all parameters of simple data type. If there are not enough scratch registers to hold all parameter data to be passed to the called routine, the excess data are passed on the stack.

Simple data types which require more than a single word of storage are passed in register pairs or register quads. The register requirement for the basic data types are:

- Eight-bit and 16-bit types require one register.
- 32-bit types require two registers.
- 64-bit types require four registers.

Allocation of the scratch registers for function calls proceeds in a left-to-right fashion, starting with register **R15** and progressing in reverse order to **R12**. The compiler tries to fit each parameter into the scratch registers and, if it can, allocates those registers to the incoming parameter. If the parameter requires more scratch registers than are free, it is noted and is passed on the stack. All parameters which are passed on the stack are pushed in reverse order.

Function return values

The compiler uses the scratch registers to return values to the caller.

- The eight-bit and 16-bit type **char**, **int**, **short**, enumerations, and any pointer type are returned in **R15**
- The 32-bit types **long** and **float** (and **double** if compiled with **double** equivalent to **float**) are returned in the register pair **R15–R14**, with **R15** holding the most-significant word of the result and **R14** the least-significant word.
- The 64-bit types **long long** and **double** are returned in the register quad **R15–R12** with **R15** holding the most-significant word of the result and **R12** the least-significant word.

Examples

This section contains some examples of the calling convention in use.

Example #1

```
void fun1(int u, int v);
```

Reading from left to right, the parameter **u** is passed in register **R15** and **v** is passed in **R14**. The scratch registers **R12** and **R13** are not used to pass parameters and can be used in **fun1** without needing to be preserved.

Example #2

```
void fun1(int u, long v, int w);
```

The parameter **u** is passed in register **R15**. Because **v** requires two registers to hold its value it is passed in the register pair **R14–R13** with **R14** holding the high part of **v** and **R13** the low part. The final parameter **w** is passed in **R12**.

Example #3

```
void fun1(int u, long v, int w, int x);
```

The parameter **u** is passed in register **R15**. Because **v** requires two registers to hold its value it is passed in the register pair **R14–R13** with **R14** holding the high part of **v** and **R13** the low part. The final parameter **w** is passed in **R12**. As all scratch registers are now used, **x** is passed by placing it on the stack.

Example #4

```
void fun1(int u, long v, long w);
```

The parameter **u** is passed in register **R15**. Because **v** requires two registers to hold its value it is passed in the register pair **R14–R13** with **R14** holding the high part of **v** and **R13** the low part. When considering **w**, there is only one free scratch register left, which is **R12**. The compiler cannot fit **w** into a single register and therefore places the argument onto the stack—the compiler does not split the value into two and pass half in a register and half on the stack.

Example #5

```
void fun1(int u, long v, long w, int x, int y);
```

The parameter **u** is passed in register **R15**. Because **v** requires two registers to hold its value it is passed in the register pair **R14–R13** with **R14** holding the high part of **v** and **R13** the low part. When considering **w**, there is only one free scratch register left, which is **R12**. The compiler cannot fit **w** into a single register and therefore places the argument onto the stack—the compiler does not split the value into two and pass half in a register and half on the stack.

When considering **x** the compiler sees that **R12** is unused and so passes **x** in **R12**. All scratch registers are used when considering **y**, so the argument is placed onto the stack. The parameters **w** and **x** are pushed onto the stack before the call and are pushed in reverse order, with **y** pushed before **w**.

This example shows two parameters, **w** and **y**, that are passed to the called routine on the stack, but they are separated by a parameter **x** that is passed in a register.



Assembler User Guide

This manual is a reference for the CrossWorks assembler. It does not explain the architecture of the process machine or teach how to construct an application in assembly code.

The *assembler* converts assembly source code to relocatable object code in object code files. The *linker* combines object code files to form an application containing the final instructions.

Command-line syntax

To invoke the assembler, use the following syntax:

has [*option...*] *file*

file is the source file to assemble and *option* is a command-line option. Options are case sensitive and cannot be abbreviated.

In this section

-D (Define macro symbol)

Syntax

`-Dname`
`-Dname=value`

Description

This option instructs the assembler to define a symbol for the compilation unit. If no value is given, the symbol is assigned the value -1.

-g (Generate debugging information)

Syntax

`-g`

Description

The `-g` option instructs the assembler to insert debugging information into the output file. This allows you to single step through assembly language files at the source level, with all its annotation, rather than studying a disassembly of the code. And declared, typed data is displayed rather than simply its addresses.

-I (Define user include directories)

Syntax

`-Idirectory`

The `-I` option adds *directory* to the end of the list of directories, to search for source files included (using quotation marks) by the **INCLUDE** and **INCLUDEBIN** directives.

-J (Define system include directories)

Syntax

-J*directory*

The **-J** option adds *directory* to the end of the list of directories, to search for source files included (using triangular brackets) by the **INCLUDE** and **INCLUDEBIN** directives.

-o (Set output file name)

Syntax

`-o filename`

Description

The `-o` option instructs the assembler to write its object file to *filename*.

-Rc (Set default code section name)

Syntax

`-Rc,name`

Description

The -Rc command-line option sets the name of the section the assembler uses with the **TEXT** directive. If it is not specified, the default name for the section is **CODE**.

Project property

Section Options > Code Section Name

-Rd (Set default initialized data section name)

Syntax

`-Rd,name`

Description

The **-Rd** command-line option sets the name of the section the assembler uses for the **DATA** directive. If it is not specified, the default name for the section is **IDATA0**.

Project property

Section Options > Data Section Name

-Ri (Set default ISR section name)

Syntax

`-Ri,name`

Description

The **-Ri** command-line option sets the name of the section the assembler uses for the **ISR** directive. If it is not specified, the default name for the section is **ISR**.

Project property

Section Options > ISR Section Name

-Rk (Set default read-only section name)

-Rk,*name*

Description

The **-Rk** command-line option sets the name of the section the assembler uses for the **CONST** directive. If it is not specified, the default name for the section is **CONST**.

Project property

Section Options > Constant Section Name

-Rv (Set default vector section name)

-Rv,*name*

Description

The **-Rv** command-line option sets the name of the section the assembler uses for the **VECTORS** directive. If it is not specified, the default name for the section is **INTVEC**.

Project property

Section Options > Vector Section Name

-Rz (Set default zeroed section name)

-Rz,*name*

Description

The **-Rz** command-line option sets the name of the section the assembler uses for the BSS directive. If it is not specified, the default name for the section is **UDATA0**.

Project property

Section Options > Zeroed Section Name

-V (Version information)

Syntax

-V

Description

The -V switch instructs the assembler to display its version information.

-w (Suppress warnings)

Syntax

-w

Description

This option instructs the assembler not to issue any warnings.

Project property

[General Options > Suppress Warnings](#)

-we (Treat warnings as errors)

Syntax

-we

Description

This option directs the assembler to treat all warnings as errors.

Project property

General Options > Treat Warnings as Errors

Source format

A statement is a combination of mnemonics, operands, and comments that defines the object code to be created at assembly time. Each line of source code contains a single statement.

Assembler source lines

Assembler statements take the form:

[label] [operation] [operands] [comment]

All fields are optional, although the operand or label fields may be required if certain directives or instructions are used in the operation field.

Label Field

The label field starts at the left of the line, with no preceding spaces. A label name is a sequence of alphanumeric characters, starting with a letter. You can also use the dollar sign '\$' and underline character '_' in label names. A colon may be placed directly after the label, or it can be omitted. If a colon is placed after a label, it defines that label to have the value of the location counter in the current section.

Operation field

The operation field contains either a machine instruction or an assembler directive. You must write these in either all uppercase or all lowercase—mixed case is not allowed. The operation field must not start at the leftmost position of the line; at least one space must precede it, if there is no label field. At least one space must separate the label field and the operation field.

Operand field

The contents of the operand depend upon the instruction or directive in the operation field. Different instructions and directives have different operand field formats. Please refer to the specific directive documentation for details of the operand field.

Comment field

The comment field is optional. It contains information that is not essential to the assembler but is useful for documentation. The comment field must be separated from any preceding fields by at least one space.

Comments

To help others better understand some particularly tricky piece of code, you can insert comments into the source code. Comments are informational and have no significance for the assembler. They come in two forms: single-line comments and multi-line comments.

Single-line comments

A single-line comment is introduced either by the single character ; or by the two consecutive characters //.

Syntax

```
// character...  
; character...
```

The assembler ignores all characters from the comment introducer to the end of the line. This type of comment is particularly good when you want to comment a single assembler line.

Multi-line comments

A multi-line comment resembles a standard C comment, it is introduced by the characters /* and is terminated by */.

Syntax

```
/* character... */
```

Anything between these delimiters is ignored by the assembler. You can use this type of comment to place large amounts of commentary, such as copyright notices or functional descriptions, into your code.

Types

In contrast to most assemblers, the CrossWorks assembler fully understands data types. The most well-known and widely used assembler that uses data typing extensively is Microsoft's MASM and its many clones. If you've used MASM, you should be comfortable with the concept of data types in an assembler and with the CrossWorks implementation of data typing.

If you haven't used MASM, you may wonder why data typing should be put into an assembler, given that many assembly programs are written without the help of data types. But there are many good reasons to do so, even without the precedent set by Microsoft, and the two most valuable benefits are:

- The ability to catch potential or real errors at assembly time rather than letting them go undetected until applications are deployed.
- Data typing is an additional and effective source of program documentation, describing the way data are grouped and represented.

We don't expect you to fully appreciate the usefulness of assembly-level data typing until you use it in an application and gain first-hand experience of both the benefits mentioned above. Of course, it's still possible to write (almost) typeless assembly code using the CrossWorks assembler, if you should wish to do so, but effective use of data typing is a real programmer aid when writing code. Lastly, we should mention another important benefit data typing brings: the interaction between properly typed assembly code and the debugger. If you correctly type your data, the debugger will present the values held in memory, using a format based on the type of the object rather than as a string of hexadecimal bytes. Having source-level debugging information displayed in a human-readable format is another way to improve productivity.

Built-in types

The CrossWorks assembler provides a number of built-in or predefined data types. They correspond to those in a high-level language such as C. You can use them to allocate data storage; for instance, the following allocates one byte of data for the **count** symbol:

```
count    DV      BYTE
```

The directive **DV** allocates one byte of space for **count** in the current section and sets **count**'s type to **BYTE**.

Type name	Size in bytes	Description
BYTE	1	Unsigned 8-bit byte
WORD	<i>processor-dependent</i>	Unsigned word, dependent upon processor word size
LONG	4	Unsigned 32-bit word
CHAR	1	8-bit character
ADDR	<i>processor-dependent</i>	Address

Array types

You can declare arrays of any predefined or user-defined type. Arrays are used extensively in high-level languages; therefore, we decided they should be available in the CrossWorks assembler for easier integration with C.

An array type is constructed by specifying the number of array elements in brackets after the data type.

Syntax

`type [array-size]`

This declares an array of *array-size* elements, each of data type *type*. The array size must be an absolute constant known at assembly time.

Example

The type...

```
BYTE[ 8 ]
```

...declares an array of eight bytes.

Pointer types

You can declare pointers to types, as in most high-level languages.

Syntax

type PTR

This declares a pointer to the data type *type*.

Example

The type...

```
CHAR PTR
```

...declares a pointer to a character. The built-in type **ADDR** is identical to the type **BYTE PTR**.

Structure types

Using the **STRUC**, **UNION**, and **FIELD** directives, you can define data items that are grouped together. Such a group is called a *structure* and can be thought of in the same way as a structure or *union* in C. Structured types are bracketed between **STRUC** and **ENDSTRUC**, and should contain only **FIELD** directives; similarly, unions are bracketed between **UNION** and **ENDUNION**, and should only contain **FIELD** directives.

Example

We could declare a structure type called **Amount** that has two members, **Dollars** and **Cents**, like this:

```
Amount STRUC
Dollars FIELD LONG
Centse FIELD BYTE
ENDSTRUC
```

The field **Dollars** is declared to be of type **LONG** and **Cents** is of type **BYTE** (so we can count lots of Dollars, and a small amount of loose change).

In structures, fields are allocated one after another, increasing the size of the structure for each field added. For a union, all fields are overlaid, and the size of the union is the size of the largest field within the union.

Example

For a 32-bit, big-endian machine, we could overlay four bytes over a 32-bit word like this:

```
Word UNION
asWord FIELD WORD
asBytes FIELD BYTE[4]
ENDUNION
```

The most useful thing about user-defined structures is that they act like any built-in data type, so you can allocate space for variables of the structure type:

```
Balance DV Amount
```

Here we've declared enough storage for the variable **Balance** to hold an **Amount**, and the assembler (and debugger) knows that **Balance** is of type **Amount**.

Compilation units and libraries

When applications grow large, they are usually broken into smaller, manageable pieces called *compilation units*. Each piece is compiled separately, then the pieces are stitched together by the linker to produce the final application.

When you partition a application into separate compilation units, you will need to indicate how a symbol defined in one unit is referenced by the code in other units. This section will show how to declare exported and imported symbols that can be used in more than one unit.

When building applications, you often find pieces of code that can be reused in other applications. Rather than duplicating such source code, you can package these units into a *library*.

The CrossWorks tools were designed to be flexible and let you to easily write space-efficient programs using libraries and separate compilation. To that end, the assembler-and-linker combination provides a number of features not found in many compilation systems.

- Optimum-sized branches — The linker automatically resizes branches to labels too far away to be reached by a branch instruction. This is completely transparent to the programmer—when you use branch instructions, your linked program will always use the smallest possible branch. This capability is deferred to the linker so even branches across compilation units are optimized.
- Removing dead code and data — The most important feature of the linker is its ability to leave unreferenced code and data out of the final application. The linker discards all code and data fragments that cannot be reached from any entry symbols.
- Whole-program optimization — The linker can optimize the application as a whole, rather than on a per-function or per-compilation-unit basis.

Directive reference

This section describes the directives supported by the assembler.

ALIGN

Syntax

ALIGN *type | number*

The operand given after the directive defines the alignment requirement. If a type is given, the location counter is adjusted to be divisible by the size of the type with no remainder. If a number is given, the location counter is adjusted to be divisible by 2^{number} with no remainder.

Example

```
ALIGN LONG
```

This aligns the location counter to lie on a 4-byte boundary (because the type **LONG** is 4 bytes in size).

Example

```
ALIGN 3
```

This aligns the location counter to lie on an 8-byte boundary (because 2^3 equals 8).

BREAK

Syntax

BREAK

SEGEND

Description

The **SEGEND** and **BREAK** directives start a new *fragment* within the current section. A fragment is set of instructions the linker will elect to include in its output *if a reference is made to one of the instructions in the fragment*. If no reference is made to a fragment, the linker will not include that fragment in the output.

BSS

Syntax

BSS

Description

The **BSS** and **ZDATA** directives select the default, zeroed data section. The section is named **UDATA0** unless it has been renamed via the **-Rz** command-line option.

CODE

Syntax

CODE

Description

The **CODE** and **TEXT** directives select the default code section. The section is named **CODE** unless it has been renamed via the **-Rc** command-line option.

CONST

Syntax

CONST

Description

The CONST directive selects the default, read-only data section. The section is named CONST unless it has been renamed via the -Rk command-line option.

DATA

Syntax

DATA

Description

The **DATA** directive selects the default, initialized-data section. The section is named **IDATA0** unless it has been renamed via the **-Rk** command-line option.

DB

Syntax

DB *initializer* [, *initializer*]...

Description

A synonym for **DC.B**, see [DC.B](#).

DC.B

Syntax

DC.B *initializer* [, *initializer*]...

Description

The **DC.B** directive defines an object as an initialized array of bytes. If the directive is labeled, the label is assigned the location counter of the current section before the data is placed in that section. If a single initializer is present, the label's data type is set to **BYTE**; otherwise, it is set to be a fixed array of **BYTE**, the bounds of which are set by the number of elements defined.

Example

```
Mask DC.B 0x01, 0x03, 0x07, 0x0f, 0x1f, 0x3f, 0x7f, 0xff
```

This defines the label **Mask** and allocates eight bytes with the given values. The type of **Mask** is set to **BYTE[8]**, an array of eight bytes, because eight values are listed.

You use the **DB** directive to define string data. When the assembler sees a string, it expands it into a series of bytes and places those into the current section.

Example

```
BufOvfl DC.B 13, 10, "WARNING: buffer overflow", 0
```

This emits the bytes 13 and 10 into the current section, followed by the ASCII bytes comprising the string, and finally a trailing zero byte.

DC.W

Syntax

DC.W *initializer* [, *initializer*]...

DW *initializer* [, *initializer*]...

Description

The **DC.W** directive defines an object as an initialized array of words i.e. 2 bytes. If the directive is labeled, the label is assigned the location counter of the current section before the data is placed in that section. If a single initializer is present, the label's data type is set to **WORD**; otherwise, it is set to be a fixed array of **WORD**, the bounds of which are set by the number of elements defined.

Note

The location counter is *not* aligned before allocating space.

DC.L

Syntax

DC.L *initializer* [, *initializer*]...

DL *initializer* [, *initializer*]...

Description²

The {DC.L} directive defines an object as an initialized array of longs i.e. 4 bytes. If the directive is labeled, the label is assigned the location counter of the current section before the data is placed in that section. If a single initializer is present, the label's data type is set to **LONG**; otherwise, it is set to be a fixed array of **LONG** values, the bounds of which are set by the number of elements defined.

Note

The location counter is *not* aligned before allocating space.

DL

Syntax

DL *initializer* [, *initializer*]...

Description

A synonym for **DC.L**, see [DC.L](#).

DS.B

Syntax

DS.B *n*

RMB *n*

Description

These directives generate *n* bytes of zeros into the current section and adjusts the location counter accordingly. If the directive is labeled, the label is assigned the location counter of the current section before the space is allocated in that section. If *n* is one, the label's data type is set to **BYTE**; otherwise, it is set to be a fixed array of **BYTE[n]** elements.

DSECT

Syntax

DSECT "*section-name*"

Description

The **DSECT** directive creates a new, initialized-data section named *section-name*. Subsequent data-allocation directives are directed to this section.

Example

```
DSECT "CALIBRATION"
```

DS.L

Syntax

DS.L *n*

Description

These directives generate *n* long words of zeros in the current section and adjust the location counter accordingly. If the directive is labeled, the label is assigned the location counter of the current section before the space is allocated. If *n* is one, the label's data type is set to **LONG**; otherwise, it is set to be a fixed array of **LONG[n]** elements.

Note

The location counter is *not* aligned before allocating space.

DS.W

Syntax

DS.W *n*

RMW *n*

Description

These directives generate *n* words of zeros in the current section and adjust the location counter accordingly. If the directive is labeled, the label is assigned the location counter of the current section before the space is allocated. If *n* is one, the label's data type is set to **WORD**; otherwise, it is set to be a fixed array of **WORD[n]** elements.

The number of bytes per word is determined by the target processor. For 32-bit processors, one word is four bytes; for 8-bit and 16-bit processors, one word is two bytes.

Note

The location counter is *not* aligned before allocating space.

DV

Syntax

DV *datatype* [=initializer]

Description

This directive reserves space for a data item of type *datatype* and, optionally, initializes it to a value. The initializer is a comma-separated list of numbers and strings.

Note

The location counter is *not* aligned before allocating space.

DW

Syntax

`DW initializer [, initializer]...`

Description

A synonym for `DC.W`, see [DC.W](#).

ELSE

Syntax

ELSE

Description

The **ELSE** directive introduces the 'else' part of an **IF** construct. See **IF** for more information.

END

Syntax

END

Description

The optional **END** directive indicates the end of assembly—no text beyond **END** is processed.

ENDIF

Syntax

ENDIF

Description

The **ENDIF** directive closes the innermost **IF** construct. See [IF](#) for more information.

EQU

Syntax

symbol EQU expression symbol = expression

Description

The assembler evaluates the expression and assigns its value to the symbol. The expression need not be constant or even known at assembly time; it can be any value and may include complex operations involving external symbols.

EVEN

Syntax

EVEN

Description

The **EVEN** directive is equivalent to **ALIGN 1** and aligns the location counter to the next even address.

EXPORT

Syntax

EXPORT *symbol*

PUBLIC *symbol*

Description

The **EXPORT** and **PUBLIC** directives export the definition of *symbol*, making it available to other compilation units.

FILL

Syntax

FILL *size, value*

Description

The **FILL** directive generates *size* bytes of *value* into the current section and adjusts the location counter accordingly.

Example

```
FILL 5, ' '
```

This generates five spaces in the current section.

IF

Syntax

IF *expression*

The **IF** directive provides a conditional-assembly feature.

The structure of conditional assembly is much like that used by high-level language conditional constructs and by the C pre-processor. The directives **IF**, **IFDEF**, **IFNDEF**, **ELIF**, and **ENDIF** are available.

These directives may be prefixed with a # and can start in the first column, thus enabling them to look like C pre-processor directives.

The controlling expression must be an absolute assembly-time constant. When the expression is non-zero, the true conditional arm is assembled; when the expression is zero, the false conditional body, if any, is assembled.

The **IFDEF** and **IFNDEF** directives are specialized forms of the **IF** directive. **IFDEF** tests for the existence of the supplied symbol, **IFNDEF** tests for the non-existence of the supplied symbol.

Example

```
IF type == 1
    CALL type1
ELSE
    IF type == 2
        CALL type2
    ELSE
        CALL type3
    ENDIF
ENDIF
```

The nested conditional can be replaced by using the **ELIF** directive, which acts like **ELSE IF**:

```
IF type == 1
    CALL type1
ELIF type == 2
    CALL type2
ELSE
    CALL type3
ENDIF
```

Example

The usual practice is to use a symbol, **DEBUG**, as a flag to either include or exclude debugging code. Now you can use **IFDEF** to conditionally assemble some parts of your application, depending on whether the **_DEBUG** symbol is defined.

```
IFDEF _DEBUG
    CALL DumpAppState
ENDIF
```

IMPORT

Syntax

IMPORT *symbol, symbol, ...*

EXTERN *symbol, symbol, ...*

EXTRN *symbol, symbol, ...*

Description

The **IMPORT** directive defines **symbol** as being *external*, that is, defined by another compilation unit.

INCLUDE

Syntax

INCLUDE "filename"

INCLUDE <filename>

Description

The **INCLUDE** directive inserts the contents of the source file *filename* into the assembly. If *filename* is enclosed in quotation marks, the user include directories are searched; if *filename* is enclosed in triangular brackets, the system include directories are searched.

INCLUDEBIN

Syntax

INCLUDEBIN "filename"

INCLUDEBIN <filename>

Description

The **INCLUDEBIN** directive inserts the contents of the file *filename* into the current section as binary data. If *filename* is enclosed in quotation marks, the user include directories are searched; if *filename* is enclosed in triangular brackets, the system include directories are searched.

INIT

Syntax

INIT "section-name"

Description

The **INIT** directive places a copy of the section denoted by *name* into the current section. This directive can be used, for example, to copy initialized-data sections from read-only memory into writable memory.

ISR

Syntax

ISR

Description

The **ISR** directive selects the default ISR section. The section is named **ISR** unless it has been renamed via the **-Ri** command-line option.

KEEP

Syntax

KEEP

Description

A synonym for **ROOT**, see [ROOT](#).

PSECT

Syntax

PSECT "*section-name*"

Description

The **PSECT** directive creates a new program section with the name *section-name*. Subsequent instructions and data-allocation directives are directed to this section.

Example

```
PSECT "BOOT"
```

RMB

Syntax

RMB *n*

Description

A synonym for **DS.B**, see [DS.B](#).

RML

Syntax

RML *n*

Description

A synonym for **DS.L**, see [DS.L](#).

RMW

Syntax

RMW *n*

Description

A synonym for **DS.W**, see [DS.W](#).

RODATA

Syntax

RODATA

Description

A synonym for **CONST**, see [CONST](#).

ROOT

Syntax

ROOT

Description

The **ROOT** directive instructs the linker that this is a root fragment and *must not be discarded when constructing the output file*. Normally, only startup code and vector sections use this facility.

RSEG

Syntax

```
RSEG name [:type] [(alignment)]
```

Description

The **RSEG** directive creates a named section called *name*, with an optional type, and aligns the section at the optional *alignment*. The section type can be one of **CODE**, **DATA**, **BSS**, **CONST**, or **UNTYPED**. The alignment value is an assemble-time constant expression that is the power of 2 upon which to align the section: an alignment value of 1 will cause the section to be aligned on even byte locations.

SET

Syntax

symbol SET expression

Description

SET evaluates the expression, which must be an assemble-time constant. The **SET** directive allows redefinition of an existing symbol, whereas the **EQU** directive does not.

TEXT

Syntax

TEXT

Description

A synonym for **CODE**, see [CODE](#).

USECT

Syntax

USECT "*section-name*"

Description

The **USECT** directive creates a new, uninitialized-data section with the name *section-name*. Subsequent data allocation directives are directed to this section.

Example

```
USECT "SCRATCHPAD"
```

VECTORS

Syntax

VECTORS

Description

The **VECTORS** directive selects the default, interrupt-vector section. The section is named **INTVEC**, unless it has been renamed by the **-Rv** command-line option.

ZDATA

Syntax

ZDATA

Description

A synonym for **BSS**, see [BSS](#).

Expressions

The assembler can manipulate constants and relocatable values at assembly time. If the assembler cannot resolve these to a constant value (for example, an expression involving the value of an external symbol cannot be resolved at assembly time), the expression is passed to the linker to resolve.

Integer constants

Integer constants represent integer values and can be represented in binary, octal, decimal, or hexadecimal. You can specify the radix for the integer constant by adding a radix, specified as a suffix to the number. If no radix specifier is given, the constant is decimal.

Syntax

decimal-digit digit... [B | O | Q | D | H]

The radix suffix **B** denotes binary, **O** and **Q** denote octal, **D** denotes decimal, and **H** denotes hexadecimal. Radix suffixes can be given either in lowercase or uppercase letters.

Hexadecimal constants must always start with a decimal digit (0 to 9), otherwise the assembler will mistake the constant for a symbol—for example, **0FCH** is interpreted as a hexadecimal constant but **FCH** is interpreted as a symbol.

You can specify hexadecimal constants in two other formats common with many assemblers:

Syntax

0x *digit digit...*

\$ *digit digit...*

The **0x** notation is exactly how hexadecimal constants are written in C, and the **\$** notation is common in many assemblers for Motorola parts.

String constants

A string constant consists of one or more ASCII characters enclosed in single or double quotation marks.

Syntax

"character..."

You can specify non-printable characters in string constants using escape sequences. An escape sequence is introduced by the backslash character '\'.

The following escape sequences are supported:

Sequence	Description
\"	Double quotation mark
\'	Single quotation mark
\\"	Backslash
\b	Backspace, ASCII code 8
\f	Form feed, ASCII code 12
\n	New line, ASCII code 10
\r	Carriage return, ASCII code 13
\v	Vertical tab, ASCII code 11
\ooo	Octal code of character where o is an octal digit
\xhh	Hexadecimal code of character where h is a hexadecimal digit

Labels

Use labels to give symbolic names to addresses of instructions or data. The most common form are *code labels*, which can be used—as the operands of call, branch, and jump instructions—to transfer program control to a new instruction. Also common are *data labels* that label data-storage areas.

Syntax

label [: | ::] [*directive* | *instruction*]

The label field starts at the leftmost position of the line, with no preceding spaces. The colon after the label is optional; if it is present, the assembler immediately defines the label as a code label or data label. Some directives, such as **EQU**, require that you do not place a colon after the label.

Example

```
ExitPt: RET
```

This defines **ExitPt** as a code label for the **RET** instruction.

A label followed by a double colon makes the label public.

Operators

Each operator has a precedence, and the following table lists the precedence of the operators, from highest to lowest:

Operator	Group
DEFINED SIZEOF HBYTE LBYTE HWORD LWORD STARTOF ENDOF SFB SFE NOT ! LNOT !! THIS \$	Monadic prefix operators
* / %	Multiplicative operators
+ -	Additive operators
SHL SHR ASHR << >>	Shifting operators
LT GT LE GE < > <= >=	Relational operators
EQ NE == !=	Equality operators
AND &	Bit-wise and
XOR ^	Bit-wise exclusive-or
OR	Bit-wise inclusive-or
LAND &&	Logical and
LOR	Logical or

All integer operands are considered as *unsigned 64-bit values*.

!

Syntax

`! expression`

Description

True if *expression* is false, and false if *expression* is true.

Example

```
! 3      ; evaluates to false, 0
```

\$

Syntax

\$

Description

The \$ operator returns an expression that denotes the location counter at the start of the source line.

Note

The location counter returned by \$ does not change, even if code is emitted for the source line.

Example

A typical use of \$ is to compute the size of a string or of a block of memory:

```
MyString      DB    "Why would you count the number of characters"  
                  DB    "in a string when the assembler can do it?"  
MyStringLen  EQU   $-MyString
```

+

Syntax

expression-1 + expression-2

Description

Add *expression-1* to *expression-2*.

Example

```
1 + 2      ; evaluates to 3
```

-

Syntax

expression-1 - expression-2

Description

Add *expression-1* to *expression-2*.

Example

```
1 - 5      ; evaluates to -4
```

*

Syntax

*expression-1 * expression-2*

Description

Multiplies *expression-1* by *expression-2*.

Example

```
7 * 5      ; evaluates to 35
```

/

Syntax

expression-1 / expression-2

Description

Divides *expression-1* by *expression-2*, producing an integer quotient. If *expression-2* is zero, the quotient is defined to be zero.

Example

```
7 / 5      ; evaluates to 1
```

%

Syntax

expression-1 % expression-2

Description

Produces the remainder after division of *expression-1* by *expression-2*. If *expression-2* is zero, the remainder is defined to be zero.

Example

```
7 % 5      ; evaluates to 2
```

Λ

Syntax

expression-1 ^ expression-2

Description

Produces the bit-wise exclusive-or of *expression-1* and *expression-2*.

Example

```
0AAH 0F0H      ; evaluates to 05AH
```

&

Syntax

expression-1 & expression-2

Description

Produces the bit-wise conjunction (and) of *expression-1* and *expression-2*.

Example

```
0AAH & 0F0H      ; evaluates to 0A0H
```

&&

Syntax

expression-1 && expression-2

Description

True if both *expression-1* and *expression-2* are true.

Example

```
1 && 0      ; evaluates to false (0)
```

==

Syntax

expression-1 = expression-2

Description

True if *expression-1* and *expression-2* are equal.

Example

```
1 == 3      ; evaluates to false, 0
```

!=

Syntax

expression-1 == expression-2

Description

True *expression-1* and *expression-2* are not equal.

Example

```
1 != 3      ; evaluates to true, 1
```

<

Syntax

expression-1 < expression-2

Description

True if *expression-1* is less than *expression-2*.

Example

```
1 < 3      ; evaluates to true, 1
```

<=

Syntax

expression-1 <= *expression-2*

Description

True if *expression-1* is less than or equal to *expression-2*.

Example

```
3 <= 3      ; evaluates to true, 1
```

<<

Syntax

expression-1 << expression-2

Description

Shifts *expression-1* left by *expression-2* bits.

Example

```
1 << 7      ; evaluates to 128
```

>

Syntax

expression-1 > expression-2

Description

True if *expression-1* is greater than *expression-2*.

Example

```
1 > 3      ; evaluates to false, 0
```

>=

Syntax

expression-1 >= *expression-2*

Description

True if *expression-1* is greater than or equal to *expression-2*.

Example

```
3 >= 3      ; evaluates to true, 1
```

>>

Syntax

expression-1 >> expression-2

Description

Shifts *expression-1* right by *expression-2* bits.

Example

```
128 >> 7      ; evaluates to 1
```

Syntax

expression-1 | expression-2

Description

Produces the bit-wise disjunction (or) of *expression-1* and *expression-2*.

Example

```
0AAH | 0F0H      ; evaluates to 0FAH
```

||

Syntax

expression-1 || expression-2

Description

True if either *expression-1* or *expression-2* is true.

Example

```
1 || 0      ; evaluates to true (1)
```

ASHR

Syntax

expression-1 ASHR *expression-2*

Description

Shifts *expression-1* arithmetically right (propagating the sign bit) by *expression-2* bits.

Example

```
-3 ASHR 4      ; evaluates to -1 as sign bit is propagated
```

DEFINED

Syntax

DEFINED *symbol*

You can use the **DEFINED** operator to see whether a symbol is defined. Typically, this is used with conditional directives to control whether a portion of a file will be assembled.

The **DEFINED** operator returns a Boolean result which is true if the symbol is defined at that point in the file, and is false otherwise. Note that this operator only inquires whether the symbol is known to the assembler, not whether it has a known value: imported symbols are considered to be defined even though the assembler does not know their value.

DEFINED cannot detect whether a macro has been defined.

Example

The following shows how **DEFINED** works in a number of cases.

```
. IMPORT X
Y      EQU    10
B1     EQU    DEFINED X ; true (1)
B2     EQU    DEFINED Y ; true (1)
B3     EQU    DEFINED Z ; false (0) - not defined yet
B4     EQU    DEFINED U ; false (0) - never defined
Z      EQU    100
```

ENDOF

Syntax

ENDOF *section-name*

SFE *section-name*

Description

If the argument to **ENDOF** is a section name, the result of **ENDOF** is a link-time expression representing the start of the given section. It is an error if the section name is not known to the assembler.

EQ

Syntax

expression-1 EQ expression-2

Description

A synonym for ==, see [==](#).

GE

Syntax

expression-1 GE expression-2

Description

A synonym for `>=`, see [>=](#).

GT

Syntax

expression-1 GT expression-2

Description

A synonym for `>`, see [>](#).

HBYTE

Syntax

HBYTE *expression*

Description

Extract bits 8 to 15 of *expression*.

Example

```
HBYTE $FEDCBA98      ; evaluates to $BA
```

HIGH

Syntax

HIGH *expression*

Description

A synonym for **HBYTE**, see [HBYTE](#).

HWORD

Syntax

HWORD *expression*

Description

Extract bits 16 to 31 of *expression*.

Example

```
HWORD $FEDCBA98      ; evaluates to $FEDC
```

LAND

Syntax

expression-1 LAND expression-2

Description

A synonym for **&&**, see [&&](#).

LBYTE

Syntax

LBYTE *expression*

Description

Extract the low-order 8 bits of *expression*.

Example

```
LBYTE $FEDCBA98      ; evaluates to $98
```

LE

Syntax

expression-1 LE expression-2

Description

A synonym for <=, see [<=](#).

LNOT

Syntax

LNOT *expression*

Description

A synonym for **!**, see [!](#).

LOR

Syntax

expression-1 LOR expression-2

Description

A synonym for `||`, see [||](#).

LT

Syntax

expression-1 LT expression-2

Description

A synonym for <, see [<](#).

LHALF

Syntax

LHALF *expression*

Description

Synonym for **LWORD**, [LWORD](#).

LOW

Syntax

LOW *expression*

Description

A synonym for **LBYTE**, see [LBYTE](#).

LWORD

Syntax

LWORD *expression*

Description

Extract the low-order 16 bits of *expression*.

Example

```
LWORD $FEDCBA98      ; evaluates to $BA98
```

NE

Syntax

expression-1 NE expression-2

Description

A synonym for !=, see [!=](#).

OR

Syntax

expression-1 OR expression-2

Description

A synonym for |, see [OR](#).

SHL

Syntax

expression-1 SHL expression-2

Description

A synonym for <<, see [<<](#).

SHR

Syntax

expression-1 SHR expression-2

Description

A synonym for `>>`, see [>>](#).

SIZEOF

Syntax

SIZEOF (*expression*)

SIZEOF *section-name*

Description

If the argument to **SIZEOF** is a parenthesized expression, the result of **SIZEOF** is an integer value that is the size of the type associated with the expression. The assembler reports an error if the expression has no type.

If the argument to **SIZEOF** is a section name, the result of **SIZEOF** is a link-time expression representing the size of the given section. It is an error if the section name is not known to the assembler.

Example

```
X      VAR      LONG[100]
XSIZE  EQU      SIZEOF X      ; 400, 100 four byte elements
XOSIZE EQU      SIZEOF X[0]   ; 4, size of LONG
```

STARTOF

Syntax

STARTOF *section-name*

SFB *section-name*

Description

If the argument to **STARTOF** is a section name, the result of **STARTOF** is a link-time expression representing the start of the given section. It is an error if the section name is not known to the assembler.

THIS

Syntax

THIS

Description

A synonym for \$, see [\\$](#).

UHALF

Syntax

UHALF *expression*

Description

Synonym for **HWORD**, [HWORLD](#).

XOR

Syntax

expression-1 XOR expression-2

Description

A synonym for `^`, see [^](#).

Macros

The structure of a macro definition consists of a name, some optional arguments, the body of the macro, and a termination keyword. The syntax to define a macro is:

Syntax

```
{name} MACRO arg1, arg2, ..., argn
  {macro-body}
ENDMACRO | ENDM
```

The name of the macro has the same requirements as a label name (in particular, it must start in the first column). The arguments are a comma-separated list of identifiers. The body of the macro can have arbitrary assembly-language text, including other macro definitions and invocations, and conditional and file-inclusion directives. A macro is instantiated by using its name together with optional, actual argument values. A macro instantiation has to occur on its own line—it cannot be used within an expression or as an argument to an assembly-code mnemonic or directive. The syntax to invoke a macro is:

Syntax

```
name actual1, actual2, ..., actualn // comment
```

When a macro is instantiated, the macro body is inserted into the assembly text with actual values replacing the arguments that were in the body of the macro definition.

Labels in macros

When labels are used in macros, they must be unique for each instantiation to avoid duplicate-label-definition errors. The assembler provides a label-generation mechanism, for situations where the label name isn't significant, and a mechanism for constructing specific label names.

If a macro definition contains a jump to other instructions in the macro definition, it is likely that the actual name of the label isn't important. To facilitate this, a label of the form *name?* can be used.

In some instances, invoking a macro should result in the definition of a label. In the simplest case, the label can be passed as an argument to the macro; however, there are cases when the label name should be constructed from other tokens. The macro definition facility provides two constructs to enable this:

- Tokens can be concatenated by putting ## between them.
- The value of a constant symbol can be used by prefixing the label with \$\$.

Loops

If multiple definitions are required, a loop structure can be used. This can be achieved either by recursive macro definitions or by the use of the **LOOP** directive.

Example

```
P2TAB MACRO N
    IF N
    P2TAB N-1
    ENDIF
    DW 1<<N
ENDMACRO

POWER2TAB 10
```

This creates a table of ten powers of 2—that is: 1, 2, 4, 8, and so on, up to 1024.

If the loop counter is a large number, a recursive macro may consume considerable machine resources. Use the **LOOP** directive to avoid this, because it is an iterative rather than recursive solution.

Syntax

```
LOOP expression
    loop-body
ENDLOOP
```

The loop-control expression must be a compile-time constant. The loop body can contain any assembly text (including further loop constructs) except macro definitions (because that would result in multiple definitions of the same macro). The above recursive definition can be recast in an iterative style:

Example

```
POWER2TAB:
    x      SET      0
    LOOP    x <= 10
            DC.W    1<<x
    x      SET      x+1
    ENDLOOP
```

Note that the label-naming capabilities using ?, \$\$, and ## are not available within the body of a loop. If the loop body is to declare labels, a recursive macro definition should be used; or use a combination of macro invocation to define the labels and use the loops to define the text of the label.



Linker User Guide

The linker **hld** is responsible for linking together the object files which make up your application together with some run-time startup code and any support libraries.

Although the compiler driver usually invokes the linker for you, we fully describe how the linker can be used stand-alone. If you are maintaining your project with a make-like program, you may wish to use this information to invoke the linker directly rather than using the compiler driver.

The linker performs the following functions:

- resolves references between object modules;
- extracts object modules from archives to resolve unsatisfied references
- combines all fragments belonging to the same section into a contiguous region
- removes all unreferenced code and data
- runs an architecture-specific optimizer to improve the object code
- fixes the size of span-dependent instructions
- computes all relocatable values
- produces a linked application and writes it in a number of formats

Command line syntax

You invoke the linker using the following syntax:

```
hld [ option | file ]...
```

Files

file is either an object file or library file to include in the link and it must be in CrossWorks object or library format.

Options

option is a command-line option. Options are case sensitive and cannot be abbreviated.

Command line options

This section describes the command line options accepted by the CrossWorks linker.

-D (Define linker symbol)

Syntax

`-Dname=[symbol | number]`

Description

This option instructs the linker to define the symbol *name* as either the value *number* or the low-level symbol *symbol*. You can specify *number* in either decimal or hexadecimal notation using a **0x** prefix.

Project property

Linker Options > Linker Symbol Definitions

-F (Set output format)

Syntax

-F*format*

Description

The **-F** option instructs the linker to write its output in the format *fmt*. The linker supports the following formats:

- **-Fsrec** — Motorola S-record format
- **-Fhex** — Intel extended hex format
- **-Txt** — Texas Instruments hex format
- **-Flst** — Hexadecimal listing
- **-Fbin** — Binary format
- **-Fhzx** — Rowley native format

The default format, if no other format is specified, is **-Fhzx**.

-g (Propagate debugging information)

Syntax

`-g`

Description

The `-g` option instructs the linker to propagate debugging information contained in the individual object files into the linked image. If you intend to debug your application at the source level, you must use this option when linking your program.

-K (Keep linker symbol)

Syntax

`-Kname`

Description

The CrossWorks linker removes unused code and data from the output file. This process is called *deadstripping*. To prevent the linker from deadstripping unreferenced code and data you wish to keep, you must use the `-K` command line option to force inclusion of symbols.

Project property

Linker Options > Keep Symbols

Example

If you have a C function, `contextSwitch` that must be kept in the output file (and which the linker will normally remove), you can force its inclusion using:

```
-K_contextSwitch
```

-I- (Do not link standard libraries)

Syntax

-I-

Description

The -I option instructs the linker not to link standard libraries automatically included by the compiler or by the assembler **INCLUDELIB** directive. If you use this options you must supply your own library functions or provide the names of alternative sets of libraries to use.

Project property

Linker Options > Include Standard Libraries

-I (Link library)

Syntax

-Ix

Description

Link the library **libx.hza** from the library directory. The library directory is, by default **\$(InstallDir)/lib**, but can be changed with the **-L** option.

-L (Set library directory path)

Syntax

`-Ldir`

Description

Sets the library directory to *dir*. If -L is not specified on the command line, the default location to search for libraries is set to `$(InstallDir)/lib`.

-M (Display linkage map)

Syntax

-M

-M*file*

Description

The **-M** option prints a linkage map to standard output; **-M***file* prints a linkage map to *filename*.

-m (Generate for 64K part)

Syntax

`-m64k`

Description

This option instructs the linker to generate code for an MSP430 with at most 64 kilobytes of code memory (a compact model). Some of the code transformations performed by the linker are code-model-dependent, in particular whether `CALL` or `CALLA` should be used for procedure abstraction and how the stack is modified.

For some processors, such as the CC430, although they have an MSP430X core, they do not have code memory that extends beyond the first 64 kilobytes of the address space. In this case, it is beneficial, in terms of code space, data space, and execution time, to use the compact memory model which limits the total address space to 64 kilobytes.

-m (Generate for 1M part)

Syntax

`-m1m`

Description

This option instructs the linker to generate code for an MSP430 with at up to 1 megabyte of code memory (a large model). Some of the code transformations performed by the linker are code-model-dependent, in particular whether `CALL` or `CALLA` should be used for procedure abstraction and how the stack is modified.

For some processors, such as the CC430, although they have an MSP430X core, they do not have code memory that extends beyond the first 64 kilobytes of the address space. In this case, it is beneficial, in terms of code space, data space, and execution time, to use the compact memory model which limits the total address space to 64 kilobytes.

-mcpux (Enable MSP430X processor)

Syntax

-mcpux

Description

This option instructs the linker to generate code for the 20-bit MSP430X CPU core rather than a 16-bit MSP430 core. Note that it is not possible to mix code generated for the MSP430X with code generated for the MSP430.

By default the linker selects large model when compiling code for an MSP430X. If your target processor has an MSP430X core with a total memory space of less than 64K, you will use less code and data space, and decrease execution time, if you select the compact memory model with the **-m64k** switch.

-o (Set output file name)

Syntax

`-o filename`

Description

The `-o` option instructs the linker to write its linked output to *filename*.

-Obl (Enable block locality optimization)

Syntax

-Obl

Description

Enables the block locality improvement optimization. This optimization moves blocks of code in order reduce span-dependent jump sizes on many architectures.

This optimization is extremely compute intensive but delivers very good results on many applications. It will always reduce code size and execution time because the size of span-dependent jumps are reduced.

-Ocm (Enable code motion optimization)

Syntax

`-Ocm`

Description

Enables the code motion optimization. Code motion moves blocks of instructions from one place to another to reduce the number of jump instructions in the final program. Code motion will always reduce code size and increase execution speed.

It is extremely difficult to debug a program which has been linked with code motion enabled because parts of functions will be moved around the program and merged with other functions.

[Code Generation Options > Code Motion Optimization](#)

-Oxc (Enable code factoring optimization)

Syntax

-Oxc[=n]

Description

Enables the code factoring optimization. Code factoring is also commonly called *common block subroutine packing*, *cross calling*, and *procedure abstraction*. Code factoring finds common instruction sequences and replaces each common sequence with a subroutine call to one instance of that sequence.

Code factoring will always reduce the size of a program at the expense of execution speed as there is an overhead for the additional subroutine call and return instructions.

The option parameter *n* defines the number of bytes that must the common instruction sequence must contain before it is abstracted into a subroutine. Smaller values of *n* are likely to find more common sequences and will transform the code into a smaller, but slower, program. Larger values of *n* will find fewer common sequences, where each of those sequences are longer and will transform the code in to a slightly larger, and slightly faster, program.

The time complexity of the algorithm use depends upon *n*. Smaller values of *n* require more time for optimization to find and transform the small code sequences, whereas larger values of *n* requires less time to run as fewer common code sequences will be identified. You can also limit the number of code factoring passes using the **-Oxcp** option.

It is extremely difficult to debug a program which has been linked with code factoring enabled because parts of functions will be extracted and placed into their own subroutine.

Project properties

[Code Generation Options > Code Factoring Optimization](#)

[Code Generation Options > Code Subroutine Size](#)

-Oxcp (Set code factoring passes)

Syntax

-Oxcp[=n]

Description

Sets the maximum number of code factoring passes to *n*, or sets unlimited code factoring if *n* is omitted.

Each pass of the code factoring optimization may increase the maximum subroutine depth required by the linked application by one call. If stack space is at a premium, you can limit the additional subroutine depth introduced by the code factoring optimization to *n*. For instance, specifying **-Oxcp=1** will cause the application to use only a single depth of subroutines, with no other calls, when performing code factoring; specifying **-Oxcp=2** will introduce up to two additional subroutines (mainline code calls a subroutine which then calls another subroutine) and will require up to two additional return addresses on the call stack.

Setting *n* higher leads to higher code compression but introduces more subroutines and makes the code slower to execute—you may wish to limit the number of subroutines, their size, and the subroutine depth to strike a balance between speed, code space, and stack requirements.

For processors with a small hardware stack, it may be appropriate to limit the code factoring optimization to only a few levels of subroutines so that the hardware stack does not overflow, or even to disable code factoring completely if stack space is at a premium.

Project property

[Code Generation Options > Code Factoring Passes](#)

-Oxcx (Enable extreme code factoring optimization)

Syntax

`-Oxcx}{=n}`

Description

This optimization is identical to the Code Factoring optimization except that it works much harder to find common code sequences and, consequently, is much slower than the standard cross calling optimization. We recommend that you do not use this optimization unless you wish to reduce code size to the smallest possible as this optimization takes a long time to run for large programs.

-Oph (Enable peephole optimization)

Syntax

`-Oph`

Description

Enables peephole optimizations. Peephole optimizations transform local code sequences into more efficient code sequences using a collection of common idioms. Peephole optimization will always reduce code size and increase execution speed.

Project property

[Code Generation Options > Peephole Optimization](#)

-Oxj (Cross jumping optimization)

Syntax

`-Oxj`

Description

Enables the cross jumping optimization. Cross jumping finds identical code sequences that can be shared, deletes all copies and reroutes control flow to exactly one instance of the code sequence. Cross jumping will always reduce code size at the expense of executing an additional jump instruction.

Project property

[Code Generation Options > Cross Jumping Optimization](#)

-Osf (Enable subroutine flattening optimizations)

Syntax

-Osf

Description

Enables flattening optimizations. Calls to subroutines immediately followed by an unconditional return instruction are converted into jumps to the subroutine.

-Ojc (Enable jump chaining optimization)

Syntax

`-Ojc`

Description

Enables the jump chaining optimization. Jump chaining reduces the size of span-dependent jumps by finding a closer jump instruction to the same target address and reroutes the original jump to that jump. This optimization always reduces code size at the expense of execution speed because of the jump chains introduced.

Project property

[Code Generation Options > Jumping Chaining Optimization](#)

-Ojt (Enable jump threading optimization)

Syntax

`-Ojt`

Description

Enables the jump threading optimization. Jump threading finds jumps to jump instructions and reroutes the original jump instruction to the final destination. Jump threading will always increase execution speed and may reduce code size. A jump will not be rerouted if, in doing so, the size of the jump instruction increases.

Project property

[Code Generation Options > Jumping Threading Optimization](#)

-Ojt (Enable tail merge optimization)

Syntax

`-Otm`

Description

Enables the tail merging optimization. Tail merging finds identical code sequences at the end of functions that can be shared, deletes all copies and reroutes control flow to exactly one instance of the code sequence. Tail merging will always reduce code size at the expense of executing an additional jump instruction.

Project property

[Code Generation Options > Tail Merging Optimization](#)

-Oz (Optimize Sections)

Syntax

`-Oz=section,section,...`

Description

The options allows specific sections to be optimized. By default the *Code* section will be optimized.

Project property

[Linker Options > Optimize Sections](#)

Example

To optimize the **CODE** and **BOOTCODE** sections:

`-Oz=CODE,BOOTCODE`

-R (Rename sections)

Syntax

`-Rsection=new`

Description

This option renames the input modules in *section* to be *new*.

Project property

Linker Options > Rename Sections

Example

To rename the input modules in section **LIB_CODE** to **LR_CODE**:

`-RLIBC_CODE=LR_CODE`

-T (Locate sections)

Syntax

`-Tsection,...=start[-end]...`

Description

This option sets the way that sections are aggregated and laid out in memory. The *start* and *end* addresses are inclusive and define the memory segments into which sections in the list are placed. Sections are allocated in the order that they are specified in the list.

Project property

Section layout is configured using the XML-format memory map file so this option cannot be set directly in the CrossStudio IDE.

Example

To aggregate and place the **CODE** and **CONST** sections into the memory segment 0x1000 through 0xffef inclusive and 0x10000 through 0xfffff inclusive and with **CONST** placed before **CODE**:

```
-TCONST , CODE=0x1000-0xffef+0x10000-0xfffff
```

To aggregate the **IDATA0** and **UDATA0** sections into the memory segment 0x200 through 0xaff placing **IDATA0** before **UDATA0**:

```
-TIDATA0 , UDATA0=0x200-0xaff
```

-we (Treat warnings as errors)

Syntax

`-we`

Description

This option directs the linker to treat all warnings as errors.

Project property

General Options > Treat Warnings as Errors

-w (Suppress warnings)

Syntax

-w

Description

This option instructs the linker not to issue any warnings.

Project property

General Options > Suppress Warnings

-v (Verbose execution)

Syntax

-v

Description

This option instructs the linker to issue progress messages.

-V (Display version)

Syntax

-V

Description

This option instructs the linker to display its version information.



C Library User Guide

This section describes the library and how to use and customize it.

The libraries supplied with CrossWorks have all the support necessary for input and output using the standard C functions **printf** and **scanf**, support for the **assert** function, both 32-bit and 64-bit floating point, and are capable of being used in a multi-threaded environment. However, to use these facilities effectively you will need to customize the low-level details of *how* to input and output characters, what to do when an assertion fails, how to provide protection in a multithreaded environment, and how to use the available hardware to the best of its ability.

Floating point

The CrossWorks C library uses IEEE floating point format as specified by the ISO 60559 standard with restrictions.

This library favors code size and execution speed above absolute precision. It is suitable for applications that need to run quickly and not consume precious resources in limited environments. The library does not implement features rarely used by simple applications: floating point exceptions, rounding modes, and subnormals.

NaNs and infinities are supported and correctly generated. The only rounding mode supported is round-to-nearest. Subnormals are always flushed to a correctly-signed zero. The mathematical functions use stable approximations and do their best to cater ill-conditioned inputs.

Single and double precision

CrossWorks C allows you to choose whether the **double** data type uses the IEC 60559 32-bit or 64-bit format. The following sections describe the details of why you would want to choose a 32-bit **double** rather than a 64-bit **double** in many circumstances.

Why choose 32-bit doubles?

Many users are surprised when using **float** variables exclusively that sometimes their calculations are compiled into code that calls for **double** arithmetic. They point out that the C standard allows **float** arithmetic to be carried out only using **float** operations and not to automatically promote to the **double** data type of classic K&R C.

This is valid point. However, upon examination, even the simplest calculations can lead to **double** arithmetic. Consider:

```
// Compute sin(2x)
float sin_two_x(float x)
{
    return sinf(2.0 * x);
}
```

This looks simple enough. We're using the **sinf** function which computes the sine of a **float** and returns a **float** result. There appears to be no mention of a **double** anywhere, yet the compiler generates code that calls **double** support routines—but why?

The answer is that the constant **2.0** is a **double** constant, not a **float** constant. That is enough to force the compiler to convert both operands of the multiplication to **double** format, perform the multiplication in **double** precision, and then convert the result back to **float** precision. To avoid this surprise, the code should have been written:

```
// Compute sin(2x)
float sin_two_x(float x)
{
    return sinf(2.0F * x);
}
```

This uses a single precision floating-point constant **2.0F**. It's all too easy to forget to correctly type your floating-point constants, so if you compile your program with **double** meaning the same as **float**, you can forget all about adding the '**F**' suffix to your floating point constants.

As an aside, the C99 standard is very strict about the way that floating-point is implemented and the latitude the compiler has to rearrange and manipulate expressions that have floating-point operands. The compiler cannot second-guess user intention and use a number of useful mathematical identities and algebraic simplifications because in the world of IEC 60559 arithmetic many algebraic identities, such as $x * 1 = x$, do not hold when **x** takes one of the special values NaN, infinity, or negative zero.

More reasons to choose 32-bit doubles

Floating-point constants are not the only silent way that **double** creeps into your program. Consider this:

```
void write_results(float x)
{
    printf("After all that x=%f\n", x);
}
```

Again, no mention of a **double** anywhere, but **double** support routines are now required. The reason is that ISO C requires that **float** arguments are promoted to **double** when they are passed to the non-fixed part of variadic functions such as **printf**. So, even though your application may never mention **double**, **double** arithmetic may be required simply because you use **printf** or one of its near relatives.

If, however, you compile your code with 32-bit doubles, then there is no requirement to promote a **float** to a **double** as they share the same internal format.

Why choose 64-bit doubles?

If your application requires very accurate floating-point, more precise than the seven decimal digits supported by the **float** format, then you have little option but to use **double** arithmetic as there is no simple way to increase the precision of the **float** format. The **double** format delivers approximately 15 decimal digits of precision.

Multithreading

The CrossWorks libraries support multithreading, for example, where you are using CTL or a third-party real-time operating system (RTOS).

Where you have single-threaded processes, there is a single flow of control. However, in multithreaded applications there may be several flows of control which access the same functions, or the same resources, concurrently. To protect the integrity of resources, any code you write for multithreaded applications must be *reentrant* and *thread-safe*.

Reentrancy and thread safety are both related to the way functions in a multithreaded application handle resources.

Reentrant functions

A reentrant function does not hold static data over successive calls and does not return a pointer to static data. For this type of function, the caller provides all the data that the function requires, such as pointers to any workspace. This means that multiple concurrent calls to the function do not interfere with each other, that the function can be called in mainline code, and that the function can be called from an interrupt service routine.

Thread-safe functions

A thread-safe function protects shared resources from concurrent access using locks. In C, local variables are held in processor registers or are on the stack. Any function that does not use static data, or other shared resources, is thread-safe. In general, thread-safe functions are safe to call from any thread but cannot be called directly, or indirectly, from an interrupt service routine.

Thread safety in the CrossWorks library

In the CrossWorks C library:

- some functions are inherently thread-safe, for example **strcmp**.
- some functions, such as **malloc**, are not thread-safe by default but can be made thread-safe by implementing appropriate lock functions.
- other functions are only thread-safe if passed appropriate arguments, for example **tmpnam**.
- some functions are never thread-safe, for example **setlocale**.

We define how the functions in the C library can be made thread-safe if needed. If you use a third-party library in a multi-threaded system and combine it with the CrossWorks C library, you will need to ensure that the third-party library can be made thread-safe in just the same way that the CrossWorks C library can be made thread-safe.

Implementing mutual exclusion in the C library

The CrossWorks C library ships as standard with callouts to functions that provide thread-safety in a multithreaded application. If your application has a single thread of execution, the default implementation of these functions does nothing and your application will run without modification.

If your application is intended for a multithreaded environment and you wish to use the CrossWorks C library, you must implement the following locking functions:

- `_heap_lock` and `_heap_unlock` to provide thread-safety for all heap operations such as `malloc`, `free`, and `realloc`.
- `_printf_lock` and `_printf_unlock` to provide thread-safety for `printf` and relatives.
- `_scanf_lock` and `_scanf_unlock` to provide thread-safety for `scanf` and relatives.
- `_debug_io_lock` and `_debug_io_unlock` to provide thread-safety for semi-hosting support in the CrossStudio I/O function.

If you create a CTL project using the **New Project** wizard, CrossWorks provides implementations of these using CTL event sets. You're free to reimplement them as you see fit.

If you use a third-party RTOS with the CrossWorks C library, you will need to use whatever your RTOS provides for mutual exclusion, typically a semaphore, a mutex, or an event set.

Input and output

The C library provides all the standard C functions for input and output except for the essential items of where to output characters printed to **stdout** and where to read characters from **stdin**.

If you want to output to a UART, to an LCD, or input from a keyboard using the standard library print and scan functions, you need to customize the low-level input and output functions.

Customizing putchar

To use the standard output functions `putchar`, `puts`, and `printf`, you need to customize the way that characters are written to the standard output device. These output functions rely on a function `__putchar` that outputs a character and returns an indication of whether it was successfully written.

The prototype for `__putchar` is

```
int __putchar(int ch);
```

Sending all output to the CrossStudio virtual terminal

You can send all output to the CrossStudio virtual terminal by supplying the following implementation of the `__putchar` function in your code:

```
#include <debugio.h>

int __putchar(int ch)
{
    return debug_putchar(ch);
}
```

This hands off output of the character `ch` to the low-level debug output routine, `debug_putchar`.

Whilst this is an adequate implementation of `__putchar`, it does consume stack space for an unnecessary nested call and associated register saving. A better way of achieving the same result is to define the low-level symbol for `__putchar` to be equivalent to the low-level symbol for `debug_putchar`. To do this, we need to instruct the linker to make the symbols equivalent.

- Select the project node in the **Project Explorer**.
- Display the **Properties Window**.
- Enter the text `-D__putchar=_debug_putchar` into the **Additional Options** property of the **Linker Options** group.

Note that there are three leading underscores in `__putchar` and a single leading underscore in `_debug_putchar` because the C compiler automatically prepends an underscore to all global symbols.

Sending all output to another device

If you need to output to a physical device, such as a UART, the following notes will help you:

- If the character cannot be written for any reason, `putchar` *must* return `EOF`. Just because a character can't be written immediately is not a reason to return `EOF`: you can busy-wait or tasking (if applicable) to wait until the character is ready to be written.
- The higher layers of the library do not translate C's end of line character '`\n`' before passing it to `putchar`. If you are directing output to a serial line connected to a terminal, for instance, you will most likely need to output a carriage return and line feed when given the character '`\n`' (ASCII code 10).

The standard functions that perform input and output are the **printf** and **scanf** functions. These functions convert between internal binary and external printable data. In some cases, though, you need to read and write formatted data on other channels, such as other RS232 ports. This section shows how you can extend the I/O library to best implement these function.

Classic custom printf-style output

Assume that we need to output formatted data to two UARTs, numbered 0 and 1, and we have a functions **uart0_putc** and **uart1_putc** that do just that and whose prototypes are:

```
int uart0_putc(int ch, __printf_t *ctx);
int uart1_putc(int ch, __printf_t *ctx);
```

These functions return a positive value if there is no error outputting the character and EOF if there was an error. The second parameter, **ctx**, is the *context* that the high-level formatting routines use to implement the C standard library functions.

Using a classic implementation, you would use **sprintf** to format the string for output and then output it:

```
void uart0_printf(const char *fmt, ...)
{
    char buf[80], *p;
    va_list ap;
    va_start(ap, fmt);
    vsnprintf(buf, sizeof(buf), fmt, ap);
    for (p = buf; *p; ++p)
        uart0_putc(*p, 0); // null context
    va_end(ap);
}
```

We would, of course, need an identical routine for outputting to the other UART. This code is portable, but it requires an intermediate buffer of 80 characters. On small systems, this is quite an overhead, so we could reduce the buffer size to compensate. Of course, the trouble with that means that the maximum number of characters that can be output by a single call to **uart0_printf** is also reduced. What would be good is a way to output characters to one of the UARTs without requiring an intermediate buffer.

CrossWorks printf-style output

CrossWorks provides a solution for just this case by using some internal functions and data types in the CrossWorks library. These functions and types are define in the header file <**_vfprintf.h**>.

The first thing to introduce is the **__printf_t** type which captures the current state and parameters of the format conversion:

```
typedef struct __printf_tag
{
    size_t charcount;
    size_t maxchars;
    char *string;
    int (*output_fn)(int, struct __printf_tag *ctx);
```

```
} __printf_t;
```

This type is used by the library functions to direct what the formatting routines do with each character they need to output. If **string** is non-zero, the character is appended is appended to the string pointed to by **string**; if **output_fn** is non-zero, the character is output through the function **output_fn** with the context passed as the second parameter.

The member **charcount** counts the number of characters currently output, and **maxchars** defines the maximum number of characters output by the formatting routine **__vfprintf**.

We can use this type and function to rewrite **uart0_printf**:

```
int uart0_printf(const char *fmt, ...)
{
    int n;
    va_list ap;
    __printf_t iod;
    va_start(ap, fmt);
    iod.string = 0;
    iod.maxchars = INT_MAX;
    iod.output_fn = uart0_putc;
    n = __vfprintf(&iod, fmt, ap);
    va_end(ap);
    return n;
}
```

This function has no intermediate buffer: when a character is ready to be output by the formatting routine, it calls the **output_fn** function in the descriptor **iod** to output it immediately. The maximum number of characters isn't limited as the **maxchars** member is set to **INT_MAX**. If you wanted to limit the number of characters output you can simply set the **maxchars** member to the appropriate value before calling **__vfprintf**.

We can adapt this function to take a UART number as a parameter:

```
int uart_printf(int uart, const char *fmt, ...)
{
    int n;
    va_list ap;
    __printf_t iod;
    va_start(ap, fmt);
    iod.is_string = 0;
    iod.maxchars = INT_MAX;
    iod.output_fn = uart ? uart1_putc : uart0_putc;
    n = __vfprintf(&iod, fmt, ap);
    va_end(ap);
    return n;
}
```

Now we can use:

```
uart_printf(0, "This is uart %d\n...", 0);
uart_printf(1, "..and this is uart %d\n", 1);
```

__vfprintf returns the actual number of characters printed, which you may wish to dispense with and make the **uart_printf** routine return **void**.

Extending input functions

The formatted input functions would be implemented in the same manner as the output functions: read a string into an intermediate buffer and parse using `sscanf`. However, we can use the low-level routines in the CrossWorks library for formatted input without requiring the intermediate buffer.

The type `__stream_scanf_t` is:

```
typedef struct
{
    char is_string;
    int (*getc_fn)(void);
    int (*ungetc_fn)(int);
} __stream_scanf_t;
```

The function `getc_fn` reads a single character from the UART, and `ungetc_fn` pushes back a character to the UART. You can push at most one character back onto the stream.

Here's an implementation of functions to read and write from a single UART:

```
static int uart0_ungot = EOF;

int uart0_getc(void)
{
    if (uart0_ungot)
    {
        int c = uart0_ungot;
        uart0_ungot = EOF;
        return c;
    }
    else
        return read_char_from_uart(0);
}

int uart0_ungetc(int c)
{
    uart0_ungot = c;
}
```

You can use these two functions to perform formatted input using the UART:

```
int uart0_scanf(const char *fmt, ...)
{
    __stream_scanf_t iod;
    va_list a;
    int n;
    va_start(a, fmt);
    iod.is_string = 0;
    iod.getc_fn = uart0_getc;
    iod.ungetc_fn = uart0_ungetc;
    n = __vfscanf((__scanf_t *)&iod, (const unsigned char *)fmt, a);
    va_end(a);
    return n;
}
```

Using this template, we can add functions to do additional formatted input from other UARTs or devices, just as we did for formatted output.

Locales

The CrossWorks C library supports wide characters, multi-byte characters and locales. However, as not all programs require full localization, you can tailor the exact support provided by the CrossWorks C library to suit your application. These sections describe how to add new locales to your application and customize the runtime footprint of the C library.

Unicode, ISO 10646, and wide characters

The ISO standard 10646 is identical to the published Unicode standard and the CrossWorks C library uses the Unicode 6.2 definition as a base. Hence, whenever you see the term 'Unicode' in this document, it is equivalent to Unicode 6.2 and ISO/IEC 10646:2011.

The CrossWorks C library supports both 16-bit and 32-bit wide characters, depending upon the setting of wide character width in the project.

When compiling with 16-bit wide characters, all characters in the Basic Multilingual Plane are representable in a single `wchar_t` (values 0 through 0xFFFF). When compiling with 32-bit wide characters, all characters in the Basic Multilingual Plane and planes 1 through 16 are representable in a single `wchar_t` (values 0 through 0x10FFFF).

The wide character type will hold Unicode code points in a locale that is defined to use Unicode and character type functions such as `iswalpha` will work correctly on all Unicode code points.

Multi-byte characters

CrossWorks supports multi-byte encoding and decoding of characters. Most new software on the desktop uses Unicode internally and UTF-8 as the external, on-disk encoding for files and for transport over 8-bit mediums such as network connections.

However, in embedded software there is still a case to use code pages, such as ISO-Latin1, to reduce the footprint of an application whilst also providing extra characters that do not form part of the ASCII character set.

The CrossWorks C library can support both models and you can choose a combination of models, dependent upon locale, or construct a custom locale.

The standard C and POSIX locales

The standard C locale is called simply ‘C’. In order to provide POSIX compatibility, the name ‘POSIX’ is a synonym for ‘C’.

The C locale is fixed and supports only the ASCII character set with character codes 0 through 127. There is no multi-byte character support, so the character encoding between wide and narrow characters is simply one-to-one: a narrow character is converted to a wide character by zero extension. Thus, ASCII encoding of narrow characters is compatible with the ISO 10646 (Unicode) encoding of wide characters in this locale.

Additional locales in source form

The CrossWorks C library provides only the 'C' locale; if you need other locales, you must provide those by linking them into your application. We have constructed a number of locales from the Unicode Common Locale Data Repository (CLDR) and provided them in source form in the `$(StudioDir)/src` folder for you to include in your application.

A C library locale is divided into two parts:

- the locale's date, time, numeric, and monetary formatting information
- how to convert between multi-byte characters and wide characters by the functions in the C library.

The first, the locale data, is independent of how characters are represented. The second, the code set in use, defines how to map between narrow, multi-byte, and wide characters.

Installing a locale

If the locale you request using `setlocale` is neither ‘C’ nor ‘POSIX’, the C library calls the function `__user_find_locale` to find a user-supplied locale. The standard implementation of this function is to return a null pointer which indicates that no additional locales are installed and, hence, no locale matches the request.

The prototype for `__user_find_locale` is:

```
const __RAL_locale_t *__user_find_locale(const char *locale);
```

The parameter `locale` is the locale to find; the locale name is terminated either by a zero character or by a semicolon. The locale name, up to the semicolon or zero, is identical to the name passed to `setlocale` when you select a locale.

Now let’s install the Hungarian locale using both UTF-8 and ISO 8859-2 encodings. The UTF-8 codecs are included in the CrossWorks C library, but the Hungarian locale and the ISO 8859-2 codec are not.

You will find the file `locale_hu_HU.c` in the source directory as described in the previous section. Add this file to your project.

Although this adds the data needed for the locale, it does not make the locale available for the C library: we need to write some code for `__user_find_locale` to return the appropriate locales.

To create the locales, we need to add the following code and data to tie everything together:

```
#include <__crossworks.h>

static const __RAL_locale_t hu_HU_utf8 = {
    "hu_HU.utf8",
    &locale_hu_HU,
    &codeset_utf8
};

static const __RAL_locale_t hu_HU_iso_8859_2 = {
    "hu_HU.iso_8859_2",
    &locale_hu_HU,
    &codeset_iso_8859_2
};

const __RAL_locale_t *
__user_find_locale(const char *locale)
{
    if (__RAL_compare_locale_name(locale, hu_HU_utf8.name) == 0)
        return &hu_HU_utf8;
    else if (__RAL_compare_locale_name(locale, hu_HU_iso_8859_2.name) == 0)
        return &hu_HU_iso_8859_2;
    else
        return 0;
}
```

The function `__RAL_compare_locale_name` matches locale names up to a terminating null character, or a semicolon (which is required by the implementation of `setlocale` in the C library when setting multiple locales using `LC_ALL`).

In addition to this, you must provide a buffer, `__user_locale_name_buffer`, for locale names encoded by `setlocale`. The buffer must be large enough to contain five locale names, one for each category. In the above example, the longest locale name is `hu_HU.iso_8859_2` which is 16 characters in length. Using this information, buffer must be at least $(16+1) \times 5 = 85$ characters in size:

```
const char __user_locale_name_buffer[85];
```

Setting a locale directly

Although we support `setlocale` in its full generality, most likely you'll want to set a locale once and forget about it. You can do that by including the locale in your application and writing to the instance variables that hold the underlying locale data for the CrossWorks C library.

For instance, you might wish to use Czech locale with a UTF codeset:

```
static __RAL_locale_t cz_locale =
{
    "cz_CZ.utf8",
    &__RAL_cs_CZ_locale,
    &__RAL_codeset_utf8
};
```

You can install this directly into the locale without using `setlocale`:

```
__RAL_global_locale.__category[LC_COLLATE] = &cz_locale;
__RAL_global_locale.__category[LC_CTYPE] = &cz_locale;
__RAL_global_locale.__category[LC_MONETARY] = &cz_locale;
__RAL_global_locale.__category[LC_NUMERIC] = &cz_locale;
__RAL_global_locale.__category[LC_TIME] = &cz_locale;
```

Complete API reference

This section contains a complete reference to the CrossWorks C library API.

File	Description
<code><assert.h></code>	Describes the diagnostic facilities which you can build into your application.
<code><debugio.h></code>	Describes the virtual console services and semi-hosting support that CrossStudio provides to help you when developing your applications.
<code><cruntime.h></code>	Defines the interface to functions that the C compiler calls when generating code. For instance, it contains the runtime routines for all floating point operators and conversion, and shifts, multiplies, and divides, for each of the integer types. In general, you do not need to call these routines yourself directly, but they are documented here should you need to call them from assembly language. These functions abide by the standard calling conventions of the compiler.
<code><ctype.h></code>	Describes the character classification and manipulation functions.
<code><errno.h></code>	Describes the macros and error values returned by the C library.
<code><float.h></code>	Defines macros that expand to various limits and parameters of the standard floating point types.
<code><in430.h></code>	Describes the intrinsic functions that are mainly compatible with IAR's EW430 v2 product.
<code><inmsp.h></code>	Describes the intrinsic functions that are mainly compatible with IAR's EW430 v3 product.
<code><limits.h></code>	Describes the macros that define the extreme values of underlying C types.
<code><locale.h></code>	Describes support for localization specific settings.
<code><math.h></code>	Describes the mathematical functions provided by the C library.
<code><setjmp.h></code>	Describes the non-local goto capabilities of the C library.
<code><stdarg.h></code>	Describes the way in which variable parameter lists are accessed.
<code><stddef.h></code>	Describes standard type definitions.
<code><stdio.h></code>	Describes the formatted input and output functions.
<code><stdlib.h></code>	Describes the general utility functions provided by the C library.

<code><string.h></code>	Describes the string handling functions provided by the C library.
<code><time.h></code>	Describes the functions to get and manipulate date and time information provided by the C library.
<code><wchar.h></code>	Describes the facilities you can use to manipulate wide characters.

<assert.h>

API Summary

Macros	
<code>assert</code>	Allows you to place assertions and diagnostic tests into programs
Functions	
<code>_assert</code>	User defined behaviour for the assert macro

__assert

Synopsis

```
void __assert(const char *expression,  
             const char *filename,  
             int line);
```

Description

There is no default implementation of **__assert**. Keeping **__assert** out of the library means that you can customize its behaviour without rebuilding the library. You must implement this function where **expression** is the stringized expression, **filename** is the filename of the source file and **line** is the linenumber of the failed assertion.

assert

Synopsis

```
#define assert(e) ...
```

Description

If **NDEBUG** is defined as a macro name at the point in the source file where `<assert.h>` is included, the **assert** macro is defined as:

```
#define assert(ignore) ((void)0)
```

If **NDEBUG** is not defined as a macro name at the point in the source file where `<assert.h>` is included, the **assert** macro expands to a **void** expression that calls `__assert`.

```
#define assert(e) ((e) ? (void)0 : __assert(#e, __FILE__, __LINE__))
```

When such an **assert** is executed and **e** is false, **assert** calls the `__assert` function with information about the particular call that failed: the text of the argument, the name of the source file, and the source line number. These are the stringized expression and the values of the preprocessing macros `__FILE__` and `__LINE__`.

Note

The **assert** macro is redefined according to the current state of **NDEBUG** each time that `<assert.h>` is included.

<cruntime.h>

The header file <cruntime.h> defines the interface to functions that the C compiler calls when generating code. For instance, it contains the runtime routines for floating point operations and conversion, with shifts, multiplies, and divides for each of the integer types. In general, you do not need to call these routines directly from your own C code. These functions are documented here should you need to call them from assembly language. These functions abide by the standard calling conventions of the compiler. Not every implementation of CrossWorks will provide all these functions.

API Summary

Integer multiplication	
<u>_int16_mul</u>	Multiply two 16-bit signed or unsigned integers forming a 16-bit product
<u>_int16_mul_8x8</u>	Multiply two 8-bit signed integers forming a 16-bit signed product
<u>_int16_mul_asgn</u>	Multiply a 16-bit signed or unsigned integer in memory by a 16-bit integer
<u>_int32_mul</u>	Multiply two 32-bit signed or unsigned integers forming a 32-bit product
<u>_int32_mul_16x16</u>	Multiply two 16-bit signed integers forming a 32-bit signed product
<u>_int32_mul_asgn</u>	Multiply a 32-bit signed or unsigned integer in memory by a 32-bit integer
<u>_int64_mul</u>	Multiply two 64-bit signed or unsigned integers forming a 64-bit product
<u>_int64_mul_32x32</u>	Multiply two 32-bit signed integers forming a 64-bit signed product
<u>_int64_mul_asgn</u>	Multiply a 64-bit signed or unsigned integer in memory by a 64-bit integer
<u>_uint16_mul_8x8</u>	Multiply two 8-bit unsigned integers forming a 16-bit unsigned product
<u>_uint32_mul_16x16</u>	Multiply two 16-bit unsigned integers forming a 32-bit unsigned product
<u>_uint64_mul_32x32</u>	Multiply two 32-bit unsigned integers forming a 64-bit unsigned product
Integer division	
<u>_int16_div</u>	Divide two 16-bit signed integers and return the 16-bit signed quotient

<u>_int16_div_asgn</u>	Divide a 16-bit signed integer in memory by a 16-bit signed integer
<u>_int16_mod</u>	Divide two 16-bit signed integers and return the 16-bit signed remainder after division
<u>_int16_mod_asgn</u>	Divide a 16-bit signed integer in memory by a 16-bit signed integer and assign it the 16-bit remainder
<u>_int32_div</u>	Divide two 32-bit signed integers and return the 32-bit signed quotient
<u>_int32_div_asgn</u>	Divide a 32-bit signed integer in memory by a 32-bit signed integer
<u>_int32_mod</u>	Divide two 32-bit signed integers and return the 32-bit signed remainder after division
<u>_int32_mod_asgn</u>	Divide a 32-bit signed integer in memory by a 32-bit signed integer and assign it the 32-bit remainder
<u>_int64_div</u>	Divide two 64-bit signed integers and return the 64-bit signed quotient
<u>_int64_div_asgn</u>	Divide a 64-bit signed integer in memory by a 64-bit signed integer
<u>_int64_mod</u>	Divide two 64-bit signed integers and return the 64-bit signed remainder after division
<u>_int64_mod_asgn</u>	Divide a 64-bit signed integer in memory by a 64-bit signed integer and assign it the 64-bit remainder
<u>_uint16_div</u>	Divide two 16-bit unsigned integers and return the 16-bit unsigned quotient
<u>_uint16_div_asgn</u>	Divide a 16-bit unsigned integer in memory by a 16-bit unsigned integer
<u>_uint16_mod</u>	Divide two 16-bit unsigned integers and return the 16-bit unsigned remainder after division
<u>_uint16_mod_asgn</u>	Divide a 16-bit unsigned integer in memory by a 16-bit unsigned integer and assign it the 16-bit remainder
<u>_uint32_div</u>	Divide two 32-bit unsigned integers and return the 32-bit unsigned quotient
<u>_uint32_div_asgn</u>	Divide a 32-bit unsigned integer in memory by a 32-bit unsigned integer
<u>_uint32_mod</u>	Divide two 32-bit unsigned integers and return the 32-bit unsigned remainder after division
<u>_uint32_mod_asgn</u>	Divide a 32-bit unsigned integer in memory by a 32-bit unsigned integer and assign it the 32-bit remainder
<u>_uint64_div</u>	Divide two 64-bit unsigned integers and return the 64-bit unsigned quotient

<code>_uint64_div_asgn</code>	Divide a 64-bit unsigned integer in memory by a 64-bit unsigned integer
<code>_uint64_mod</code>	Divide two 64-bit unsigned integers and return the 64-bit unsigned remainder after division
<code>_uint64_mod_asgn</code>	Divide a 64-bit unsigned integer in memory by a 64-bit unsigned integer and assign it the 64-bit remainder
Integer shifts	
<code>_int16_asr</code>	Shift a 16-bit signed integer arithmetically right by a variable number of bit positions
<code>_int16_asr_asgn</code>	Shift a 16-bit signed integer in memory arithmetically right by a variable number of bit positions
<code>_int16_lsl</code>	Shift a 16-bit signed integer left by a variable number of bit positions
<code>_int16_lsl_asgn</code>	Shift a 16-bit signed integer in memory left by a variable number of bit positions
<code>_int16_lsr</code>	Shift a 16-bit unsigned integer logically right by a variable number of bit positions
<code>_int16_lsr_asgn</code>	Shift a 16-bit unsigned integer in memory logically right by a variable number of bit positions
<code>_int32_asr</code>	Shift a 32-bit signed integer arithmetically right by a variable number of bit positions
<code>_int32_asr_asgn</code>	Shift a 32-bit signed integer in memory arithmetically right by a variable number of bit positions
<code>_int32_lsl</code>	Shift a 32-bit signed integer left by a variable number of bit positions
<code>_int32_lsl_asgn</code>	Shift a 32-bit signed integer in memory left by a variable number of bit positions
<code>_int32_lsr</code>	Shift a 32-bit unsigned integer logically right by a variable number of bit positions
<code>_int32_lsr_asgn</code>	Shift a 32-bit unsigned integer in memory logically right by a variable number of bit positions
<code>_int64_asr</code>	Shift a 64-bit signed integer arithmetically right by a variable number of bit positions
<code>_int64_asr_asgn</code>	Shift a 64-bit signed integer in memory arithmetically right by a variable number of bit positions
<code>_int64_lsl</code>	Shift a 64-bit signed integer left by a variable number of bit positions
<code>_int64_lsl_asgn</code>	Shift a 64-bit signed integer in memory left by a variable number of bit positions

<u>_int64_lsr</u>	Shift a 64-bit unsigned integer logically right by a variable number of bit positions
<u>_int64_lsr_asgn</u>	Shift a 64-bit unsigned integer in memory logically right by a variable number of bit positions
Floating-point arithmetic	
<u>_float32_add</u>	Add two 32-bit floating point values
<u>_float32_add_1</u>	Add one to a 32-bit floating point value
<u>_float32_add_asgn</u>	Add a 32-bit floating point value to a 32-bit floating point value in memory
<u>_float32_div</u>	Divide two 32-bit floating point values
<u>_float32_div_asgn</u>	Divide a 32-bit floating point value in memory by a 32-bit floating point value
<u>_float32_mul</u>	Multiply two 32-bit floating point values
<u>_float32_mul_asgn</u>	Multiply a 32-bit floating point value in memory by a 32-bit floating point value
<u>_float32_neg</u>	Negate a 32-bit floating point value
<u>_float32_sqr</u>	Square a 32-bit floating point value
<u>_float32_sub</u>	Subtract two 32-bit floating point values
<u>_float32_sub_asgn</u>	Subtract a 32-bit floating point value from a 32-bit floating point value in memory
<u>_float64_add</u>	Add two 64-bit floating point values
<u>_float64_add_1</u>	Add one to a 64-bit floating point value
<u>_float64_add_asgn</u>	Add a 64-bit floating point value to a 64-bit floating point value in memory
<u>_float64_div</u>	Divide two 64-bit floating point values
<u>_float64_div_asgn</u>	Divide a 64-bit floating point value in memory by a 64-bit floating point value
<u>_float64_mul</u>	Multiply two 64-bit floating point values
<u>_float64_mul_asgn</u>	Multiply a 64-bit floating point value in memory by a 64-bit floating point value
<u>_float64_neg</u>	Negate a 64-bit floating point value
<u>_float64_sqr</u>	Square a 64-bit floating point value
<u>_float64_sub</u>	Subtract two 64-bit floating point values
<u>_float64_sub_asgn</u>	Subtract a 64-bit floating point value from a 64-bit floating point value in memory
Floating point comparison	
<u>_float32_eq</u>	Compare two 32-bit floating point values for equality
<u>_float32_eq_0</u>	Compare 32-bit floating point value to zero

<u>float32_lt</u>	Compare two 32-bit floating point values
<u>float32_lt_0</u>	Compare 32-bit floating point value with zero
<u>float64_eq</u>	Compare two 64-bit floating point values for equality
<u>float64_eq_0</u>	Compare 64-bit floating point value to zero
<u>float64_lt</u>	Compare two 64-bit floating point values
<u>float64_lt_0</u>	Compare 64-bit floating point value with zero
Integer to floating point conversions	
<u>int16_to_float32</u>	Convert a 16-bit signed integer to a 32-bit floating point value
<u>int16_to_float64</u>	Convert a 16-bit signed integer to a 64-bit floating point value
<u>int32_to_float32</u>	Convert a 32-bit signed integer to a 32-bit floating point value
<u>int32_to_float64</u>	Convert a 32-bit signed integer to a 64-bit floating point value
<u>int64_to_float32</u>	Convert a 64-bit signed integer to a 32-bit floating point value
<u>int64_to_float64</u>	Convert a 64-bit signed integer to a 64-bit floating point value
<u>uint16_to_float32</u>	Convert a 16-bit unsigned integer to a 32-bit floating point value
<u>uint16_to_float64</u>	Convert a 16-bit unsigned integer to a 64-bit floating point value
<u>uint32_to_float32</u>	Convert a 32-bit unsigned integer to a 32-bit floating point value
<u>uint32_to_float64</u>	Convert a 32-bit unsigned integer to a 64-bit floating point value
<u>uint64_to_float32</u>	Convert a 64-bit unsigned integer to a 32-bit floating point value
<u>uint64_to_float64</u>	Convert a 64-bit unsigned integer to a 64-bit floating point value
Floating point to integer conversions	
<u>float32_to_int16</u>	Convert a 32-bit floating point value to a 16-bit signed integer
<u>float32_to_int32</u>	Convert a 32-bit floating point value to a 32-bit signed integer
<u>float32_to_int64</u>	Convert a 32-bit floating point value to a 64-bit signed integer

<u>float32_to_uint16</u>	Convert a 32-bit floating point value to a 16-bit unsigned integer
<u>float32_to_uint32</u>	Convert a 32-bit floating point value to a 32-bit unsigned integer
<u>float32_to_uint64</u>	Convert a 32-bit floating point value to a 64-bit unsigned integer
Floating point conversions	
<u>float32_to_float64</u>	Convert a 32-bit floating point value to a 64-bit floating point value
<u>float64_to_float32</u>	Convert a 64-bit floating point value to a 32-bit floating point value

__float32_add

Synopsis

```
float32_t __float32_add(float32_t augend,  
                         float32_t addend);
```

Description

__float32_add adds **addend** to **augend** and returns the sum as the result.

__float32_add_1

Synopsis

```
float32_t __float32_add_1(float32_t augend);
```

Description

__float32_add_1 adds one to **augend** and returns the sum as the result.

__float32_add_asgn

Synopsis

```
float32_t __float32_add_asgn(float32_t *augend,  
                           float32_t addend);
```

Description

__float32_add_asgn updates the floating-point value pointed to by **augend** by adding **addend** to it. The stored sum is returned as the result.

__float32_div

Synopsis

```
float32_t __float32_div(float32_t dividend,  
                         float32_t divisor);
```

Description

__float32_div divides **dividend** by **divisor** and returns the quotient as the result.

__float32_div_asgn

Synopsis

```
float32_t __float32_div_asgn(float32_t *dividend,  
                           float32_t divisor);
```

Description

__float32_div_asgn updates the floating-point value pointed to by **dividend** by dividing it by **divisor**. The stored quotient is returned as the result.

__float32_eq

Synopsis

```
int __float32_eq(float32_t arg0,  
                 float32_t arg1);
```

Description

`__float32_eq` compares `arg0` to `arg1`. `__float32_eq` returns zero if `arg0` is different from `arg1`, and a non-zero value if `arg0` is equal to `arg1`.

__float32_eq_0

Synopsis

```
int __float32_eq_0(float32_t arg);
```

Description

`__float32_eq_0` compares `arg` to zero. `__float32_eq_0` returns a non-zero value if `arg` is zero, and a zero value if `arg` is non-zero.

__float32_lt

Synopsis

```
int __float32_lt(float32_t arg0,  
                 float32_t arg1);
```

Description

__float32_lt compares **arg0** to **arg1**. **__float32_lt** returns a non-zero value if **arg0** is less than **arg1**, and zero if **arg0** is equal to or greater than **arg1**.

__float32_lt_0

Synopsis

```
int __float32_lt_0(float32_t arg0,  
                    float32_t arg1);
```

Description

__float32_lt_0 compares **arg** to zero. **__float32_lt_0** returns a non-zero value if **arg** is less than zero, and zero if **arg0** is equal to or greater than zero.

__float32_mul

Synopsis

```
float32_t __float32_mul(float32_t multiplicand,  
                         float32_t multiplier);
```

Description

__float32_mul multiplies **multiplicand** by **multiplier** and returns the product as the result.

__float32_mul_asgn

Synopsis

```
float32_t __float32_mul_asgn(float32_t *multiplicand,  
                           float32_t multiplier);
```

Description

__float32_mul_asgn updates the floating-point value pointed to by **multiplicand** by multiplying it by **multiplier**. The stored product is returned as the result.

__float32_neg

Synopsis

```
float32_t __float32_neg(float32_t arg);
```

Description

__float32_neg negates **arg** and returns the result.

__float32_sqr

Synopsis

```
float32_t __float32_sqr(float32_t arg);
```

Description

__float32_sqr squares **arg** by multiplying **arg** by itself.

__float32_sub

Synopsis

```
float32_t __float32_sub(float32_t minuend,  
                         float32_t subtrahend);
```

Description

__float32_sub subtracts **subtrahend** from **minuend** and returns the difference as the result.

__float32_sub_asgn

Synopsis

```
float32_t __float32_sub_asgn(float32_t *minuend,  
                           float32_t subtrahend);
```

Description

__float32_sub_asgn updates the floating-point value pointed to by **minuend** by subtracting **subtrahend** from it. The stored difference is returned as the result.

__float32_to_float64

Synopsis

```
float64_t __float32_to_float64(float32_t arg);
```

Description

__float32_to_float64 converts the 32-bit floating value **arg** to a 64-bit floating point value and returns the converted value as the result.

__float32_to_int16

Synopsis

```
int16_t __float32_to_int16(float32_t arg);
```

Description

__float32_to_int16 converts the floating value **arg** to a 16-bit signed integer, truncating towards zero, and returns the truncated value as the result.

__float32_to_int32

Synopsis

```
int32_t __float32_to_int32(float32_t arg);
```

Description

__float32_to_int32 converts the floating value **arg** to a 32-bit signed integer, truncating towards zero, and returns the truncated value as the result.

__float32_to_int64

Synopsis

```
int64_t __float32_to_int64(float32_t arg);
```

Description

__float32_to_int64 converts the floating value **arg** to a 64-bit signed integer, truncating towards zero, and returns the truncated value as the result.

__float32_to_uint16

Synopsis

```
uint16_t __float32_to_uint16(float32_t arg);
```

Description

__float32_to_uint16 converts the floating value **arg** to a 16-bit unsigned integer, truncating towards zero, and returns the truncated value as the result.

__float32_to_uint32

Synopsis

```
uint32_t __float32_to_uint32(float32_t arg);
```

Description

__float32_to_uint32 converts the floating value **arg** to a 32-bit unsigned integer, truncating towards zero, and returns the truncated value as the result.

__float32_to_uint64

Synopsis

```
uint64_t __float32_to_uint64(float32_t arg);
```

Description

`__float32_to_uint64` converts the floating value `arg` to a 64-bit unsigned integer, truncating towards zero, and returns the truncated value as the result.

__float64_add

Synopsis

```
float64_t __float64_add(float64_t augend,  
                         float64_t addend);
```

Description

__float64_add adds **addend** to **augend** and returns the sum as the result.

__float64_add_1

Synopsis

```
float64_t __float64_add_1(float64_t augend);
```

Description

__float64_add_1 adds one to **augend** and returns the sum as the result.

__float64_add_asgn

Synopsis

```
float64_t __float64_add_asgn(float64_t *augend,  
                           float64_t addend);
```

Description

__float64_add_asgn updates the floating-point value pointed to by **augend** by adding **addend** to it. The stored sum is returned as the result.

__float64_div

Synopsis

```
float64_t __float64_div(float64_t dividend,  
                         float64_t divisor);
```

Description

__float64_div divides **dividend** by **divisor** and returns the quotient as the result.

__float64_div_asgn

Synopsis

```
float64_t __float64_div_asgn(float64_t *dividend,  
                           float64_t divisor);
```

Description

__float64_div_asgn updates the floating-point value pointed to by **dividend** by dividing it by **divisor**. The stored quotient is returned as the result.

__float64_eq

Synopsis

```
int __float64_eq(float64_t arg0,  
                 float64_t arg1);
```

Description

`__float64_eq` compares `arg0` to `arg1`. `__float64_eq` returns zero if `arg0` is different from `arg1`, and a non-zero value if `arg0` is equal to `arg1`.

__float64_eq_0

Synopsis

```
int __float64_eq_0(float64_t arg);
```

Description

`__float64_eq_0` compares `arg` to zero. `__float64_eq_0` returns a non-zero value if `arg` is zero, and a zero value if `arg` is non-zero.

__float64_lt

Synopsis

```
int __float64_lt(float64_t arg0,  
                  float64_t arg1);
```

Description

`__float64_lt` compares `arg0` to `arg1`. `__float64_lt` returns a non-zero value if `arg0` is less than `arg1`, and zero if `arg0` is equal to or greater than `arg1`.

__float64_lt_0

Synopsis

```
int __float64_lt_0(float64_t arg0,  
                    float64_t arg1);
```

Description

__float64_lt_0 compares **arg** to zero. **__float64_lt_0** returns a non-zero value if **arg** is less than zero, and zero if **arg0** is equal to or greater than zero.

__float64_mul

Synopsis

```
float64_t __float64_mul(float64_t multiplicand,  
                         float64_t multiplier);
```

Description

__float64_mul multiplies **multiplicand** by **multiplier** and returns the product as the result.

__float64_mul_asgn

Synopsis

```
float64_t __float64_mul_asgn(float64_t *multiplicand,  
                           float64_t multiplier);
```

Description

__float64_mul_asgn updates the floating-point value pointed to by **multiplicand** by multiplying it by **multiplier**. The stored product is returned as the result.

__float64_neg

Synopsis

```
float64_t __float64_neg(float64_t arg);
```

Description

__float64_neg negates **arg** and returns the result.

__float64_sqr

Synopsis

```
float64_t __float64_sqr(float64_t arg);
```

Description

__float64_sqr squares **arg** by multiplying **arg** by itself.

__float64_sub

Synopsis

```
float64_t __float64_sub(float64_t minuend,  
                         float64_t subtrahend);
```

Description

__float64_sub subtracts **subtrahend** from **minuend** and returns the difference as the result.

__float64_sub_asgn

Synopsis

```
float64_t __float64_sub_asgn(float64_t *minuend,  
                           float64_t subtrahend);
```

Description

__float64_sub_asgn updates the floating-point value pointed to by **minuend** by subtracting **subtrahend** from it. The stored difference is returned as the result.

__float64_to_float32

Synopsis

```
float32_t __float64_to_float32(float64_t arg);
```

Description

__float64_to_float32 converts the 64-bit floating value **arg** to a 32-bit floating point value and returns the converted value as the result.

__int16_asr

Synopsis

```
int16_t __int16_asr(int16_t arg,  
                     int bits);
```

Description

__int16_asr shifts **arg** arithmetically right by **bits** bit positions, replicating the sign bit, and returns the shifted result.

__int16_asr_asgn

Synopsis

```
int16_t __int16_asr_asgn(int16_t *arg,  
                           int bits);
```

Description

__int16_asr_asgn updates the 16-bit signed integer pointed to by **arg** by arithmetically shifting it right by **its** bit positions, replicating the sign bit. The shifted value is returned as the result.

__int16_div

Synopsis

```
int16_t __int16_div(int16_t dividend,  
                     int16_t divisor);
```

Description

__int16_div divides **dividend** by **divisor** and returns the signed quotient, truncated towards zero, as the result.

__int16_div_asgn

Synopsis

```
int16_t __int16_div_asgn(int16_t *dividend,  
                           int16_t divisor);
```

Description

__int16_div_asgn updates the 16-bit signed integer pointed to by **dividend** by dividing it by **divisor** and truncated towards zero. The quotient is returned as the result.

__int16_lsl

Synopsis

```
int16_t __int16_lsl(int16_t arg,  
                     int bits);
```

Description

__int16_lsl shifts **arg** left by **bits** bit positions, shifting zeros in from the left.

__int16_lsl_asgn

Synopsis

```
uint16_t __int16_lsl_asgn(uint16_t *arg,  
                           int bits);
```

Description

__int16_lsl_asgn updates the 16-bit unsigned integer pointed to by **arg** by shifting it left by **bits** bit positions, shifting in zeros in from the right. The shifted value is returned as the result.

__int16_lsr

Synopsis

```
uint16_t __int16_lsr(uint16_t arg,  
                      int bits);
```

Description

__int16_lsr shifts **arg** logically right by **bits** bit positions, shifting in zeros from the left, and returns the shifted result.

__int16_lsr_asgn

Synopsis

```
uint16_t __int16_lsr_asgn(uint16_t *arg,  
                           int bits);
```

Description

__int16_lsr_asgn updates the 16-bit unsigned integer pointed to by **arg** by logically shifting it right by **bits** bit positions, shifting in zeros from the right. The shifted value is returned as the result.

__int16_mod

Synopsis

```
int16_t __int16_mod(int16_t dividend,  
                     int16_t divisor);
```

Description

__int16_mod divides **dividend** by **divisor** and returns the signed remainder after division as the result.

__int16_mod_asgn

Synopsis

```
int16_t __int16_mod_asgn(int16_t *dividend,  
                           int16_t divisor);
```

Description

__int16_mod_asgn updates the 16-bit signed integer pointed to by **dividend** by assigning it the remainder after division of **dividend** by **divisor**. The remainder is returned as the result.

__int16_mul

Synopsis

```
int16_t __int16_mul(int16_t multiplicand,  
                     int16_t multiplier);
```

Description

__int16_mul multiplies **multiplicand** by **multiplier** and returns the product as the result. As only the lower 16 bits of the product are returned, **__int16_mul** returns correct products, modulo 16 bits, for both signed and unsigned arguments.

__int16_mul_8x8

Synopsis

```
int16_t __int16_mul_8x8(int8_t multiplicand,  
                           int8_t multiplier);
```

Description

__int16_mul_8x8 multiplies **multiplicand** by **multiplier** and returns the 16-bit signed product as the result.

__int16_mul_asgn

Synopsis

```
int16_t __int16_mul_asgn(int16_t *multiplicand,  
                           int16_t multiplier);
```

Description

__int16_mul_asgn updates the 16-bit signed integer pointed to by **multiplicand** by multiplying it by **multiplier**. The product is returned as the result. As only the lower 16 bits of the product are returned, **__int16_mul_asgn** returns correct products, modulo 16 bits, for both signed and unsigned arguments.

__int16_to_float32

Synopsis

```
float32_t __int16_to_float32(int16_t arg);
```

Description

__int16_to_float32 converts the 16-bit signed integer **arg** to a 32-bit floating value and returns the floating value as the result. As all 16-bit integers can be represented exactly in 32-bit floating point format, rounding is never necessary.

__int16_to_float64

Synopsis

```
float64_t __int16_to_float64(int16_t arg);
```

Description

__int16_to_float64 converts the 16-bit signed integer **arg** to a 64-bit floating value and returns the floating value as the result. As all 16-bit integers can be represented exactly in 64-bit floating point format, rounding is never necessary.

__int32_asr

Synopsis

```
int32_t __int32_asr(int32_t arg,  
                     int bits);
```

Description

__int32_asr shifts **arg** arithmetically right by **bits** bit positions, replicating the sign bit, and returns the shifted result.

__int32_asr_asgn

Synopsis

```
int32_t __int32_asr_asgn(int32_t *arg,  
                           int bits);
```

Description

__int32_asr_asgn updates the 32-bit signed integer pointed to by **arg** by arithmetically shifting it right by **its** bit positions, replicating the sign bit. The shifted value is returned as the result.

__int32_div

Synopsis

```
int32_t __int32_div(int32_t dividend,  
                     int32_t divisor);
```

Description

__int32_div divides **dividend** by **divisor** and returns the signed quotient, truncated towards zero, as the result.

__int32_div_asgn

Synopsis

```
int32_t __int32_div_asgn(int32_t *dividend,  
                           int32_t divisor);
```

Description

__int32_div_asgn updates the 32-bit signed integer pointed to by **dividend** by dividing it by **divisor** and truncated towards zero. The quotient is returned as the result.

__int32_lsl

Synopsis

```
int32_t __int32_lsl(int32_t arg,  
                     int bits);
```

Description

__int32_lsl shifts **arg** left by **bits** bit positions, shifting zeros in from the left.

__int32_lsl_asgn

Synopsis

```
uint32_t __int32_lsl_asgn(uint32_t *arg,  
                           int bits);
```

Description

__int32_lsl_asgn updates the 32-bit unsigned integer pointed to by **arg** by shifting it left by **bits** bit positions, shifting in zeros in from the right. The shifted value is returned as the result.

__int32_lsr

Synopsis

```
uint32_t __int32_lsr(uint32_t arg,  
                      int bits);
```

Description

__int32_lsr shifts **arg** logically right by **bits** bit positions, shifting in zeros from the left, and returns the shifted result.

__int32_lsr_asgn

Synopsis

```
uint32_t __int32_lsr_asgn(uint32_t *arg,  
                           int bits);
```

Description

__int32_lsr_asgn updates the 32-bit unsigned integer pointed to by **arg** by logically shifting it right by **bits** bit positions, shifting in zeros from the right. The shifted value is returned as the result.

__int32_mod

Synopsis

```
int32_t __int32_mod(int32_t dividend,  
                     int32_t divisor);
```

Description

__int32_mod divides **dividend** by **divisor** and returns the signed remainder after division as the result.

__int32_mod_asgn

Synopsis

```
int32_t __int32_mod_asgn(int32_t *dividend,  
                           int32_t divisor);
```

Description

__int32_mod_asgn updates the 32-bit signed integer pointed to by **dividend** by assigning it the remainder after division of **dividend** by **divisor**. The remainder is returned as the result.

__int32_mul

Synopsis

```
int32_t __int32_mul(int32_t multiplicand,  
                     int32_t multiplier);
```

Description

__int32_mul multiplies **multiplicand** by **multiplier** and returns the product as the result. As only the lower 32 bits of the product are returned, **__int32_mul** returns correct products, modulo 32 bits, for both signed and unsigned arguments.

__int32_mul_16x16

Synopsis

```
int32_t __int32_mul_16x16(int16_t multiplicand,  
                           int16_t multiplier);
```

Description

this multiplies **multiplicand** by **multiplier** and returns the 32-bit signed product as the result.

__int32_mul_asgn

Synopsis

```
int32_t __int32_mul_asgn(int32_t *multiplicand,  
                           int32_t multiplier);
```

Description

__int32_mul_asgn updates the 32-bit signed integer pointed to by **multiplicand** by multiplying it by **multiplier**. The product is returned as the result. As only the lower 32 bits of the product are returned, **__int32_mul_asgn** returns correct products, modulo 32 bits, for both signed and unsigned arguments.

__int32_to_float32

Synopsis

```
float32_t __int32_to_float32(int32_t arg);
```

Description

__int32_to_float32 converts the 32-bit signed integer **arg** to a 32-bit floating value, rounding if required, and returns the appropriately rounded value as the result.

__int32_to_float64

Synopsis

```
float64_t __int32_to_float64(int32_t arg);
```

Description

__int32_to_float64 converts the 32-bit signed integer **arg** to a 64-bit floating value and returns the floating value as the result. As all 32-bit integers can be represented exactly in 64-bit floating point format, rounding is never necessary.

__int64_asr

Synopsis

```
int64_t __int64_asr(int64_t arg,  
                     int bits);
```

Description

__int64_asr shifts **arg** arithmetically right by **bits** bit positions, replicating the sign bit, and returns the shifted result.

__int64_asr_asgn

Synopsis

```
int64_t __int64_asr_asgn(int64_t *arg,  
                           int bits);
```

Description

__int64_asr_asgn updates the 64-bit signed integer pointed to by **arg** by arithmetically shifting it right by **bits** bit positions, replicating the sign bit. The shifted value is returned as the result.

__int64_div

Synopsis

```
int64_t __int64_div(int64_t dividend,  
                     int64_t divisor);
```

Description

__int64_div divides **dividend** by **divisor** and returns the signed quotient, truncated towards zero, as the result.

__int64_div_asgn

Synopsis

```
int64_t __int64_div_asgn(int64_t *dividend,  
                           int64_t divisor);
```

Description

__int64_div_asgn updates the 64-bit signed integer pointed to by **dividend** by dividing it by **divisor** and truncated towards zero. The quotient is returned as the result.

__int64_lsl

Synopsis

```
int64_t __int64_lsl(int64_t arg,  
                     int bits);
```

Description

__int64_lsl shifts **arg** left by **bits** bit positions, shifting zeros in from the left.

__int64_lsl_asgn

Synopsis

```
uint64_t __int64_lsl_asgn(uint64_t *arg,  
                           int bits);
```

Description

__int64_lsl_asgn updates the 64-bit unsigned integer pointed to by **arg** by shifting it left by **bits** bit positions, shifting in zeros in from the right. The shifted value is returned as the result.

__int64_lsr

Synopsis

```
uint64_t __int64_lsr(uint64_t arg,  
                      int bits);
```

Description

__int64_lsr shifts **arg** logically right by **bits** bit positions, shifting in zeros from the left, and returns the shifted result.

__int64_lsr_asgn

Synopsis

```
uint64_t __int64_lsr_asgn(uint64_t *arg,  
                           int bits);
```

Description

__int64_lsr_asgn updates the 64-bit unsigned integer pointed to by **arg** by logically shifting it right by **bits** bit positions, shifting in zeros from the right. The shifted value is returned as the result.

__int64_mod

Synopsis

```
int64_t __int64_mod(int64_t dividend,  
                     int64_t divisor);
```

Description

__int64_mod divides **dividend** by **divisor** and returns the signed remainder after division as the result.

__int64_mod_asgn

Synopsis

```
int64_t __int64_mod_asgn(int64_t *dividend,  
                           int64_t divisor);
```

Description

__int64_mod_asgn updates the 64-bit signed integer pointed to by **dividend** by assigning it the remainder after division of **dividend** by **divisor**. The remainder is returned as the result.

__int64_mul

Synopsis

```
int64_t __int64_mul(int64_t multiplicand,  
                     int64_t multiplier);
```

Description

__int64_mul multiplies **multiplicand** by **multiplier** and returns the product as the result. As only the lower 64 bits of the product are returned, **__int64_mul** returns correct products, modulo 64 bits, for both signed and unsigned arguments.

__int64_mul_32x32

Synopsis

```
int64_t __int64_mul_32x32(int32_t multiplicand,  
                           int32_t multiplier);
```

Description

this multiplies **multiplicand** by **multiplier** and returns the 64-bit signed product as the result.

__int64_mul_asgn

Synopsis

```
int64_t __int64_mul_asgn(int64_t *multiplicand,  
                           int64_t multiplier);
```

Description

__int64_mul_asgn updates the 64-bit signed integer pointed to by **multiplicand** by multiplying it by **multiplier**. The product is returned as the result. As only the lower 64 bits of the product are returned, **__int64_mul_asgn** returns correct products, modulo 64 bits, for both signed and unsigned arguments.

__int64_to_float32

Synopsis

```
float32_t __int64_to_float32(int64_t arg);
```

Description

__int64_to_float32 converts the 64-bit signed integer **arg** to a 32-bit floating value, rounding if required, and returns the appropriately rounded value as the result.

__int64_to_float64

Synopsis

```
float64_t __int64_to_float64(int64_t arg);
```

Description

__int64_to_float64 converts the 64-bit signed integer **arg** to a 64-bit floating value, rounding if required, and returns the appropriately rounded value as the result.

__uint16_div

Synopsis

```
uint16_t __uint16_div(uint16_t dividend,  
                      uint16_t divisor);
```

Description

__uint16_div divides **dividend** by **divisor** and returns the unsigned quotient, truncated towards zero, as the result.

__uint16_div_asgn

Synopsis

```
uint16_t __uint16_div_asgn(uint16_t *dividend,  
                           uint16_t divisor);
```

Description

__uint16_div_asgn updates the 16-bit unsigned integer pointed to by **dividend** by dividing it by **divisor** and truncated towards zero. The quotient is returned as the result.

__uint16_mod

Synopsis

```
uint16_t __uint16_mod(uint16_t dividend,  
                      uint16_t divisor);
```

Description

__uint16_mod divides **dividend** by **divisor** and returns the unsigned remainder after division as the result.

__uint16_mod_asgn

Synopsis

```
uint16_t __uint16_mod_asgn(uint16_t *dividend,  
                           uint16_t divisor);
```

Description

__uint16_mod_asgn updates the 16-bit unsigned integer pointed to by **dividend** by assigning it the remainder after division of **dividend** by **divisor**. The remainder is returned as the result.

__uint16_mul_8x8

Synopsis

```
uint16_t __uint16_mul_8x8(uint8_t multiplicand,  
                           uint8_t multiplier);
```

Description

__uint16_mul_8x8 multiplies **multiplicand** by **multiplier** and returns the 16-bit unsigned product as the result.

__uint16_to_float32

Synopsis

```
float32_t __uint16_to_float32(uint16_t arg);
```

Description

__uint16_to_float32 converts the 16-bit unsigned integer **arg** to a 32-bit floating value and returns the floating value as the result. As all 16-bit unsigned integers can be represented exactly in 32-bit floating point format, rounding is never necessary.

__uint16_to_float64

Synopsis

```
float64_t __uint16_to_float64(uint16_t arg);
```

Description

__uint16_to_float64 converts the 16-bit unsigned integer **arg** to a 64-bit floating value and returns the floating value as the result. As all 16-bit unsigned integers can be represented exactly in 64-bit floating point format, rounding is never necessary.

__uint32_div

Synopsis

```
uint32_t __uint32_div(uint32_t dividend,  
                      uint32_t divisor);
```

Description

__uint32_div divides **dividend** by **divisor** and returns the unsigned quotient, truncated towards zero, as the result.

__uint32_div_asgn

Synopsis

```
uint32_t __uint32_div_asgn(uint32_t *dividend,  
                           uint32_t divisor);
```

Description

__uint32_div_asgn updates the 32-bit unsigned integer pointed to by **dividend** by dividing it by **divisor** and truncated towards zero. The quotient is returned as the result.

__uint32_mod

Synopsis

```
uint32_t __uint32_mod(uint32_t dividend,  
                      uint32_t divisor);
```

Description

__uint32_mod divides **dividend** by **divisor** and returns the unsigned remainder after division as the result.

__uint32_mod_asgn

Synopsis

```
uint32_t __uint32_mod_asgn(uint32_t *dividend,  
                           uint32_t divisor);
```

Description

__uint32_mod_asgn updates the 32-bit unsigned integer pointed to by **dividend** by assigning it the remainder after division of **dividend** by **divisor**. The remainder is returned as the result.

__uint32_mul_16x16

Synopsis

```
uint32_t __uint32_mul_16x16(uint16_t multiplicand,  
                           uint16_t multiplier);
```

Description

__uint32_mul_16x16 multiplies **multiplicand** by **multiplier** and returns the 32-bit unsigned product as the result.

__uint32_to_float32

Synopsis

```
float32_t __uint32_to_float32(uint32_t arg);
```

Description

__uint32_to_float32 converts the 32-bit unsigned integer **arg** to a 32-bit floating value, rounding if required, and returns the appropriately rounded value as the result.

__uint32_to_float64

Synopsis

```
float64_t __uint32_to_float64(uint32_t arg);
```

Description

__uint32_to_float64 converts the 32-bit unsigned integer **arg** to a 64-bit floating value and returns the floating value as the result. As all 32-bit unsigned integers can be represented exactly in 64-bit floating point format, rounding is never necessary.

__uint64_div

Synopsis

```
uint64_t __uint64_div(uint64_t dividend,  
                      uint64_t divisor);
```

Description

__uint64_div divides **dividend** by **divisor** and returns the unsigned quotient, truncated towards zero, as the result.

__uint64_div_asgn

Synopsis

```
uint64_t __uint64_div_asgn(uint64_t *dividend,  
                           uint64_t divisor);
```

Description

__uint64_div_asgn updates the 64-bit unsigned integer pointed to by **dividend** by dividing it by **divisor** and truncated towards zero. The quotient is returned as the result.

__uint64_mod

Synopsis

```
uint64_t __uint64_mod(uint64_t dividend,  
                      uint64_t divisor);
```

Description

__uint64_mod divides **dividend** by **divisor** and returns the unsigned remainder after division as the result.

__uint64_mod_asgn

Synopsis

```
uint64_t __uint64_mod_asgn(uint64_t *dividend,  
                           uint64_t divisor);
```

Description

__uint64_mod_asgn updates the 64-bit unsigned integer pointed to by **dividend** by assigning it the remainder after division of **dividend** by **divisor**. The remainder is returned as the result.

__uint64_mul_32x32

Synopsis

```
uint64_t __uint64_mul_32x32(uint32_t multiplicand,  
                           uint32_t multiplier);
```

Description

__uint64_mul_32x32 multiplies **multiplicand** by **multiplier** and returns the 64-bit unsigned product as the result.

__uint64_to_float32

Synopsis

```
float32_t __uint64_to_float32(uint64_t arg);
```

Description

__uint64_to_float32 converts the 64-bit unsigned integer **arg** to a 32-bit floating value, rounding if required, and returns the appropriately rounded value as the result.

__uint64_to_float64

Synopsis

```
float64_t __uint64_to_float64(uint64_t arg);
```

Description

__uint64_to_float64 converts the 64-bit unsigned integer **arg** to a 64-bit floating value, rounding if required, and returns the appropriately rounded value as the result.

<ctype.h>

API Summary

Classification functions	
isalnum	Is character alphanumeric?
isalpha	Is character alphabetic?
isblank	Is character a space or horizontal tab?
iscntrl	Is character a control?
isdigit	Is character a decimal digit?
isgraph	Is character any printing character except space?
islower	Is character a lowercase letter?
isprint	Is character printable?
ispunct	Is character a punctuation mark?
isspace	Is character a whitespace character?
isupper	Is character an uppercase letter?
isxdigit	Is character a hexadecimal digit?
Conversion functions	
tolower	Convert uppercase character to lowercase
toupper	Convert lowercase character to uppercase
Classification functions (extended)	
isalnum_l	Is character alphanumeric?
isalpha_l	Is character alphabetic?
isblank_l	Is character a space or horizontal tab?
iscntrl_l	Is character a control character?
isdigit_l	Is character a decimal digit?
isgraph_l	Is character any printing character except space?
islower_l	Is character a lowercase letter?
isprint_l	Is character printable?
ispunct_l	Is character a punctuation mark?
isspace_l	Is character a whitespace character?
isupper_l	Is character an uppercase letter?
isxdigit_l	Is character a hexadecimal digit?
Conversion functions (extended)	
tolower_l	Convert uppercase character to lowercase

toupper_I

Convert lowercase character to uppercase

isalnum

Synopsis

```
int isalnum(int c);
```

Description

isalnum returns nonzero (true) if and only if the value of the argument **c** is an alphabetic or numeric character.

isalnum_l

Synopsis

```
int isalnum_l(int c,  
             locale_t loc);
```

Description

isalnum_l returns nonzero (true) if and only if the value of the argument **c** is a alphabetic or numeric character in locale **loc**.

isalpha

Synopsis

```
int isalpha(int c);
```

Description

isalpha returns true if the character **c** is alphabetic. That is, any character for which **isupper** or **islower** returns true is considered alphabetic in addition to any of the locale-specific set of alphabetic characters for which none of **iscntrl**, **isdigit**, **ispunct**, or **isspace** is true.

In the 'C' locale, **isalpha** returns nonzero (true) if and only if **isupper** or **islower** return true for value of the argument **c**.

isalpha_l

Synopsis

```
int isalpha_l(int c,  
             locale_t loc);
```

Description

isalpha_l returns nonzero (true) if and only if **isupper** or **islower** return true for value of the argument **c** in locale **loc**.

isblank

Synopsis

```
int isblank(int c);
```

Description

isblank returns nonzero (true) if and only if the value of the argument **c** is either a space character (' ') or the horizontal tab character ('\t').

isblank_l

Synopsis

```
int isblank_l(int c,  
             locale_t loc);
```

Description

isblank_l returns nonzero (true) if and only if the value of the argument **c** is either a space character (' ') or the horizontal tab character ('\t') in locale **loc**.

iscntrl

Synopsis

```
int iscntrl(int c);
```

Description

iscntrl returns nonzero (true) if and only if the value of the argument **c** is a control character. Control characters have values 0 through 31 and the single value 127.

iscntrl_l

Synopsis

```
int iscntrl_l(int c,  
              locale_t loc);
```

Description

iscntrl_l returns nonzero (true) if and only if the value of the argument **c** is a control character in locale **loc**.

isdigit

Synopsis

```
int isdigit(int c);
```

Description

isdigit returns nonzero (true) if and only if the value of the argument **c** is a digit.

isdigit_l

Synopsis

```
int isdigit_l(int c,  
             locale_t loc);
```

Description

isdigit_l returns nonzero (true) if and only if the value of the argument **c** is a decimal digit in locale **loc**.

isgraph

Synopsis

```
int isgraph(int c);
```

Description

isgraph returns nonzero (true) if and only if the value of the argument **c** is any printing character except space (' ').

isgraph_l

Synopsis

```
int isgraph_l(int c,  
             locale_t loc);
```

Description

isgraph_l returns nonzero (true) if and only if the value of the argument **c** is any printing character except space (' ') in locale **loc**.

islower

Synopsis

```
int islower(int c);
```

Description

islower returns nonzero (true) if and only if the value of the argument **c** is an lowercase letter.

islower_l

Synopsis

```
int islower_l(int c,  
             locale_t loc);
```

Description

islower_l returns nonzero (true) if and only if the value of the argument **c** is an lowercase letter in locale **loc**.

isprint

Synopsis

```
int isprint(int c);
```

Description

isprint returns nonzero (true) if and only if the value of the argument **c** is any printing character including space (' ').

isprint_l

Synopsis

```
int isprint_l(int c,  
             locale_t loc);
```

Description

isprint_l returns nonzero (true) if and only if the value of the argument **c** is any printing character including space (' ') in locale **loc**.

ispunct

Synopsis

```
int ispunct(int c);
```

Description

ispunct returns nonzero (true) for every printing character for which neither **isspace** nor **isalnum** is true.

ispunct_l

Synopsis

```
int ispunct_l(int c,  
             locale_t loc);
```

Description

ispunct_l returns nonzero (true) for every printing character for which neither **isspace** nor **isalnum** is true in in locale **loc**.

isspace

Synopsis

```
int isspace(int c);
```

Description

isspace returns nonzero (true) if and only if the value of the argument **c** is a standard white-space character. The standard white-space characters are space (' '), form feed ('\f'), new-line ('\n'), carriage return ('\r'), horizontal tab ('\t'), and vertical tab ('\v').

isspace_l

Synopsis

```
int isspace_l(int c,  
             locale_t loc);
```

Description

`isspace_l` returns nonzero (true) if and only if the value of the argument `c` is a standard white-space character in in locale `loc`.

isupper

Synopsis

```
int isupper(int c);
```

Description

isupper returns nonzero (true) if and only if the value of the argument **c** is an uppercase letter.

isupper_l

Synopsis

```
int isupper_l(int c,  
             locale_t loc);
```

Description

`isupper_l` returns nonzero (true) if and only if the value of the argument `c` is an uppercase letter in locale `loc`.

isxdigit

Synopsis

```
int isxdigit(int c);
```

Description

isxdigit returns nonzero (true) if and only if the value of the argument **c** is a hexadecimal digit.

isxdigit_l

Synopsis

```
int isxdigit_l(int c,  
               locale_t loc);
```

Description

`isxdigit_l` returns nonzero (true) if and only if the value of the argument `c` is a hexadecimal digit in locale `loc`.

tolower

Synopsis

```
int tolower(int c);
```

Description

tolower converts an uppercase letter to a corresponding lowercase letter. If the argument **c** is a character for which **isupper** is true and there are one or more corresponding characters, as specified by the current locale, for which **islower** is true, the **tolower** function returns one of the corresponding characters (always the same one for any given locale); otherwise, the argument is returned unchanged.

Note that even though **isupper** can return true for some characters, **tolower** may return that uppercase character unchanged as there are no corresponding lowercase characters in the locale.

tolower_l

Synopsis

```
int tolower_l(int c,  
             locale_t loc);
```

Description

tolower_l converts an uppercase letter to a corresponding lowercase letter in locale **loc**. If the argument **c** is a character for which **isupper** is true in locale **loc**, **tolower_l** returns the corresponding lowercase letter; otherwise, the argument is returned unchanged.

toupper

Synopsis

```
int toupper(int c);
```

Description

toupper converts a lowercase letter to a corresponding uppercase letter. If the argument is a character for which **islower** is true and there are one or more corresponding characters, as specified by the current locale, for which **isupper** is true, **toupper** returns one of the corresponding characters (always the same one for any given locale); otherwise, the argument is returned unchanged. Note that even though **islower** can return true for some characters, **toupper** may return that lowercase character unchanged as there are no corresponding uppercase characters in the locale.

toupper_l

Synopsis

```
int toupper_l(int c,  
              locale_t loc);
```

Description

toupper_l converts a lowercase letter to a corresponding uppercase letter in locale **loc**. If the argument **c** is a character for which **islower** is true in locale **loc**, **toupper_l** returns the corresponding uppercase letter; otherwise, the argument is returned unchanged.

<debugio.h>

API Summary

File Functions	
<code>debug_clearerr</code>	Clear error indicator
<code>debug_fclose</code>	Closes an open stream
<code>debug_feof</code>	Check end of file condition
<code>debug_ferror</code>	Check error indicator
<code>debug_fflush</code>	Flushes buffered output
<code>debug_fgetc</code>	Read a character from a stream
<code>debug_fgetpos</code>	Return file position
<code>debug_fgets</code>	Read a string
<code>debug_filesize</code>	Return the size of a file
<code>debug_fopen</code>	Opens a file on the host PC
<code>debug_fprintf</code>	Formatted write
<code>debug_fprintf_c</code>	Formatted write
<code>debug_fputc</code>	Write a character
<code>debug_fputs</code>	Write a string
<code>debug_fread</code>	Read data
<code>debug_freopen</code>	Reopens a file on the host PC
<code>debug_fscanf</code>	Formatted read
<code>debug_fscanf_c</code>	Formatted read
<code>debug_fseek</code>	Set file position
<code>debug_fsetpos</code>	Set file position
<code>debug_ftell</code>	Return file position
<code>debug_fwrite</code>	Write data
<code>debug_remove</code>	Deletes a file on the host PC
<code>debug_rename</code>	Renames a file on the host PC
<code>debug_rewind</code>	Set file position to the beginning
<code>debug_tmpfile</code>	Open a temporary file
<code>debug_tmpnam</code>	Generate temporary filename
<code>debug_ungetc</code>	Push a character
<code>debug_vfprintf</code>	Formatted write
<code>debug_vfscanf</code>	Formatted read

Debug Terminal Output Functions	
<code>debug_printf</code>	Formatted write
<code>debug_printf_c</code>	Formatted write
<code>debug_putchar</code>	Write a character
<code>debug_puts</code>	Write a string
<code>debug_vprintf</code>	Formatted write
Debug Terminal Input Functions	
<code>debug_getch</code>	Blocking character read
<code>debug_getchar</code>	Line-buffered character read
<code>debug_getd</code>	Line-buffered double read
<code>debug_getf</code>	Line-buffered float read
<code>debug_geti</code>	Line-buffered integer read
<code>debug_getl</code>	Line-buffered long read
<code>debug_getll</code>	Line-buffered long long read
<code>debug_gets</code>	String read
<code>debug_getu</code>	Line-buffered unsigned integer
<code>debug_getul</code>	Line-buffered unsigned long read
<code>debug_getull</code>	Line-buffered unsigned long long read
<code>debug_kbhit</code>	Polled character read
<code>debug_scanf</code>	Formatted read
<code>debug_scanf_c</code>	Formatted read
<code>debug_vscanf</code>	Formatted read
Debugger Functions	
<code>debug_abort</code>	Stop debugging
<code>debug_break</code>	Stop target
<code>debug_enabled</code>	Test if debug input/output is enabled
<code>debug_exit</code>	Stop debugging
<code>debug_getargs</code>	Get arguments
<code>debug_loadsymbols</code>	Load debugging symbols
<code>debug_runtime_error</code>	Stop and report error
<code>debug_unloadsymbols</code>	Unload debugging symbols
Misc Functions	
<code>debug_getenv</code>	Get environment variable value
<code>debug_perror</code>	Display error
<code>debug_system</code>	Execute command

debug_time**get time**

debug_abort

Synopsis

```
void debug_abort(void);
```

Description

`debug_abort` causes the debugger to exit and a failure result is returned to the user.

debug_break

Synopsis

```
void debug_break(void);
```

Description

debug_break causes the debugger to stop the target and position the cursor at the line that called **debug_break**.

debug_clearerr

Synopsis

```
void debug_clearerr(DEBUG_FILE *stream);
```

Description

debug_clearerr clears any error indicator or end of file condition for the **stream**.

debug_enabled

Synopsis

```
int debug_enabled(void);
```

Description

debug_enabled returns non-zero if the debugger is connected - you can use this to test if a debug input/output functions will work.

debug_exit

Synopsis

```
void debug_exit(int result);
```

Description

debug_exit causes the debugger to exit and **result** is returned to the user.

debug_fclose

Synopsis

```
int debug_fclose(DEBUG_FILE *stream);
```

Description

`debug_fclose` flushes any buffered output of the `stream` and then closes the stream.

`debug_fclose` returns 0 on success or -1 if there was an error.

debug_feof

Synopsis

```
int debug_feof(DEBUG_FILE *stream);
```

Description

debug_feof returns non-zero if the end of file condition is set for the **stream**.

debug_ferror

Synopsis

```
int debug_ferror(DEBUG_FILE *stream);
```

Description

debug_ferror returns non-zero if the error indicator is set for the **stream**.

debug_fflush

Synopsis

```
int debug_fflush(DEBUG_FILE *stream);
```

Description

debug_fflush flushes any buffered output of the **stream**.

debug_fflush returns 0 on success or -1 if there was an error.

debug_fgetc

Synopsis

```
int debug_fgetc(DEBUG_FILE *stream);
```

Description

debug_fgetc reads and returns the next character on **stream** or -1 if no character is available.

debug_fgetpos

Synopsis

```
int debug_fgetpos(DEBUG_FILE *stream,  
                  long *pos);
```

Description

debug_fgetpos is equivalent to **debug_fseek**.

debug_fgets

Synopsis

```
char *debug_fgets(char *s,  
                  int n,  
                  DEBUG_FILE *stream);
```

Description

debug_fgets reads at most **n-1** characters or the characters up to (and including) a newline from the input stream into the array pointed to by **s**. A null character is written to the array after the input characters.

debug_fgets returns **s** on success, or 0 on error or end of file.

debug_filesize

Synopsis

```
int debug_filesize(DEBUG_FILE *stream);
```

Description

debug_filesize returns the size of the file associated with the **stream** in bytes.

debug_filesize returns -1 on error.

debug_fopen

Synopsis

```
DEBUG_FILE *debug_fopen(const char *filename,  
                        const char *mode);
```

Description

debug_fopen opens the **filename** on the host PC and returns a stream or **0** if the open fails. The **filename** is a host PC filename which is opened relative to the debugger working directory. The **mode** is a string containing one of:

- **r** open file for reading.
- **w** create file for writing.
- **a** open or create file for writing and position at the end of the file.
- **r+** open file for reading and writing.
- **w+** create file for reading and writing.
- **a+** open or create text file for reading and writing and position at the end of the file.

followed by one of:

- **t** for a text file.
- **b** for a binary file.

debug_fopen returns a stream that can be used to access the file or **0** if the open fails.

debug_fprintf

Synopsis

```
int debug_fprintf(DEBUG_FILE *stream,
                  const char *format,
                  ...);
```

Description

debug_fprintf writes to **stream**, under control of the string pointed to by **format** that specifies how subsequent arguments are converted for output. The **format** string is a standard C printf format string. The actual formatting is performed on the host by the debugger and therefore **debug_fprintf** consumes only a very small amount of code and data space, only the overhead to call the function.

If there are insufficient arguments for the format, the behavior is undefined. If the format is exhausted while arguments remain, the excess arguments are evaluated but are otherwise ignored.

debug_fprintf returns the number of characters transmitted, or a negative value if an output or encoding error occurred.

debug_fprintf_c

Synopsis

```
int debug_fprintf_c(DEBUG_FILE *stream,
                     __code const char *format,
                     ...);
```

Description

`debug_fprintf_c` is equivalent to `debug_fprintf` with the format string in code memory.

debug_fputc

Synopsis

```
int debug_fputc(int c,  
                DEBUG_FILE *stream);
```

Description

debug_fputc writes the character **c** to the output **stream**.

debug_fputc returns the character written or -1 if an error occurred.

debug_fputs

Synopsis

```
int debug_fputs(const char *s,  
                 DEBUG_FILE *stream);
```

Description

debug_fputs writes the string pointed to by **s** to the output **stream** and appends a new-line character. The terminating null character is not written.

debug_fputs returns -1 if a write error occurs; otherwise it returns a nonnegative value.

debug_fread

Synopsis

```
int debug_fread(void *ptr,
                 int size,
                 int nobj,
                 DEBUG_FILE *stream);
```

Description

debug_fread reads from the input **stream** into the array **ptr** at most **nobj** objects of size **size**.

debug_fread returns the number of objects read. If this number is different from **nobj** then **debug_feof** and **debug_ferror** can be used to determine status.

debug_freopen

Synopsis

```
DEBUG_FILE *debug_freopen(const char *filename,  
                           const char *mode,  
                           DEBUG_FILE *stream);
```

Description

debug_freopen is the same as **debug_open** except the file associated with the **stream** is closed and the opened file is then associated with the **stream**.

debug_fscanf

Synopsis

```
int debug_fscanf(DEBUG_FILE *stream,  
                 const char *format,  
                 ...);
```

Description

debug_fscanf reads from the input **stream**, under control of the string pointed to by **format**, that specifies how subsequent arguments are converted for input. The **format** string is a standard C scanf format string. The actual formatting is performed on the host by the debugger and therefore **debug_fscanf** consumes only a very small amount of code and data space, only the overhead to call the function.

If there are insufficient arguments for the format, the behavior is undefined. If the format is exhausted while arguments remain, the excess arguments are evaluated but are otherwise ignored.

debug_fscanf returns number of characters read, or a negative value if an output or encoding error occurred.

debug_fscanf_c

Synopsis

```
int debug_fscanf_c(DEBUG_FILE *stream,  
                   __code const char *format,  
                   ...);
```

Description

debug_fscanf_c is equivalent to **debug_fscanf** with the format string in code memory.

debug_fseek

Synopsis

```
int debug_fseek(DEBUG_FILE *stream,
                 long offset,
                 int origin);
```

Description

debug_fseek sets the file position for the **stream**. A subsequent read or write will access data at that position.

The **origin** can be one of:

- 0 sets the position to **offset** bytes from the beginning of the file.
- 1 sets the position to **offset** bytes relative to the current position.
- 2 sets the position to **offset** bytes from the end of the file.

Note that for text files **offset** must be zero. **debug_fseek** returns zero on success, non-zero on error.

debug_fsetpos

Synopsis

```
int debug_fsetpos(DEBUG_FILE *stream,  
                  const long *pos);
```

Description

debug_fsetpos is equivalent to **debug_fseek** with 0 as the **origin**.

debug_ftell

Synopsis

```
long debug_ftell(DEBUG_FILE *stream);
```

Description

debug_ftell returns the current file position of the **stream**.

debug_ftell returns -1 on error.

debug_fwrite

Synopsis

```
int debug_fwrite(const void *ptr,
                  int size,
                  int nobj,
                  DEBUG_FILE *stream);
```

Description

debug_fwrite write to the output **stream** from the array **ptr** at most **nobj** objects of size **size**.

debug_fwrite returns the number of objects written. If this number is different from **nobj** then **debug_feof** and **debug_ferror** can be used to determine status.

debug_getargs

Synopsis

```
int debug_getargs(unsigned bufsize,  
                  unsigned char *buf);
```

Description

debug_getargs stores the debugger command line arguments into the memory pointed at by **buf** up to a maximum of **bufsize** bytes. The command line is stored as a C **argc** array of null terminated string and the number of entries is returned as the result.

debug_getch

Synopsis

```
int debug_getch(void);
```

Description

debug_getch reads one character from the Debug Terminal. This function will block until a character is available.

debug_getchar

Synopsis

```
int debug_getchar(void);
```

Description

debug_getchar reads one character from the **Debug Terminal**. This function uses line input and will therefore block until characters are available and ENTER has been pressed.

debug_getchar returns the character that has been read.

debug_getd

Synopsis

```
int debug_getd(double *);
```

Description

debug_getd reads a double from the **Debug Terminal**. The number is written to the double object pointed to by **d**.

debug_getd returns zero on success or -1 on error.

debug_getenv

Synopsis

```
char *debug_getenv(char *name);
```

Description

debug_getenv returns the value of the environment variable **name** or 0 if the environment variable cannot be found.

debug_getf

Synopsis

```
int debug_getf(float *f);
```

Description

`debug_getf` reads an float from the **Debug Terminal**. The number is written to the float object pointed to by `f`.

`debug_getf` returns zero on success or -1 on error.

debug_geti

Synopsis

```
int debug_geti(int *i);
```

Description

debug_geti reads an integer from the **Debug Terminal**. If the number starts with **0x** it is interpreted as a hexadecimal number, if it starts with **0** it is interpreted as an octal number, if it starts with **0b** it is interpreted as a binary number, otherwise it is interpreted as a decimal number. The number is written to the integer object pointed to by **i**.

debug_geti returns zero on success or -1 on error.

debug_getl

Synopsis

```
int debug_getl(long *l);
```

Description

debug_getl reads a long from the **Debug Terminal**. If the number starts with **0x** it is interpreted as a hexadecimal number, if it starts with **0** it is interpreted as an octal number, if it starts with **b** it is interpreted as a binary number, otherwise it is interpreted as a decimal number. The number is written to the long object pointed to by **l**.

debug_getl returns zero on success or -1 on error.

debug_getll

Synopsis

```
int debug_getll(long long *ll);
```

Description

debug_getll reads a long long from the **Debug Terminal**. If the number starts with **0x** it is interpreted as a hexadecimal number, if it starts with **0** it is interpreted as an octal number, if it starts with **0b** it is interpreted as a binary number, otherwise it is interpreted as a decimal number. The number is written to the long long object pointed to by **ll**.

debug_getll returns zero on success or -1 on error.

debug_gets

Synopsis

```
char *debug_gets(char *s);
```

Description

debug_gets reads a string from the Debug Terminal in memory pointed at by **s**. This function will block until ENTER has been pressed.

debug_gets returns the value of **s**.

debug_getu

Synopsis

```
int debug_getu(unsigned *u);
```

Description

debug_getu reads an unsigned integer from the **Debug Terminal**. If the number starts with **0x** it is interpreted as a hexadecimal number, if it starts with **0** it is interpreted as an octal number, if it starts with **0b** it is interpreted as a binary number, otherwise it is interpreted as a decimal number. The number is written to the unsigned integer object pointed to by **u**.

debug_getu returns zero on success or -1 on error.

debug_getul

Synopsis

```
int debug_getul(unsigned long *ul);
```

Description

`debug_getul` reads an unsigned long from the **Debug Terminal**. If the number starts with **0x** it is interpreted as a hexadecimal number, if it starts with **0** it is interpreted as an octal number, if it starts with **0b** it is interpreted as a binary number, otherwise it is interpreted as a decimal number. The number is written to the long object pointed to by `ul`.

`debug_getul` returns zero on success or -1 on error.

debug_getull

Synopsis

```
int debug_getull(unsigned long long *ull);
```

Description

debug_getull reads an unsigned long long from the **Debug Terminal**. If the number starts with **0x** it is interpreted as a hexadecimal number, if it starts with **0** it is interpreted as an octal number, if it starts with **0b** it is interpreted as a binary number, otherwise it is interpreted as a decimal number. The number is written to the long long object pointed to by **ull**.

debug_getull returns zero on success or -1 on error.

debug_kbhit

Synopsis

```
int debug_kbhit(void);
```

Description

debug_kbhit polls the Debug Terminal for a character and returns a non-zero value if a character is available or 0 if not.

debug_loadsymbols

Synopsis

```
void debug_loadsymbols(const char *filename,  
                      const void *address,  
                      const char *breaksymbol);
```

Description

debug_loadsymbols instructs the debugger to load the debugging symbols in the file denoted by **filename**. The **filename** is a (macro expanded) host PC filename which is relative to the debugger working directory. The **address** is the load address which is required for debugging position independent executables, supply **NULL** for regular executables. The **breaksymbol** is the name of a symbol in the filename to set a temporary breakpoint on or **NULL**.

debug_perror

Synopsis

```
void debug_perror(const char *s);
```

Description

debug_perror displays the optional string **s** on the **Debug Terminal** together with a string corresponding to the **errno** value of the last Debug IO operation.

debug_printf

Synopsis

```
int debug_printf(const char *format,  
                 ...);
```

Description

debug_printf writes to the **Debug Terminal**, under control of the string pointed to by **format** that specifies how subsequent arguments are converted for output. The **format** string is a standard C printf format string. The actual formatting is performed on the host by the debugger and therefore **debug_printf** consumes only a very small amount of code and data space, only the overhead to call the function.

If there are insufficient arguments for the format, the behavior is undefined. If the format is exhausted while arguments remain, the excess arguments are evaluated but are otherwise ignored.

debug_printf returns the number of characters transmitted, or a negative value if an output or encoding error occurred.

debug_printf_c

Synopsis

```
int debug_printf_c(__code const char *format,  
                   ...);
```

Description

`debug_printf_c` is equivalent to `debug_printf` with the format string in code memory.

debug_putchar

Synopsis

```
int debug_putchar(int c);
```

Description

debug_putchar write the character **c** to the Debug Terminal.

debug_putchar returns the character written or -1 if a write error occurs.

debug_puts

Synopsis

```
int debug_puts(const char *);
```

Description

debug_puts writes the string **s** to the Debug Terminal followed by a new-line character.

debug_puts returns -1 if a write error occurs, otherwise it returns a nonnegative value.

debug_remove

Synopsis

```
int debug_remove(const char *filename);
```

Description

debug_remove removes the filename denoted by **filename** and returns **0** on success or **-1** on error. The **filename** is a host PC filename which is relative to the debugger working directory.

debug_rename

Synopsis

```
int debug_rename(const char *oldfilename,  
                 const char *newfilename);
```

Description

debug_rename renames the file denoted by **oldpath** to **newpath** and returns zero on success or non-zero on error. The **oldpath** and **newpath** are host PC filenames which are relative to the debugger working directory.

debug_rewind

Synopsis

```
void debug_rewind(DEBUG_FILE *stream);
```

Description

debug_rewind sets the current file position of the **stream** to the beginning of the file and clears any error and end of file conditions.

debug_runtime_error

Synopsis

```
void debug_runtime_error(const char *error);
```

Description

debug_runtime_error causes the debugger to stop the target, position the cursor at the line that called **debug_runtime_error**, and display the null-terminated string pointed to by **error**.

debug_scnf

Synopsis

```
int debug_scnf(const char *format,  
               ...);
```

Description

debug_scnf reads from the **Debug Terminal**, under control of the string pointed to by **format** that specifies how subsequent arguments are converted for input. The **format** string is a standard C `scanf` format string. The actual formatting is performed on the host by the debugger and therefore **debug_scnf** consumes only a very small amount of code and data space, only the overhead to call the function.

If there are insufficient arguments for the format, the behavior is undefined. If the format is exhausted while arguments remain, the excess arguments are evaluated but are otherwise ignored.

debug_scnf returns number of characters read, or a negative value if an output or encoding error occurred.

debug_scnf_c

Synopsis

```
int debug_scnf_c(__code const char *format,  
                  ...);
```

Description

debug_scnf_c is equivalent to **debug_scnf** with the format string in code memory.

debug_system

Synopsis

```
int debug_system(char *command);
```

Description

debug_system executes the **command** with the host command line interpreter and returns the commands exit status.

debug_time

Synopsis

```
long debug_time(long *ptr);
```

Description

debug_time returns the number of seconds elapsed since midnight (00:00:00), January 1, 1970, coordinated universal time (UTC), according to the system clock of the host computer. The return value is stored in ***ptr** if **ptr** is not NULL.

debug_tmpfile

Synopsis

```
DEBUG_FILE *debug_tmpfile(void);
```

Description

debug_tmpfile creates a temporary file on the host PC which is deleted when the stream is closed.

debug_tmpnam

Synopsis

```
char *debug_tmpnam(char *str);
```

Description

debug_tmpnam returns a unique temporary filename. If **str** is **NULL** then a static buffer is used to store the filename, otherwise the filename is stored in **str**. On success a pointer to the string is returned, on failure **0** is returned.

debug_ungetc

Synopsis

```
int debug_ungetc(int c,  
                  DEBUG_FILE *stream);
```

Description

debug_ungetc pushes the character **c** onto the input **stream**. If successful **c** is returned, otherwise -1 is returned.

debug_unloadsymbols

Synopsis

```
void debug_unloadsymbols(const char *filename);
```

Description

debug_unloadsymbols instructs the debugger to unload the debugging symbols (previously loaded by a call to **debug_loadsymbols**) in the file denoted by **filename**. The **filename** is a host PC filename which is relative to the debugger working directory.

debug_vfprintf

Synopsis

```
int debug_vfprintf(DEBUG_FILE *stream,
                   const char *format,
                   __va_list);
```

Description

debug_vfprintf is equivalent to **debug_fprintf** with arguments passed using **stdarg.h** rather than a variable number of arguments.

debug_vfscanf

Synopsis

```
int debug_vfscanf(DEBUG_FILE *stream,
                  const char *format,
                  __va_list);
```

Description

debug_vfscanf is equivalent to **debug_fscanf** with arguments passed using **stdarg.h** rather than a variable number of arguments.

debug_vprintf

Synopsis

```
int debug_vprintf(const char *format,  
                  __va_list);
```

Description

debug_vprintf is equivalent to **debug_printf** with arguments passed using **stdarg.h** rather than a variable number of arguments.

debug_vscanf

Synopsis

```
int debug_vscanf(const char *format,  
                 __va_list);
```

Description

debug_vscanf is equivalent to **debug_scanf** with arguments passed using **stdarg.h** rather than a variable number of arguments.

<errno.h>

API Summary

Error numbers	
EDOM	Domain error
EILSEQ	Illegal byte sequence
EINVAL	Invalid argument
ENOMEM	No memory available
ERANGE	Result too large or too small
Macros	
errno	Last-set error condition

EDOM

Synopsis

```
#define EDOM    . . .
```

Description

EDOM - an input argument is outside the defined domain of a mathematical function.

EILSEQ

Synopsis

```
#define EILSEQ ...
```

Description

EILSEQ - A wide-character code has been detected that does not correspond to a valid character, or a byte sequence does not form a valid wide-character code.

EINVAL

Synopsis

```
#define EINVAL 0x06
```

Description

EINVAL - An argument was invalid, or a combination of arguments was invalid.

ENOMEM

Synopsis

```
#define ENOMEM    0x05
```

Description

ENOMEM - no memory can be allocated by a function in the library. Note that **malloc**, **calloc**, and **realloc** do not set **errno** to **ENOMEM** on failure, but other library routines (such as **duplocale**) may set **errno** to **ENOMEM** when memory allocation fails.

ERANGE

Synopsis

```
#define ERANGE ...
```

Description

ERANGE - the result of the function is too large (overflow) or too small (underflow) to be represented in the available space.

errno

Synopsis

```
int errno;
```

Description

errno is treated as an writable l-value, but the implementation of how the l-value is read an written is hidden from the user.

The value of **errno** is zero at program startup, but is never set to zero by any library function. The value of **errno** may be set to a nonzero value by a library function, and this effect is documented in each function that does so.

Note

The ISO standard does not specify whether **errno** is a macro or an identifier declared with external linkage. Portable programs must not make assumptions about the implementation of **errno**.

In this implementation, **errno** expands to a function call to **__errno** (MSP430, AVR, MAXQ) or **__aeabi_errno_addr** (ARM) that returns a pointer to a volatile **int**. This function can be implemented by the application to provide a thread-specific **errno**.

<float.h>

API Summary

Double exponent minimum and maximum values	
DBL_MAX_10_EXP	The maximum exponent value in base 10 of a double
DBL_MAX_EXP	The maximum exponent value of a double
DBL_MIN_10_EXP	The minimal exponent value in base 10 of a double
DBL_MIN_EXP	The minimal exponent value of a double
Implementation	
DBL_DIG	The number of digits of precision of a double
DBL_MANT_DIG	The number of digits in a double
DECIMAL_DIG	The number of decimal digits that can be rounded without change
FLT_DIG	The number of digits of precision of a float
FLT_EVAL_METHOD	The evaluation format
FLT_MANT_DIG	The number of digits in a float
FLT_RADIX	The radix of the exponent representation
FLT_ROUNDS	The rounding mode
Float exponent minimum and maximum values	
FLT_MAX_10_EXP	The maximum exponent value in base 10 of a float
FLT_MAX_EXP	The maximum exponent value of a float
FLT_MIN_10_EXP	The minimal exponent value in base 10 of a float
FLT_MIN_EXP	The minimal exponent value of a float
Double minimum and maximum values	
DBL_EPSILON	The difference between 1 and the least value greater than 1 of a double
DBL_MAX	The maximum value of a double
DBL_MIN	The minimal value of a double
Float minimum and maximum values	
FLT_EPSILON	The difference between 1 and the least value greater than 1 of a float
FLT_MAX	The maximum value of a float
FLT_MIN	The minimal value of a float

DBL_DIG

Synopsis

```
#define DBL_DIG 15
```

Description

DBL_DIG specifies The number of digits of precision of a **double**.

DBL_EPSILON

Synopsis

```
#define DBL_EPSILON 2.2204460492503131E-16
```

Description

DBL_EPSILON the minimum positive number such that $1.0 + \text{DBL_EPSILON} \neq 1.0$.

DBL_MANT_DIG

Synopsis

```
#define DBL_MANT_DIG 53
```

Description

DBL_MANT_DIG specifies the number of base [FLT_RADIX](#) digits in the mantissa part of a **double**.

DBL_MAX

Synopsis

```
#define DBL_MAX 1.7976931348623157E+308
```

Description

DBL_MAX is the maximum value of a **double**.

DBL_MAX_10_EXP

Synopsis

```
#define DBL_MAX_10_EXP +308
```

Description

DBL_MAX_10_EXP is the maximum value in base 10 of the exponent part of a **double**.

DBL_MAX_EXP

Synopsis

```
#define DBL_MAX_EXP +1024
```

Description

DBL_MAX_EXP is the maximum value of base [FLT_RADIX](#) in the exponent part of a **double**.

DBL_MIN

Synopsis

```
#define DBL_MIN 2.2250738585072014E-308
```

Description

DBL_MIN is the minimum value of a **double**.

DBL_MIN_10_EXP

Synopsis

```
#define DBL_MIN_10_EXP -307
```

Description

DBL_MIN_10_EXP is the minimum value in base 10 of the exponent part of a **double**.

DBL_MIN_EXP

Synopsis

```
#define DBL_MIN_EXP -1021
```

Description

DBL_MIN_EXP is the minimum value of base [FLT_RADIX](#) in the exponent part of a **double**.

DECIMAL_DIG

Synopsis

```
#define DECIMAL_DIG 17
```

Description

DECIMAL_DIG specifies the number of decimal digits that can be rounded to a floating-point number without change to the value.

FLT_DIG

Synopsis

```
#define FLT_DIG 6
```

Description

FLT_DIG specifies The number of digits of precision of a **float**.

FLT_EPSILON

Synopsis

```
#define FLT_EPSILON 1.19209290E-07F // decimal constant
```

Description

FLT_EPSILON the minimum positive number such that $1.0 + \text{FLT_EPSILON} \neq 1.0$.

FLT_EVAL_METHOD

Synopsis

```
#define FLT_EVAL_METHOD 0
```

Description

FLT_EVAL_METHOD specifies that all operations and constants are evaluated to the range and precision of the type.

FLT_MANT_DIG

Synopsis

```
#define FLT_MANT_DIG 24
```

Description

FLT_MANT_DIG specifies the number of base [FLT_RADIX](#) digits in the mantissa part of a [float](#).

FLT_MAX

Synopsis

```
#define FLT_MAX      3.40282347E+38F
```

Description

FLT_MAX is the maximum value of a **float**.

FLT_MAX_10_EXP

Synopsis

```
#define FLT_MAX_10_EXP +38
```

Description

FLT_MAX_10_EXP is the maximum value in base 10 of the exponent part of a **float**.

FLT_MAX_EXP

Synopsis

```
#define FLT_MAX_EXP +128
```

Description

FLT_MAX_EXP is the maximum value of base [FLT_RADIX](#) in the exponent part of a [float](#).

FLT_MIN

Synopsis

```
#define FLT_MIN      1.17549435E-38F
```

Description

FLT_MIN is the minimum value of a **float**.

FLT_MIN_10_EXP

Synopsis

```
#define FLT_MIN_10_EXP -37
```

Description

FLT_MIN_10_EXP is the minimum value in base 10 of the exponent part of a **float**.

FLT_MIN_EXP

Synopsis

```
#define FLT_MIN_EXP -125
```

Description

FLT_MIN_EXP is the minimum value of base [FLT_RADIX](#) in the exponent part of a [float](#).

FLT_RADIX

Synopsis

```
#define FLT_RADIX 2
```

Description

FLT_RADIX specifies the radix of the exponent representation.

FLT_ROUNDS

Synopsis

```
#define FLT_ROUNDS 1
```

Description

FLT_ROUNDS specifies the rounding mode of floating-point addition is round to nearest.

<inmsp.h>

The header file <inmsp.h> defines a number of intrinsic functions of general use for the MSP430 processor. This file is written to be compatible, and in some cases an enhancement of, the <in430.h> file in version 3 of IAR's Embedded Workbench for MSP430 (EW430) product.

API Summary

Status register manipulation	
<u>__bic_SR_register</u>	Clear bits in status register
<u>__bic_SR_register_on_exit</u>	Clear bits in stacked status register
<u>__bis_SR_register</u>	Set bits in status register
<u>__bis_SR_register_on_exit</u>	Set bits in stacked status register
<u>__disable_interrupt</u>	Disable global interrupts
<u>__enable_interrupt</u>	Enable global interrupts
<u>__low_power_mode_0</u>	Enter low power mode 0
<u>__low_power_mode_1</u>	Enter low power mode 1
<u>__low_power_mode_2</u>	Enter low power mode 2
<u>__low_power_mode_3</u>	Enter low power mode 3
<u>__low_power_mode_4</u>	Enter low power mode 4
<u>__low_power_mode_off_on_exit</u>	Enter active mode when interrupt return
<u>__set_interrupt</u>	Restore global interrupts
Byte order manipulation	
<u>__swap_bytes</u>	Swap order of bytes in a word
<u>__swap_long_bytes</u>	Swap order of bytes in a long
<u>__swap_words</u>	Swap order of words in a long
Bit order manipulation	
<u>__bit_reverse_char</u>	Reverse the order of bits in a char
<u>__bit_reverse_long</u>	Reverse the order of bits in a long
<u>__bit_reverse_long_long</u>	Reverse the order of bits in a long long
<u>__bit_reverse_short</u>	Reverse the order of bits in a short
Bit counting	
<u>__bit_count_leading_zeros_char</u>	Count the number of leading zero bits in a char
<u>__bit_count_leading_zeros_long</u>	Count the number of leading zero bits in a long
<u>__bit_count_leading_zeros_long_long</u>	Count the number of leading zero bits in a long long
<u>__bit_count_leading_zeros_short</u>	Count the number of leading zero bits in a short

Register manipulation	
<u>get_register</u>	Read from processor register
<u>set_register</u>	Write to processor register
Binary coded decimal arithmetic	
<u>bcd_add_long</u>	Add two 32-bit values using decimal arithmetic
<u>bcd_add_long_long</u>	Add two 64-bit values using decimal arithmetic
<u>bcd_add_short</u>	Add two 16-bit values using decimal arithmetic
<u>bcd_negate_long</u>	Negate a 32-bit value using decimal arithmetic
<u>bcd_negate_long_long</u>	Negate a 64-bit value using decimal arithmetic
<u>bcd_negate_short</u>	Negate a 16-bit value using decimal arithmetic
<u>bcd_subtract_long</u>	Subtract two 32-bit values using decimal arithmetic
<u>bcd_subtract_long_long</u>	Subtract two 64-bit values using decimal arithmetic
<u>bcd_subtract_short</u>	Subtract two 16-bit values using decimal arithmetic
Miscellaneous functions	
<u>delay_cycles</u>	Delay execution for a number of cycles
<u>even_in_range</u>	Assert value is a restricted range
<u>insert_opcode</u>	Insert an opcode
<u>no_operation</u>	Insert a NOP instruction
Extended memory functions	
<u>read_extended_byte</u>	Read a byte from extend memory
<u>read_extended_long</u>	Read a long from extended memory
<u>read_extended_word</u>	Read a word from extended memory
<u>write_extended_byte</u>	Write a byte to extended memory
<u>write_extended_long</u>	Write a long to extended memory
<u>write_extended_word</u>	Write a word to extended memory

__bcd_add_long

Synopsis

```
unsigned long __bcd_add_long(unsigned long x,  
                           unsigned long y);
```

Description

__bcd_add_long adds **x** to **y** using decimal arithmetic. Both **x** and **y** must be binary coded decimal numbers and the result is a binary coded decimal number.

__bcd_add_long is an intrinsic function and produces inline code.

__bcd_add_long_long

Synopsis

```
unsigned long long __bcd_add_long_long(unsigned long long x,  
                                      unsigned long long y);
```

Description

__bcd_add_long_long adds **x** to **y** using decimal arithmetic. Both **x** and **y** must be binary coded decimal numbers and the result is a binary coded decimal number.

__bcd_add_long_long is an intrinsic function and produces inline code.

__bcd_add_short

Synopsis

```
unsigned __bcd_add_short(unsigned x,  
                         unsigned y);
```

Description

__bcd_add_short adds **x** to **y** using decimal arithmetic. Both **x** and **y** must be binary coded decimal numbers and the result is a binary coded decimal number.

__bcd_add_short is an intrinsic function and produces inline code.

__bcd_negate_long

Synopsis

```
unsigned long __bcd_negate_long(unsigned long x);
```

Description

__bcd_negate_long negates (computes the 9's complement of) **x** using decimal arithmetic. **x** must be a binary coded decimal number and the result is a binary coded decimal number.

__bcd_negate_long is an intrinsic function and produces inline code.

__bcd_negate_long_long

Synopsis

```
unsigned long long __bcd_negate_long_long(unsigned long long x);
```

Description

__bcd_negate_long_long negates (computes the 9's complement of) **x** using decimal arithmetic. **x** must be a binary coded decimal number and the result is a binary coded decimal number.

__bcd_negate_long_long is an intrinsic function and produces inline code.

__bcd_negate_short

Synopsis

```
unsigned __bcd_negate_short(unsigned x);
```

Description

__bcd_negate_short negates (computes the 9's complement of) **x** using decimal arithmetic. **x** must be a binary coded decimal number and the result is a binary coded decimal number.

__bcd_negate_short is an intrinsic function and produces inline code.

__bcd_subtract_long

Synopsis

```
unsigned long __bcd_subtract_long(unsigned long x,  
                                  unsigned long y);
```

Description

__bcd_subtract_long subtracts **y** from **x** using decimal arithmetic. Both **x** and **y** must be binary coded decimal numbers and the result is a binary coded decimal number.

__bcd_subtract_long is an intrinsic function and produces inline code.

__bcd_subtract_long_long

Synopsis

```
unsigned long long __bcd_subtract_long_long(unsigned long long x,  
                                         unsigned long long y);
```

Description

__bcd_subtract_long_long subtracts **y** from **x** using decimal arithmetic. Both **x** and **y** must be binary coded decimal numbers and the result is a binary coded decimal number.

__bcd_subtract_long_long is an intrinsic function and produces inline code.

__bcd_subtract_short

Synopsis

```
unsigned __bcd_subtract_short(unsigned x,  
                             unsigned y);
```

Description

__bcd_subtract_short subtracts **y** from **x** using decimal arithmetic. Both **x** and **y** must be binary coded decimal numbers and the result is a binary coded decimal number.

__bcd_subtract_short is an intrinsic function and produces inline code.

__bic_SR_register

Synopsis

```
unsigned __bic_SR_register(unsigned mask);
```

Description

__bic_SR_register clears the bits specified in **mask** in the MSP430 status register (i.e. it bitwise ands the complement of **mask** into the status register).

__bic_SR_register returns the value of the MSP430 status register before the update.

__bic_SR_register is an intrinsic function and produces inline code.

__bic_SR_register_on_exit

Synopsis

```
unsigned __bic_SR_register_on_exit(unsigned mask);
```

Description

__bic_SR_register_on_exit clears the bits specified in **mask** in the saved status register of an interrupt function (i.e. it bitwise ands the complement of **mask** into the saved status register). This allows you to change the operating mode of the MSP430 on return from the interrupt service routine, such as changing the low power mode.

__bic_SR_register_on_exit returns the value of the saved MSP430 status register before the update.

__bic_SR_register_on_exit is an intrinsic function and produces inline code.

Note

__bic_SR_register_on_exit can only be used in interrupt functions—an error is reported if it is used outside an interrupt function.

__bis_SR_register

Synopsis

```
unsigned __bis_SR_register(unsigned mask);
```

Description

__bis_SR_register sets the bits specified in **mask** in the MSP430 status register (i.e. it bitwise-ors **mask** into the status register).

__bis_SR_register returns the value of the MSP430 status register before the update.

__bis_SR_register is an intrinsic function and produces inline code.

__bis_SR_register_on_exit

Synopsis

```
unsigned __bis_SR_register_on_exit(unsigned);
```

Description

__bis_SR_register_on_exit sets the bits specified in **mask** in the saved status register of an interrupt function (i.e. it bitwise ands the complement of **mask** into the saved status register). This allows you to change the operating mode of the MSP430 on return from the interrupt service routine, such as changing the low power mode.

__bis_SR_register_on_exit returns the value of the saved MSP430 status register before the update.

__bis_SR_register_on_exit is an intrinsic function and produces inline code.

Note

__bis_SR_register_on_exit can only be used in interrupt functions—an error is reported if it is used outside an interrupt function.

__bit_count_leading_zeros_char

Synopsis

```
int __bit_count_leading_zeros_char(unsigned char x);
```

Description

`__bit_count_leading_zeros_char` counts the number of leading binary zero bits in `x`.

`__bit_count_leading_zeros_char` is an intrinsic function and produces inline code.

__bit_count_leading_zeros_long

Synopsis

```
int __bit_count_leading_zeros_long(unsigned long x);
```

Description

`__bit_count_leading_zeros_long` counts the number of leading binary zero bits in `x`.

`__bit_count_leading_zeros_long` is an intrinsic function and produces inline code.

__bit_count_leading_zeros_long_long

Synopsis

```
int __bit_count_leading_zeros_long_long(unsigned long long x);
```

Description

__bit_count_leading_zeros_long_long counts the number of leading binary zero bits in **x**.

__bit_count_leading_zeros_long_long is an intrinsic function and produces inline code.

__bit_count_leading_zeros_short

Synopsis

```
int __bit_count_leading_zeros_short(unsigned short x);
```

Description

__bit_count_leading_zeros_short counts the number of leading binary zero bits in **x**.

__bit_count_leading_zeros_short is an intrinsic function and produces inline code.

__bit_reverse_char

Synopsis

```
unsigned char __bit_reverse_char(unsigned char x);
```

Description

__bit_reverse_char swaps the order of all bits of **x** and returns that as its result.

__bit_reverse_char is an intrinsic function and produces inline code.

__bit_reverse_long

Synopsis

```
unsigned long __bit_reverse_long(unsigned long x);
```

Description

__bit_reverse_long swaps the order of all bits of **x** and returns that as its result.

__bit_reverse_long is an intrinsic function and produces inline code.

__bit_reverse_long_long

Synopsis

```
unsigned long long __bit_reverse_long_long(unsigned long long x);
```

Description

__bit_reverse_long_long swaps the order of all bits of **x** and returns that as its result.

__bit_reverse_long_long is an intrinsic function and produces inline code.

__bit_reverse_short

Synopsis

```
unsigned short __bit_reverse_short(unsigned int x);
```

Description

__bit_reverse_short swaps the order of all bits of **x** and returns that as its result.

__bit_reverse_short is an intrinsic function and produces inline code.

__delay_cycles

Synopsis

```
void __delay_cycles(unsigned long n);
```

Description

__delay_cycles delays program execution for exactly **n** processor cycles.
n must be a compile-time constant.

__delay_cycles is an intrinsic function and produces inline code.

__disable_interrupt

Synopsis

```
void __disable_interrupt(void);
```

Description

__disable_interrupt disables global interrupts by clearing the **GIE** bit in the status register.

__disable_interrupt returns the value of the status register before the **GIE** bit is cleared.

__disable_interrupt is an intrinsic function and produces inline code.

__enable_interrupt

Synopsis

```
void __enable_interrupt(void);
```

Description

__enable_interrupt enables global interrupts by setting the **GIE** bit in the status register.

__enable_interrupt returns the value of the status register before the **GIE** bit is set.

__enable_interrupt is an intrinsic function and produces inline code.

__even_in_range

Synopsis

```
void __even_in_range(unsigned x,  
                     unsigned r);
```

Description

`__even_in_range` is provided for IAR compatibility. `__even_in_range` returns `x`.

__get_register

Synopsis

```
unsigned __get_register(unsigned reg);
```

Description

__get_register reads CPU register **reg** and returns its contents. **__get_register** should be used for writing small wrapper routines in C that can be hand checked for correctness.

__get_register is an intrinsic function and produces inline code.

__insert_opcode

Synopsis

```
void __insert_opcode(const unsigned op);
```

Description

__insert_opcode inserts **op** into the code stream and can be used to insert special instructions directly into function code. **op** must be a compile-time constant.

__insert_opcode is an intrinsic function and produces inline code.

__low_power_mode_0

Synopsis

```
void __low_power_mode_0(void);
```

Description

__low_power_mode_0 enters MSP430 low power mode 0. In this mode the CPU and MCLK are disabled; SMCLK and ACLK are active.

__low_power_mode_0 is an intrinsic function and produces inline code.

__low_power_mode_1

Synopsis

```
void __low_power_mode_1(void);
```

Description

`__low_power_mode_1` enters MSP430 low power mode 1. In this mode the CPU, MCLK, and DCO are disabled; SMCLK and ACLK are active; the DC generator is disabled if the DCO is not used for MCLK or SMCLK in active mode.

`__low_power_mode_1` is an intrinsic function and produces inline code.

__low_power_mode_2

Synopsis

```
void __low_power_mode_2(void);
```

Description

__low_power_mode_2 enters MSP430 low power mode 1. In this mode the CPU, MCLK, SMCLK, and DCO are disabled; ACLK is active and the DC generator is enabled.

__low_power_mode_2 is an intrinsic function and produces inline code.

__low_power_mode_3

Synopsis

```
void __low_power_mode_3(void);
```

Description

__low_power_mode_3 enters MSP430 low power mode 3. In this mode the CPU, MCLK, SMCLK, and DCO are disabled; ACLK is active and the DC generator is disabled.

__low_power_mode_3 is an intrinsic function and produces inline code.

__low_power_mode_4

Synopsis

```
void __low_power_mode_4(void);
```

Description

`__low_power_mode_4` enters MSP430 low power mode 4. In this mode the CPU and all clocks are disabled.

`__low_power_mode_4` is an intrinsic function and produces inline code.

__low_power_mode_off_on_exit

Synopsis

```
void __low_power_mode_off_on_exit(void);
```

Description

__low_power_mode_off_on_exit turns low power mode off when an interrupt returns, causing the halted CPU to resume in active mode with all clocks enabled.

Note

__low_power_mode_off_on_exit can only be used in interrupt functions—an error is reported if it is used outside an interrupt function.

__low_power_mode_off_on_exit is an intrinsic function and produces inline code.

__no_operation

Synopsis

```
void __no_operation(void);
```

Description

__no_operation inserts a NOP instruction into the code stream.

__no_operation is an intrinsic function and produces inline code.

__read_extended_byte

Synopsis

```
unsigned __read_extended_byte(unsigned long addr);
```

Description

__read_extended_byte reads a byte from the 20-bit extended address **addr** and returns it as its result.

Note

__read_extended_byte can only be used on MSP430X devices.

__read_extended_long

Synopsis

```
unsigned long __read_extended_long(unsigned long addr);
```

Description

__read_extended_long reads a long from the 20-bit extended address **addr** and returns it as its result.

Note

__read_extended_long can only be used on MSP430X devices.

__read_extended_word

Synopsis

```
unsigned __read_extended_word(unsigned long addr);
```

Description

__read_extended_word reads a word from the 20-bit extended address **addr** and returns it as its result.

Note

__read_extended_word can only be used on MSP430X devices.

__set_interrupt

Synopsis

```
void __set_interrupt(unsigned state);
```

Description

__set_interrupt copies the GIE flag stores held in (by a call to **__disable_interrupt**) into the status register.

__set_interrupt is an intrinsic function and produces inline code.

__set_register

Synopsis

```
void __set_register(unsigned reg,  
                    unsigned value);
```

Description

__set_register sets CPU register **reg** to **value**. **reg** must be a compile-time constant, and **value** can be any expression. Note that the compiler emits a MOVW instruction to move **value** to **reg** and does not save **reg** in the function entry nor restore it on function exit, so you must ensure that you respect the calling conventions of the compiler. Also, using **reg** does not reserve **reg** from the compiler register allocator, so you must be careful not to overwrite a local. **__set_register** should be used for writing small wrapper routines in C that can be hand checked for correctness.

__set_register returns **value**.

__set_register is an intrinsic function and produces inline code.

__swap_bytes

Synopsis

```
unsigned __swap_bytes(unsigned x);
```

Description

__swap_bytes swaps the order of high and low bytes of **x** and returns that as its result.

__swap_bytes is an intrinsic function and produces inline code.

__swap_long_bytes

Synopsis

```
unsigned long __swap_long_bytes(unsigned long x);
```

Description

__swap_long_bytes swaps the order of all bytes of **x** and returns that as its result.

__swap_long_bytes is an intrinsic function and produces inline code.

__swap_words

Synopsis

```
unsigned long __swap_words(unsigned long x);
```

Description

__swap_words swaps the order of the high and low words of **x** and returns that as its result.

__swap_words is an intrinsic function and produces inline code.

__write_extended_byte

Synopsis

```
void __write_extended_byte(unsigned long addr,  
                           unsigned value);
```

Description

`__write_extended_byte` writes the byte **value** to the 20-bit extended address **addr**.

Note

`__write_extended_byte` can only be used on MSP430X devices.

__write_extended_long

Synopsis

```
void __write_extended_long(unsigned long addr,  
                           unsigned long value);
```

Description

__write_extended_long writes the long **value** to the 20-bit extended address **addr**.

Note

__write_extended_long can only be used on MSP430X devices.

__write_extended_word

Synopsis

```
void __write_extended_word(unsigned long addr,  
                           unsigned value);
```

Description

__write_extended_word writes the word **value** to the 20-bit extended address **addr**.

Note

__write_extended_word can only be used on MSP430X devices.

<In430.h>

The header file <in430.h> defines a number of intrinsic functions of general use for the MSP430 processor. This file is written to be compatible, and in some cases an enhancement of, the corresponding file in version 2 of IAR's Embedded Workbench for MSP430 (EW430) product.

API Summary

Binary coded decimal arithmetic	
<u>_DADD16</u>	Add two 16-bit values using decimal arithmetic
<u>_DADD32</u>	Add two 32-bit values using decimal arithmetic
<u>_DADD64</u>	Add two 64-bit values using decimal arithmetic
<u>_DNEG16</u>	Negate a 16-bit value using decimal arithmetic
<u>_DNEG32</u>	Negate a 32-bit value using decimal arithmetic
<u>_DNEG64</u>	Negate a 64-bit value using decimal arithmetic
<u>_DSUB16</u>	Subtract two 16-bit values using decimal arithmetic
<u>_DSUB32</u>	Subtract two 32-bit values using decimal arithmetic
<u>_DSUB64</u>	Subtract two 64-bit values using decimal arithmetic
Byte order manipulation	
<u>_LSWPB</u>	Swap order of bytes in a long
<u>_LSPW</u>	Swap order of words in a long
<u>_SWPB</u>	Swap order of bytes in a word
Miscellaneous functions	
<u>_NOP</u>	Insert a NOP instruction
<u>_OPC</u>	Insert an opcode
Status register manipulation	
<u>_BIC_SR</u>	Clear bits in status register
<u>_BIC_SR_IRQ</u>	Clear bits in stacked status register
<u>_BIS_SR</u>	Set bits in status register
<u>_BIS_SR_IRQ</u>	Set bits in stacked status register
<u>_DINT</u>	Disable global interrupts
<u>_EINT</u>	Enable global interrupts

_BIC_SR

Synopsis

```
#define _BIC_SR(X) __bic_SR_register(X)
```

Description

A synonym for [__bic_SR_register](#).

_BIC_SR_IRQ

Synopsis

```
#define _BIC_SR_IRQ(X) __bic_SR_register_on_exit(X)
```

Description

A synonym for [__bic_SR_register_on_exit](#).

_BIS_SR

Synopsis

```
#define _BIS_SR(X) __bis_SR_register(X)
```

Description

A synonym for [__bis_SR_register](#).

_BIS_SR_IRQ

Synopsis

```
#define _BIS_SR_IRQ(X) __bis_SR_register_on_exit(X)
```

Description

A synonym for [__bis_SR_register_on_exit](#).

_DADD16

Synopsis

```
#define _DADD16(X, Y) __bcd_add_short(X, Y)
```

Description

A synonym for [__bcd_add_short](#).

_DADD32

Synopsis

```
#define _DADD32(X, Y) __bcd_add_long(X, Y)
```

Description

A synonym for [__bcd_add_long](#).

_DADD64

Synopsis

```
#define _DADD64(X, Y) __bcd_add_long_long(X, Y)
```

Description

A synonym for [__bcd_add_long_long](#).

_DINT

Synopsis

```
#define _DINT() __disable_interrupt()
```

Description

A synonym for [__disable_interrupt](#).

_DNEG16

Synopsis

```
#define _DNEG16(X) __bcd_negate_short(X)
```

Description

A synonym for [__bcd_negate_short](#).

_DNEG32

Synopsis

```
#define _DNEG32(X) __bcd_negate_long(X)
```

Description

A synonym for [__bcd_negate_long](#).

_DNEG64

Synopsis

```
#define _DNEG64(X) __bcd_negate_long_long(X)
```

Description

A synonym for [__bcd_negate_long_long](#).

_DSUB16

Synopsis

```
#define _DSUB16(X, Y) __bcd_subtract_short(X, Y)
```

Description

A synonym for [__bcd_subtract_short](#).

_DSUB32

Synopsis

```
#define _DSUB32(X, Y) __bcd_subtract_long(X, Y)
```

Description

A synonym for [__bcd_subtract_long](#).

_DSUB64

Synopsis

```
#define _DSUB64(X, Y) __bcd_subtract_long_long(X, Y)
```

Description

A synonym for [__bcd_subtract_long_long](#).

_EINT

Synopsis

```
#define _EINT() __enable_interrupt()
```

Description

A synonym for [__enable_interrupt](#).

_LSWPB

Synopsis

```
#define _LSWPB(X) __swap_long_bytes(X)
```

Description

A synonym for [__swap_long_bytes](#).

_LSWPW

Synopsis

```
#define _LSWPW(X) __swap_words(X)
```

Description

A synonym for [__swap_words](#).

_NOP

Synopsis

```
#define _NOP() __no_operation()
```

Description

A synonym for [__no_operation](#).

_OPC

Synopsis

```
#define _OPC(X) __insert_opcode(X)
```

Description

A synonym for [__insert_opcode](#).

_SWPB

Synopsis

```
#define _SWPB(X) __swap_bytes(X)
```

Description

A synonym for [__swap_bytes](#).

<iso646.h>

Overview

The header <iso646.h> defines macros that expand to the corresponding tokens to ease writing C programs with keyboards that do not have keys for frequently-used operators.

API Summary

Macros	
<code>and</code>	Alternative spelling for logical and operator
<code>and_eq</code>	Alternative spelling for logical and-equals operator
<code>bitand</code>	Alternative spelling for bitwise and operator
<code>bitor</code>	Alternative spelling for bitwise or operator
<code>compl</code>	Alternative spelling for bitwise complement operator
<code>not</code>	Alternative spelling for logical not operator
<code>not_eq</code>	Alternative spelling for not-equal operator
<code>or</code>	Alternative spelling for logical or operator
<code>or_eq</code>	Alternative spelling for bitwise or-equals operator
<code>xor</code>	Alternative spelling for bitwise exclusive or operator
<code>xor_eq</code>	Alternative spelling for bitwise exclusive-or-equals operator

and

Synopsis

```
#define and      &&
```

Description

and defines the alternative spelling for `&&`.

and_eq

Synopsis

```
#define and_eq  &=
```

Description

`and_eq` defines the alternative spelling for `&=`.

bitand

Synopsis

```
#define bitand &
```

Description

bitand defines the alternative spelling for &.

bitor

Synopsis

```
#define bitor |
```

Description

bitor defines the alternative spelling for `|`.

compl

Synopsis

```
#define compl ~
```

Description

compl defines the alternative spelling for ~.

not

Synopsis

```
#define not      !
```

Description

not defines the alternative spelling for **!**.

not_eq

Synopsis

```
#define not_eq !=
```

Description

not_eq defines the alternative spelling for !=.

Or

Synopsis

```
#define or      ||
```

Description

or defines the alternative spelling for `||`.

or_eq

Synopsis

```
#define or_eq |=
```

Description

or_eq defines the alternative spelling for |=.

XOR

Synopsis

```
#define xor      ^
```

Description

xor defines the alternative spelling for **^**.

xor_eq

Synopsis

```
#define xor_eq ^=
```

Description

xor_eq defines the alternative spelling for `^=`.

<limits.h>

API Summary

Long integer minimum and maximum values	
LONG_MAX	Maximum value of a long integer
LONG_MIN	Minimum value of a long integer
ULONG_MAX	Maximum value of an unsigned long integer
Character minimum and maximum values	
CHAR_MAX	Maximum value of a plain character
CHAR_MIN	Minimum value of a plain character
SCHAR_MAX	Maximum value of a signed character
SCHAR_MIN	Minimum value of a signed character
UCHAR_MAX	Maximum value of an unsigned char
Long long integer minimum and maximum values	
LLONG_MAX	Maximum value of a long long integer
LLONG_MIN	Minimum value of a long long integer
ULLONG_MAX	Maximum value of an unsigned long long integer
Short integer minimum and maximum values	
SHRT_MAX	Maximum value of a short integer
SHRT_MIN	Minimum value of a short integer
USHRT_MAX	Maximum value of an unsigned short integer
Integer minimum and maximum values	
INT_MAX	Maximum value of an integer
INT_MIN	Minimum value of an integer
UINT_MAX	Maximum value of an unsigned integer
Type sizes	
CHAR_BIT	Number of bits in a character
Multi-byte values	
MB_LEN_MAX	maximum number of bytes in a multi-byte character

CHAR_BIT

Synopsis

```
#define CHAR_BIT    8
```

Description

CHAR_BIT is the number of bits for smallest object that is not a bit-field (byte).

CHAR_MAX

Synopsis

```
#define CHAR_MAX    255
```

Description

CHAR_MAX is the maximum value for an object of type **char**.

CHAR_MIN

Synopsis

```
#define CHAR_MIN    0
```

Description

CHAR_MIN is the minimum value for an object of type **char**.

INT_MAX

Synopsis

```
#define INT_MAX    2147483647
```

Description

INT_MAX is the maximum value for an object of type int.

INT_MIN

Synopsis

```
#define INT_MIN (-2147483647 - 1)
```

Description

INT_MIN is the minimum value for an object of type **int**.

LLONG_MAX

Synopsis

```
#define LLONG_MAX 9223372036854775807LL
```

Description

LLONG_MAX is the maximum value for an object of type **long long int**.

LLONG_MIN

Synopsis

```
#define LLONG_MIN (-9223372036854775807LL - 1)
```

Description

LLONG_MIN is the minimum value for an object of type **long long int**.

LONG_MAX

Synopsis

```
#define LONG_MAX 2147483647L
```

Description

LONG_MAX is the maximum value for an object of type **long int**.

LONG_MIN

Synopsis

```
#define LONG_MIN (-2147483647L - 1)
```

Description

LONG_MIN is the minimum value for an object of type **long int**.

MB_LEN_MAX

Synopsis

```
#define MB_LEN_MAX 4
```

Description

MB_LEN_MAX is the maximum number of bytes in a multi-byte character for any supported locale. Unicode (ISO 10646) characters between 0 and 10FFFF inclusive are supported which convert to a maximum of four bytes in the UTF-8 encoding.

SCHAR_MAX

Synopsis

```
#define SCHAR_MAX 127
```

Description

SCHAR_MAX is the maximum value for an object of type **signed char**.

SCHAR_MIN

Synopsis

```
#define SCHAR_MIN (-128)
```

Description

SCHAR_MIN is the minimum value for an object of type **signed char**.

SHRT_MAX

Synopsis

```
#define SHRT_MAX 32767
```

Description

SHRT_MAX is the minimum value for an object of type **short int**.

SHRT_MIN

Synopsis

```
#define SHRT_MIN (-32767 - 1)
```

Description

SHRT_MIN is the minimum value for an object of type **short int**.

UCHAR_MAX

Synopsis

```
#define UCHAR_MAX 255
```

Description

UCHAR_MAX is the maximum value for an object of type **unsigned char**.

UINT_MAX

Synopsis

```
#define UINT_MAX    4294967295U
```

Description

UINT_MAX is the maximum value for an object of type **unsigned int**.

ULLONG_MAX

Synopsis

```
#define ULLONG_MAX 18446744073709551615ULL
```

Description

ULLONG_MAX is the maximum value for an object of type **unsigned long long int**.

ULONG_MAX

Synopsis

```
#define ULONG_MAX 4294967295UL
```

Description

ULONG_MAX is the maximum value for an object of type **unsigned long int**.

USHRT_MAX

Synopsis

```
#define USHRT_MAX 65535
```

Description

USHRT_MAX is the minimum value for an object of type **unsigned short int**.

<locale.h>

API Summary

Structures	
Iconv	Formatting info for numeric values
Functions	
localeconv	Get current locale data
setlocale	Set Locale

Iconv

Synopsis

```
typedef struct {
    char *decimal_point;
    char *thousands_sep;
    char *grouping;
    char *int_curr_symbol;
    char *currency_symbol;
    char *mon_decimal_point;
    char *mon_thousands_sep;
    char *mon_grouping;
    char *positive_sign;
    char *negative_sign;
    char int_frac_digits;
    char frac_digits;
    char p_cs_precedes;
    char p_sep_by_space;
    char n_cs_precedes;
    char n_sep_by_space;
    char p_sign_posn;
    char n_sign_posn;
    char int_p_cs_precedes;
    char int_n_cs_precedes;
    char int_p_sep_by_space;
    char int_n_sep_by_space;
    char int_p_sign_posn;
    char int_n_sign_posn;
} lconv;
```

Description

Iconv structure holds formatting information on how numeric values are to be written. Note that the order of fields in this structure is not consistent between implementations, nor is it consistent between C89 and C99 standards.

The members **decimal_point**, **grouping**, and **thousands_sep** are controlled by **LC_NUMERIC**, the remainder by **LC_MONETARY**.

The members **int_n_cs_precedes**, **int_n_sep_by_space**, **int_n_sign_posn**, **int_p_cs_precedes**, **int_p_sep_by_space**, and **int_p_sign_posn** are added by the C99 standard.

We have standardized on the ordering specified by the ARM EABI for the base of this structure. This ordering is neither that of C89 nor C99.

Member	Description
currency_symbol	Local currency symbol.
decimal_point	Decimal point separator.
frac_digits	Amount of fractional digits to the right of the decimal point for monetary quantities in the local format.

grouping	Specifies the amount of digits that form each of the groups to be separated by thousands_sep separator for non-monetary quantities.
int_curr_symbol	International currency symbol.
int_frac_digits	Amount of fractional digits to the right of the decimal point for monetary quantities in the international format.
mon_decimal_point	Decimal-point separator used for monetary quantities.
mon_grouping	Specifies the amount of digits that form each of the groups to be separated by mon_thousands_sep separator for monetary quantities.
mon_thousands_sep	Separators used to delimit groups of digits to the left of the decimal point for monetary quantities.
negative_sign	Sign to be used for negative monetary quantities.
n_cs_precedes	Whether the currency symbol should precede negative monetary quantities.
n_sep_by_space	Whether a space should appear between the currency symbol and negative monetary quantities.
n_sign_posn	Position of the sign for negative monetary quantities.
positive_sign	Sign to be used for nonnegative (positive or zero) monetary quantities.
p_cs_precedes	Whether the currency symbol should precede nonnegative (positive or zero) monetary quantities.
p_sep_by_space	Whether a space should appear between the currency symbol and nonnegative (positive or zero) monetary quantities.
p_sign_posn	Position of the sign for nonnegative (positive or zero) monetary quantities.
thousands_sep	Separators used to delimit groups of digits to the left of the decimal point for non-monetary quantities.

localeconv

Synopsis

```
localeconv(void);
```

Description

localeconv returns a pointer to a structure of type **lconv** with the corresponding values for the current locale filled in.

setlocale

Synopsis

```
char *setlocale(int category,  
                const char *locale);
```

Description

setlocale sets the current locale. The **category** parameter can have the following values:

Name	Locale affected
LC_ALL	Entire locale
LC_COLLATE	Affects strcoll and strxfrm
LC_CTYPE	Affects character handling
LC_MONETARY	Affects monetary formatting information
LC_NUMERIC	Affects decimal-point character in I/O and string formatting operations
LC_TIME	Affects strftime

The **locale** parameter contains the name of a C locale to set or if **NULL** is passed the current locale is not changed.

Return Value

setlocale returns the name of the current locale.

<math.h>

API Summary

Comparison Macros	
<code>isgreater</code>	Is greater
<code>isgreaterequal</code>	Is greater or equal
<code>isless</code>	Is less
<code>islessequal</code>	Is less or equal
<code>islessgreater</code>	Is less or greater
<code>isunordered</code>	Is unordered
Classification Macros	
<code>fpclassify</code>	Classify floating type
<code>isfinite</code>	Test for a finite value
<code>isinf</code>	Test for infinity
<code>isnan</code>	Test for NaN
<code>isnormal</code>	Test for a normal value
<code>signbit</code>	Test sign
Trigonometric functions	
<code>cos</code>	Compute cosine of a double
<code>cosf</code>	Compute cosine of a float
<code>sin</code>	Compute sine of a double
<code>sinf</code>	Compute sine of a float
<code>tan</code>	Compute tangent of a double
<code>tanf</code>	Compute tangent of a double
Inverse trigonometric functions	
<code>acos</code>	Compute inverse cosine of a double
<code>acosf</code>	Compute inverse cosine of a float
<code>asin</code>	Compute inverse sine of a double
<code>asinf</code>	Compute inverse sine of a float
<code>atan</code>	Compute inverse tangent of a double
<code>atan2</code>	Compute inverse tangent of a ratio of doubles
<code>atan2f</code>	Compute inverse tangent of a ratio of floats
<code>atanf</code>	Compute inverse tangent of a float
Exponential and logarithmic functions	

<code>exp</code>	Compute exponential of a double
<code>exp2</code>	Compute binary exponential of a double
<code>exp2f</code>	Compute binary exponential of a float
<code>expf</code>	Compute exponential of a float
<code>expm1</code>	Compute exponential minus one of a double
<code>expm1f</code>	Compute exponential minus one of a float
<code>frexp</code>	Set exponent of a double
<code>frexpf</code>	Set exponent of a float
<code>ilogb</code>	Compute integer binary logarithm of a double
<code>ilogbf</code>	Compute integer binary logarithm of a float
<code>Idexp</code>	Adjust exponent of a double
<code>Idexpf</code>	Adjust exponent of a float
<code>log</code>	Compute natural logarithm of a double
<code>log10</code>	Compute common logarithm of a double
<code>log10f</code>	Compute common logarithm of a float
<code>log1p</code>	Compute natural logarithm plus one of a double
<code>log1pf</code>	Compute natural logarithm plus one of a float
<code>log2</code>	Compute binary logarithm of a double
<code>log2f</code>	Compute binary logarithm of a float
<code>logb</code>	Compute floating-point base logarithm of a double
<code>logbf</code>	Compute floating-point base logarithm of a float
<code>logf</code>	Compute natural logarithm of a float
<code>scalbln</code>	Scale a double
<code>scalblnf</code>	Scale a float
<code>scalbn</code>	Scale a double
<code>scalbnf</code>	Scale a float

Rounding and remainder functions

<code>ceil</code>	Compute smallest integer not greater than a double
<code>ceilf</code>	Compute smallest integer not greater than a float
<code>floor</code>	Compute largest integer not greater than a double
<code>floorf</code>	Compute largest integer not greater than a float
<code>fmod</code>	Compute remainder after division of two doubles
<code>fmodf</code>	Compute remainder after division of two floats
<code>llrint</code>	Round and cast double to long long
<code>llrintf</code>	Round and cast float to long long

llround	Round and cast double to long long
llroundf	Round and cast float to long long
lrint	Round and cast double to long
lrintf	Round and cast float to long
lround	Round and cast double to long
lroundf	Round and cast float to long
modf	Break a double into integer and fractional parts
modff	Break a float into integer and fractional parts
nearbyint	Round double to nearby integral value
nearbyintf	Round float to nearby integral value
remainder	Compute remainder of a double
remainderf	Compute remainder of a float
remquo	Compute remainder and quotient of a double
remquof	Compute remainder and quotient of a float
rint	Round a double to an integral value
rintf	Round a float to an integral value
round	Round a double to the nearest integral value
roundf	Round a float to the nearest integral value
trunc	Truncate a double value
truncf	Truncate a float value
Power functions	
cbrt	Compute cube root of a double
cbrtf	Compute cube root of a float
hypot	Compute complex magnitude of two doubles
hypotf	Compute complex magnitude of two floats
pow	Raise a double to a power
powf	Raise a float to a power
sqrt	Compute square root of a double
sqrtf	Compute square root of a float
Absolute value functions	
fabs	Compute absolute value of a double
fabsf	Compute absolute value of a float
Maximum, minimum, and positive difference functions	
fdim	Compute positive difference of two doubles
fdimf	Compute positive difference of two floats

fmax	Compute maximum of two doubles
fmaxf	Compute maximum of two floats
fmin	Compute minimum of two doubles
fminf	Compute minimum of two floats
Hyperbolic functions	
cosh	Compute hyperbolic cosine of a double
coshf	Compute hyperbolic cosine of a float
sinh	Compute hyperbolic sine of a double
sinhf	Compute hyperbolic sine of a float
tanh	Compute hyperbolic tangent of a double
tanhf	Compute hyperbolic tangent of a float
Inverse hyperbolic functions	
acosh	Compute inverse hyperbolic cosine of a double
acoshf	Compute inverse hyperbolic cosine of a float
asinh	Compute inverse hyperbolic sine of a double
asinhf	Compute inverse hyperbolic sine of a float
atanh	Compute inverse hyperbolic tangent of a double
atanhf	Compute inverse hyperbolic tangent of a float
Fused multiply functions	
fma	Compute fused multiply-add of doubles
fmaf	Compute fused multiply-add of floats
Floating-point manipulation functions	
copysign	Copy magnitude and sign of a double
copysignf	Copy magnitude and sign of a float
nextafter	Next representable double value
nextafterf	Next representable float value
Error and Gamma functions	
erf	Compute error function of a double
erfc	Compute complementary error function of a double
erfcf	Compute complementary error function of a float
erff	Compute error function of a float
lgamma	Compute log-gamma function of a double
lgammaf	Compute log-gamma function of a float
tgamma	Compute gamma function of a double
tgammaf	Compute gamma function of a float

acos

Synopsis

```
double acos(double x);
```

Description

acos returns the principal value, in radians, of the inverse circular cosine of **x**. The principal value lies in the interval [0, PI] radians.

If $|x| > 1$, **errno** is set to **EDOM** and **acos** returns **HUGE_VAL**.

If **x** is NaN, **acos** returns **x**. If $|x| > 1$, **acos** returns NaN.

acosf

Synopsis

```
float acosf(float x);
```

Description

acosf returns the principal value, in radians, of the inverse circular cosine of **x**. The principal value lies in the interval [0, PI] radians.

If $|x| > 1$, **errno** is set to **EDOM** and **acosf** returns **HUGE_VAL**.

If **x** is NaN, **acosf** returns **x**. If $|x| < 1$, **acosf** returns NaN.

acosh

Synopsis

```
double acosh(double x);
```

Description

acosh returns the non-negative inverse hyperbolic cosine of **x**.

acosh(x) is defined as **log(x + sqrt(x^2 – 1))**, assuming completely accurate computation.

If **x < 1**, **errno** is set to **EDOM** and **acosh** returns **HUGE_VAL**.

If **x < 1**, **acosh** returns **NaN**.

If **x** is **NaN**, **acosh** returns **NaN**.

acoshf

Synopsis

```
float acoshf(float x);
```

Description

acoshf returns the non-negative inverse hyperbolic cosine of **x**.

acoshf(x) is defined as **log(x + sqrt(x^2 – 1))**, assuming completely accurate computation.

If **x < 1**, **errno** is set to **EDOM** and **acoshf** returns **HUGE_VALF**.

If **x < 1**, **acoshf** returns NaN.

If **x** is NaN, **acoshf** returns that NaN.

asin

Synopsis

```
double asin(double x);
```

Description

asin returns the principal value, in radians, of the inverse circular sine of **x**. The principal value lies in the interval $[-\frac{1}{2}\pi, +\frac{1}{2}\pi]$ radians.

If $|x| > 1$, **errno** is set to **EDOM** and **asin** returns **HUGE_VAL**.

If **x** is NaN, **asin** returns **x**. If $|x| > 1$, **asin** returns NaN.

asinf

Synopsis

```
float asinf(float x);
```

Description

asinf returns the principal value, in radians, of the inverse circular sine of **val**. The principal value lies in the interval $[-\frac{1}{2}\pi, +\frac{1}{2}\pi]$ radians.

If $|x| > 1$, **errno** is set to **EDOM** and **asinf** returns **HUGE_VALF**.

If **x** is NaN, **asinf** returns **x**. If $|x| > 1$, **asinf** returns NaN.

asinh

Synopsis

```
double asinh(double x);
```

Description

asinh calculates the hyperbolic sine of **x**.

If $|x| > \sim 709.782$, **errno** is set to **EDOM** and **asinh** returns **HUGE_VAL**.

If **x** is $+\infty$, $-\infty$, or **NaN**, **asinh** returns $|x|$. If $|x| > \sim 709.782$, **asinh** returns $+\infty$ or $-\infty$ depending upon the sign of **x**.

asinhf

Synopsis

```
float asinhf(float x);
```

Description

asinhf calculates the hyperbolic sine of **x**.

If $|x| > \sim 88.7228$, **errno** is set to **EDOM** and **asinhf** returns **HUGE_VALF**.

If **x** is $+\infty$, $-\infty$, or **NaN**, **asinhf** returns $|x|$. If $|x| > \sim 88.7228$, **asinhf** returns $+\infty$ or $-\infty$ depending upon the sign of **x**.

atan

Synopsis

```
double atan(double x);
```

Description

atan returns the principal value, in radians, of the inverse circular tangent of **x**. The principal value lies in the interval $[-\frac{1}{2}\pi, +\frac{1}{2}\pi]$ radians.

atan2

Synopsis

```
double atan2(double x,  
            double y);
```

Description

atan2 returns the value, in radians, of the inverse circular tangent of **y** divided by **x** using the signs of **x** and **y** to compute the quadrant of the return value. The principal value lies in the interval $[-\frac{1}{2}\pi/2, +\frac{1}{2}\pi]$ radians. If **x** = 0, **errno** is set to **EDOM** and **atan2** returns **HUGE_VAL**.

atan2(x, NaN) is NaN.

atan2(NaN, x) is NaN.

atan2(±0, +(anything but NaN)) is ±0.

atan2(±0, -(anything but NaN)) is ±π.

atan2(±(anything but 0 and NaN), 0) is ± $\frac{1}{2}\pi$.

atan2(±(anything but ∞ and NaN), +∞) is ±0.

atan2(±(anything but ∞ and NaN), -∞) is ±π.

atan2(±∞, +∞) is ± $\frac{1}{4}\pi$.

atan2(±∞, -∞) is ± $\frac{3}{4}\pi$.

atan2(±∞, (anything but 0, NaN, and ∞)) is ± $\frac{1}{2}\pi$.

atan2f

Synopsis

```
float atan2f(float y,  
            float x);
```

Description

atan2f returns the value, in radians, of the inverse circular tangent of **y** divided by **x** using the signs of **x** and **y** to compute the quadrant of the return value. The principal value lies in the interval $[-\frac{1}{2}\pi, +\frac{1}{2}\pi]$ radians.

If **x** = **y** = 0, **errno** is set to **EDOM** and **atan2f** returns **HUGE_VALF**.

atan2f(x, NaN) is **NaN**.

atan2f(NaN, x) is **NaN**.

atan2f(± 0 , +(anything but NaN)) is ± 0 .

atan2f(± 0 , -(anything but NaN)) is $\pm \pi$.

atan2f(\pm (anything but 0 and NaN), 0) is $\pm \frac{1}{2}\pi$.

atan2f(\pm (anything but ∞ and NaN), $+\infty$) is ± 0 .

atan2f(\pm (anything but ∞ and NaN), $-\infty$) is $\pm \pi$.

atan2f($\pm \infty$, $+\infty$) is $\pm \frac{1}{4}\pi$.

atan2f($\pm \infty$, $-\infty$) is $\pm \frac{3}{4}\pi$.

atan2f($\pm \infty$, (anything but 0, NaN, and ∞)) is $\pm \frac{1}{2}\pi$.

atanf

Synopsis

```
float atanf(float x);
```

Description

atanf returns the principal value, in radians, of the inverse circular tangent of x. The principal value lies in the interval $[-\frac{1}{2}\pi, +\frac{1}{2}\pi]$ radians.

atanh

Synopsis

```
double atanh(double x);
```

Description

atanh returns the inverse hyperbolic tangent of **x**.

If $|x| \geq 1$, **errno** is set to **EDOM** and **atanh** returns **HUGE_VAL**.

If $|x| > 1$ **atanh** returns NaN.

If **x** is NaN, **atanh** returns that NaN.

If **x** is 1, **atanh** returns ∞ .

If **x** is -1, **atanh** returns $-\infty$.

atanhf

Synopsis

```
float atanhf(float x);
```

Description

atanhf returns the inverse hyperbolic tangent of **x**.

If $|x| > 1$ **atanhf** returns NaN. If **x** is NaN, **atanhf** returns that NaN. If **x** is 1, **atanhf** returns ∞ . If **x** is -1, **atanhf** returns $-\infty$.

cbrt

Synopsis

```
double cbrt(double x);
```

Description

cbrt computes the cube root of **x**.

cbrtf

Synopsis

```
float cbrtf(float x);
```

Description

cbrtf computes the cube root of **x**.

ceil

Synopsis

```
double ceil(double x);
```

Description

ceil computes the smallest integer value not less than **x**.

ceil (± 0) is ± 0 . **ceil** ($\pm \infty$) is $\pm \infty$.

ceilf

Synopsis

```
float ceilf(float x);
```

Description

ceilf computes the smallest integer value not less than x.

ceilf (± 0) is ± 0 . **ceilf** ($\pm \infty$) is $\pm \infty$.

copysign

Synopsis

```
double copysign(double x,  
                 double y);
```

Description

copysign returns a value with the magnitude of **x** and the sign of **y**.

copysignf

Synopsis

```
float copysignf(float x,  
                 float y);
```

Description

copysignf returns a value with the magnitude of **x** and the sign of **y**.

COS

Synopsis

```
double cos(double x);
```

Description

cos returns the radian circular cosine of **x**.

If $|x| > 10^9$, **errno** is set to **EDOM** and **cos** returns **HUGE_VAL**.

If **x** is NaN, **cos** returns **x**. If $|x|$ is ∞ , **cos** returns NaN.

cosf

Synopsis

```
float cosf(float x);
```

Description

cosf returns the radian circular cosine of x.

If $|x| > 10^9$, **errno** is set to **EDOM** and **cosf** returns **HUGE_VALF**.

If x is NaN, **cosf** returns x. If $|x|$ is ∞ , **cosf** returns NaN.

cosh

Synopsis

```
double cosh(double x);
```

Description

cosh calculates the hyperbolic cosine of **x**.

If $|x| > \sim 709.782$, **errno** is set to **EDOM** and **cosh** returns **HUGE_VAL**.

If **x** is $+\infty$, $-\infty$, or **NaN**, **cosh** returns $|x|$. If $|x| > \sim 709.782$, **cosh** returns $+\infty$ or $-\infty$ depending upon the sign of **x**.

coshf

Synopsis

```
float coshf(float x);
```

Description

coshf calculates the hyperbolic sine of **x**.

If $|x| > \sim 88.7228$, **errno** is set to **EDOM** and **coshf** returns **HUGE_VALF**.

If **x** is $+\infty$, $-\infty$, or **NaN**, **coshf** returns $|x|$.

If $|x| > \sim 88.7228$, **coshf** returns $+\infty$ or $-\infty$ depending upon the sign of **x**.

erf

Synopsis

```
double erf(double x);
```

Description

erf returns the error function for **x**.

erfc

Synopsis

```
double erfc(double x);
```

Description

erfc returns the complementary error function for **x**.

erfcf

Synopsis

```
float erfcf(float x);
```

Description

erfcf returns the complementary error function for **x**.

erff

Synopsis

```
float erff(float x);
```

Description

erff returns the error function for **x**.

exp

Synopsis

```
double exp(double x);
```

Description

exp computes the base-*e* exponential of *x*.

If $|x| > \sim 709.782$, **errno** is set to **EDOM** and **exp** returns **HUGE_VAL**.

If *x* is NaN, **exp** returns NaN.

If *x* is ∞ , **exp** returns ∞ .

If *x* is $-\infty$, **exp** returns 0.

exp2

Synopsis

```
double exp2(double x);
```

Description

exp2 returns 2 raised to the power of x.

exp2f

Synopsis

```
float exp2f(float x);
```

Description

exp2f returns 2 raised to the power of **x**.

expf

Synopsis

```
float expf(float x);
```

Description

expf computes the base-*e* exponential of **x**.

If $|x| > \sim 88.722$, **errno** is set to **EDOM** and **expf** returns **HUGE_VALF**. If **x** is NaN, **expf** returns NaN.

If **x** is ∞ , **expf** returns ∞ .

If **x** is $-\infty$, **expf** returns 0.

expm1

Synopsis

```
double expm1(double x);
```

Description

expm1 returns e raised to the power of x minus one.

expm1f

Synopsis

```
float expm1f(float x);
```

Description

expm1f returns e raised to the power of x minus one.

fabs

Synopsis

```
double fabs(double x);
```

fabsf

Synopsis

```
float fabsf(float x);
```

Description

fabsf computes the absolute value of the floating-point number **x**.

fdim

Synopsis

```
double fdim(double x,  
           double y);
```

Description

fdim returns the positive difference between **x** and **y**.

fdimf

Synopsis

```
float fdimf(float x,  
           float y);
```

Description

fdimf returns the positive difference between **x** and **y**.

floor

Synopsis

```
double floor(double);
```

floor computes the largest integer value not greater than x.

floor (± 0) is ± 0 . **floor** ($\pm \infty$) is $\pm \infty$.

floorf

Synopsis

```
float floorf(float);
```

floorf computes the largest integer value not greater than **x**.

floorf(± 0) is ± 0 . **floorf($\pm \infty$)** is $\pm \infty$.

fma

Synopsis

```
double fma(double x,  
          double y,  
          double z);
```

Description

fma computes $x \times y + z$ with a single rounding.

fmaf

Synopsis

```
float fmaf(float x,  
          float y,  
          float z);
```

Description

fmaf computes $x \times y + z$ with a single rounding.

fmax

Synopsis

```
double fmax(double x,  
           double y);
```

Description

fmax determines the maximum of **x** and **y**.

fmax (**NaN**, **y**) is **y**. **fmax** (**x**, **NaN**) is **x**.

fmaxf

Synopsis

```
float fmaxf(float x,  
           float y);
```

Description

fmaxf determines the maximum of **x** and **y**.

fmaxf (NaN, y) is **y**. **fmaxf(x, NaN)** is **x**.

fmin

Synopsis

```
double fmin(double x,  
           double y);
```

Description

fmin determines the minimum of **x** and **y**.

fmin (**NaN**, **y**) is **y**. **fmin** (**x**, **NaN**) is **x**.

fminf

Synopsis

```
float fminf(float x,  
           float y);
```

Description

fminf determines the minimum of **x** and **y**.

fminf (**NaN**, **y**) is **y**. **fminf** (**x**, **NaN**) is **x**.

fmod

Synopsis

```
double fmod(double x,  
           double y);
```

Description

fmod computes the floating-point remainder of **x** divided by **y**. #b #this returns the value $x - n y$, for some integer n such that, if **y** is nonzero, the result has the same sign as **x** and magnitude less than the magnitude of **y**.

fmod (**NaN**, **y**) is **NaN**. **fmod** (**x**, **NaN**) is **NaN**. **fmod** (± 0 , **y**) is ± 0 for **y** not zero.

fmod (∞ , **y**) is **NaN**.

fmod (**x**, 0) is **NaN**.

fmod (**x**, $\pm \infty$) is **x** for **x** not infinite.

fmodf

Synopsis

```
float fmodf(float x,  
           float y);
```

Description

fmodf computes the floating-point remainder of **x** divided by **y**. **fmodf** returns the value $x - n y$, for some integer n such that, if **y** is nonzero, the result has the same sign as **x** and magnitude less than the magnitude of **y**.

fmodf (**NaN**, **y**) is **NaN**. **fmodf** (**x**, **NaN**) is **NaN**. **fmodf** (± 0 , **y**) is ± 0 for **y** not zero.

fmodf (∞ , **y**) is **NaN**.

fmodf (**x**, 0) is **NaN**.

fmodf (**x**, $\pm \infty$) is **x** for **x** not infinite.

fpclassify

Synopsis

```
#define fpclassify(x) (__is_float32(x) ? __float32_classify(x) : __float64_classify(x))
```

Description

fpclassify classifies **x** as NaN, infinite, normal, subnormal, zero, or into another implementation-defined category. **fpclassify** returns one of:

- **FP_ZERO**
- **FP_SUBNORMAL**
- **FP_NORMAL**
- **FP_INFINITE**
- **FP_NAN**

frexp

Synopsis

```
double frexp(double x,
             int *exp);
```

Description

frexp breaks a floating-point number into a normalized fraction and an integral power of 2.

frexp stores power of two in the **int** object pointed to by **exp** and returns the value **x**, such that **x** has a magnitude in the interval [1/2, 1) or zero, and value equals **x** * 2^{**exp**}.

If **x** is zero, both parts of the result are zero.

If **x** is ∞ or NaN, **frexp** returns **x** and stores zero into the **int** object pointed to by **exp**.

frexpf

Synopsis

```
float frexpf(float x,  
            int *exp);
```

Description

frexpf breaks a floating-point number into a normalized fraction and an integral power of 2.

frexpf stores power of two in the **int** object pointed to by **frexpf** and returns the value **x**, such that **x** has a magnitude in the interval [$\frac{1}{2}$, 1) or zero, and value equals **x** * 2^{exp} .

If **x** is zero, both parts of the result are zero.

If **x** is ∞ or NaN, **frexpf** returns **x** and stores zero into the **int** object pointed to by **exp**.

hypot

Synopsis

```
double hypot(double x,  
            double y);
```

Description

hypot computes the square root of the sum of the squares of **x** and **y**, $\sqrt{x^2 + y^2}$, without undue overflow or underflow. If **x** and **y** are the lengths of the sides of a right-angled triangle, then **hypot** computes the length of the hypotenuse.

If **x** or **y** is $+\infty$ or $-\infty$, **hypot** returns ∞ .

If **x** or **y** is NaN, **hypot** returns NaN.

hypotf

Synopsis

```
float hypotf(float x,  
            float y);
```

Description

hypotf computes the square root of the sum of the squares of **x** and **y**, $\sqrt{x^2 + y^2}$, without undue overflow or underflow. If **x** and **y** are the lengths of the sides of a right-angled triangle, then **hypotf** computes the length of the hypotenuse.

If **x** or **y** is $+\infty$ or $-\infty$, **hypotf** returns ∞ . If **x** or **y** is NaN, **hypotf** returns NaN.

ilogb

Synopsis

```
int ilogb(double x);
```

Description

ilogb returns the integral part of the logarithm of *x*, using **FLT_RADIX** as the base for the logarithm.

ilogbf

Synopsis

```
int ilogbf(float x);
```

Description

ilogbf returns the integral part of the logarithm of **x**, using **FLT_RADIX** as the base for the logarithm.

isfinite

Synopsis

```
#define isfinite(x) (sizeof(x) == sizeof(float) ? __float32_isfinite(x) : __float64_isfinite(x))
```

Description

isfinite determines whether **x** is a finite value (zero, subnormal, or normal, and not infinite or NaN). **isfinite** returns a non-zero value if and only if **x** has a finite value.

isgreater

Synopsis

```
#define isgreater(x,y) (!isunordered(x, y) && (x > y))
```

Description

isgreater returns whether **x** is greater than **y**.

isgreaterequal

Synopsis

```
#define isgreaterequal(x,y) (!isunordered(x, y) && (x >= y))
```

Description

isgreaterequal returns whether **x** is greater than or equal to **y**.

isinf

Synopsis

```
#define isinf(x) (sizeof(x) == sizeof(float) ? __float32_isinf(x) : __float64_isinf(x))
```

Description

isinf determines whether **x** is an infinity (positive or negative). The determination is based on the type of the argument.

isless

Synopsis

```
#define isless(x,y) (!isunordered(x, y) && (x < y))
```

Description

isless returns whether **x** is less than **y**.

islessequal

Synopsis

```
#define islessequal(x,y) (!isunordered(x, y) && (x <= y))
```

Description

islessequal returns whether x is less than or equal to y.

islessgreater

Synopsis

```
#define islessgreater(x,y) (!isunordered(x, y) && (x < y || x > y))
```

Description

islessgreater returns whether **x** is less than or greater than **y**.

isnan

Synopsis

```
#define isnan(x) (sizeof(x) == sizeof(float) ? __float32_isnan(x) : __float64_isnan(x))
```

Description

isnan determines whether **x** is a NaN. The determination is based on the type of the argument.

isnormal

Synopsis

```
#define isnormal(x) (sizeof(x) == sizeof(float) ? __float32_isnormal(x) : __float64_isnormal(x))
```

Description

isnormal determines whether **x** is a normal value (zero, subnormal, or normal, and not infinite or NaN).. **isnormal** returns a non-zero value if and only if **x** has a normal value.

isunordered

Synopsis

```
#define isunordered(a,b) (fpclassify(a) == FP_NAN || fpclassify(b) == FP_NAN)
```

Description

isunordered returns whether **x** or **y** are unordered values.

Idexp

Synopsis

```
double ldexp(double x,  
            int exp);
```

Description

Idexp multiplies a floating-point number by an integral power of 2.

Idexp returns $x * 2^{\text{exp}}$.

If the result overflows, **errno** is set to **ERANGE** and **Idexp** returns **HUGE_VALF**.

If **x** is ∞ or **NaN**, **Idexp** returns **x**. If the result overflows, **Idexp** returns ∞ .

Idexpf

Synopsis

```
float ldexpf(float x,  
            int exp);
```

Description

Idexpf multiplies a floating-point number by an integral power of 2.

Idexpf returns $x * 2^{\text{exp}}$. If the result overflows, **errno** is set to **ERANGE** and **Idexpf** returns **HUGE_VALF**.

If **x** is ∞ or **NaN**, **Idexpf** returns **x**. If the result overflows, **Idexpf** returns ∞ .

Igamma

Synopsis

```
double lgamma(double x);
```

Description

Igamma returns the natural logarithm of the gamma function for x.

lgammaf

Synopsis

```
float lgammaf(float x);
```

Description

lgammaf returns the natural logarithm of the gamma function for **x**.

llrint

Synopsis

```
long long int llrint(double x);
```

Description

llrint rounds **x** to an integral value and returns it as a long long int.

llrintf

Synopsis

```
long long int llrintf(float x);
```

Description

llrintf rounds *x* to an integral value and returns it as a long long int.

llround

Synopsis

```
long long int llround(double x);
```

Description

llround rounds **x** to an integral value, with halfway cases rounded away from zero, and returns it as a **long long int**.

llroundf

Synopsis

```
long long int llroundf(float x);
```

Description

llroundf rounds *x* to an integral value, with halfway cases rounded away from zero, and returns it as a long long int.

log

Synopsis

```
double log(double x);
```

Description

log computes the base-e logarithm of **x**.

If **x** = 0, **errno** is set to **ERANGE** and **log** returns **-HUGE_VAL**. If **x** < 0, **errno** is set to **EDOM** and **log** returns **-HUGE_VAL**.

If **x** < 0 or **x** = $-\infty$, **log** returns NaN.

If **x** = 0, **log** returns $-\infty$.

If **x** = ∞ , **log** returns ∞ .

If **x** = NaN, **log** returns **x**.

log10

Synopsis

```
double log10(double x);
```

Description

log10 computes the base-10 logarithm of **x**.

If **x** = 0, **errno** is set to **ERANGE** and **log10** returns **-HUGE_VAL**. If **x** < 0, **errno** is set to **EDOM** and **log10** returns **-HUGE_VAL**.

If **x** < 0 or **x** = $-\infty$, **log10** returns NaN.

If **x** = 0, **log10** returns $-\infty$.

If **x** = ∞ , **log10** returns ∞ .

If **x** = NaN, **log10** returns **x**.

log10f

Synopsis

```
float log10f(float x);
```

Description

log10f computes the base-10 logarithm of **x**.

If **x** = 0, **errno** is set to **ERANGE** and **log10f** returns **-HUGE_VALF**. If **x** < 0, **errno** is set to **EDOM** and **log10f** returns **-HUGE_VALF**.

If **x** < 0 or **x** = $-\infty$, **log10f** returns NaN.

If **x** = 0, **log10f** returns $-\infty$.

If **x** = ∞ , **log10f** returns ∞ .

If **x** = NaN, **log10f** returns **x**.

log1p

Synopsis

```
double log1p(double x);
```

Description

log1p computes the base-*e* logarithm of *x* plus one.

log1pf

Synopsis

```
float log1pf(float x);
```

Description

log1pf computes the base-*e* logarithm of *x* plus one.

log2

Synopsis

```
double log2(double x);
```

Description

log2 computes the base-2 logarithm of **x**.

log2f

Synopsis

```
float log2f(float x);
```

Description

log2f computes the base-2 logarithm of **x**.

logb

Synopsis

```
double logb(double x);
```

Description

logb computes the base-*FLT_RADIX* logarithm of *x*.

logbf

Synopsis

```
float logbf(float x);
```

Description

logbf computes the base-*FLT_RADIX* logarithm of *x*.

logf

Synopsis

```
float logf(float x);
```

Description

logf computes the base-e logarithm of **x**.

If **x** = 0, **errno** is set to **ERANGE** and **logf** returns **-HUGE_VALF**. If **x** < 0, **errno** is set to **EDOM** and **logf** returns **-HUGE_VALF**.

If **x** < 0 or **x** = $-\infty$, **logf** returns NaN.

If **x** = 0, **logf** returns $-\infty$.

If **x** = ∞ , **logf** returns ∞ .

If **x** = NaN, **logf** returns **x**.

lrint

Synopsis

```
long int lrint(double x);
```

Description

lrint rounds **x** to an integral value and returns it as a long int.

lrintf

Synopsis

```
long int lrintf(float x);
```

Description

lrintf rounds *x* to an integral value and returns it as a long int.

lround

Synopsis

```
long int lround(double x);
```

Description

lround rounds *x* to an integral value, with halfway cases rounded away from zero, and returns it as a long int.

lroundf

Synopsis

```
long int lroundf(float x);
```

Description

lroundf rounds *x* to an integral value, with halfway cases rounded away from zero, and returns it as a long int.

modf

Synopsis

```
double modf(double x,  
           double *iptr);
```

Description

modf breaks **x** into integral and fractional parts, each of which has the same type and sign as **x**.

The integral part (in floating-point format) is stored in the object pointed to by **iptr** and **modf** returns the signed fractional part of **x**.

modff

Synopsis

```
float modff(float x,  
           float *iptr);
```

Description

modff breaks **x** into integral and fractional parts, each of which has the same type and sign as **x**.

The integral part (in floating-point format) is stored in the object pointed to by **iptr** and **modff** returns the signed fractional part of **x**.

nearbyint

Synopsis

```
double nearbyint(double);
```

Description

nearbyint Rounds x to an integral value.

nearbyintf

Synopsis

```
float nearbyintf(float);
```

Description

nearbyintf Rounds x to an integral value.

nextafter

Synopsis

```
double nextafter(double x,  
                 double y);
```

Description

nextafter Returns the next representable value after **x** in the direction of **y**.

nextafterf

Synopsis

```
float nextafterf(float x,  
                 float y);
```

Description

nextafterf Returns the next representable value after **x** in the direction of **y**.

pow

Synopsis

```
double pow(double x,  
          double y);
```

Description

pow computes **x** raised to the power **y**.

If **x** < 0 and **y** ≤ 0, **errno** is set to **EDOM** and **pow** returns **-HUGE_VAL**. If **x** ≤ 0 and **y** is not an integer value, **errno** is set to **EDOM** and **pow** returns **-HUGE_VAL**.

If **y** = 0, **pow** returns 1.

If **y** = 1, **pow** returns **x**.

If **y** = **NaN**, **pow** returns **NaN**.

If **x** = **NaN** and **y** is anything other than 0, **pow** returns **NaN**.

If **x** < -1 or 1 < **x**, and **y** = +∞, **pow** returns +∞.

If **x** < -1 or 1 < **x**, and **y** = -∞, **pow** returns 0.

If -1 < **x** < 1 and **y** = +∞, **pow** returns +0.

If -1 < **x** < 1 and **y** = -∞, **pow** returns +∞.

If **x** = +1 or **x** = -1 and **y** = +∞ or **y** = -∞, **pow** returns **NaN**.

If **x** = +0 and **y** > 0 and **y** ≠ **NaN**, **pow** returns +0.

If **x** = -0 and **y** > 0 and **y** ≠ **NaN** or **y** not an odd integer, **pow** returns +0.

If **x** = +0 and **y** and **y** ≠ **NaN**, **pow** returns +∞.

If **x** = -0 and **y** > 0 and **y** ≠ **NaN** or **y** not an odd integer, **pow** returns +∞.

If **x** = -0 and **y** is an odd integer, **pow** returns -0.

If **x** = +∞ and **y** > 0 and **y** ≠ **NaN**, **pow** returns +∞.

If **x** = +∞ and **y** < 0 and **y** ≠ **NaN**, **pow** returns +0.

If **x** = -∞, **pow** returns **pow(-0, y)**

If **x** < 0 and **x** ≠ ∞ and **y** is a non-integer, **pow** returns **NaN**.

powf

Synopsis

```
float powf(float x,  
          float y);
```

Description

powf computes **x** raised to the power **y**.

If **x** < 0 and **y** ≤ 0, **errno** is set to **EDOM** and **powf** returns **-HUGE_VALF**. If **x** ≤ 0 and **y** is not an integer value, **errno** is set to **EDOM** and **powf** returns **-HUGE_VALF**.

If **y** = 0, **powf** returns 1.

If **y** = 1, **powf** returns **x**.

If **y** = **NaN**, **powf** returns **NaN**.

If **x** = **NaN** and **y** is anything other than 0, **powf** returns **NaN**.

If **x** < -1 or 1 < **x**, and **y** = +∞, **powf** returns +∞.

If **x** < -1 or 1 < **x**, and **y** = -∞, **powf** returns 0.

If -1 < **x** < 1 and **y** = +∞, **powf** returns +0.

If -1 < **x** < 1 and **y** = -∞, **powf** returns +∞.

If **x** = +1 or **x** = -1 and **y** = +∞ or **y** = -∞, **powf** returns **NaN**.

If **x** = +0 and **y** > 0 and **y** ≠ **NaN**, **powf** returns +0.

If **x** = -0 and **y** > 0 and **y** ≠ **NaN** or **y** not an odd integer, **powf** returns +0.

If **x** = +0 and **y** and **y** ≠ **NaN**, **powf** returns +∞.

If **x** = -0 and **y** > 0 and **y** ≠ **NaN** or **y** not an odd integer, **powf** returns +∞.

If **x** = -0 and **y** is an odd integer, **powf** returns -0.

If **x** = +∞ and **y** > 0 and **y** ≠ **NaN**, **powf** returns +∞.

If **x** = +∞ and **y** < 0 and **y** ≠ **NaN**, **powf** returns +0.

If **x** = -∞, **powf** returns **powf(-0, y)**

If **x** < 0 and **x** ≠ ∞ and **y** is a non-integer, **powf** returns **NaN**.

remainder

Synopsis

```
double remainder(double numer,  
                double denom);
```

Description

remainder computes the remainder of **numer** divided by **denom**.

remainderf

Synopsis

```
float remainderf(float numer,  
                 float denom);
```

Description

remainderf computes the remainder of **numer** divided by **denom**.

remquo

Synopsis

```
double remquo(double numer,
              double denom,
              int *quot);
```

Description

remquo computes the remainder of **numer** divided by **denom** and the quotient pointed by **quot**.

remquo

Synopsis

```
float remquof(float numer,
              float denom,
              int *quot);
```

Description

remquo computes the remainder of **numer** divided by **denom** and the quotient pointed by **quot**.

rint

Synopsis

```
double rint(double x);
```

Description

rint rounds **x** to an integral value.

rintf

Synopsis

```
float rintf(float x);
```

Description

rintf rounds **x** to an integral value.

round

Synopsis

```
double round(double x);
```

Description

round rounds **x** to an integral value, with halfway cases rounded away from zero.

roundf

Synopsis

```
float roundf(float x);
```

Description

roundf rounds **x** to an integral value, with halfway cases rounded away from zero.

scalbln

Synopsis

```
double scalbln(double x,  
               long int exp);
```

Description

scalbln multiplies **x** by **FLT_RADIX** raised to the power **exp**.

scalblnf

Synopsis

```
float scalblnf(float x,  
               long int exp);
```

Description

scalblnf multiplies **x** by **FLT_RADIX** raised to the power **exp**.

scalbn

Synopsis

```
double scalbn(double x,  
             int exp);
```

Description

scalbn multiplies a floating-point number by an integral power of **DBL_RADIX**.

As floating-point arithmetic conforms to IEC 60559, **DBL_RADIX** is 2 and **scalbn** is (in this implementation) identical to **lDEXP**.

scalbn returns $x * \text{DBL_RADIX}^{\text{exp}}$.

If the result overflows, **errno** is set to **ERANGE** and **scalbn** returns **HUGE_VAL**.

If **x** is ∞ or **NaN**, **scalbn** returns **x**.

If the result overflows, **scalbn** returns ∞ .

See Also

lDEXP

scalbnf

Synopsis

```
float scalbnf(float x,  
             int exp);
```

Description

scalbnf multiplies a floating-point number by an integral power of **FLT_RADIX**.

As floating-point arithmetic conforms to IEC 60559, **FLT_RADIX** is 2 and **scalbnf** is (in this implementation) identical to **ldexpf**.

scalbnf returns $x * \text{FLT_RADIX}^{\text{exp}}$.

If the result overflows, **errno** is set to **ERANGE** and **scalbnf** returns **HUGE_VALF**.

If **x** is ∞ or **NaN**, **scalbnf** returns **x**. If the result overflows, **scalbnf** returns ∞ .

See Also

ldexpf

signbit

Synopsis

```
#define signbit(x) (sizeof(x) == sizeof(float) ? __float32_signbit(x) : __float64_signbit(x))
```

Description

signbit macro determines whether the sign of x is negative. **signbit** returns a non-zero value if and only if x is negative.

sin

Synopsis

```
double sin(double x);
```

Description

sin returns the radian circular sine of **x**.

If $|x| > 10^9$, **errno** is set to **EDOM** and **sin** returns **HUGE_VAL**.

sin returns **x** if **x** is NaN. **sin** returns NaN if $|x|$ is ∞ .

sinf

Synopsis

```
float sinf(float x);
```

Description

sinf returns the radian circular sine of **x**.

If $|x| > 10^9$, **errno** is set to **EDOM** and **sinf** returns **HUGE_VALF**.

sinf returns **x** if **x** is NaN. **sinf** returns NaN if $|x|$ is ∞ .

sinh

Synopsis

```
double sinh(double x);
```

Description

sinh calculates the hyperbolic sine of **x**.

If $|x| \geq 782$, **errno** is set to **EDOM** and **sinh** returns **HUGE_VAL**.

If **x** is $+\infty$, $-\infty$, or **NaN**, **sinh** returns $|x|$. If $|x| > \sim 709.782$, **sinh** returns $+\infty$ or $-\infty$ depending upon the sign of **x**.

sinhf

Synopsis

```
float sinhf(float x);
```

Description

sinhf calculates the hyperbolic sine of **x**.

If $|x| > \sim 88.7228$, **errno** is set to **EDOM** and **sinhf** returns **HUGE_VALF**.

If **x** is $+\infty$, $-\infty$, or **NaN**, **sinhf** returns $|x|$. If $|x| > \sim 88.7228$, **sinhf** returns $+\infty$ or $-\infty$ depending upon the sign of **x**.

sqrt

Synopsis

```
double sqrt(double x);
```

Description

sqrt computes the nonnegative square root of **x**. C90 and C99 require that a domain error occurs if the argument is less than zero. **sqrt** deviates and always uses IEC 60559 semantics.

If **x** is +0, **sqrt** returns +0.

If **x** is -0, **sqrt** returns -0.

If **x** is ∞ , **sqrt** returns ∞ .

If **x** < 0, **sqrt** returns NaN.

If **x** is NaN, **sqrt** returns that NaN.

sqrtf

Synopsis

```
float sqrtf(float x);
```

Description

sqrtf computes the nonnegative square root of *x*. C90 and C99 require that a domain error occurs if the argument is less than zero. **sqrtf** deviates and always uses IEC 60559 semantics.

If *x* is +0, **sqrtf** returns +0.

If *x* is -0, **sqrtf** returns -0.

If *x* is ∞ , **sqrtf** returns ∞ .

If *x* < 0, **sqrtf** returns NaN.

If *x* is NaN, **sqrtf** returns that NaN.

tan

Synopsis

```
double tan(double x);
```

Description

tan returns the radian circular tangent of **x**.

If $|x| > 10^9$, **errno** is set to **EDOM** and **tan** returns **HUGE_VAL**.

If **x** is NaN, **tan** returns **x**. If $|x|$ is ∞ , **tan** returns NaN.

tanf

Synopsis

```
float tanf(float x);
```

Description

tanf returns the radian circular tangent of **x**.

If $|x| > 10^9$, **errno** is set to **EDOM** and **tanf** returns **HUGE_VALF**.

If **x** is NaN, **tanf** returns **x**. If $|x|$ is ∞ , **tanf** returns NaN.

tanh

Synopsis

```
double tanh(double x);
```

Description

tanh calculates the hyperbolic tangent of **x**.

If **x** is NaN, **tanh** returns NaN.

tanhf

Synopsis

```
float tanhf(float x);
```

Description

tanhf calculates the hyperbolic tangent of x.

If x is NaN, **tanhf** returns NaN.

tgamma

Synopsis

```
double tgamma(double x);
```

Description

tgamma returns the gamma function for **x**.

tgammaf

Synopsis

```
float tgammaf(float x);
```

Description

tgammaf returns the gamma function for **x**.

trunc

Synopsis

```
double trunc(double x);
```

Description

trunc rounds *x* to an integral value that is not larger in magnitude than *x*.

truncf

Synopsis

```
float truncf(float x);
```

Description

truncf rounds **x** to an integral value that is not larger in magnitude than **x**.

<setjmp.h>

API Summary

Functions	
longjmp	Restores the saved environment
setjmp	Save calling environment for non-local jump

longjmp

Synopsis

```
void longjmp(jmp_buf env,  
             int val);
```

Description

longjmp restores the environment saved by **setjmp** in the corresponding **env** argument. If there has been no such invocation, or if the function containing the invocation of **setjmp** has terminated execution in the interim, the behavior of **longjmp** is undefined.

After **longjmp** is completed, program execution continues as if the corresponding invocation of **setjmp** had just returned the value specified by **val**.

Note

longjmp cannot cause **setjmp** to return the value 0; if **val** is 0, **setjmp** returns the value 1.

Objects of automatic storage allocation that are local to the function containing the invocation of the corresponding **setjmp** that do not have **volatile** qualified type and have been changed between the **setjmp** invocation and **this** call are indeterminate.

setjmp

Synopsis

```
int setjmp( jmp_buf env);
```

Description

setjmp saves its calling environment in the **env** for later use by the **longjmp** function.

On return from a direct invocation **setjmp** returns the value zero. On return from a call to the **longjmp** function, the **setjmp** returns a nonzero value determined by the call to **longjmp**.

The environment saved by a call to **setjmp** consists of information sufficient for a call to the **longjmp** function to return execution to the correct block and invocation of that block, were it called recursively.

<stdarg.h>

API Summary

Macros	
va_arg	Get variable argument value
va_copy	Copy var args
va_end	Finish access to variable arguments
va_start	Start access to variable arguments

va_arg

Synopsis

```
type va_arg(va_list ap,
            type);
```

Description

va_arg expands to an expression that has the specified type and the value of the **type** argument. The **ap** parameter must have been initialized by **va_start** or **va_copy**, without an intervening invocation of **va_end**. You can create a pointer to a **va_list** and pass that pointer to another function, in which case the original function may make further use of the original list after the other function returns.

Each invocation of the **va_arg** macro modifies **ap** so that the values of successive arguments are returned in turn. The parameter **type** must be a type name such that the type of a pointer to an object that has the specified type can be obtained simply by postfixing a * to **type**.

If there is no actual next argument, or if **type** is not compatible with the type of the actual next argument (as promoted according to the default argument promotions), the behavior of **va_arg** is undefined, except for the following cases:

- one type is a signed integer type, the other type is the corresponding unsigned integer type, and the value is representable in both types;
- one type is pointer to **void** and the other is a pointer to a character type.

The first invocation of the **va_arg** macro after that of the **va_start** macro returns the value of the argument after that specified by **parmN**. Successive invocations return the values of the remaining arguments in succession.

va_copy

Synopsis

```
void va_copy(va_list dest,  
            val_list src);
```

Description

va_copy initializes **dest** as a copy of **src**, as if the **va_start** macro had been applied to **dest** followed by the same sequence of uses of the **va_arg** macro as had previously been used to reach the present state of **src**. Neither the **va_copy** nor **va_start** macro shall be invoked to reinitialize **dest** without an intervening invocation of the **va_end** macro for the same **dest**.

va_end

Synopsis

```
void va_end(va_list ap);
```

Description

va_end indicates a normal return from the function whose variable argument list **ap** was initialised by **va_start** or **va_copy**. The **va_end** macro may modify **ap** so that it is no longer usable without being reinitialized by **va_start** or **va_copy**. If there is no corresponding invocation of **va_start** or **va_copy**, or if **va_end** is not invoked before the return, the behavior is undefined.

va_start

Synopsis

```
void va_start(va_list ap,  
             paramN);
```

Description

va_start initializes **ap** for subsequent use by the **va_arg** and **va_end** macros.

The parameter **paramN** is the identifier of the last fixed parameter in the variable parameter list in the function definition (the one just before the ', ...').

The behaviour of **va_start** and **va_arg** is undefined if the parameter **paramN** is declared with the **register** storage class, with a function or array type, or with a type that is not compatible with the type that results after application of the default argument promotions.

va_start must be invoked before any access to the unnamed arguments.

va_start and **va_copy** must not be invoked to reinitialize **ap** without an intervening invocation of the **va_end** macro for the same **ap**.

<stddef.h>

API Summary

Macros	
NULL	NULL pointer
offsetof	offsetof
Types	
ptrdiff_t	ptrdiff_t type
size_t	size_t type

NULL

Synopsis

```
#define NULL 0
```

Description

NULL is the null pointer constant.

offsetof

Synopsis

```
#define offsetof(type, member)
```

Description

offsetof returns the offset in bytes to the structure **member**, from the beginning of its structure **type**.

ptrdiff_t

Synopsis

```
typedef __RAL_PTRDIFF_T ptrdiff_t;
```

Description

ptrdiff_t is the signed integral type of the result of subtracting two pointers.

size_t

Synopsis

```
typedef __RAL_SIZE_T size_t;
```

Description

size_t is the unsigned integral type returned by the sizeof operator.

<stdio.h>

API Summary

Character and string I/O functions	
getchar	Read a character from standard input
gets	Read a string from standard input
putchar	Write a character to standard output
puts	Write a string to standard output
Formatted output functions	
printf	Write formatted text to standard output
snprintf	Write formatted text to a string with truncation
sprintf	Write formatted text to a string
vprintf	Write formatted text to standard output using variable argument context
vsnprintf	Write formatted text to a string with truncation using variable argument context
vsprintf	Write formatted text to a string using variable argument context
Formatted input functions	
scanf	Read formatted text from standard input
sscanf	Read formatted text from string
vscanf	Read formatted text from standard using variable argument context
vsscanf	Read formatted text from a string using variable argument context

getchar

Synopsis

```
int getchar(void);
```

Description

getchar reads a single character from the standard input stream.

If the stream is at end-of-file or a read error occurs, **getchar** returns **EOF**.

gets

Synopsis

```
char *gets(char *s);
```

Description

gets reads characters from standard input into the array pointed to by **s** until end-of-file is encountered or a new-line character is read. Any new-line character is discarded, and a null character is written immediately after the last character read into the array.

gets returns **s** if successful. If end-of-file is encountered and no characters have been read into the array, the contents of the array remain unchanged and **gets** returns a null pointer. If a read error occurs during the operation, the array contents are indeterminate and **gets** returns a null pointer.

printf

Synopsis

```
int printf(const char *format,  
          ...);
```

Description

printf writes to the standard output stream using **putchar**, under control of the string pointed to by **format** that specifies how subsequent arguments are converted for output.

If there are insufficient arguments for the format, the behavior is undefined. If the format is exhausted while arguments remain, the excess arguments are evaluated but are otherwise ignored.

printf returns the number of characters transmitted, or a negative value if an output or encoding error occurred.

Formatted output control strings

The format is composed of zero or more directives: ordinary characters (not '%', which are copied unchanged to the output stream; and conversion specifications, each of which results in fetching zero or more subsequent arguments, converting them, if applicable, according to the corresponding conversion specifier, and then writing the result to the output stream.

Each conversion specification is introduced by the character '%'. After the '%' the following appear in sequence:

- Zero or more *flags* (in any order) that modify the meaning of the conversion specification.
- An optional *minimum field width*. If the converted value has fewer characters than the field width, it is padded with spaces (by default) on the left (or right, if the left adjustment flag has been given) to the field width. The field width takes the form of an asterisk '*' or a decimal integer.
- An optional precision that gives the minimum number of digits to appear for the 'd', 'i', 'o', 'u', 'x', and 'X' conversions, the number of digits to appear after the decimal-point character for 'e', 'E', 'f', and 'F' conversions, the maximum number of significant digits for the 'g' and 'G' conversions, or the maximum number of bytes to be written for 's' conversions. The precision takes the form of a period '.' followed either by an asterisk '*' or by an optional decimal integer; if only the period is specified, the precision is taken as zero. If a precision appears with any other conversion specifier, the behavior is undefined.
- An optional length modifier that specifies the size of the argument.
- A conversion specifier character that specifies the type of conversion to be applied.

As noted above, a field width, or precision, or both, may be indicated by an asterisk. In this case, an int argument supplies the field width or precision. The arguments specifying field width, or precision, or both, must appear (in that order) before the argument (if any) to be converted. A negative field width argument is taken as a '-' flag followed by a positive field width. A negative precision argument is taken as if the precision were omitted.

Some library variants do not support width and precision specifiers in order to reduce code and data space requirements; please ensure that you have selected the correct library in the **Printf Width/Precision Support** property of the project if you use these.

Flag characters

The flag characters and their meanings are:

'-'

The result of the conversion is left-justified within the field. The default, if this flag is not specified, is that the result of the conversion is left-justified within the field.

'+'

The result of a signed conversion *always* begins with a plus or minus sign. The default, if this flag is not specified, is that it begins with a sign only when a negative value is converted.

space

If the first character of a signed conversion is not a sign, or if a signed conversion results in no characters, a space is prefixed to the result. If the space and '+' flags both appear, the space flag is ignored.

'#'

The result is converted to an *alternative form*. For 'o' conversion, it increases the precision, if and only if necessary, to force the first digit of the result to be a zero (if the value and precision are both zero, a single '0' is printed). For 'x' or 'X' conversion, a nonzero result has '0x' or '0X' prefixed to it. For 'e', 'E', 'f', 'F', 'g', and 'G' conversions, the result of converting a floating-point number always contains a decimal-point character, even if no digits follow it. (Normally, a decimal-point character appears in the result of these conversions only if a digit follows it.) For 'g' and 'F' conversions, trailing zeros are not removed from the result. As an extension, when used in 'p' conversion, the results has '#' prefixed to it. For other conversions, the behavior is undefined.

'0'

For 'd', 'i', 'o', 'u', 'x', 'X', 'e', 'E', 'f', 'F', 'g', and 'G' conversions, leading zeros (following any indication of sign or base) are used to pad to the field width rather than performing space padding, except when converting an infinity or NaN. If the '0' and '-' flags both appear, the '0' flag is ignored. For 'd', 'i', 'o', 'u', 'x', and 'X' conversions, if a precision is specified, the '0' flag is ignored. For other conversions, the behavior is undefined.

Length modifiers

The length modifiers and their meanings are:

'hh'

Specifies that a following 'd', 'i', 'o', 'u', 'x', or 'X' conversion specifier applies to a **signed char** or **unsigned char** argument (the argument will have been promoted according to the integer promotions, but its value will be converted to **signed char** or **unsigned char** before printing); or that a following 'n' conversion specifier applies to a pointer to a **signed char** argument.

'h'

Specifies that a following 'd', 'i', 'o', 'u', 'x', or 'X' conversion specifier applies to a **short int** or **unsigned short int** argument (the argument will have been promoted according to the integer promotions, but its value is converted to **short int** or **unsigned short int** before printing); or that a following 'n' conversion specifier applies to a pointer to a **short int** argument.

'l'

Specifies that a following 'd', 'i', 'o', 'u', 'x', or 'X' conversion specifier applies to a **long int** or **unsigned long int** argument; that a following 'n' conversion specifier applies to a pointer to a **long int** argument; or has no effect on a following 'e', 'E', 'f', 'F', 'g', or 'G' conversion specifier. Some library variants do not support the 'l' length modifier in order to reduce code and data space requirements; please ensure that you have selected the correct library in the **Printf Integer Support** property of the project if you use this length modifier.

'll'

Specifies that a following 'd', 'i', 'o', 'u', 'x', or 'X' conversion specifier applies to a **long long int** or **unsigned long long int** argument; that a following 'n' conversion specifier applies to a pointer to a **long long int** argument. Some library variants do not support the 'll' length modifier in order to reduce code and data space requirements; please ensure that you have selected the correct library in the **Printf Integer Support** property of the project if you use this length modifier.

If a length modifier appears with any conversion specifier other than as specified above, the behavior is undefined. Note that the C99 length modifiers 'j', 'z', 't', and 'L' are not supported.

Conversion specifiers

The conversion specifiers and their meanings are:

'd', 'i'

The argument is converted to signed decimal in the style [-]ddd. The precision specifies the minimum number of digits to appear; if the value being converted can be represented in fewer digits, it is expanded with leading spaces. The default precision is one. The result of converting a zero value with a precision of zero is no characters.

'o', 'u', 'x', 'X'

The unsigned argument is converted to unsigned octal for 'o', unsigned decimal for 'u', or unsigned hexadecimal notation for 'x' or 'X' in the style ddd the letters 'abcdef' are used for 'x' conversion and the letters 'ABCDEF' for 'X' conversion. The precision specifies the minimum number of digits to appear; if the value being converted can be represented in fewer digits, it is expanded with leading spaces. The default precision is one. The result of converting a zero value with a precision of zero is no characters.

'f', 'F'

A double argument representing a floating-point number is converted to decimal notation in the style [-]ddd.ddd, where the number of digits after the decimal-point character is equal to the precision specification. If the precision is missing, it is taken as 6; if the precision is zero and the '#' flag is not specified,

no decimal-point character appears. If a decimal-point character appears, at least one digit appears before it. The value is rounded to the appropriate number of digits. A double argument representing an infinity is converted to ‘inf’. A double argument representing a NaN is converted to ‘nan’. The ‘F’ conversion specifier produces ‘INF’ or ‘NAN’ instead of ‘inf’ or ‘nan’, respectively. Some library variants do not support the ‘f’ and ‘F’ conversion specifiers in order to reduce code and data space requirements; please ensure that you have selected the correct library in the **Printf Floating Point Support** property of the project if you use these conversion specifiers.

‘e’, ‘E’

A double argument representing a floating-point number is converted in the style $[-]d.ddde\pm dd$, where there is one digit (which is nonzero if the argument is nonzero) before the decimal-point character and the number of digits after it is equal to the precision; if the precision is missing, it is taken as 6; if the precision is zero and the ‘#’ flag is not specified, no decimal-point character appears. The value is rounded to the appropriate number of digits. The ‘E’ conversion specifier produces a number with ‘E’ instead of ‘e’ introducing the exponent. The exponent always contains at least two digits, and only as many more digits as necessary to represent the exponent. If the value is zero, the exponent is zero. A double argument representing an infinity is converted to ‘inf’. A double argument representing a NaN is converted to ‘nan’. The ‘E’ conversion specifier produces ‘INF’ or ‘NAN’ instead of ‘inf’ or ‘nan’, respectively. Some library variants do not support the ‘f’ and ‘F’ conversion specifiers in order to reduce code and data space requirements; please ensure that you have selected the correct library in the **Printf Floating Point Support** property of the project if you use these conversion specifiers.

‘g’, ‘G’

A double argument representing a floating-point number is converted in style ‘f’ or ‘e’ (or in style ‘F’ or ‘e’ in the case of a ‘G’ conversion specifier), with the precision specifying the number of significant digits. If the precision is zero, it is taken as one. The style used depends on the value converted; style ‘e’ (or ‘E’) is used only if the exponent resulting from such a conversion is less than -4 or greater than or equal to the precision. Trailing zeros are removed from the fractional portion of the result unless the ‘#’ flag is specified; a decimal-point character appears only if it is followed by a digit. A double argument representing an infinity is converted to ‘inf’. A double argument representing a NaN is converted to ‘nan’. The ‘G’ conversion specifier produces ‘INF’ or ‘NAN’ instead of ‘inf’ or ‘nan’, respectively. Some library variants do not support the ‘f’ and ‘F’ conversion specifiers in order to reduce code and data space requirements; please ensure that you have selected the correct library in the **Printf Floating Point Support** property of the project if you use these conversion specifiers.

‘c’

The argument is converted to an **unsigned char**, and the resulting character is written.

‘s’

The argument is be a pointer to the initial element of an array of character type. Characters from the array are written up to (but not including) the terminating null character. If the precision is specified, no more than that many characters are written. If the precision is not specified or is greater than the size of the array, the array must contain a null character.

'p'

The argument is a pointer to **void**. The value of the pointer is converted in the same format as the 'x' conversion specifier with a fixed precision of $2 * \text{sizeof}(\text{void } *)$.

'n'

The argument is a pointer to a signed integer into which is *written* the number of characters written to the output stream so far by the call to the formatting function. No argument is converted, but one is consumed. If the conversion specification includes any flags, a field width, or a precision, the behavior is undefined.

'%'

A '%' character is written. No argument is converted.

Note that the C99 width modifier 'l' used in conjunction with the 'c' and 's' conversion specifiers is not supported and nor are the conversion specifiers 'a' and 'A'.

putchar

Synopsis

```
int putchar(int c);
```

Description

putchar writes the character **c** to the standard output stream.

putchar returns the character written. If a write error occurs, **putchar** returns **EOF**.

puts

Synopsis

```
int puts(const char *s);
```

Description

puts writes the string pointed to by **s** to the standard output stream using **putchar** and appends a new-line character to the output. The terminating null character is not written.

puts returns **EOF** if a write error occurs; otherwise it returns a nonnegative value.

scanf

Synopsis

```
int scanf(const char *format,  
         ...);
```

Description

scanf reads input from the standard input stream under control of the string pointed to by **format** that specifies the admissible input sequences and how they are to be converted for assignment, using subsequent arguments as pointers to the objects to receive the converted input.

If there are insufficient arguments for the format, the behavior is undefined. If the format is exhausted while arguments remain, the excess arguments are evaluated but are otherwise ignored.

scanf returns the value of the macro **EOF** if an input failure occurs before any conversion. Otherwise, **scanf** returns the number of input items assigned, which can be fewer than provided for, or even zero, in the event of an early matching failure.

Formatted input control strings

The format is composed of zero or more directives: one or more white-space characters, an ordinary character (neither % nor a white-space character), or a conversion specification.

Each conversion specification is introduced by the character %. After the %, the following appear in sequence:

- An optional assignment-suppressing character *.
- An optional nonzero decimal integer that specifies the maximum field width (in characters).
- An optional length modifier that specifies the size of the receiving object.
- A conversion specifier character that specifies the type of conversion to be applied.

The formatted input function executes each directive of the format in turn. If a directive fails, the function returns. Failures are described as input failures (because of the occurrence of an encoding error or the unavailability of input characters), or matching failures (because of inappropriate input).

A directive composed of white-space character(s) is executed by reading input up to the first non-white-space character (which remains unread), or until no more characters can be read.

A directive that is an ordinary character is executed by reading the next characters of the stream. If any of those characters differ from the ones composing the directive, the directive fails and the differing and subsequent characters remain unread. Similarly, if end-of-file, an encoding error, or a read error prevents a character from being read, the directive fails.

A directive that is a conversion specification defines a set of matching input sequences, as described below for each specifier. A conversion specification is executed in the following steps:

- Input white-space characters (as specified by the `isspace` function) are skipped, unless the specification includes a `[`, `c`, or `n` specifier.
- An input item is read from the stream, unless the specification includes an `n` specifier. An input item is defined as the longest sequence of input characters which does not exceed any specified field width and which is, or is a prefix of, a matching input sequence. The first character, if any, after the input item remains unread. If the length of the input item is zero, the execution of the directive fails; this condition is a matching failure unless end-of-file, an encoding error, or a read error prevented input from the stream, in which case it is an input failure.
- Except in the case of a `%` specifier, the input item (or, in the case of a `%n` directive, the count of input characters) is converted to a type appropriate to the conversion specifier. If the input item is not a matching sequence, the execution of the directive fails: this condition is a matching failure. Unless assignment suppression was indicated by a `*`, the result of the conversion is placed in the object pointed to by the first argument following the format argument that has not already received a conversion result. If this object does not have an appropriate type, or if the result of the conversion cannot be represented in the object, the behavior is undefined.

Length modifiers

The length modifiers and their meanings are:

'hh'

Specifies that a following `'d'`, `'i'`, `'o'`, `'u'`, `'x'`, `'X'`, or `'n'` conversion specifier applies to an argument with type pointer to **signed char** or pointer to **unsigned char**.

'h'

Specifies that a following `'d'`, `'i'`, `'o'`, `'u'`, `'x'`, `'X'`, or `'n'` conversion specifier applies to an argument with type pointer to **short int** or **unsigned short int**.

'l'

Specifies that a following `'d'`, `'i'`, `'o'`, `'u'`, `'x'`, `'X'`, or `'n'` conversion specifier applies to an argument with type pointer to **long int** or **unsigned long int**; that a following `'e'`, `'E'`, `'f'`, `'F'`, `'g'`, or `'G'` conversion specifier applies to an argument with type pointer to **double**. Some library variants do not support the `'l'` length modifier in order to reduce code and data space requirements; please ensure that you have selected the correct library in the **Printf Integer Support** property of the project if you use this length modifier.

'll'

Specifies that a following `'d'`, `'i'`, `'o'`, `'u'`, `'x'`, `'X'`, or `'n'` conversion specifier applies to an argument with type pointer to **long long int** or **unsigned long long int**. Some library variants do not support the `'ll'` length modifier in order to reduce code and data space requirements; please ensure that you have selected the correct library in the **Printf Integer Support** property of the project if you use this length modifier.

If a length modifier appears with any conversion specifier other than as specified above, the behavior is undefined. Note that the C99 length modifiers `'j'`, `'z'`, `'t'`, and `'L'` are not supported.

Conversion specifiers

'd'

Matches an optionally signed decimal integer, whose format is the same as expected for the subject sequence of the **strtol** function with the value 10 for the **base** argument. The corresponding argument must be a pointer to signed integer.

'i'

Matches an optionally signed integer, whose format is the same as expected for the subject sequence of the **strtol** function with the value zero for the **base** argument. The corresponding argument must be a pointer to signed integer.

'o'

Matches an optionally signed octal integer, whose format is the same as expected for the subject sequence of the **strtol** function with the value 18 for the **base** argument. The corresponding argument must be a pointer to signed integer.

'u'

Matches an optionally signed decimal integer, whose format is the same as expected for the subject sequence of the **strtoul** function with the value 10 for the **base** argument. The corresponding argument must be a pointer to unsigned integer.

'x'

Matches an optionally signed hexadecimal integer, whose format is the same as expected for the subject sequence of the **strtoul** function with the value 16 for the **base** argument. The corresponding argument must be a pointer to unsigned integer.

'e', 'f', 'g'

Matches an optionally signed floating-point number whose format is the same as expected for the subject sequence of the **strtod** function. The corresponding argument shall be a pointer to floating. Some library variants do not support the 'e', 'f' and 'F' conversion specifiers in order to reduce code and data space requirements; please ensure that you have selected the correct library in the **Scarf Floating Point Support** property of the project if you use these conversion specifiers.

'c'

Matches a sequence of characters of exactly the number specified by the field width (one if no field width is present in the directive). The corresponding argument must be a pointer to the initial element of a character array large enough to accept the sequence. No null character is added.

's'

Matches a sequence of non-white-space characters. The corresponding argument must be a pointer to the initial element of a character array large enough to accept the sequence and a terminating null character, which will be added automatically.

'['

Matches a nonempty sequence of characters from a set of expected characters (the *scanset*). The corresponding argument must be a pointer to the initial element of a character array large enough to accept the sequence and a terminating null character, which will be added automatically. The conversion specifier includes all subsequent characters in the format string, up to and including the matching right bracket ']'. The characters between the brackets (the *scanlist*) compose the scanset, unless the character after the left bracket is a circumflex '^', in which case the scanset contains all characters that do not appear in the scanlist between the circumflex and the right bracket. If the conversion specifier begins with '[]' or '[^]', the right bracket character is in the scanlist and the next following right bracket character is the matching right bracket that ends the specification; otherwise the first following right bracket character is the one that ends the specification. If a '-' character is in the scanlist and is not the first, nor the second where the first character is a '^', nor the last character, it is treated as a member of the scanset. Some library variants do not support the '[' conversion specifier in order to reduce code and data space requirements; please ensure that you have selected the correct library in the **Scanf Classes Supported** property of the project if you use this conversion specifier.

'p'

Reads a sequence output by the corresponding '%p' formatted output conversion. The corresponding argument must be a pointer to a pointer to **void**.

'n'

No input is consumed. The corresponding argument shall be a pointer to signed integer into which is to be written the number of characters read from the input stream so far by this call to the formatted input function. Execution of a '%n' directive does not increment the assignment count returned at the completion of execution of the fscanf function. No argument is converted, but one is consumed. If the conversion specification includes an assignment-suppressing character or a field width, the behavior is undefined.

'%'

Matches a single '%' character; no conversion or assignment occurs.

Note that the C99 width modifier 'l' used in conjunction with the 'c', 's', and '[' conversion specifiers is not supported and nor are the conversion specifiers 'a' and 'A'.

snprintf

Synopsis

```
int snprintf(char *s,
             size_t n,
             const char *format,
             ...);
```

Description

snprintf writes to the string pointed to by **s** under control of the string pointed to by **format** that specifies how subsequent arguments are converted for output.

If **n** is zero, nothing is written, and **s** can be a null pointer. Otherwise, output characters beyond the $n-1^{\text{st}}$ are discarded rather than being written to the array, and a null character is written at the end of the characters actually written into the array. A null character is written at the end of the conversion; it is not counted as part of the returned value.

If there are insufficient arguments for the format, the behavior is undefined. If the format is exhausted while arguments remain, the excess arguments are evaluated but are otherwise ignored.

If copying takes place between objects that overlap, the behavior is undefined.

snprintf returns the number of characters that would have been written had **n** been sufficiently large, not counting the terminating null character, or a negative value if an encoding error occurred. Thus, the null-terminated output has been completely written if and only if the returned value is nonnegative and less than **n**.

sprintf

Synopsis

```
int sprintf(char *s,
            const char *format,
            ...);
```

Description

sprintf writes to the string pointed to by **s** under control of the string pointed to by **format** that specifies how subsequent arguments are converted for output. A null character is written at the end of the characters written; it is not counted as part of the returned value.

If there are insufficient arguments for the format, the behavior is undefined. If the format is exhausted while arguments remain, the excess arguments are evaluated but are otherwise ignored.

If copying takes place between objects that overlap, the behavior is undefined.

sprintf returns number of characters transmitted (not counting the terminating null), or a negative value if an output or encoding error occurred.

sscanf

Synopsis

```
int sscanf(const char *s,  
          const char *format,  
          ...);
```

Description

sscanf reads input from the string **s** under control of the string pointed to by **format** that specifies the admissible input sequences and how they are to be converted for assignment, using subsequent arguments as pointers to the objects to receive the converted input.

If there are insufficient arguments for the format, the behavior is undefined. If the format is exhausted while arguments remain, the excess arguments are evaluated but are otherwise ignored.

sscanf returns the value of the macro **EOF** if an input failure occurs before any conversion. Otherwise, **sscanf** returns the number of input items assigned, which can be fewer than provided for, or even zero, in the event of an early matching failure.

vprintf

Synopsis

```
int vprintf(const char *format,  
           __va_list arg);
```

Description

vprintf writes to the standard output stream using **putchar** under control of the string pointed to by **format** that specifies how subsequent arguments are converted for output. Before calling **vprintf**, **arg** must be initialized by the **va_start** macro (and possibly subsequent **va_arg** calls). **vprintf** does not invoke the **va_end** macro.

vprintf returns the number of characters transmitted, or a negative value if an output or encoding error occurred.

Note

vprintf is equivalent to **printf** with the variable argument list replaced by **arg**.

vscanf

Synopsis

```
int vscanf(const char *format,  
          __va_list arg);
```

Description

vscanf reads input from the standard input stream under control of the string pointed to by **format** that specifies the admissible input sequences and how they are to be converted for assignment, using subsequent arguments as pointers to the objects to receive the converted input. Before calling **vscanf**, **arg** must be initialized by the **va_start** macro (and possibly subsequent **va_arg** calls). **vscanf** does not invoke the **va_end** macro.

If there are insufficient arguments for the format, the behavior is undefined.

vscanf returns the value of the macro **EOF** if an input failure occurs before any conversion. Otherwise, **vscanf** returns the number of input items assigned, which can be fewer than provided for, or even zero, in the event of an early matching failure.

Note

vscanf is equivalent to **scanf** with the variable argument list replaced **arg**.

vsnprintf

Synopsis

```
int vsnprintf(char *s,
              size_t n,
              const char *format,
              __va_list arg);
```

Description

vsnprintf writes to the string pointed to by **s** under control of the string pointed to by **format** that specifies how subsequent arguments are converted for output. Before calling **vsnprintf**, **arg** must be initialized by the **va_start** macro (and possibly subsequent **va_arg** calls). **vsnprintf** does not invoke the **va_end** macro.

If **n** is zero, nothing is written, and **s** can be a null pointer. Otherwise, output characters beyond the $n - 1^{\text{st}}$ are discarded rather than being written to the array, and a null character is written at the end of the characters actually written into the array. A null character is written at the end of the conversion; it is not counted as part of the returned value.

If there are insufficient arguments for the format, the behavior is undefined. If the format is exhausted while arguments remain, the excess arguments are evaluated but are otherwise ignored.

If copying takes place between objects that overlap, the behavior is undefined.

vsnprintf returns the number of characters that would have been written had **n** been sufficiently large, not counting the terminating null character, or a negative value if an encoding error occurred. Thus, the null-terminated output has been completely written if and only if the returned value is nonnegative and less than **n**.

Note

vsnprintf is equivalent to **snprintf** with the variable argument list replaced by **arg**.

vsprintf

Synopsis

```
int vsprintf(char *s,  
            const char *format,  
            __va_list arg);
```

Description

vsprintf writes to the string pointed to by **s** under control of the string pointed to by **format** that specifies how subsequent arguments are converted for output. Before calling **vsprintf**, **arg** must be initialized by the **va_start** macro (and possibly subsequent **va_arg** calls). **vsprintf** does not invoke the **va_end** macro.

A null character is written at the end of the characters written; it is not counted as part of the returned value.

If there are insufficient arguments for the format, the behavior is undefined. If the format is exhausted while arguments remain, the excess arguments are evaluated but are otherwise ignored.

If copying takes place between objects that overlap, the behavior is undefined.

vsprintf returns number of characters transmitted (not counting the terminating null), or a negative value if an output or encoding error occurred.

Note

vsprintf is equivalent to **sprintf** with the variable argument list replaced by **arg**.

vsscanf

Synopsis

```
int vsscanf(const char *s,  
           const char *format,  
           __va_list arg);
```

Description

vsscanf reads input from the string **s** under control of the string pointed to by **format** that specifies the admissible input sequences and how they are to be converted for assignment, using subsequent arguments as pointers to the objects to receive the converted input. Before calling **vsscanf**, **arg** must be initialized by the **va_start** macro (and possibly subsequent **va_arg** calls). **vsscanf** does not invoke the **va_end** macro.

If there are insufficient arguments for the format, the behavior is undefined.

vsscanf returns the value of the macro **EOF** if an input failure occurs before any conversion. Otherwise, **vsscanf** returns the number of input items assigned, which can be fewer than provided for, or even zero, in the event of an early matching failure.

Note

vsscanf is equivalent to **sscanf** with the variable argument list replaced by **arg**.

<stdlib.h>

API Summary

Macros	
<code>EXIT_FAILURE</code>	EXIT_FAILURE
<code>EXIT_SUCCESS</code>	EXIT_SUCCESS
<code>MB_CUR_MAX</code>	Maximum number of bytes in a multi-byte character in the current locale
<code>RAND_MAX</code>	RAND_MAX
Types	
<code>div_t</code>	Structure containing quotient and remainder after division of an int
<code>ldiv_t</code>	Structure containing quotient and remainder after division of a long
<code>lldiv_t</code>	Structure containing quotient and remainder after division of a long long
Integer arithmetic functions	
<code>abs</code>	Return an integer absolute value
<code>div</code>	Divide two ints returning quotient and remainder
<code>labs</code>	Return a long integer absolute value
<code>ldiv</code>	Divide two longs returning quotient and remainder
<code>llabs</code>	Return a long long integer absolute value
<code>lldiv</code>	Divide two long longs returning quotient and remainder
Memory allocation functions	
<code>calloc</code>	Allocate space for an array of objects and initialize them to zero
<code>free</code>	Frees allocated memory for reuse
<code>malloc</code>	Allocate space for a single object
<code>realloc</code>	Resizes allocated memory space or allocates memory space
String to number conversions	
<code>atof</code>	Convert string to double
<code>atoi</code>	Convert string to int
<code>atol</code>	Convert string to long
<code>atoll</code>	Convert string to long long

strtod	Convert string to double
strtof	Convert string to float
strtol	Convert string to long
strtoll	Convert string to long long
strtoul	Convert string to unsigned long
strtoull	Convert string to unsigned long long
Pseudo-random sequence generation functions	
rand	Return next random number in sequence
srand	Set seed of random number sequence
Search and sort functions	
bsearch	Search a sorted array
qsort	Sort an array
Environment	
atexit	Set function to be execute on exit
exit	Terminates the calling process
Number to string conversions	
itoa	Convert int to string
ltoa	Convert long long to string
ltoa	Convert long to string
ulltoa	Convert unsigned long long to string
ultoa	Convert unsigned long to string
utoa	Convert unsigned to string
Multi-byte/wide character conversion functions	
mblen	Determine number of bytes in a multi-byte character
mblen_l	Determine number of bytes in a multi-byte character
Multi-byte/wide string conversion functions	
mbstowcs	Convert multi-byte string to wide string
mbstowcs_l	Convert multi-byte string to wide string using specified locale
mbtowc	Convert multi-byte character to wide character
mbtowc_l	Convert multi-byte character to wide character

EXIT_FAILURE

Synopsis

```
#define EXIT_FAILURE    1
```

Description

`EXIT_FAILURE` pass to `exit` on unsuccessful termination.

EXIT_SUCCESS

Synopsis

```
#define EXIT_SUCCESS    0
```

Description

EXIT_SUCCESS pass to **exit** on successful termination.

MB_CUR_MAX

Synopsis

```
#define MB_CUR_MAX __RAL_mb_max(&__RAL_global_locale)
```

Description

MB_CUR_MAX expands to a positive integer expression with type **size_t** that is the maximum number of bytes in a multi-byte character for the extended character set specified by the current locale (category LC_CTYPE).

MB_CUR_MAX is never greater than **MB_LEN_MAX**.

RAND_MAX

Synopsis

```
#define RAND_MAX 32767
```

Description

RAND_MAX expands to an integer constant expression that is the maximum value returned by [rand](#).

abs

Synopsis

```
int abs(int j);
```

Description

abs returns the absolute value of the integer argument **j**.

atexit

Synopsis

```
int atexit(void (*func)(void));
```

Description

atexit registers **function** to be called when the application has exited. The functions registered with **atexit** are executed in reverse order of their registration. **atexit** returns 0 on success and non-zero on failure.

atof

Synopsis

```
double atof(const char *nptr);
```

Description

atof converts the initial portion of the string pointed to by **nptr** to a **double** representation.

atof does not affect the value of **errno** on an error. If the value of the result cannot be represented, the behavior is undefined.

Except for the behavior on error, **atof** is equivalent to `strtod(nptr, (char **)NULL)`.

atof returns the converted value.

See Also

[strtod](#)

atoi

Synopsis

```
int atoi(const char *nptr);
```

Description

atoi converts the initial portion of the string pointed to by **nptr** to an **int** representation.

atoi does not affect the value of **errno** on an error. If the value of the result cannot be represented, the behavior is undefined.

Except for the behavior on error, **atoi** is equivalent to `(int)strtol(nptr, (char **)NULL, 10)`.

atoi returns the converted value.

See Also

[strtol](#)

atol

Synopsis

```
long int atol(const char *nptr);
```

Description

atol converts the initial portion of the string pointed to by **nptr** to a **long int** representation.

atol does not affect the value of **errno** on an error. If the value of the result cannot be represented, the behavior is undefined.

Except for the behavior on error, **atol** is equivalent to `strtol(nptr, (char **)NULL, 10)`.

atol returns the converted value.

See Also

[strtol](#)

atoll

Synopsis

```
long long int atoll(const char *nptr);
```

Description

atoll converts the initial portion of the string pointed to by **nptr** to a **long long int** representation.

atoll does not affect the value of **errno** on an error. If the value of the result cannot be represented, the behavior is undefined.

Except for the behavior on error, **atoll** is equivalent to **strtoll(nptr, (char **)NULL, 10)**.

atoll returns the converted value.

See Also

[strtoll](#)

bsearch

Synopsis

```
void *bsearch(const void *key,
              const void *buf,
              size_t num,
              size_t size,
              int (*compare)(const void *, const void *)) ;
```

Description

bsearch searches the array ***base** for the specified ***key** and returns a pointer to the first entry that matches or null if no match. The array should have **num** elements of **size** bytes and be sorted by the same algorithm as the **compare** function.

The **compare** function should return a negative value if the first parameter is less than second parameter, zero if the parameters are equal, and a positive value if the first parameter is greater than the second parameter.

calloc

Synopsis

```
void *calloc(size_t nobj,  
            size_t size);
```

Description

calloc allocates space for an array of **nmemb** objects, each of whose size is **size**. The space is initialized to all zero bits.

calloc returns a null pointer if the space for the array of object cannot be allocated from free memory; if space for the array can be allocated, **calloc** returns a pointer to the start of the allocated space.

div

Synopsis

```
div_t div(int numer,  
         int denom);
```

Description

div computes **numer / denom** and **numer % denom** in a single operation.

div returns a structure of type **div_t** comprising both the quotient and the remainder. The structures contain the members **quot** (the quotient) and **rem** (the remainder), each of which has the same type as the arguments **numer** and **denom**. If either part of the result cannot be represented, the behavior is undefined.

See Also

[div_t](#)

div_t

Description

`div_t` stores the quotient and remainder returned by [div](#).

exit

Synopsis

```
void exit(int exit_code);
```

Description

exit returns to the startup code and performs the appropriate cleanup process.

free

Synopsis

```
void free(void *p);
```

Description

free causes the space pointed to by **ptr** to be deallocated, that is, made available for further allocation. If **ptr** is a null pointer, no action occurs.

If **ptr** does not match a pointer earlier returned by **calloc**, **malloc**, or **realloc**, or if the space has been deallocated by a call to **free** or **realloc**, the behavior is undefined.

itoa

Synopsis

```
char *itoa(int val,  
          char *buf,  
          int radix);
```

Description

itoa converts **val** to a string in base **radix** and places the result in **buf**.

itoa returns **buf** as the result.

If **radix** is greater than 36, the result is undefined.

If **val** is negative and **radix** is 10, the string has a leading minus sign (-); for all other values of **radix**, **value** is considered unsigned and never has a leading minus sign.

See Also

[ltoa](#), [lltoa](#), [ultoa](#), [ulltoa](#), [utoa](#)

labs

Synopsis

```
long int labs(long int j);
```

Description

labs returns the absolute value of the long integer argument **j**.

ldiv

Synopsis

```
ldiv_t ldiv(long int numer,  
           long int denom);
```

Description

ldiv computes **numer / denom** and **numer % denom** in a single operation.

ldiv returns a structure of type **ldiv_t** comprising both the quotient and the remainder. The structures contain the members **quot** (the quotient) and **rem** (the remainder), each of which has the same type as the arguments **numer** and **denom**. If either part of the result cannot be represented, the behavior is undefined.

See Also

[ldiv_t](#)

ldiv_t

Description

ldiv_t stores the quotient and remainder returned by [ldiv](#).

llabs

Synopsis

```
long long int llabs(long long int j);
```

Description

llabs returns the absolute value of the long long integer argument **j**.

lldiv

Synopsis

```
lldiv_t lldiv(long long int numer,  
             long long int denom);
```

lldiv computes **numer / denom** and **numer % denom** in a single operation.

lldiv returns a structure of type [**lldiv_t**](#) comprising both the quotient and the remainder. The structures contain the members **quot** (the quotient) and **rem** (the remainder), each of which has the same type as the arguments **numer** and **denom**. If either part of the result cannot be represented, the behavior is undefined.

See Also

[**lldiv_t**](#)

Ildiv_t

Description

Ildiv_t stores the quotient and remainder returned by **Ildiv**.

lltoa

Synopsis

```
char *lltoa(long long val,
            char *buf,
            int radix);
```

Description

lltoa converts **val** to a string in base **radix** and places the result in **buf**.

lltoa returns **buf** as the result.

If **radix** is greater than 36, the result is undefined.

If **val** is negative and radix is 10, the string has a leading minus sign (-); for all other values of **radix**, **value** is considered unsigned and never has a leading minus sign.

See Also

[itoa](#), [ltoa](#), [ultoa](#), [ulltoa](#), [utoa](#)

Itoa

Synopsis

```
char *ltoa(long val,  
          char *buf,  
          int radix);
```

Description

Itoa converts **val** to a string in base **radix** and places the result in **buf**.

Itoa returns **buf** as the result.

If **radix** is greater than 36, the result is undefined.

If **val** is negative and radix is 10, the string has a leading minus sign (-); for all other values of **radix**, **value** is considered unsigned and never has a leading minus sign.

See Also

[itoa](#), [lltoa](#), [ultoa](#), [ulltoa](#), [utoa](#)

malloc

Synopsis

```
void *malloc(size_t size);
```

Description

malloc allocates space for an object whose size is specified by 'b size and whose value is indeterminate.

malloc returns a null pointer if the space for the object cannot be allocated from free memory; if space for the object can be allocated, **malloc** returns a pointer to the start of the allocated space.

mblen

Synopsis

```
int mblen(const char *s,  
          size_t n);
```

Description

mblen determines the number of bytes contained in the multi-byte character pointed to by **s** in the current locale.

If **s** is a null pointer, **mblen** returns a nonzero or zero value, if multi-byte character encodings, respectively, do or do not have state-dependent encodings

If **s** is not a null pointer, **mblen** either returns 0 (if **s** points to the null character), or returns the number of bytes that are contained in the multi-byte character (if the next **n** or fewer bytes form a valid multi-byte character), or returns -1 (if they do not form a valid multi-byte character).

Note

Except that the conversion state of the **mbtowc** function is not affected, it is equivalent to

```
mbtowc((wchar_t *)0, s, n);
```

Note

It is guaranteed that no library function in the Standard C library calls **mblen**.

See Also

[mblen_I](#), [mbtowc](#)

mblen_l

Synopsis

```
int mblen_l(const char *s,  
            size_t n,  
            __locale_s *loc);
```

Description

mblen_l determines the number of bytes contained in the multi-byte character pointed to by **s** in the locale **loc**.

If **s** is a null pointer, **mblen_l** returns a nonzero or zero value, if multi-byte character encodings, respectively, do or do not have state-dependent encodings

If **s** is not a null pointer, **mblen_l** either returns 0 (if **s** points to the null character), or returns the number of bytes that are contained in the multi-byte character (if the next **n** or fewer bytes form a valid multi-byte character), or returns -1 (if they do not form a valid multi-byte character).

Note

Except that the conversion state of the **mbtowc_l** function is not affected, it is equivalent to

```
mbtowc((wchar_t *)0, s, n, loc);
```

Note

It is guaranteed that no library function in the Standard C library calls **mblen_l**.

See Also

[mblen_l](#), [mbtowc_l](#)

mbstowcs

Synopsis

```
size_t mbstowcs(wchar_t *pwcs,
                 const char *s,
                 size_t n);
```

Description

mbstowcs converts a sequence of multi-byte characters that begins in the initial shift state from the array pointed to by **s** into a sequence of corresponding wide characters and stores not more than **n** wide characters into the array pointed to by **pwcs**.

No multi-byte characters that follow a null character (which is converted into a null wide character) will be examined or converted. Each multi-byte character is converted as if by a call to the **mbtowc** function, except that the conversion state of the **mbtowc** function is not affected.

No more than **n** elements will be modified in the array pointed to by **pwcs**. If copying takes place between objects that overlap, the behavior is undefined.

mbstowcs returns **-1** if an invalid multi-byte character is encountered, otherwise **mbstowcs** returns the number of array elements modified (if any), not including a terminating null wide character.

mbstowcs_l

Synopsis

```
size_t mbstowcs_l(wchar_t *pwcs,
                   const char *s,
                   size_t n,
                   __locale_s *loc);
```

Description

mbstowcs_l is as **mbstowcs** except that the local **loc** is used for the conversion as opposed to the current locale.

See Also

[mbstowcs](#).

mbtowc

Synopsis

```
int mbtowc(wchar_t *pwc,  
           const char *s,  
           size_t n);
```

Description

mbtowc converts a single multi-byte character to a wide character in the current locale.

If **s** is a null pointer, **mbtowc** returns a nonzero value if multi-byte character encodings are state-dependent in the current locale, and zero otherwise.

If **s** is not null and the object that **s** points to is a wide-character null character, **mbtowc** returns 0.

If **s** is not null and the object that points to forms a valid multi-byte character, **mbtowc** returns the length in bytes of the multi-byte character.

If the object that points to does not form a valid multi-byte character within the first **n** characters, it returns -1.

See Also

[mbtowc_l](#)

mbtowc_l

Synopsis

```
int mbtowc_l(wchar_t *pwc,
              const char *s,
              size_t n,
              __locale_s *loc);
```

Description

mbtowc_l converts a single multi-byte character to a wide character in locale **loc**.

If **s** is a null pointer, **mbtowc_l** returns a nonzero value if multi-byte character encodings are state-dependent in the locale **loc**, and zero otherwise.

If **s** is not null and the object that **s** points to is a wide-character null character, **mbtowc_l** returns 0.

If **s** is not null and the object that points to forms a valid multi-byte character, **mbtowc_l** returns the length in bytes of the multi-byte character.

If the object that **s** points to does not form a valid multi-byte character within the first **n** characters, it returns -1.

See Also

[mbtowc](#)

qsort

Synopsis

```
void qsort(void *buf,
           size_t num,
           size_t size,
           int (*compare)(const void *, const void *));
```

qsort sorts the array ***base** using the **compare** function. The array should have **num** elements of **size** bytes. The **compare** function should return a negative value if the first parameter is less than second parameter, zero if the parameters are equal and a positive value if the first parameter is greater than the second parameter.

rand

Synopsis

```
int rand(void);
```

Description

rand computes a sequence of pseudo-random integers in the range 0 to **RAND_MAX**.

rand returns the computed pseudo-random integer.

realloc

Synopsis

```
void *realloc(void *p,  
            size_t size);
```

Description

realloc deallocates the old object pointed to by **ptr** and returns a pointer to a new object that has the size specified by **size**. The contents of the new object is identical to that of the old object prior to deallocation, up to the lesser of the new and old sizes. Any bytes in the new object beyond the size of the old object have indeterminate values.

If **ptr** is a null pointer, **realloc** behaves like **realloc** for the specified size. If memory for the new object cannot be allocated, the old object is not deallocated and its value is unchanged.

realloc returns a pointer to the new object (which may have the same value as a pointer to the old object), or a null pointer if the new object could not be allocated.

If **ptr** does not match a pointer earlier returned by **calloc**, **malloc**, or **realloc**, or if the space has been deallocated by a call to **free** or **realloc**, the behavior is undefined.

srand

Synopsis

```
void srand(unsigned int seed);
```

Description

srand uses the argument **seed** as a seed for a new sequence of pseudo-random numbers to be returned by subsequent calls to **rand**. If **srand** is called with the same seed value, the same sequence of pseudo-random numbers is generated.

If **rand** is called before any calls to **srand** have been made, a sequence is generated as if **srand** is first called with a seed value of 1.

See Also

[rand](#)

strtod

Synopsis

```
double strtod(const char *nptr,  
            char **endptr);
```

Description

strtod converts the initial portion of the string pointed to by **nptr** to a **double** representation.

First, **strtod** decomposes the input string into three parts: an initial, possibly empty, sequence of white-space characters (as specified by [isspace](#)), a subject sequence resembling a floating-point constant, and a final string of one or more unrecognized characters, including the terminating null character of the input string. **strtod** then attempts to convert the subject sequence to a floating-point number, and return the result.

The subject sequence is defined as the longest initial subsequence of the input string, starting with the first non-white-space character, that is of the expected form. The subject sequence contains no characters if the input string is empty or consists entirely of white space, or if the first non-white-space character is other than a sign or a permissible letter or digit.

The expected form of the subject sequence is an optional plus or minus sign followed by a nonempty sequence of decimal digits optionally containing a decimal-point character, then an optional exponent part.

If the subject sequence begins with a minus sign, the value resulting from the conversion is negated.

A pointer to the final string is stored in the object pointed to by **strtod**, provided that **endptr** is not a null pointer.

If the subject sequence is empty or does not have the expected form, no conversion is performed, the value of **nptr** is stored in the object pointed to by **endptr**, provided that **endptr** is not a null pointer.

strtod returns the converted value, if any. If no conversion could be performed, zero is returned. If the correct value is outside the range of representable values, **HUGE_VAL** is returned according to the sign of the value, if any, and the value of the macro [errno](#) is stored in [errno](#).

strtof

Synopsis

```
float strtod(const char *nptr,  
            char **endptr);
```

Description

strtod converts the initial portion of the string pointed to by **nptr** to a **double** representation.

First, **strtod** decomposes the input string into three parts: an initial, possibly empty, sequence of white-space characters (as specified by **isspace**), a subject sequence resembling a floating-point constant, and a final string of one or more unrecognized characters, including the terminating null character of the input string. **strtod** then attempts to convert the subject sequence to a floating-point number, and return the result.

The subject sequence is defined as the longest initial subsequence of the input string, starting with the first non-white-space character, that is of the expected form. The subject sequence contains no characters if the input string is empty or consists entirely of white space, or if the first non-white-space character is other than a sign or a permissible letter or digit.

The expected form of the subject sequence is an optional plus or minus sign followed by a nonempty sequence of decimal digits optionally containing a decimal-point character, then an optional exponent part.

If the subject sequence begins with a minus sign, the value resulting from the conversion is negated. A pointer to the final string is stored in the object pointed to by **endptr**, provided that **endptr** is not a null pointer.

If the subject sequence is empty or does not have the expected form, no conversion is performed, the value of **nptr** is stored in the object pointed to by **endptr**, provided that **endptr** is not a null pointer.

strtod returns the converted value, if any. If no conversion could be performed, zero is returned. If the correct value is outside the range of representable values, **HUGE_VALF** is returned according to the sign of the value, if any, and the value of the macro **errno** is stored in **errno**.

strtol

Synopsis

```
long int strtol(const char *nptr,
                char **endptr,
                int base);
```

Description

strtol converts the initial portion of the string pointed to by **nptr** to a **long int** representation.

First, **strtol** decomposes the input string into three parts: an initial, possibly empty, sequence of white-space characters (as specified by [isspace](#)), a subject sequence resembling an integer represented in some radix determined by the value of **base**, and a final string of one or more unrecognized characters, including the terminating null character of the input string. **strtol** then attempts to convert the subject sequence to an integer, and return the result.

When converting, no integer suffix (such as U, L, UL, LL, ULL) is allowed.

If the value of **base** is zero, the expected form of the subject sequence is an optional plus or minus sign followed by an integer constant.

If the value of **base** is between 2 and 36 (inclusive), the expected form of the subject sequence is an optional plus or minus sign followed by a sequence of letters and digits representing an integer with the radix specified by **base**. The letters from a (or A) through z (or Z) represent the values 10 through 35; only letters and digits whose ascribed values are less than that of **base** are permitted.

If the value of **base** is 16, the characters '0x' or '0X' may optionally precede the sequence of letters and digits, following the optional sign.

The subject sequence is defined as the longest initial subsequence of the input string, starting with the first non-white-space character, that is of the expected form. The subject sequence contains no characters if the input string is empty or consists entirely of white space, or if the first non-white-space character is other than a sign or a permissible letter or digit.

If the subject sequence has the expected form and the value of **base** is zero, the sequence of characters starting with the first digit is interpreted as an integer constant. If the subject sequence has the expected form and the value of **base** is between 2 and 36, it is used as the base for conversion.

If the subject sequence begins with a minus sign, the value resulting from the conversion is negated.

A pointer to the final string is stored in the object pointed to by **endptr**, provided that **endptr** is not a null pointer.

If the subject sequence is empty or does not have the expected form, no conversion is performed, the value of **nptr** is stored in the object pointed to by **endptr**, provided that **endptr** is not a null pointer.

strtol returns the converted value, if any. If no conversion could be performed, zero is returned. If the correct value is outside the range of representable values, **LONG_MIN** or **LONG_MAX** is returned according to the sign of the value, if any, and the value of the macro **errno** is stored in **errno**.

strtoll

Synopsis

```
long long int strtoll(const char *nptr,
                      char **endptr,
                      int base);
```

Description

strtoll converts the initial portion of the string pointed to by **nptr** to a **long int** representation.

First, **strtoll** decomposes the input string into three parts: an initial, possibly empty, sequence of white-space characters (as specified by [isspace](#)), a subject sequence resembling an integer represented in some radix determined by the value of **base**, and a final string of one or more unrecognized characters, including the terminating null character of the input string. **strtoll** then attempts to convert the subject sequence to an integer, and return the result.

When converting, no integer suffix (such as U, L, UL, LL, ULL) is allowed.

If the value of **base** is zero, the expected form of the subject sequence is an optional plus or minus sign followed by an integer constant.

If the value of **base** is between 2 and 36 (inclusive), the expected form of the subject sequence is an optional plus or minus sign followed by a sequence of letters and digits representing an integer with the radix specified by **base**. The letters from a (or A) through z (or Z) represent the values 10 through 35; only letters and digits whose ascribed values are less than that of **base** are permitted.

If the value of **base** is 16, the characters '0x' or '0X' may optionally precede the sequence of letters and digits, following the optional sign.

The subject sequence is defined as the longest initial subsequence of the input string, starting with the first non-white-space character, that is of the expected form. The subject sequence contains no characters if the input string is empty or consists entirely of white space, or if the first non-white-space character is other than a sign or a permissible letter or digit.

If the subject sequence has the expected form and the value of **base** is zero, the sequence of characters starting with the first digit is interpreted as an integer constant. If the subject sequence has the expected form and the value of **base** is between 2 and 36, it is used as the base for conversion.

If the subject sequence begins with a minus sign, the value resulting from the conversion is negated.

A pointer to the final string is stored in the object pointed to by **endptr**, provided that **endptr** is not a null pointer.

If the subject sequence is empty or does not have the expected form, no conversion is performed, the value of **nptr** is stored in the object pointed to by **endptr**, provided that **endptr** is not a null pointer.

strtoll returns the converted value, if any. If no conversion could be performed, zero is returned. If the correct value is outside the range of representable values, **LLONG_MIN** or **LLONG_MAX** is returned according to the sign of the value, if any, and the value of the macro **ERANGE** is stored in **errno**.

strtoul

Synopsis

```
unsigned long int strtoul(const char *nptr,
                           char **endptr,
                           int base);
```

Description

strtoul converts the initial portion of the string pointed to by **nptr** to a **long int** representation.

First, **strtoul** decomposes the input string into three parts: an initial, possibly empty, sequence of white-space characters (as specified by [isspace](#)), a subject sequence resembling an integer represented in some radix determined by the value of **base**, and a final string of one or more unrecognized characters, including the terminating null character of the input string. **strtoul** then attempts to convert the subject sequence to an integer, and return the result.

When converting, no integer suffix (such as U, L, UL, LL, ULL) is allowed.

If the value of **base** is zero, the expected form of the subject sequence is an optional plus or minus sign followed by an integer constant.

If the value of **base** is between 2 and 36 (inclusive), the expected form of the subject sequence is an optional plus or minus sign followed by a sequence of letters and digits representing an integer with the radix specified by **base**. The letters from a (or A) through z (or Z) represent the values 10 through 35; only letters and digits whose ascribed values are less than that of **base** are permitted.

If the value of **base** is 16, the characters '0x' or '0X' may optionally precede the sequence of letters and digits, following the optional sign.

The subject sequence is defined as the longest initial subsequence of the input string, starting with the first non-white-space character, that is of the expected form. The subject sequence contains no characters if the input string is empty or consists entirely of white space, or if the first non-white-space character is other than a sign or a permissible letter or digit.

If the subject sequence has the expected form and the value of **base** is zero, the sequence of characters starting with the first digit is interpreted as an integer constant. If the subject sequence has the expected form and the value of **base** is between 2 and 36, it is used as the base for conversion.

If the subject sequence begins with a minus sign, the value resulting from the conversion is negated.

A pointer to the final string is stored in the object pointed to by **endptr**, provided that **endptr** is not a null pointer.

If the subject sequence is empty or does not have the expected form, no conversion is performed, the value of **nptr** is stored in the object pointed to by **endptr**, provided that **endptr** is not a null pointer.

strtoul returns the converted value, if any. If no conversion could be performed, zero is returned. If the correct value is outside the range of representable values, **LONG_MAX** or **ULONG_MAX** is returned according to the sign of the value, if any, and the value of the macro **ERANGE** is stored in **errno**.

strtoull

Synopsis

```
unsigned long long int strtoull(const char *nptr,  
                                char **endptr,  
                                int base);
```

Description

strtoull converts the initial portion of the string pointed to by **nptr** to a **long int** representation.

First, **strtoull** decomposes the input string into three parts: an initial, possibly empty, sequence of white-space characters (as specified by [isspace](#)), a subject sequence resembling an integer represented in some radix determined by the value of **base**, and a final string of one or more unrecognized characters, including the terminating null character of the input string. **strtoull** then attempts to convert the subject sequence to an integer, and return the result.

When converting, no integer suffix (such as U, L, UL, LL, ULL) is allowed.

If the value of **base** is zero, the expected form of the subject sequence is an optional plus or minus sign followed by an integer constant.

If the value of **base** is between 2 and 36 (inclusive), the expected form of the subject sequence is an optional plus or minus sign followed by a sequence of letters and digits representing an integer with the radix specified by **base**. The letters from a (or A) through z (or Z) represent the values 10 through 35; only letters and digits whose ascribed values are less than that of **base** are permitted.

If the value of **base** is 16, the characters '0x' or '0X' may optionally precede the sequence of letters and digits, following the optional sign.

The subject sequence is defined as the longest initial subsequence of the input string, starting with the first non-white-space character, that is of the expected form. The subject sequence contains no characters if the input string is empty or consists entirely of white space, or if the first non-white-space character is other than a sign or a permissible letter or digit.

If the subject sequence has the expected form and the value of **base** is zero, the sequence of characters starting with the first digit is interpreted as an integer constant. If the subject sequence has the expected form and the value of **base** is between 2 and 36, it is used as the base for conversion.

If the subject sequence begins with a minus sign, the value resulting from the conversion is negated.

A pointer to the final string is stored in the object pointed to by **endptr**, provided that **endptr** is not a null pointer.

If the subject sequence is empty or does not have the expected form, no conversion is performed, the value of **nptr** is stored in the object pointed to by **endptr**, provided that **endptr** is not a null pointer.

strtoull returns the converted value, if any. If no conversion could be performed, zero is returned. If the correct value is outside the range of representable values, [LLONG_MAX](#) or [ULLONG_MAX](#) is returned according to the sign of the value, if any, and the value of the macro [ERANGE](#) is stored in [errno](#).

ulltoa

Synopsis

```
char *ulltoa(unsigned long long val,  
            char *buf,  
            int radix);
```

Description

ulltoa converts **val** to a string in base **radix** and places the result in **buf**.

ulltoa returns **buf** as the result.

If **radix** is greater than 36, the result is undefined.

See Also

[itoa](#), [ltoa](#), [lltoa](#), [ultoa](#), [utoa](#)

ultoa

Synopsis

```
char *ultoa(unsigned long val,  
            char *buf,  
            int radix);
```

Description

ultoa converts **val** to a string in base **radix** and places the result in **buf**.

ultoa returns **buf** as the result.

If **radix** is greater than 36, the result is undefined.

See Also

[itoa](#), [ltoa](#), [lltoa](#), [ulltoa](#), [utoa](#)

utoa

Synopsis

```
char *utoa(unsigned val,  
          char *buf,  
          int radix);
```

Description

utoa converts **val** to a string in base **radix** and places the result in **buf**.

utoa returns **buf** as the result.

If **radix** is greater than 36, the result is undefined.

See Also

[itoa](#), [ltoa](#), [lltoa](#), [ultoa](#), [ulltoa](#)

<string.h>

Overview

The header file <string.h> defines functions that operate on arrays that are interpreted as null-terminated strings.

Various methods are used for determining the lengths of the arrays, but in all cases a **char *** or **void *** argument points to the initial (lowest addressed) character of the array. If an array is accessed beyond the end of an object, the behavior is undefined.

Where an argument declared as **size_t n** specifies the length of an array for a function, *n* can have the value zero on a call to that function. Unless explicitly stated otherwise in the description of a particular function, pointer arguments must have valid values on a call with a zero size. On such a call, a function that locates a character finds no occurrence, a function that compares two character sequences returns zero, and a function that copies characters copies zero characters.

API Summary

Copying functions	
memccpy	Copy memory with specified terminator (POSIX extension)
memcpy	Copy memory
memcpy_fast	Copy memory
memmove	Safely copy overlapping memory
mempcpy	Copy memory (GNU extension)
strcat	Concatenate strings
strcpy	Copy string
 strdup	Duplicate string (POSIX extension)
strlcat	Copy string up to a maximum length with terminator (BSD extension)
strlcpy	Copy string up to a maximum length with terminator (BSD extension)
strncat	Concatenate strings up to maximum length
strncpy	Copy string up to a maximum length
strndup	Duplicate string (POSIX extension)
Comparison functions	
memcmp	Compare memory
strcasecmp	Compare strings ignoring case (POSIX extension)

strcmp	Compare strings
strncasecmp	Compare strings up to a maximum length ignoring case (POSIX extension)
strncmp	Compare strings up to a maximum length
Search functions	
memchr	Search memory for a character
strcasestr	Find first case-insensitive occurrence of a string within string
strchr	Find character within string
strcspn	Compute size of string not prefixed by a set of characters
strncasestr	Find first case-insensitive occurrence of a string within length-limited string
strnchr	Find character in a length-limited string
strnlen	Calculate length of length-limited string (POSIX extension)
strnstr	Find first occurrence of a string within length-limited string
strpbrk	Find first occurrence of characters within string
strrchr	Find last occurrence of character within string
strsep	Break string into tokens (4.4BSD extension)
strspn	Compute size of string prefixed by a set of characters
strstr	Find first occurrence of a string within string
strtok	Break string into tokens
strtok_r	Break string into tokens, reentrant version (POSIX extension)
Miscellaneous functions	
memset	Set memory to character
strerror	Decode error code
strlen	Calculate length of string

memccpy

Synopsis

```
void *memccpy(void *s1,
              const void *s2,
              int c,
              size_t n);
```

Description

memccpy copies at most **n** characters from the object pointed to by **s2** into the object pointed to by **s1**. The copying stops as soon as **n** characters are copied or the character **c** is copied into the destination object pointed to by **s1**. The behavior of **memccpy** is undefined if copying takes place between objects that overlap.

memccpy returns a pointer to the character immediately following **c** in **s1**, or **NULL** if **c** was not found in the first **n** characters of **s2**.

Note

memccpy conforms to POSIX.1-2008.

memchr

Synopsis

```
void *memchr(const void *s,  
             int c,  
             size_t n);
```

Description

memchr locates the first occurrence of **c** (converted to an **unsigned char**) in the initial **n** characters (each interpreted as **unsigned char**) of the object pointed to by **s**. Unlike **strchr**, **memchr** does *not* terminate a search when a null character is found in the object pointed to by **s**.

memchr returns a pointer to the located character, or a null pointer if **c** does not occur in the object.

memcmp

Synopsis

```
int memcmp(const void *s1,  
          const void *s2,  
          size_t n);
```

Description

memcmp compares the first **n** characters of the object pointed to by **s1** to the first **n** characters of the object pointed to by **s2**. **memcmp** returns an integer greater than, equal to, or less than zero as the object pointed to by **s1** is greater than, equal to, or less than the object pointed to by **s2**.

memcpy

Synopsis

```
void *memcpy(void *s1,  
            const void *s2,  
            size_t n);
```

Description

memcpy copies **n** characters from the object pointed to by **s2** into the object pointed to by **s1**. The behavior of **memcpy** is undefined if copying takes place between objects that overlap.

memcpy returns the value of **s1**.

memcpy_fast

Synopsis

```
void *memcpy_fast(void *s1,  
                  const void *s2,  
                  size_t n);
```

Description

memcpy_fast copies **n** characters from the object pointed to by **s2** into the object pointed to by **s1**. The behavior of **memcpy_fast** is undefined if copying takes place between objects that overlap. The implementation of **memcpy_fast** is optimized for speed for all cases of **memcpy** and as such has a large code memory requirement. This function is implemented for little-endian ARM and 32-bit Thumb-2 instruction sets only.

memcpy_fast returns the value of **s1**.

memmove

Synopsis

```
void *memmove(void *s1,  
             const void *s2,  
             size_t n);
```

Description

memmove copies **n** characters from the object pointed to by **s2** into the object pointed to by **s1** ensuring that if **s1** and **s2** overlap, the copy works correctly. Copying takes place as if the **n** characters from the object pointed to by **s2** are first copied into a temporary array of **n** characters that does not overlap the objects pointed to by **s1** and **s2**, and then the **n** characters from the temporary array are copied into the object pointed to by **s1**.

memmove returns the value of **s1**.

mempcpy

Synopsis

```
void *mempcpy(void *s1,  
              const void *s2,  
              size_t n);
```

Description

mempcpy copies **n** characters from the object pointed to by **s2** into the object pointed to by **s1**. The behavior of **mempcpy** is undefined if copying takes place between objects that overlap.

mempcpy returns a pointer to the byte following the last written byte.

Note

This is an extension found in GNU libc.

memset

Synopsis

```
void *memset(void *s,  
            int c,  
            size_t n);
```

Description

memset copies the value of **c** (converted to an **unsigned char**) into each of the first **n** characters of the object pointed to by **s**.

memset returns the value of **s**.

strcasecmp

Synopsis

```
int strcasecmp(const char *s1,  
              const char *s2);
```

Description

strcasecmp compares the string pointed to by **s1** to the string pointed to by **s2** ignoring differences in case. **strcasecmp** returns an integer greater than, equal to, or less than zero if the string pointed to by **s1** is greater than, equal to, or less than the string pointed to by **s2**.

Note

strcasecmp conforms to POSIX.1-2008.

strcasestr

Synopsis

```
char *strcasestr(const char *s1,  
                  const char *s2);
```

Description

strcasestr locates the first occurrence in the string pointed to by **s1** of the sequence of characters (excluding the terminating null character) in the string pointed to by **s2** without regard to character case.

strcasestr returns a pointer to the located string, or a null pointer if the string is not found. If **s2** points to a string with zero length, **strcasestr** returns **s1**.

Note

strcasestr is an extension commonly found in Linux and BSD C libraries.

strcat

Synopsis

```
char *strcat(char *s1,  
            const char *s2);
```

Description

strcat appends a copy of the string pointed to by **s2** (including the terminating null character) to the end of the string pointed to by **s1**. The initial character of **s2** overwrites the null character at the end of **s1**. The behavior of **strcat** is undefined if copying takes place between objects that overlap.

strcat returns the value of **s1**.

strchr

Synopsis

```
char *strchr(const char *s,  
             int c);
```

Description

strchr locates the first occurrence of **c** (converted to a **char**) in the string pointed to by **s**. The terminating null character is considered to be part of the string.

strchr returns a pointer to the located character, or a null pointer if **c** does not occur in the string.

strcmp

Synopsis

```
int strcmp(const char *s1,  
          const char *s2);
```

Description

strcmp compares the string pointed to by **s1** to the string pointed to by **s2**. **strcmp** returns an integer greater than, equal to, or less than zero if the string pointed to by **s1** is greater than, equal to, or less than the string pointed to by **s2**.

strcpy

Synopsis

```
char *strcpy(char *s1,  
           const char *s2);
```

Description

strcpy copies the string pointed to by **s2** (including the terminating null character) into the array pointed to by **s1**. The behavior of **strcpy** is undefined if copying takes place between objects that overlap.

strcpy returns the value of **s1**.

strcspn

Synopsis

```
size_t strcspn(const char *s1,  
                const char *s2);
```

Description

strcspn computes the length of the maximum initial segment of the string pointed to by **s1** which consists entirely of characters not from the string pointed to by **s2**.

strcspn returns the length of the segment.

strup

Synopsis

```
char *strup(const char *s1);
```

Description

strup duplicates the string pointed to by **s1** by using **malloc** to allocate memory for a copy of **s** and then copying **s**, including the terminating null, to that memory. **strup** returns a pointer to the new string or a null pointer if the new string cannot be created. The returned pointer can be passed to **free**.

Note

strup conforms to POSIX.1-2008 and SC22 TR 24731-2.

strerror

Synopsis

```
char *strerror(int num);
```

Description

strerror maps the number in **num** to a message string. Typically, the values for **num** come from **errno**, but **strerror** can map any value of type **int** to a message.

strerror returns a pointer to the message string. The program must not modify the returned message string. The message may be overwritten by a subsequent call to **strerror**.

strlcat

Synopsis

```
size_t strlcat(char *s1,  
               const char *s2,  
               size_t n);
```

Description

strlcat appends no more than **n**–**strlen(dst)**–1 characters pointed to by **s2** into the array pointed to by **s1** and always terminates the result with a null character if **n** is greater than zero. Both the strings **s1** and **s2** must be terminated with a null character on entry to **strlcat** and a byte for the terminating null should be included in **n**. The behavior of **strlcat** is undefined if copying takes place between objects that overlap.

strlcat returns the number of characters it tried to copy, which is the sum of the lengths of the strings **s1** and **s2** or **n**, whichever is smaller.

Note

strlcat is commonly found in OpenBSD libraries.

strlcpy

Synopsis

```
size_t strlcpy(char *s1,  
               const char *s2,  
               size_t n);
```

Description

strlcpy copies up to **n**–1 characters from the string pointed to by **s2** into the array pointed to by **s1** and always terminates the result with a null character. The behavior of **strlcpy** is undefined if copying takes place between objects that overlap.

strlcpy returns the number of characters it tried to copy, which is the length of the string **s2** or **n**, whichever is smaller.

Note

strlcpy is commonly found in OpenBSD libraries and contrasts with **strncpy** in that the resulting string is always terminated with a null character.

strlen

Synopsis

```
size_t strlen(const char *s);
```

Description

strlen returns the length of the string pointed to by **s**, that is the number of characters that precede the terminating null character.

strncasecmp

Synopsis

```
int strncasecmp(const char *s1,  
                 const char *s2,  
                 size_t n);
```

Description

strncasecmp compares not more than **n** characters from the array pointed to by **s1** to the array pointed to by **s2** ignoring differences in case. Characters that follow a null character are not compared.

strncasecmp returns an integer greater than, equal to, or less than zero, if the possibly null-terminated array pointed to by **s1** is greater than, equal to, or less than the possibly null-terminated array pointed to by **s2**.

Note

strncasecmp conforms to POSIX.1-2008.

strncasestr

Synopsis

```
char *strncasestr(const char *s1,  
                  const char *s2,  
                  size_t n);
```

Description

strncasestr searches at most **n** characters to locate the first occurrence in the string pointed to by **s1** of the sequence of characters (excluding the terminating null character) in the string pointed to by **s2** without regard to character case.

strncasestr returns a pointer to the located string, or a null pointer if the string is not found. If **s2** points to a string with zero length, **strncasestr** returns **s1**.

Note

strncasestr is an extension commonly found in Linux and BSD C libraries.

strncat

Synopsis

```
char *strncat(char *s1,  
              const char *s2,  
              size_t n);
```

Description

strncat appends not more than **n** characters from the array pointed to by **s2** to the end of the string pointed to by **s1**. A null character in **s1** and characters that follow it are not appended. The initial character of **s2** overwrites the null character at the end of **s1**. A terminating null character is always appended to the result. The behavior of **strncat** is undefined if copying takes place between objects that overlap.

strncat returns the value of **s1**.

strnchr

Synopsis

```
char *strnchr(const char *str,  
              size_t n,  
              int ch);
```

Description

strnchr searches not more than **n** characters to locate the first occurrence of **c** (converted to a **char**) in the string pointed to by **s**. The terminating null character is considered to be part of the string.

strnchr returns a pointer to the located character, or a null pointer if **c** does not occur in the string.

strcmp

Synopsis

```
int strcmp(const char *s1,  
          const char *s2,  
          size_t n);
```

Description

strcmp compares not more than **n** characters from the array pointed to by **s1** to the array pointed to by **s2**. Characters that follow a null character are not compared.

strcmp returns an integer greater than, equal to, or less than zero, if the possibly null-terminated array pointed to by **s1** is greater than, equal to, or less than the possibly null-terminated array pointed to by **s2**.

strncpy

Synopsis

```
char *strncpy(char *s1,  
             const char *s2,  
             size_t n);
```

Description

strncpy copies not more than **n** characters from the array pointed to by **s2** to the array pointed to by **s1**. Characters that follow a null character in **s2** are not copied. The behavior of **strncpy** is undefined if copying takes place between objects that overlap. If the array pointed to by **s2** is a string that is shorter than **n** characters, null characters are appended to the copy in the array pointed to by **s1**, until **n** characters in all have been written.

strncpy returns the value of **s1**.

Note

No null character is implicitly appended to the end of **s1**, so **s1** will only be terminated by a null character if the length of the string pointed to by **s2** is less than **n**.

strndup

Synopsis

```
char *strndup(const char *s1,  
              size_t n);
```

Description

strndup duplicates at most **n** characters from the string pointed to by **s1** by using **malloc** to allocate memory for a copy of **s1**.

If the length of string pointed to by **s1** is greater than **n** characters, only **n** characters will be duplicated. If **n** is greater than the length of string pointed to by **s1**, all characters in the string are copied into the allocated array including the terminating null character.

strndup returns a pointer to the new string or a null pointer if the new string cannot be created. The returned pointer can be passed to **free**.

Note

strndup conforms to POSIX.1-2008 and SC22 TR 24731-2.

strnlen

Synopsis

```
size_t strnlen(const char *s,  
               size_t n);
```

Description

strnlen returns the length of the string pointed to by **s**, up to a maximum of **n** characters. **strnlen** only examines the first **n** characters of the string **s**.

Note

strnlen conforms to POSIX.1-2008.

strnstr

Synopsis

```
char *strnstr(const char *s1,  
              const char *s2,  
              size_t n);
```

Description

strnstr searches at most **n** characters to locate the first occurrence in the string pointed to by **s1** of the sequence of characters (excluding the terminating null character) in the string pointed to by **s2**.

strnstr returns a pointer to the located string, or a null pointer if the string is not found. If **s2** points to a string with zero length, **strnstr** returns **s1**.

Note

strnstr is an extension commonly found in Linux and BSD C libraries.

strpbrk

Synopsis

```
char *strpbrk(const char *s1,  
              const char *s2);
```

Description

strpbrk locates the first occurrence in the string pointed to by **s1** of any character from the string pointed to by **s2**.

strpbrk returns a pointer to the character, or a null pointer if no character from **s2** occurs in **s1**.

strrchr

Synopsis

```
char *strrchr(const char *s,  
              int c);
```

Description

strrchr locates the last occurrence of **c** (converted to a **char**) in the string pointed to by **s**. The terminating null character is considered to be part of the string.

strrchr returns a pointer to the character, or a null pointer if **c** does not occur in the string.

strsep

Synopsis

```
char *strsep(char **stringp,  
             const char *delim);
```

Description

strsep locates, in the string referenced by ***stringp**, the first occurrence of any character in the string **delim** (or the terminating null character) and replaces it with a null character. The location of the next character after the delimiter character (or NULL, if the end of the string was reached) is stored in ***stringp**. The original value of ***stringp** is returned.

An empty field (that is, a character in the string **delim** occurs as the first character of ***stringp**) can be detected by comparing the location referenced by the returned pointer to the null character.

If ***stringp** is initially null, **strsep** returns null.

Note

strsep is an extension commonly found in Linux and BSD C libraries.

strspn

Synopsis

```
size_t strspn(const char *s1,  
              const char *s2);
```

Description

strspn computes the length of the maximum initial segment of the string pointed to by **s1** which consists entirely of characters from the string pointed to by **s2**.

strspn returns the length of the segment.

strstr

Synopsis

```
char *strstr(const char *s1,  
            const char *s2);
```

Description

strstr locates the first occurrence in the string pointed to by **s1** of the sequence of characters (excluding the terminating null character) in the string pointed to by **s2**.

strstr returns a pointer to the located string, or a null pointer if the string is not found. If **s2** points to a string with zero length, **strstr** returns **s1**.

strtok

Synopsis

```
char *strtok(char *s1,  
            const char *s2);
```

Description

strtok A sequence of calls to **strtok** breaks the string pointed to by **s1** into a sequence of tokens, each of which is delimited by a character from the string pointed to by **s2**. The first call in the sequence has a non-null first argument; subsequent calls in the sequence have a null first argument. The separator string pointed to by **s2** may be different from call to call.

The first call in the sequence searches the string pointed to by **s1** for the first character that is not contained in the current separator string pointed to by **s2**. If no such character is found, then there are no tokens in the string pointed to by **s1** and **strtok** returns a null pointer. If such a character is found, it is the start of the first token.

strtok then searches from there for a character that is contained in the current separator string. If no such character is found, the current token extends to the end of the string pointed to by **s1**, and subsequent searches for a token will return a null pointer. If such a character is found, it is overwritten by a null character, which terminates the current token. **strtok** saves a pointer to the following character, from which the next search for a token will start.

Each subsequent call, with a null pointer as the value of the first argument, starts searching from the saved pointer and behaves as described above.

Note

strtok maintains static state and is therefore not reentrant and not thread safe. See [strtok_r](#) for a thread-safe and reentrant variant.

See Also

[strsep](#), [strtok_r](#).

strtok_r

Synopsis

```
char *strtok_r(char *s1,
               const char *s2,
               char **s3);
```

Description

strtok_r is a reentrant version of the function **strtok** where the state is maintained in the object of type **char *** pointed to by **s3**.

Note

strtok_r conforms to POSIX.1-2008 and is commonly found in Linux and BSD C libraries.

See Also

[strtok](#).

<time.h>

API Summary

Types	
clock_t	Clock type
time_t	Time type
tm	Time structure
Functions	
asctime	Convert a struct tm to a string
asctime_r	Convert a struct tm to a string
ctime	Convert a time_t to a string
ctime_r	Convert a time_t to a string
difftime	Calculates the difference between two times
gmtime	Convert a time_t to a struct tm
gmtime_r	Convert a time_t to a struct tm
localtime	Convert a time_t to a struct tm
localtime_r	Convert a time_t to a struct tm
mktime	Convert a struct tm to time_t
strftime	Format a struct tm to a string

asctime

Synopsis

```
char *asctime(const tm *tp);
```

Description

asctime converts the ***tp** struct to a null terminated string of the form Sun Sep 16 01:03:52 1973. The returned string is held in a static buffer. **asctime** is not re-entrant.

asctime_r

Synopsis

```
char *asctime_r(const tm *tp,  
                 char *buf);
```

Description

asctime_r converts the ***tp** struct to a null terminated string of the form Sun Sep 16 01:03:52 1973 in **buf** and returns **buf**. The **buf** must point to an array at least 26 bytes in length.

clock_t

Synopsis

```
typedef long clock_t;
```

Description

clock_t is the type returned by the **clock** function.

ctime

Synopsis

```
char *ctime(const time_t *tp);
```

Description

ctime converts the ***tp** to a null terminated string. The returned string is held in a static buffer, this function is not re-entrant.

ctime_r

Synopsis

```
char *ctime_r(const time_t *tp,  
             char *buf);
```

Description

ctime_r converts the ***tp** to a null terminated string in **buf** and returns **buf**. The **buf** must point to an array at least 26 bytes in length.

difftime

Synopsis

```
double difftime(time_t time2,
                 time_t time1);
```

Description

difftime returns **time1 - time0** as a double precision number.

gmtime

Synopsis

```
gmtime(const time_t *tp);
```

Description

gmtime converts the ***tp** time format to a **struct tm** time format. The returned value points to a static object - this function is not re-entrant.

gmtime_r

Synopsis

```
gmtime_r(const time_t *tp,  
         tm *result);
```

Description

gmtime_r converts the ***tp** time format to a **struct tm** time format in ***result** and returns **result**.

localtime

Synopsis

```
localtime(const time_t *tp);
```

Description

localtime converts the ***tp** time format to a **struct tm** local time format. The returned value points to a static object - this function is not re-entrant.

localtime_r

Synopsis

```
localtime_r(const time_t *tp,  
           tm *result);
```

Description

localtime_r converts the ***tp** time format to a **struct tm** local time format in ***result** and returns **result**.

mktme

Synopsis

```
time_t mktme(tm *tp);
```

Description

mktme validates (and updates) the ***tp** struct to ensure that the **tm_sec**, **tm_min**, **tm_hour**, **tm_mon** fields are within the supported integer ranges and the **tm_mday**, **tm_mon** and **tm_year** fields are consistent. The validated ***tp** struct is converted to the number of seconds since UTC 1 January 1970 and returned.

strftime

Synopsis

```
size_t strftime(char *s,
               size_t smax,
               const char *fmt,
               const tm *tp);
```

Description

strftime formats the ***tp** struct to a null terminated string of maximum size **smax**-1 into the array at ***s** based on the **fmt** format string. The format string consists of conversion specifications and ordinary characters. Conversion specifications start with a % character followed by an optional # character. The following conversion specifications are supported:

Specification	Description
%s	Abbreviated weekday name
%A	Full weekday name
%b	Abbreviated month name
%B	Full month name
%c	Date and time representation appropriate for locale
%#c	Date and time formatted as "%A, %B %#d, %Y, %H:%M: %S" (Microsoft extension)
%C	Century number
%d	Day of month as a decimal number [01,31]
%#d	Day of month without leading zero [1,31]
%D	Date in the form %m/%d/%y (POSIX.1-2008 extension)
%e	Day of month [1,31], single digit preceded by space
%F	Date in the format %Y-%m-%d
%h	Abbreviated month name as %b
%H	Hour in 24-hour format [00,23]
%#H	Hour in 24-hour format without leading zeros [0,23]
%l	Hour in 12-hour format [01,12]
%#l	Hour in 12-hour format without leading zeros [1,12]
%j	Day of year as a decimal number [001,366]
%#j	Day of year as a decimal number without leading zeros [1,366]
%k	Hour in 24-hour clock format [0,23] (POSIX.1-2008 extension)

%l	Hour in 12-hour clock format [0,12] (POSIX.1-2008 extension)
%m	Month as a decimal number [01,12]
%#m	Month as a decimal number without leading zeros [1,12]
%M	Minute as a decimal number [00,59]
%#M	Minute as a decimal number without leading zeros [0,59]
%n	Insert newline character (POSIX.1-2008 extension)
%p	Locale's a.m or p.m indicator for 12-hour clock
%r	Time as %l:%M:%s %p (POSIX.1-2008 extension)
%R	Time as %H:%M (POSIX.1-2008 extension)
%S	Second as a decimal number [00,59]
%t	Insert tab character (POSIX.1-2008 extension)
%T	Time as %H:%M:%S
%#S	Second as a decimal number without leading zeros [0,59]
%U	Week of year as a decimal number [00,53], Sunday is first day of the week
%#U	Week of year as a decimal number without leading zeros [0,53], Sunday is first day of the week
%w	Weekday as a decimal number [0,6], Sunday is 0
%W	Week number as a decimal number [00,53], Monday is first day of the week
%#W	Week number as a decimal number without leading zeros [0,53], Monday is first day of the week
%x	Locale's date representation
%#x	Locale's long date representation
%X	Locale's time representation
%y	Year without century, as a decimal number [00,99]
%#y	Year without century, as a decimal number without leading zeros [0,99]
%Y	Year with century, as decimal number
%z,%Z	Timezone name or abbreviation
%%	%

time_t

Synopsis

```
typedef long time_t;
```

Description

time_t is a long type that represents the time in number of seconds since UTC 1 January 1970, negative values indicate time before UTC 1 January 1970.

tm

Synopsis

```
typedef struct {
    int tm_sec;
    int tm_min;
    int tm_hour;
    int tm_mday;
    int tm_mon;
    int tm_year;
    int tm_wday;
    int tm_yday;
    int tm_isdst;
} tm;
```

Description

tm structure has the following fields.

Member	Description
tm_sec	seconds after the minute - [0,59]
tm_min	minutes after the hour - [0,59]
tm_hour	hours since midnight - [0,23]
tm_mday	day of the month - [1,31]
tm_mon	months since January - [0,11]
tm_year	years since 1900
tm_wday	days since Sunday - [0,6]
tm_yday	days since January 1 - [0,365]
tm_isdst	daylight savings time flag

<wchar.h>

API Summary

Character minimum and maximum values	
WCHAR_MAX	Maximum value of a wide character
WCHAR_MIN	Minimum value of a wide character
Constants	
WEOF	End of file indication
Types	
wchar_t	Wide character type
wint_t	Wide integer type
Copying functions	
wcscat	Concatenate strings
wcscopy	Copy string
wcsncat	Concatenate strings up to maximum length
wcsncpy	Copy string up to a maximum length
wmemccpy	Copy memory with specified terminator (POSIX extension)
wmemcpy	Copy memory
wmemmove	Safely copy overlapping memory
wmempcpy	Copy memory (GNU extension)
Comparison functions	
wcscmp	Compare strings
wcsncmp	Compare strings up to a maximum length
wmemcmp	Compare memory
Search functions	
wcschr	Find character within string
wcscspn	Compute size of string not prefixed by a set of characters
wcsnchr	Find character in a length-limited string
wcsnlen	Calculate length of length-limited string
wcsnstr	Find first occurrence of a string within length-limited string
wcspbrk	Find first occurrence of characters within string
wcsrchr	Find last occurrence of character within string

wcsspn	Compute size of string prefixed by a set of characters
wcsstr	Find first occurrence of a string within string
wcstok	Break string into tokens
wcstok_r	Break string into tokens (reentrant version)
wmemchr	Search memory for a wide character
wstrsep	Break string into tokens
Miscellaneous functions	
wcsdup	Duplicate string
wcslen	Calculate length of string
wmemset	Set memory to wide character
Multi-byte/wide string conversion functions	
mbrtowc	Convert multi-byte character to wide character
mbrtowc_l	Convert multi-byte character to wide character
msbinit	Query conversion state
wcrtomb	Convert wide character to multi-byte character (restartable)
wcrtomb_l	Convert wide character to multi-byte character (restartable)
wctob	Convert wide character to single-byte character
wctob_l	Convert wide character to single-byte character
Multi-byte to wide character conversions	
mbrlen	Determine number of bytes in a multi-byte character
mbrlen_l	Determine number of bytes in a multi-byte character
mbsrtowcs	Convert multi-byte string to wide character string
mbsrtowcs_l	Convert multi-byte string to wide character string
Single-byte to wide character conversions	
btowc	Convert single-byte character to wide character
btowc_l	Convert single-byte character to wide character

WCHAR_MAX

Synopsis

```
#define WCHAR_MAX ...
```

Description

WCHAR_MAX is the maximum value for an object of type **wchar_t**. Although capable of storing larger values, the maximum value implemented by the conversion functions in the library is the value 0x10FFFF defined by ISO 10646.

WCHAR_MIN

Synopsis

```
#define WCHAR_MIN ...
```

Description

WCHAR_MIN is the minimum value for an object of type **wchar_t**.

WEOF

Synopsis

```
#define WEOF ((wint_t)~0U)
```

Description

WEOF expands to a constant value that does not correspond to any character in the wide character set. It is typically used to indicate an end of file condition.

btowc

Synopsis

```
wint_t btowc(int c);
```

Description

btowc function determines whether **c** constitutes a valid single-byte character. If **c** is a valid single-byte character, **btowc** returns the wide character representation of that character.

btowc returns WEOF if **c** has the value EOF or if (**unsigned char**)**c** does not constitute a valid single-byte character in the initial shift state.

btowc_l

Synopsis

```
wint_t btowc_l(int c,  
                locale_t loc);
```

Description

btowc_l function determines whether **c** constitutes a valid single-byte character in the locale **loc**. If **c** is a valid single-byte character, **btowc_l** returns the wide character representation of that character.

btowc_l returns WEOF if **c** has the value EOF or if (unsigned char)**c** does not constitute a valid single-byte character in the initial shift state.

mbrlen

Synopsis

```
size_t mbrlen(const char *s,  
              size_t n,  
              mbstate_t *ps);
```

Note

mbrlen function is equivalent to the call:

```
mbrtowc(NULL, s, n, ps != NULL ? ps : &internal);
```

where **internal** is the **mbstate_t** object for the **mbrlen** function, except that the expression designated by **ps** is evaluated only once.

mbrlen_l

Synopsis

```
size_t mbrlen_l(const char *s,
                  size_t n,
                  mbstate_t *ps,
                  locale_t loc);
```

Note

mbrlen_l function is equivalent to the call:

```
mbrtowc_l(NULL, s, n, ps != NULL ? ps : &internal, loc);
```

where **internal** is the **mbstate_t** object for the **mbrlen** function, except that the expression designated by **ps** is evaluated only once.

mbrtowc

Synopsis

```
size_t mbrtowc(wchar_t *pwc,
                 const char *s,
                 size_t n,
                 mbstate_t *ps);
```

Description

mbrtowc converts a single multi-byte character to a wide character in the current locale.

If **s** is a null pointer, **mbrtowc** is equivalent to `mbrtowc(NULL, "", 1, ps)`, ignoring **pwc** and **n**.

If **s** is not null and the object that **s** points to is a wide-character null character, **mbrtowc** returns 0.

If **s** is not null and the object that points to forms a valid multi-byte character with at most **n** bytes, **mbrtowc** returns the length in bytes of the multi-byte character and stores that wide character to the object pointed to by **pwc** (if **pwc** is not null).

If the object that points to forms an incomplete, but possibly valid, multi-byte character, **mbrtowc** returns -2. If the object that points to does not form a partial multi-byte character, **mbrtowc** returns -1.

See Also

[mbtowc](#), [mbrtowc_l](#)

mbrtowc_l

Synopsis

```
size_t mbrtowc_l(wchar_t *pwc,
                  const char *s,
                  size_t n,
                  mbstate_t *ps,
                  locale_t loc);
```

Description

mbrtowc_l converts a single multi-byte character to a wide character in the locale **loc**.

If **s** is a null pointer, **mbrtowc_l** is equivalent to `mbrtowc(NULL, "", 1, ps)`, ignoring **pwc** and **n**.

If **s** is not null and the object that **s** points to is a wide-character null character, **mbrtowc_l** returns 0.

If **s** is not null and the object that points to forms a valid multi-byte character with at most **n** bytes, **mbrtowc_l** returns the length in bytes of the multi-byte character and stores that wide character to the object pointed to by **pwc** (if **pwc** is not null).

If the object that points to forms an incomplete, but possibly valid, multi-byte character, **mbrtowc_l** returns -2.

If the object that points to does not form a partial multi-byte character, **mbrtowc_l** returns -1.

See Also

[mbrtowc](#), [mbtowc_l](#)

mbsrtowcs

Synopsis

```
size_t mbsrtowcs(wchar_t *dst,
                  const char **src,
                  size_t len,
                  mbstate_t *ps);
```

Description

mbsrtowcs converts a sequence of multi-byte characters that begins in the conversion state described by the object pointed to by **ps**, from the array indirectly pointed to by **src** into a sequence of corresponding wide characters. If **dst** is not a null pointer, the converted characters are stored into the array pointed to by **dst**. Conversion continues up to and including a terminating null character, which is also stored.

Conversion stops earlier in two cases: when a sequence of bytes is encountered that does not form a valid multi-byte character, or (if **dst** is not a null pointer) when **len** wide characters have been stored into the array pointed to by **dst**. Each conversion takes place as if by a call to the **mbtowc** function.

If **dst** is not a null pointer, the pointer object pointed to by **src** is assigned either a null pointer (if conversion stopped due to reaching a terminating null character) or the address just past the last multi-byte character converted (if any). If conversion stopped due to reaching a terminating null character and if **dst** is not a null pointer, the resulting state described is the initial conversion state.

See Also

[mbsrtowcs_l](#), [mbtowc](#)

mbsrtowcs_l

Synopsis

```
size_t mbsrtowcs_l(wchar_t *dst,
                     const char **src,
                     size_t len,
                     mbstate_t *ps,
                     locale_t loc);
```

Description

mbsrtowcs_l converts a sequence of multi-byte characters that begins in the conversion state described by the object pointed to by **ps**, from the array indirectly pointed to by **src** into a sequence of corresponding wide characters. If **dst** is not a null pointer, the converted characters are stored into the array pointed to by **dst**. Conversion continues up to and including a terminating null character, which is also stored.

Conversion stops earlier in two cases: when a sequence of bytes is encountered that does not form a valid multi-byte character, or (if **dst** is not a null pointer) when **len** wide characters have been stored into the array pointed to by **dst**. Each conversion takes place as if by a call to the **mbtowc** function.

If **dst** is not a null pointer, the pointer object pointed to by **src** is assigned either a null pointer (if conversion stopped due to reaching a terminating null character) or the address just past the last multi-byte character converted (if any). If conversion stopped due to reaching a terminating null character and if **dst** is not a null pointer, the resulting state described is the initial conversion state.

See Also

[mbsrtowcs_l](#), [mbtowc](#)

msbinit

Synopsis

```
int msbinit(const mbstate_t *ps);
```

Description

msbinit function returns nonzero if **ps** is a null pointer or if the pointed-to object describes an initial conversion state; otherwise, **msbinit** returns zero.

wchar_t

Synopsis

```
typedef __RAL_WCHAR_T wchar_t;
```

Description

wchar_t holds a single wide character.

Depending on implementation you can control whether **wchar_t** is represented by a short 16-bit type or the standard 32-bit type.

wcrtomb

Synopsis

```
size_t wcrtomb(char *s,
                wchar_t wc,
                mbstate_t *ps);
```

If **s** is a null pointer, **wcrtomb** function is equivalent to the call **wcrtomb(buf, L'\0', ps)** where **buf** is an internal buffer.

If **s** is not a null pointer, **wcrtomb** determines the number of bytes needed to represent the multibyte character that corresponds to the wide character given by **wc**, and stores the multibyte character representation in the array whose first element is pointed to by **s**. At most **MB_CUR_MAX** bytes are stored. If **wc** is a null wide character, a null byte is stored; the resulting state described is the initial conversion state.

wcrtomb returns the number of bytes stored in the array object. When **wc** is not a valid wide character, an encoding error occurs: **wcrtomb** stores the value of the macro **EILSEQ** in **errno** and returns **(size_t)(-1)**; the conversion state is unspecified.

wcrtomb_l

Synopsis

```
size_t wcrtomb_l(char *s,
                  wchar_t wc,
                  mbstate_t *ps,
                  locale_t loc);
```

If **s** is a null pointer, **wcrtomb_l** function is equivalent to the call **wcrtomb_l(buf, L'\0', ps, loc)** where **buf** is an internal buffer.

If **s** is not a null pointer, **wcrtomb_l** determines the number of bytes needed to represent the multibyte character that corresponds to the wide character given by **wc**, and stores the multibyte character representation in the array whose first element is pointed to by **s**. At most **MB_CUR_MAX** bytes are stored. If **wc** is a null wide character, a null byte is stored; the resulting state described is the initial conversion state.

wcrtomb_l returns the number of bytes stored in the array object. When **wc** is not a valid wide character, an encoding error occurs: **wcrtomb_l** stores the value of the macro **EILSEQ** in **errno** and returns (**size_t**)(-1); the conversion state is unspecified.

wcscat

Synopsis

```
wchar_t *wcscat(wchar_t *s1,  
                 const wchar_t *s2);
```

Description

wcscat appends a copy of the wide string pointed to by **s2** (including the terminating null wide character) to the end of the wide string pointed to by **s1**. The initial character of **s2** overwrites the null wide character at the end of **s1**. The behavior of **wcscat** is undefined if copying takes place between objects that overlap.

wcscat returns the value of **s1**.

wcschr

Synopsis

```
wchar_t *wcschr(const wchar_t *s,  
                 wchar_t c);
```

Description

wcschr locates the first occurrence of **c** in the wide string pointed to by **s**. The terminating wide null character is considered to be part of the string.

wcschr returns a pointer to the located wide character, or a null pointer if **c** does not occur in the string.

WCSCMP

Synopsis

```
int wcscmp(const wchar_t *s1,  
           const wchar_t *s2);
```

Description

wcscmp compares the wide string pointed to by **s1** to the wide string pointed to by **s2**. **wcscmp** returns an integer greater than, equal to, or less than zero if the wide string pointed to by **s1** is greater than, equal to, or less than the wide string pointed to by **s2**.

WCSCPY

Synopsis

```
wchar_t *wcscpy(wchar_t *s1,  
                 const wchar_t *s2);
```

Description

wcscpy copies the wide string pointed to by **s2** (including the terminating null wide character) into the array pointed to by **s1**. The behavior of **wcscpy** is undefined if copying takes place between objects that overlap.

wcscpy returns the value of **s1**.

WCSCSPN

Synopsis

```
size_t wcscspn(const wchar_t *s1,  
                const wchar_t *s2);
```

Description

wcscspn computes the length of the maximum initial segment of the wide string pointed to by **s1** which consists entirely of wide characters not from the wide string pointed to by **s2**.

wcscspn returns the length of the segment.

wcsdup

Synopsis

```
wchar_t *wcsdup(const wchar_t *s1);
```

Description

wcsdup duplicates the wide string pointed to by **s1** by using **malloc** to allocate memory for a copy of **s** and then copying **s**, including the terminating wide null character, to that memory. The returned pointer can be passed to **free**. **wcsdup** returns a pointer to the new wide string or a null pointer if the new string cannot be created.

Note

wcsdup is an extension commonly found in Linux and BSD C libraries.

wcslen

Synopsis

```
size_t wcslen(const wchar_t *s);
```

Description

wcslen returns the length of the wide string pointed to by *s*, that is the number of wide characters that precede the terminating null wide character.

wcsncat

Synopsis

```
wchar_t *wcsncat(wchar_t *s1,  
                  const wchar_t *s2,  
                  size_t n);
```

Description

wcsncat appends not more than **n** wide characters from the array pointed to by **s2** to the end of the wide string pointed to by **s1**. A null wide character in **s1** and wide characters that follow it are not appended. The initial wide character of **s2** overwrites the null wide character at the end of **s1**. A terminating wide null character is always appended to the result. The behavior of **wcsncat** is undefined if copying takes place between objects that overlap.

wcsncat returns the value of **s1**.

wcsnchr

Synopsis

```
wchar_t *wcsnchr(const wchar_t *str,  
                  size_t n,  
                  wchar_t ch);
```

Description

wcsnchr searches not more than **n** wide characters to locate the first occurrence of **c** in the wide string pointed to by **s**. The terminating wide null character is considered to be part of the wide string.

wcsnchr returns a pointer to the located wide character, or a null pointer if **c** does not occur in the string.

wcsncmp

Synopsis

```
int wcsncmp(const wchar_t *s1,  
           const wchar_t *s2,  
           size_t n);
```

Description

wcsncmp compares not more than **n** wide characters from the array pointed to by **s1** to the array pointed to by **s2**. Characters that follow a null wide character are not compared.

wcsncmp returns an integer greater than, equal to, or less than zero, if the possibly null-terminated array pointed to by **s1** is greater than, equal to, or less than the possibly null-terminated array pointed to by **s2**.

WCSncpy

Synopsis

```
wchar_t *wcsncpy(wchar_t *s1,  
                  const wchar_t *s2,  
                  size_t n);
```

Description

wcsncpy copies not more than **n** wide characters from the array pointed to by **s2** to the array pointed to by **s1**. Wide characters that follow a null wide character in **s2** are not copied. The behavior of **wcsncpy** is undefined if copying takes place between objects that overlap. If the array pointed to by **s2** is a wide string that is shorter than **n** wide characters, null wide characters are appended to the copy in the array pointed to by **s1**, until **n** characters in all have been written.

wcsncpy returns the value of **s1**.

wcsnlen

Synopsis

```
size_t wcsnlen(const wchar_t *s,  
               size_t n);
```

Description

this returns the length of the wide string pointed to by **s**, up to a maximum of **n** wide characters. **wcsnlen** only examines the first **n** wide characters of the string **s**.

Note

wcsnlen is an extension commonly found in Linux and BSD C libraries.

WCSNSTR

Synopsis

```
wchar_t *wcsnstr(const wchar_t *s1,  
                  const wchar_t *s2,  
                  size_t n);
```

Description

wcsnstr searches at most **n** wide characters to locate the first occurrence in the wide string pointed to by **s1** of the sequence of wide characters (excluding the terminating null wide character) in the wide string pointed to by **s2**.

wcsnstr returns a pointer to the located string, or a null pointer if the string is not found. If **s2** points to a string with zero length, **wcsnstr** returns **s1**.

Note

wcsnstr is an extension commonly found in Linux and BSD C libraries.

wcspbrk

Synopsis

```
wchar_t *wcspbrk(const wchar_t *s1,  
                  const wchar_t *s2);
```

Description

wcspbrk locates the first occurrence in the wide string pointed to by **s1** of any wide character from the wide string pointed to by **s2**.

wcspbrk returns a pointer to the wide character, or a null pointer if no wide character from **s2** occurs in **s1**.

wcsrchr

Synopsis

```
wchar_t *wcsrchr(const wchar_t *s,  
                  wchar_t c);
```

Description

wcsrchr locates the last occurrence of **c** in the wide string pointed to by **s**. The terminating wide null character is considered to be part of the string.

wcsrchr returns a pointer to the wide character, or a null pointer if **c** does not occur in the wide string.

WCSSPN

Synopsis

```
size_t wcsspn(const wchar_t *s1,  
              const wchar_t *s2);
```

Description

wcsspn computes the length of the maximum initial segment of the wide string pointed to by **s1** which consists entirely of wide characters from the wide string pointed to by **s2**.

wcsspn returns the length of the segment.

WCSSTR

Synopsis

```
wchar_t *wcsstr(const wchar_t *s1,  
                 const wchar_t *s2);
```

Description

wcsstr locates the first occurrence in the wide string pointed to by **s1** of the sequence of wide characters (excluding the terminating null wide character) in the wide string pointed to by **s2**.

wcsstr returns a pointer to the located wide string, or a null pointer if the wide string is not found. If **s2** points to a wide string with zero length, **wcsstr** returns **s1**.

wcstok

Synopsis

```
wchar_t *wcstok(wchar_t *s1,  
                 const wchar_t *s2);
```

Description

wcstok A sequence of calls to **wcstok** breaks the wide string pointed to by **s1** into a sequence of tokens, each of which is delimited by a wide character from the wide string pointed to by **s2**. The first call in the sequence has a non-null first argument; subsequent calls in the sequence have a null first argument. The separator wide string pointed to by **s2** may be different from call to call.

The first call in the sequence searches the wide string pointed to by **s1** for the first wide character that is not contained in the current separator wide string pointed to by **s2**. If no such wide character is found, then there are no tokens in the wide string pointed to by **s1** and **wcstok** returns a null pointer. If such a wide character is found, it is the start of the first token.

wcstok then searches from there for a wide character that is contained in the current wide separator string. If no such wide character is found, the current token extends to the end of the wide string pointed to by **s1**, and subsequent searches for a token will return a null pointer. If such a wide character is found, it is overwritten by a wide null character, which terminates the current token. **wcstok** saves a pointer to the following wide character, from which the next search for a token will start.

Each subsequent call, with a null pointer as the value of the first argument, starts searching from the saved pointer and behaves as described above.

Note

wcstok maintains static state and is therefore not reentrant and not thread safe. See [wcstok_r](#) for a thread-safe and reentrant variant.

wcstok_r

Synopsis

```
wchar_t *wcstok_r(wchar_t *s1,  
                   const wchar_t *s2,  
                   wchar_t **s3);
```

Description

wcstok_r is a reentrant version of the function **wcstok** where the state is maintained in the object of type **wchar_t *** pointed to by **s3**.

Note

wcstok_r is an extension commonly found in Linux and BSD C libraries.

See Also

[wcstok](#).

wctob

Synopsis

```
int wctob(wint_t c);
```

Description

wctob determines whether **c** corresponds to a member of the extended character set whose multi-byte character representation is a single byte when in the initial shift state in the current locale.

Description

this returns EOF if **c** does not correspond to a multi-byte character with length one in the initial shift state. Otherwise, it returns the single-byte representation of that character as an **unsigned char** converted to an **int**.

wctob_I

Synopsis

```
int wctob_l(wint_t c,  
            locale_t loc);
```

Description

wctob_I determines whether **c** corresponds to a member of the extended character set whose multi-byte character representation is a single byte when in the initial shift state in locale **loc**.

Description

wctob_I returns **EOF** if **c** does not correspond to a multi-byte character with length one in the initial shift state. Otherwise, it returns the single-byte representation of that character as an **unsigned char** converted to an **int**.

wint_t

Synopsis

```
typedef long wint_t;
```

Description

`wint_t` is an integer type that is unchanged by default argument promotions that can hold any value corresponding to members of the extended character set, as well as at least one value that does not correspond to any member of the extended character set (WEOF).

wmemccpy

Synopsis

```
wchar_t *wmemccpy(wchar_t *s1,  
                   const wchar_t *s2,  
                   wchar_t c,  
                   size_t n);
```

Description

wmemccpy copies at most **n** wide characters from the object pointed to by **s2** into the object pointed to by **s1**. The copying stops as soon as **n** wide characters are copied or the wide character **c** is copied into the destination object pointed to by **s1**. The behavior of **wmemccpy** is undefined if copying takes place between objects that overlap.

wmemccpy returns a pointer to the wide character immediately following **c** in **s1**, or **NULL** if **c** was not found in the first **n** wide characters of **s2**.

Note

wmemccpy conforms to POSIX.1-2008.

wmemchr

Synopsis

```
wchar_t *wmemchr(const wchar_t *s,  
                  wchar_t c,  
                  size_t n);
```

Description

wmemchr locates the first occurrence of **c** in the initial **n** characters of the object pointed to by **s**. Unlike **wcschr**, **wmemchr** does *not* terminate a search when a null wide character is found in the object pointed to by **s**.

wmemchr returns a pointer to the located wide character, or a null pointer if **c** does not occur in the object.

wmemcmp

Synopsis

```
int memcmp(const wchar_t *s1,
           const wchar_t *s2,
           size_t n);
```

Description

wmemcmp compares the first **n** wide characters of the object pointed to by **s1** to the first **n** wide characters of the object pointed to by **s2**. **wmemcmp** returns an integer greater than, equal to, or less than zero as the object pointed to by **s1** is greater than, equal to, or less than the object pointed to by **s2**.

wmemcpy

Synopsis

```
wchar_t *wmemcpy(wchar_t *s1,  
                  const wchar_t *s2,  
                  size_t n);
```

Description

wmemcpy copies **n** wide characters from the object pointed to by **s2** into the object pointed to by **s1**. The behavior of **wmemcpy** is undefined if copying takes place between objects that overlap.

wmemcpy returns the value of **s1**.

wmemmove

Synopsis

```
wchar_t *wmemmove(wchar_t *s1,  
                   const wchar_t *s2,  
                   size_t n);
```

Description

wmemmove copies **n** wide characters from the object pointed to by **s2** into the object pointed to by **s1** ensuring that if **s1** and **s2** overlap, the copy works correctly. Copying takes place as if the **n** wide characters from the object pointed to by **s2** are first copied into a temporary array of **n** wide characters that does not overlap the objects pointed to by **s1** and **s2**, and then the **n** wide characters from the temporary array are copied into the object pointed to by **s1**.

wmemmove returns the value of **s1**.

wmempcpy

Synopsis

```
wchar_t *wmempcpy(wchar_t *s1,  
                   const wchar_t *s2,  
                   size_t n);
```

Description

wmempcpy copies **n** wide characters from the object pointed to by **s2** into the object pointed to by **s1**. The behavior of **wmempcpy** is undefined if copying takes place between objects that overlap.

wmempcpy returns it returns a pointer to the wide character following the last written wide character.

Note

This is an extension found in GNU libc.

wmemset

Synopsis

```
wchar_t *wmemset(wchar_t *s,  
                  wchar_t c,  
                  size_t n);
```

Description

wmemset copies the value of **c** into each of the first **n** wide characters of the object pointed to by **s**.

wmemset returns the value of **s**.

wstrsep

Synopsis

```
wchar_t *wstrsep(wchar_t **stringp,  
                  const wchar_t *delim);
```

Description

wstrsep locates, in the wide string referenced by ***stringp**, the first occurrence of any wide character in the wide string **delim** (or the terminating wide null character) and replaces it with a wide null character. The location of the next character after the delimiter wide character (or NULL, if the end of the string was reached) is stored in ***stringp**. The original value of ***stringp** is returned.

An empty field (that is, a wide character in the string **delim** occurs as the first wide character of ***stringp**) can be detected by comparing the location referenced by the returned pointer to a wide null character.

If ***stringp** is initially null, **wstrsep** returns null.

Note

wstrsep is not an ISO C function, but appears in BSD4.4 and Linux.

<wctype.h>

API Summary

Classification functions	
iswalnum	Is character alphanumeric?
iswalpha	Is character alphabetic?
iswblank	Is character blank?
iswcntrl	Is character a control?
iswctype	Determine character type
iswdigit	Is character a decimal digit?
iswgraph	Is character a control?
iswlower	Is character a lowercase letter?
iswprint	Is character printable?
iswpunct	Is character punctuation?
iswspace	Is character a whitespace character?
iswupper	Is character an uppercase letter?
iswdxdigit	Is character a hexadecimal digit?
wctype	Construct character class
Conversion functions	
towctrans	Translate character
towlower	Convert uppercase character to lowercase
towupper	Convert lowercase character to uppercase
wctrans	Construct character mapping
Classification functions (extended)	
iswalnum_l	Is character alphanumeric?
iswalpha_l	Is character alphabetic?
iswblank_l	Is character blank?
iswcntrl_l	Is character a control?
iswctype_l	Determine character type
iswdigit_l	Is character a decimal digit?
iswgraph_l	Is character a control?
iswlower_l	Is character a lowercase letter?
iswprint_l	Is character printable?
iswpunct_l	Is character punctuation?

iswspace_l	Is character a whitespace character?
iswupper_l	Is character an uppercase letter?
iswxdigit_l	Is character a hexadecimal digit?
Conversion functions (extended)	
towctrans_l	Translate character
towlower_l	Convert uppercase character to lowercase
toupper_l	Convert lowercase character to uppercase
wctrans_l	Construct character mapping

iswalnum

Synopsis

```
int iswalnum(wint_t c);
```

Description

iswalnum tests for any wide character for which **iswalpha** or **iswdigit** is true.

iswalnum_l

Synopsis

```
int iswalnum_l(wint_t c,  
                locale_t loc);
```

Description

iswalnum_l tests for any wide character for which **iswalpha_l** or **iswdigit_l** is true in the locale **loc**.

iswalphα

Synopsis

```
int iswalphα(wint_t c);
```

Description

iswalphα returns true if the wide character **c** is alphabetic. Any character for which **iswupper** or **iswlower** returns true is considered alphabetic in addition to any of the locale-specific set of alphabetic characters for which none of **iswcntrl**, **iswdigit**, **iswpunct**, or **iswspace** is true.

In the 'C' locale, **iswalphα** returns nonzero (true) if and only if **iswupper** or **iswlower** return true for the value of the argument **c**.

iswalphal_I

Synopsis

```
int iswalphal_I(wint_t c,  
                 locale_t loc);
```

Description

iswalphal_I returns true if the wide character **c** is alphabetic in the locale **loc**. Any character for which **iswupper_I** or **iswlower_I** returns true is considered alphabetic in addition to any of the locale-specific set of alphabetic characters for which none of **iswcntrl_I**, **iswdigit_I**, **iswpunct_I**, or **iswspace_I** is true.

iswblank

Synopsis

```
int iswblank(wint_t c);
```

Description

iswblank tests for any wide character that is a standard blank wide character or is one of a locale-specific set of wide characters for which **iswspace** is true and that is used to separate words within a line of text. The standard blank wide are space and horizontal tab.

In the 'C' locale, **iswblank** returns true only for the standard blank characters.

iswblank_l

Synopsis

```
int iswblank_l(wint_t c,
                locale_t loc);
```

Description

iswblank_l tests for any wide character that is a standard blank wide character in the locale **loc** or is one of a locale-specific set of wide characters for which **iswspace_l** is true and that is used to separate words within a line of text. The standard blank wide are space and horizontal tab.

iswcntrl

Synopsis

```
int iswcntrl(wint_t c);
```

Description

iswcntrl tests for any wide character that is a control character.

iswcntrl_l

Synopsis

```
int iswcntrl_l(wint_t c,  
                locale_t loc);
```

Description

iswcntrl_l tests for any wide character that is a control character in the locale **loc**.

iswctype

Synopsis

```
int iswctype(wint_t c,  
            wctype_t t);
```

Description

iswctype determines whether the wide character **c** has the property described by **t** in the current locale.

iswctype_l

Synopsis

```
int iswctype_l(wint_t c,
                wctype_t t,
                locale_t loc);
```

Description

iswctype_l determines whether the wide character **c** has the property described by **t** in the locale **loc**.

iswdigit

Synopsis

```
int iswdigit(wint_t c);
```

Description

iswdigit tests for any wide character that corresponds to a decimal-digit character.

iswdigit_l

Synopsis

```
int iswdigit_l(wint_t c,  
                locale_t loc);
```

Description

iswdigit_l tests for any wide character that corresponds to a decimal-digit character in the locale **loc**.

iswgraph

Synopsis

```
int iswgraph(wint_t c);
```

Description

iswgraph tests for any wide character for which **iswprint** is true and **iswspace** is false.

iswgraph_l

Synopsis

```
int iswgraph_l(wint_t c,
                locale_t loc);
```

Description

iswgraph_l tests for any wide character for which **iswprint** is true and **iswspace** is false in the locale **loc**.

iswlower

Synopsis

```
int iswlower(wint_t c);
```

Description

iswlower tests for any wide character that corresponds to a lowercase letter or is one of a locale-specific set of wide characters for which none of **iswcntrl**, **iswdigit**, **iswpunct**, or **iswspace** is true.

iswlower_l

Synopsis

```
int iswlower_l(wint_t c,
                locale_t loc);
```

Description

iswlower_l tests for any wide character that corresponds to a lowercase letter in the locale **loc** or is one of a locale-specific set of wide characters for which none of **iswcntrl_l**, **iswdigit_l**, **iswpunct_l**, or **iswspace_l** is true.

iswprint

Synopsis

```
int iswprint(wint_t c);
```

Description

iswprint returns nonzero (true) if and only if the value of the argument **c** is any printing character.

iswprint_l

Synopsis

```
int iswprint_l(wint_t c,  
               locale_t loc);
```

Description

`iswprint_l` returns nonzero (true) if and only if the value of the argument `c` is any printing character in the locale `loc`.

iswpunct

Synopsis

```
int iswpunct(wint_t c);
```

Description

iswpunct tests for any printing wide character that is one of a locale-specific set of punctuation wide characters for which neither **iswspace** nor **iswalnum** is true.

iswpunct_l

Synopsis

```
int iswpunct_l(wint_t c,  
                locale_t loc);
```

Description

iswpunct_l tests for any printing wide character that is one of a locale-specific set of punctuation wide characters in locale **loc** for which neither **iswspace_l** nor **iswalnum_l** is true.

iswspace

Synopsis

```
int iswspace(wint_t c);
```

Description

iswspace tests for any wide character that corresponds to a locale-specific set of white-space wide characters for which none of **iswalnum**, **iswgraph**, or **iswpunct** is true.

iswspace_l

Synopsis

```
int iswspace_l(wint_t c,
                locale_t loc);
```

Description

iswspace_l tests for any wide character that corresponds to a locale-specific set of white-space wide characters in the locale **loc** for which none of **iswalnum**, **iswgraph_l**, or **iswpunct_l** is true.

iswupper

Synopsis

```
int iswupper(wint_t c);
```

Description

iswupper tests for any wide character that corresponds to an uppercase letter or is one of a locale-specific set of wide characters for which none of **iswcntrl**, **iswdigit**, **iswpunct**, or **iswspace** is true.

iswupper_l

Synopsis

```
int iswupper_l(wint_t c,  
                locale_t loc);
```

Description

iswupper_l tests for any wide character that corresponds to an uppercase letter or is one of a locale-specific set of wide characters in the locale **loc** for which none of **iswcntrl_l**, **iswdigit_l**, **iswpunct_l**, or **iswspace_l** is true.

iswxdigit

Synopsis

```
int iswxdigit(wint_t c);
```

Description

iswxdigit tests for any wide character that corresponds to a hexadecimal digit.

iswxdigit_l

Synopsis

```
int iswxdigit_l(wint_t c,  
                 locale_t loc);
```

Description

iswxdigit_l tests for any wide character that corresponds to a hexadecimal digit in the locale **loc**.

towctrans

Synopsis

```
wint_t towctrans(wint_t c,  
                  wctrans_t t);
```

Description

towctrans maps the wide character **c** using the mapping described by **t** in the current locale.

towctrans_l

Synopsis

```
wint_t towctrans_l(wint_t c,  
                    wctrans_t t,  
                    locale_t loc);
```

Description

towctrans_l maps the wide character **c** using the mapping described by **t** in the current locale.

towlower

Synopsis

```
wint_t towlower(wint_t c);
```

Description

towlower converts an uppercase letter to a corresponding lowercase letter.

If the argument **c** is a wide character for which **iswupper** is true and there are one or more corresponding wide characters, in the current locale, for which **iswlower** is true, **towlower** returns one (and always the same one for any given locale) of the corresponding wide characters; otherwise, **c** is returned unchanged.

towlower_l

Synopsis

```
wint_t towlower_l(wint_t c,  
                  locale_t loc);
```

Description

towlower_l converts an uppercase letter to a corresponding lowercase letter in locale **loc**.

If the argument **c** is a wide character for which **iswupper_l** is true and there are one or more corresponding wide characters, in the locale **loc**, for which **iswlower_l** is true, **towlower_l** returns one (and always the same one for any given locale) of the corresponding wide characters; otherwise, **c** is returned unchanged.

towupper

Synopsis

```
wint_t towupper(wint_t c);
```

Description

towupper converts a lowercase letter to a corresponding uppercase letter.

If the argument **c** is a wide character for which **iswlower** is true and there are one or more corresponding wide characters, in the current current locale, for which **iswupper** is true, **towupper** returns one (and always the same one for any given locale) of the corresponding wide characters; otherwise, **c** is returned unchanged.

towupper_l

Synopsis

```
wint_t towupper_l(wint_t c,  
                   locale_t loc);
```

Description

towupper_l converts a lowercase letter to a corresponding uppercase letter in locale **loc**.

If the argument **c** is a wide character for which **iswlower_l** is true and there are one or more corresponding wide characters, in the locale **loc**, for which **iswupper_l** is true, **towupper_l** returns one (and always the same one for any given locale) of the corresponding wide characters; otherwise, **c** is returned unchanged.

wctrans

Synopsis

```
wctrans_t wctrans(const char *property);
```

Description

wctrans constructs a value of type **wctrans_t** that describes a mapping between wide characters identified by the string argument **property**.

If **property** identifies a valid mapping of wide characters in the current locale, **wctrans** returns a nonzero value that is valid as the second argument to **towctrans**; otherwise, it returns zero.

Note

The only mappings supported are "tolower" and "toupper".

wctrans_l

Synopsis

```
wctrans_t wctrans_l(const char *property,  
                     locale_t loc);
```

Description

wctrans_l constructs a value of type **wctrans_t** that describes a mapping between wide characters identified by the string argument **property** in locale **loc**.

If **property** identifies a valid mapping of wide characters in the locale **loc**, **wctrans_l** returns a nonzero value that is valid as the second argument to **towctrans_l**; otherwise, it returns zero.

Note

The only mappings supported are "tolower" and "toupper".

wctype

Synopsis

```
wctype_t wctype(const char *property);
```

Description

wctype constructs a value of type **wctype_t** that describes a class of wide characters identified by the string argument **property**.

If **property** identifies a valid class of wide characters in the current locale, **wctype** returns a nonzero value that is valid as the second argument to **iswctype**; otherwise, it returns zero.

Note

The only mappings supported are "alnum", "alpha", "blank", "cntrl", "digit", "graph", "lower", "print", "punct", "space", "upper", and "xdigit".

<xlocale.h>

API Summary

Functions	
duplocale	Duplicate current locale data
freelocale	Free a locale
localeconv_I	Get locale data
newlocale	Create a new locale

duplocale

Synopsis

```
locale_t duplocale(locale_t loc);
```

Description

duplocale duplicates the locale object referenced by **loc**.

If there is insufficient memory to duplicate **loc**, **duplocale** returns **NULL** and sets **errno** to **ENOMEM** as required by POSIX.1-2008.

Duplicated locales must be freed with **freelocale**.

This is different behavior from the GNU glibc implementation which makes no mention of setting **errno** on failure.

Note

This extension is derived from BSD, POSIX.1, and glibc.

freelocale

Synopsis

```
int freelocale(locale_t loc);
```

Description

freelocale frees the storage associated with **loc**.

freelocale zero on success, -1 on error.

localeconv_I

Synopsis

```
localeconv_l(locale_t loc);
```

Description

localeconv_I returns a pointer to a structure of type **Iconv** with the corresponding values for the locale **loc** filled in.

newlocale

Synopsis

```
locale_t newlocale(int category_mask,  
                  const char *locale,  
                  locale_t base);
```

Description

newlocale creates a new locale object or modifies an existing one. If the **base** argument is **NULL**, a new locale object is created.

category_mask specifies the locale categories to be set or modified. Values for **category_mask** are constructed by a bitwise-inclusive OR of the symbolic constants **LC_CTYPE_MASK**, **LC_NUMERIC_MASK**, **LC_TIME_MASK**, **LC_COLLATE_MASK**, **LC_MONETARY_MASK**, and **LC_MESSAGES_MASK**.

For each category with the corresponding bit set in **category_mask**, the data from the locale named by **locale** is used. In the case of modifying an existing locale object, the data from the locale named by **locale** replaces the existing data within the locale object. If a completely new locale object is created, the data for all sections not requested by **category_mask** are taken from the default locale.

The locales ‘C’ and ‘POSIX’ are equivalent and defined for all settings of **category_mask**:

If **locale** is **NULL**, then the ‘C’ locale is used. If **locale** is an empty string, **newlocale** will use the default locale.

If **base** is **NULL**, the current locale is used. If **base** is **LC_GLOBAL_LOCALE**, the global locale is used.

If **mask** is **LC_ALL_MASK**, **base** is ignored.

Note

POSIX.1-2008 does not specify whether the locale object pointed to by **base** is modified or whether it is freed and a new locale object created.

Implementation

The category mask **LC_MESSAGES_MASK** is not implemented as POSIX messages are not implemented.



Utilities Reference

Compiler driver

This section describes the switches accepted by the compiler driver, **cc**. The compiler driver is capable of controlling compilation by all supported language compilers and the final link by the linker. It can also construct libraries automatically.

In contrast to many compilation and assembly language development systems, with you don't invoke the assembler or compiler directly. Instead you'll normally use the compiler driver **cc** as it provides an easy way to get files compiled, assembled, and linked. This section will introduce you to using the compiler driver to convert your source files to object files, executables, or other formats.

We recommend that you use the compiler driver rather than use the assembler or compiler directly because there the driver can assemble multiple files using one command line and can invoke the linker for you too. There is no reason why you should not invoke the assembler or compiler directly yourself, but you'll find that typing in all the required options is quite tedious-and why do that when **cc** will provide them for you automatically?

File naming conventions

The compiler driver uses file extensions to distinguish the language the source file is written in. The compiler driver recognizes the extension **.c** as C source files, **.s** and **.asm** as assembly code files.

The compiler driver recognizes the extension **.hzo** as object files, **.hza** as library files and **.xml** as special-purpose XML files.

We strongly recommend that you adopt these extensions for your source files and object files because you'll find that using the tools is much easier if you do.

C language files

When the compiler driver finds a file with a **.c** extension, it runs the C compiler to convert it to object code.

Assembly language files

When the compiler driver finds a file with a **.s** or **.asm** extension, it runs the C preprocessor and then the assembler to convert it to object code.

Object code files

When the compiler driver finds a file with a **.hzo** or **.hza** extension, it passes it to the linker to include it in the final application.

Command-line options

This section describes the command-line options accepted by the CrossWorks compiler driver.

-ansi (Warn about potential ANSI problems)

Syntax

-ansi

Description

Warn about potential problems that conflict with the relevant ANSI or ISO standard for the files that are compiled.

-ar (Archive output)

Syntax

-ar

Description

This switch instructs the compiler driver to archive all output files into a library. Using **-ar** implies **-c**.

Example

The following command compiles **file1.c**, **file2.asm**, and **file3.c** to object code and archives them into the library file **libfunc.hza** together with the object file **file4.hzo**.

```
cc -ar file1.c file2.asm file3.c file4.hzo -o libfunc.hza
```

-c (Compile to object code, do not link)

Syntax

```
-c
```

Description

All named files are compiled to object code modules, but are not linked. You can use the **-o** option to name the output if you just supply one input filename.

Example

The following command compiles **file1.c** and **file4.c** to produce the object files **file1.o** and **file4.hzo**.

```
cc -c file1.c file4.c
```

The following command compiles **file1.c** and produces the object file **obj/file1.hzo**.

```
cc -c file.c -o obj/file1.o
```

-cpu (Set MSP430 architecture)

Syntax

```
-cpu -cpux -cpux64k
```

Description

Specifies the version of the instruction set to generate code for. The options are:

- **-cpu** — MSP430 instruction set
- **-cpux** — MSP430X instruction set with 20-bit PC
- **-cpux64k** — MSP430X instruction set with 16-bit PC

Example

To select compilation for MSP430X architecture you would use:

```
cc -cpux ...
```

-d (Define linker symbol)

Syntax

`-dname=value`

Description

You can define linker symbols using the **-d** option. The symbol definitions are passed to linker.

Example

The following defines the symbol, **STACK_SIZE** with a value of 512.

```
-dSTACK_SIZE=512
```

-D (Define macro symbol)

Syntax

`-Dname`
`-Dname=value`

Description

You can define preprocessor macros using the `-D` option. The macro definitions are passed on to the respective language compiler which is responsible for interpreting the definitions and providing them to the programmer within the language.

The first form above defines the macro *name* but without an associated replacement value, and the second defines the same macro with the replacement value *value*.

Example

The following defines two macros, **SUPPORT_FLOAT** with a value of 1 and **LITTLE_ENDIAN** with no replacement value.

```
-DSUPPORT_FLOAT=1 -DLITTLE_ENDIAN
```

-E (Preprocess)

Syntax

-E

Description

This option preprocesses the supplied file and outputs the result to the standard output.

Example

The following preprocesses the file **file.c** supplying the macros, **SUPPORT_FLOAT** with a value of 1 and **LITTLE_ENDIAN**.

```
-E -DSUPPORT_FLOAT=1 -DLITTLE_ENDIAN file.c
```

-F (Set output format)

Syntax

-F*fmt*

Description

The **-F** option instructs the linker to write its output in the format *fmt*. The linker supports the following formats:

- **-Fsrec** — Motorola S-record format
- **-Fhex** — Intel extended hex format
- **-Ftek** — Tektronix hex format
- **-Txt** — Texas Instruments hex format
- **-Flst** — Hexadecimal listing
- **-Fhzx** — Rowley native format

The default format, if no other format is specified, is **-Fhzx**.

-g (Generate debugging information)

Syntax

`-g`

Description

The `-g` option instructs the compiler and assembler to generate source level debugging information for the debugger to use.

-help (Display help information)

Syntax

-help

Description

Displays a short summary of the options accepted by the compiler driver.

-io (Select I/O library implementation)

Syntax

`-io=i`

Description

This option specifies the I/O library implementation that is included in the linked image. The options are:

- `-io=d` — I/O library is implemented using debugIO e.g calls to `printf` will call `debug_printf`.
- `-io=t` — I/O library is implemented on the target, debugIO is not used.
- `-io=t+d` — I/O library is implemented on the target, debugIO is not used but debugIO is enabled.

-I (Define user include directories)

Syntax

`-Idirectory`

Description

In order to find include files the compiler driver arranges for the compilers to search a number of standard directories. You can add directories to the search path using the -I switch which is passed on to each of the language processors.

You can specify more than one include directory by separating each directory component with either a comma or semicolon.

-I- (Exclude standard include directories)

Syntax

-I-

Description

Usually the compiler and assembler search for include files in the standard include directory created when the product is installed. If for some reason you wish to exclude these system locations from being searched when compiling a file, the -I- option will do this for you.

-J (Define system include directories)

Syntax

`-Jdirectory`

Description

The `-J` option adds *directory* to the end of the list of directories to search for source files included (using triangular brackets) by the `#include` preprocessor command.

You can specify more than one include directory by separating each directory component with either a comma or semicolon in the property

-K (Keep linker symbol)

Syntax

`-Kname`

Description

The linker removes unused code and data from the output file. This process is called *deadstripping*. To prevent the linker from deadstripping unreferenced code and data you wish to keep, you must use the `-K` command line option to force inclusion of symbols.

Example

If you have a C function, `contextSwitch` that must be kept in the output file (and which the linker will normally remove), you can force its inclusion using:

```
-K_contextSwitch
```

Because `-K` is passed to the linker as an option, you must prefix the C function or variable name with an underscore as the CrossWorks C compiler prefixes all external symbols with an underscore when constructing linker symbols.

-L (Set library directory path)

Syntax

`-Ldir`

Description

Sets the library directory to *dir*. If -L is not specified on the command line, the default location to search for libraries is set to `$(InstallDir)/lib`.

-I- (Do not link standard libraries)

Syntax

-I-

Description

The -I option instructs the compiler driver not to link standard libraries. If you use this option you must supply your own library functions or libraries.

-make (Make-style build)

Syntax

-make

Description

The **-make** option avoids build steps based on the modification date of the output file and modification date of the input file and its dependencies.

-mul (Set MSP430 multiplier architecture)

Syntax

-mul16 -mul32

Description

Specifies the multiplier type to generate code for. The options are:

- **-mul16** — 16-bit multiplier
- **-mul32** — 32-bit multiplier

Example

To select compilation for a 32-bit multiplier

```
cc -mul32 ...
```

-M (Display linkage map)

Syntax

-M

Description

The **-M** option prints a linkage map named the same as the linker output file with the **.map** file extension.

-n (Dry run, no execution)

Syntax

-n

Description

When **-n** is specified, the compiler driver processes options as usual, but does not execute any subprocesses to compile, assemble, archive or link applications.

-nostderr (No stderr output)

Syntax

-nostderr

Description

When **-nostderr** is specified, any stderr output of subprocesses is redirected to stdout.

-o (Set output file name)

Syntax

`-o filename`

Description

The `-o` option instructs the compiler driver to write linker or archiver output to *filename*.

-O (Optimize output)

Syntax

`-Ox`

Description

Pass the optimization option `-Ox` to the compiler and linker. Specific `-O` optimization options are described in the compiler and linker reference sections.

-printf (Select printf capability)

Syntax

`-printf=c`

Description

The `-printf` option selects the printf capability for the linked executable. The options are:

- `-printf=i` — integer is supported
- `-printf=li` — long integer is supported
- `-printf=ll` — long long integer is supported
- `-printf=f` — floating point is supported
- `-printf=wp` — width and precision is supported

-R (Set section name)

Syntax

`-R x name`

Description

These options name the default name of the sections generated by the compiler/assembler to be *name*. The options are:

- `-Rc name` — change the default name of the code section
- `-Rd name` — change the default name of the data section
- `-Ri name` — change the default name of the isr section
- `-Rk name` — change the default name of the const section
- `-Rv name` — change the default name of the vector section
- `-Rz name` — change the default name of the bss section

-scanf (Select scanf capability)

Syntax

`-scanf= c`

Description

The `-scanf` option selects the scanf capability for the linked executable. The options are:

- `-scanf=i` — integer is supported
- `-scanf=li` — long integer is supported
- `-scanf=ll` — long long integer is supported
- `-scanf=f` — floating point is supported
- `-scanf=wp` — % [...] and %[^...] character class is supported

-sd (Treat double as float)

Syntax

-sd

Description

The **-sd** option instructs the compiler to compile double as float and selects the appropriate library for linking.

-v (Verbose execution)

Syntax

-v

Description

The **-v** switch displays command lines executed by the compiler driver.

-w (Suppress warnings)

Syntax

-w

Description

This option instructs the compiler, assembler, and linker not to issue any warnings.

-we (Treat warnings as errors)

Syntax

-we

Description

This option directs the compiler, assembler, and linker to treat all warnings as errors.

-Wa (Pass option to tool)

Syntax

`-Wtool option`

Description

The -W command-line option passes *option* directly to the specified *tool*. Supported tools are

- `-Wa` — pass option to assembler
- `-Wc` — pass option to compiler
- `-WI` — pass option to linker

Example

The following example passes the (compiler specific) -version option to the compiler

```
cc ... -Wc-version
```

-x (Specify file types)

Syntax

`-x type`

Description

The `-x` option causes the compiler driver to treat subsequent files to be of the following file type

- `-xa` — archives/libraries
- `-xasm` — assembly code files
- `-xc` — C code files
- `-xo` — object code files

Example

The following command line enables an assembly code file with the extension `.arm` to be assembled.

```
cc -xasm a.arm
```

-y (Use project template)

Syntax

`-y t`

Description

If required this option must be the first option on the command line. It instantiates a project template type from the installed packages. The files and common project properties of the project template are used by the compiler driver. Project configurations are not supported by the compiler driver, use CrossBuild if you require project configurations.

Example

The following command builds an executable based on the MSP430_C_EXECUTABLE project template.

```
cc -yMSP430_C_EXECUTABLE -zTarget=MSP430F5172 file.c -o file.hzx
```

-z (Set project property)

Syntax

`-z p = v`

Description

Sets the value of the project property *p* to the value *v*.

Example

The following command compiles the file arguments and puts the resulting object files into the directory **objects**.

```
cc -c file1.c file2.c -zbuild_output_directory=objects
```

Compiler driver

This section describes the switches accepted by the compiler driver, **hcl**. The compiler driver is capable of controlling compilation by all supported language compilers and the final link by the linker. It can also construct libraries automatically.

In contrast to many compilation and assembly language development systems, with you don't invoke the assembler or compiler directly. Instead you'll normally use the compiler driver **hcl** as it provides an easy way to get files compiled, assembled, and linked. This section will introduce you to using the compiler driver to convert your source files to object files, executables, or other formats.

We recommend that you use the compiler driver rather than use the assembler or compiler directly because there the driver can assemble multiple files using one command line and can invoke the linker for you too. There is no reason why you should not invoke the assembler or compiler directly yourself, but you'll find that typing in all the required options is quite tedious-and why do that when **hcl** will provide them for you automatically?

File naming conventions

The compiler driver uses file extensions to distinguish the language the source file is written in. The compiler driver recognizes the extension **.c** as C source files, **.s** and **.asm** as assembly code files, and **.hzo** as object code files.

We strongly recommend that you adopt these extensions for your source files and object files because you'll find that using the tools is much easier if you do.

C language files

When the compiler driver finds a file with a **.c** extension, it runs the C compiler to convert it to object code.

Assembly language files

When the compiler driver finds a file with a **.s** or **.asm** extension, it runs the assembler to convert it to object code.

Object code files

When the compiler driver finds a file with a **.hzo** extension, it passes it to the linker to include it in the final application.

Command-line options

This section describes the command-line options accepted by the CrossWorks compiler driver.

-ansi (Warn about potential ANSI problems)

Syntax

-ansi

Description

Warn about potential problems that conflict with the relevant ANSI or ISO standard for the files that are compiled.

Project property

Compiler Options > Enforce ANSI Checking

-ar (Archive output)

Syntax

-ar

Description

This switch instructs the compiler driver to archive all output files into a library. Using **-ar** implies **-c**.

Example

The following command compiles **file1.c**, **file2.asm**, and **file3.c** to object code and archives them into the library file **libfunc.hza**.

```
hcl file1.c file2.asm file3.c -o libfunc.hza
```

-c (Compile to object code, do not link)

Syntax

-c

Description

All named files are compiled to object code modules, but are not linked.

-g (Generate debugging information)

Syntax

`-g`

Description

The `-g` option instructs the compiler and assembler to generate debugging information (line numbers and data type information) for the debugger to use and instructs the linker not to strip that debugging information.

Project property

Build Options > Include Debug Information

-D (Define macro symbol)

Syntax

`-Dname`
`-Dname=value`

Description

You can define preprocessor macros using the `-D` option. The macro definitions are passed on to the respective language compiler which is responsible for interpreting the definitions and providing them to the programmer within the language.

The first form above defines the macro *name* but without an associated replacement value, and the second defines the same macro with the replacement value *value*.

Project property

[Preprocessor Options > Preprocessor Definitions](#)

Example

The following defines two macros, **SUPPORT_FLOAT** with a value of 1 and **LITTLE_ENDIAN** with no replacement value.

```
-DSUPPORT_FLOAT=1 -DLITTLE_ENDIAN
```

-F (Set output format)

Syntax

-F*format*

Description

The **-F** option instructs the linker to write its output in the format *fmt*. The linker supports the following formats:

- **-Fsrec** — Motorola S-record format
- **-Fhex** — Intel extended hex format
- **-Ftek** — Tektronix hex format
- **-Txt** — Texas Instruments hex format
- **-Flst** — Hexadecimal listing
- **-Fhzx** — Rowley native format

The default format, if no other format is specified, is **-Fhzx**.

-h (Display help information)

Syntax

-h

Description

Displays a short summary of the options accepted by the compiler driver.

-I (Define user include directories)

Syntax

`-Idirectory`

Description

In order to find include files the compiler driver arranges for the compilers to search a number of standard directories. You can add directories to the search path using the -I switch which is passed on to each of the language processors.

Project property

Preprocessor Options > User Include Directories

You can specify more than one include directory by separating each directory component with either a comma or semicolon.

-J (Define system include directories)

Syntax

-J*directory*

Description

The -J option adds *directory* to the end of the list of directories to search for source files included (using triangular brackets) by the #include preprocessor command.

Project property

Preprocessor Options > System Include Directories

You can specify more than one include directory by separating each directory component with either a comma or semicolon in the property

-K (Keep linker symbol)

Syntax

`-Kname`

Description

The CrossWorks linker removes unused code and data from the output file. This process is called *deadstripping*. To prevent the linker from deadstripping unreferenced code and data you wish to keep, you must use the **-K** command line option to force inclusion of symbols.

Example

If you have a C function, **contextSwitch** that must be kept in the output file (and which the linker will normally remove), you can force its inclusion using:

```
-K_contextSwitch
```

Because **-K** is passed to the linker as an option, you must prefix the C function or variable name with an underscore as the CrossWorks C compiler prefixes all external symbols with an underscore when constructing linker symbols.

-I (Link library)

Syntax

-Ix

Description

Link the library **libx.hza** from the library directory. The library directory is, by default \$(InstallDir)/lib, but can be changed with -L option.

-L (Set library directory path)

Syntax

`-Ldir`

Description

Sets the library directory to *dir*. If -L is not specified on the command line, the default location to search for libraries is set to `$(InstallDir)/lib`.

-I- (Exclude standard include directories)

Syntax

-I-

Description

Usually the compiler and assembler search for include files in the standard include directory created when the product is installed. If for some reason you wish to exclude these system locations from being searched when compiling a file, the -I- option will do this for you.

Project property

Preprocessor Options > Ignore Includes

Note

The -I- option will clear any include directories previously set with the -I- option, so you must ensure that -I- comes before setting any directories you wish to search. Therefore, the following command line has a different effect to the command line above:

```
hcl -I../include -I../lib/include -I- file.c
```

-I- (Do not link standard libraries)

Syntax

-I-

Description

The -I option instructs the linker not to link standard libraries automatically included by the compiler or by the assembler **INCLUDELIB** directive. If you use this options you must supply your own library functions or provide the names of alternative sets of libraries to use.

Project property

Linker Options > Include Standard Libraries

-m (Machine-level options)

Syntax

`-mx`

Description

Pass the option `-mx` to the compiler, assembler, and linker to select appropriate memory-model and code generation characteristics. Specific `-mx` options are described in the C compiler and linker reference sections.

-M (Display linkage map)

Syntax

-M

-M*file*

Description

The **-M** option prints a linkage map to standard output; **-M***file* prints a linkage map to *filename*.

-n (Dry run, no execution)

Syntax

-n

Description

When **-n** is specified, the compiler driver processes options as usual, but does not execute any subprocesses to compile, assemble, or link applications.

-o (Set output file name)

Syntax

`-o filename`

Description

The `-o` option instructs the compiler driver to write linked output to *filename*.

-O (Optimize output)

Syntax

`-mx`

Description

Pass the optimization option `-Ox` to the compiler and linker. Specific `-O` optimization options are described in the compiler and linker reference sections.

-R (Set section name)

Syntax

-Rx

Description

Pass the option -Rx to the compiler and assembler to select standard section names. Specific -Rx options are described in the C compiler and assembler reference sections.

-s- (Exclude standard startup code)

Syntax

-s-

Description

C code requires a small startup file containing system initialization code to be executed before entering **main**. The standard startup code is found in the object file **\$(InstallDir)/lib/crt0.hzo** and the compiler driver automatically links this into your program. If, however, you do not require the standard startup code because you have a pure assembly language application, you can request the compiler driver to exclude this standard startup code from the link using the -s- option.

You will find the source code for the standard startup module crt0 in the file **\$(InstallDir)/src/crt0.asm**.

-v (Verbose execution)

Syntax

-v

Description

The **-v** switch displays command lines executed by the compiler driver.

-V (Display version)

Syntax

-V

Description

The compiler driver and other tools usually operate without displaying any information messages or banners, only diagnostics such as errors and warnings are displayed.

If the -V switch is given, the compiler driver displays its version and it passes the switch on to each compiler and the linker so that they display their respective versions.

-w (Suppress warnings)

Syntax

-w

Description

This option instructs the compiler, assembler, and linker not to issue any warnings.

Project property

Build Options > Suppress Warnings

-we (Treat warnings as errors)

Syntax

-we

Description

This option directs the compiler, assembler, and linker to treat all warnings as errors.

Project property

Build Options > Treat Warnings as Errors

-Wa (Pass option to assembler)

Syntax

`-Wa,option`

Description

The `-Wa` command-line option passes *option* directly to the assembler.

Example

The following command-line option passes `-V` directly to the assembler—the effect of this is to force the compiler to display its version information.

```
hcl -Wa,-V
```

-Wc (Pass option to compiler)

Syntax

`-Wc,option`

Description

The `-Wc` command-line option passes *option* directly to the compiler.

Example

The following command-line option passes `-V` directly to the compiler—the effect of this is to force the compiler to display its version information.

```
hcl -Wc,-V
```

-Wl (Pass option to linker)

Syntax

`-Wl,option`

Description

The `-Wl` command-line option passes *option* directly to the linker.

Example

The following command-line option passes `-V` directly to the linker—the effect of this is to force the linker to display its version information.

```
hcl -Wl,-V
```

Hex extractor

The hex extractor **hex** tool prepares images in a number of formats to burn into EPROM or flash memory.

Example

```
hex -Fhex app.hzx
```

This will generate a single Intel hex, **app.hzx.hex**, which contains all code and data in the application. The addresses in the output file are the physical addresses of where the code and data are to be loaded.

Command line options

This section describes the command line options accepted by the hex extractor.

-T (Extract named section)

Syntax

`-Tname`

Description

The **-T** option extracts the named section from the input file. By default, all loadable sections are extracted from the input file. You can specify multiple **-T** options on the command line to extract more than one section.

Example

```
hex app.hzx -Ftxt -TIDATA0 -TCODE
```

This reads the application file **app.hzx**, extracts the sections **IDATA0** and **CODE** (ignoring all others) and writes them to the file **app.hzx.txt**.

-F (Set output format)

Syntax

-F*fmt*

Description

The **-F** option sets the output format to *fmt*. The supported output formats are:

- **-Fsrec** — Motorola S-record format
- **-Fhex** — Intel extended hex format
- **-Txt** — Texas Instruments hex format
- **-Flst** — Hexadecimal listing
- **-Fbin** — Binary format

-o (Set output prefix)

Syntax

`-o prefix`

Description

The `-o` option sets the prefix to use for the created files. If `-o` is not specified on the command line, the input file name is used as the output prefix.

Example

```
hex app.hzx -Fhex -o app
```

-P (Pad space)

Syntax

`-Pval`

Description

The **-P** option pads space directives with *val*.

Example

```
hex app.hzx -P0x00
```

This pads space directives in the output file with **0x00**.

-V (Display version)

Syntax

-V

Description

The -V option instructs the hex extractor to display its version information.

Librarian

The librarian, or archiver, creates and manages *object code libraries*. An object code library is a collection of object files consolidated into a single file, called an *archive*. The benefit of an archive is that you can pass it to the linker, which will search the archive to resolve symbols needed during a link.

Automatic archiving

The compiler driver **hcl** can create archives if given the **-ar** option. This is more convenient than manipulating archives by hand, so we recommend that you use the compiler driver to construct archives.

Command syntax

You can invoke the archiver using the following syntax:

```
har [ option ] archive file...
```

archive is the archive to operate on. *file* is an object file to add, replace, or delete from the archive, as determined by *option*. *option* is a command-line option. Options are case sensitive and cannot be abbreviated.

-c (Create archive)

Syntax

```
har -c archive-name object-file...
```

Description

This option creates a new archive, overwriting any archive that already exists with the same name.

Example

To create an archive called **cclib.hza**, which initially contains the two object code files **ir.hzo** and **cg.hzo**, you would use:

```
har -c cclib.hza ir.hzo cg.hzo
```

-r (Add or replace archive member)

har -r archive-name [object-file...]

Description

You can replace members in an archive using the **-r** switch. If you specify a file to add to the archive, and the archive doesn't contain that member already, the file is appended to the archive as a new member.

Example

To replace the member **ir.hzo** in the archive **cclib.hza** with the file **ir.hzo** on disk, you would use:

```
har cclib.hza -r ir.hzo
```

-d (Delete archive members)

Syntax

```
har -d archive-name [object-file...]
```

Description

You can remove members from the archive by using the **-d** switch, short for *delete*.

Example

To remove the member **ir.hzo** from the archive **cclib.hza**, you would use:

```
har cclib.hza -d ir.hzo
```

-t (List archive members)

Syntax

```
har -t archive-name [object-file...]
```

Description

To show the members that comprise an archive, use the **-t** switch. The member's names are listed with their sizes. If you only give the archive name on the command line, the archiver lists all the members contained in the archive. However, you can list the attributes of specific members of the archive by specifying the names of the members you are interested in.

Example

To list all the members of the archive **cclib.hza**, use:

```
har -t cclib.hza
```

To list only the attributes of the member **ir.hzo** that is contained in the archive **cclib.hza**, use:

```
har -t cclib.hza ir.hzo
```

Command-Line Project Builder

CrossBuild is a program used to build your software from the command line without using **CrossStudio**. You can, for example, use **CrossBuild** for nightly (automated) builds, production builds, and batch builds.

Building with a CrossStudio project file

You can specify a CrossStudio project file:

Syntax

```
crossbuild [options...] project-file
```

You must specify a configuration to build using **-config**. For instance:

```
crossbuild -config "V5T Thumb LE Release" arm.hzp
```

The above example uses the configuration **V5T Thumb LE Release** to build all projects in the solution contained in **arm.hzp**.

To build a specific project that is in a solution, you can specify it using the **-project** option. For example:

```
crossbuild -config "V5T Thumb LE Release" -project "libm" libc.hzp
```

This example will use the configuration **V5T Thumb LE Release** to build the project **libm** that is contained in **libc.hzp**.

If your project file imports other project files (using the <import...> mechanism), when denoting projects you must specify the solution names as a comma-separated list in parentheses after the project name:

```
crossbuild -config "V5T Thumb LE Release" -project "libc(C Library)" arm.hzp
```

libc(C Library) specifies the **libc** project in the **C Library** solution that has been imported by the project file **arm.hzp**.

To build a specific solution that has been imported from other project files, you can use the **-solution** option. This option takes the solution names as a comma-separated list. For example:

```
crossbuild -config "ARM Debug" -solution "ARM Targets,EB55" arm.hzp
```

In this example, **ARM Targets,EB55** specifies the **EB55** solution imported by the **ARM Targets** solution, which was itself imported by the project file **arm.hzp**.

You can do a batch build using the **-batch** option:

```
crossbuild -config "ARM Debug" -batch libc.hzp
```

This will build the projects in **libc.hzp** that are marked for batch build in the configuration **ARM Debug**.

By default, a *make-style* build will be done—i.e., the dates of input files are checked against the dates of output files, and the build is avoided if the output is up to date. You can force a complete build by using the **-rebuild** option. Alternatively, to remove all output files, use the **-clean** option.

To see the commands being used in the build, use the **-echo** option. To also see why commands are being executed, use the **-verbose** option. You can see what commands will be executed, without executing them, by using the **-show** option.

Building without a CrossStudio project file

To use **CrossBuild** without a CrossStudio project, specify the name of an installed project template, the name of the project, and the files to build. For example:

```
crossbuild -config ... -template LM3S_EXE -project myproject -file main.c
```

Or, instead of a template, you can specify a project type:

```
crossbuild -config ... -type "Library" -project myproject -file main.c
```

You can specify project properties with the **-property** option:

```
crossbuild ... -property Target=LM3S811
```

Command-line options

This section describes the command-line options accepted by CrossBuild.

-batch (Batch build)

Syntax

-batch

Description

Perform a batch build.

-config (Select build configuration)

Syntax

-config *name*

Description

Specify the configuration for a build. If the configuration *name* can't be found, CrossBuild will list the available configurations.

-clean (Remove output files)

Syntax

-clean

Description

Remove all output files resulting from the build process.

-D (Define macro)

Syntax

`-D macro=value`

Description

Define a CrossWorks macro value for the build process.

-echo (Show command lines)

Syntax

`-echo`

Description

Show the command lines as they are executed.

-file (Build a named file)

Syntax

`-file name`

Description

Build the file *name*. Use with **-template** or **-type**.

-packagesdir (Specify packages directory)

Syntax

`-packagesdir dir`

Description

Override the default value of the `$(PackagesDir)` macro.

-project (Specify project to build)

Syntax

-project *name*

Description

Specify the name of the project to build. When used with a project file, if CrossBuild can't find the specified project, the names of available projects are listed.

-property (Set project property)

Syntax

-project *name=value*

Description

Specify the value of a project property — use with **-template** or **-type**. If CrossBuild cannot find the specified property, a list of the properties is shown.

-rebuild (Always rebuild)

Syntax

-rebuild

Description

Always execute the build commands.

-show (Dry run, don't execute)

Syntax

-show

Description

Show the command lines that would be executed, but do not execute them.

-solution (Specify solution to build)

Syntax

-solution *name*

Description

Specify the name of the solution to build. If CrossBuild cannot find the given solution, the valid solution names are listed.

-studiodir (Specify CrossStudio directory)

Syntax

-studiodir *name*

Description

Override the default value of the **\$(StudioDir)** macro.

-template (Specify project template)

Syntax

-template *name*

Description

Specify the project template to use. If CrossBuild cannot find the specified template then a list of template names is shown.

-time (Time the build)

Syntax

-time

Description

Show the time taken for the build.

-threadnum (Specify number of build threads)

Syntax

-threadnum *n*

Description

Specify the number of build threads to use for the build. The default is zero which will use the number of processor cores on your machine.

-type (Specify project type)

Syntax

-type *name*

Description

Specify the project type to use. If CrossBuild cannot find the specified project type then a list of project type names is shown.

-verbose (Show build information)

Syntax

-verbose

Description

Show extra information relating to the build process.

Command-Line Project Download and Debug

The **CrossLoad** program can be used to download and, optionally, debug applications without using CrossStudio.

In order to carry out a download or verify, **CrossLoad** needs to know what target interface to use. The supported target interfaces vary between operating systems; to list the supported target interfaces, use the **-listtargets** option:

```
crossload -listtargets
```

This command will produce a list of target interface names and descriptions, such as:

usb	USB CrossConnect
parport	Parallel Port Interface
sim	Simulator

Use the **-target** option followed by the desired target interface's name to specify which interface to use:

```
crossload -target usb ...
```

CrossLoad normally is used to download and/or verify projects created and built with CrossStudio. To do this, you must specify the target interface you want to use, the CrossStudio solution file, the project name, and the build configuration. The following command line will download and verify the debug version of the project **MyProject** contained within the **MySolution.hzp** solution file, using a USB CrossConnect:

```
crossload -target usb -solution MySolution.hzp -project MyProject -config Debug
```

In some cases, it is useful to download a program that was not created with CrossStudio by using the settings from an existing CrossStudio project. You might want to do this if your existing project describes specific loaders or scripts required in order to download the application. To do this, you simply add the name of the file you want to download to the command line. For example, the following command line will download the Intel hex file **ExternalApp.hex** using the release settings of the project **MyProject** connecting, using a USB CrossConnect:

```
crossload -target usb -solution MySolution.hzp -project MyProject -config Release  
ExternalApp.hex
```

CrossLoad can download and verify a range of file types. The supported file types vary between systems; to list the file types supported on your system, use the **-listfiletypes** option:

```
crossload -listfiletypes
```

This produces a list of the supported file types. For example:

hxx	CrossStudio Executable File
bin	Binary File
ihex	Intel Hex File
hex	Hex File

tihex	TI Hex File
srec	Motorola S-Record File

CrossLoad will attempt to determine the type of any load file given to it. If it cannot do this, you may specify the file type using the **-filetype** option:

```
crossload -target usb -solution MySolution.hzp -project MyProject -config Release
ExternalApp.txt -filetype tihex
```

It is possible, with some targets, to download without specifying a CrossStudio project. In such cases, you only need to specify the target interface and the load file. For example, the following will download **myapp.s19** using a USB CrossConnect:

```
crossload -target usb myapp.s19
```

Each target interface has a range of configurable properties allowing you to customize the default behaviour. To list the target properties and their current values, use the **-listprops** option:

```
crossload -target parport -listprops
```

This command will list the **parport** target-interfaces properties, a description of what the properties are, and their current values:

```
Name: JTAG Clock Divider
Description: The amount to divide the JTAG clock frequency.
Value : 1

Name: Parallel Port
Description: The parallel port connection to use to connect to target.
Value : Lpt1

Name: Parallel Port Sharing
Description: Specifies whether sharing of the parallel port with other device drivers or
programs is permitted.
Value : No
```

You can modify a target property using the **-setprop** option. For example, the following command line would set the parallel port interfaced used to **Lpt2**:

```
crossload -target parport -setprop "Parallel Port"="Lpt2" ...
```

Command line debugging

You can instruct CrossLoad to start a command-line debugging session by using **-debug** and optional **-break** and **-script** options. For example:

```
crossload -target sim -solution mysolution.hzp -project myproject -config "ARM RAM Debug" -  
debug -break main
```

This will load the executable created with the **ARM RAM Debug** configuration for **myproject** onto the simulator and run it until its **main** function is called.

A command prompt is then shown that will accept JavaScript statements. The debugger functionality is accessed using the built-in JavaScript object **Debug**, so all debugger commands are entered using the form **Debug.command()**.

Managing breakpoints

You can set breakpoints on global symbols using the **Debug.breakexpr("expr")** method. The type of the symbol will determine the breakpoint that is set. For example...

```
Debug.breakexpr( "fn1" )
```

...will set a breakpoint on entry to the **fn1** function, and...

```
Debug.breakexpr( "var1" )
```

...will set a breakpoint when the variable **var1** is written. This method can also be used set breakpoints on addresses. For example...

```
Debug.breakexpr( "0x248" )
```

...will cause a breakpoint when the address **0x248** is executed, and...

```
Debug.breakexpr( "(unsigned[1])0xec8" )
```

...will cause a breakpoint when the word at the address **0xec8** is written.

You can use the **Debug.breakline("filename", linenumber)** method to set breakpoints on specific lines of code. For example, to set a breakpoint at line number 4 of **c:/directory/file.c**, you can use:

```
Debug.breakline( "c:/directory/file.c" , 4)
```

Note the use of forward slashes when specifying filenames.

To refer to the current file (the one where the debugger is located), you can use the **Debug.getfilename()** method. Similarly, the current line number is accessed using the **Debug.getlinenumber()** method. Using these functions, you can set a breakpoint at a line-offset from the current position. For example...

```
Debug.breakline( Debug.getfilename() , Debug.getlinenumber() +4 )
```

...will break at 4 lines after the current line.

You can use the **Debug.breakdata("expr", value, readNotWrite)** method to set a breakpoint for when a value is written to a global variable. For example...

```
Debug.breakdata( "var1" , 4 , false )
```

...will cause a breakpoint when the value 4 is written to variable **var**. The third parameter, **readNotWrite** specifies whether a breakpoint is set on reading (true) or writing (false) the data.

Each method of setting a breakpoint accepts three optional arguments: *temporary*, *counter*, and *hardware*.

A *temporary breakpoint* is removed the next time it occurs. For example...

```
Debug.breakexpr("fn1()", true)
```

...will break on entry to **fn1** unless another breakpoint occurs before this one.

Counted breakpoints are ignored for the specified number of hits. For example...

```
Debug.breakexpr("fn1()", false, 9)
```

...will break the 10th time **fn1** is called.

The **hardware** argument specifies whether the debugger should use a hardware breakpoint in preference to a software breakpoint. This can be used to set breakpoints on code that is copied to RAM prior to the copying.

The **breakexpr** and **breakline** methods return a positive breakpoint number that can be used to delete the breakpoint using the **Debug.deletebreak(number)** method. For example:

```
fn1bkpt = Debug.breakexpr("fn1")
...
Debug.deletebreak(fn1bkpt)
```

To delete all breakpoints, supply zero to the **deletebreak** method. Note that temporary breakpoints do not have breakpoint numbers.

The **Debug.showbreak(number)** method displays information about a breakpoint.

To show all breakpoints, supply zero to the **showbreak** method.

Some targets support *exception breakpoints*, which can be listed using the **Debug.showexceptions()** method. For example, on an ARM9 or XScale target:

```
> Debug.showexceptions()
Reset disabled
Undef enabled
SWI disabled
P_Abort enabled
D_Abort enabled
IRQ disabled
FIQ disabled
>
```

You can enable or disable an exception with the **Debug.enableexception("exception", enable)** method. For example...

```
Debug.enableexception("IRQ", true)
```

...will enable breakpoints when the IRQ exception occurs.

Some targets support *breakpoint chaining*. This enables breakpoints to be paired, with one breakpoint enabling another one. For example:

```
> first = Debug.breakdata("count", 3)
```

```
> second = Debug.breakexpr("fn1")
> Debug.chainbreak(first, second)
```

When **count** is written with the value 3, the breakpoint at **fn1** is enabled; so when **fn1** is subsequently called, if ever, the breakpoint occurs. To remove breakpoint chaining, specify 0 as the second argument. For example:

```
Debug.chainbreak(first, 0)
```

Deleting either of the chained breakpoints will break the chain.

Displaying state

You can display the register state of the current context using the **Debug.printRegisters** method, the local variables of the current context using the **Debug.printLocals()** method and the global variables by using the **Debug.printGlobals()** method. To display single variables, use the **Debug.print("expr"[,"format"])** method. For example, where **int i = -1**:

```
> Debug.print("i")
0xffffffff
> Debug.print("i", "d")
-1
> Debug.print("i", "u")
4294967295
>
```

You can change the default radix, used when printing numbers, with the **Debug.setPrintRadix(radix)** method. For example:

```
> Debug.setPrintRadix(10)
> Debug.print("i")
-1
> Debug.setPrintRadix(8)
> Debug.print("i")
037777777777
>
```

The **Debug.print** method is used to access registers...

```
> Debug.print("@pc")
0x000002ac
>
```

...and memory, too:

```
> Debug.print("((unsigned[2])0x0)")
[0xeafffffe, 0xe59ff018]
>
```

You can use the print method to update variables, registers, and memory using assignment operators:

```
> Debug.print("x=45")
0x0000002d
> Debug.print("x+=45")
0x0000005a
>
```

You can change whether character pointers are displayed as null-terminated strings using the **Debug.setPrintString(bool)** method. For example, where **const char *string = "hello"**:

```
> Debug.print("string")
hello
> Debug.print("string", "p")
0x00000070
```

```
> Debug.setprintstring(false)
> Debug.print("string")
0x00000770
> Debug.print("string", "s")
hello
>
```

To change the maximum number of array elements that will be displayed, use the **Debug.setprintarray(n)** method. For example, where **unsigned array[4] = {1, 2, 3, 4};**:

```
> Debug.print("array", "d")
[1, 2, 3, 4]
> Debug.setprintarray(2)
> Debug.print("array", "d")
[1, 2]
```

You can use the **Debug.evaluate(expr)** method to return the value of variables rather than displaying them. For example...

```
> x = Debug.evaluate("x")
> if (x == -1) Debug.echo("x is 45")
x is 45
>
```

...where the method **Debug.echo(str)** outputs its string argument.

Locating the current context

You can use the **Debug.where()** method to display a backtrace of the functions that have been called. Each entry in the backtrace has its own *framenumber* which can be supplied to the **Debug.locate(framenumber)** method. Framenumbers start at zero and are incremented for each function call. So framenumber zero is the current location, framenumber one is the caller of the current location, and so on. For example...

```
> Debug.where()
0) int debug_printf(const char* fmt=5)  C:\svn\shared\target\libc\debug_printf.c:6
1) int main()   C:\tmp\try\main.c:17
2) ???  C:\svn\arm\arm\source\crt0.s:237
>
```

...then...

```
Debug.locate(1)
```

...will locate the debugger context at **main** and...

```
Debug.locate(0)
```

...will change the debugger location back to **debug_printf**.

When the debugger locates (either because `locate` has been called or it has stopped), the corresponding source line is displayed. You can display source lines around the located line by using the **Debug.list(before, after)** method, which specifies the number of lines to display before and after the located line.

You can set the debugger to locate (and step) to machine instructions using the method **Debug.setmode(mode)**. Setting the mode to 1 selects interleaved mode (source code interleaved with assembly code). Setting the mode to 2 selects assembly mode (disassembly with source code annotation). Setting the mode to 0 selects source mode. For example:

```
> Debug.setmode(2)
0000031C E1A0C00D  mov r12, sp
> Debug.stepinto()
00000320 E92DD800  stmfd sp!, {r11-r12, lr-pc}
>Debug.setmode(0)
>
```

You can locate the debugger at a specified program counter by using the **Debug.locatepc(pc)** method. For example, you can disassemble from specific address:

```
> Debug.setmode(2)
> Debug.locatepc(0x2f4)
000002F4      E59F30D0  ldr r3, [pc, #+0x0D0]
> Debug.list(0, 1)
000002F4      E59F30D0  ldr r3, [pc, #+0x0D0]
000002F8      E50B3020  str r3, [r11, #-0x020]
>
```

You can locate the debugger to a full register context using the **Debug.locateregisters(registers)** method. This method takes an array that specifies each register value, typically in ascending register number order. You can use the **Debug.printregisters()** method to see the the order. For example, for an ARM7, ARM9, or XScale:

```
var a = new Array()  
a[0] = 0 // r0 value  
?  
a[15] = 0x2f4 // pc value  
a[16] = 0x10 // cspr value  
Debug.locateregisters(a)
```

You can put the debugger context back at the stopped state by calling **Debug.locate** without any parameters:

```
Debug.locate()
```

Controlling execution

To continue execution from a breakpoint, use the **Debug.go()** method. You can single step into function calls with **Debug.stepinto()**. You can single step over function calls by using the **Debug.stepover()** method. To complete execution of the current function, use the **Debug.stepout()** method.

You will get the debugger prompt immediately when the **go**, **stepinto**, **stepover** or **stepout** methods are called. If you want to wait for the target to stop (for example in a script), you need to use the **Debug.wait(msTimeout)** method, which returns 0 if the millisecond timeout occurred or 1 if execution has stopped. For example...

```
> Debug.go(); Debug.wait(1000)
```

...will wait for one second or until a breakpoint occurs. If a breakpoint isn't reached, you can use the method **Debug.breaknow()** to stop execution. You can end the debug session with the **Debug.quit()** method.

Support packages

The preceding examples assume that the support packages required to carry out the download or debugging have already been installed using CrossStudio's package manager. On some systems however, it is not possible or desirable to use CrossStudio to do this. This section describes how to manually install packages from the command line and specify where CrossLoad should look for them.

The first thing to do is decide on the directory path to store the installed packages, we're going to use an environment variable **PACKAGES_DIR** to specify this. For example:

```
export PACKAGES_DIR=/my_crossload_packages
echo $PACKAGES_DIR
```

Please note, Windows command prompt users should use **set** instead of **export** and **%PACKAGES_DIR%** instead of **\$PACKAGES_DIR**.

Next, we need to get hold of the package .hzq or .hzr files to be installed. These can be downloaded from our [package website](#) or [package archive](#).

Once we have got the package files, the **mkpkg** tool can be used to install the packages. For example:

```
mkpkg -x CMSIS_3.hzq $PACKAGES_DIR
mkpkg -x LPC1000.hzq $PACKAGES_DIR
```

By default, CrossLoad will look for packages in CrossStudio's packages directory. We can override this so that our local package installation is used instead with CrossLoad's **-packagesdir** option. For example:

```
crossload -packagesdir $PACKAGES_DIR -target usb -solution MySolution.hzp -project
MyProject -config Debug
```

Command-line options

This section describes the command-line options accepted by CrossLoad.

Usage

crossload [*options...*] [*files...*]

ARM Usage

crossload [*options...*] [*files...*] **-serve** [*arguments...*]

-break (Stop execution at symbol)

Syntax

-break *symbol*

Description

When used with the **-debug** option, this will stop execution at *symbol*.

-config (Specify build configuration)

Syntax

-config *name*

Description

Specify the build configuration to use.

-connection (Specify connection)

Syntax

-connection *name*

Description

Specify the connection to use.

-debug (Enter command line debugging)

Syntax

`-debug`

Description

Enable command-line debugging. A command prompt is displayed at which debugger commands can be entered. The command prompt has a simple history and editing mechanism.

-eraseall (Erase all flash memory)

Syntax

-eraseall

Description

Erase all flash memory rather than just the flash memory to be programmed.

-filetype (Specify load file type)

Syntax

-filetype *filetype*

Description

Specify the type of the file to download. By default, **CrossLoad** will attempt to detect the file type, you should use this option if **CrossLoad** cannot determine the file type or to override the detection and force the type to a specific value. Use the **-listfiletypes** option to list the supported file types.

-help (Display help)

Syntax

-help

Description

Display the command-line options **CrossLoad** accepts.

-listfiletypes (Display supported load file types)

Syntax

-listfiletypes

Description

Lists all the supported file types.

-listprops (Display target properties)

Syntax

-listprops

Description

List the target properties of the target specified by the **-target** option.

-listtargets (Display supported target interfaces)

Syntax

-listtargets

Description

List all the supported target interfaces.

-loadaddress (Set load address)

Syntax

-loadaddress *address*

Description

When downloading a load file that doesn't contain any address information, such a binary file, this option specifies the base address to which the file should be downloaded.

-loader (Specify loader configuration)

Syntax

-loader *config*

Description

Select the loader configuration to use for the download.

-nodifferential (Inhibit differential download)

Syntax

-nodifferential

Description

Do not use differential downloading.

-nodisconnect (Inhibit target disconnection)

Syntax

-nodisconnect

Description

Do not disconnect the target interface when finished.

-nodownload (Inhibit download)

Syntax

-nodownload

Description

Do not download, just verify.

-noverify (Inhibit verification)

Syntax

-noverify

Description

Do not verify the downloaded application.

-packagesdir (Specify package directory)

Syntax

-packagesdir *directory*

Description

Set \$(PackagesDir) to *directory*.

-project (Specify project name)

Syntax

-project *name*

Description

Specify the name of the desired project.

-quiet (Be silent)

Syntax

-quiet

Description

Do not output any progress messages.

-script (Execute debug script)

Syntax

-script *file*

Description

When used with the **-debug** option, this will execute the debug commands in *file*.

-serve (Run semihosting server)

Syntax

-serve

Description

Serve CrossStudio debug I/O operations. Any command-line arguments following this option will be passed to the target application. The application can access them either by calling **debug_getargs** or by compiling the startup code in **crt0.s** or **crt0.asm** with the **FULL_LIBRARY** C preprocessor symbol defined so that **argc** and **argv** are passed to **main**.

-setprop (Set target interface property)

Syntax

`-setprop property=value`

Description

Set the target interface property *property* to *value*.

-solution (Specify solution file)

Syntax

-solution *file*

Description

Specify the CrossWorks solution file to use.

-studiodir (Specify Studio directory)

Syntax

-studiodir *directory*

Description

Set **\$(StudioDir)** to *directory*.

-target (Specify target interface)

Syntax

-target *name*

Description

Specify the target interface to use. Use the **-listtargets** option to list the supported target interfaces.

-verbose (Display additional status)

Syntax

-verbose

Description

Produce verbose output.

Command-Line Scripting

CrossScript is a program that allows you to run CrossStudio's JavaScript (ECMAScript) interpreter from the command line.

The primary purpose of **CrossScript** is to facilitate the creation of platform-independent build scripts.

Syntax

```
crossscript [options] file...
```

Command-line options

This section describes the command-line options accepted by CrossScript.

-define (Define global variable)

Syntax

-define *variable*=*value*

Description

-help (Show usage)

Syntax

-help

Description

Display usage information and command line options.

-load (Load script file)

Syntax

-load *path*

Description

Loads the script file *path*.

-define (Verbose output)

Syntax

-verbose

Description

Produces verbose output.

CrossScript classes

CrossScript provides the following predefined classes:

- [BinaryFile](#)
- [CWSys](#)
- [WScript](#)

Example uses

The following example demonstrates using **CrossScript** to increment a build number:

First, add a JavaScript file to your project called `incbuild.js` containing the following code:

```
function incbuild()
{
    var file = "buildnum.h"
    var text = "#define BUILDNUMBER "
    var s = CWSys.readStringFromFile(file);
    var n;
    if (s == undefined)
        n = 1;
    else
        n = eval(s.substring(text.length)) + 1;
    CWSys.writeStringToFile(file, text + n);
}

// Executed when script loaded.
incbuild();
```

Add a file called `getbuildnum.h` to your project containing the following code:

```
#ifndef GETBUILDNUM_H
#define GETBUILDNUM_H

unsigned getBuildNumber();

#endif
```

Add a file called `getbuildnum.c` to your project containing the following code:

```
#include "getbuildnum.h"
#include "buildnum.h"

unsigned getBuildNumber()
{
    return BUILDNUMBER;
}
```

Now, to combine these:

- Set the **Build Options > Always Rebuild** project property of `getbuildnum.c` to **Yes**.
- Set the **User Build Step Options > Pre-Compile Command** project property of `getbuildnum.c` to `"$(StudioDir)/bin/crossscript" -load "$(ProjectDir)/incbuild.js"`.

Embed

Embed is a program that converts a binary file into a C/C++ array definition.

The primary purpose of the **Embed** tool is to provide a simple method of embedding files into an application. This may be useful if you want to include firmware images, bitmaps, etc. in your application without having to read them first from an external source.

Syntax

```
embed variable_name input_file output_file
```

variable_name is the name of the C/C++ array to be initialised with the binary data.

input_file is the path to the binary input file.

output_file is the path to the C/C++ source file to generate.

Example

To convert a binary file *image.bin* to a C/C++ file called *image.h*:

```
embed img image.bin image.h
```

This will generate the following output in *image.h*:

```
static const unsigned char img[] = {
    0x5B, 0x95, 0xA4, 0x56, 0x16, 0x5F, 0x2D, 0x47,
    0xC5, 0x04, 0xD4, 0x8D, 0x73, 0x40, 0x31, 0x66,
    0x3E, 0x81, 0x90, 0x39, 0xA3, 0x8E, 0x22, 0x37,
    0x3C, 0x63, 0xC8, 0x30, 0x90, 0x0C, 0x54, 0xA4,
    0xA2, 0x74, 0xC2, 0x8C, 0x1D, 0x56, 0x57, 0x05,
    0x45, 0xCE, 0x3B, 0x92, 0xAD, 0x0B, 0x2C, 0x39,
    0x92, 0x59, 0xB9, 0x9D, 0x01, 0x30, 0x59, 0x9F,
    0xC5, 0xEA, 0xCE, 0x35, 0xF6, 0x4B, 0x05, 0xBF
};
```

Header file generator

The command line program **mkhdr** generates a C or C++ header file from a CrossWorks memory map file.

Using the header generator

For each register definition in the memory map file a corresponding **#define** is generated in the header file. The **#define** is named the same as the register name and is defined as a volatile pointer to the address.

The type of the pointer is derived from the size of the register. A four-byte register generates an unsigned long pointer. A two-byte register generates an unsigned short pointer. A one-byte register will generate an unsigned char pointer.

If a register definition in the memory map file has bitfields then preprocessor symbols are generated for each bitfield. Each bitfield will have two preprocessor symbols generated, one representing the mask and one defining the start bit position. The bitfield preprocessor symbol names are formed by prepending the register name to the bitfield name. The mask definition has **_MASK** appended to it and the start definition has **_BIT** appended to it.

For example consider the following definitions in the file **memorymap.xml**.

```
<RegisterGroup start="0xFFFFF000" name="AIC">
  <Register start="+0x00" size="4" name="AIC_SMR0">
    <BitField size="3" name="PRIOR" start="0" />
    <BitField size="2" name="SRCTYPE" start="5" />
  </Register>
  ...

```

We can generate the header file associated with this file using:

```
mkhdr memorymap.xml memorymap.h
```

This generates the following definitions in the file **memorymap.h**.

```
#define AIC_SMR0 (*volatile unsigned long *)0xFFFFF000)
#define AIC_SMR0_PRIOR_MASK 0x7
#define AIC_SMR0_PRIOR_BIT 0
#define AIC_SMR0_SRCTYPE_MASK 0x60
#define AIC_SMR0_SRCTYPE_BIT 5
```

These definitions can be used in the following way in a C/C++ program:

Reading a register

```
unsigned r = AIC_SMR0;
```

Writing a register

```
AIC_SMR0 = (priority << AIC_SMR0_PRIOR_BIT) | (srctype << AIC_SMR0_SRCTYPE_BIT);
```

Reading a bitfield

```
unsigned srctype = (AIC_SMR0 & AIC_SMR0_SRCTYPE_MASK) >> AIC_SMR0_SRCTYPE_BIT;
```

Writing a bitfield

```
AIC_SMR0 = (AIC_SMR0 & ~AIC_SMR0_SRCTYPE_MASK) | ((srctype & AIC_SMR0_SRCTYPE_MASK) << AIC_SMR0_SRCTYPE_BIT)
```

Command line options

This section describes the command line options accepted by the header file generator.

Syntax

mkhdr *inputfile* *outputfile* *targetname* [*option...*]

inputfile is the name of the source CrossWorks memory map file. **outputfile** is the the name of the file to write.

-regbaseoffsets (Use offsets from peripheral base)

Syntax

-regbaseoffsets

Description

Instructs the header generator to include offsets of registers from the peripheral base.

-nobitfields (Inhibit bitfield macros)

Syntax

-nobitfields

Description

Instructs the header generator not to generate any definitions for bitfields.

Package generator

To create a package the program **mkpkg** can be used. The set of files to put into the package should be in the desired location in the `$(PackagesDir)` directory. The **mkpkg** command should be run with `$(PackagesDir)` as the working directory and all files to go into the package must be referred to using relative paths. A package must have a package description file that is placed in the `$(PackagesDir)/packages` directory. The package description file name must end with `_package.xml`. If a package is to create entries in the new project wizard then it must have a file name `project_templates.xml`.

For example, a package for the mythical FX150 processor would supply the following files:

- A project template file called `targets/FX150/project_templates.xml`. The format of the project templates file is described in [Project Templates file format](#).
- The `$(PackagesDir)`-relative files that define the functionality of the package.
- A package description file called `packages/FX150_package.xml`. The format of the package description file is described in [Package Description file format](#).

The package file `FX150.hzq` would be created using the following command line:

```
mkpkg -c packages/FX150.hzq targets/FX150/project_templates.xml ... packages/
FX150_package.xml
```

You can list the contents of the package using the **-t** option:

```
mkpkg -t packages/FX150.hzq
```

You can remove an entry from a package using the **-d** option:

```
mkpkg -d packages/FX150.hzq -d fileName
```

You can add or replace a file into an existing package using the **-r** option:

```
mkpkg -r packages/FX150.hzq -r fileName
```

You can extract files from an existing package using the **-x** option:

```
mkpkg -x packages/FX150.hzq outputDirectory
```

You can automate the package creation process using a **Combining** project type.

- Using the new project wizard create a combining project in the directory `$(PackagesDir)`.
- Set the **Output File Path** property to be `$(PackagesDir)/packages/mypackage.hzq`.
- Set the **Combine command** property to `$(StudioDir)/bin/mkpkg -c $(CombiningOutputFilePath) $(CombiningRelInputPaths)`.
- Add the files you want to go into the package into the project using the Project Explorer.
- Right-click the project node in the Project Explorer and choose **Build**.

When a package is installed, the files in the package are copied into the desired `$(PackagesDir)`-relative locations. When a file is copied into the `$(PackagesDir)/packages` directory and its filename ends with

_package.xml the file \$(PackagesDir)/packages/installed_packages.xml is updated with an entry:

```
<include filename="FX150_package.xml" />
```

During development of a package you can manually edit this file. The same applies to the file \$(PackagesDir)/targets/project_templates.xml which will contain a reference to your project_templates.xml file.

Usage:

```
mkpkg [options] packageFileName file1 file2 ...
```

Option	Description
-c	Create a new package.
-compress level	Change compression level (0 for none, 9 for maximum).
-d	Remove files from a package.
-f	Output files to stdout.
-r	Replace files in a package.
-readonly	Force all files to have read only attribute.
-t	List the contents of a package.
-v	Be chatty.
-V	Show version information.
-x	Extract files from a package.



Appendices

File formats

This section describes the file formats CrossWorks uses:

Memory Map file format

Describes the memory map file format that defines memory regions and registers in a microcontroller.

Section Placement file format

Describes the section placement file format that maps program sections to memory areas in the target microcontroller.

Project file format

Describes the format of CrossStudio project files.

Project Templates file format

Describes the format of project template files used by the **New Project** wizard.

Property Groups file format

Describes the format of the property groups file you can use to define 'meta-properties'.

Package Description file format

Describes the format of the package description files you use to create packages other users can install in CrossStudio.

External Tools file format

Describes the format of external tool configuration files you use to extend CrossStudio.

Memory Map file format

CrossStudio memory-map files are structured using XML syntax for its simple construction and parsing.

The first entry of the project file defines the XML document type used to validate the file format.

```
<!DOCTYPE Board_Memory_Definition_File>
```

The next entry is the `Root` element. There can only be one `Root` element in a memory map file:

```
<Root name="My Board">
```

A `Root` element has a `name` attribute — every element in a memory map file has a `name` attribute. Names should be unique within a hierarchy level. Within a `Root` element, there are `MemorySegment` elements that represent regions within the memory map.

```
<Root name="My Board">
  <MemorySegment name="Flash" start="0x1000" size="0x200" access="ReadOnly">
```

`MemorySegment` elements have the following attributes:

- `start`: The start address of the memory segment. A simple expression, usually a hexadecimal number with a `0x` prefix.
- `size`: The size of the memory segment. A simple expression, usually a hexadecimal number with a `0x` prefix.
- `access`: The permissible access types of the memory segment. One of `ReadOnly`, `Read/Write`, `WriteOnly`, or `None`.
- `address_symbol`: A symbolic name for the start address of the memory segment.
- `size_symbol`: A symbolic name for the size of the memory segment.
- `address_symbol`: A symbolic name for the end address of the memory segment.

`RegisterGroup` elements are used to organize registers into groups. `Register` elements are used to define peripheral registers:

```
<Root name="My Board" >
  <MemorySegment name="System" start="0x2000" size="0x200" >
    <RegisterGroup name="Peripheral1" start="0x2100" size="0x10" >
      <Register name="Register1" start="+0x8" size="4" >
```

`RegisterGroup` elements have the same attributes as `MemorySegment` elements. `Register` elements have the following attributes:

- `name`: Register names should be valid C/C++ identifier names, i.e., alphanumeric characters and underscores are allowed but names cannot start with a number.
- `start`: The start address of the memory segment. Either a C-style hexadecimal number or, if given a `+` prefix, an offset from the enclosing element's start address.
- `size`: The size of the register in bytes, either 1, 2, or 4.

- *access*: The same as the *access* attribute of the `MemorySegment` element.
- *address_symbol*: The same as the *address_symbol* attribute of the `MemorySegment` element.

A `Register` element can contain `BitField` elements that represent the bits in a peripheral register:

```
<Root name="My Board" >
  <MemorySegment name="System" start="0x2000" size="0x200" >
    <RegisterGroup name="Peripheral1" start="0x2100" size="0x10" >
      <Register name="Register1" start="+0x8" size="4" >
        <BitField name="Bits_0_to_3" start="0" size="4" />
```

`BitField` elements have the following attributes:

- *name*: The same as the *name* attribute of the `RegisterGroup` element.
- *start*: The starting bit position, 0–31.
- *size*: The total number of bits, 1–32.

A `Bitfield` element can contain `Enum` elements:

```
<Root name="My Board" >
  <RegisterGroup name="Peripheral1" start="0x2100" size="0x10" >
    <Register name="Register1" start="+0x8" size="4" >
      <BitField name="Bits_0_to_3" start="0" size="4" >
        <Enum name="Enum3" start="3" />
        <Enum name="Enum5" start="5" />
```

You can import CMSIS SVD files (see <http://www.onarm.com/>) into a memory map using the `ImportSVD` element:

```
<ImportSVD filename="$(TargetsDir)/targets/Manufacturer1/Processor1.svd.xml">
```

The *filename* attribute is an absolute filename which is macro-expanded using CrossWorks system macros.

When a memory map file is loaded either for the memory map viewer or to be used for linking or debugging, it is preprocessed using the (as yet undocumented) CrossWorks XML preprocessor.

Section Placement file format

CrossStudio section-placement files are structured using XML syntax to enable simple construction and parsing.

The first entry of the project file defines the XML document type used to validate the file format:

```
<!DOCTYPE Linker_Placement_File>
```

The next entry is the `Root` element. There can only be one `Root` element in a memory map file:

```
<Root name="Flash Placement">
```

A `Root` element has a `name` attribute. Every element in a section-placement file has a `name` attribute. Each name should be unique within its hierarchy level. Within a `Root` element, there are `MemorySegment` elements. These correspond to memory regions defined in a memory map file that will be used in conjunction with the section-placement file when linking a program. For example:

```
<Root name="Flash Placement">
<MemorySegment name="FLASH">
```

A `MemorySegment` contains `ProgramSection` elements that represent program sections created by the C/C++ compiler and assembler. The order of `ProgramSection` elements within a `MemorySegment` element represents the order in which the sections will be placed when linking a program. The first `ProgramSection` will be placed first and the last one will be placed last.

```
<Root name="My Board" >
<MemorySegment name="FLASH">
  <ProgramSection name=".text">
```

`ProgramSection` elements have the following attributes:

- `address_symbol`: A symbolic name for the start address of the section.
- `alignment`: The required alignment of the program section; a decimal number specifying the byte alignment.
- `end_symbol`: A symbolic name for the end address of the section.
- `load`: If **Yes**, the section is loaded. If **No**, the section isn't loaded.
- `runin`: This specifies the name of the section to copy this section to.
- `size`: The optional size of the program section in bytes, a hexadecimal number with a 0x prefix.
- `size_symbol`: A symbolic name for the size of the section.
- `start`: The optional start address of the program section, a hexadecimal number with a 0x prefix.

When a section placement file is used for linking it is preprocessed using the (as yet undocumented) CrossWorks XML preprocessor.

Project file format

CrossStudio project files are held in text files with the .hzb extension. Because you may want to edit project files, and perhaps generate them, they are structured using XML syntax to enable simple construction and parsing.

The first entry of the project file defines the XML document type used to validate the file format:

```
<!DOCTYPE CrossStudio_Project_File>
```

The next entry is the `solution` element; there can only be one `solution` element in a project file. This specifies the solution name displayed in the **Project Explorer** and has a `version` attribute that defines the file-format version of the project file. Solutions can contain projects, projects can contain folders and files, and folders can contain folders and files. This hierarchy is reflected in the XML nesting—for example:

```
<solution version="1" Name="solutionname">
  <project Name="projectname">
    <file Name="filename" />
    <folder Name="foldername">
      <file Name="filename2" />
    </folder>
  </project>
</solution>
```

Note that each entry has a `Name` attribute. Names of `project` elements must be unique to the `solution`, and names of `folder` elements must be unique to the `project`, but names of files do not need to be unique.

Each `file` element must have a `file_name` attribute that is unique to the `project`. Ideally, the `file_name` is a file path relative to the `project` (or `solution` directory), but you can also specify a full file path, if you want to. File paths are case-sensitive and use "/" as the directory separator. They may contain macro instantiations, so file paths cannot contain the "\$" character. For example...

```
<file file_name="$(StudioDir)/source/crt0.s" Name="crt0.s" />
```

...will be expanded using the value of `$(StudioDir)` when the file is referenced from CrossStudio.

Project properties are held in configuration elements with the `Name` attribute of the configuration element corresponding to the configuration name, e.g., "Debug". At a given project level (i.e., `solution`, `project`, `folder`), there can only be one named configuration element—i.e., all properties defined for a configuration are in single configuration element.

```
<project Name="projectname">
?
<configuration project_type="Library" Name="Common" />
<configuration Name="Release" build_debug_information="No" />
?
</project>
```

You can use the `import` element to link projects:

```
<import file_name="target/libc.hzb" />
```

Project Templates file format

The CrossStudio New Project dialog works from a file called `project_templates.xml` in the targets subdirectory of the CrossStudio installation directory. Because you may want to add your own new project types, they are structured using XML syntax to enable simple construction and parsing.

The first entry of the project file defines the XML document type used to validate the file format:

```
<!DOCTYPE Project_Templates_File>
```

The next entry is the `projects` element, which is used to group a set of new project entries into an XML hierarchy.

```
<projects>
  <project> ...
</projects>
```

Each entry has a `project` element that contains the class of the project (attribute `caption`), the name of the project (attribute `name`), its type (attribute `type`) and a description (attribute `description`). For example:

```
<project caption="ARM Evaluator7T" name="Executable"
  description="An executable for an ARM Evaluator7T." type="Executable" />
```

The project type can be one of these:

- *Executable*: — a fully linked executable.
- *Library*: — a static library.
- *Object file*: — an object file.
- *Staging*: — a staging project.
- *Combining*: — a combining project.
- *Externally Built Executable*: — an externally built executable.

The configurations to be created for the project are defined using the `configuration` element, which must have a `name` attribute:

```
<configuration name="ARM RAM Release" />
```

The property values to be created for the project are defined using the `property` element. If you have a defined value, you can specify this using the `value` attribute and, optionally, set the property in a defined configuration, such as:

```
<property name="target_reset_script" configuration="RAM"
  value="Evaluator7T_ResetWithRamAtZero()" />
```

Alternatively, you can include a property that will be shown to the user, prompting them to supply a value as part of the new-project process.

```
<property name="linker_output_format" />
```

The folders to be created are defined using the `folder` element. The `folder` element must have a `name` attribute and can also have a `filter` attribute. For example:

```
<folder name="Source Files" filter="c;cpp;cxx;cc;h;s;asm;inc" />
```

The files to be in the project are specified using the `file` element. You can use build-system macros (see [Project macros](#)) to specify files located in the CrossStudio installation directory. Files will be copied to the project directory or just left as references, depending on the value of the `expand` attribute:

```
<file name="$(StudioDir)/source/crt0.s" expand="no" />
```

You can define the set of configurations that can be referred to in the top-level `configurations` element:

```
<configurations>
  <configuration> ...
</configurations>
```

This contains the set of all configurations that can be created when a project is created. Each configuration is defined using a `configuration` element, which can define the property values for that configuration. For example:

```
<configuration name="Debug">
  <property name="build_debug_information" value="Yes">
```

Property Groups file format

The CrossStudio project system provides a means to create new properties that change a number of project property settings and can also set C pre-processor definitions when selected. Such properties are called *property groups* and are defined in a property-groups file. The property-group file to use for a project is defined by the **Property Groups File** property. These files usually define target-specific properties and are structured using XML syntax to enable simple construction and parsing.

The first entry of the property groups file defines the XML document type, which is used to validate the file format:

```
<!DOCTYPE CrossStudio_Group_Values>
```

The next entry is the `propertyGroups` element, which is used to group a set of property groups entries into an XML hierarchy:

```
<propertyGroups>
  <groupdots
  ?
  <groupdots
</propertyGroups>
```

Each group has the name of the group (attribute `name`), the name of the options category (attribute `group`), short (attribute `short`) and long (attribute `long`) help descriptions, and a default value (attribute `default`). For example:

```
<group short="Target Processor" group="Build Options" short="Target Processor"
       long="Select a set of target options" name="Target" default="STR912FW44" />
```

Each group has a number of `groupEntry` elements that define the enumerations of the group.

```
<group...>
  <groupEntry>
  ...
  ...
  <groupEntry>
  ...
</group>
```

Each `groupEntry` has the name of the entry (attribute `name`), e.g.:

```
<groupEntry name="STR910FW32">
```

A `groupEntry` has the property values and C pre-processor definitions that are set when the `groupEntry` is selected; they are specified with `property` and `cdefine` elements. For example:

```
<groupEntry>
  ...
    <property>
  ...

```

```
<cdefine>
...
<property>
...
</groupEntry>
```

A **property** element has the property's name (attribute `name`), its value (attribute `value`), and an optional configuration (attribute `configuration`):

```
<property name="linker_memory_map_file"
  value="$(StudioDir)/targets/ST_STR91x/ST_STR910FM32_MemoryMap.xml" />
```

A **cdefine** element has the C preprocessor name (attribute `name`) and its value (attribute `value`):

```
<cdefine value="STR910FM32" name="TARGET_PROCESSOR" />
```

Package Description file format

Package-description files are XML files used by CrossStudio to describe a support package, its contents, and any dependencies it has on other packages.

Each package file must contain one package element that describes the package. Optionally, the package element can contain a collection of file, history, and documentation elements to be used by CrossStudio for documentation purposes.

The filename of the package-description file should match that of the package and end in "*_package.xml*".

Below is an example of two package-description files. The first is for a base chip-support package for the LPC2000; the second is for a board-support package dependent on the first:

Philips_LPC2000_package.xml

```
<!DOCTYPE CrossStudio_Package_Description_File>
<package cpu_manufacturer="Philips" cpu_family="LPC2000" version="1.1"
crossstudio_versions="8:1.6-" author="Rowley Associates Ltd" >
  <file file_name="$(TargetsDir)/Philips_LPC210X/arm_target_Philips_LPC210X.htm"
title="LPC2000 Support Package Documentation" />
  <file file_name="$(TargetsDir)/Philips_LPC210X/Loader.hzp" title="LPC2000 Loader
Application Solution" />
  <group title="System Files">
    <file file_name="$(TargetsDir)/Philips_LPC210X/Philips_LPC210X_Startup.s" title="LPC2000
Startup Code" />
    <file file_name="$(TargetsDir)/Philips_LPC210X/Philips_LPC210X_Target.js" title="LPC2000
Target Script" />
  </group>
  <history>
    <version name="1.1" >
      <description>Corrected LPC21xx header files and memory maps to include GPIO ports 2
and 3.</description>
      <description>Modified loader memory map so that .libmem sections will be placed
correctly.</description>
    </version>
    <version name="1.0" >
      <description>Initial Release.</description>
    </version>
  </history>
  <documentation>
    <section name="Supported Targets">
      <p>This CPU support package supports the following LPC2000 targets:
        <ul>
          <li>LPC2103</li>
          <li>LPC2104</li>
          <li>LPC2105</li>
          <li>LPC2106</li>
          <li>LPC2131</li>
          <li>LPC2132</li>
          <li>LPC2134</li>
          <li>LPC2136</li>
          <li>LPC2138</li>
        </ul>
      </p>
    </section>
  </documentation>
```

```
</documentation>
</package>
```

CrossFire_LPC2138_package.xml

```
<!DOCTYPE CrossStudio_Package_Description_File>
<package cpu_manufacturer="Philips" cpu_family="LPC2000" cpu_name="LPC2138"
board_manufacturer="Rowley Associates" board_name="CrossFire LPC2138"
dependencies="Philips_LPC2000" version="1.0">
  <file file_name="$(SamplesDir)/CrossFire_LPC2138/CrossFire_LPC2138.hzp" title="CrossFire
LPC2138 Samples Solution" />
  <file file_name="$(SamplesDir)/CrossFire_LPC2138/ctl/ctl.hzp" title="CrossFire LPC2138 CTL
Samples Solution" />
</package>
```

Package elements

The package element describes the support package, its contents, and any dependencies it has on other packages. Valid attributes for this element are:

Attribute	Description
author	The author of the package.
board_manufacturer	The manufacturer of the board supported by the package (<i>if omitted, CPU manufacturer will be used</i>).
board_name	The name of the specific board supported by the package (<i>only required for board-support packages</i>).
cpu_family	The family name of the CPU supported by the package (<i>optional</i>).
cpu_manufacturer	The manufacturer of the CPU supported by the package.
cpu_name	The name of the specific CPU supported by the package (<i>may be omitted if the CPU family is specified</i>).
crossstudio_versions	A string describing which version of CrossStudio supports the package (<i>optional</i>). The format of the string is <code>target_id_number:version_range_string</code> .
description	A description of the package (<i>optional</i>).
dependencies	A semicolon-separated list of packages the package requires to be installed in order to work.
installation_directory	The directory in which the package should be installed (<i>optional\--if undefined, defaults to "\$(PackagesDir)"</i>).
title	A short description of the package (<i>optional</i>).

version	The package version number.
---------	-----------------------------

File elements

The `file` element is used by CrossStudio for documentation purposes by adding links to files of interest within the package such as example project files and documentation.

Attribute	Description
<code>file_name</code>	The file path of the file.
<code>title</code>	A description of the file.

Optionally, `file` elements can be grouped into categories using the `group` element.

Group elements

The `group` element is used for categorizing files described by `file` elements into a particular group.

Attribute	Description
<code>title</code>	Title of the group.

History elements

The `history` element is used to hold a description of the package's version history.

The `history` element should contain a collection of `version` elements.

Version element

The `version` element is used to hold the description of a particular version of the package.

Attribute	Description
<code>name</code>	The name of the version being described.

The `version` element should contain a collection of `description` elements.

Description elements

Each `description` element contains text that describes a feature of the package version.

Documentation elements

The documentation element is used to provide arbitrary documentation for the package.

The documentation element should contain a collection of one or more section elements.

Section elements

The section element contains package documentation in XHTML format.

Attribute	Description
name	The title of the documentation section.

target_id_number

The following table lists the possible target ID numbers:

Target	ID
AVR	4
ARM	8
MSP430	9
MAXQ20	18
MAXQ30	19

version_range_string

The version_range_string can be any of the following:

- *version_number*: The package will only work on *version_number*.
- *version_number*-: The package will work on *version_number* or any future version.
- -*version_number*: The package will work on *version_number* or any earlier version.
- *low_version_number-high_version_number*: The package will work on *low_version_number*, *high_version_number* or any version in between.

External Tools file format

CrossStudio external-tool configuration files are structured using XML syntax for its simple construction and parsing.

Tool configuration files

The CrossStudio application will read the tool configuration file when it starts up. By default, CrossStudio will read the file \${StudioUserDir}/tools.xml.

Structure

All tools are wrapped in a **tools** element:

```
<tools>
  ?
</tools>
```

Inside the tools element are **item** elements that define each tool:

```
<tools>
  <item name="logical name">
    ?
  </item>
</tools>
```

The **item** element requires an **name** attribute, which is an internal name for the tool, and has an optional *wait* element. When CrossStudio invokes the tool on a file or project, it uses the *wait* element to determine whether it should wait for the external tool to complete before continuing. If the *wait* attribute is not provided or is set to *yes*, CrossStudio will wait for external tool to complete.

The way that the tool is presented in CrossStudio is configured by elements inside the

- **element.**

menu

The **menu** element defines the wording used inside menus. You can place a shortcut to the menu using an ampersand, which must be escaped using **&** in XML, before the shortcut letter. For instance:

```
<menu>&#038;PC-lint (Unit Check)</menu>
```

text

The optional **text** element defines the wording used in contexts other than menus, for instance when the tool appears as a tool button with a label. If **text** is not provided, the tool's textual appearance outside the menu is taken from the **menu** element (and is presented without an underline). For instance:

```
<text>PC-lint (Unit Check)</text>
```

tip

The optional **tip** element defines the status tip, shown on the status line, when moving over the tool inside CrossStudio:

```
<tip>Run a PC-lint unit checkout on the selected file or folder</tip>
```

key

The optional **key** element defines the accelerator key, or key chord, to use to invoke the tool using the keyboard. You can construct the key sequence using modifiers **Ctrl**, **Shift**, and **Alt**, and can specify more than one key in a sequence (note: Windows and Linux only; OS X does not provide key chords). For instance:

```
<key>Ctrl+L, Ctrl+I</key>
```

message

The optional **message** element defines the text shown in the tool log in CrossStudio when running the tool. For example:

```
<message>Linting</message>
```

match

The optional **match** element defines which documents the tool will operator on. The match is performed using the file extension of the document. If the file extension of the document matches one of the wildcards provided, the tool will run on that document. If there is no **match** element, the tool will run on all documents. For instance:

```
<match>*.c;*.cpp</match>
```

commands

The **commands** element defines the command line to run to invoke the tool. The command line is expanded using macros applicable to the file derived from the current build configuration and the project settings. Most importantly, the standard **\$(InputPath)** macro expands to a full pathname for the target file.

Additional macros constructed by CrossStudio are:

- **\$(DEFINES)** is the set of **-D** options applicable to the current file, derived from the current configuration and project settings.
- **\$(INCLUDES)** is the set of **-I** options applicable to the current file, derived from the current configuration and project settings.

For instance:

```
<commands>
  &quot;$(LINTDIR)/lint-nt&quot; -i$(LINTDIR)/lnt &quot;$(LINTDIR)/lnt/co-gcc.lnt&quot;
  $(DEFINES) $(INCLUDES) -D__GNUC__ -u -b +macros -w2 -e537 +fie +ffn -width(0,4) -hFl
  &quot;-format=%f:%l:%C:s%t:s%m&quot; &quot;$(InputPath)&quot;;
</commands>
```

In this example we intend **\$(LINTDIR)** to point to the directly where PC-lint is installed and for **\$(LINTDIR)** to be defined as a CrossStudio global macro. You can set global macros using **Project > Macros**.

Note that additional **"** entities are placed around pathnames in the **commands** section—this is to ensure that paths that contain spaces are correctly interpreted when the command is executed by CrossStudio.

General Build Properties

Build

Property	Description
Always Rebuild build_always_rebuild - Boolean	Specifies whether or not to always rebuild the project/folder/file.
Batch Build Configurations batch_build_configurations - StringList	The set of configurations to batch build.
Build Quietly build_quietly - Boolean	Suppress the display of startup banners and information messages.
Enable Unused Symbol Removal build_remove_unused_symbols - Boolean	Enable the removal of unused symbols from the executable.
Exclude From Build build_exclude_from_build - Boolean	Specifies whether or not to exclude the project/folder/file from the build.
Include Debug Information build_debug_information - Boolean	Specifies whether symbolic debug information is generated.
Intermediate Directory build_intermediate_directory - DirPath	Specifies a relative path to the intermediate file directory. This property will have macro expansion applied to it. The macro \$(IntDir) is set to this value.
Memory Map File linker_memory_map_file - ProjFileName	The name of the file containing the memory map description.
Memory Map Macros linker_memory_map_macros - StringList	Macro values to substitue in memory map nodes. Each macro is defined as name=value and are seperated by ;.
Output Directory build_output_directory - DirPath	Specifies a relative path to the output file directory. This property will have macro expansion applied to it. The macro \$(OutDir) is set to this value. The macro \$(RootRelativeOutDir) is set relative to the Root Output Directory if specified.
Project Can Build In Parallel project_can_build_in_parallel - Enumeration	Specifies that dependent projects can be built in parallel. Default is No for Staging and Combining project types, Yes for all other project types.
Project Dependencies project_dependencies - StringList	Specifies the projects the current project depends upon.
Project Directory project_directory - String	Path of the project directory relative to the directory containing the project file. The macro \$(ProjectDir) is set to the absolute path of this property.

Project Macros macros – StringList	Specifies macro values which are expanded in project properties and for file names in Common configuration only. Each macro is defined as name=value and are separated by ;.
Project Type project_type – Enumeration	Specifies the type of project to build. The options are Executable , Library , Object file , Staging , Combining , Externally Built Executable .
Property Groups File property_groups_file_path – ProjFileName	The file containing the property groups for this project. This is applicable to Executable and Externally Built Executable project types only.
Root Output Directory build_root_output_directory – DirPath	Allows a common root output directory to be specified that can be referenced using the \$(RootOutDir) macro.
Suppress Warnings build_suppress_warnings – Boolean	Don't report warnings.
Tool Chain Directory build_toolchain_directory – DirPath	Specify the root of the toolchain directory. This property will have macro expansion applied to it. The macro \$(ToolChainDir) is set to this value.
Treat Warnings as Errors build_treat_warnings_as_errors – Boolean	Treat all warnings as errors.

Combining

Property	Description
Combine Command combine_command – Unknown	The command to execute. This property will have macro expansion applied to it with the macro \$(CombiningOutputFilePath) set to the output filepath of the combine command and the macro \$(CombiningRelInputPaths) is set to the (project relative) names of all of the files in the project.
Combine Command Working Directory combine_command_wd – String	The working directory in which the combine command is run. This property will have macro expansion applied to it.
Output File Path combine_output_filepath – String	The output file path the stage command will create. This property will have macro expansion applied to it.
Set To Read-only combine_set_READONLY – Enumeration	Set the output file to read only or read/write.

External Build

Property	Description
----------	-------------

Build Command external_build_command – Unknown	The command line to build the executable e.g. make. This property will have macro expansion applied to it.
Clean Command external_clean_command – Unknown	The command line to clean the executable e.g. make clean. This property will have macro expansion applied to it.

File

Property	Description
File Encoding file_codec – Enumeration	Specifies the encoding to use when reading and writing the file.
File Name file_name – String	The name of the file. This property will have global macro expansion applied to it. The following macros are set based on the value: \$(InputDir) relative directory of file, \$(InputName) file name without directory or extension, \$(InputFileName) file name, \$(InputExt) file name extension, \$(InputPath) absolute path to the file name, \$(RelInputPath) relative path from project directory to the file name.
File Open Action file_open_with – Enumeration	Specifies how to open the file when it is double clicked.
File Type file_type – Enumeration	The type of file. Default setting uses the file extension to determine file type.
Flag file_flag – Enumeration	Flag which you can use to draw attention to important files in your project.

Folder

Property	Description
Dynamic Folder Directory path – DirPath	Dynamic folder directory specification.
Dynamic Folder Exclude exclude – StringList	Dynamic folder exclude specification - ; separated wildcards.
Dynamic Folder Filter filter – String	Dynamic folder filter specification - ; separated wildcards.
Dynamic Folder Recurse recurse – Boolean	Dynamic folder recurse into subdirectories.
Unity Build Exclude Filter unity_build_exclude_filter – String	The filter specification to exclude from the unity build - ; separated wildcards.
Unity Build File Name unity_build_file_name – FileName	The file name created that #includes all files in the folder for the unity build.

General

Property	Description
Inherited Configurations inherited_configurations – StringList	The list of configurations that are inherited by this configuration.

Library

Property	Description
Library File Name build_output_file_name – FileName	Specifies a name to override the default library file name.

Package

Property	Description
Package Dependencies package_dependencies – StringList	Specifies the packages the current project depends upon.

Project

Property	Description
Flag project_flag – Enumeration	Flag which you can use to draw attention to important projects in your solution.

Solution

Property	Description
Flag solution_flag – Enumeration	Flag which you can use to draw attention to important projects in your solution.

Source Code

Property	Description
Inhibit Source Indexing project_inhibit_indexing – Boolean	Disable source indexing for projects that would normally be indexed (executable and library projects).

Staging

Property	Description
Output File Path stage_output_filepath – String	The output file path the stage command will create. This property will have macro expansion applied to it.
Set To Read-only stage_set_READONLY – Enumeration	Set the output file permissions to read only or read/write.
Stage Command stage_command – Unknown	The command to execute. This property will have macro expansion applied to it with the additional \$(StageOutputFilePath) macro set to the output filepath of the stage command.
Stage Command Working Directory stage_command_wd – String	The working directory in which the stage command is run. This property will have macro expansion applied to it.
Stage Post-Build Command stage_post_build_command – Unknown	The command to execute after staging commands have executed. This property will have macro expansion applied to it.
Stage Post-Build Command Working Directory stage_post_build_command_wd – String	The working directory where the post build command runs. This property will have macro expansion applied to it.

Compilation Properties

Assembler

Property	Description
Additional Assembler Options asm_additional_options – StringList	Enables additional options to be supplied to the assembler. This property will have macro expansion applied to it.
Additional Assembler Options From File asm_additional_options_from_file – ProjFileName	Enables additional options to be supplied to the assembler from a file. This property will have macro expansion applied to it.

Code Generation

Property	Description
Block Localization Optimization optimize_block_locality – Boolean	Reduce spand-dependent jumps by rearranging basic blocks to improve their locality.
Code Factoring Optimization optimize_cross_calling – Enumeration	Reduces code size at the expense of execution speed by factoring common code sequences into subroutines.
Code Factoring Passes linker_cross_call_maximum_passes – IntegerRange	The maximum number of passes to perform when code factoring (0=unlimited).
Code Factoring Subroutine Size linker_cross_call_minimum_subroutine_size –	The minimum size of subroutine created by code factoring.
Code Motion Optimization optimize_code_motion – Boolean	Rearrange code to reduce the number of jump instructions.
Copy Propagation Optimization optimize_copy_propagation – Boolean	Tries to eliminate copy instructions and reduce code size.
Cross Jumping Optimization optimize_cross_jumping – Boolean	Always reduces code size at the expense of a single jump instruction.
Dead Code Elimination optimize_dead_code – Boolean	Remove code that is not referenced by the application.
Enable Exception Support cpp_enable_exceptions – Boolean	Specifies whether exception support is enabled for C++ programs.
Enable RTTI Support cpp_enable_rtti – Boolean	Specifies whether RTTI support is enabled for C++ programs.
Flattening Optimization optimize_flattening – Boolean	Subroutines that are just a call followed by a return are flattened into a jump.
Instruction Set msp430_insn_set – Enumeration	The architecture instruction set to use for code generation.

Jump Chaining Optimization optimize_jump_chaining - Boolean	Reduce spand-dependent jump sizes by chaining jumps together.
Jump Threading Optimization optimize_jump_threading - Boolean	Follow jump chains and retarget jumps to jump instructions.
Memory Size msp430_memory_size - Enumeration	The memory size to use for MSP430X code generation.
Optimization Strategy compiler_optimization_strategy - Enumeration	Minimize code size or maximize execution speed (positive values).
Peephole Optimization optimize_peepholes - Boolean	Find instruction sequences that can be replaced with faster, smaller code.
Register Allocation optimize_register_allocation - Enumeration	Whether to allocate registers to locals or locals and global addresses.
Tail Merging Optimization optimize_tail_merging - Boolean	Always reduces code size at the expense of a single jump instruction.
Treat 'double' as 'float' double_is_float - Boolean	Forces the compiler to make 'double' equivalent to 'float'.
Use Hardware Multiplier build_use_hardware_multiplier - Enumeration	Enables code generation for the hardware multiplier.

Compiler

Property	Description
Additional C Compiler Only Options c_only_additional_options - StringList	Enables additional options to be supplied to the C compiler only. This property will have macro expansion applied to it.
Additional C Compiler Only Options From File c_only_additional_options_from_file - ProjFile	Enables additional options to be supplied to the C compiler only from a file. This property will have macro expansion applied to it.
Additional C Compiler Options c_additional_options - StringList	Enables additional options to be supplied to the C compiler. This property will have macro expansion applied to it.
Additional C Compiler Options From File c_additional_options_from_file - ProjFileName	Enables additional options to be supplied to the C compiler from a file. This property will have macro expansion applied to it.
Additional C++ Compiler Only Options cpp_only_additional_options - StringList	Enables additional options to be supplied to the C++ compiler only. This property will have macro expansion applied to it.
Additional C++ Compiler Only Options From File cpp_only_additional_options_from_file - ProjF	Enables additional options to be supplied to the C++ compiler only from a file. This property will have macro expansion applied to it.

Enforce ANSI Checking c_enforce_ansi_checking - Boolean	Perform additional checks for ensure strict conformance to the selected ISO (ANSI) C or C++ standard.
Object File Name build_object_file_name - FileName	Specifies a name to override the default object file name.

Preprocessor

Property	Description
Ignore Includes c_ignore_includes - Boolean	Ignore the include directories properties.
Preprocessor Definitions c_preprocessor_definitions - StringList	Specifies one or more preprocessor definitions. This property will have macro expansion applied to it.
Preprocessor Undefineds c_preprocessor_undefineds - StringList	Specifies one or more preprocessor undefineds. This property will have macro expansion applied to it.
System Include Directories c_system_include_directories - StringList	Specifies the system include path. This property will have macro expansion applied to it.
Undefine All Preprocessor Definitions c_undefine_all_preprocessor_definitions - Boolean	Does not define any standard preprocessor definitions.
User Include Directories c_user_include_directories - StringList	Specifies the user include path. This property will have macro expansion applied to it.

Section

Property	Description
Code Section Name default_code_section - String	Specifies the default name to use for the program code section.
Constant Section Name default_const_section - String	Specifies the default name to use for the read-only constant section.
Data Section Name default_data_section - String	Specifies the default name to use for the initialized, writable data section.
ISR Section Name default_isr_section - String	Specifies the default name to use for the ISR code.
Vector Section Name default_vector_section - String	Specifies the default name to use for the interrupt vector section.
Zeroed Section Name default_zeroed_section - String	Specifies the default name to use for the zero-initialized, writable data section.

User Build Step

Property	Description
Post-Compile Command compile_post_build_command – Unknown	A command to run after the compile command has completed. This property will have macro expansion applied to it with the additional \$(TargetPath) macro set to the output filepath of the compiler command.
Post-Compile Working Directory compile_post_build_command_wd – DirPath	The working directory where the post-compile command is run. This property will have macro expansion applied to it.
Pre-Compile Command compile_pre_build_command – Unknown	A command to run before the compile command. This property will have macro expansion applied to it.
Pre-Compile Command Output File Path compile_pre_build_command_output_file_name	The pre-compile generated file name. This property will have macro expansion applied to it.
Pre-Compile Working Directory compile_pre_build_command_wd – DirPath	The working directory where the pre-compile command is run. This property will have macro expansion applied to it.

Debugging Properties

Debugger

Property	Description
Command Arguments debug_command_arguments – String	The command arguments passed to the executable. This property will have macro expansion applied to it.
Debug Dependent Projects debug_dependent_projects – Boolean	Debugger will debug dependent projects.
Debug Symbols File external_debug_symbols_file_name – ProjFileName	The name of the debug symbols file. This property will have macro expansion applied to it. If it is not defined then the main load file is used.
Debug Symbols Load Address external_debug_symbols_load_address – String	The (code) address to be added to the debug symbol (code) addresses.
Entry Point Symbol debug_entry_point_symbol – String	Debugger will start execution at symbol if defined.
Implement Software Breakpoints enableSoftwareBreakpoints – Boolean	Implement software breakpoints using the first hardware breakpoint.
Initial Breakpoint Is Set debug_initial_breakpoint_set_option – Enumerator	Specify when the initial breakpoint should be set
Leave Target Running debug_leave_target_running – Boolean	Debugger will leave the target running on debug stop.
Register Definition File debug_register_definition_file – ProjFileName	The name of the file containing register definitions.
Set Initial Breakpoint At debug_initial_breakpoint – String	An initial breakpoint to set if no other breakpoints exist
Start Address external_start_address – String	The address to start the externally built executable running from.
Start From Entry Point Symbol debug_start_from_entry_point_symbol – Boolean	If yes the debugger will start execution from the entry point symbol. If no the debugger will start execution from the core specific location.
Startup Completion Point debug_startup_completion_point – String	Specifies the point in the program where startup is complete. Software breakpoints and debugIO will be enabled after this point has been reached.
Thread Maximum debug_threads_max – IntegerRange	The maximum number of threads to display.
Threads Script File debug_threads_script – ProjFileName	The threads script used by the debugger.
Working Directory debug_working_directory – DirPath	The working directory for a debug session. This property will have macro expansion applied to it.

Loader

Property	Description
Additional Load File Address[0] debug_additional_load_file_address – String	The address to load the additional load file.
Additional Load File Address[1] debug_additional_load_file_address1 – String	The address to load the additional load file.
Additional Load File Address[2] debug_additional_load_file_address2 – String	The address to load the additional load file.
Additional Load File Address[3] debug_additional_load_file_address3 – String	The address to load the additional load file.
Additional Load File Type[0] debug_additional_load_file_type – Enumeration	The file type of the additional load file. The options are Detect, hzx, bin, ihex, hex, tihex, srec .
Additional Load File Type[1] debug_additional_load_file_type1 – Enumeration	The file type of the additional load file. The options are Detect, hzx, bin, ihex, hex, tihex, srec .
Additional Load File Type[2] debug_additional_load_file_type2 – Enumeration	The file type of the additional load file. The options are Detect, hzx, bin, ihex, hex, tihex, srec .
Additional Load File Type[3] debug_additional_load_file_type3 – Enumeration	The file type of the additional load file. The options are Detect, hzx, bin, ihex, hex, tihex, srec .
Additional Load File[0] debug_additional_load_file – ProjFileName	Additional file to load on debug load. This property will have macro expansion applied to it.
Additional Load File[1] debug_additional_load_file1 – ProjFileName	Additional file to load on debug load. This property will have macro expansion applied to it.
Additional Load File[2] debug_additional_load_file2 – ProjFileName	Additional file to load on debug load. This property will have macro expansion applied to it.
Additional Load File[3] debug_additional_load_file3 – ProjFileName	Additional file to load on debug load. This property will have macro expansion applied to it.
Load File external_build_file_name – ProjFileName	The name of the main load file. This property will have macro expansion applied to it. If it is not defined then the output filepath of the linker command is used.
Load File Address external_load_address – String	The address to download the main load file to.
Load File Type external_load_file_type – Enumeration	The file type of the main load file. The options are Detect, hzx, bin, ihex, hex, tihex, srec .
No Load Sections target_loader_no_load_sections – StringList	Names of (loadable) sections not to load.

Target

Property	Description
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Identify String msp430_identify_string – String	The string the identify process returns for the target
Release JTAG releaseJTAG – Boolean	Release the JTAG signals when "Reset" or "Start Without Debugging" are used and on "Stop Debugging".

Target Loader

Property	Description
Enable BSL Segment Erase/Write unlockBSL – Boolean	BSL Segments can be erased/written.
Enable Info SegmentA Erase/Write unlockSegmentA – Boolean	Info SegmentA can be erased/written.
Erase All target_loader_erase_all – Enumeration	If set to Yes , all of the FLASH memory on the target will be erased prior to downloading the application. If set to No , only the areas of FLASH containing the program being downloaded will be erased. If set to Default the behaviour is target specific.

Executable Project Properties

Library

Property	Description
Exclude Default Library Helper Functions link_use_multi_threaded_libraries – Boolean	Specifies whether to exclude default library helper functions.
Include Standard Libraries link_include_standard_libraries – Boolean	Specifies whether the standard libraries should be linked into your application.
Standard Libraries Directory link_standard_libraries_directory – String	Specifies where to find the standard libraries

Linker

Property	Description
Additional Input Files linker_additional_files – StringList	Enables additional object and library files to be supplied to the linker.
Additional Linker Options linker_additional_options – StringList	Enables additional options to be supplied to the linker.
Additional Linker Options From File linker_additional_options_from_file – ProjFile	Enables additional options to be supplied to the linker from a file.
Additional Output Format linker_output_format – Enumeration	The format used when creating an additional linked output file. The options are: <ul style="list-style-type: none"> • None do not create an additional output file. • hex create an Intel Hex file. • lst create a hex file. • srec create a Motorola S-Record file. • bin create a binary file.
Checksum Algorithm linker_checksum_algorithm – Enumeration	The algorithm used to checksum sections.
Checksum Sections linker_checksum_sections – StringList	The list of sections to checksum using the set checksum algorithm.
Generate Absolute Listing linker_absolute_listing – Boolean	Generate an absolute listing of the application.
Generate Map File linker_map_file – Boolean	Specifies whether to generate a linkage map file.
Heap Size linker_heap_size – IntegerRange	The number of bytes to allocate for the application's heap.

Keep Symbols linker_keep_symbols – StringList	Specifies the symbols that should be kept by the linker even if they are not reachable.
Linker Symbol Definitions link_symbol_definitions – StringList	Specifies one or more linker symbol definitions.
Optimize Sections optimize_sections – StringList	The list of section names to optimize.
Pad Space pad_space – Boolean	Replace space instructions with the pad value.
Pad Space Value pad_space_value – IntegerHex	The value to replace space instructions with.
Rename Sections rename_sections – StringList	The list of input module section names to rename.
Section Placement File linker_section_placement_file – ProjFileName	The name of the file containing section placement description.
Section Placement Macros linker_section_placement_macros – StringList	Macro values to substitue in section placement nodes - MACRO1=value1;MACRO2=value2.
Section Placement Segments linker_section_placements_segments – StringList	The start and size of named segments in the section placement file, these are used when no memory map file is available. Each segment is specified by NAME RWX HEXSTART HEXSIZE for example FLASH RX 0x08000000 0x00010000
Stack Size linker_stack_size – IntegerRange	The number of bytes to allocate for the application's stack.
Verbose Output verbose – Boolean	Show verbose output - useful for long optimisations.

Printf/Scanf

Property	Description
Printf Floating Point Supported linker_printf_fp_enabled – Boolean	Are floating point numbers supported by the printf function group.
Printf Integer Support linker_printf_fmt_level – Enumeration	The largest integer type supported by the printf function group.
Printf Width/Precision Supported linker_printf_width_precision_supported – Boolean	Enables support for width and precision specification in the printf function group.
Scanf Classes Supported linker_scanf_character_group_matching_enabled	Enables support for %[...] and %[^...] character class matching in the scanf functions.
Scanf Floating Point Supported linker_scanf_fp_enabled – Boolean	Are floating point numbers supported by the scanf function group.
Scanf Integer Support linker_scanf_fmt_level – Enumeration	The largest integer type supported by the scanf function group.

Wide Characters Supported linker_printf_wchar_enabled – Boolean	Are wide characters supported by the printf function group.
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User Build Step

Property	Description
Link Patch Command linker_patch_build_command – Unknown	A command to run after the link but prior to additional binary file generation. This property will have macro expansion applied to it with the additional \$(TargetPath) macro set to the output filepath of the linker command.
Link Patch Working Directory linker_patch_build_command_wd – DirPath	The working directory where the link patch command is run. This property will have macro expansion applied to it.
Post-Link Command linker_post_build_command – Unknown	A command to run after the link command has completed. This property will have macro expansion applied to it with the additional \$(TargetPath) macro set to the output filepath of the linker command and \$(PostLinkOutputFilePath) set to the value of the output filepath of the post link command.
Post-Link Output File linker_post_build_command_output_file – String	The name of the file created by the post-link command. This property will have macro expansion applied to it.
Post-Link Working Directory linker_post_build_command_wd – DirPath	The working directory where the post-link command is run. This property will have macro expansion applied to it.
Pre-Link Command linker_pre_build_command – Unknown	A command to run before the link command. This property will have macro expansion applied to it.
Pre-Link Working Directory linker_pre_build_command_wd – DirPath	The working directory where the pre-link command is run. This property will have macro expansion applied to it.

System Macros

System Macro Values

Property	Description
<code>\$(Date)</code> \$(Date) – String	Day Month Year e.g. 21 June 2011.
<code>\$(DateDay)</code> \$(DateDay) – String	Year e.g. 2011.
<code>\$(DateMonth)</code> \$(DateMonth) – String	Month e.g. June.
<code>\$(DateYear)</code> \$(DateYear) – String	Day e.g. 21.
<code>\$(DesktopDir)</code> \$(DesktopDir) – String	Path to users desktop directory.
<code>\$(DocumentsDir)</code> \$(DocumentsDir) – String	Path to users documents directory.
<code>\$(HomeDir)</code> \$(HomeDir) – String	Path to users home directory.
<code>\$(HostArch)</code> \$(HostArch) – String	The CPU architecture that CrossStudio is running on e.g. x86.
<code>\$(HostDLL)</code> \$(HostDLL) – String	The file extension for dynamic link libraries on the CPU that CrossStudio is running on e.g. .dll.
<code>\$(HostDLLExt)</code> \$(HostDLLExt) – String	The file extension for dynamic link libraries used by the operating system that CrossStudio is running on e.g. .dll, .so, .dylib.
<code>\$(HostEXE)</code> \$(HostEXE) – String	The file extension for executables on the CPU that CrossStudio is running on e.g. .exe.
<code>\$(HostOS)</code> \$(HostOS) – String	The name of the operating system that CrossStudio is running on e.g. win.
<code>\$(Micro)</code> \$(Micro) – String	The CrossStudio target e.g. ARM.
<code>\$(PackagesDir)</code> \$(PackagesDir) – String	Path to the users packages directory.
<code>\$(Platform)</code> \$(Platform) – String	The target platform.
<code>\$(ProductNameShort)</code> \$(ProductNameShort) – String	The product name.
<code>\$(SamplesDir)</code> \$(SamplesDir) – String	Path to the samples subdirectory of the packages directory.

<code>\$(StudioArchiveFileExt)</code>	The filename extension of a studio archive file.
<code>\$(StudioBuildToolExeName)</code>	The filename of the build tool executable.
<code>\$(StudioBuildToolName)</code>	The name of the build tool executable.
<code>\$(StudioDir)</code>	The install directory of the product.
<code>\$(StudioExeName)</code>	The filename of the studio executable.
<code>\$(StudioMajorVersion)</code>	The major release version of software.
<code>\$(StudioMinorVersion)</code>	The minor release version of software.
<code>\$(StudioName)</code>	The full name of studio.
<code>\$(StudioNameShort)</code>	The short name of studio.
<code>\$(StudioPackageFileExt)</code>	The filename extension of a studio package file.
<code>\$(StudioProjectFileExt)</code>	The filename extension of a studio project file.
<code>\$(StudioRevision)</code>	The release revision of software.
<code>\$(StudioScriptToolExeName)</code>	The filename of the script tool executable.
<code>\$(StudioScriptToolName)</code>	The name of the script tool executable.
<code>\$(StudioSessionFileExt)</code>	The filename extension of a studio session file.
<code>\$(StudioUserDir)</code>	The directory containing the user data.
<code>\$(TargetID)</code>	ID number representing the CrossStudio target.
<code>\$(TargetsDir)</code>	Path to the targets subdirectory of the packages directory.
<code>\$(Time)</code>	Hour:Minutes:Seconds e.g. 15:34:03.
<code>\$(TimeHour)</code>	Hour e.g. 15.

\$(TimeMinute) \$(TimeMinute) – String	Hour e.g. 34.
\$(TimeSecond) \$(TimeSecond) – String	Hour e.g. 03.

Build Macros

(Build Macro Values)

Property	Description
<code>\$(AsmOptions)</code> \$(AsmOptions) – String	A space seperated list of assembler options for the external assemble command.
<code>\$(COnlyOptions)</code> \$(COnlyOptions) – String	A space seperated list of compiler options for the external c compile command.
<code>\$(COOptions)</code> \$(COOptions) – String	A space seperated list of compiler options for the external c and c++ compile commands.
<code>\$(CombiningOutputFilePath)</code> \$(CombiningOutputFilePath) – String	The full path of the output file of the combining command.
<code>\$(CombiningRelInputPaths)</code> \$(CombiningRelInputPaths) – String	The relative inputs to the combining command.
<code>\$(Configuration)</code> \$(Configuration) – String	The build configuration e.g. ARM Flash Debug.
<code>\$(Defines)</code> \$(Defines) – String	The preprocessor defines property value for the external compile command.
<code>\$(DependencyPath)</code> \$(DependencyPath) – String	The path of the dependency file for the external compile command.
<code>\$(EXE)</code> \$(EXE) – String	The default file extension for an executable file including the dot e.g. .elf.
<code>\$(FolderName)</code> \$(FolderName) – String	The folder name of the containing folder.
<code>\$(Includes)</code> \$(Includes) – String	The user includes property value for the external compile command.
<code>\$(InputDir)</code> \$(InputDir) – String	The absolute directory of the input file.
<code>\$(InputExt)</code> \$(InputExt) – String	The extension of an input file not including the dot e.g. cpp.
<code>\$(InputFileName)</code> \$(InputFileName) – String	The name of an input file relative to the project directory.
<code>\$(InputName)</code> \$(InputName) – String	The name of an input file relative to the project directory without the extension.
<code>\$(InputPath)</code> \$(InputPath) – String	The absolute name of an input file including the extension.
<code>\$(IntDir)</code> \$(IntDir) – String	The macro-expanded value of the Intermediate Directory project property.

<code>\$(LIB)</code> \$(LIB) – String	The default file extension for a library file including the dot e.g. .lib.
<code>\$(LinkOptions)</code> \$(LinkOptions) – String	A space seperated list of compiler options for the external link command.
<code>\$(LinkerScriptPath)</code> \$(LinkerScriptPath) – String	The full path of the linker script file for the link command.
<code>\$(MapPath)</code> \$(MapPath) – String	The full path of the map file of the external link command.
<code>\$(OBJ)</code> \$(OBJ) – String	The default file extension for an object file including the dot e.g. .o.
<code>\$(Objects)</code> \$(Objects) – String	A space seperated list of files for the external archive or link command.
<code>\$(ObjectsFilePath)</code> \$(ObjectsFilePath) – String	The filename containing the files for the external archive or link command.
<code>\$(OutDir)</code> \$(OutDir) – String	The macro-expanded value of the Output Directory project property.
<code>\$(PackageExt)</code> \$(PackageExt) – String	The file extension of a package file e.g. hzq.
<code>\$(PostLinkOutputFilePath)</code> \$(PostLinkOutputFilePath) – String	The full path of the output file of the post link command.
<code>\$(ProjectDir)</code> \$(ProjectDir) – String	The absolute value of the Project Directory project property of the current project. If this isn't set then the directory containing the solution file.
<code>\$(ProjectName)</code> \$(ProjectName) – String	The project name of the current project.
<code>\$(ProjectNodeName)</code> \$(ProjectNodeName) – String	The name of the selected project node.
<code>\$(RelInputPath)</code> \$(RelInputPath) – String	The relative path of the input file to the project directory.
<code>\$(RelTargetPath)</code> \$(RelTargetPath) – String	The project directory relative path of the output file of the link or compile command.
<code>\$(RootOutDir)</code> \$(RootOutDir) – String	The macro-expanded value of the Root Output Directory project property.
<code>\$(RootRelativeOutDir)</code> \$(RootRelativeOutDir) – String	The relative path to get from the path specified by the Output Directory project property to the path specified by the Root Output Directory project property.
<code>\$(SolutionDir)</code> \$(SolutionDir) – String	The absolute path of the directory containing the solution file.
<code>\$(SolutionExt)</code> \$(SolutionExt) – String	The extension of the solution file without the dot.

<code>\$(SolutionFileName)</code> <code>\$(SolutionFileName) – String</code>	The filename of the solution file.
<code>\$(SolutionName)</code> <code>\$(SolutionName) – String</code>	The basename of the solution file.
<code>\$(SolutionPath)</code> <code>\$(SolutionPath) – String</code>	The absolute path of the solution file.
<code>\$(StageOutputFilePath)</code> <code>\$(StageOutputFilePath) – String</code>	The full path of the output file of the stage command.
<code>\$(TargetPath)</code> <code>\$(TargetPath) – String</code>	The full path of the output file of the link or compile command.
<code>\$(ToolChainDir)</code> <code>\$(ToolChainDir) – String</code>	The macro-expanded value of the Tool Chain Directory project property.

BinaryFile

The following table lists the BinaryFile object's member functions.

BinaryFile.crc32(offset, length) returns the CRC-32 checksum of an address range *length* bytes long, starting at *offset*. This function computes a CRC-32 checksum on a block of data using the standard CRC-32 polynomial (0x04C11DB7) with an initial value of 0xFFFFFFFF. Note that this implementation doesn't reflect the input or the output and the result is inverted.

BinaryFile.length() returns the length of the binary file in bytes.

BinaryFile.load(path) loads binary file from *path*.

BinaryFile.peekBytes(offset, length) returns byte array containing *length* bytes peeked from *offset*.

BinaryFile.peekUint32(offset, littleEndian) returns a 32-bit word peeked from *offset*. The *littleEndian* argument specifies the endianness of the access, if true or undefined it will be little endian, otherwise it will be big endian.

BinaryFile.pokeBytes(offset, byteArray) poke byte array *byteArray* to *offset*.

BinaryFile.pokeUint32(offset, value, littleEndian) poke a *value* to 32-bit word located at *offset*. The *littleEndian* argument specifies the endianness of the access, if true or undefined it will be little endian, otherwise it will be big endian.

BinaryFile.resize(length, fill) resizes the binary image to *length* bytes. If the operation extends the size, the binary image will be padded with bytes of value *fill*.

BinaryFile.save(path) saves binary file to *path*.

BinaryFile.saveRange(path, offset, length) saves part of the binary file to *path*. The *offset* argument specifies the byte offset to start from. The *length* argument specifies the maximum number of bytes that should be saved.

CWSys

The following table lists the CWSys object's member functions.

CWSys.appendStringToFile(path, string) appends <i>string</i> to the end of the file <i>path</i> .
CWSys.copyFile(srcPath, destPath) copies file <i>srcPath</i> to <i>destPath</i> .
CWSys.crc32(array) returns the CRC-32 checksum of the byte array <i>array</i> . This function computes a CRC-32 checksum on a block of data using the standard CRC-32 polynomial (0x04C11DB7) with an initial value of 0xFFFFFFFF. Note that this implementation doesn't reflect the input or the output and the result is inverted.
CWSys.fileExists(path) returns true if file <i>path</i> exists.
CWSys.exit(status) terminates CrossScript with exit code <i>status</i> (CrossScript Only).
CWSys.fileSize(path) return the number of bytes in file <i>path</i> .
CWSys.getRunStderr() returns the stderr output from the last <i>CWSys.run()</i> call.
CWSys.getRunStdout() returns the stdout output from the last <i>CWSys.run()</i> call.
CWSys.makeDirectory(path) create the directory <i>path</i> .
CWSys.packU32(array, offset, number, le) packs <i>number</i> into the <i>array</i> at <i>offset</i> .
CWSys.popup(text) prompt the user with text and return true for yes and false for no.
CWSys.readByteArrayFromFile(path) returns the byte array contained in the file <i>path</i> .
CWSys.readStringFromFile(path) returns the string contained in the file <i>path</i> .
CWSys.removeDirectory(path) remove the directory <i>path</i> .
CWSys.removeFile(path) deletes file <i>path</i> .
CWSys.renameFile(oldPath, newPath) renames file <i>oldPath</i> to be <i>newPath</i> .
CWSys.run(cmd, wait) runs command line <i>cmd</i> optionally waits for it to complete if <i>wait</i> is true.
CWSys.unpackU32(array, offset, le) returns the number unpacked from the <i>array</i> at <i>offset</i> .
CWSys.writeByteArrayToFile(path, array) creates a file <i>path</i> containing the byte array <i>array</i> .
CWSys.writeStringToFile(path, string) creates a file <i>path</i> containing <i>string</i> .

Debug

The following table lists the Debug object's member functions.

Debug.breakexpr(expression, count, hardware) set a breakpoint on <i>expression</i> , with optional ignore <i>count</i> and use <i>hardware</i> parameters. Return the, none zero, allocated breakpoint number.
Debug.breakline(filename, linenumber, temporary, count, hardware) set a breakpoint on <i>filename</i> and <i>linenumber</i> , with optional <i>temporary</i> , ignore <i>count</i> and use <i>hardware</i> parameters. Return the, none zero, allocated breakpoint number.
Debug.breaknow() break execution now.
Debug.deletebreak(number) delete the specified breakpoint or all breakpoints if zero is supplied.
Debug.disassembly(source, labels, before, after) set debugger mode to disassembly mode. Optionally specify <i>source</i> and <i>labels</i> to be displayed and the number of bytes to disassemble <i>before</i> and <i>after</i> the located program counter.
Debug.echo(s) display string.
Debug.enableexception(exception, enable) <i>enable</i> break on <i>exception</i> .
Debug.evaluate(expression) evaluates debug <i>expression</i> and returns it as a JavaScript value.
Debug.getfilename() return located filename.
Debug.getlinenumber() return located linenumber.
Debug.go() continue execution.
Debug.locate(frame) locate the debugger to the optional <i>frame</i> context.
Debug.locatepc(pc) locate the debugger to the specified <i>pc</i> .
Debug.locateregisters(registers) locate the debugger to the specified <i>register</i> context.
Debug.print(expression, fmt) evaluate and display debug <i>expression</i> using optional <i>fmt</i> . Supported formats are <i>b</i> binary, <i>c</i> character, <i>d</i> decimal, <i>e</i> scientific float, <i>f</i> decimal float, <i>g</i> scientific or decimal float, <i>i</i> signed decimal, <i>o</i> octal, <i>p</i> pointer value, <i>s</i> null terminated string, <i>u</i> unsigned decimal, <i>x</i> hexadecimal.
Debug.printglobals() display global variables.
Debug.printlocals() display local variables.
Debug.quit() stop debugging.
Debug.setprintarray(elements) set the maximum number of array elements for printing variables.
Debug.setprintradix(radix) set the default radix for printing variables.
Debug.setprintstring(c) set the default to print character pointers as strings.
Debug.showbreak(number) show information on the specified breakpoint or all breakpoints if zero is supplied.
Debug.showexceptions() show the exceptions.
Debug.source(before, after) set debugger mode to source mode. Optionally specify the number of source lines to display <i>before</i> and <i>after</i> the location.
Debug.stepinto() step an instruction or a statement.

Debug.stepout() continue execution and break on return from current function.

Debug.stepover() step an instruction or a statement stepping over function calls.

Debug.stopped() return stopped state.

Debug.wait(ms) wait *ms* milliseconds for a breakpoint and return the number of the breakpoint that hit.

Debug.where() display call stack.

WScript

The following table lists the WScript object's member functions.

WScript.Echo(s) echos string s to the output terminal.