



CrossWorks for AVR 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 CrossWorks package.

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.

Tasking Library User Guide

Contains documentation on using the CrossWorks tasking library to write multi-threaded applications.

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 AVR is a complete C development system for Atmel AVR 8-bit microcontrollers that runs on Windows, Mac OS, Linux, and Solaris.

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

CrossStudio IDE

CrossWorks for AVR 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.
- *Utilities*: A set of tools for generating output files in multiple formats and a command line facility for flashing your applications onto the target board provide the final stage of the software development system.

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 AVR 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**.
- 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, Linux, and Solaris 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, Solaris, 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:\crossworks\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 AVR, there are a variety of other resources you can use to find out more.

CrossWorks for AVR website

- <http://www.rowley.co.uk/avr/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 UserVoice forum:

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

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.

Release notes

Release 2.1

Build

- Pre-compile and pre-link commands now stop build immediately if an error exit code is returned.
- Fixed an incompatibility in generation of 64-bit doubles exposed by different compilers for OS X and Windows/Linux.
- Added ISR section, pragmas, and control
- Build system now outputs a message when build has failed and 'keep going on error' has been enabled.

Compiler

- Fix rare live register clobber on function entry.

CrossBuild

- CrossBuild no longer sends stderr output from build commands to stdout. The -nostderr option has been added in case old behaviour is still required.

CrossLoad

- Added -load and -define options to CrossLoad.
- CrossLoad can now use CrossStudio target interfaces.
- Fixed the calling of connect scripts. Private configurations can now be specified. The -config option is no longer required if project has only one configuration.
- Added -eraseall option to crossload.

CrossStudio

- Added support for building and debugging using an external AVR GCC toolchain.
- Added property to the terminal emulator to disconnect/reconnect when the target interface is connected/disconnected.
- Added support for starred files in Project Explorer.
- New file dialog no longer appends extension if it already exists.
- Right click on the project window shows the target and placement menus when the property groups file is specific to a configuration.
- Linux version of license manager now uses Ethernet addresses of adapters that are not activated
- Fixed additional options from file project properties not releasing file when build is complete.
- Status bar messages can now be copied to clipboard.
- Fixed memory map file caching when downloading and not debugging.
- Fixed mis-optimization of ECMAScript IR which caused '<' to fail in some cases.
- Added new filter feature to register window.

- Fixed 'Go To Included File' so that ignores comments.
- New project wizard now works correctly when PackagesDir contains Unicode characters.
- Fixed erase, lock and unlock operations.
- Fixed package manager prompting for installation directory unnecessarily when installing packages.
- Linux, Mac OS X and Solaris versions of CrossStudio no longer need to be started using an absolute path.
- Fix initial size and resize of Macro dialog
- Fixed the opening of files in CrossStudio from Mac OS X Finder.
- Fixed 'Allow Multiple CrossStudios' environment option when set to 'No' on Mac OS X.
- Added TargetID system macro.
- Fixed potential crash in XML/HTML syntax coloring.
- Corrected target compatibility check dialog behavior.
- Added CrossStudio launcher.
- Hovering over a warning or error icon in the margin brings up diagnostic tooltip.
- Fixed DNS bug causing downloads to hang.
- Fixed Qt settings files being saved with root ownership when installer run using sudo (Unix only).
- Improved CrossStudio startup speed when many packages are installed.
- Target Connection menu can now search for targets by name; Ctrl+Shift+T is accelerator to Target Connection menu.
- Packages now downloaded using content delivery network by default.
- Package manager update now installs missing or out of date associated packages.
- Fixed initial colour of binary diff window.
- Fixed 'Send e-mail' button in license manager (Mac OS X only).
- Added **Package Dependencies** project property.
- Legacy packages are now always displayed in package manager if installed.
- Package manager now defaults to upgrading dependent packages when installing a new package.
- Register group selector now scrolls if it is larger than the width of the display.
- Fixed rename box artefact when closing a register group (Incident #3852)
- Help > Contents window is now categorized.
- Fixed font dialog not updating sample text (Incident #5474)
- Fixed open on-error location of text files using ISO-8859 encoding (Incident #5798)
- Fixed slow population of Source Navigator list view (Incident #5911)
- Defer history window refresh if the window is not visible.
- Using Ctrl+Wheel to zoom the HTML browser now works in the same way as Internet Explorer and Chrome.
- Changes to the project through the Project Manager dialog are now reflected to the Project Explorer when settings are shown under the node. (Incident #5829)
- Fixed column size problems in Project Manager when changing views. (Incident #4965)
- Better handling of codec selection when files are loaded and saved. (Incident #5798)
- Fixed crash when using 'File > Open CrossStudio' to open folders on Mac OS X.
- Code editor now marks file as modified if inconsistent line endings have been corrected.
- Find in files now uses 'Look in files matching' field when doing a solution/project search.

- Fixed issue when auto-documenting structures where const and volatile qualifiers on members were sometimes discarded.
- Removed capability to auto-load of last project on IDE startup.
- Added Reload to Project Explorer toolbar and Project menu to reload the last project, if no project loaded, or the current project.
- Added Reload to Browser window to reload the source HTML.

Debug

- Added support for Arduino/Wiring target interfaces.
- Moved **Erase All** and **No Load Sections** target properties to be debug project properties.
- Added debug project properties that specify the initial breakpoint settings. The environment equivalents are now the default values for these project properties.
- Added support in debugger for 0b numbers on expressions.

Library

- Fixed problem printing very large long longs requiring 19 decimal digits. Fixed problem with incorrect sign-extension for some library configurations.
- Fixed `__vfprintf` which sometimes over-eagerly swaps to floating format when using `%g`.
- `sprintf` and friends print `-inf` for negative infinity.
- Fixed printing zero in `%u` and other integer formats using width/precision unsupported mode (incident #4944)
- Fixed definition of `UINT8_C` in `stdint.h`.
- Fixed `mktime` when presented with out-of-bounds member values (incident #2722)
- Fixed `wchar_t` to unsigned. (Incident #5979)
- Fix bug in `realloc()` when reducing the size of an existing allocation. (Incident #6006)
- Added runtime support for 32-bit x 32-bit to 64-bit long long multiplication.

CTL

- Fixed rescheduling from `ctl_byte/message_queue_post` when `notempty` event flag is used.
- Successfully calling `ctl_events_wait()`, `ctl_mutex_lock()`, `ctl_semaphore_wait()` will return immediately i.e. not cause a reschedule.
- ISR's now run on their own stacks.
- CTL - fixed priority restore on mutex unlock when higher priority waiting task has timed out.

Miscellaneous

- Added `-x` option to `mkpkg`.
- Register and bitfield definitions in the memory map can now include descriptions.
- Added `BinaryFile` script class.

Release 2.0.4

- Added **Auto Surround** editor configuration option to enable or disable automatically surrounding text when there is an active selection.
- Added **Auto Comment** editor configuration option to enable or disable automatically swapping the line comments when there is an active selection.
- Enhancements to the threads window
 - Sentinel USB tokens now work under Linux (Ubuntu 8.04 and 10.04 tested with Sentinel USB Daemon v7.5.2).
 - The filename of the threads script need not be fixed as threads.js it can now be specified using the Threads Script file type property.
 - The threads script can specify the set of displayed columns.
 - Can be sorted by clicking on a column.
 - Gives a better indication of the selected thread.
 - The threads script can be written so that the register state of a thread is retrieved when the thread is selected.
 - The threads script has access to the TargetInterface object.
- Save Solution As.. now reloads the saved solution.
- File > Open now opens file browser in a sensible place.
- Reworked some alert notification dialogs.
- Documentation for a subset of header files now generated automatically by internal tools.
- Improvements in License Manager dialog on Mac OS.
- Fixed lock up on Mac OS version when file is modified externally.
- Fixed code editor jumping to start of file when Outline window is active.
- Device identify now uses the target processor property to differentiate devices that have the same jtagid/signature.
- Support for debugging debugWIRE bootloader executables.
- Target window "Erase All" action greyed out for debugWIRE targets.
- Target property "Erase All" not shown for debugWIRE and ISP targets.
- Fixed start debugging with Step Into when debugIO is used.
- Fixed breakpoint on main when startup completion breakpoint is used.
- Fixed debugger data memory access on devices which have a gap between IO registers and SRAM.
- Fixed project properties update in the project window when target/placement changed by project explorer menu.
- Added Arduino target interface.
- On windows hosts serial port name target interface properties can be right clicked to select the COM port.

Release 2.0.3

- Fixed windows libusb0 installation problems.

- Added `debug_enabled()` function that returns true if the application is being debugged.

Release 2.0.2

- Removed Disconnect(Disable DebugWire) target menu entry - the ISP interface can now be used to disable DebugWIRE.
- Added support for JTAG programming and debugging of JTAG MEGA and XMEGA devices using:
 - [PC Parallel Port to AVR/MAXQ 10 pin JTAG.](#)
 - [PC Parallel Port to ARM 20 pin JTAG.](#)
 - [CrossConnect for ARM 20 pin JTAG.](#)

Note that the 20 pin connectors require a convertor board/cable to connect to a standard AVR 10 pin JTAG header.

- Removed programming menu entries from the project explorer.
- Support for `__eeprom` qualifier on XMEGA devices.
- Support for data breakpoints on XMEGA devices.
- Support for aligned powers of two data range breakpoints on JTAG MEGA devices.
- Added linker and crt0.asm support for building bootloader executables.
- JTAGICEmkII/AVRDragon JTAG and PDI target interfaces now support the "Erase All" property.
- JTAGICEmkII/AVRDragon target interfaces now use hardware breakpoint support for stepping functions.
- Target interfaces now have a "No Load Sections" property to stop named sections being loaded.
- On windows hosts the functions in libusb0.dll are now accessed by symbol names which should enable newer versions of libusb0 to be used.
- Fixed decimal display in registers window.
- File names in projects can now have embedded periods, e.g. "foo.bar.c".
- New File dialog now supports embedded periods in file names.
- Fixed editor crash when editing doxygen style comments.
- Debug actions are now available on the disassembly window toolbar.
- Additional assembler/compiler/linker options properties can now be held in a file referenced by new project properties.
- Added `debug_load_symbols/debug_unload_symbols` functions to enable debugging of dynamically loaded applications.
- Disassembler now displays data sections as hex (rather than trying to disassemble).
- Terminal emulator can (and does) set DTR signal on connect.
- Terminal emulator supports ansi clear display sequence and `\r`.
- On windows hosts the terminal emulator port property can be right clicked to select the list of available COM ports.
- Added `-docgen` option to `cpphtml` tool to enable html to be generated from structured comments.

Release 2.0.1

- Corrected assembly code executable project template's startup code.
- Added option to disable spell checker
- Added option to disable paste on middle mouse button click and made it default to off.

Release 2.0

Start over.

Known Problems



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 CrossWorks help **Browser** window, you may find it more convenient to view using an external web browser so you can still see the entire CrossWorks window. To do so, simply right-click on the help content in the CrossWorks **Browser** and choose **Open in 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.

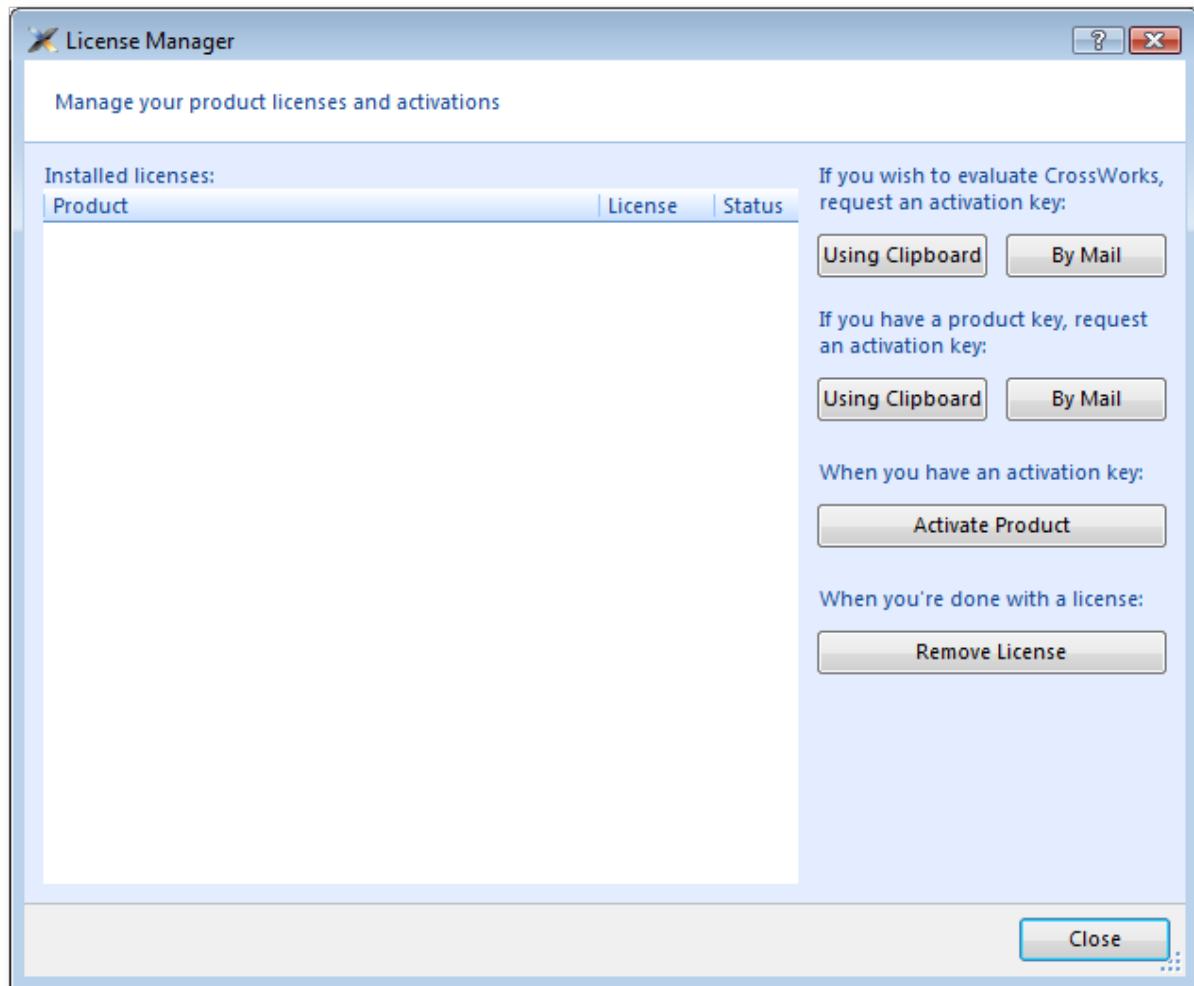
Debugging externally built applications

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 CrossStudio'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.

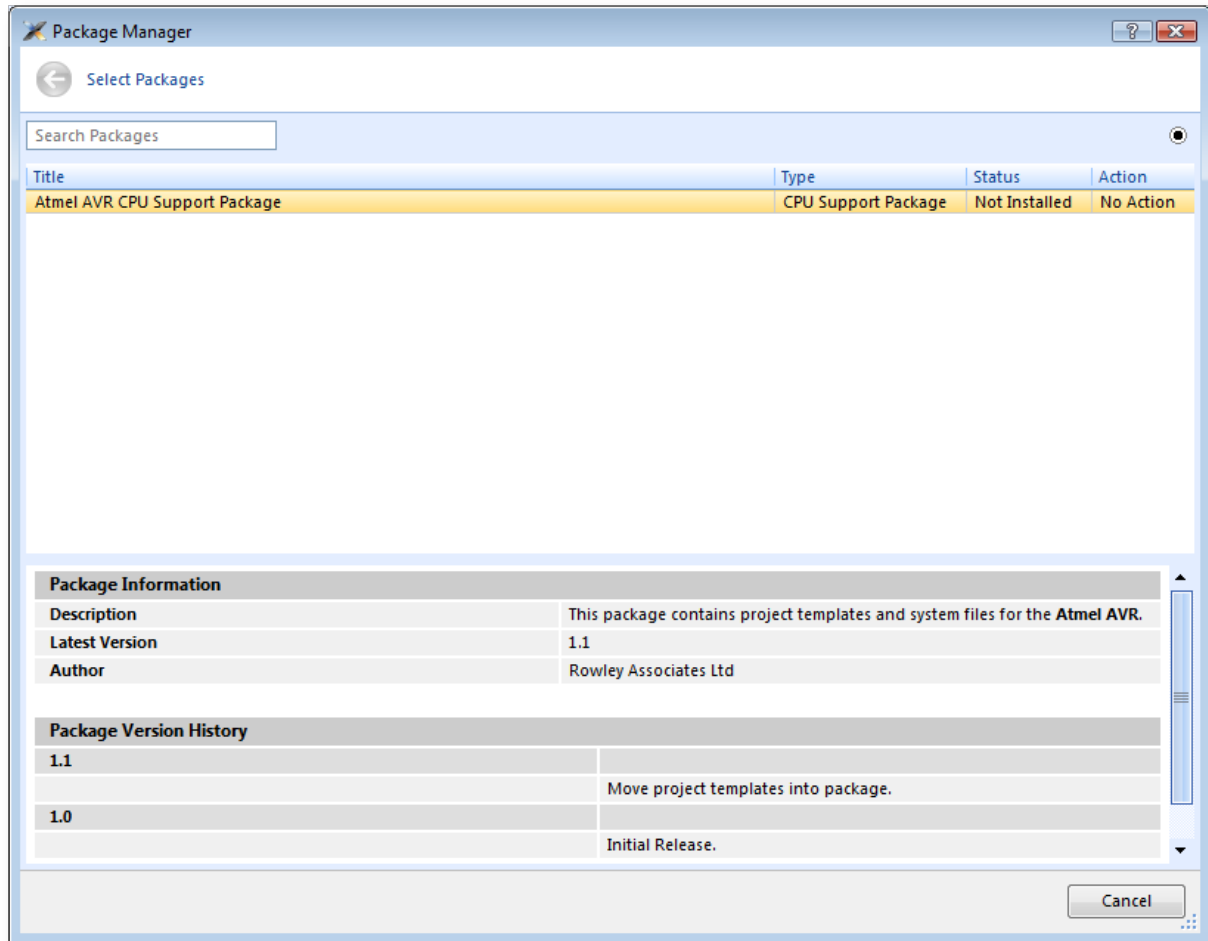
In this tutorial, we are going to use CrossStudio's **Package Manager** to download, install, and use the Atmel AVR CPU Support Package.

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

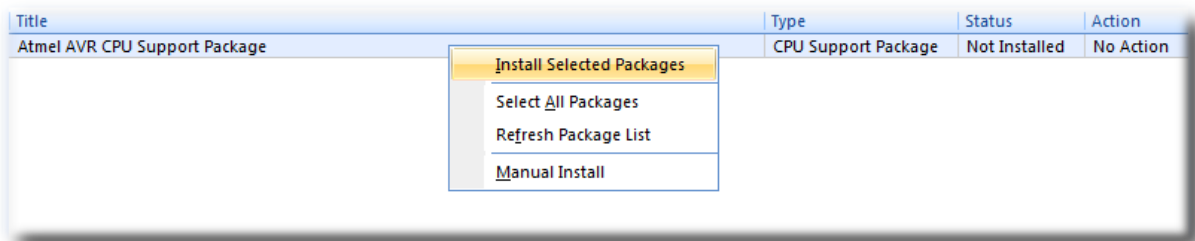
Downloading and installing a support package

To download and install a support package:

- Choose **Tools > Manage Packages**.
- Select the Atmel AVR 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:

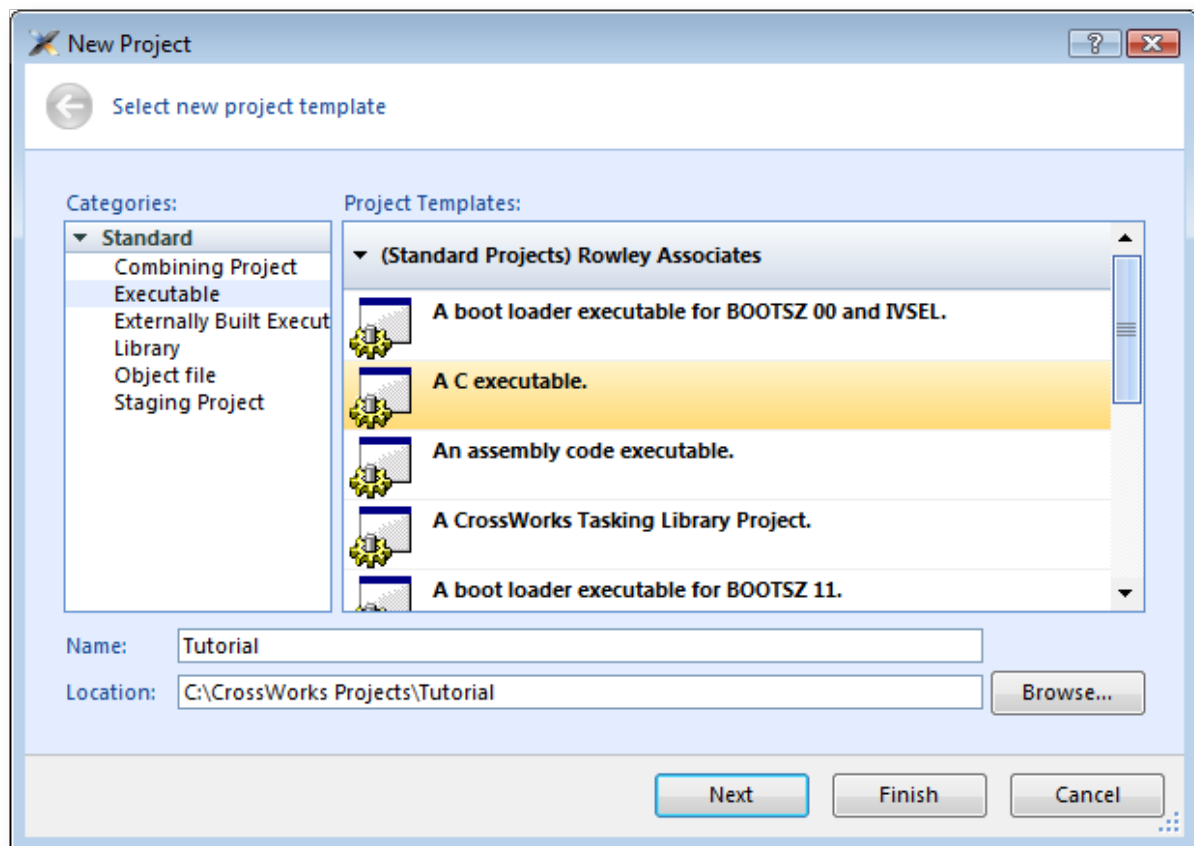
- Choose **Tools > Show Installed Packages** to list the support packages you have installed on your system. You should see the name of the **Atmel AVR CPU Support Package** you just installed.
- Click **Atmel AVR CPU Support Package** to view the support package page in the CrossStudio **Browser** window. 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:

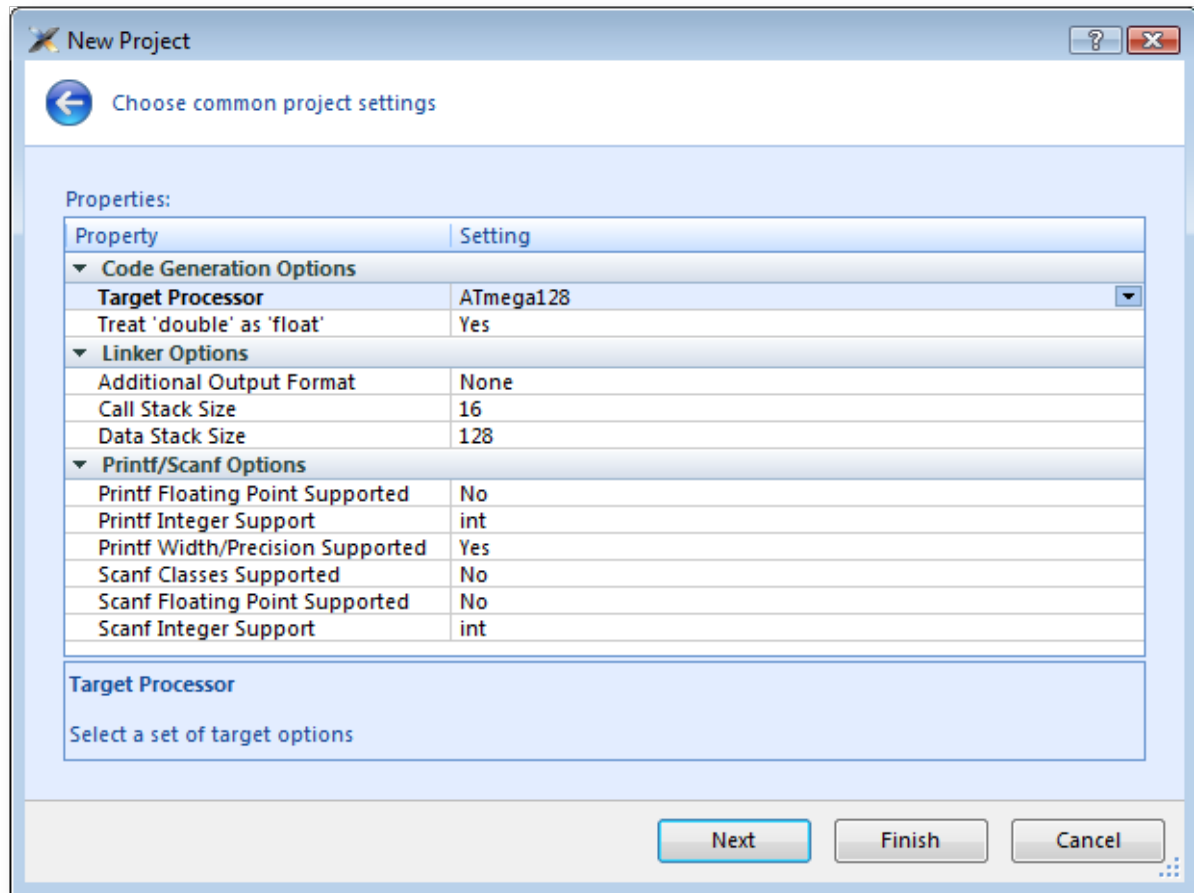
- Choose **File > New Project** or press **Ctrl+Shift+N**

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



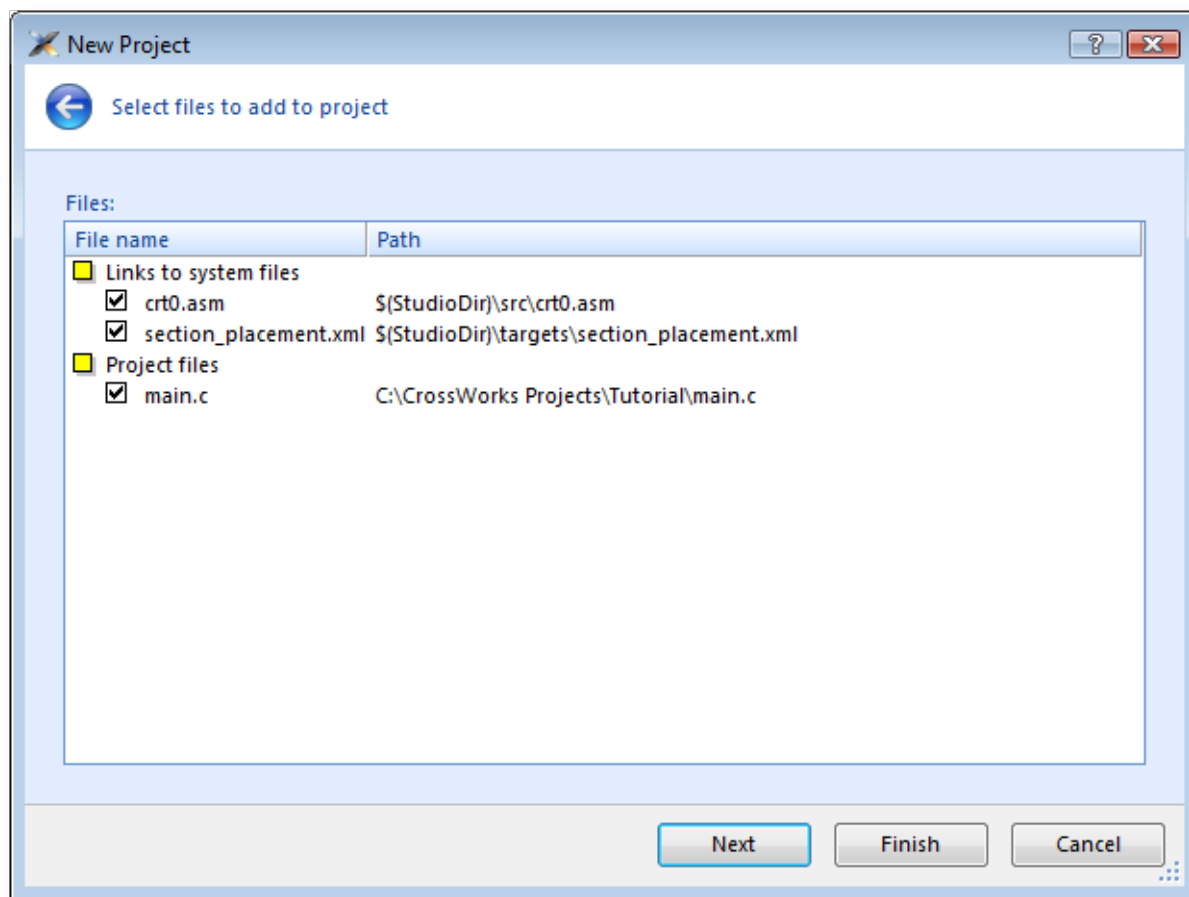
We'll create a project to develop our application in C:

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 CrossStudio 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.

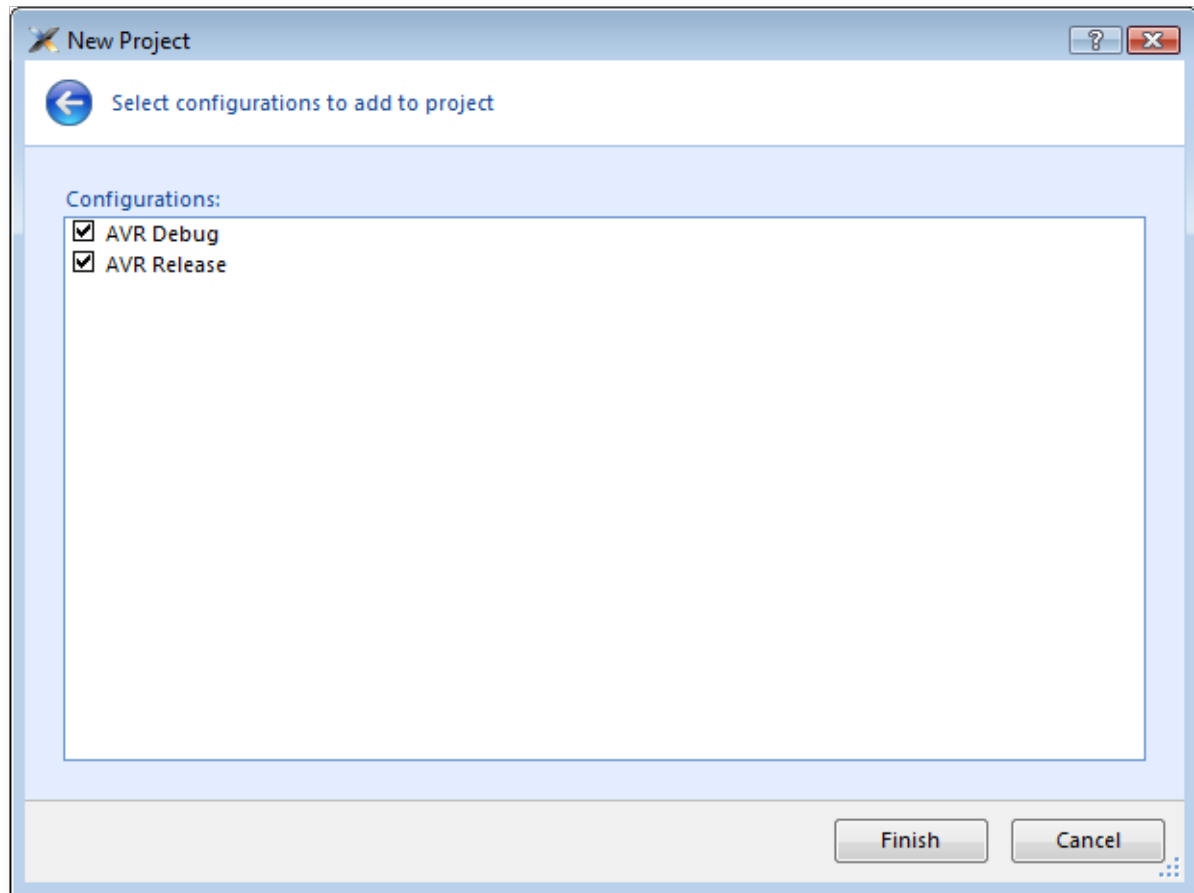


The **Links to system files** group shows the links to CrossStudio system files that will be created in the project. Because these files are links, the default behavior is that they will be shared with other projects—so modifying one will affect all projects containing similar links. To prevent accidental 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.

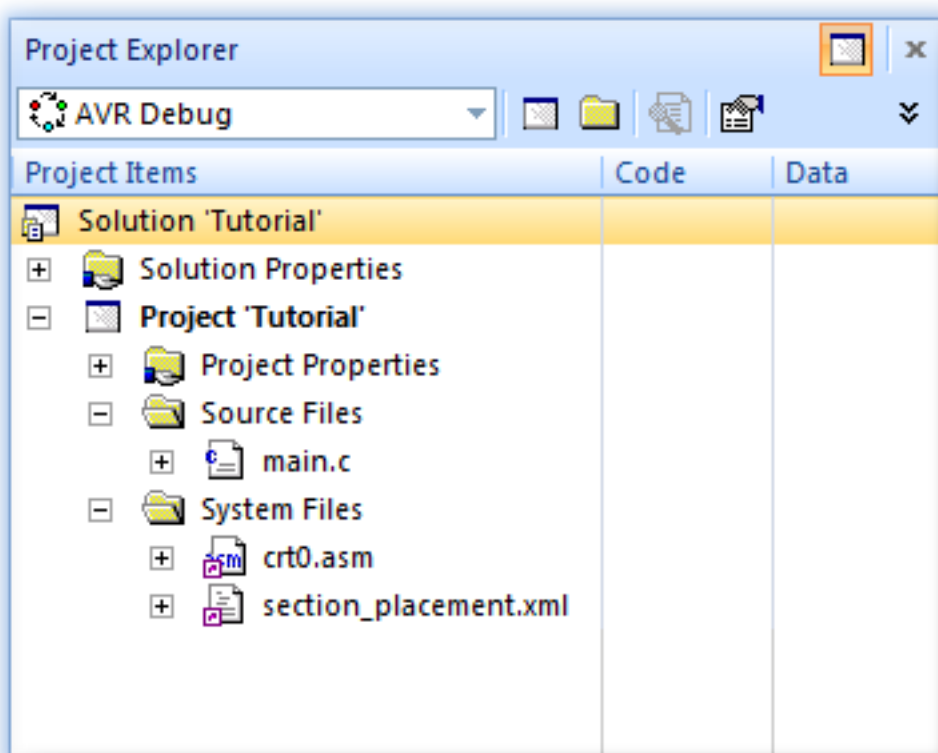
The **Project Explorer** shows the overall structure of your project. To invoke it, do one of the following:

- 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
`section_placement.xml` — informs the linker how to arrange program sections in memory

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 CrossStudio IDE. For this, we will add one pre-prepared file and one new file to the project.

Adding an existing file to a project

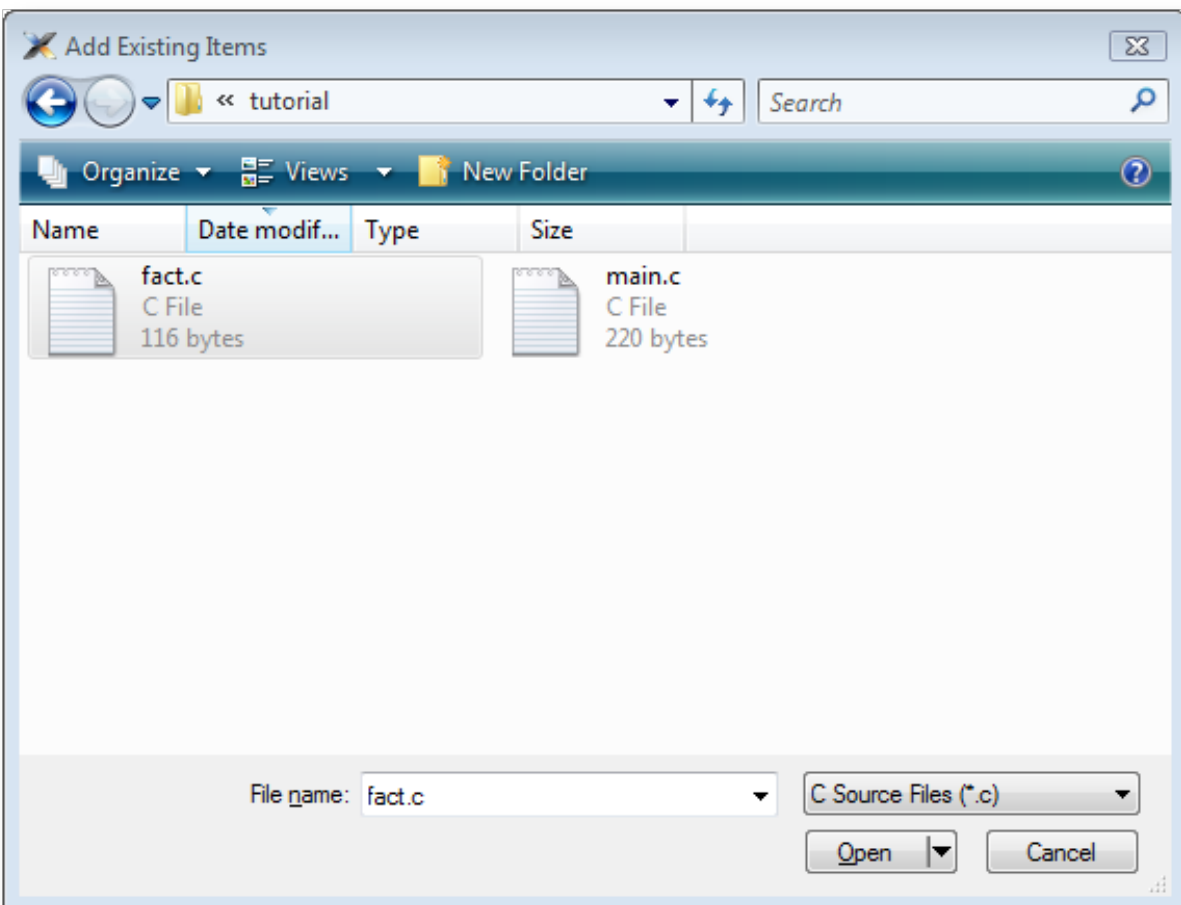
To add one of the existing tutorial files to the project:

- Choose **Project > Add Existing File**.

—or—

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

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

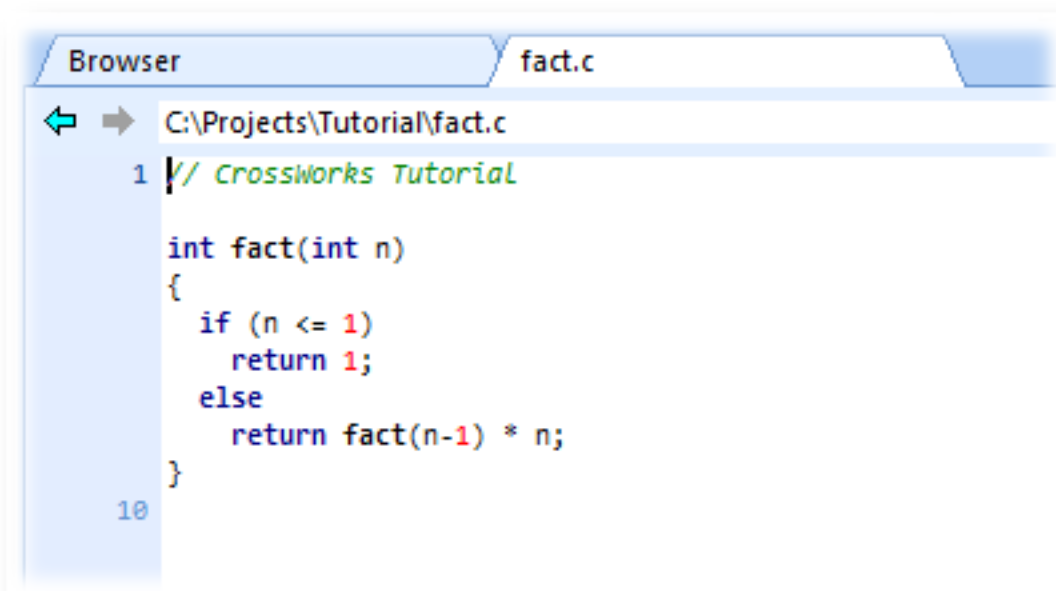


Click **Open** to add the file to the project. The **Project Explorer** will list `fact.c` in the **Project Items' Source Files** folder, with a shortcut arrow because the file is not in the project's home directory. Rather than edit the file in the tutorial directory, we'll put a copy of it into the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



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.

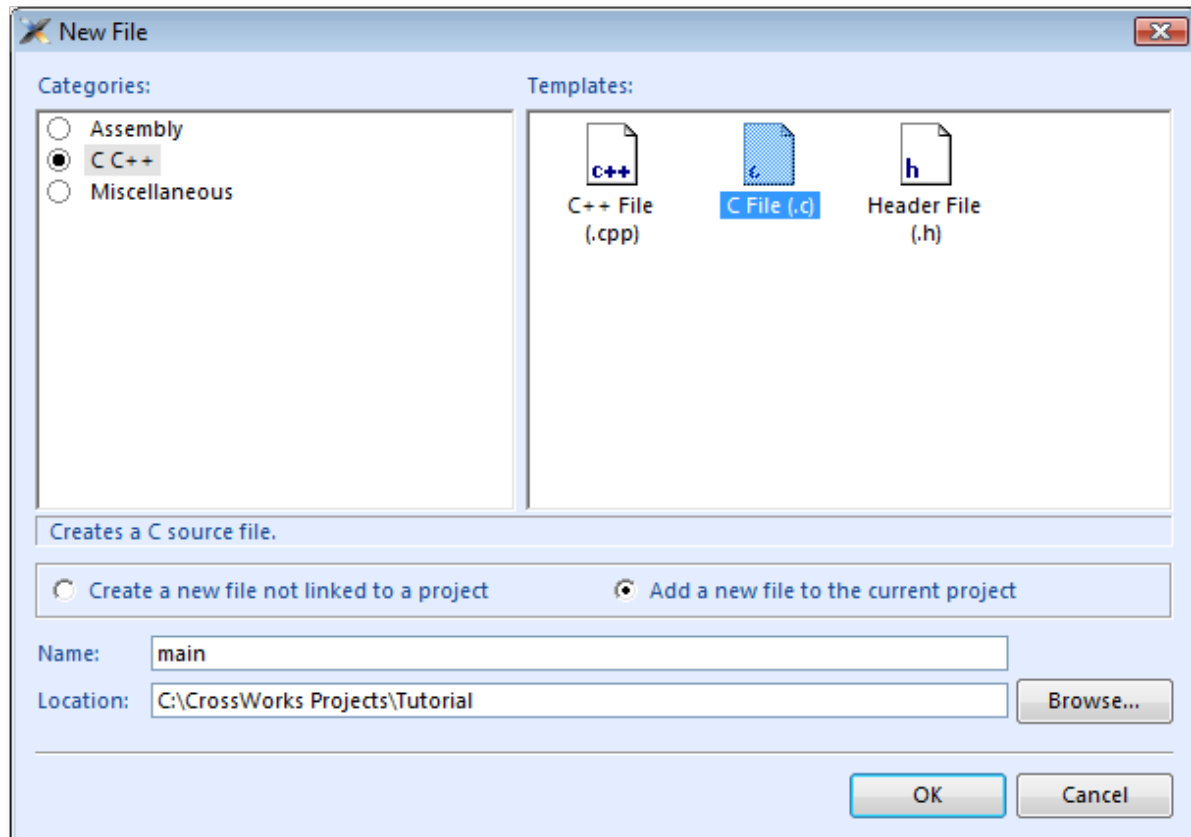
—or—

- Type **Ctrl+N**.

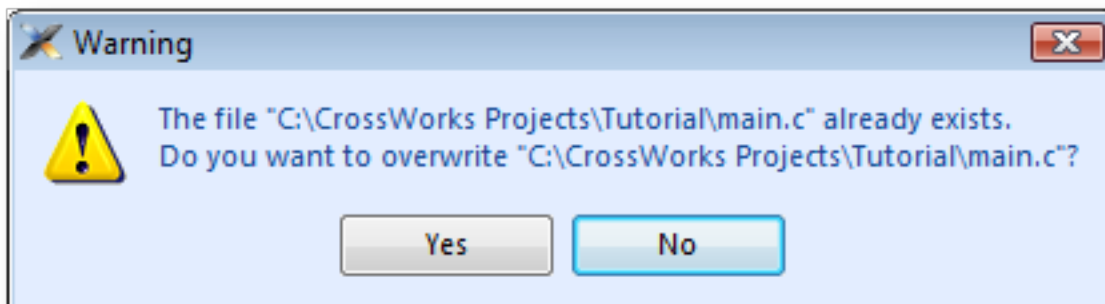
The **New File** dialog appears.

- 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:



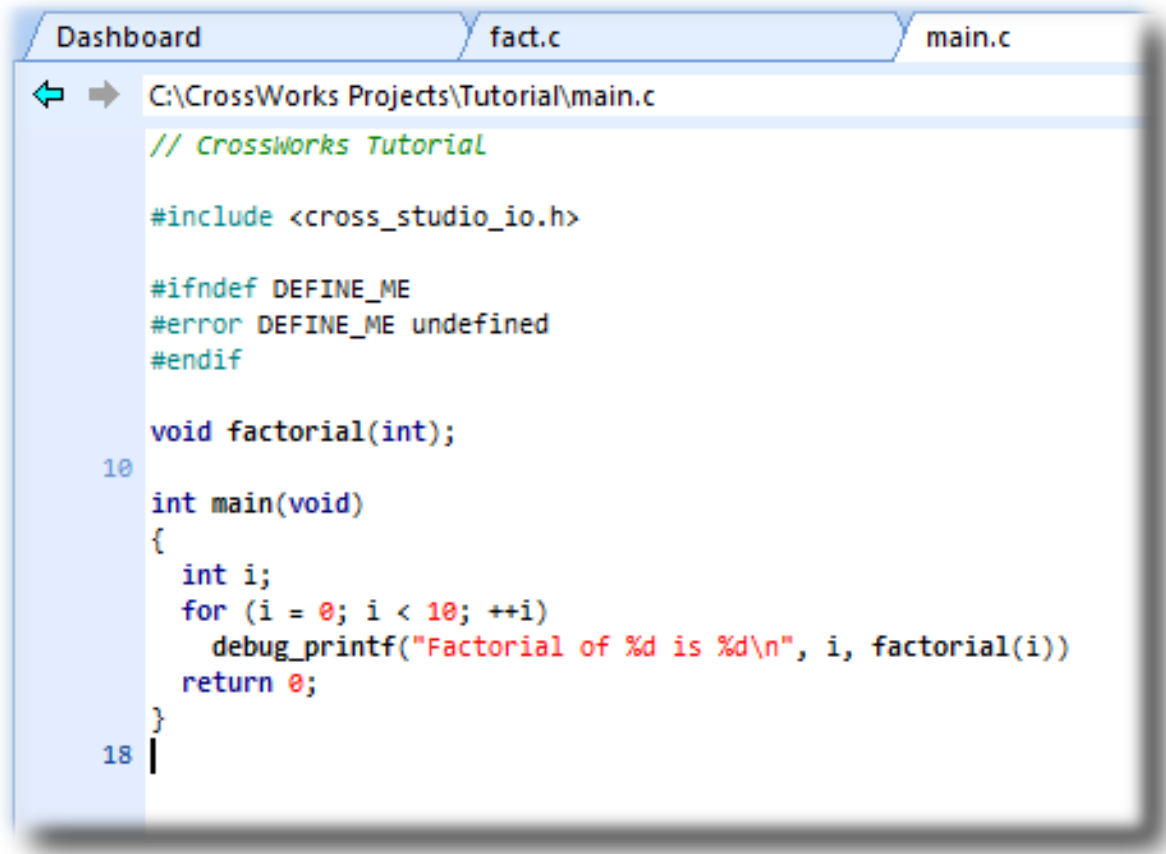
Click **Yes** to overwrite the file and continue with the tutorial.

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

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

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



```
Dashboard fact.c main.c
C:\CrossWorks Projects\Tutorial\main.c
// 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.

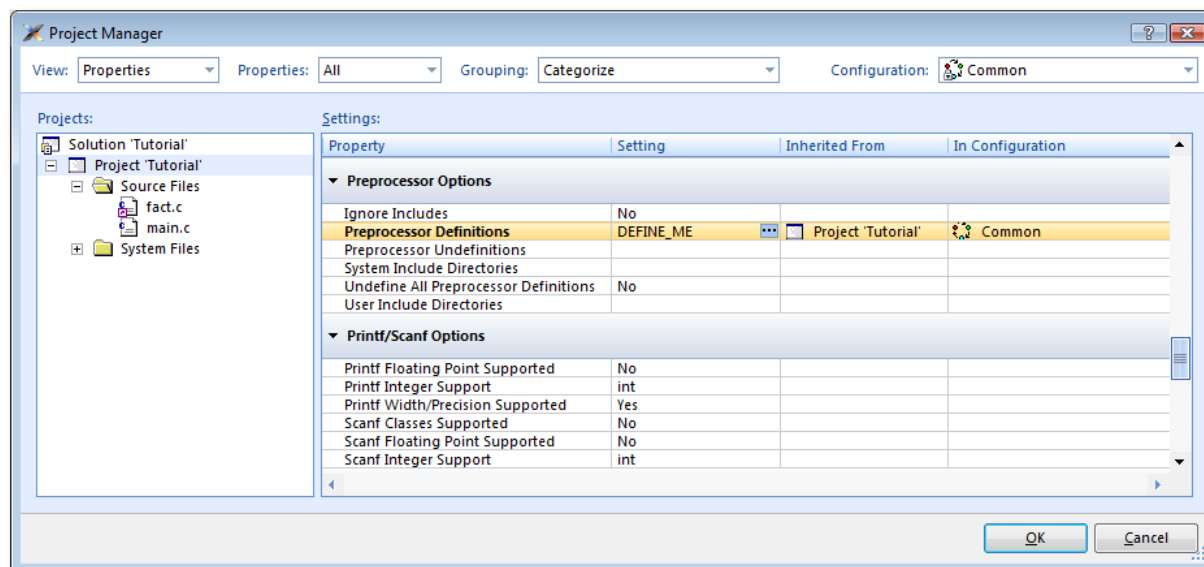
Adding a C preprocessor definition

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 **AVR 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 **AVR Release** configuration. However, because we are going to use the debugger, we shall use the **AVR 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.

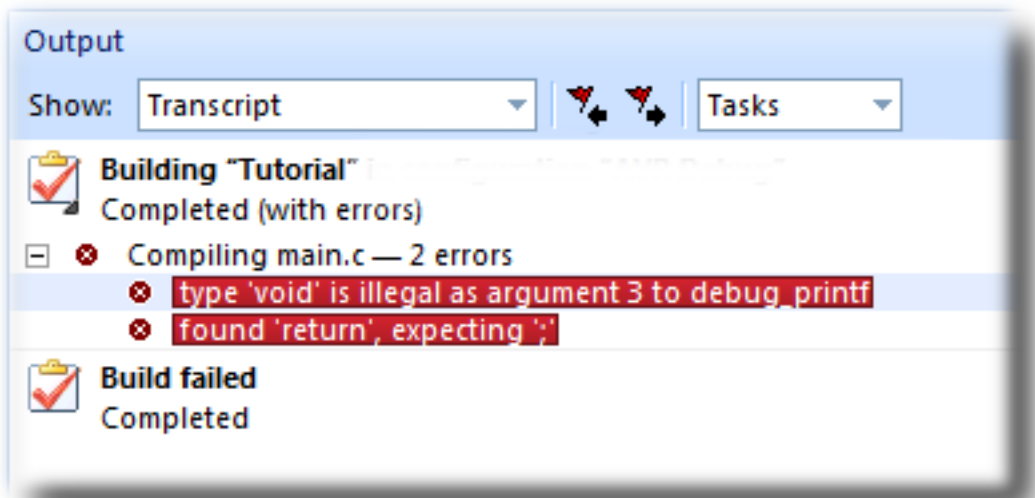
—or—

- Type **F7**.

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

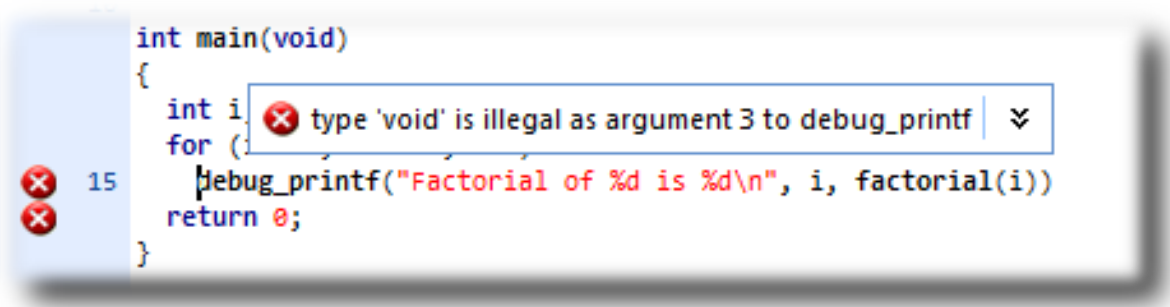
- In the **Project Explorer**, right-click the Tutorial project node.
- Select **Build** from the shortcut menu.

CrossStudio 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

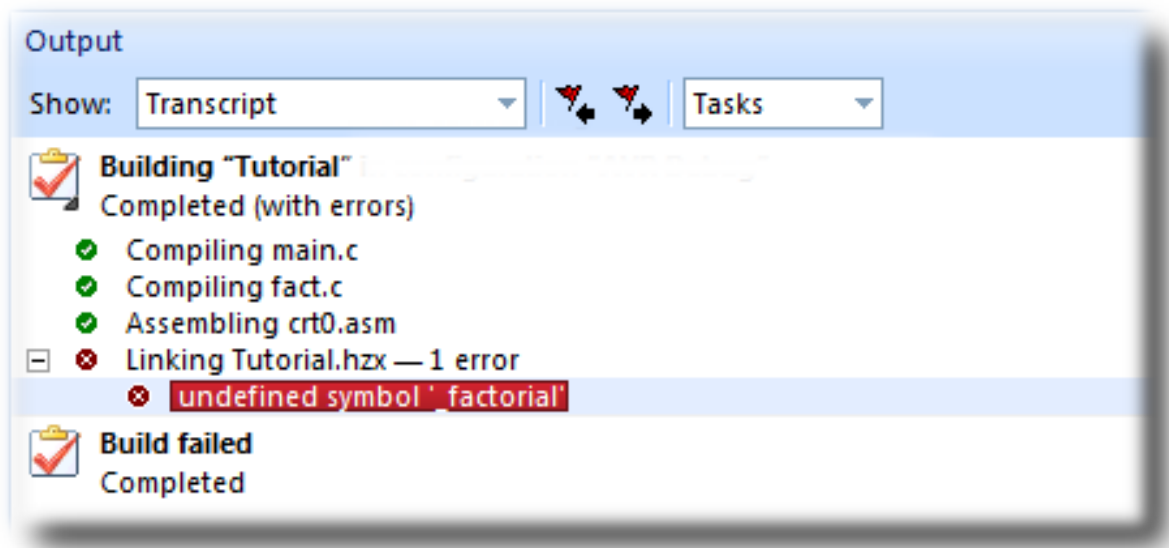
The file `main.c` contains two errors. After compilation, CrossStudio moves the cursor to the line containing the first reported error and displays an error message in the **Output** window. (You can change this behavior by modifying the **Text Editor > Editing Options > Enable Popup Diagnostics** environment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



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

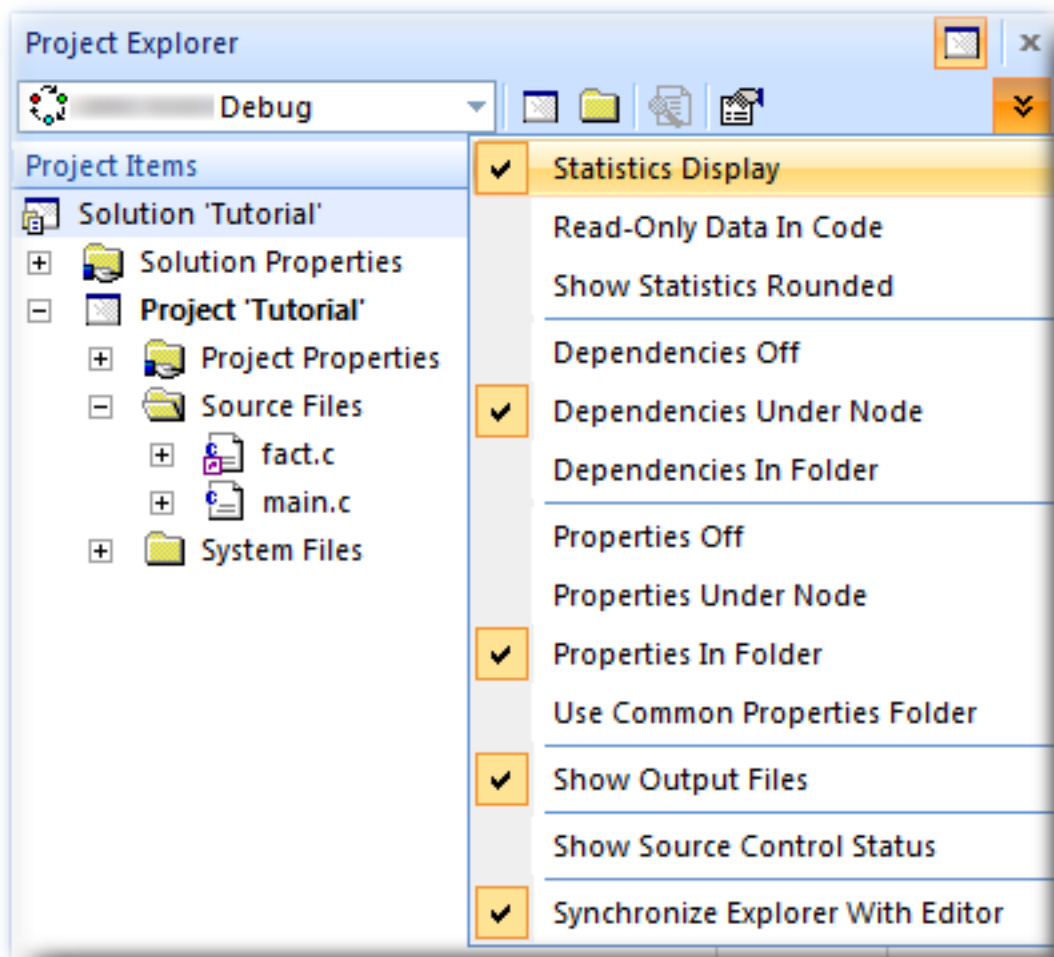
Now that the project has no errors and builds correctly, we can turn our attention to uncovering exactly how our application fits in memory and how to navigate around it.

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 CrossStudio 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**.

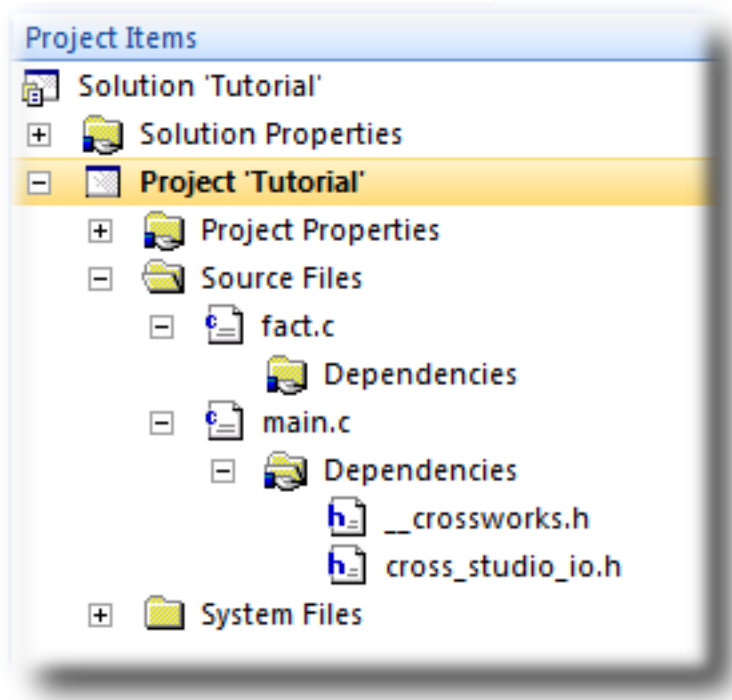
Project Items	Code	Data
 Solution 'Tutorial'		
 Solution Properties		
 Project 'Tutorial'	2,148	28
 Project Properties		
 Source Files		
 fact.c	80	
 main.c	100	24
 System Files		

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, CrossStudio finds and records the relationships between files—that is, it finds which files depend upon other files. CrossStudio uses these known relationships when it builds the project again, to minimize the amount of work required to bring the project up to date.

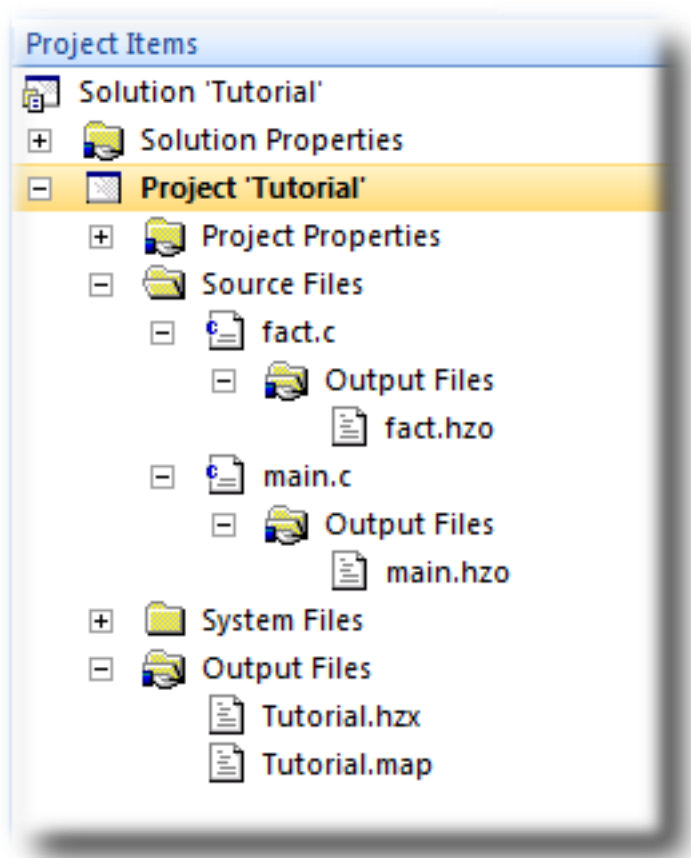
To show the dependencies for a project, use the **Options** button on the **Project Explorer** tool bar to ensure that either **Dependencies Under Node** or **Dependencies In Folder** is checked. Once checked, dependent files are shown as sub-nodes of the file that depends on them.



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 CrossStudio 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**.

CrossStudio 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.

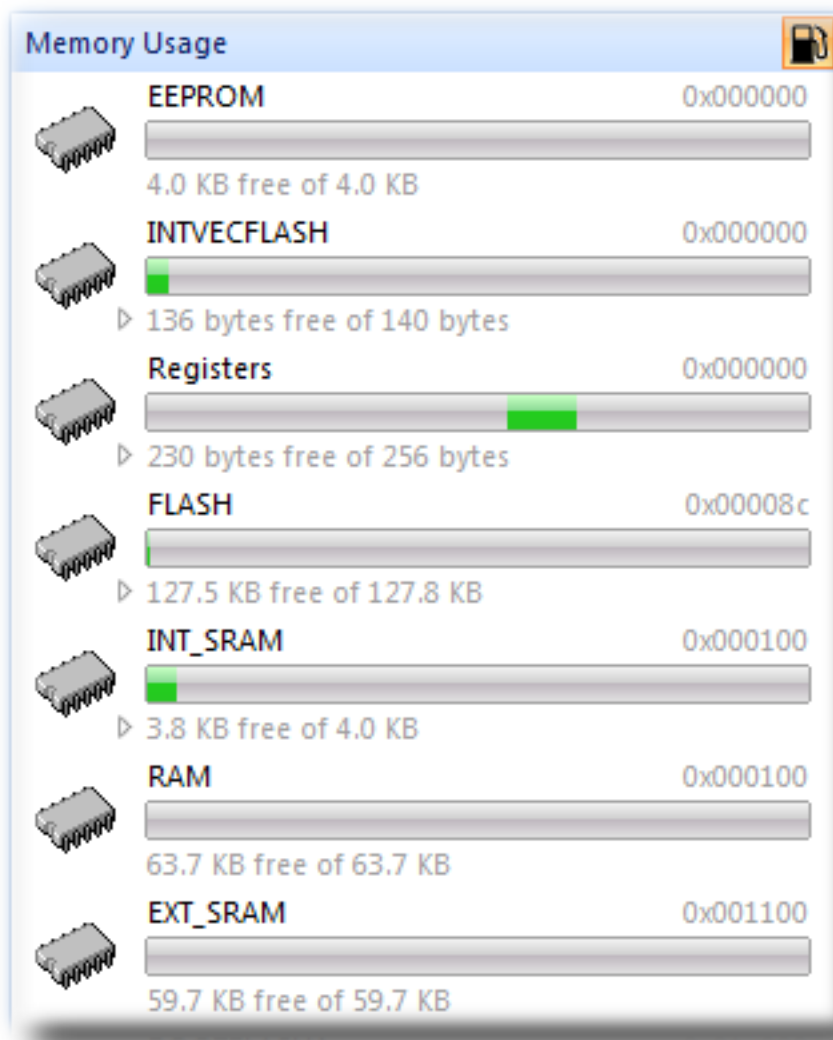
Using Memory Usage Window features

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**.

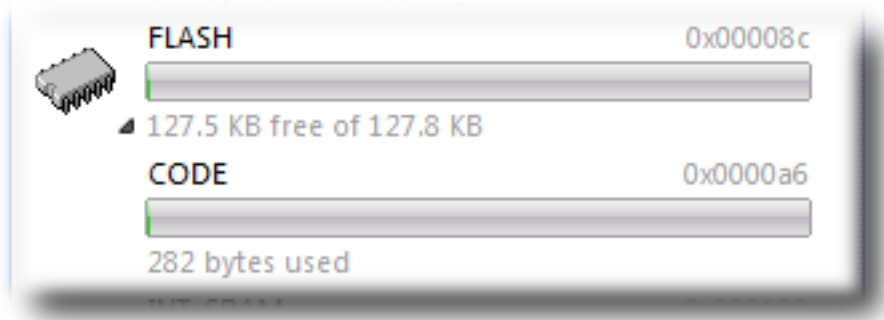
For the Tutorial project, the **Memory Usage** window shows this:



From this, you can see:

- The **RAM** segment is located at 000100, is 63.7 KB in length, and has 63.7 KB of unused memory.
- The **FLASH** segment is located at 00008C, is 127.8 KB in length, and has 127.5 KB of unused memory.

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



From this, you can see that the the **CODE** section is located at 0000A6 and is 282 bytes in length.

Using Symbol Browser features

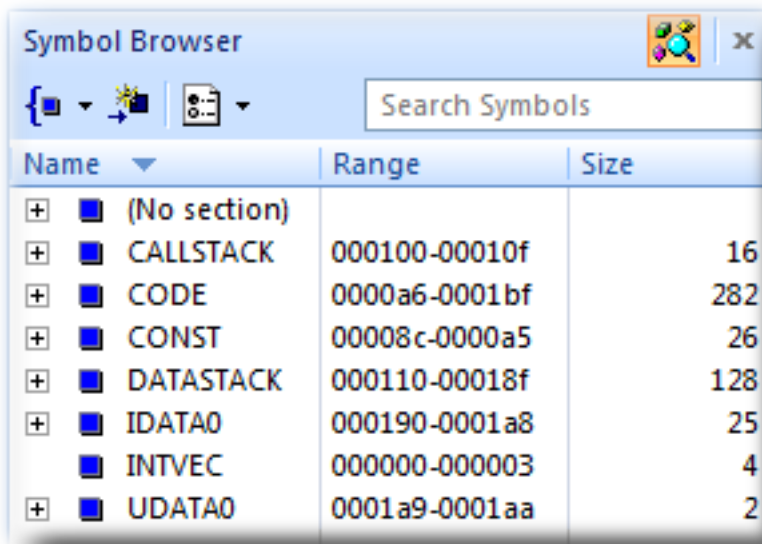
For a more-detailed view of how your application is laid out in memory than the **Memory Usage** window provides, you can use the **Symbol Browser**. It allows you to navigate your application, see which data objects and functions have been linked into your application, what their sizes are, which section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

To activate the Symbol Browser:

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

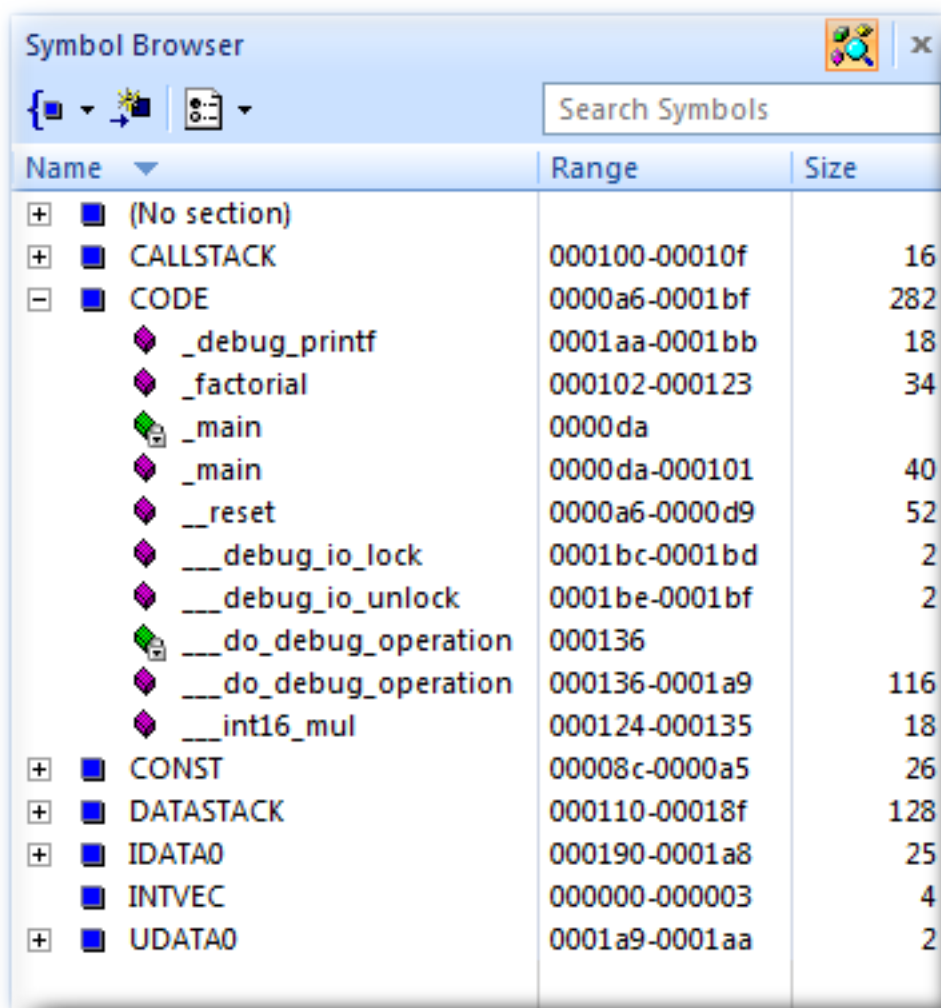
Drilling down into the application

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



From this, you can see that the **CODE** section is 282 bytes in size and is placed in memory between address 0000A6 and 0001BF, inclusive. Similarly, the zeroed data section **UDATA0** is 2 bytes in size and is placed between 0001A9 and 0001AA. The **CONST** section that holds string constants and read-only data is 26 bytes in size, and is located between 00008C and 0000A5. 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: CrossStudio displays the individual functions that have been placed in memory and their sizes:



Here, we can see that **main** is 40 bytes in size and is placed in memory between addresses 0000DA and 000101, inclusive, and that **factorial** is 34 bytes and occupies addresses 000102 through 000123. Just as in the **Project Explorer**, if you double-click a function, CrossStudio 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. CrossStudio 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 CrossStudio 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 CrossStudio 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 > AVR Simulator**.

—or—

- Choose **View > Targets** to activate the **Targets** window.
- In the **Targets** window, double-click **AVR Simulator**.

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



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

- **White** — No target is connected.
- **Yellow** — Target is connected.
- **Solid green** — Target is free running, not under control of CrossStudio 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** — CrossStudio is programming the application into the target.

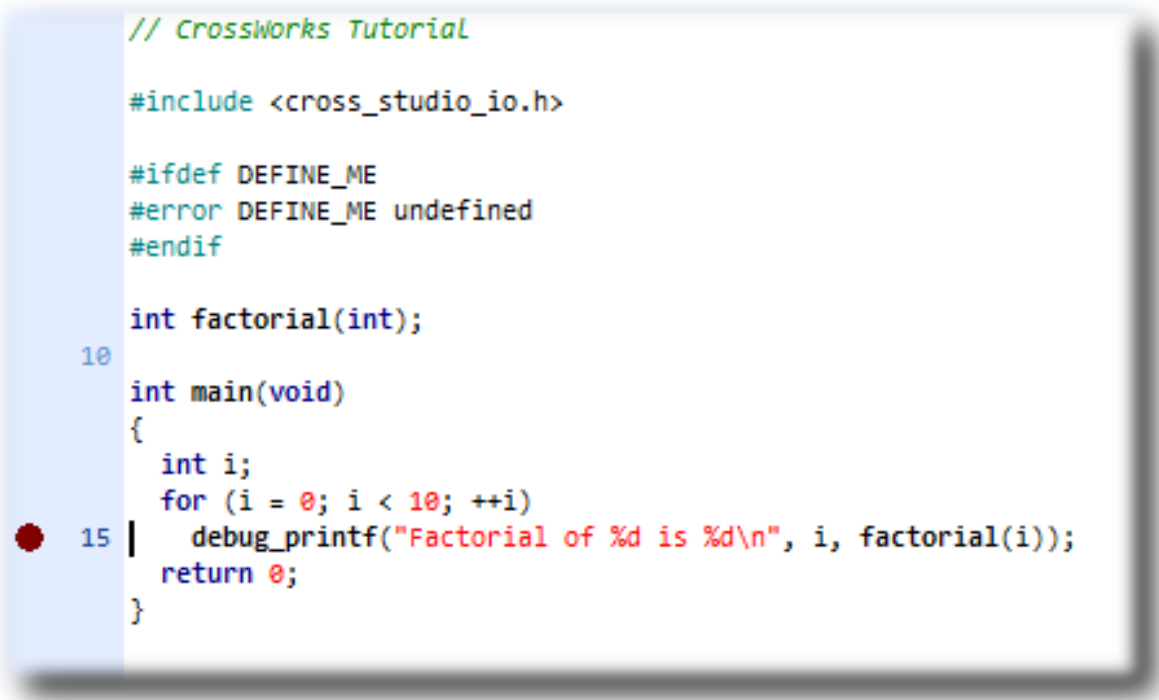
Double-clicking the **Target Status** will show the **Targets** window, if it is not already visible.

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

CrossStudio 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.

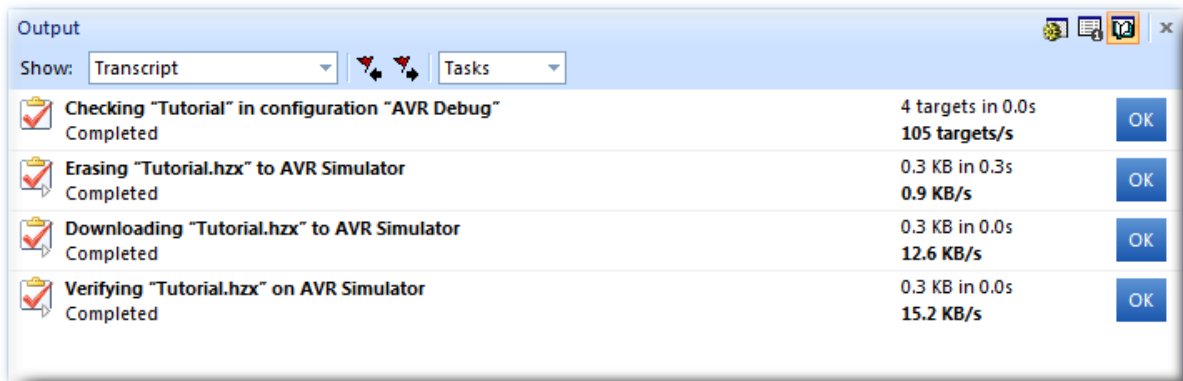


The gutter displays an icon on lines where breakpoints are set. The **Breakpoints** window updates to show where each breakpoint is set and whether it's set, disabled, or invalid—you can find more detailed information in the [Breakpoints window](#) section. The breakpoints you set are stored in a session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

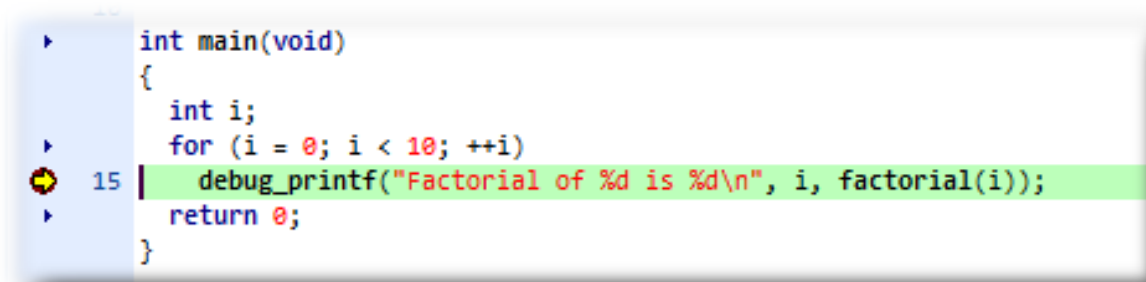
Starting the application

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. CrossStudio 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:

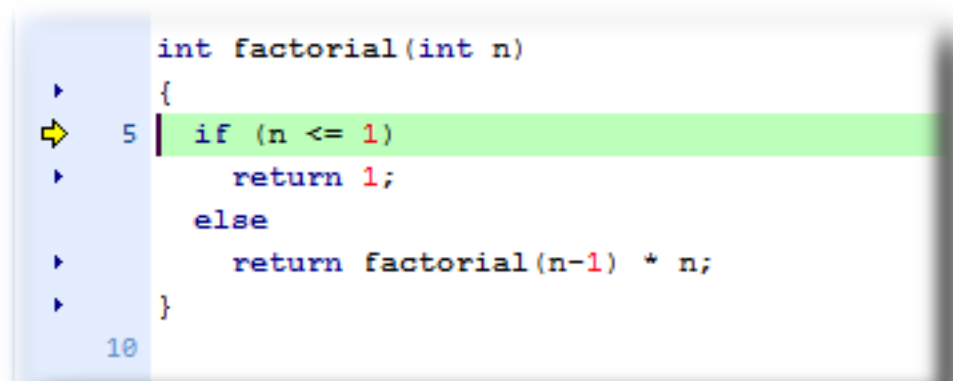


The program stops at our breakpoint and a yellow arrow in the gutter indicates where the program is paused.



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.

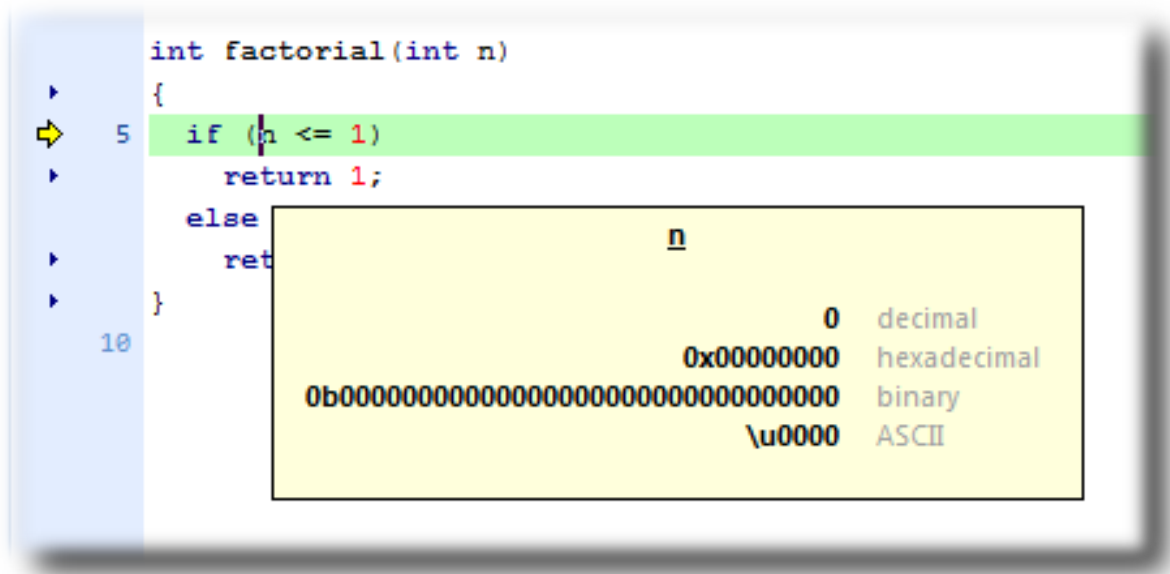


You can step out of a function by choosing **Debug > Step Out**, by typing **Shift+F11**, or by clicking the **Step Out** button on the **Debug** tool bar. You can also step to a specific statement by choosing **Debug > Run To Cursor**. To allow your application to run to the next breakpoint, choose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

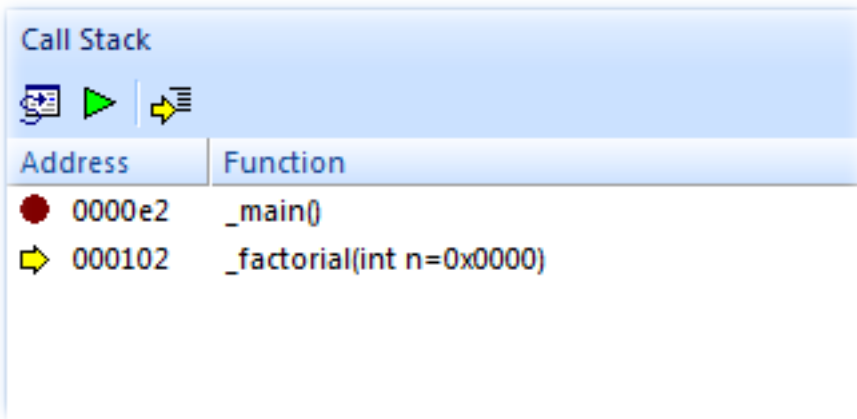


You can configure CrossStudio to display data tips in a variety of formats at the same time using the **Environment Options** dialog. You can also use the **Autos**, **Locals**, **Globals**, **Watch**, and **Memory** windows to view variables and memory. These windows are described in [CrossStudio User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

item 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. CrossStudio provides the tools you need to do so.

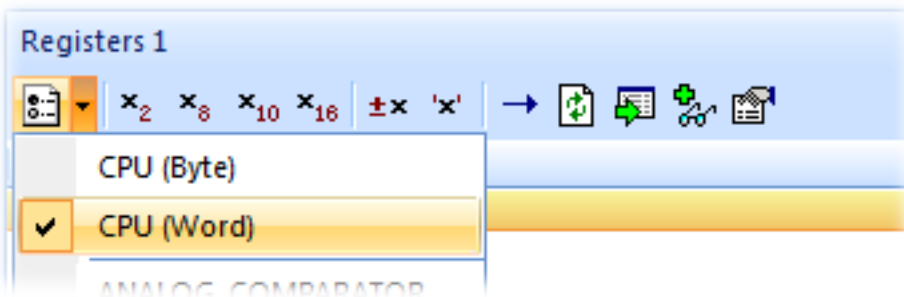
Setting up again

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.

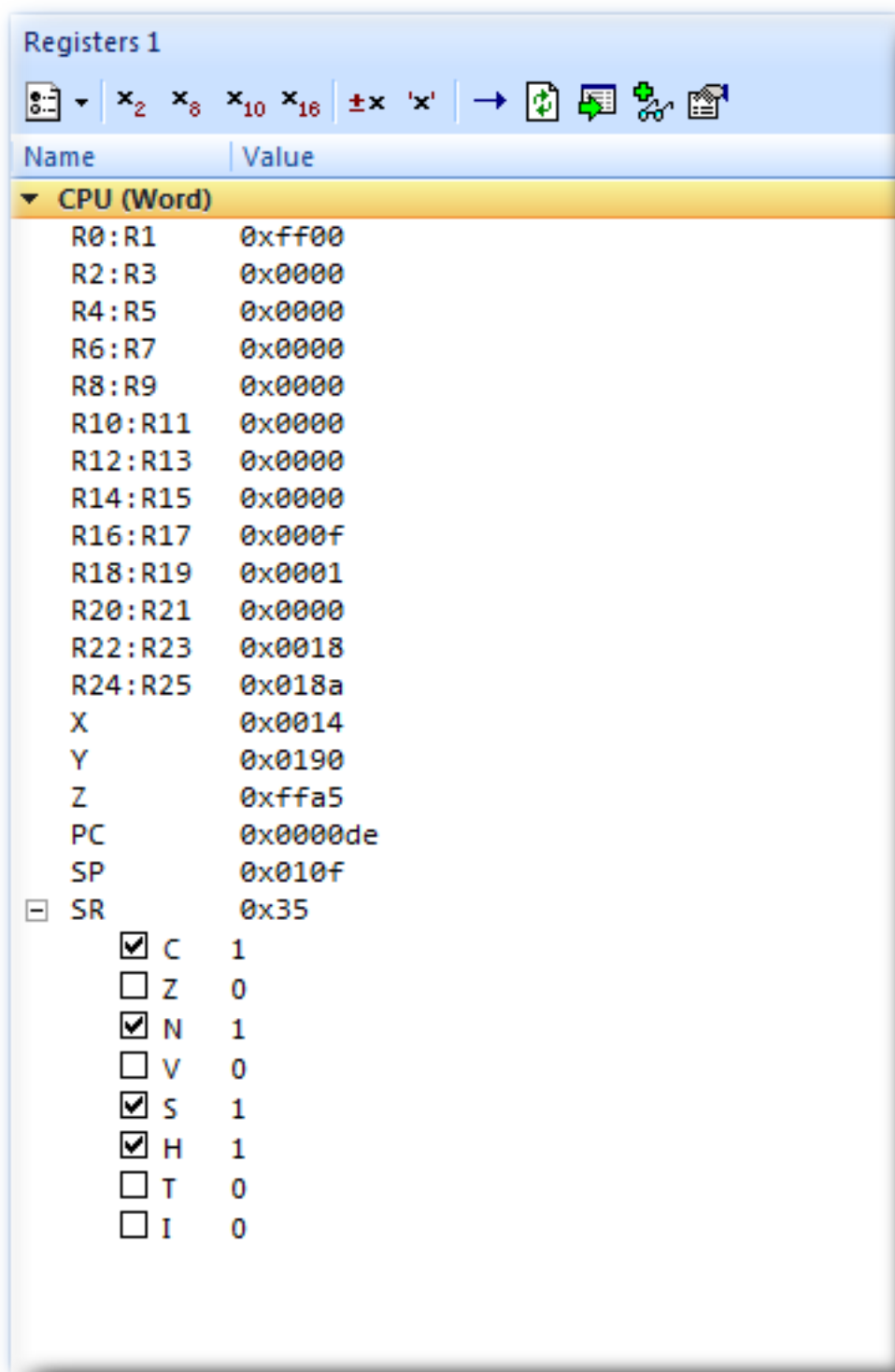
You can see the current processor state in the **Register** windows. To show the first **Registers** window:

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

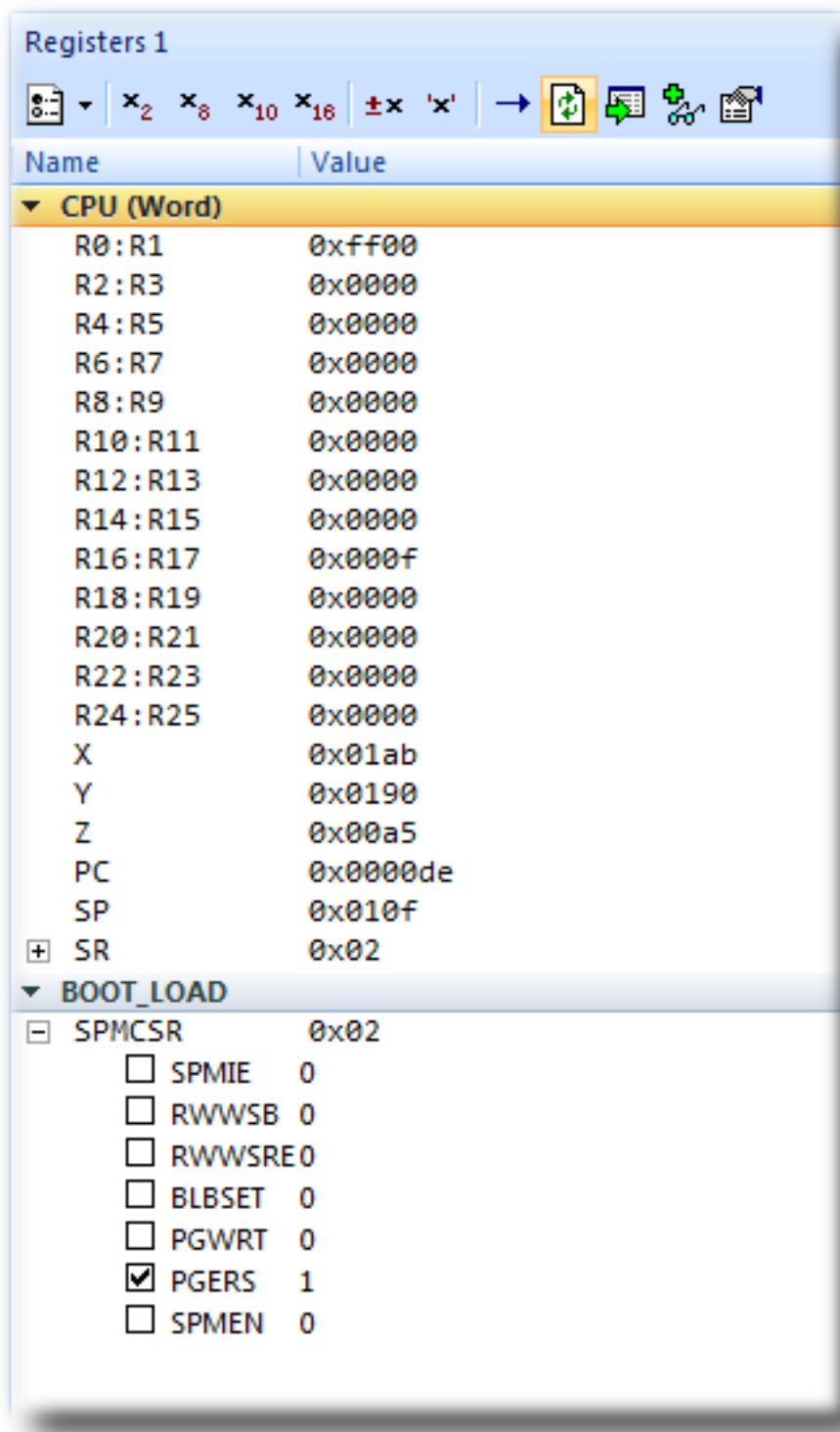
The **Registers** window can be used to view CPU and peripheral registers. First we shall look at just the CPU registers. To do this, use the **Registers 1** window's **Register Groups** menu to select **CPU (Word)**.



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 bootloader registers, select **BOOT_LOAD** from the **Register Groups** menu.



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.

```

Disassembly
_main + 0x4

— main.c — 10 —
int main(void)
{
  int i;
  for (i = 0; i < 10; ++i)
0000DA      2d20 MOV R18, R0
0000DC      2d30 MOV R19, R0
  debug_printf("Factorial of %d is %d\n", i, factorial(i));
➔ 0000DE      01d9 MOVW R26, R18
0000E0      d010 RCALL 32; 0x00102  <_factorial>
0000E2      93ba ST -Y, R27
0000E4      93aa ST -Y, R26
0000E6      933a ST -Y, R19
0000E8      932a ST -Y, R18
0000EA      e9a0 LDI R26, 0x90
0000EC      e0b1 LDI R27, 0x01
0000EE      d05d RCALL 186; 0x001aa
0000F0      9624 ADIW R28,4

— main.c — 16 —
  for (i = 0; i < 10; ++i)
0000F2      5f2f SUBI R18,255
0000F4      4f3f SBCI R19,255
0000F6      302a CPI R18, 10
0000F8      0530 CPC R19, R0
0000FA      f38c BRLT -30; 0x000de

— main.c — 15 —
  debug_printf("Factorial of %d is %d\n", i, factorial(i));
  return 0;
0000FC      2da0 MOV R26, R0
0000FE      2db0 MOV R27, R0
000100      9508 RET

```

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**.

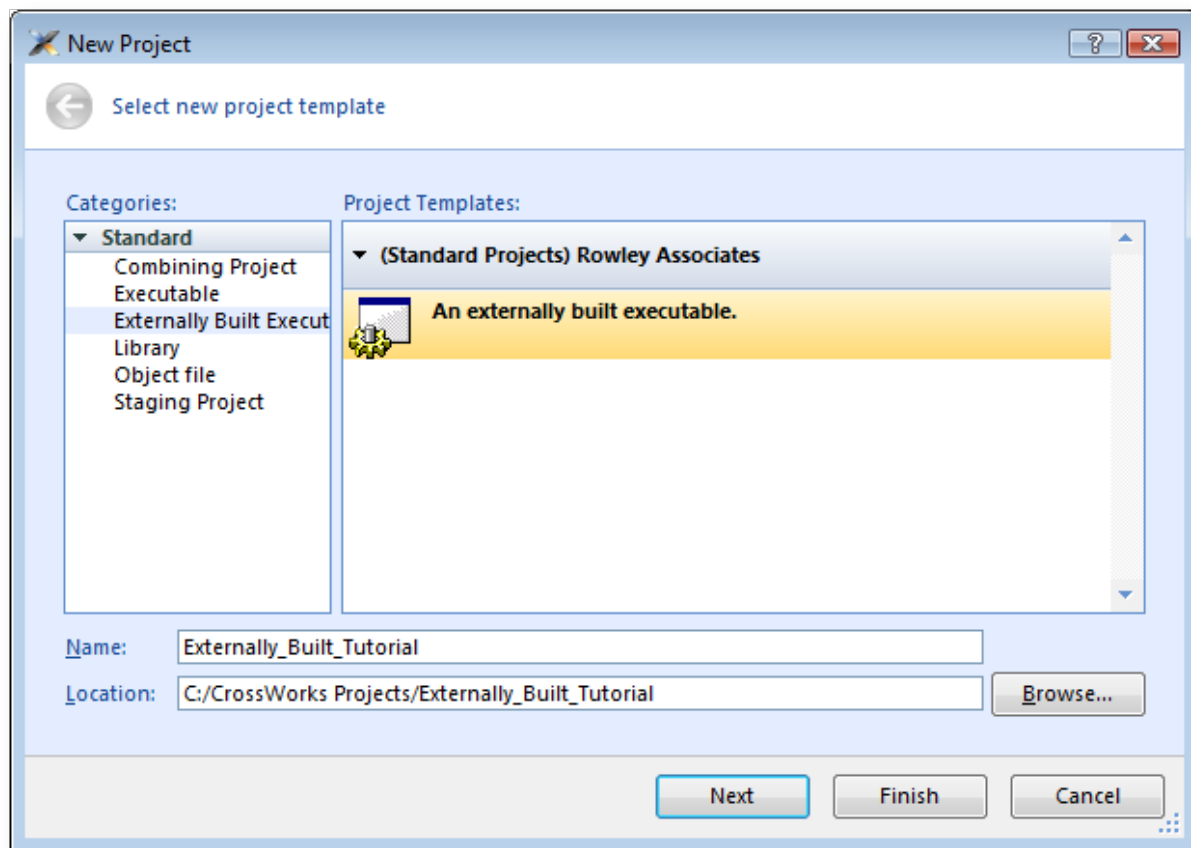
Debugging externally built applications

This section describes how to debug applications that were not built by CrossStudio. 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**.

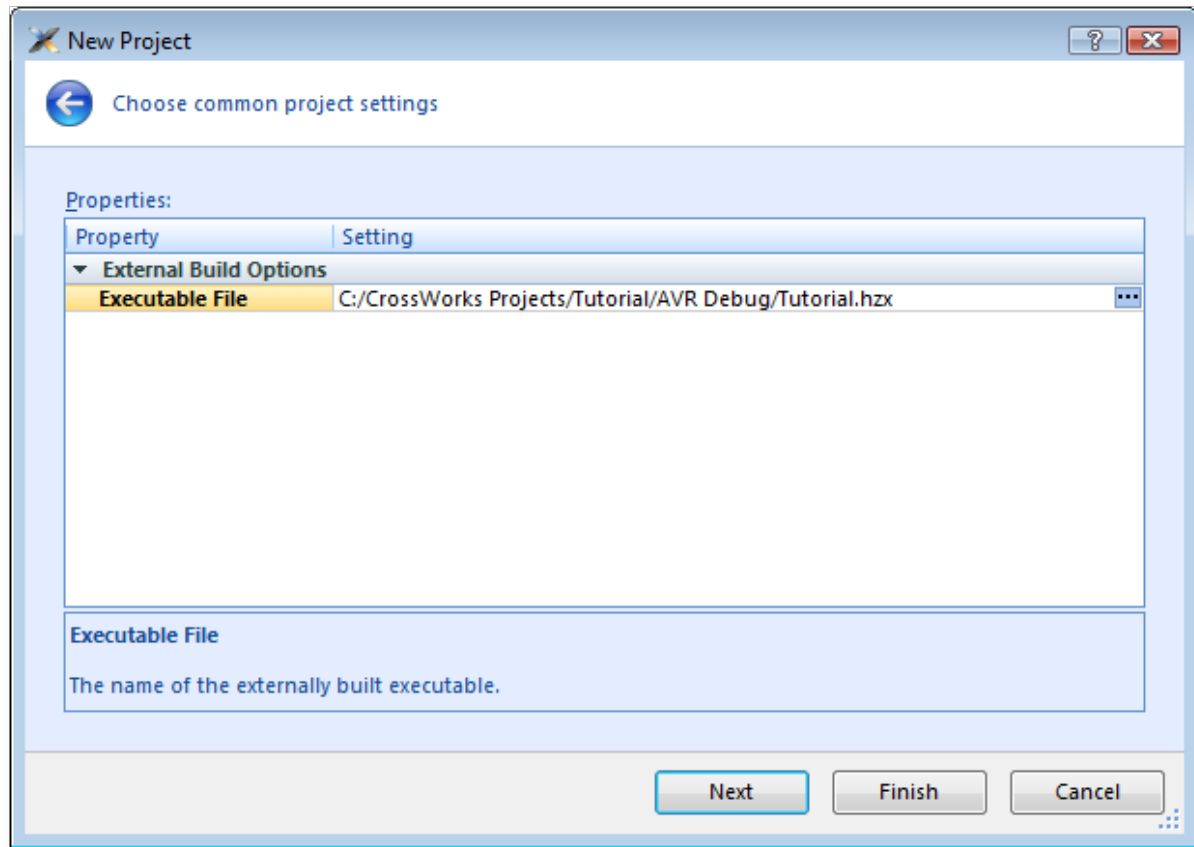
The **New Project** dialog appears. It displays the set of project types and project templates.



We'll create an externally built executable project:

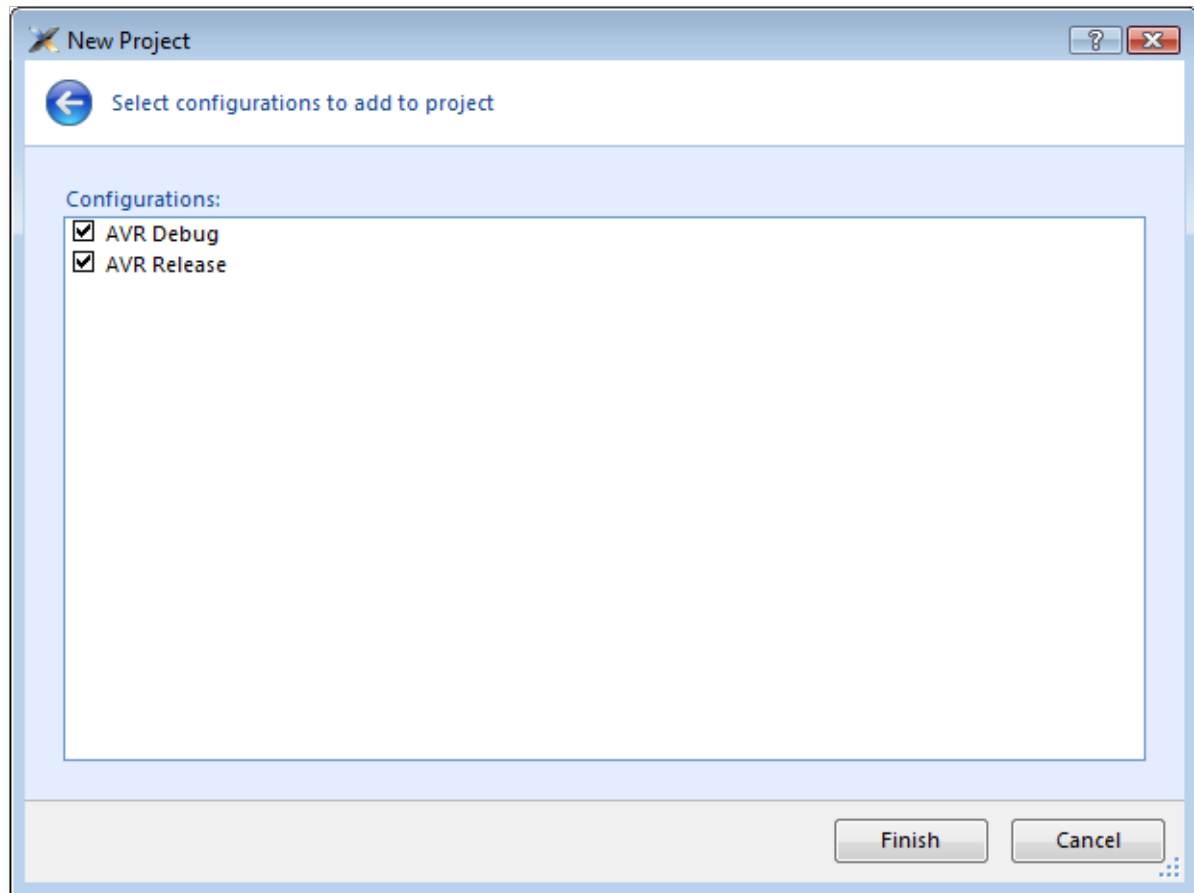
- In the **Categories** pane, select the **Standard > Externally Built Executable** project type.
- In the **Project Templates** pane, select the **An externally built executable** icon, which selects the type of project to add.
- Type `Externally_Built_Tutorial` in the **Name** field, which names the 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 **AVR Debug** configuration, the path to the executable file will be `C:/CrossWorks Projects/Tutorial/AVR 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. Use the **Left** and **Right** keys to display the required menu.
3. Use the **Up** or **Down** key to select the required command or submenu. Press Enter to execute a selected command.
4. 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 cursor position in the editor window. For text files, the caret position pane displays the line number and column number of the cursor 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.
- 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; when you return to **Debug** perspective on the next debug session, the windows will be restored to how you laid them out in that perspective.

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 to which you have subscribed. 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 cursor over a word and press **F1**, the help-system page most likely to be useful is displayed in the HTML browser. This 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 **hzip**, 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 was not built by CrossWorks.
- *Library*: — a group of object files collected into a single file (sometimes called an *archive*).
- *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 extension **.cpp** or **.cxx** will be compiled by a C++ compiler.
- A file with the object-file extension **.o** or **.hzo** will be linked.
- A file with the library-file extension **.a** or **.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.

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**.

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)`.

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" />
</Root>
```

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 database (sometimes called a *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. This operation is called *Add To Source Control*.
- Fetching files in the project from source control. This operation is called *Get Latest Version*.
- Locking and unlocking files in the project for editing. The lock operation is called *Check Out*. The unlock operation is called *Undo Check Out*. These are optional for some source-control providers.
- Comparing a file in the project with the latest version in source control. This operation is called *Show Differences*.
- Merging a file in the project with the latest version in source control with reference to the original version. This operation is called *Merge* and requires an external, three-way merge tool.
- Committing changes made to project files into source control. This operation is called *Check In*.

Choosing your source-control provider

The source-control system you are using must be enabled.

To enable a provider:

1. Choose **Tools > Options** or press **Alt+,**.
2. Select the **Source Control** category in the options dialog.
3. Set the **Source Control Provider** to the appropriate provider.
4. Set the provider-specific options.
5. Set **Enable Source Code Control Integration** to **Yes**.

Note: The source-control provider information is stored in the CrossWorks global environment, so you can only use one provider for all your CrossWorks projects.

Connecting to the source-control system

You must connect each CrossWorks project individually to the source-control system.

To connect to the source-control system:

- Choose **VCS > Connect**.

The login dialog that appears enables you to specify your user name and password, and to select the source-control database. These details will be saved in the session file (the password is encrypted) so you won't need to specify this information each time the project is loaded.

To map files in the project to those in the source-control system, specify a local root directory and the corresponding directory in source control (called the **remote root**). Once you have provided this information, the files in your project that are within the local root directory are considered to be in, or can be added to, source control.

After the login dialog, you will be presented with a dialog where you specify the local and remote roots. The local root can be selected using a directory browser and the remote root can be selected using the source-control explorer. With both browsers, you can create new directories—such as when starting a new project or if you don't have any projects in source control.

Opening a project from source control

To fetch a project in source control to a local directory:

1. Choose **Source Control > Open Solution**. This will show the login dialog and then the source-control explorer.
2. Select a CrossWorks project file (the extension is **.{hzip}**) using the file list of the source-control explorer.
3. Use the mappings dialog that appears to specify the local root directory, i.e., where you want the project files to go.
4. A dialog will list the files to get from source control and, after confirmation, those files are fetched and the project file is loaded into CrossWorks.

Files source-control status

Determining the source-control status of a file can be an expensive operation. CrossWorks will do this when:

- A file node is selected by the **Project Explorer**.
- The source-control status is displayed in the **Project Explorer** and the file node is visible there, too.
- Before a recursive source-control operation.
- After a source-control operation.

A file will be in one of the following states:

- *Controlled*: The file is in source control.
- *Not Controlled*: The file is not in source control.
- *Checked Out*: The file is checked out.
- *Old*: The file is older than the most-recent version in source control.
- *Checked Out and Old*: Both of the above.

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 **Project > Source Control > Refresh Status**.

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 a single file to the source-control system:

1. In the **Project Explorer**, right-click a file.
2. Choose **Add To Source Control**.
3. Optionally, add a comment to help distinguish this version of the file later.
4. Click **OK**.

To add multiple files to the source-control system:

1. In the **Project Explorer**, right-click a solution, project, or folder.
2. Choose **Add To Source Control (Recursive)**.
3. The dialog will list the files that can be added, i.e., those whose status is **Not Controlled**.
4. In that dialog, you can deselect any files you don't want to add to source control.
5. You may optionally add a comment.
6. Click **OK**.

Checking files out

To check out a single file in the project:

1. In the **Project Explorer**, right-click the file to check out.
2. Choose **Check Out**.
3. Add a comment.
4. Click **OK**.

To check out multiple files in the project:

1. In the **Project Explorer**, right-click the solution, project, or folder to check out.
2. Choose **Source Control > Check Out (Recursive)**.

The dialog box will list the files that can be checked out, i.e., ones whose status is **Controlled**.

1. In the dialog, deselect the files you do not wish want to check out and add a comment.
2. Click **OK**.

Checking files in

To check in a single file:

1. In the **Project Explorer**, right-click the file to check in.
2. Choose **Source Control > Check In**.
3. Enter an optional comment.
4. Click **OK**.

To check in multiple files:

1. In the **Project Explorer**, right-click a solution, project, or folder.
2. From the shortcut menu, choose **Source Control > Check In (Recursive)**.

The dialog box will list the files that can be checked in.

1. In the dialog, deselect the items you do not wish to check in and add a comment.
2. Click **OK**.

Undoing a check out

To undo the check out of a single file:

1. In the **Project Explorer**, right-click a file node.
2. Choose **Source Control > Undo Check Out**.

To undo check out of multiple files:

1. In the **Project Explorer**, right-click a solution, project, or folder.
2. Choose **Source Control > Undo Check Out (Recursive)**.

The dialog box will list the files that have a status of **Checked Out** and are therefore eligible for this operation.

1. In the dialog, deselect the files you do not wish to revert.
2. Click **OK**.

Getting the latest version

To get the latest version of a single file:

1. In the **Project Explorer**, right-click the file to get.
2. Choose **Source Control > Get Latest Version**.

To get the latest version of multiple files:

1. In the **Project Explorer**, right-click a solution, project, or folder.
2. Choose **Source Control > Get Latest Version (Recursive)**.

The dialog will list the files that have a status of **Controlled**, **Checked Out** or **Old**.

1. In the dialog, you can deselect the files you don't want to get.
2. Click **OK**.

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)*.

Merging files

To use merging, you must have a merge tool. To define the merge command line CrossWorks generates, choose **Tools > Options > Source Control > Merge Command Line**. The command line is defined as a list of strings to avoid problems with spaces in arguments. The merge 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.
- *\$(commonfile)*: The filename of the version of the file you originally edited and the file which will be produced by the merge tool.
- *\$(localname)*: A display name for *\$(localfile)*.
- *\$(remotename)*: A display name for *\$(remotefile)*.
- *\$(commonname)*: A display name for *\$(commonfile)*.

To merge the file in the project and the version checked into source control:

1. In the **Project Explorer**, right-click the file node.
2. Choose **Source Control > Merge**.

When the external tool has finished, if *\$(commonfile)* has been modified, you will be asked if you want to overwrite the file in the project with *\$(commonfile)*.

Source-control explorer

The **Source Control Explorer** dialog is used when selecting the remote root directory and when **Project > Source Control > Open Solution From** is selected.

To activate the Source Control Explorer:

- Choose **VCS > Explorer**.

The **Source Control Explorer** lists the directories and files in source control. You can use the directory side of the dialog to create new directories and to refresh the list, if that is required by the source-control provider.

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
Checked Out	If Yes , the file is checked out by you to the project location; if No , the file is not checked out.
Different	If Yes , the checked-out file differs from the version in the source control system; if No , they are identical.
File Path	The pathname of the file in the source-control system.
Local Revision	The revision number/name of the local file.
Old Version	If Yes , the file in the project location is an old version compared to the latest version in the source-control system.
Provider Status	The source-control provider status of the file.
Remote Revision	The revision number/name of the most-recent version in source control.
Status	The source-control status of the file.

Visual SourceSafe provider

The Visual SourceSafe source-control provider is implemented using the SourceSafe OLE Automation interface provided in ssapi.dll. The two versions of ssapi.dll are supported by CrossWorks, they can be identified (using the OLE/COM Object Viewer of Visual Studio) as:

- Visual SourceSafe 6.0 Type Library (Ver 5.1)
- Visual SourceSafe 8.0 Type Library (Ver 5.2)

Other versions have not been tested. If you get an error when connecting to the database, try registering the type library using the DOS command `regsvr32 ssapi.dll`.

Provider-specific options

The following environment options are supported:

Property	Description
Exclusive Checkout	If Yes, check outs will be exclusive.

Connecting to the source-control system

When connecting to source control, the working directory of the SourceSafe root \$ is used to initially set the file mappings. Subsequently, the provider will not change the working directory of SourceSafe or refer to it for operations.

Source-control operations

In general, all CrossWorks source-control operations map directly to SourceSafe operations with default flag behavior.

The **Add To Source Control** operation will create SourceSafe projects, if they don't exist.

Source-control operations are performed one file at a time, there are no recursive SourceSafe project operations.

SourceOffSite provider

The SourceGear SourceOffsite source-control provider has been tested with SourceOffSite Classic 3.5.3 server.

Provider-specific options

The following environment options are supported:

Property	Description
Home Directory	The directory to the <code>servers</code> subdirectory in your SOS client installation.
Port	The port number used by your SOS server.
Server	The name or IP address of the computer running the SOS server.

Connecting to the source-control system

When connecting to source control, the working directory of the SourceSafe root \$ is used initially to set the file mappings. Subsequently, the provider will not change the working directory of SourceSafe or refer to it for operations.

Source-control operations

For each server connection, SourceOffSite maintains a file that has control information about the local files that have been fetched. The SourceOffSite provider will keep this file updated as it performs single-file operations. However, to update the project and files list, you will need to use the directory list's shortcut menu to choose **VCS > Refresh Status**.

In general, all CrossWorks source-control operations map directly to SourceSafe operations with default flag behavior.

The **Add To Source Control** operation will create SourceSafe projects, if they don't exist.

The operations are performed one file at a time, i.e., there are no recursive SourceSafe project operations.

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 <code>svn</code> 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.
Repository URL	The Subversion URL to the repository.

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 have been implemented using SVN commands. There are no multiple file operations, each operation is done on a single file and is committed as part of the operation.

Operation	Command
Get Status	<code>svn status --show-updates</code> for local directories that are in SVN control. <code>svn info</code> for directories in the repository.
Add To Source Control	<code>svn add</code> and <code>svn commit</code> for each directory not in SVN control. <code>svn add</code> and <code>svn commit</code> for the file.
Get Latest	<code>svn update -N</code> for each directory not in SVN control. Optional removal of the local file for overwrite case and <code>svn update</code> .
Check Out	Optional removal of the local file for overwrite case and <code>svn update</code> . <code>svn lock</code> to lock the file.

Undo Check Out	<code>svn unlock</code> to unlock the file. Optional <code>svn update</code> to get the latest version.
Check In	<code>svn commit</code> for the 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>'.'</code> . <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 Rowley Associates website, you cannot use the **Package Manager** to install packages and it will be necessary to manually install them.

To manually install a package:

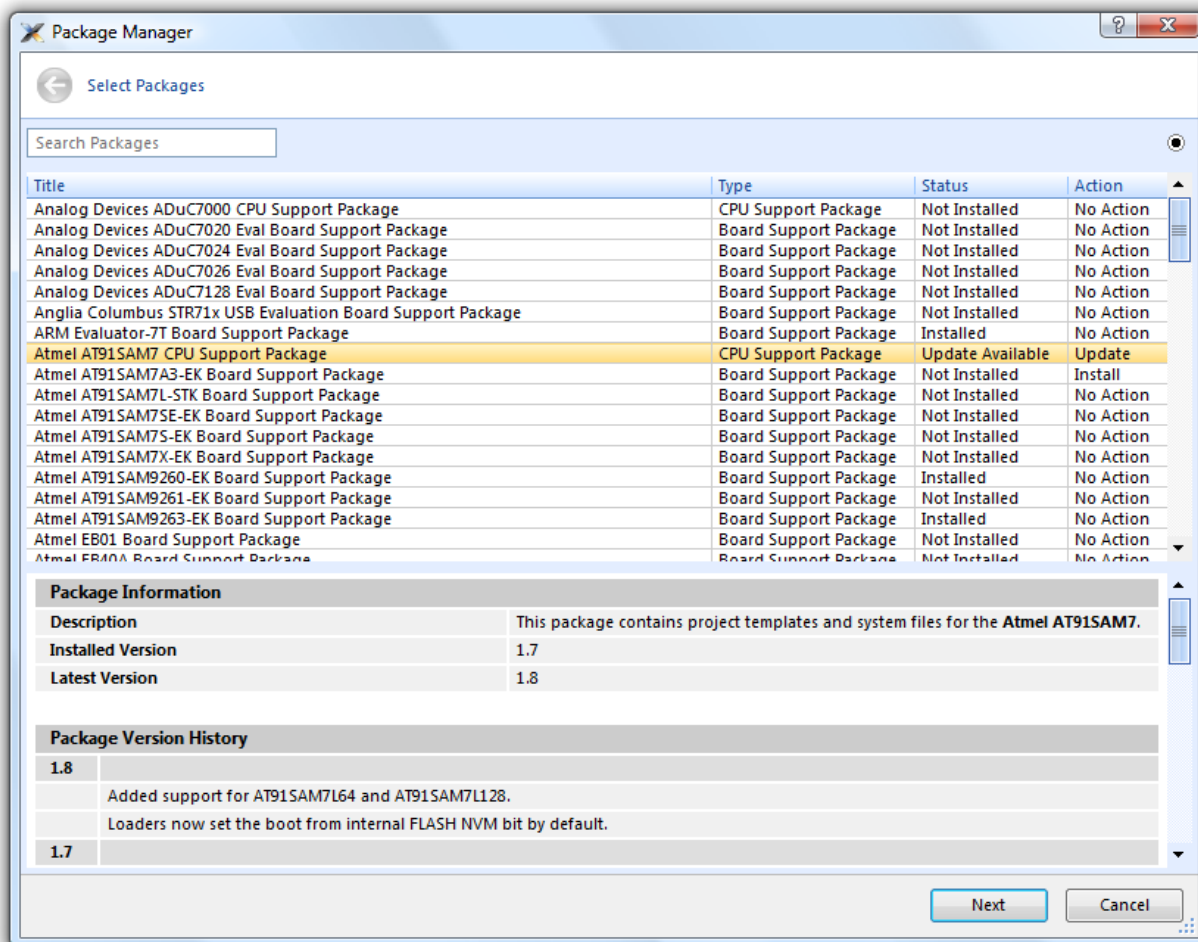
1. Choose **Tools > Packages > Manually Install Packages**.
2. Select the package file(s) you want to install.
3. Click **Open** to install the packages.

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 Package** (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 open/close the node. Double-clicking a project node sets 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
	Adds a new file to the active project using the New File dialog.
	Adds existing files to the active project.
	Removes files, folders, projects, and links from the project.
	Creates a new folder in the active project.

	Menu of build operations.
	Disassembles the active project.
	Menu of Project Explorer options.
	Displays 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.
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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.

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.

To activate the Source Navigator:

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

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 any changed files and updates the **Source Navigator** with the changes. Progress information and any errors are sent to the Source Navigator Log in the **Output** window when parsing.

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**

Symbol browser

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
	Groups symbols by source filename.
	Groups symbols by symbol type (equates, functions, labels, sections, and variables).
	Groups symbols by the section where they are defined.
	Moves the cursor to the statement that defined the symbol.
	Determines what 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
	Private Equate A private symbol not defined relative to a section.
	Public Equate A public symbol that is not defined relative to a section.
	Private Function A private function symbol.
	Public Function A public function symbol.
	Private Label A private data symbol, defined relative to a section.
	Public Label A public data symbol, defined relative to a section.
	Section A program section.

Choosing what to show

To activate the Symbol Browser window:

- Choose **Project > 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:

1. Click the **Field Chooser** button on the **Symbol Browser** toolbar.
2. 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:

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

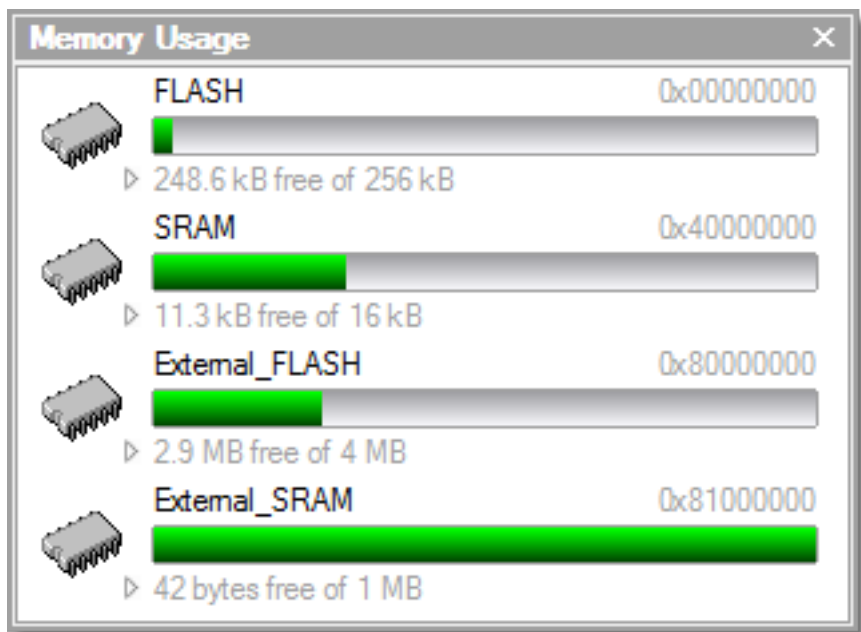
1. Choose **Project > Symbol Browser** or press **Ctrl+Alt+Y**.
2. In the **Grouping** button menu on the **Symbol Browser** toolbar, select **Group By Type**.
3. Ensure the **Size** field is checked in the **Field Chooser** button's menu.
4. Ensure that the filter on the **Symbol Browser** toolbar is 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 **Project > 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.

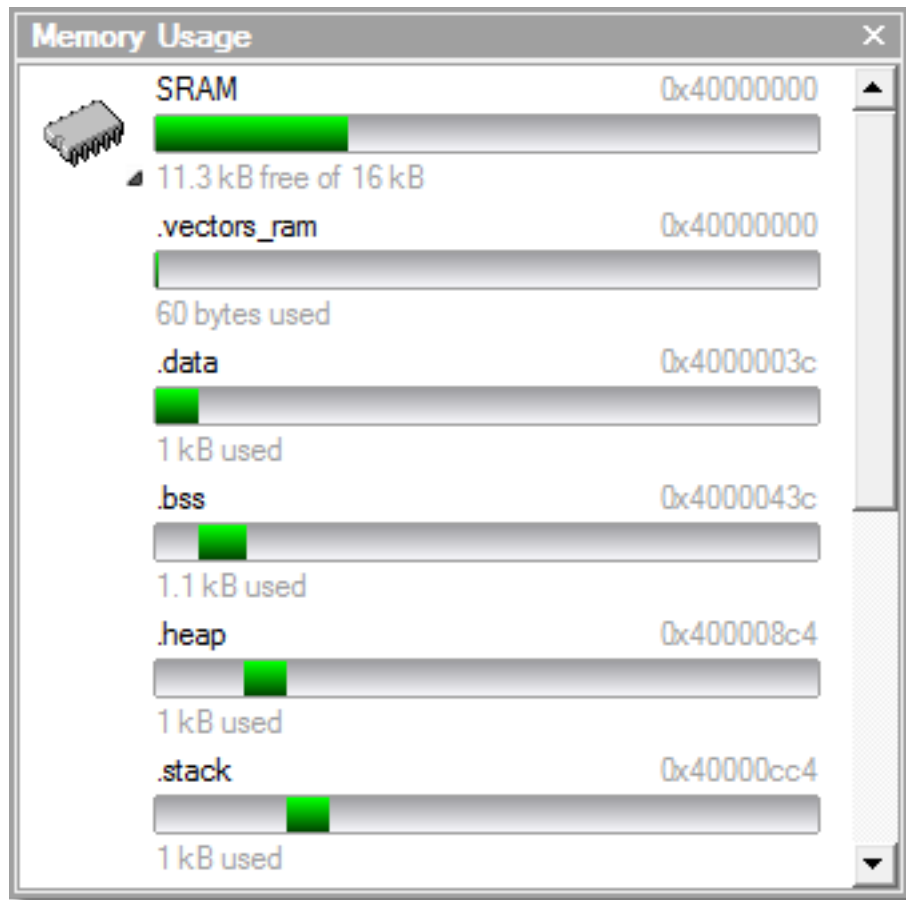
To activate the Memory Usage window:

- 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

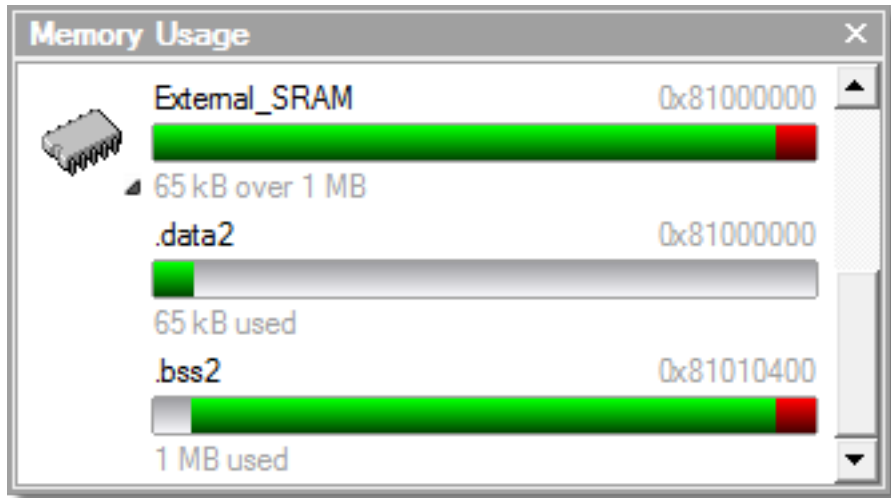
The **Memory Usage** window can also be used to visualize how program sections have been placed in memory. To display the program sections, simply click the memory segment to expand it; or, alternatively, right-click and choose **Show Memory Sections** from the shortcut menu.



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](#).

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 view 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 keyboard's cursor keys, the scroll bars, or the mouse's scroll wheel.

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

Keystroke	Description
Up	Moves the insertion point up one line
Down	Moves the insertion point down one line
Left	Moves the insertion point left one character
Right	Moves the insertion point right one character
Home	Moves the insertion point to the first character on the line; pressing Home a second time moves the insertion point to the leftmost column
End	Moves the insertion point to the end of the line
PageUp	Moves the insertion point up one page
PageDown	Moves the insertion point down one page
Ctrl+Left	Moves the insertion point left one word
Ctrl+Right	Moves the insertion point right one word
Ctrl+Home	Moves the insertion point to the start of the document
Ctrl+End	Moves the insertion point to the end of the document
Alt+Up	Moves the insertion point up five lines
Alt+Down	Moves the insertion point down five lines
Ctrl+Up	Scrolls the document up one line in the window without moving the insertion point
Ctrl+Down	Scrolls the document down one line in the window without moving the insertion point

Selecting text

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 left mouse button to end selection.

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 cursor 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**.

If overstrike mode is enabled, the **OVR** status indicator will be enabled 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 put the editor into overstrike mode.

Deleting text

The text editor supports the following common editing keystrokes:

Keystroke	Description
Backspace	Deletes the character before the insertion point
Delete	Deletes the character after the insertion point
Ctrl+Backspace	Deletes one word before the insertion point
Ctrl+Delete	Deletes 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 your cursor at the end of 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

To copy selected text to the clipboard:

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

The Windows standard 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 Windows standard 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 Windows standard 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 Windows standard 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 > Advanced > Undo All** or press **Ctrl+K, Ctrl+Z**.

To redo one editing action:

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

The Windows standard 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 > Advanced > 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 cursor 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.

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 can increase or decrease the indentation level of a selection.

To increase indentation of selected text:

- Choose **Selection > Increase Line Indent** or press **Tab**.

To decrease indentation of selected text:

- Choose **Selection > Decrease Line Indent** or press **Shift+Tab**.

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.

Changing 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.'

Indenting

The editor uses the **Tab** key to increase or decrease the indentation level. 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 the indentation size:

1. Set the **Indent Size** property for the required language.

The editor can optionally use tab characters to fill whitespace when indenting. The use of tabs for filling whitespace can be selected in the editor's **Language** settings.

To select tab or space fill when indenting:

1. 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 cursor position 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:

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

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

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

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

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

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

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

Bookmarks

To edit a document elsewhere and then return to your current location, add a bookmark.

Dropping bookmarks

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

You will also find the **Toggle Bookmark** button in the **Text Edit** toolbar.

Moving through bookmarks you've set

You can move through the bookmarks you've set in the current document or in all documents:

Keystroke	Description
F2	Moves to the next bookmark in the current document
BookmarkOrevInDocument	Moves to the previous bookmark in the current document
Ctrl+Q, F2	Moves to the first bookmark in the current document
Ctrl+Q, Shift+F2	Moves to the last bookmark in the current document

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 is moved 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 is moved to the last bookmark in the document.

Removing bookmarks

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 has been removed.

To remove all bookmarks in a document:

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

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**.

—or—

- Right-click the toolbar area to display the **View** menu.
- Choose **Clipboard Ring** from the shortcut menu.

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 an item from the clipboard ring into the current document:

1. Move the cursor to where you want to paste the item into the document.
2. Display the pop-up menu of the item to paste by clicking the arrow on the right of the item.
3. Choose *Paste*.

—or—

1. Make the item you want to paste the current item by clicking it.
2. Move the cursor to where you want to paste the item into 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 cursor 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. Display the pop-up menu of the item to delete by clicking the arrow at the right of the item.
2. Choose **Delete**.

To remove all items from the clipboard ring:

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

—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** button 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.

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.
\xhhh	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.

<code>?</code>	Match zero or one occurrences of the preceding expression.
<code>{n}</code>	Match n occurrences of the preceding expression.
<code>{n,}</code>	Match at least n occurrences of the preceding expression.
<code>{,m}</code>	Match at most m occurrences of the preceding expression.
<code>{n,m}</code>	Match at least n and at most m occurrences of the preceding expression.
<code>^</code>	Beginning of line.
<code>\$</code>	End of line.
<code>\b</code>	Word boundary.
<code>\B</code>	Non-word boundary.
<code>(e)</code>	Capture expression e .
<code>\n</code>	Back-reference to n 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
<code>u\w.d</code>		Search for any-length string containing one or more word characters beginning with the character 'u' and ending in the character 'd'.
<code>^.*;\$</code>		Search for any lines ending in a semicolon.
<code>(typedef.+s+)(\S+);</code>	<code>\1TEST_\2;</code>	Find C type definition and insert the string 'TEST' onto the beginning of the type name.

Debugging windows

This section describes the windows you can use to debug your application.

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
	Displays the selected item in binary.
	Displays the selected item in octal.
	Displays the selected item in decimal.
	Displays the selected item in hexadecimal.
	Displays the selected item as a signed decimal.
	Displays the selected item as a character or Unicode character.
	Sets the range displayed in the active Memory window to where the selected item is stored.
	Sorts the variables alphabetically by name.
	Sorts the 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
	Displays the selected item in binary.
	Displays the selected item in octal.
	Displays the selected item in decimal.
	Displays the selected item in hexadecimal.
	Displays the selected item as a signed decimal.
	Displays the selected item as a character or Unicode character.
	Sets the range displayed in the active memory window to where the selected item is stored.
	Sorts the variables alphabetically by name.
	Sorts the 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
	Displays the selected item in binary.
	Displays the selected item in octal.
	Displays the selected item in decimal.
	Displays the selected item in hexadecimal.
	Displays the selected item as a signed decimal.
	Displays the selected item as a character or Unicode character.
	Sets the range displayed in the active memory window to the address where the selected item is stored.
	Sorts the watch items alphabetically by name.
	Sorts 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 watch 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
	Displays the CPU, special function register, and peripheral register groups.
	Displays the selected item in binary.
	Displays the selected item in octal.
	Displays the selected item in decimal.
	Displays the selected item in hexadecimal.
	Displays the selected item as a signed decimal.
	Displays the selected item as a character or Unicode character.
	Force reads a register, ignoring the access property of the register.
	Updates the selected register group.
	Sets 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** windows show the contents of the connected target's memory areas.

To activate the first Memory window:











- Choose **Debug > Other Windows > Memory > Memory 1** or press **Ctrl+T, M, 1**.


There are four memory window in total and you can display other memory windows similarly.

The memory window does not show the complete address space of the target; instead you must enter both the start address and the number of bytes to display. You can specify the start address and size using *debugger expressions*, which enables you to position the memory display at the start address of a variable or to use a value in 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 or single step, and whenever you traverse the call stack. If any values that were previously displayed have changed, they are highlighted in red.

Memory window user interface

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

Button	Description
Address	Start address to display (a debugger expression).
Size	Number of bytes to display (a debugger expression).
	Select binary display.
	Select octal display.
	Select unsigned decimal display.
	Select signed decimal display.
	Select hexadecimal display.
	Select byte display, which includes an ASCII display.
	Select 2-byte display.
	Select 4-byte display.
	Evaluate the address and size expressions, and update the Memory window.
	Move the data display up one line.

	Move the data display down one line.
	Move the data display up by Size bytes.
	Move the data display down by Size bytes.

Left-click operations

The following operations are available by left-clicking the mouse:

Action	Description
Single Click	First click selects the line, second click selects the displayed memory value. Once the memory value is selected, it can be modified by entering a new value. Note that the input radix is the same as the display radix; i.e., 0x is not required to specify a hex number.

Shortcut menu commands

The shortcut menu contains the following commands:

Action	Description
Auto Evaluate	Re-evaluate Address and Size each time the Memory window is updated.
Set Number of Columns	Set the number of columns to display, the default being 8.
Access Memory By Display Width	Access memory in terms of the display width.
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 .

Using the memory window

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.

You can change a value in the **Memory** window by clicking the value to change and editing it as a text field.

Note that, when you modify memory values, you need to prefix hexadecimal numbers with **0x**, binary numbers with **0b**, and octal numbers with **0**.

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
	Creates a new breakpoint using the New Breakpoint dialog.
	Toggles the selected breakpoint between enabled and disabled states.
	Removes the selected breakpoint.
	Moves the cursor to the statement at which the selected breakpoint is set.
	Deletes all breakpoints.
	Disables all breakpoints.
	Enables all breakpoints.
	Creates a new breakpoint group and makes it active.

The main part of the **Breakpoints** window shows what breakpoints have been 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—

- On the **Breakpoints** window toolbar, click the **Enable All Breakpoints** button.

To disable all breakpoints:

- Choose **Breakpoints > Disable All Breakpoints**.







—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
	Moves the cursor to where the call was made to the selected frame.
	Sets the debugger context to the selected stack frame.
	Moves the debugger context down one stack to the called function.
	Moves the debugger context up one stack to the calling function.
	Selects the fields to display for each entry in the call stack.
	Sets the debugger context to the most recent stack frame and moves the cursor 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 cursor 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 cursor 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 cursor 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";
}
```

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**.

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.

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**.

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 breakpoint 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.

Utility windows

This section describes the utility windows.

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
	Connects the target interface selected in the Targets window.
	Disconnects the connected target interface.
	Reconnects the connected target interface.
	Resets the connected target interface.
	Displays 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—

1. In the **Targets** window, click the target to connect.
2. On the **Targets** window toolbar, click the **Connect** button

—or—

1. In the **Targets** window, right-click the target to connect.
2. 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 systems 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 (AVR, MSP430, and MAXQ products)
- 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:

1. Set the required terminal emulator properties.
2. 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 will be transmitted to the communications port and any data received from the communications port will be 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:

1. 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 so it can be used by other applications.

Supported control codes

The terminal supports a limited set of control codes:

Control code	Description
<BS>	Backspace
<LF>	Linefeed
<LF>	Linefeed {mo Why duplicated?}
<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:

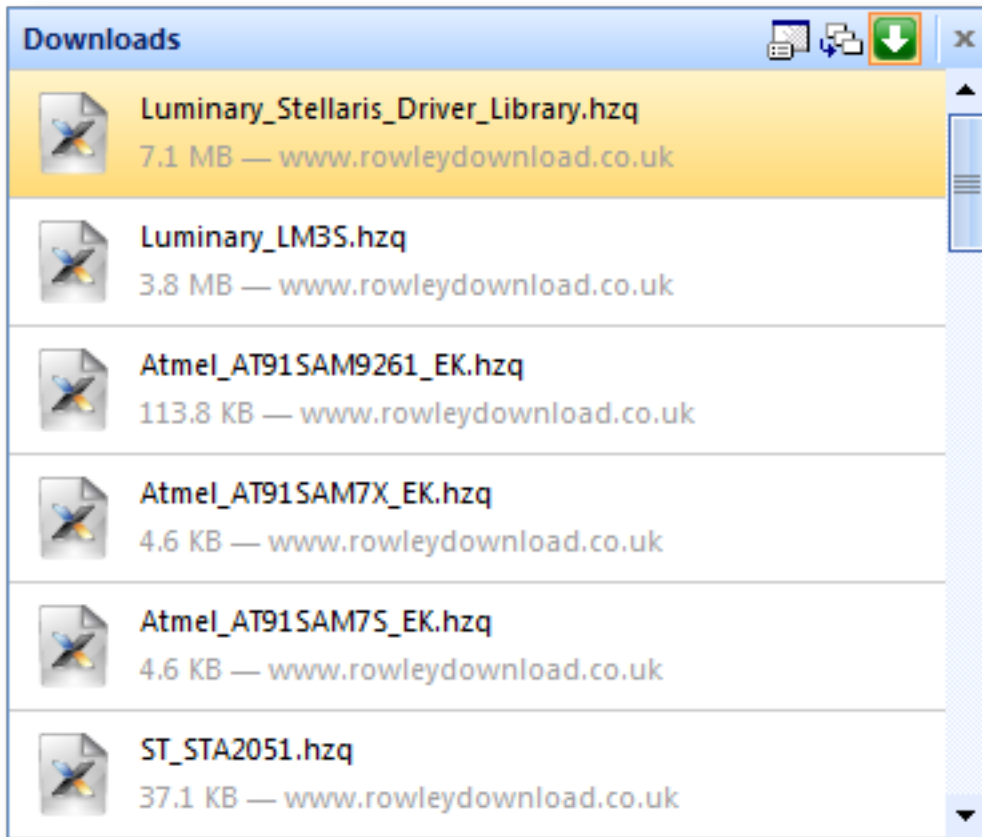
- Choose **Tools > Options** or press **Alt+,**.

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.

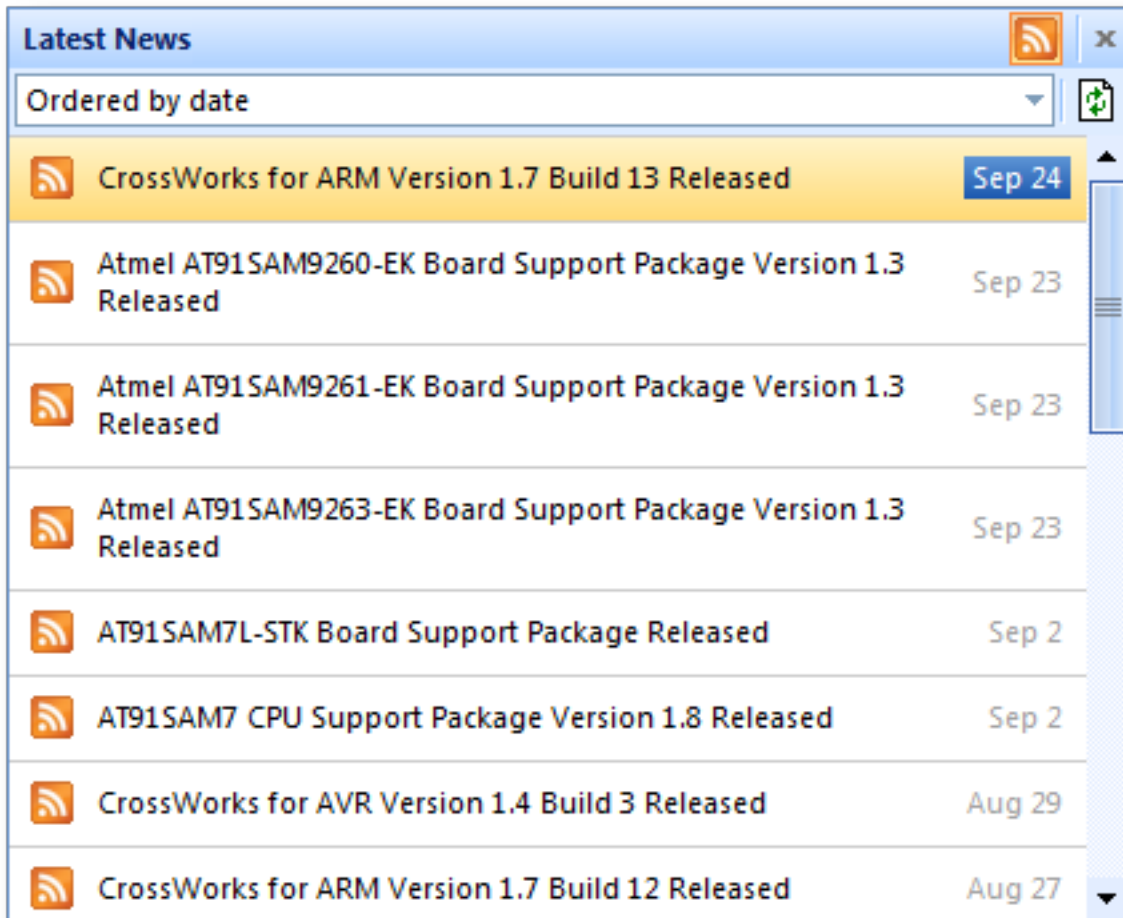


To activate the Downloads window:

- 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**.

Memory-map editor

memory-map files are tree-structured descriptions of the target memory map. They are used by the compiler to ensure correct placement of program sections, and by the debugger so it knows which addresses are valid on the target and which program sections to load. You can also use them files to direct the debugger to display memory-mapped peripherals. Usually, you don't need to modify memory-map files—they will be set up for the particular targets CrossStudio supports—but it is useful to view them with the memory-map editor.

To open memory-map files, choose **File > Open** and select the XML file that contains the memory map or, alternatively, use the **View Memory Map** option on the shortcut menu of the **Project Explorer**.

The memory-map editor provides a tree-structured view of the memory space of a target. The memory map consists of a set of different node types arranged in a hierarchy. These nodes have properties that can be modified using the **Properties** window when the node is selected. These properties and the placement of nodes within the memory map are used as input to the program-building process so the linker knows where sections should be placed. Additionally, the debugger uses the information in memory-map files to enable register and memory displays.

The memory-map editor supports the following node types:

Root

The top node of the memory map.

Memory Segment

A range of addresses that represents a region in target memory.

Program Section

Represents a program section of your application.

Register Group

Represents an area in memory that contains a group of related registers.

Register

Represents a memory-mapped register.

Bit Field

Part of a memory-mapped register.

The following statements hold regarding the creation and movement of nodes within a memory:

- Memory segments can be within the **Root** segment.
- Program sections must be within a memory segment.
- Register groups can be within the Root or within a memory segment.
- Registers can be within memory segments or register groups.
- Bitfields can be within registers.

All nodes have both mandatory and optional properties. The value of the mandatory Name property should be unique within the memory map.

Memory-segment and register-group properties

Start Address

A hexadecimal number stating where memory begins (lowest address).

Start Address Symbol

The name of a linker symbol to generate with the value of the Start Address.

Size

A hexadecimal number specifying the size in bytes of the memory segment.

Size Symbol

The name of a linker symbol to generate with the value of the Size.

Access Type

Specifies whether the memory segment is read only or read/write.

Program section properties

Start Address

An optional hexadecimal value representing the absolute load position of the section. If this isn't set, the relative placement of the program section within the memory segment will determine the load position of the section.

Size

An optional decimal value specifying the size in bytes of the program section.

Load

Specifies whether the section should be loaded by the debugger.

Alignment

An optional decimal value specifying the alignment requirements of the section.

Section To Run In

An optional name of another program section to which this program section will be copied.

Input Section Names

The optional names of the files that will be placed in this section.

Register properties

Start Address

A hexadecimal value specifying where the register is placed.

Start Address Symbol

The name of a linker symbol to generate with the value of the Start Address.

Register Type

Optional, a C type specifying how you want to display the register. This defaults to the word length of the target processor.

Endian

Optional, specifies the byte order of a multibyte register. This defaults to the byte order of the target processor.

Bitfield properties**Bit Offset**

A decimal value that sets the starting bit position of the bit field. Bit 0 is the first bit position.

Bit Length

A decimal value that defines the number of bits in the field.

The memory-map editor shares many of the attributes of the text editor, and the same key-bindings—for example, cut, copy and paste—are accessible from the **Edit** menu. But in addition to the standard editor capabilities, the memory-map editor supports moving nodes up and down within a hierarchy. This enables adjusting the sequence of program sections.

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 Options

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.
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.
Show Error Window on Build Error Environment/Build/Show Error Window on Build Error – Boolean	Shows the Errors window if there is a build error.
Toolchain Root Directory Environment/Build/Tool Chain Root Directory – String	Specifies where to find the toolchain (compilers etc).

Window Options

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 Options

Property	Description
Clear Disassembly Breakpoints On Debug Stop Environment/Debugger/Clear Disassembly Breakpoint - Boolean	Clear Disassembly Breakpoints On Debug Stop
Initial Breakpoint Is Set Environment/Debugger/Set Initial Breakpoint - Enumeration	Specify when the initial breakpoint should be set
Set Initial Breakpoint At Environment/Debugger/Initial Breakpoint - String	An initial breakpoint to set if no other breakpoints exist

Debugging Options

Property	Description
TLS Expression Environment/Debugger/TLS Expression - String	Default expression the debugger evaluates to get the base of Thread Local Storage

Display Options

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 CPU Registers In Locals Window Environment/Debugger/Locals Display Registers - Boolean	Specify whether the locals window should display CPU registers
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	Show char * as null terminated string
Source Path Environment/Debugger/Source Path - StringList	Global search path to find source files.

Extended Data Tips Options

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 Options

Property	Description
Step Using Hardware Step Environment/Debugger/Step Using Hardware Step – Boolean	Step using hardware single stepping rather than setting breakpoints

Window Options

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 Options

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 Options

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 Options

Property	Description
Check For Latest News Environment/Internet/RSS Update – Boolean	Specifies whether to enable downloading of the Latest News RSS feeds.

Check For Packages Environment/Internet/Check Packages – Boolean	Specifies whether to enable downloading of the list of available packages.
Check For Updates Environment/Internet/Check Updates – Boolean	Specifies whether to enable checking for software updates.
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 Options

Property	Description
Launch Latest Installations Only Environment/Launcher Use Latest Installations Only – Boolean	Specifies whether the CrossStudio launcher should only consider the latest installations of CrossWorks 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 Options

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 Options

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 Options

Property	Description
Allow Multiple CrossStudios Environment/Permit Multiple Studio Instances – Boolean	Allow more than one CrossStudio to run at the same time.
New Project Directory Environment/General/Solution Directory – String	The directory where projects are created.
Project Templates File Environment/General/Project Templates – String	The project templates file.
Splash Screen Environment/Splash Screen – Enumeration	How to display the splash screen on startup.

Status Bar Options

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 Options

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 – Font	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 Settings

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++ Settings

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 Settings

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 Settings

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.
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Source Control Environment Options

Configuration Options

Property	Description
Enable Source Control Integration Environment/Source Code Control/ Enabled – Boolean	Source Control integration enabled.
Source Control Provider Environment/Source Code Control/ Provider – Enumeration	The source control provider to use.

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 Options

Property	Description
Inhibit Add Dialog Environment/Source Code Control/ InhibitAddDialog – Boolean	Inhibits the dialog when adding a file to source control.
Inhibit Check In Dialog Environment/Source Code Control/ InhibitCheckinDialog – Boolean	Inhibits the dialog when checking in a file to source control.
Inhibit Check Out Dialog Environment/Source Code Control/ InhibitCheckoutDialog – Boolean	Inhibits the dialog when checking out a file from source control.
Inhibit Check Out On Edit Dialog Environment/Source Code Control/ InhibitCheckoutOnEditDialog – Boolean	Inhibits the check out on edit dialog.
Inhibit Get Latest Dialog Environment/Source Code Control/ InhibitGetLatestDialog – Boolean	Inhibits the dialog when updating the local version from the source control version.

Inhibit Undo Check Out Dialog Environment/Source Code Control/ InhibitUndoCheckoutDialog - Boolean	Inhibits the dialog when undoing a checkout to source control.
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Text Editor Environment Options

Cursor Fence Options

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 Options

Property	Description
Allow Drag and Drop Editing Text Editor/Drag Drop Editing – Boolean	Enables dragging and dropping of selections in the text editor.
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.
Bold Popup Diagnostic Messages Text Editor/Bold Popup Diagnostics – Boolean	Displays popup diagnostic messages in bold for easier reading.
Check Spelling Text Editor/Spell Checking – Boolean	Enable spell checking in comments.
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.

Copy On Mouse Select Text Editor/Copy On Mouse Select – Boolean	Automatically copy text to clipboard when marking a selection with the mouse.
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 Popup Diagnostics Text Editor/Enable Popup Diagnostics – Boolean	Enables on-screen diagnostics in the text editor.
Enable Virtual Space Text Editor/Enable Virtual Space – Boolean	Permit the cursor to move into locations that do not currently contain text.
FIXME Tag List Text Editor/FIXME Tags – StringList	Set the tags to display as FIXMEs.
Numeric Keypad Editing Text Editor/Numeric Keypad Enabled – Boolean	Selects whether the numeric keypad plus and minus buttons copy and cut text.
Paste On Mouse Middle Button Text Editor/Paste On Mouse Middle Button – Boolean	Paste text from clipboard when mouse middle button is pressed.
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 Options

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.

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.

Save Options

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.
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 Options

Property	Description
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 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.

Clipboard Ring Options

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 Options

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 contents.

Project Explorer Options

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.
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 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 Properties Environment/Project Explorer/Properties Display – Enumeration	Controls how the properties are displayed.
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 Code Control Status – 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 get 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 Options

Property	Description
Properties Displayed Environment/General/Properties Displayed – Enumeration	Set how the properties are displayed.
Show Property Details Environment/General/Property View Details – Boolean	Show or hide the property description.

Windows Window Options

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.

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](#).

AVR simulator

The AVR simulator target interface provides access to CrossStudio's AVR simulator. This target interface supports program loading and debugging. The simulator supports the instruction set defined in *ATMEL AVR Instruction Set – Rev. 0856B-06/99*. Additionally, the simulator will simulate EEPROM memory access and provides an extension mechanism to enable device simulation using JavaScript. The memory system simulated (flash, RAM, EEPROM) is defined by the Target processor property of the selected project in the active build configuration.

- [AVR Simulator Target Interface](#)

JTAG ICE

The JTAG ICE target interface provides access to Atmel's JTAG ICE Mk I. This target interface supports program loading and debugging, and access to the lock bits, fuse bits, and signature/calibration bytes immediately after connecting to the target.

- [JTAG ICE Target Interface](#)

JTAGICE mkII

The JTAGICE mkII target interfaces provide access to Atmel's JTAGICE mkII. Both USB and serial port host PC connections are supported, as is JTAG, debugWIRE, PDI, and ISP target connections. The JTAG, debugWIRE, PDI, and ISP target connections support program loading. The JTAG, debugWIRE, and PDI target connections support interactive debugging. The JTAG, PDI, and ISP connections support access to the lock bits, fuse bits, and signature/calibration bytes immediately after connecting to the target.

- [JTAGICE mkII \(Serial Port to JTAG\)](#),
- [JTAGICE mkII \(Serial Port to debugWIRE\)](#),
- [JTAGICE mkII \(Serial Port to ISP\)](#),
- [JTAGICE mkII \(Serial Port to PDI\)](#),
- [JTAGICE mkII \(USB to JTAG\)](#),
- [JTAGICE mkII \(USB to debugWIRE\)](#),

- [JTAGICE mkII \(USB to ISP\)](#),
- [JTAGICE mkII \(USB to PDI\)](#)

AVRDragon

The AVRDragon target interfaces provide access to Atmel's AVRDragon. JTAG, debugWIRE, and ISP target connections are supported. The JTAG, debugWIRE, and ISP target connections support program loading. The JTAG and debugWIRE target connections support interactive debugging. The JTAG and ISP connections support access to the lock bits, fuse bits, and signature/calibration bytes. When debugging with the JTAG interface, three hardware breakpoints are available for use; however, one of these breakpoints will be needed for single stepping. Two of the hardware breakpoints can be used as data breakpoints. When debugging with the debugWIRE interface, no hardware breakpoints are available.

- [AVRDragon \(JTAG\)](#),
- [AVRDragon \(debugWIRE\)](#),
- [AVRDragon \(ISP\)](#)

STK500 high voltage

The Atmel STK500 high voltage target interface provides access to Atmel's STK500 high voltage programming. This target interface supports program loading and access to the fuse bits and lock bits.

- [STK500-High Voltage Target Interface](#)

STK500-ISP Target Interface

The Atmel STK500-ISP target interface provides access to Atmel's STK500 ISP programming. This target interface supports program loading and access to the fuse bits and lock bits.

- [STK500-ISP Target Interface](#)

AVRISP

The Atmel STK500-ISP/AVRISP target interface provides access to Atmel's AVRISP programmer. This target interface supports program loading and access to the fuse bits and lock bits.

- [AVRISP Target Interface](#).

AVRISP mkII

The Atmel AVRISP mkII target interface provides access to Atmel's AVRISP mkII programmer. This target interface supports program loading and access to the fuse bits and lock bits.

- [AVRISP mkII target interface](#)

Parallel port

The Parallel Port Target Interface provides access to JTAG-based AVR devices via a PC parallel (printer) port JTAG cable. This target interface supports program loading and debugging and access to the fuse and lock bits. This target interface supports the [MAXQ 10-pin connector](#) and the [ARM 20-pin connector](#) with a suitable converter board.

- [Parallel Port Target Interface](#)

CrossConnect

The CrossConnect Target Interface provides access to JTAG-based AVR devices via a [CrossConnect](#) with a suitable converter board. This target interface supports program loading and debugging and access to the fuse and lock bits.

- [CrossConnect Target Interface](#)

Arduino

This target interface only supports program loading. To use this target interface, set the target options to connect and disconnect when debugging starts and stops, respectively. Then connect to the target interface, then disconnect from it. You can then press start without debugging, which will connect to the Arduino, download the application, and then disconnect from the target interface.

Note that you can set the **Port Used By Target Interface** Terminal Emulator property which will cause the Terminal Emulator to disconnect/reconnect when downloading.

- [Arduino Target Interface](#)

Downloading capabilities

The JTAG and PDI target connections support the **Erase All** target property. When **Erase All** is set to **Yes**, a chip erase is performed prior to download. If you wish to preserve the EEPROM, set the appropriate fuse bit. When the target property **Erase All** is set to **No**, program loading causes the relevant flash pages to be erased prior to programming. Note that, on JTAG MEGA devices, the page erasing (and subsequent programming) is done in debug mode and, as such, is considerably slower than when **Erase All** is set to **Yes**.

Debug capabilities

When debugging JTAG MEGA devices, you will have access to four hardware breakpoints—but one of them will be needed for single stepping. Two of the hardware breakpoints may be used as (byte-sized) data breakpoints or as an aligned powers of 2 range breakpoint.

When debugging XMEGA devices, you will have access to two hardware (byte-sized) data breakpoints that can also be used as a range data breakpoint. The two data breakpoints can have conditional data values, using the following **breakpoint expressions**:

- `x == 5` — Break when x is read/written with 5.
- `x > 5` — Break when x is read/written with a value greater than 5.
- `x >= 5` — Break when x is read/written with a value greater than or equal to 5.
- `x < 5` — Break when x is read/written with a value less than 5.
- `x <= 5` — Break when x is read/written with a value less than or equal to 5.
- `x >= 5 && x <= 45` — Break when x is read/written with a value in the range 5 to 45.
- `x < 5 || x > 45` — Break when x is read/written with a value not in the range 5 to 45.
- `(x & 1) == 1` — Break when x is read/written with an odd value.

Note that `>=` and `<` are implemented using `>` and `<=` and, as such, won't work for zero values.

The JTAGICE mkII and AVRDragon target interfaces provide support for software breakpoints, which are used by default when setting program execute breakpoints. The target-interface property **Hardware Breakpoints** can be set to **Yes** to disallow setting software breakpoints.

JTAG, PDI, ISP, and High Voltage shortcut menu entries

Fuse Bits

This displays the fuse bits editor.

Lock Bits

This displays the lock bits editor.

Signature/Calibration Bytes

This displays the signature and calibration bytes.

debugWIRE target shortcut menu entries

Disconnect (Disable debugWIRE)

This requires the ISP connection in addition to the debugWIRE connection, and will disable the DWEN fuse and disconnect.

STK500 target shortcut menu entries

ST500 Settings

This displays a dialog used to specify the oscillator frequency, target voltage, and analog reference voltage supplied by the STK500 to the target processor.

AVR Core Simulator Target Interface

Target

Property	Description
Device Type device_id - String	The detected type of the currently connected target device.

JTAG ICE Target Interface

Connection

Property	Description
Baud Rate <code>baudRate</code> – Enumeration	The speed of the serial communication.
External Reset Required <code>externalResetRequired</code> – Boolean	Apply external reset on connect.
Port Name <code>portName</code> – String	The name of the serial port connected to the JTAG ICE. On windows hosts you can right click to select from the set of COM ports available.
Target Clock Frequency <code>targetClock</code> – Enumeration	The nearest clock frequency of the target - used for the JTAG clock frequency.

Current

Property	Description
Hardware Version <code>hardwareVersion</code> – String	The hardware version of the target interface.
JTAG ID <code>JTAGID</code> – IntegerHex	The JTAG ID.
Software Version <code>softwareVersion</code> – String	The software version of the target interface.

Target

Property	Description
Device Type <code>device_id</code> – String	The detected type of the currently connected target device.
Target Voltage <code>operatingVoltage</code> – String	The target voltage.

JTAGICE mkII (Serial Port to JTAG) Target Interface

Connection

Property	Description
Baud Rate <code>baudRate</code> – Enumeration	The speed of the serial communication.
External Reset Required <code>externalResetRequired</code> – Boolean	Apply external reset on connect.
Hardware Breakpoints <code>useHardwareBreakpoints</code> – Boolean	Always use hardware breakpoints i.e. don't set software breakpoints.
Port Name <code>portName</code> – String	The name of the serial port connected to the JTAGICE mkII (Serial Port to JTAG). On windows hosts you can right click to select from the set of COM ports available.
Serial Number <code>connectedSerialNumber</code> – String	The serial number of the JTAG ICE MK II.
Target Clock Frequency <code>targetClock</code> – Enumeration	The nearest clock frequency of the target - used for the JTAG clock frequency.

Current

Property	Description
Hardware Version <code>hardwareVersion</code> – String	The hardware version of the target interface.
JTAG ID <code>JTAGID</code> – IntegerHex	The JTAG ID.
Software Version <code>softwareVersion</code> – String	The software version of the target interface.

Target

Property	Description
Device Type <code>device_id</code> – String	The detected type of the currently connected target device.
Target Voltage <code>operatingVoltage</code> – String	The target voltage.

JTAGICE mkII (Serial Port to debugWIRE) Target Interface

Connection

Property	Description
Baud Rate <code>baudRate</code> – Enumeration	The speed of the serial communication.
Port Name <code>portName</code> – String	The name of the serial port connected to the JTAGICE mkII (Serial Port to debugWIRE). On windows hosts you can right click to select from the set of COM ports available.
Serial Number <code>connectedSerialNumber</code> – String	The serial number of the JTAG ICE MK II.

Current

Property	Description
Hardware Version <code>hardwareVersion</code> – String	The hardware version of the target interface.
Software Version <code>softwareVersion</code> – String	The software version of the target interface.

Target

Property	Description
Device Type <code>device_id</code> – String	The detected type of the currently connected target device.
Target Voltage <code>operatingVoltage</code> – String	The target voltage.

JTAGICE mkII (Serial Port to ISP) Target Interface

Connection

Property	Description
Baud Rate baudRate – Enumeration	The speed of the serial communication.
Device Name deviceName – String	The name of the device to be programmed.
ISP Freq (Actual) ActualIspFreq – String	The actual ISP frequency which must be less than 1/4 of the target frequency.
ISP Freq (Desired) IspFreq – String	The desired ISP frequency which must be less than 1/4 of the target frequency.
Port Name portName – String	The name of the serial port connected to the JTAGICE mkII (Serial Port to ISP). On windows hosts you can right click to select from the set of COM ports available.
Serial Number connectedSerialNumber – String	The serial number of the JTAG ICE MK II.
Use Target As Device Name useTargetAsDeviceName – Boolean	Use the projects Target property as the device name.

Current

Property	Description
Hardware Version hardwareVersion – String	The hardware version of the target interface.
Software Version softwareVersion – String	The software version of the target interface.

Target

Property	Description
Device Type device_id – String	The detected type of the currently connected target device.
Target Voltage operatingVoltage – String	The target voltage.

JTAGICE mkII (Serial Port to PDI) Target Interface

Connection

Property	Description
Baud Rate <code>baudRate</code> – Enumeration	The speed of the serial communication.
Hardware Breakpoints <code>useHardwareBreakpoints</code> – Boolean	Always use hardware breakpoints i.e. don't set software breakpoints.
Port Name <code>portName</code> – String	The name of the serial port connected to the JTAGICE mkII (Serial Port to PDI). On windows hosts you can right click to select from the set of COM ports available.
Serial Number <code>connectedSerialNumber</code> – String	The serial number of the JTAG ICE MK II.

Current

Property	Description
Hardware Version <code>hardwareVersion</code> – String	The hardware version of the target interface.
Software Version <code>softwareVersion</code> – String	The software version of the target interface.

Target

Property	Description
Device Type <code>device_id</code> – String	The detected type of the currently connected target device.
Target Voltage <code>operatingVoltage</code> – String	The target voltage.

JTAGICE mkII (USB to JTAG) Target Interface

Connection

Property	Description
External Reset Required <code>externalResetRequired</code> – Boolean	Apply external reset on connect.
Hardware Breakpoints <code>useHardwareBreakpoints</code> – Boolean	Always use hardware breakpoints i.e. don't set software breakpoints.
Serial Number <code>connectedSerialNumber</code> – String	The serial number of the JTAG ICE MK II.
Target Clock Frequency <code>targetClock</code> – Enumeration	The nearest clock frequency of the target - used for the JTAG clock frequency.

Current

Property	Description
Hardware Version <code>hardwareVersion</code> – String	The hardware version of the target interface.
JTAG ID <code>JTAGID</code> – IntegerHex	The JTAG ID.
Software Version <code>softwareVersion</code> – String	The software version of the target interface.

Target

Property	Description
Connection <code>Connection</code> – String	The USB serial number of the AVR JTAGICE mkII to connect to.
Device Type <code>device_id</code> – String	The detected type of the currently connected target device.
Target Voltage <code>operatingVoltage</code> – String	The target voltage.

JTAGICE mkII (USB to debugWIRE) Target Interface

Connection

Property	Description
Serial Number <code>connectedSerialNumber</code> – String	The serial number of the JTAG ICE MK II.

Current

Property	Description
Hardware Version <code>hardwareVersion</code> – String	The hardware version of the target interface.
Software Version <code>softwareVersion</code> – String	The software version of the target interface.

Target

Property	Description
Connection <code>Connection</code> – String	The USB serial number of the AVR JTAGICE mkII to connect to.
Device Type <code>device_id</code> – String	The detected type of the currently connected target device.
Target Voltage <code>operatingVoltage</code> – String	The target voltage.

JTAGICE mkII (USB to ISP) Target Interface

Connection

Property	Description
Device Name deviceName – String	The name of the device to be programmed.
ISP Freq (Actual) ActualIspFreq – String	The actual ISP frequency which must be less than 1/4 of the target frequency.
ISP Freq (Desired) IspFreq – String	The desired ISP frequency which must be less than 1/4 of the target frequency.
Serial Number connectedSerialNumber – String	The serial number of the JTAG ICE MK II.
Use Target As Device Name useTargetAsDeviceName – Boolean	Use the projects Target property as the device name.

Current

Property	Description
Hardware Version hardwareVersion – String	The hardware version of the target interface.
Software Version softwareVersion – String	The software version of the target interface.

Target

Property	Description
Connection Connection – String	The USB serial number of the AVR JTAGICE mkII to connect to.
Device Type device_id – String	The detected type of the currently connected target device.
Target Voltage operatingVoltage – String	The target voltage.

JTAGICE mkII (USB to PDI) Target Interface

Connection

Property	Description
Hardware Breakpoints <code>useHardwareBreakpoints</code> – Boolean	Always use hardware breakpoints i.e. don't set software breakpoints.
Serial Number <code>connectedSerialNumber</code> – String	The serial number of the JTAG ICE MK II.

Current

Property	Description
Hardware Version <code>hardwareVersion</code> – String	The hardware version of the target interface.
Software Version <code>softwareVersion</code> – String	The software version of the target interface.

Target

Property	Description
Connection <code>Connection</code> – String	The USB serial number of the AVR JTAGICE mkII to connect to.
Device Type <code>device_id</code> – String	The detected type of the currently connected target device.
Target Voltage <code>operatingVoltage</code> – String	The target voltage.

AVRDragon (JTAG) Target Interface

Connection

Property	Description
External Reset Required <code>externalResetRequired</code> – Boolean	Apply external reset on connect.
Hardware Breakpoints <code>useHardwareBreakpoints</code> – Boolean	Always use hardware breakpoints i.e. don't set software breakpoints.
Serial Number <code>connectedSerialNumber</code> – String	The serial number of the JTAG ICE MK II.
Target Clock Frequency <code>targetClock</code> – Enumeration	The nearest clock frequency of the target - used for the JTAG clock frequency.

Current

Property	Description
Hardware Version <code>hardwareVersion</code> – String	The hardware version of the target interface.
JTAG ID <code>JTAGID</code> – IntegerHex	The JTAG ID.
Software Version <code>softwareVersion</code> – String	The software version of the target interface.

Target

Property	Description
Connection <code>Connection</code> – String	The USB serial number of the AVR Dragon to connect to.
Device Type <code>device_id</code> – String	The detected type of the currently connected target device.
Target Voltage <code>operatingVoltage</code> – String	The target voltage.

AVRDragon (debugWIRE) Target Interface

Connection

Property	Description
Serial Number <code>connectedSerialNumber</code> – String	The serial number of the JTAG ICE MK II.

Current

Property	Description
Hardware Version <code>hardwareVersion</code> – String	The hardware version of the target interface.
Software Version <code>softwareVersion</code> – String	The software version of the target interface.

Target

Property	Description
Connection <code>Connection</code> – String	The USB serial number of the AVR Dragon to connect to.
Device Type <code>device_id</code> – String	The detected type of the currently connected target device.
Target Voltage <code>operatingVoltage</code> – String	The target voltage.

AVRDragon (ISP) Target Interface

Connection

Property	Description
Device Name deviceName – String	The name of the device to be programmed.
ISP Freq (Actual) ActualIspFreq – String	The actual ISP frequency which must be less than 1/4 of the target frequency.
ISP Freq (Desired) IspFreq – String	The desired ISP frequency which must be less than 1/4 of the target frequency.
Serial Number connectedSerialNumber – String	The serial number of the JTAG ICE MK II.
Use Target As Device Name useTargetAsDeviceName – Boolean	Use the projects Target property as the device name.

Current

Property	Description
Hardware Version hardwareVersion – String	The hardware version of the target interface.
Software Version softwareVersion – String	The software version of the target interface.

Target

Property	Description
Connection Connection – String	The USB serial number of the AVR Dragon to connect to.
Device Type device_id – String	The detected type of the currently connected target device.
Target Voltage operatingVoltage – String	The target voltage.

STK500-High Voltage Target Interface

Connection

Property	Description
Device Name deviceName – String	The name of the device to be programmed.
Port Name portName – String	The name of the serial port connected to the STK500-High Voltage. On windows hosts you can right click to select from the set of COM ports available.
Use Target As Device Name useTargetAsDeviceName – Boolean	Use the projects Target property as the device name.

Current

Property	Description
Hardware Version hardwareVersion – String	The hardware version of the target interface.
Software Version softwareVersion – String	The software version of the target interface.

Target

Property	Description
Device Type device_id – String	The detected type of the currently connected target device.

STK500-ISP Target Interface

Connection

Property	Description
Device Name deviceName – String	The name of the device to be programmed.
Port Name portName – String	The name of the serial port connected to the STK500-High Voltage. On windows hosts you can right click to select from the set of COM ports available.
Use Target As Device Name useTargetAsDeviceName – Boolean	Use the projects Target property as the device name.

Current

Property	Description
Hardware Version hardwareVersion – String	The hardware version of the target interface.
Software Version softwareVersion – String	The software version of the target interface.

Target

Property	Description
Device Type device_id – String	The detected type of the currently connected target device.

AVRISP Target Interface

Connection

Property	Description
Device Name deviceName – String	The name of the device to be programmed.
ISP Freq (Actual) ActualIspFreq – String	The actual ISP frequency which must be less than 1/4 of the target frequency.
ISP Freq (Desired) IspFreq – String	The desired ISP frequency which must be less than 1/4 of the target frequency.
Port Name portName – String	The name of the serial port connected to the AVRISP. On windows hosts you can right click to select from the set of COM ports available.
Use Target As Device Name useTargetAsDeviceName – Boolean	Use the projects Target property as the device name.

Current

Property	Description
Hardware Version hardwareVersion – String	The hardware version of the target interface.
Software Version softwareVersion – String	The software version of the target interface.

Target

Property	Description
Device Type device_id – String	The detected type of the currently connected target device.

AVRISP mkII Target Interface

Connection

Property	Description
Device Name deviceName – String	The name of the device to be programmed.
ISP Freq (Actual) ActualIspFreq – String	The actual ISP frequency which must be less than 1/4 of the target frequency.
ISP Freq (Desired) IspFreq – String	The desired ISP frequency which must be less than 1/4 of the target frequency.
Use Target As Device Name useTargetAsDeviceName – Boolean	Use the projects Target property as the device name.

Current

Property	Description
Hardware Version hardwareVersion – String	The hardware version of the target interface.
Software Version softwareVersion – String	The software version of the target interface.

Target

Property	Description
Connection Connection – String	The USB serial number of the AVR Dragon to connect to.
Device Type device_id – String	The detected type of the currently connected target device.

Parallel Port JTAG Target Interface

Connection

Property	Description
External Reset Required <code>externalResetRequired</code> – Boolean	Apply external reset on connect.
Hardware Breakpoints <code>useHardwareBreakpoints</code> – Boolean	Always use hardware breakpoints i.e. don't set software breakpoints.
JTAG Cable Type <code>connectorType</code> – Enumeration	Is the JTAG cable an ARM 20 Pin or a AVR/MAXQ 10 Pin.
JTAG Clock Divider <code>JTAGDivider</code> – IntegerRange	The JTAG clock delay
JTAG Clock Divider (Debug) <code>JTAGDivider2</code> – IntegerRange	The JTAG clock delay when in debug mode on a JTAG Mega device.
Parallel Port <code>portName</code> – String	The name of the parallel port to use.
Parallel Port Sharing <code>portSharing</code> – Boolean	Specifies whether sharing of the parallel port with other device drivers or programs is permitted.

CrossConnect JTAG Target Interface

Connection

Property	Description
External Reset Required <code>externalResetRequired</code> – Boolean	Apply external reset on connect.
Hardware Breakpoints <code>useHardwareBreakpoints</code> – Boolean	Always use hardware breakpoints i.e. don't set software breakpoints.
JTAG Clock Divider <code>JTAGDivider</code> – IntegerRange	The JTAG clock delay
JTAG Clock Divider (Debug) <code>JTAGDivider2</code> – IntegerRange	The JTAG clock delay when in debug mode on a JTAG Mega device.

Target

Property	Description
Connection <code>Connection</code> – String	The USB serial number of the CrossConnect to connect to.

Arduino Target Interface

Connection

Property	Description
Baud Rate <code>baudRate</code> – Enumeration	The speed of the serial communication.
Port Name <code>portName</code> – String	The name of the serial port connected to the Arduino. On windows hosts you can right click to select from the set of COM ports available.

Using an external AVR GCC toolchain

You can use CrossStudio for AVR with a third party supplied AVR GCC toolchain. To do this you must start CrossStudio for AVR from the command line with the `-gcc` command line option.

```
crossstudio -gcc
```

The location of the AVR GCC toolchain is determined by the global macro `AVRGCCDIR`. To set this use the **Project > Macros...** dialog and specify the `AVRGCCDIR` value in the global macros editor.

```
AVRGCCDIR=C:/WinAVR-20100110/bin
```

Note that no CrossWorks libraries are usable when CrossStudio for AVR is used in this way.



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

-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.

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

-mxmega (Enable XMEGA processor)

Syntax

-mxmega

Description

This option instructs the compiler to generate code for the XMEGA AVR core. By default the compiler generates code for the standard AVR core. Note that it is not possible to mix code generated for the XMEGA with code generated for the standard AVR.

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 so.

-m (Set AVR code memory size)

Syntax

-m8k

-m128k

-m8m

Description

This option instructs the compiler to generate code for a standard AVR core with 8 kilobytes, 128 kilobytes, or 8 megabytes of code memory. The compiler uses this information to select the correct size of jump and call instructions for the selected code size.

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 so.

-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

`-O \textit{level}`

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.

-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.

-mxmega

- `__AVR_XMEGA` defined to 1.

-m8k

- `__AVR_FLASH_SIZE` defined to 8

-m128k

- `__AVR_FLASH_SIZE` defined to 128

-m8m

- `__AVR_FLASH_SIZE` defined to 8192

-mboot

- `__AVR_BOOTLOADER` defined.

-msd

- `__SHORT_DOUBLES` defined.

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 dataseg

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 100₁₆:

```
enum unsigned char T0CN_t {
    M0    = 1<<0,
    M1    = 1<<1,
    CT    = 1<<2,
    GATE  = 1<<3,
    TR0   = 1<<4,
    TF0   = 1<<5,
    TOM   = 1<<6,
    ET0   = 1<<7
};

enum T0CN_t T0CN __at 0x100;
```

Code-space strings

Harvard machines such as the Atmel AVR and Dallas Semiconductor MAXQ require special compiler support for addressing data held in code space—and so CrossWorks provides the `__code` keyword to store data in code space rather than data space. This does, however, lead to some inconvenient programming when dealing with constant string data because each string needs to be named and stored into code space using `__code`. The CrossWorks compiler offers a solution using the `C` qualifier to store strings into code space rather than data space. The type of a 'C'-qualified string is `__code const char *`.

Example

Without using C-qualified strings you would write:

```
void sign_on(void)
{
    static const __code char message[] = "Tynadyne wiper widget, v1.0";
    printf_c(message);
}
```

Using the CrossWorks extension you can write:

```
void sign_on(void)
{
    printf_c(C"Tynadyne wiper widget, v1.0");
}
```

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 **UART0RX_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 the 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 top-level attribute because none of their registers are unimportant on entry and exit. Using the top-level 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'.

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.

Data representation

All data items are held in the native byte order of the AVR 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	1
short and unsigned short	2	1
long and unsigned long	4	1
long long and unsigned long long	8	1
float and double (compiled with -msd)	4	1
double and long double	8	1
<i>type</i> * (pointer)	2	1
enum (enumeration)	2	1

Register use

The compiler partitions the AVR general purpose registers into three sets.

- The registers in the first set, **R20** through **R27**, are used for parameter passing and returning function results and are not preserved across functions calls.
- The registers in the second set, **R1** and **R30–R31** are used for temporary results and are not preserved across functions calls.
- The registers in the third set, **R2–R19**, are used for register variables, working storage, and temporary results and must be preserved across function calls.

Fixed registers

The C compiler requires that **R0** be zero when entering a C function. It can momentarily take non-zero values, but must be zero at the point you call a C function. The standard entry code that the C compiler lays down for an interrupt function sets **R0** to zero by default.

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:

- The eight-bit type **char** requires one register.
- The 16-bit types **int**, **short**, **enumerations**, and any pointer type require two registers.
- The 32-bit types **long** and **float** (and **double** if compiled with **double** equivalent to **float**) require four registers.
- The 64-bit types **long long** and **double** require eight registers.

Allocation of the scratch registers for function calls proceeds in a left-to-right fashion, starting with register **R27** and progressing in reverse order to **R2**. 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.

- An eight-bit type is returned in register **R27**.
- A 16-bit type is returned in **R27–R26** with **R27** holding the most significant byte of the result and **R26** the least-significant byte.
- A 32-bit type is returned in the register quad **R27–R24**, with **R27** holding the most-significant byte of the result and **R24** the least-significant byte.
- A 64-bit type is returned in the register set **R27–R20** with **R27** holding the most-significant byte of the result and **R20** the least-significant byte.

Examples

This section contains some examples of the calling convention in use.

Example #1

```
void fun1(char u, char v);
```

Reading from left to right, the parameter **u** is passed in register **R27** and **v** is passed in **R26**. The scratch registers **R20** through **R25** are not used to pass parameters and can be used in **fun1** without needing to be preserved.

Example #2

```
void fun1(char u, int v, char w);
```

The parameter **u** is passed in register **R27**. Because **v** requires two registers to hold its value it is passed in the register pair **R26–R25** with **R26** holding the high part of **v** and **R24** the low part. The final parameter **w** is passed in **R23**.

Example #3

```
void fun1(int u, long v, int w, int x);
```

The parameter **u** is passed in register pair **R27–R26**. Because **v** requires four registers to hold its value, it is passed in the register quad **R25–R22** with **R25** holding the high byte of **v** and **R22** the low byte. Parameter **w** is passed in register pair **R21–R20**. As all scratch registers are now used, **x** is placed onto the stack.

Example #4

```
void fun1(int u, long v, long w);
```

The parameter **u** is passed in register pair **R27–R26**. Because **v** requires four registers to hold its value it is passed in the register quad **R25–R22**. When considering **w**, there are only two free registers left for passing parameters, **R21** and **R20**. The compiler cannot fit **w** into this register pair and therefore places the argument onto the stack—the compiler does not split the value into two and pass half in registers 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 registers **R27–R26**. The parameter **v** is passed in the register quad **R25–R22**. When considering **w**, there are only two free parameter passing registers left, **R21** and **R20**. The compiler cannot fit **w** into the register pair **R21–R20** and therefore places the argument onto the stack. When considering **x**, the compiler sees that **R21** and **R20** are unused and so passes **x** in the register pair **R21–R20**. All parameter 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

-I*directory*

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

-Jdirectory

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. 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.

The number of bytes per word is defined by the target processor. For 32-bit processors, one word is usually four bytes, and for 8-bit and 16-bit processors, one word is usually two bytes.

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. 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 <i>o</i> is an octal digit
\xhh	Hexadecimal code of character where <i>h</i> 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 \$FB \$FE 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
```

^

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
X0SIZE 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**, **HWORD**.

XOR

Syntax

expression-1 XOR expression-2

Description

A synonym for \wedge , 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

POWERS:  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

```
POWERS:
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.



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 <__cross_studio_io.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.

To do this using the HCC environment:

- 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.

To do this using the GCC environment:

- Select the project node in the **Project Explorer**.
- Display the **Properties Window**.
- Enter the text `__putchar=debug_putchar` into the **Linker > Linker Symbol Definitions** property of the **Linker Options** group.

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 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 = __vscanf((__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.

Complete API reference

This section contains a complete reference to the CrossWorks C library API.

File	Description
<assert.h>	Describes the diagnostic facilities which you can build into your application.
<cross_studio_io.h>	Describes the virtual console services and semi-hosting support that CrossStudio provides to help you when developing your applications.
<cruntime.h>	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.
<ctype.h>	Describes the character classification and manipulation functions.
<errno.h>	Describes the macros and error values returned by the C library.
<float.h>	Defines macros that expand to various limits and parameters of the standard floating point types.
<ina90.h>	Describes intrinsic functions of general use for the AVR 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 AVR (EWA90) product.
<inavr.h>	Describes intrinsic functions of general use for the AVR processor. This file is written to be compatible, and in some cases an enhancement of, the corresponding file in version 3 of IAR's Embedded Workbench for AVR (EWAVR) product.
<limits.h>	Describes the macros that define the extreme values of underlying C types.
<locale.h>	Describes support for localization specific settings.
<math.h>	Describes the mathematical functions provided by the C library.

<code><pgmspace.h></code>	Describes functions to access data in code (program) space. This file written to be compatible with the corresponding file in IAR's Embedded Workbench for AVR products EWA90 and EWAVR.}
<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><stdio_c.h></code>	Describes functions to format and output values with formatting strings stored in code (program) space.
<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><string_c.h></code>	Describes functions that operate on arrays that are interpreted as null-terminated strings in code (program) space.
<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	
assert	Allows you to place assertions and diagnostic tests into programs
Functions	
__assert	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.

<cross_studio_io.h>

API Summary

File Functions	
debug_clearerr	Clear error indicator
debug_fclose	Closes an open stream
debug_feof	Check end of file condition
debug_ferror	Check error indicator
debug_fflush	Flushes buffered output
debug_fgetc	Read a character from a stream
debug_fgetpos	Return file position
debug_fgets	Read a string
debug_filesize	Return the size of a file
debug_fopen	Opens a file on the host PC
debug_fprintf	Formatted write
debug_fprintf_c	Formatted write
debug_fputc	Write a character
debug_fputs	Write a string
debug_fread	Read data
debug_freopen	Reopens a file on the host PC
debug_fscanf	Formatted read
debug_fscanf_c	Formatted read
debug_fseek	Set file position
debug_fsetpos	Return file position
debug_ftell	Return file position
debug_fwrite	Write data
debug_remove	Deletes a file on the host PC
debug_rename	Renames a file on the host PC
debug_rewind	Set file position to the beginning
debug_tmpfile	Open a temporary file
debug_tmpnam	Generate temporary filename
debug_ungetc	Push a character
debug_vfprintf	Formatted write
debug_vfscanf	Formatted read

Debug Terminal Output Functions	
debug_printf	Formatted write
debug_printf_c	Formatted write
debug_putchar	Write a character
debug_puts	Write a string
debug_vprintf	Formatted write
Debug Terminal Input Functions	
debug_getch	Blocking character read
debug_getchar	Line-buffered character read
debug_getd	Line-buffered double read
debug_getf	Line-buffered float read
debug_geti	Line-buffered integer read
debug_getl	Line-buffered long read
debug_getll	Line-buffered long long read
debug_gets	String read
debug_getu	Line-buffered unsigned integer
debug_getul	Line-buffered unsigned long read
debug_getull	Line-buffered unsigned long long read
debug_kbhit	Polled character read
debug_scanf	Formatted read
debug_scanf_c	Formatted read
debug_vscanf	Formatted read
Debugger Functions	
debug_abort	Stop debugging
debug_break	Stop target
debug_enabled	Test if debug input/output is enabled
debug_exit	Stop debugging
debug_getargs	Get arguments
debug_loadsymbols	Load debugging symbols
debug_runtime_error	Stop and report error
debug_unloadsymbols	Unload debugging symbols
Misc Functions	
debug_getenv	Get environment variable value
debug_perror	Display error
debug_system	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(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 **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 **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_scanf

Synopsis

```
int debug_scanf(const char *format,  
                ...);
```

Description

debug_scanf 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_scanf** 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_scanf returns number of characters read, or a negative value if an output or encoding error occurred.

debug_scanf_c

Synopsis

```
int debug_scanf_c(__code const char *format,  
                  ...);
```

Description

debug_scanf_c is equivalent to **debug_scanf** 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

```
unsigned long debug_time(unsigned 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.

<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	
__int16_mul	Multiply two 16-bit signed or unsigned integers forming a 16-bit product
__int16_mul_8x8	Multiply two 8-bit signed integers forming a 16-bit signed product
__int16_mul_asgn	Multiply a 16-bit signed or unsigned integer in memory by a 16-bit integer
__int32_mul	Multiply two 32-bit signed or unsigned integers forming a 32-bit product
__int32_mul_16x16	Multiply two 16-bit signed integers forming a 32-bit signed product
__int32_mul_asgn	Multiply a 32-bit signed or unsigned integer in memory by a 32-bit integer
__int64_mul	Multiply two 64-bit signed or unsigned integers forming a 64-bit product
__int64_mul_32x32	Multiply two 32-bit signed integers forming a 64-bit signed product
__int64_mul_asgn	Multiply a 64-bit signed or unsigned integer in memory by a 64-bit integer
__uint16_mul_8x8	Multiply two 8-bit unsigned integers forming a 16-bit unsigned product
__uint32_mul_16x16	Multiply two 16-bit unsigned integers forming a 32-bit unsigned product
__uint64_mul_32x32	Multiply two 32-bit unsigned integers forming a 64-bit unsigned product
Integer division	
__int16_div	Divide two 16-bit signed integers and return the 16-bit signed quotient

__int16_div_asgn	Divide a 16-bit signed integer in memory by a 16-bit signed integer
__int16_mod	Divide two 16-bit signed integers and return the 16-bit signed remainder after division
__int16_mod_asgn	Divide a 16-bit signed integer in memory by a 16-bit signed integer and assign it the 16-bit remainder
__int32_div	Divide two 32-bit signed integers and return the 32-bit signed quotient
__int32_div_asgn	Divide a 32-bit signed integer in memory by a 32-bit signed integer
__int32_mod	Divide two 32-bit signed integers and return the 32-bit signed remainder after division
__int32_mod_asgn	Divide a 32-bit signed integer in memory by a 32-bit signed integer and assign it the 32-bit remainder
__int64_div	Divide two 64-bit signed integers and return the 64-bit signed quotient
__int64_div_asgn	Divide a 64-bit signed integer in memory by a 64-bit signed integer
__int64_mod	Divide two 64-bit signed integers and return the 64-bit signed remainder after division
__int64_mod_asgn	Divide a 64-bit signed integer in memory by a 64-bit signed integer and assign it the 64-bit remainder
__uint16_div	Divide two 16-bit unsigned integers and return the 16-bit unsigned quotient
__uint16_div_asgn	Divide a 16-bit unsigned integer in memory by a 16-bit unsigned integer
__uint16_mod	Divide two 16-bit unsigned integers and return the 16-bit unsigned remainder after division
__uint16_mod_asgn	Divide a 16-bit unsigned integer in memory by a 16-bit unsigned integer and assign it the 16-bit remainder
__uint32_div	Divide two 32-bit unsigned integers and return the 32-bit unsigned quotient
__uint32_div_asgn	Divide a 32-bit unsigned integer in memory by a 32-bit unsigned integer
__uint32_mod	Divide two 32-bit unsigned integers and return the 32-bit unsigned remainder after division
__uint32_mod_asgn	Divide a 32-bit unsigned integer in memory by a 32-bit unsigned integer and assign it the 32-bit remainder
__uint64_div	Divide two 64-bit unsigned integers and return the 64-bit unsigned quotient

__uint64_div_asgn	Divide a 64-bit unsigned integer in memory by a 64-bit unsigned integer
__uint64_mod	Divide two 64-bit unsigned integers and return the 64-bit unsigned remainder after division
__uint64_mod_asgn	Divide a 64-bit unsigned integer in memory by a 64-bit unsigned integer and assign it the 64-bit remainder
Integer shifts	
__int16_asr	Shift a 16-bit signed integer arithmetically right by a variable number of bit positions
__int16_asr_asgn	Shift a 16-bit signed integer in memory arithmetically right by a variable number of bit positions
__int16_lsl	Shift a 16-bit signed integer left by a variable number of bit positions
__int16_lsl_asgn	Shift a 16-bit signed integer in memory left by a variable number of bit positions
__int16_lsr	Shift a 16-bit unsigned integer logically right by a variable number of bit positions
__int16_lsr_asgn	Shift a 16-bit unsigned integer in memory logically right by a variable number of bit positions
__int32_asr	Shift a 32-bit signed integer arithmetically right by a variable number of bit positions
__int32_asr_asgn	Shift a 32-bit signed integer in memory arithmetically right by a variable number of bit positions
__int32_lsl	Shift a 32-bit signed integer left by a variable number of bit positions
__int32_lsl_asgn	Shift a 32-bit signed integer in memory left by a variable number of bit positions
__int32_lsr	Shift a 32-bit unsigned integer logically right by a variable number of bit positions
__int32_lsr_asgn	Shift a 32-bit unsigned integer in memory logically right by a variable number of bit positions
__int64_asr	Shift a 64-bit signed integer arithmetically right by a variable number of bit positions
__int64_asr_asgn	Shift a 64-bit signed integer in memory arithmetically right by a variable number of bit positions
__int64_lsl	Shift a 64-bit signed integer left by a variable number of bit positions
__int64_lsl_asgn	Shift a 64-bit signed integer in memory left by a variable number of bit positions

__int64_lsr	Shift a 64-bit unsigned integer logically right by a variable number of bit positions
__int64_lsr_asgn	Shift a 64-bit unsigned integer in memory logically right by a variable number of bit positions
Floating-point arithmetic	
__float32_add	Add two 32-bit floating point values
__float32_add_1	Add one to a 32-bit floating point value
__float32_add_asgn	Add a 32-bit floating point value to a 32-bit floating point value in memory
__float32_div	Divide two 32-bit floating point values
__float32_div_asgn	Divide a 32-bit floating point value in memory by a 32-bit floating point value
__float32_mul	Multiply two 32-bit floating point values
__float32_mul_asgn	Multiply a 32-bit floating point value in memory by a 32-bit floating point value
__float32_neg	Negate a 32-bit floating point value
__float32_sqr	Square a 32-bit floating point value
__float32_sub	Subtract two 32-bit floating point values
__float32_sub_asgn	Subtract a 32-bit floating point value from a 32-bit floating point value in memory
__float64_add	Add two 64-bit floating point values
__float64_add_1	Add one to a 64-bit floating point value
__float64_add_asgn	Add a 64-bit floating point value to a 64-bit floating point value in memory
__float64_div	Divide two 64-bit floating point values
__float64_div_asgn	Divide a 64-bit floating point value in memory by a 64-bit floating point value
__float64_mul	Multiply two 64-bit floating point values
__float64_mul_asgn	Multiply a 64-bit floating point value in memory by a 64-bit floating point value
__float64_neg	Negate a 64-bit floating point value
__float64_sqr	Square a 64-bit floating point value
__float64_sub	Subtract two 64-bit floating point values
__float64_sub_asgn	Subtract a 64-bit floating point value from a 64-bit floating point value in memory
Floating point comparison	
__float32_eq	Compare two 32-bit floating point values for equality
__float32_eq_0	Compare 32-bit floating point value to zero

__float32_lt	Compare two 32-bit floating point values
__float32_lt_0	Compare 32-bit floating point value with zero
__float64_eq	Compare two 64-bit floating point values for equality
__float64_eq_0	Compare 64-bit floating point value to zero
__float64_lt	Compare two 64-bit floating point values
__float64_lt_0	Compare 64-bit floating point value with zero
Integer to floating point conversions	
__int16_to_float32	Convert a 16-bit signed integer to a 32-bit floating point value
__int16_to_float64	Convert a 16-bit signed integer to a 64-bit floating point value
__int32_to_float32	Convert a 32-bit signed integer to a 32-bit floating point value
__int32_to_float64	Convert a 32-bit signed integer to a 64-bit floating point value
__int64_to_float32	Convert a 64-bit signed integer to a 32-bit floating point value
__int64_to_float64	Convert a 64-bit signed integer to a 64-bit floating point value
__uint16_to_float32	Convert a 16-bit unsigned integer to a 32-bit floating point value
__uint16_to_float64	Convert a 16-bit unsigned integer to a 64-bit floating point value
__uint32_to_float32	Convert a 32-bit unsigned integer to a 32-bit floating point value
__uint32_to_float64	Convert a 32-bit unsigned integer to a 64-bit floating point value
__uint64_to_float32	Convert a 64-bit unsigned integer to a 32-bit floating point value
__uint64_to_float64	Convert a 64-bit unsigned integer to a 64-bit floating point value
Floating point to integer conversions	
__float32_to_int16	Convert a 32-bit floating point value to a 16-bit signed integer
__float32_to_int32	Convert a 32-bit floating point value to a 32-bit signed integer
__float32_to_int64	Convert a 32-bit floating point value to a 64-bit signed integer

__float32_to_uint16	Convert a 32-bit floating point value to a 16-bit unsigned integer
__float32_to_uint32	Convert a 32-bit floating point value to a 32-bit unsigned integer
__float32_to_uint64	Convert a 32-bit floating point value to a 64-bit unsigned integer
Floating point conversions	
__float32_to_float64	Convert a 32-bit floating point value to a 64-bit floating point value
__float64_to_float32	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 **its** 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 character?
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

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.

isalpha

Synopsis

```
int isalpha(int c);
```

Description

isalpha returns nonzero (true) if and only if **isupper** or **islower** return true for value of the argument **c**.

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 ').

isctrl

Synopsis

```
int isctrl(int c);
```

Description

isctrl 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.

isdigit

Synopsis

```
int isdigit(int c);
```

Description

isdigit returns nonzero (true) if and only if the value of the argument **c** is a digit.

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 (' ').

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.

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 (' ').

ispunct

Synopsis

```
int ispunct(int c);
```

Description

ispunct returns nonzero (true) for every printing character for which neither **isspace** nor **isalnum** is true.

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 ').

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.

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.

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, **tolower** 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 **c** is a character for which **islower** is true, **toupper** returns the corresponding uppercase letter; otherwise, the argument is returned unchanged.

<errno.h>

API Summary

Macros	
errno	Allows you to access the errno implementation
Error numbers	
EDOM	Domain error
EILSEQ	Illegal byte sequence
ERANGE	Result too large or too small
Functions	
__errno	User-defined behavior for the errno macro

EDOM

Synopsis

```
#define EDOM      0x01
```

Description

EDOM - an input argument is outside the defined domain of the mathematical function.

EILSEQ

Synopsis

```
#define EILSEQ    0x02
```

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.

ERANGE

Synopsis

```
#define ERANGE    0x03
```

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(void);
```

Description

There is no default implementation of **__errno**. Keeping **__errno** out of the library means that you can customize its behavior without rebuilding the library. A default implementation could be

```
static int errno;
```

```
int *__errno(void) { return &errno; }
```

errno

Synopsis

```
#define errno (*__errno())
```

Description

errno macro expands to a function call to **__errno** that returns a pointer to an **int**. This function can be implemented by the application to provide a thread specific **errno**.

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**.

<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.

<ina90.h>

API Summary

Miscellaneous functions	
_BREAK	Programmed breakpoint
_NOP	NOP
_OPC	Insert an opcode
_SLEEP	Put processor to sleep
_WDR	Reset the watchdog
Status register manipulation	
_CLI	Disable interrupts and return original status register
_SEI	Enable interrupts and return original status register
disable_interrupt	Disable interrupts and return original status register
enable_interrupt	Enable interrupts and return original status register

_BREAK

Synopsis

```
#define _BREAK() __breakpoint();
```

Description

see [__breakpoint](#)

_CLI

Synopsis

```
#define _CLI() __disable_interrupt()
```

Description

see [__disable_interrupt](#)

_NOP

Synopsis

```
#define _NOP() __no_operation()
```

Description

see [__no_operation](#)

_OPC

Synopsis

```
#define _OPC(op) __insert_opcode(op)
```

Description

see [__insert_opcode](#)

_SEI

Synopsis

```
#define _SEI() __enable_interrupt()
```

Description

see [__enable_interrupt](#)

_SLEEP

Synopsis

```
#define _SLEEP() __sleep()
```

Description

see [__sleep](#)

_WDR

Synopsis

```
#define _WDR() __watchdog_reset()
```

Description

see [__watchdog_reset](#)

disable_interrupt

Synopsis

```
#define disable_interrupt() __disable_interrupt()
```

Description

see [__disable_interrupt](#)

enable_interrupt

Synopsis

```
#define enable_interrupt() __enable_interrupt()
```

Description

see [__enable_interrupt](#)

<inavr.h>

API Summary

Miscellaneous functions	
__breakpoint	Programmed breakpoint
__delay_cycles	Delay execution for a number of cycles
__insert_opcode	Insert an opcode
__no_operation	NOP
__sleep	Put processor to sleep
__watchdog_reset	Reset the watchdog
Status register manipulation	
__bic_SR_register	Clear bits in status register and return original status register
__bis_SR_register	Set bits in status register and return original status register
__disable_interrupt	Disable interrupts and return original status register
__enable_interrupt	Enable interrupts and return original status register
__restore_interrupt	Restore the interrupt enables
__save_interrupt	Return the status register
Byte order manipulation	
__swap_bytes	Swap order of bytes in a word
__swap_bytes_long	Swap order of bytes in a long
__swap_nibbles	Swap nibble order within a byte
__swap_words	Swap order of words in a long

__bic_SR_register

Synopsis

```
unsigned char __bic_SR_register(unsigned char mask);
```

Description

__bic_SR_register clears the bits specified in **mask** in the AVR status register (i.e. it bitwise ands the complement of **mask** into the status register) and returns the value of the AVR status register before the update.

__bic_SR_register is an intrinsic function and produces inline code.

__bis_SR_register

Synopsis

```
unsigned char __bis_SR_register(unsigned char mask);
```

Description

__bis_SR_register sets the bits specified in **mask** in the AVR status register (i.e. it bitwise ors **mask** into the status register) and returns the value of the AVR status register before the update.

__bis_SR_register is an intrinsic function and produces inline code.

__breakpoint

Synopsis

```
#define __breakpoint() __insert_opcode(0x9598);
```

Description

__breakpoint inserts a **BREAKPOINT** opcode into the code stream.

__breakpoint 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

```
#define __disable_interrupt() __bic_SR_register(0x80)
```

Description

__disable_interrupt disables global interrupts by clearing the I bit in the status register and returns the value of the status register before the I bit is cleared. You can restore the state of the I bit from the value returned from **__disable_interrupt** by using the **__restore_interrupt** intrinsic function.

__disable_interrupt is an intrinsic function and produces inline code.

__enable_interrupt

Synopsis

```
#define __enable_interrupt() __bis_SR_register(0x80)
```

Description

__enable_interrupt enables global interrupts by setting the I bit in the status register and returns the value of the status register before the I bit is set. You can restore the state of the I bit from the value returned from **__enable_interrupt** by using the **__restore_interrupt** intrinsic function.

__enable_interrupt is an intrinsic function and produces inline code.

__insert_opcode

Synopsis

```
void __insert_opcode(unsigned short 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.

__no_operation

Synopsis

```
#define __no_operation() __insert_opcode(0x0000);
```

Description

__no_operation inserts a **NOP** opcode into the code stream.

__no_operation is an intrinsic function and produces inline code.

__restore_interrupt

Description

__restore_interrupt restores the state of the I bit in the status register to the value saved in x.

The value of x is returned from the [__disable_interrupt](#), [__enable_interrupt](#), and [__save_interrupt](#) intrinsic functions and is simply the previous value of the status register.

__restore_interrupt is an intrinsic function and produces inline code.

__save_interrupt

Synopsis

```
#define __save_interrupt() (__sr)
```

Description

__save_interrupt returns the current value of the AVR status register, including the I bit, without changing the status register. You can restore the state of the interrupt flag using the [__restore_interrupt](#) intrinsic function.

__save_interrupt is an intrinsic function and produces inline code.

__sleep

Synopsis

```
#define __sleep() __insert_opcode(0x9588);
```

Description

__sleep inserts a **SLEEP** opcode into the code stream.

__sleep 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_bytes_long

Synopsis

```
unsigned long __swap_bytes_long(unsigned long x);
```

Description

__swap_bytes_long swaps the order of all bytes of **x** and returns that as its result.

__swap_bytes_long is an intrinsic function and produces inline code.

__swap_nibbles

Description

__swap_nibbles swaps the high and low nibbles of **x** and returns that as its result. **__swap_nibbles** is an intrinsic function and produces inline code.

__swap_words

Synopsis

```
unsigned long __swap_words(unsigned long);
```

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.

__watchdog_reset

Synopsis

```
#define __watchdog_reset() __insert_opcode(0x95a8);
```

Description

__watchdog_reset inserts a WDR opcode into the code stream.

__watchdog_reset is an intrinsic function and produces inline code.

<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

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**.

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

Functions	
localeconv	Get current locale data
setlocale	Set Locale
Structures	
lconv	Formatting info for numeric values

lconv

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

lconv 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.

setlocale returns the name of the current locale.

Note

CrossWorks only supports the minimal "C" locale.

<math.h>

API Summary

Type Generic Macros	
fpclassify	Classify floating type
isfinite	Test for a finite value
isinf	Test for infinity
isnan	Test for NaN
isnormal	Test for a normal value
signbit	Test sign
Trigonometric functions	
cos	Compute cosine of a double
cosf	Compute cosine of a float
sin	Compute sine of a double
sinf	Compute sine of a float
tan	Compute tangent of a double
tanf	Compute tangent of a double
Inverse trigonometric functions	
acos	Compute inverse cosine of a double
acosf	Compute inverse cosine of a float
asin	Compute inverse sine of a double
asinf	Compute inverse sine of a float
atan	Compute inverse tangent of a double
atan2	Compute inverse tangent of a ratio of doubles
atan2f	Compute inverse tangent of a ratio of floats
atanf	Compute inverse tangent of a float
Exponential and logarithmic functions	
cbrt	Compute cube root of a double
cbrtf	Compute cube root of a float
exp	Compute exponential of a double
expf	Compute exponential of a float
frexp	Set exponent of a double
frexpf	Set exponent of a float
ldexp	Adjust exponent of a double

<code>ldexpf</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>logf</code>	Compute natural logarithm of a float
<code>pow</code>	Raise a double to a power
<code>powf</code>	Raise a float to a power
<code>scalbn</code>	Scale a double
<code>scalbnf</code>	Scale a float
<code>sqrt</code>	Compute square root of a double
<code>sqrtf</code>	Compute square root of a float
Remainder functions	
<code>fmod</code>	Compute remainder after division of two doubles
<code>fmodf</code>	Compute remainder after division of two floats
<code>modf</code>	Break a double into integer and fractional parts
<code>modff</code>	Break a float into integer and fractional parts
Nearest integer 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 float
<code>floorf</code>	Compute largest integer not greater than a float
Absolute value functions	
<code>fabs</code>	Compute absolute value of a double
<code>fabsf</code>	Compute absolute value of a float
<code>hypot</code>	Compute complex magnitude of two doubles
<code>hypotf</code>	Compute complex magnitude of two floats
Maximum, minimum, and positive difference functions	
<code>fmax</code>	Compute maximum of two doubles
<code>fmaxf</code>	Compute maximum of two floats
<code>fmin</code>	Compute minimum of two doubles
<code>fminf</code>	Compute minimum of two floats
Hyperbolic functions	
<code>cosh</code>	Compute hyperbolic cosine of a double
<code>coshf</code>	Compute hyperbolic cosine of a float
<code>sinh</code>	Compute hyperbolic sine of a double

<code>sinhf</code>	Compute hyperbolic sine of a float
<code>tanh</code>	Compute hyperbolic tangent of a double
<code>tanhf</code>	Compute hyperbolic tangent of a float
Inverse hyperbolic functions	
<code>acosh</code>	Compute inverse hyperbolic cosine of a double
<code>acoshf</code>	Compute inverse hyperbolic cosine of a float
<code>asinh</code>	Compute inverse hyperbolic sine of a double
<code>asinhf</code>	Compute inverse hyperbolic sine of a float
<code>atanh</code>	Compute inverse hyperbolic tangent of a double
<code>atanhf</code>	Compute inverse hyperbolic tangent 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 $|a| > 1$, **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**.

acosh(**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** = **y** = 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 $\pm \pi$.

atan2(\pm (anything but 0 and NaN), 0) is $\pm \frac{1}{2}\pi$.

atan2(\pm (anything but ∞ and NaN), $+\infty$) is ± 0 .

atan2(\pm (anything but ∞ and NaN), $-\infty$) is $\pm \pi$.

atan2($\pm \infty$, $+\infty$) is $\pm \frac{1}{4}\pi$.

atan2($\pm \infty$, $-\infty$) is $\pm \frac{3}{4}\pi$.

atan2($\pm \infty$, (anything but 0, NaN, and ∞)) is $\pm \frac{1}{2}\pi$.

atan2f

Synopsis

```
float atan2f(float x,  
            float y);
```

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 **val**.

If $|x| \geq 1$, **errno** is set to **EDOM** and **atanhf** returns **HUGE_VALF**.

If $|val| > 1$ **atanhf** returns NaN. If **val** is NaN, **atanhf** returns that NaN. If **val** is 1, **atanhf** returns ∞ . If **val** 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 $\pm \infty$.

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**.

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.

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.

fabs

Synopsis

```
double fabs(double x);
```

fabsf

Synopsis

```
float fabsf(float x);
```

Description

fabsf computes the absolute value of the floating-point number **x**.

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 $\pm \infty$.

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**.

If **y** = 0, **fmod** returns zero and **errno** is set to **EDOM**.

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**.

If **y** = 0, **fmodf** returns zero and **errno** is set to **EDOM**.

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) (sizeof(x) == sizeof(float) ? __float32_classify(x) :  
    __float64_classify(x))
```

Description

fpclassify macro shall classify its argument value as NaN, infinite, normal, subnormal, zero, or into another implementation-defined category. The fpclassify macro returns the value of the number classification macro 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 $x * 2^{\text{exp}}$.

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 $x * 2^{\text{exp}}$.

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**, $\sqrt{x*x + y*y}$, 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**, **sqrtf(x*x + y*y)**, 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.

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). The isfinite macro returns a non-zero value if and only if its argument has a finite value.

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.

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). The `isnormal` macro returns a non-zero value if and only if its argument has a normal value.

ldexp

Synopsis

```
double ldexp(double x,  
             int exp);
```

Description

ldexp multiplies a floating-point number by an integral power of 2.

ldexp returns $x * 2^{\text{exp}}$.

If the result overflows, **errno** is set to **ERANGE** and **ldexp** returns **HUGE_VALF**.

If **x** is ∞ or NaN, **ldexp** returns **x**. If the result overflows, **ldexp** returns ∞ .

ldexpf

Synopsis

```
float ldexpf(float x,  
             int exp);
```

Description

ldexpf multiplies a floating-point number by an integral power of 2.

ldexpf returns $x * 2^{\text{exp}}$. If the result overflows, **errno** is set to **ERANGE** and **ldexpf** returns **HUGE_VALF**.

If x is ∞ or NaN, **ldexpf** returns x . If the result overflows, **ldexpf** returns ∞ .

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**.

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 $x = \infty$, **logf** returns ∞ .

If $x = \text{NaN}$, **logf** returns x .

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**.

pow

Synopsis

```
double pow(double x,  
           double y);
```

Description

pow computes x raised to the power y .

If $x < 0$ and $y \leq 0$, **errno** is set to **EDOM** and **pow** returns **-HUGE_VAL**. If $x \leq 0$ 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 $y = \text{NaN}$, **pow** returns NaN.

If $x = \text{NaN}$ and y is anything other than 0, **pow** returns NaN.

If $x < -1$ or $1 < x$, and $y = +\infty$, **pow** returns $+\infty$.

If $x < -1$ or $1 < x$, and $y = -\infty$, **pow** returns 0.

If $-1 < x < 1$ and $y = +\infty$, **pow** returns $+0$.

If $-1 < x < 1$ and $y = -\infty$, **pow** returns $+\infty$.

If $x = +1$ or $x = -1$ and $y = +\infty$ or $y = -\infty$, **pow** returns NaN.

If $x = +0$ and $y > 0$ and $y \neq \text{NaN}$, **pow** returns $+0$.

If $x = -0$ and $y > 0$ and $y \neq \text{NaN}$ or y not an odd integer, **pow** returns $+0$.

If $x = +0$ and y and $y \neq \text{NaN}$, **pow** returns $+\infty$.

If $x = -0$ and $y > 0$ and $y \neq \text{NaN}$ or y not an odd integer, **pow** returns $+\infty$.

If $x = -0$ and y is an odd integer, **pow** returns -0 .

If $x = +\infty$ and $y > 0$ and $y \neq \text{NaN}$, **pow** returns $+\infty$.

If $x = +\infty$ and $y < 0$ and $y \neq \text{NaN}$, **pow** returns $+0$.

If $x = -\infty$, **pow** returns **pow**(-0 , y)

If $x < 0$ and $x \neq \infty$ and y is a non-integer, **pow** returns NaN.

powf

Synopsis

```
float powf(float,  
           float);
```

Description

powf computes x raised to the power y .

If $x < 0$ and $y \leq 0$, **errno** is set to **EDOM** and **powf** returns **–HUGE_VALF**. If $x \leq 0$ and y is not an integer value, **errno** is set to **EDOM** and **pow** returns **–HUGE_VALF**.

If $y = 0$, **powf** returns 1.

If $y = 1$, **powf** returns x .

If $y = \text{NaN}$, **powf** returns NaN.

If $x = \text{NaN}$ and y is anything other than 0, **powf** returns NaN.

If $x < -1$ or $1 < x$, and $y = +\infty$, **powf** returns $+\infty$.

If $x < -1$ or $1 < x$, and $y = -\infty$, **powf** returns 0.

If $-1 < x < 1$ and $y = +\infty$, **powf** returns +0.

If $-1 < x < 1$ and $y = -\infty$, **powf** returns $+\infty$.

If $x = +1$ or $x = -1$ and $y = +\infty$ or $y = -\infty$, **powf** returns NaN.

If $x = +0$ and $y > 0$ and $y \neq \text{NaN}$, **powf** returns +0.

If $x = -0$ and $y > 0$ and $y \neq \text{NaN}$ or y not an odd integer, **powf** returns +0.

If $x = +0$ and y and $y \neq \text{NaN}$, **powf** returns $+\infty$.

If $x = -0$ and $y > 0$ and $y \neq \text{NaN}$ or y not an odd integer, **powf** returns $+\infty$.

If $x = -0$ and y is an odd integer, **powf** returns -0 .

If $x = +\infty$ and $y > 0$ and $y \neq \text{NaN}$, **powf** returns $+\infty$.

If $x = +\infty$ and $y < 0$ and $y \neq \text{NaN}$, **powf** returns +0.

If $x = -\infty$, **powf** returns **powf**(-0 , y)

If $x < 0$ and $x \neq \infty$ and y is a non-integer, **powf** returns NaN.

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 shall determine whether the sign of its argument value is negative. The signbit macro returns a non-zero value if and only if its argument value 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 $|x| > 709.782$, **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. CrossWorks C 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. CrossWorks C 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.

<pgmspace.h>

API Summary

Miscellaneous functions	
strlen_P	Calculate length of a code string
Formatted output functions	
printf_P	Write code string formatted text to standard output
snprintf_P	Write code string formatted text to a string with truncation
sprintf_P	Write code string formatted text to a string
vprintf_P	Write code string formatted text to standard output using variable argument context
vsnprintf_P	Write code string formatted text to a string with truncation using variable argument context
vsprintf_P	Write code string formatted text to a string using variable argument context
Copying functions	
memcpy_P	Copy code memory to data memory
strcat_P	Concatenate a code string to a data string
strcpy_P	Copy code string to data string
strncpy_P	Copy code string to data string up to a maximum length
Formatted input functions	
scanf_P	Read code string formatted text from standard input
sscanf_P	Read code string formatted text from code string
vscanf_P	Read code string formatted text from standard using variable argument context
vsscanf_P	Read code string formatted text from a string using variable argument context
Character and string I/O functions	
puts_P	Write a code string to standard output
Comparison functions	
memcmp_P	Compare code memory with data memory
strcmp_P	Compare a code string to a data string
strncmp_P	Compare a code string to a data string up to a maximum length

memcmp_P

Synopsis

```
#define memcmp_P memcmp_c
```

Description

see [memcmp](#)

memcpy_P

Synopsis

```
#define memcpy_P memcpy_c
```

Description

see [memcpy](#)

printf_P

Synopsis

```
#define printf_P printf_c
```

Description

See [printf](#)

puts_P

Synopsis

```
#define puts_P puts_c
```

Description

See [puts](#)

scanf_P

Synopsis

```
#define scanf_P scanf_c
```

Description

See [scanf](#)

snprintf_P

Synopsis

```
#define snprintf_P snprintf_c
```

Description

See [snprintf](#)

sprintf_P

Synopsis

```
#define sprintf_P sprintf_c
```

Description

See [sprintf](#)

sscanf_P

Synopsis

```
#define sscanf_P sscanf_c
```

Description

See [sscanf](#)

strcat_P

Synopsis

```
#define strcat_P strcat_c
```

Description

see [strcat](#)

strcmp_P

Synopsis

```
#define strcmp_P strcmp_c
```

Description

see [strcmp](#)

strcpy_P

Synopsis

```
#define strcpy_P strcpy_c
```

Description

see [strcpy](#)

strlen_P

Synopsis

```
#define strlen_P strlen_c
```

Description

see [strlen](#)

strncmp_P

Synopsis

```
#define strncmp_P strncmp_c
```

Description

see [strncmp](#)

strncpy_P

Synopsis

```
#define strncpy_P strncpy_c
```

Description

see [strncpy](#)

vprintf_P

Synopsis

```
#define vprintf_P vprintf_c
```

Description

See [vprintf](#)

vscanf_P

Synopsis

```
#define vscanf_P vscanf_c
```

Description

See [vscanf](#)

vsnprintf_P

Synopsis

```
#define vsnprintf_P vsnprintf_c
```

Description

See [vsnprintf](#)

vsprintf_P

Synopsis

```
#define vsprintf_P vsprintf_c
```

Description

See [vsprintf](#)

vsscanf_P

Synopsis

```
#define vsscanf_P vsscanf_c
```

Description

See [vsscanf](#)

<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
wchar_t	Wide character 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 __PTRDIFF_T ptrdiff_t;
```

Description

ptrdiff_t is the signed integral type of the result of subtracting two pointers.

size_t

Synopsis

```
typedef __SIZE_T size_t;
```

Description

size_t is the unsigned integral type returned by the sizeof operator.

wchar_t

Synopsis

```
typedef unsigned wchar_t;
```

Description

wchar_t holds a single wide character.

<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 CrossWorks 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 CrossWorks 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 CrossWorks 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 dddd 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 CrossWorks 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±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 CrossWorks 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 CrossWorks 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*sizeof(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 `l`, `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 CrossWorks 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 CrossWorks 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 CrossWorks 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 **Scanf 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 CrossWorks 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**–1st 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**–1st 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**.

<stdio_c.h>

API Summary

Character and string I/O functions	
puts_c	Write a code string to standard output
Formatted output functions	
printf_c	Write code string formatted text to standard output
snprintf_c	Write code string formatted text to a string with truncation
sprintf_c	Write code string formatted text to a string
vprintf_c	Write code string formatted text to standard output using variable argument context
vsnprintf_c	Write code string formatted text to a string with truncation using variable argument context
vsprintf_c	Write code string formatted text to a string using variable argument context
Formatted input functions	
scanf_c	Read code string formatted text from standard input
sscanf_c	Read code string formatted text from code string
vscanf_c	Read code string formatted text from standard using variable argument context
vsscanf_c	Read code string formatted text from a string using variable argument context

printf_c

Synopsis

```
int printf_c(const __code char *format,  
            ...);
```

Description

See [printf](#)

puts_c

Synopsis

```
int puts_c(const __code char *s);
```

Description

See [puts](#)

scanf_c

Synopsis

```
int scanf_c(const __code char *format,  
            ...);
```

Description

See [scanf](#)

snprintf_c

Synopsis

```
int snprintf_c(char *s,  
               size_t n,  
               const __code char *format,  
               ...);
```

Description

See [snprintf](#)

sprintf_c

Synopsis

```
int sprintf_c(char *s,  
              const __code char *format,  
              ...);
```

Description

See [sprintf](#)

sscanf_c

Synopsis

```
int sscanf_c(const char *s,  
             const __code char *format,  
             ...);
```

Description

See [sscanf](#)

vprintf_c

Synopsis

```
int vprintf_c(const __code char *format,  
              __va_list arg);
```

Description

See [vprintf](#)

vscanf_c

Synopsis

```
int vscanf_c(const __code char *format,  
             __va_list arg);
```

Description

See [vscanf](#)

vsnprintf_c

Synopsis

```
int vsnprintf_c(char *s,  
                size_t n,  
                const __code char *format,  
                __va_list arg);
```

Description

See [vsnprintf](#)

vsprintf_c

Synopsis

```
int vsprintf_c(char *s,  
               const __code char *format,  
               __va_list arg);
```

Description

See [vsprintf](#)

vsscanf_c

Synopsis

```
int vsscanf_c(const char *s,  
              const __code char *format,  
              __va_list arg);
```

Description

See [vsscanf](#)

<stdlib.h>

API Summary

Macros	
EXIT_FAILURE	EXIT_FAILURE
EXIT_SUCCESS	EXIT_SUCCESS
RAND_MAX	RAND_MAX
Integer arithmetic functions	
abs	Return an integer absolute value
div	Divide two ints returning quotient and remainder
labs	Return a long integer absolute value
ldiv	Divide two longs returning quotient and remainder
llabs	Return a long long integer absolute value
lldiv	Divide two long longs returning quotient and remainder
Memory allocation functions	
calloc	Allocate space for an array of objects and initialize them to zero
free	Frees allocated memory for reuse
malloc	Allocate space for a single object
realloc	Resizes allocated memory space or allocates memory space
String to number conversions	
atof	Convert string to double
atoi	Convert string to int
atol	Convert string to long
atoll	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
lltoa	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
Types	
div_t	Structure containing quotient and remainder after division of an int
ldiv_t	Structure containing quotient and remainder after division of a long
lldiv_t	Structure containing quotient and remainder after division of a long long

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.

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](#)

lldiv_t

Description

`lldiv_t` stores the quotient and remainder returned by [lldiv](#).

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](#)

ltoa

Synopsis

```
char *ltoa(long val,  
            char *buf,  
            int radix);
```

Description

ltoa converts **val** to a string in base **radix** and places the result in **buf**.

ltoa 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.

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** algorithm. 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 **malloc** 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](#) or 'ref rand_max

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 strtof(const char *nptr,  
            char **endptr);
```

Description

strtof converts the initial portion of the string pointed to by **nptr** to a **double** representation.

First, **strtof** 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. **strtof** 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.

strtof 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>

API Summary

Copying functions	
memccpy	Copy memory with specified terminator (POSIX extension)
memcpy	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)
strncpy	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

memcpy

Synopsis

```
void *memcpy(void *s1,  
             const void *s2,  
             int c,  
             size_t n);
```

Description

memcpy 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 **memcpy** is undefined if copying takes place between objects that overlap.

memcpy 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

memcpy 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**.

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**.

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 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.

strdup

Synopsis

```
char *strdup(const char *s1);
```

Description

strdup 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. **strdup** 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

strdup 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.

strncpy

Synopsis

```
size_t strncpy(char *s1,  
               const char *s2,  
               size_t n);
```

Description

strncpy 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 **strncpy** is undefined if copying takes place between objects that overlap.

strncpy returns the number of characters it tried to copy, which is the length of the string **s2** or **n**, whichever is smaller.

Note

strncpy 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.

strncmp

Synopsis

```
int strncmp(const char *s1,  
            const char *s2,  
            size_t n);
```

Description

strncmp 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.

strncmp 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 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](#).

<string_c.h>

API Summary

Copying functions	
memcpy_c	Copy code memory to data memory
strcat_c	Concatenate a code string to a data string
strcpy_c	Copy code string to data string
strncpy_c	Copy code string to data string up to a maximum length
Comparison functions	
memcmp_c	Compare code memory with data memory
strcmp_c	Compare a code string to a data string
strncmp_c	Compare a code string to a data string up to a maximum length
Miscellaneous functions	
strlen_c	Calculate length of a code string

memcmp_c

Synopsis

```
int memcmp_c(const void *s1,  
             const __code void *s2,  
             size_t n);
```

Description

see [memcmp](#)

memcpy_c

Synopsis

```
void *memcpy_c(void *s1,  
               const __code void *s2,  
               size_t n);
```

Description

see [memcpy](#)

strcat_c

Synopsis

```
char *strcat_c(char *s1,  
               const __code char *s2);
```

Description

see [strcat](#)

strcmp_c

Synopsis

```
int strcmp_c(const char *s1,  
             const __code char *s2);
```

Description

see [strcmp](#)

strcpy_c

Synopsis

```
char *strcpy_c(char *s1,  
               const __code char *s2);
```

Description

see [strcpy](#)

strlen_c

Synopsis

```
size_t strlen_c(const __code char *s);
```

Description

see [strlen](#)

strncmp_c

Synopsis

```
int strncmp_c(const char *s1,  
              const __code char *s2,  
              size_t n);
```

Description

see [strncmp](#)

strncpy_c

Synopsis

```
char *strncpy_c(char *s1,  
                const __code char *s,  
                size_t n);
```

Description

see [strncpy](#)

<time.h>

API Summary

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
Types	
clock_t	Clock type
time_t	Time type
tm	Time structure

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, this function 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**.

mktime

Synopsis

```
time_t mktime(tm *tp);
```

Description

mktime 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_m_day**, **tm_mon** and **tm_year** fields are consistent. The validated ***tp** struct is converted to the number of seconds since UTC 1/1/70 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
%	Abbreviated weekday name
%A	Full weekday name
%b	Abbreviated month name
%B	Full month name
%c	Date and time representation appropriate for locale
%#c	Long date and time representation appropriate for locale
%d	Day of month [01,31]
%#d	Day of month without leading zero [1,31]
%H	Hour in 24-hour format [00,23]
%#H	Hour in 24-hour format without leading zeros [0,23]
%I	Hour in 12-hour format [01,12]
%#I	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]
%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]
%#p	Locale's a.m or p.m indicator
%S	Second as a decimal number [00,59]

%#S	Second as a decimal number without leading zeros [0,59]
%U	Week number as a decimal number [00,53], Sunday is first day of the week
%#U	Week number 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]
%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 1/1/70, negative values indicate time before UTC 1/1/70.

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
Copying functions	
wcscat	Concatenate strings
wcscpy	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
wcpbrk	Find first occurrence of characters within string
wcsrchr	Find last occurrence of character within string
wcssp	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
Types	
wchar_t	Wide character type
wint_t	Wide integer type

WCHAR_MAX

Synopsis

```
#define WCHAR_MAX 2147483647
```

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 0
```

Description

WCHAR_MIN is the minimum value for an object of type **wchar_t**.

WEOF

Synopsis

```
#define WEOF ((wint_t)0xFFFFFFFF)
```

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.

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.

wcssp

Synopsis

```
size_t wcssp(const wchar_t *s1,  
             const wchar_t *s2);
```

Description

wcssp 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**.

wcssp 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](#).

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 wmemcmp(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.



Tasking Library User Guide

This document describes the *CrossWorks Tasking Library* (CTL). The tasking (aka *multitasking*) library provides a multi-priority, preemptive, task switching and synchronization facility. Additionally, it supports a timer, interrupt service routines, and memory-block allocation.

This document is divided into three parts:

- *A whistle-stop tour of the tasking library* introduces the key concepts.
- *Putting the tasking library to use* looks in-depth at the tasking library and how to use it in your applications.
- *Reference information* is a concise reference for each function provided in the tasking library.

Overview

The tasking library enables your application to employ multiple tasks. Tasks are typically used for processing that may suspend execution while other activities occur. For example, you may have a protocol-processing task, a user-interface task, and a data-acquisition task.

Each task has its own *task stack*, which is used to store local variables and function-return information. The task stack is also used to store the CPU execution context when the task isn't executing. The CPU execution context of a task varies between machine architectures; it is typically the subset of the CPU register values that enable a task to be descheduled at any point during its execution.

The process of changing the CPU registers from one task to another is termed *taskswitching*. Task switching occurs when a CTL function is called, either from a task or from an interrupt service routine (ISR), and there is a runnable task with higher priority than the executing task. Task switching also occurs when there is a runnable task of the same priority as the executing task, if the executing task has exceeded its time-slice period. If you have more than one runnable task of the same priority, the next task (modulo priority) after the executing task is selected. This is sometimes called *round-robin scheduling*.

There is a single task list and it is kept in priority-sorted order. The task list is updated when tasks are created and deleted, and when their priority changes. The task list is traversed when a CTL function is called that could change the execution state of a task. While the task list is modified or traversed, global interrupts are disabled. Consequently, the length of the interrupt-disable period depends on the number of tasks in the task list, and the priority and type of the task affected by the CTL operation.

If you require a simple, deterministic (sometimes called *real-time*) system, you should ensure that each task has a unique priority. The task switching will always select the highest-priority task that is runnable.

CTL has a pointer to the executing task. There must always be a task executing; if there isn't, a CTL error is signaled. Typically, there will be an idle task that loops and, perhaps, puts the CPU into power-saving mode.

Global interrupts will be enabled when a task switch occurs, so you can safely call tasking library functions while interrupts are disabled.

Task synchronization and resource allocation

The CTL provides several mechanisms to synchronize execution of tasks, to serialize resource access, and to provide high-level communication.

- *Event Sets*: An event set is a word-sized variable, and tasks can wait for its specific bits (representing events) to be set to 1. Events can be used for synchronization and to serialize resource access. Events can be set by interrupt service routines.
- *Semaphores*: A semaphore is a word size variable which tasks can wait for to be non-zero. Semaphores can be used for synchronization and to serialize resource access. Semaphores can be signaled by interrupt service routines.

- *Mutexes*: A mutex is a structure that can be used to serialize resource access. Unlike semaphores, mutexes cannot be used by interrupt service routines, but do provide extra features that make mutexes preferable to semaphores for serializing resource access.
- *Message Queues*: A message queue is a structure that enables tasks to post and receive data. Message queues are used to provide a buffered communication mechanism. Messages can be sent by interrupt service routines.
- *Byte Queues*: A byte queue is a specialization of a message queue; i.e., it is a message queue in which the messages are one byte in size. Byte queues can be sent by interrupt service routines.
- *Interrupt Enable and Disable*: The tasking library provides functions that enable and disable the processor's global interrupts. These functions can be used to provide a time-critical, mutual-exclusion facility.

Note that all task synchronization is priority based, i.e., the highest-priority task that is waiting will be scheduled first.

Timer support

If your application can provide a periodic timer interrupt, you can use the timer facility of the CTL. This facility enables time slicing of equal-priority tasks, allows tasks to delay, and provides a timeout capability when waiting for something. The timer is a software counter that is incremented by your timer interrupt. The counter is typically a millisecond counter, but you can change the timer's increment to reduce the interrupt frequency.

Memory allocation support

The CTL provides a simple memory block allocator that can be used in situations for which the standard C **malloc** and **free** functions are either too slow or may block the calling task.

C library support

The CTL provides the functions required of the CrossWorks C library for multi-threading.

Tasks

Each task has a corresponding task structure that contains the following information:

- When the task isn't executing, a pointer to the stack containing the execution context.
- The priority of the task; the lowest priority is 0, the highest is 255.
- The state of the task, runnable or waiting.
- A pointer to the next task.
- If the task is waiting for something, the details of what it is waiting for.
- Thread-specific data such as **errno**.
- A pointer to a null-terminated string that names the task for debugging purposes.

Creating a task

You allocate task structures by declaring them as C variables.

```
CTL_TASK_t mainTask;
```

You create the first task by using **ctl_task_init** to turn the main program into a task. This function takes a pointer to the task structure that represents the main task, its priority, and a name as parameters.

```
ctl_task_init(&mainTask, 255, "main");
```

This function must be called before any other CrossWorks tasking library calls. The priority (second parameter) must be between 0 (the lowest priority) and 255 (the highest priority). It is advisable to create the first task with the highest priority, which enables it to create other tasks without being descheduled. The name should point to a zero-terminated ASCII string, which is shown in the **Threads** window.

You can create other tasks with the function **ctl_task_run**, which initializes a task structure and may cause a context switch. You supply the same arguments as for **ctl_task_init**, together with the function the task will run and the memory the task will use for its stack.

The function a task will run should take a **void *** parameter and not return any value.

```
void task1Fn(void *parameter)
{
    // task code goes in here
}
```

The **parameter** value is supplied to the function by the **ctl_task_run** call. Note that, when a task function returns, the **ctl_task_die** function is called, terminating the task.

You must allocate the stack for the task as a C array of **unsigned** elements.

```
unsigned task1Stack[64];
```

The stack size you need depends on the CPU (i.e., the number of registers that must be saved), the function calls the task will make, and (again depending on the CPU) the stack used for interrupt service routines. Running out of stack space is a common problem for multitasking systems, and the resulting error behavior is often misleading. Recommended practice is to initialize the stack to known values—that will make it easier to check the stack's contents with the CrossWorks debugger if problems should occur.

```
memset(task1Stack, 0xba, sizeof(task1Stack));
```

Your **ctl_task_run** function call should look something like this:

```
ctl_task_run(&task1Task,
            12,
            task1Fn,
            0,
            "task1",
            sizeof(task1Stack) / sizeof(unsigned),
            task1Stack,
            0);
```

The first parameter is a pointer to the task structure. The second parameter is the priority (in this case 12) at which the task will start executing. The third parameter is a pointer to the function to execute (in this case **task1Fn**). The fourth parameter is the value supplied to the task function (zero, in this case). The fifth parameter is a null-terminated string that names the task for debug purposes. The sixth parameter is the size of the stack, in words. The seventh parameter is the pointer to the stack. The last parameter is for systems that have a separate *call stack*, and its value is the number of words to reserve for that stack.

Changing a task's priority

You can change the priority of a task using **ctl_task_set_priority**. It takes a pointer to a task structure and the new priority as parameters, and returns the old priority.

```
old_priority = ctl_task_set_priority(&mainTask, 255); // lock scheduler
//
// ... your critical code here
//
ctl_task_set_priority(old_priority);
```

To enable time slicing, you need to set the **ctl_timeslice_period** variable before any task scheduling occurs.

```
ctl_timeslice_period = 100; // time slice period of 100 ms
```

If you want finer control over the scheduling of tasks, you can call **ctl_task_reschedule**. The following example turns **main** into a task and creates a second task. The main task ultimately will be the lowest-priority task that switches the CPU into a power-saving mode when it is scheduled—this satisfies the requirement of always having a task to execute and enables a simple, power-saving system to be implemented.

```
#include <ctl.h>
```

```
void task1(void *p)
{
    // task code; on return, the task will be terminated.
}

static CTL_TASK_t mainTask, task1Task;
static unsigned task1Stack[64];

int main(void)
{
    // Turn myself into a task running at the highest priority.
    ctl_task_init(&mainTask, 255, "main");

    // Initialize the stack of task1.
    memset(task1Stack, 0xba, sizeof(task1Stack));

    // Prepare another task to run.
    ctl_task_run(&task1Task, 1, task1, 0, "task1",
                sizeof(task1Stack) / sizeof(unsigned),
                task1Stack, 0);

    // Now that all the tasks have been created, go to the lowest priority task.
    ctl_task_set_priority(&mainTask, 0);

    // Main task, if activated because task1 is suspended, just
    // enters low-power mode and waits for task1 to run again
    // (for example, because an interrupt wakes it).
    for (;;)
    {
        // Go into low-power mode.
        sleep();
    }
}
```

Note that, initially, the main task is assigned the highest priority while it creates the other tasks; then it changes its priority to the lowest value. This technique can be used, when multiple tasks are to be created, to ensure all the tasks are created before they start to execute.

Note the use of **sizeof** when passing the stack size to **ctl_task_run**.

Event sets

Event sets are a versatile way to communicate between tasks, manage resource allocation, and synchronize tasks.

An event set is a means to synchronize tasks with other tasks and with interrupt service routines. An event set contains a set of events (one per bit), and tasks can wait for one or more of these bits to be set (i.e., to have the value 1). When a task waits on an event set, the events it is waiting for are matched against the current values—if they match, the task can still execute. If they don't match, the task is put on the task list with details about the event set and the events for which the task is waiting.

You allocate an event set by declaring it as C variable:

```
CTL_EVENT_SET_t e1;
```

A **CTL_EVENT_SET_t** is a synonym for an **unsigned** type. Thus, when an **unsigned** is 16 bits wide, an event set will contain 16 events; and when it consists of 32 bits, an event set will contain 32 events.

An event set must be initialized before any tasks can use it. To initialize an event set, use **ctl_events_init**:

```
ctl_events_init(&e1, 0);
```

You can set and clear events in an event set using the **ctl_events_set_clear** function.

```
ctl_events_set_clear(&e1, 1<<0, 1<<15);
```

This example will set the bit-zero event and clear the bit-15 event. If any tasks are waiting on this event set, the events they are waiting on will be matched against the new event set value, which could cause the task to become runnable.

You can wait for events to be set using **ctl_events_wait**. You can wait for any of the events in an event set to be set (**CTL_EVENT_WAIT_ANY_EVENTS**) or all of the events to be set (**CTL_EVENT_WAIT_ALL_EVENTS**). You can also specify that when events have been set and have been matched that they should be automatically reset (**CTL_EVENT_WAIT_ANY_EVENTS_WITH_AUTO_CLEAR** and **CTL_EVENT_WAIT_ALL_EVENTS_WITH_AUTO_CLEAR**). You can associate a timeout with a wait for an event set to stop your application blocking indefinitely.

```
ctl_events_wait(CTL_EVENT_WAIT_ANY_EVENTS,  
               &e1, 1<<15,  
               CTL_TIMEOUT_NONE, 0);
```

This example waits for bit 15 of the event set pointed to by **e1** to become set.

```
if (ctl_events_wait(CTL_EVENT_WAIT_ANY_EVENTS,  
                  &e1, 1<<15,  
                  CTL_TIMEOUT_DELAY, 1000) == 0)  
{  
    // ...timeout occurred
```

```
}
```

This example uses a timeout and tests the return result to see if the timeout occurred.

You can use **ctl_events_pulse** to set and immediately clear events. A typical use for this would be to wake up multiple threads and reset the events atomically.

Synchronizing with an ISR

The following example illustrates synchronizing a task with a function called from an ISR.

```
CTL_EVENT_SET_t e1;
CTL_TASK_s t1;

void ISRfn()
{
    // ...do work, and then...
    ctl_events_set_clear(&e1, 1<<0, 0);
}

void task1(void *p)
{
    for (;;)
    {
        ctl_events_wait(CTL_EVENT_WAIT_ANY_EVENTS,
                        &e1, 1<<0,
                        CTL_TIMEOUT_NONE, 0);

        //
        // ...do whatever needs to be done...
        //
        ctl_events_set_clear(&e1, 0, 1<<0);
    }
}
```

Synchronizing with more than one ISR

The following example illustrates synchronizing a task with functions called from two interrupt service routines.

```
CTL_EVENT_SET_t e1;
CTL_TASK_s t1;

void ISRfn1(void)
{
    // do work, and then...
    ctl_events_set_clear(&e1, 1<<0, 0);
}

void ISRfn2(void)
{
    // do work, and then...
    ctl_events_set_clear(&e1, 1<<1, 0);
}
```

```

void task1(void *p)
{
    for (;;)
    {
        unsigned e;
        e = ctl_events_wait(CTL_EVENT_WAIT_ANY_EVENTS_WITH_AUTO_CLEAR,
                           &e1, (1<<0) | (1<<1),
                           CTL_TIMEOUT_NONE, 0);

        if (e & (1<<0))
        {
            // ISRfn1 completed
        }
        else if (e & (1<<1))
        {
            // ISRfn2 completed
        }
        else
        {
            // error
        }
    }
}

```

Resource serialization with an event set

The following example illustrates resource serialization of two tasks.

```

CTL_EVENT_SET_t e1;

void task1(void)
{
    for (;;)
    {
        // Acquire resource.
        ctl_events_wait(CTL_EVENT_WAIT_ANY_EVENTS_WITH_AUTO_CLEAR,
                       &e1, 1<<0,
                       CTL_TIMEOUT_NONE, 0);
        // Resource is now been acquired.

        ?

        // Release acquired resource.
        ctl_events_set_clear(&e1, 1<<0, 0);
        // Resource is now released.
    }
}

void task2(void)
{
    for (;;)
    {
        // Acquire resource.
        ctl_events_wait(CTL_EVENT_WAIT_ANY_EVENTS_WITH_AUTO_CLEAR,
                       &e1, 1<<0,
                       CTL_TIMEOUT_NONE, 0);
        // Resource is now acquired.

        ?
    }
}

```

```
        // Release acquired resource.  
        ctl_events_set_clear(&e1, 1<<0, 0);  
        // Resource is now been released.  
    }  
}  
  
void main(void)  
{  
    // Initialize event set.  
    ctl_events_init(&e1, 1<<0);  
    // Create tasks and let them run.  
}
```

Note that **e1** is initialized with the event set; without this, neither task would acquire the resource.

Semaphores

CTL provides *semaphores* to use for synchronization and resource allocation.

A semaphore is a counter which tasks can wait for to be non-zero. When a semaphore is non-zero and a task waits on it, the semaphore value is decremented and the task continues executing. When a semaphore is zero and a task waits on it, the task will be suspended until the semaphore is signaled. When a semaphore is signaled and no tasks are waiting for it, the semaphore's value is incremented. When a semaphore is signaled and tasks are waiting, one of the tasks is made runnable.

You allocate a semaphore by declaring it as a C variable. For example:

```
CTL_SEMAPHORE_t s1;
```

A **CTL_SEMAPHORE_t** is a synonym for an **unsigned** type, so the maximum value of the counter is dependent upon the word size of the processor (16 or 32 bits).

A semaphore must be initialized before any tasks can use it. To initialize a semaphore, use **ctl_semaphore_init**:

```
ctl_semaphore_init(&s1, 1);
```

To signal a semaphore, use **ctl_semaphore_signal**:

```
ctl_semaphore_signal(&s1);
```

The highest-priority task waiting on the semaphore pointed at by **s1** will be made runnable by this call. If no tasks are waiting on the semaphore, the semaphore's value is incremented.

To wait for a semaphore with an optional timeout, use **ctl_semaphore_wait**:

```
ctl_semaphore_wait(&s1, CTL_TIMEOUT_NONE, 0);
```

This example will block the task if the semaphore is zero, otherwise it will decrement the semaphore and execution will continue.

```
if (ctl_semaphore_wait(&s1, CTL_TIMEOUT_ABSOLUTE, ctl_get_current_time()+1000) == 0)
{
    // ...timeout occurred
}
```

This example uses a timeout and tests the return result to see if the timeout occurred.

Task synchronization in an interrupt service routine

The following example illustrates synchronizing a task with a function called from an interrupt service routine.

```
CTL_SEMAPHORE_t s1;

void ISRfn()
```

```
{
    // Detected something, signal the waiting task.
    ctl_semaphore_signal(&s1);
}

void task1(void *p)
{
    for (;;)
    {
        // Wait for ISR to signal that an event happened.
        ctl_semaphore_wait(&s1, CTL_TIMEOUT_NONE, 0);
        // Deal with the event.
    }
}
```

Resource serialization with semaphore

The following example illustrates resource serialization of two tasks:

```
CTL_SEMAPHORE_t s1 = 1;

void task1(void)
{
    for (;;)
    {
        // Wait for resource.
        ctl_semaphore_wait(&s1, CTL_TIMEOUT_NONE, 0);
        // Resource has now been acquired, do something with it.

        ?

        // And now release it...
        ctl_semaphore_signal(&s1);
        // Resource is now released.
    }
}

void task2(void)
{
    for (;;)
    {
        ctl_semaphore_wait(&s1, CTL_TIMEOUT_NONE, 0);
        // Resource has now been acquired, do something with it.

        ?

        // And now release it...
        ctl_semaphore_signal(&s1);
        // Resource has now been released.
    }
}

int main(void)
{
    // Initialize semaphore.
    ctl_semaphore_init(&s1, 1);
}
```

Note that **s1** is initialized to one; without this, neither task would acquire the resource.

Mutexes

A mutex is a structure that can be used to serialize resource access. Tasks can lock and unlock mutexes. Each mutex has a *lock count* that enables a task to recursively lock the mutex. Tasks must ensure that the number of unlocks matches the number of locks. When a mutex has already been locked by another task, a task that wants to lock it must wait until the mutex becomes unlocked. The task that locks a mutex is assigned a higher priority than any other tasks waiting to lock that mutex; this avoids what is often called *priority inversion*, which can prevent some tasks from ever getting access to a required resource. Mutexes cannot be used by interrupt service routines.

You allocate a mutex by declaring it as a C variable. For example:

```
CTL_MUTEX_t mutex;
```

A mutex must be initialized before any task can use it. To initialize a mutex, use **ctl_mutex_init** as in this example:

```
ctl_mutex_init(&mutex);
```

You can lock a mutex with an optional timeout by using **ctl_mutex_lock**:

```
ctl_mutex_lock(&mutex, CTL_TIMEOUT_NONE, 0);
```

You can unlock a mutex by using **ctl_mutex_unlock**:

```
ctl_mutex_unlock(&mutex);
```

Note: Only the locking task must unlock a successfully-locked mutex.

Resource serialization with mutex

The following example illustrates resource serialization of two tasks.

```
CTL_MUTEX_t mutex;

void fn1(void)
{
    ctl_lock_mutex(&mutex, CTL_TIMEOUT_NONE, 0);
    ?
    ctl_unlock_mutex(&mutex);
}

void fn2(void)
{
    ctl_lock_mutex(&mutex, CTL_TIMEOUT_NONE, 0);
    ?
    fn1();
    ?
    ctl_unlock_mutex(&mutex);
}
```

```
}

void task1(void)
{
    for (;;)
    {
        fn2()
    }
}

void task2(void)
{
    for (;;)
    {
        fn1();
    }
}

int main(void)
{
    ?
    ctl_mutex_init(&mutex);
    ?
}
```

Note that **task1** locks the mutex twice by calling **fn2** which then calls **fn1**.

Message queues

Message queues provide buffers between tasks and interrupt service routines.

A *message queue* is a structure that enables tasks to post and receive messages. A *message* is a generic (void) pointer and, as such, can be used to send data that will fit into a pointer type (two or four bytes, depending upon the processor's word size) or to pass a pointer to a block of memory. The message queue uses a buffer to enable a number of posts to be completed without receives occurring. The buffer keeps the posted messages in FIFO order, so the oldest message is received first. When the buffer isn't full, a post will put the message at the back of the queue and the calling task continues execution. When the buffer is full, a post will block the calling task until there is room for the message. When the buffer isn't empty, a receive will return the message from the front of the queue and continue execution of the calling task. When the buffer is empty, a receive will block the calling task until a message is posted.

Initializing a message queue

You allocate a message queue by declaring it as a C variable:

```
CTL_MESSAGE_QUEUE_t m1;
```

A message queue is initialized using `ctl_message_queue_init`:

```
void *queue[20];  
?  
ctl_message_queue_init(&m1, queue, 20);
```

This example uses a 20-element array for the message queue. The array is a **void *** so pointers to memory or (cast) integers can be communicated via a message queue.

Posting to a message queue

You can post a message to a message queue with an optional timeout by using the `ctl_message_queue_post` function.

```
ctl_message_queue_post(&m1, (void *)45, CTL_TIMEOUT_NONE, 0);
```

This example posts the integer 45 to the message queue.

You can post multiple messages to a message queue with an optional timeout using `ctl_message_queue_post_multi`:

```
if (ctl_message_queue_post_multi(&m1, 4, messages, CTL_TIMEOUT_ABSOLUTE,  
    ctl_get_current_time()+1000) != 4)  
{  
    // timeout occurred  
}
```

This example tests the return result to see if the timeout occurred.

If you want to post a message and you cannot afford to block (e.g. inside an interrupt service routine), you can use **ctl_message_queue_post_nb** (or **ctl_message_queue_post_multi_nb** if you want to post multiple messages):

```
if (ctl_message_queue_post_nb(&m1, (void *)45) == 0)
{
    // queue is full
}
```

This example tests the return result to see if the post failed.

Receiving from a message queue

You can use **ctl_message_queue_receive** to receive a message with an optional timeout:

```
void *msg;
ctl_message_queue_receive(&m1, &msg, CTL_TIMEOUT_NONE, 0);
```

This example receives the oldest message in the message queue.

Use **ctl_message_queue_receive_multi** to receive multiple messages from a message queue with an optional timeout:

```
if (ctl_message_queue_multi_receive(&m1, 4, msgs, CTL_TIMEOUT_DELAY, 1000) != 4)
{
    // timeout occurred
}
```

This example tests the return result to see if the timeout occurred.

If you want to receive a message and you don't want to block (e.g., when executing interrupt service routine), you can use **ctl_message_queue_receive_nb** (or **ctl_message_queue_receive_multi_nb** to receive multiple messages).

```
if (ctl_message_queue_receive_nb(&m1, &msg) == 0)
{
    // queue is empty
}
```

Producer-consumer example

The following example uses a message queue to implement the producer-consumer problem.

```
CTL_MESSAGE_QUEUE_t m1;
void *queue[20];

void task1(void)
{
    ?
    ctl_message_queue_post(&m1, (void *)i, CTL_TIMEOUT_NONE, 0);
}
```

```

    ?
}

void task2(void)
{
    void *msg;
    ?
    ctl_message_queue_receive(&m1, &msg, CTL_TIMEOUT_NONE, 0);
    ?
}

int main(void)
{
    ?
    ctl_message_queue_init(&m1, queue, 20);
    ?
}

```

Advanced use

You can associate event flags with a message queue that are set (and similarly cleared) when the message queue is not full and not empty using the function **ctl_message_queue_setup_events**.

For example, you can use this to wait for messages to arrive from multiple message (or byte) queues:

```

CTL_MESSAGE_QUEUE_t m1, m2;
CTL_EVENT_SET_t e;
ctl_message_queue_setup_events(&m1, &e, 1<<0, 1<<1));
ctl_message_queue_setup_events(&m2, &e, 1<<2, 1<<3));
?
switch (ctl_events_wait(CTL_EVENT_WAIT_ANY_EVENTS,
                        &e, (1<<0) | (1<<2),
                        CTL_TIMEOUT_NONE, 0))
{
    case 1<<0:
        ctl_message_queue_receive(&m1, ...
        break;
    case 1<<2:
        ctl_message_queue_receive(&m2, ...
        break;
}

```

This example sets up and waits for the not-empty event of message queue **m1** and the not-empty event of message queue **m2**. When the wait completes, it reads from the appropriate message queue. Note that you *should not* use a ‘with auto clear’ event wait type when waiting for events associated with a message queue.

You can use **ctl_message_queue_num_used** to test how many messages are in a message queue and **ctl_message_queue_num_free** to learn how many free messages are in a message queue. With these functions you can poll the message queue:

```

while (ctl_message_queue_num_free(&m1) < 10)
    ctl_task_timeout_wait(ctl_get_current_time() + 1000);
ctl_message_queue_post_multi(&m1, 10, ...

```

This example waits for 10 elements to be free before it posts 10 elements.

Byte queues

Byte queues provide byte-based buffers between tasks and interrupt service routines.

A *byte queue* is a structure that enables tasks to post and receive data bytes. The byte queue has a buffer, which enables a number of posts to be completed without receives occurring. The buffer keeps the posted bytes in FIFO order, so the oldest byte is received first. When the buffer isn't full, a post will put the byte at the back of the queue and the calling task continues execution. When the buffer is full, a post will block the calling task until there is room for the byte. When the buffer isn't empty, a receive will return the byte from the front of the queue and continue execution of the calling task. When the buffer is empty, a receive will block the calling task until a byte is posted.

Initializing a byte queue

You allocate a byte queue by declaring it as a C variable:

```
CTL_BYTE_QUEUE_t m1;
```

A byte queue is initialized using **ctl_byte_queue_init**:

```
unsigned char queue[20];  
?  
ctl_byte_queue_init(&m1, queue, 20);
```

This example uses an 20-element array for the byte queue.

Posting to a byte queue

You can post a byte to a byte queue with an optional timeout using **ctl_byte_queue_post**:

```
ctl_byte_queue_post(&m1, 45, CTL_TIMEOUT_NONE, 0);
```

This example posts the byte 45 to the byte queue.

You can post multiple bytes to a byte queue with an optional timeout using **ctl_byte_queue_post_multi**:

```
if (ctl_byte_queue_post(&m1, 4, bytes, CTL_TIMEOUT_ABSOLUTE, ctl_get_current_time()+1000) !=  
4)  
{  
    // timeout occurred  
}
```

This example uses a timeout and tests the return result to see if the timeout occurred.

If you want to post a byte and you don't want to block access (e.g., from an interrupt service routine), you can use **ctl_byte_queue_post_nb** (or **ctl_byte_queue_post_multi_nb** to post multiple bytes).

```
if (ctl_byte_queue_post_nb(&m1, 45) == 0)
{
    // queue is full
}
```

This example tests the return result to see if the post failed.

Receiving from a byte queue

You can receive a byte with an optional timeout by using **ctl_byte_queue_receive**:

```
unsigned char msg;
ctl_byte_queue_receive(&m1, &msg, CTL_TIMEOUT_NONE, 0);
```

This example receives the oldest byte in the byte queue.

You can receive multiple bytes from a byte queue with an optional timeout using **ctl_byte_queue_receive_multi**:

```
if (ctl_byte_queue_receive_multi(&m1, 4, bytes, CTL_TIMEOUT_DELAY, 1000) != 4)
{
    // timeout occurred
}
```

This example tests the return result to see if the timeout occurred.

If you want to receive a byte and you don't want to block (e.g., from an interrupt service routine), you can use **ctl_byte_queue_receive_nb** (or **ctl_byte_queue_receive_multi_nb** to receive multiple bytes).

```
if (ctl_byte_queue_receive_nb(&m1, &msg) == 0)
{
    // queue is empty
}
```

Producer-consumer example

The following example uses a byte queue to implement the producer-consumer problem.

```
CTL_BYTE_QUEUE_t m1;
void *queue[20];

void task1(void)
{
    ?
    ctl_byte_queue_post(&m1, (void *)i, CTL_TIMEOUT_NONE, 0);
    ?
}

void task2(void)
{

```

```

void *msg;
?
ctl_byte_queue_receive(&m1, &msg, CTL_TIMEOUT_NONE, 0);
?
}

int main(void)
{
?
  ctl_byte_queue_init(&m1, queue, 20);
?
}

```

Advanced Use

You can associate event flags with a byte queue that are set (and similarly cleared) when the byte queue is not full and not empty using the function **ctl_byte_queue_setup_events**.

For example, you can use this to wait for messages to arrive from multiple byte (or message) queues.

```

CTL_BYTE_QUEUE_t m1, m2;
CTL_EVENT_SET_t e;
ctl_byte_queue_setup_events(&m1, &e, 1<<0, 1<<1);
ctl_byte_queue_setup_events(&m2, &e, 1<<2, 1<<3);
?
switch (ctl_events_wait(CTL_EVENT_WAIT_ANY_EVENTS,
                        &e, (1<<0) | (1<<2),
                        CTL_TIMEOUT_NONE, 0))
{
  case 1<<0:
    ctl_byte_queue_receive(&m1, ...
    break;
  case 1<<2:
    ctl_byte_queue_receive(&m2, ...
    break;
}

```

This example sets up and waits for the not-empty event of byte queue **m1** and the not-empty event of byte queue **m2**. When the wait completes, it reads from the appropriate byte queue. Note that you *must not* use a ‘with auto clear’ event wait type when waiting on events associated with a byte queue.

You can use **ctl_byte_queue_num_used** to test how many bytes are in a byte queue and **ctl_byte_queue_num_free** to learn how many free bytes are in a byte queue. With these functions, you can poll the byte queue:

```

while (ctl_byte_queue_num_free(&m1) < 10)
  ctl_task_timeout_wait(ctl_get_current_time()+1000);
ctl_byte_queue_post_multi(&m1, 10, ...

```

This example waits for 10 elements to be free before it posts 10 elements.

Timers and interrupts

This section deals with how CTL timers work.

Global interrupts control

CTL provides functions that enable and disable the global interrupt enables of the processor. CTL uses this mechanism when accessing the task list. It can also be used to provide a fast, mutual-exclusion facility for time-critical uses.

You can disable interrupts by using **ctl_global_interrupts_disable** and you can enable interrupts by using **ctl_global_interrupts_enable**.

If you don't know if interrupts are currently disabled, you can use **ctl_global_interrupts_set**. This will either disable or enable interrupts, depending on the parameter, and will return the previous interrupt-enable state:

```
int en = ctl_global_interrupts_set(0); // disable
?
if (en)
    ctl_global_interrupts_enable(); // set to previous state
```

You can call a tasking library function that causes a task switch with global interrupts disabled. The tasking library will ensure that, when the next task is scheduled, global interrupts are enabled.

Timer support

The current time is held as a 32-bit value in the variable **ctl_current_time**. This variable is incremented by the number held in **ctl_time_increment** each time an ISR calls **ctl_increment_tick_from_isr**.

```
void timerISR(void)
{
    ctl_increment_tick_from_isr();
    // Your timer code goes here.
}

int main(void)
{
    ctl_time_increment = 10;
    // User must set up timerISR to be called every 100 ms.
    ?
}
```

By convention, the timer implements a millisecond counter, but you can set the timer's interrupt-and-increment rate to a value that is appropriate for your application.

You can atomically read **ctl_current_time** by using the **ctl_get_current_time** function on systems whose word size is not 32 bits.

You can use **ctl_timeout_wait** to suspend execution of a task for a fixed period. Note: **ctl_timeout_wait** takes as its parameter the time to resume execution, not the duration: always call this function with **ctl_get_current_time()+duration**.

```
ctl_timeout_wait(ctl_get_current_time()+100);
```

This example suspends execution of the calling task for 100 ticks of the **ctl_current_time** variable.

The counter is implemented as a 32-bit number, so you can delay for a maximum of a 31-bit number.

```
ctl_timeout_wait(ctl_get_current_time() + 0x7fffffff);
```

This example suspends execution of the calling task for the maximum possible time.

Interrupt service routines

Interrupt service routines (ISR) can communicate with CTL tasks using a subset of the CTL programming interface. An ISR should not call any of the CTL functions that can block; if your ISR calls a blocking function, **ctl_handle_error** will be called. To detect whether a task or an ISR has called a function, CTL uses the global variable **ctl_interrupt_count**. Interrupt service routines must increment this variable on entry and decrement it on exit. Any CTL functions called by an ISR that require a task reschedule will set the variable **ctl_reschedule_on_last_isr_exit**.

On exit from an interrupt service routine, **ctl_interrupt_count** is decremented to zero and, if **ctl_reschedule_on_last_isr_exit** is set (after resetting **ctl_reschedule_on_last_isr_exit**), a CTL reschedule operation occurs. The support for writing ISRs differs, depending on the target. In general, on entry to an ISR the following is needed:

```
// ... preserve register state here
++ctl_interrupt_count;
```

...and, on exit from an ISR:

```
ctl_interrupt_count--;
if (ctl_interrupt_count == 0 && ctl_reschedule_on_last_isr_exit)
{
    ctl_reschedule_on_last_isr_exit = 0;
    // reschedule
}
else
{
    // ...restore register state here
}
```

Memory areas

Memory areas provide your application with dynamic allocation of fixed-sized memory blocks. Memory areas should be used in preference to the standard C library **malloc** and **free** functions if the calling task cannot block or if memory allocation is done by an ISR.

You allocate a memory area by declaring it as a C variable:

```
CTL_MEMORY_AREA_t m1;
```

Before using a memory area, you must initialize it using **ctl_memory_area_init**:

```
unsigned mem[20];
?
ctl_memory_area_init(&m1, mem, 2, 10);
```

This example uses a 20-element array for the memory area's working storage. The array is split into 10 blocks, each block being two words in size.

To allocate a block from a memory area, use **ctl_memory_area_allocate**. If the memory block cannot be allocated, zero is returned.

```
unsigned *block = ctl_memory_area_allocate(&m1);
if (block)
{
    // Block has been allocated.
}
else
{
    // No block has been allocated.
}
```

When you have finished with a memory block, use **ctl_memory_area_free** to return it to the memory area *from which it was allocated* so it can be reused:

```
ctl_memory_area_free(&m1, block);
```

You can associate an event flag with the *block available* state of a memory queue to wait for a memory block to become available:

```
CTL_MEMORY_AREA_t m0, m1, m2;
?
CTL_EVENT_SET_t e;
?
ctl_memory_area_setup_events(&m0, &e, 1<<0);
ctl_memory_area_setup_events(&m1, &e, 1<<1);
ctl_memory_area_setup_events(&m2, &e, 1<<2);
?
switch (ctl_events_wait(CTL_EVENT_WAIT_ANY_EVENTS,
                        &e, (1<<0)|(1<<1)|(1<<2),
                        0, 0))
{
```

```
case l<<0:
    x = ctl_memory_area_allocate(&m0, ...
    break;
case l<<1:
    x = ctl_memory_area_allocate(&m1, ...
    break;
case l<<2:
    x = ctl_memory_area_allocate(&m2, ...
    break;
}
```

This example sets up and waits for the block-available events of memory areas **m0**, **m1**, and **m2**. When the wait completes, it attempts to allocate memory from the appropriate memory area. Note that you should *not* use a *with-auto-clear* event wait type when waiting on events associated with a memory area.

Task scheduling example

An example task list could be:

- task1, priority 2, waiting
- task2, priority 1, runnable
- task3, priority 1, executing
- task4, priority 1, runnable
- task5, priority 0, runnable

task2 waits, so task3 is selected to execute:

- task1, priority 2, waiting
- task2, priority 1, waiting
- task3, priority 1, executing
- task4, priority 1, runnable
- task5, priority 0, runnable

An interrupt occurs that makes task1 runnable, which is higher priority than task3 so task1 executes:

- task1, priority 2, executing
- task2, priority 1, waiting
- task3, priority 1, runnable
- task4, priority 1, runnable
- task5, priority 0, runnable

task1 waits, causing task3 to execute:

- task1, priority 2, waiting
- task2, priority 1, waiting
- task3, priority 1, executing
- task4, priority 1, runnable
- task5, priority 0, runnable

An interrupt occurs and task3 has used its timeslice period, so task4 is selected to execute:

- task1, priority 2, waiting
- task2, priority 1, waiting
- task3, priority 1, runnable
- task4, priority 1, executing
- task5, priority 0, runnable

An interrupt occurs and makes task2 runnable, but task4 hasn't used its timeslice period, so it is left to execute:

- task1, priority 2, waiting
- task2, priority 1, runnable

- task3, priority 1, runnable
- task4, priority 1, executing
- task5, priority 0, runnable

A interrupt occurs and task4 has used its timeslice period:

- task1, priority 2, waiting
- task2, priority 1, executing
- task3, priority 1, runnable
- task4, priority 1, runnable
- task5, priority 0, runnable

AVR implementation details

Interrupt service routines

The AVR CrossWorks C compiler provides the `__ctl_interrupt` modifier that will generate the required code on entry and exit from the interrupt service routines. All you have to do is write your interrupt-handling code.

```
void basic_timer_irq(void) __ctl_interrupt[TIMER0_COMP_vect]
{
    // Do your interrupt handling here.
}
```

The ISR will run on a dedicated stacks which avoids having to allocate stack spaces for ISR's on each task stacks. You must specify the dedicated stack sizes using the linker symbols **CTL_IRQ_CALL_STACK_SIZE** and **CTL_IRQ_DATA_STACK_SIZE**. For example, using `CTL_IRQ_CALL_STACK_SIZE=64` will allocate 64 bytes for the ISR's call stack and `CTL_IRQ_DATA_STACK_SIZE=64` will allocate 64 bytes for the ISR's data stack.

CTL Revisions

CTL has been supplied with various 1.x releases of CrossWorks, and its revision history is available in the corresponding release notes—such releases are termed CTL V1. CTL is supplied in 2.x releases of CrossWorks and is termed CTL V2. This document explains the differences between CTL V1 and CTL V2.

Scheduling implementation

In CTL V1, the executing task was removed from the task list and then put back on when it was descheduled. In CTL V2, the executing task isn't moved from the task list. This change enables CTL to run on the Cortex-M3, results in smaller code with faster context switching, and reduces the interrupt-lockout period.

In CTL V1, rescheduling would happen on exit from the last nested interrupt service routine. In CTL V2, a reschedule only occurs on exit from the last nested interrupt service routine if the run state of a task has changed.

Mutexes

POSIX thread-style mutexes have been added.

Task restore

The new function `ctl_task_restore` allows tasks that have been removed from the task list (using `ctl_task_remove`) to be returned to the task list again.

Suspended task state

The new task state `suspended` has been added. It can be used instead of removing and restoring a task from the task list.

Thread-specific data pointer

The new member `data` has been added to the task structure. It can be used to store thread-specific data.

Task execution time

The new global variable `ctl_last_schedule_time` has been added, and a new field `execution_time` has been added to the task structure to hold the cumulative number of timer ticks since the task began executing.

Change to global interrupt functions

The functions `ctl_global_interrupts_disable` and `ctl_global_interrupts_enable` no longer return the previous interrupt-enables state. If you need that, use `ctl_global_interrupts_set` instead.

Other API changes

The function `ctl_task_set_priority` returns the old task priority.

Header file changes

In CTL V1, the file `ctl/include/ctl_api.h` contained CTL declarations and board-support declarations. In CTL V2, the file `ctl/include/ctl.h` contains CTL declarations. In CTL V2, the file `ctl/include/ctl_api.h` includes `ctl/source/ctl.h` and has board-support declarations for backwards compatibility.

Removed support for interrupt re-enabling

The following functions have been removed from CTL V2:

- `ctl_global_interrupts_re_enable_from_isr`
- `ctl_global_interrupts_un_re_enable_from_isr`

These are defined in `ctl_api.h` to use their libarm equivalents. Rather than use these functions, it is recommended to re-enable interrupts in the `irq_handler`.

Removed support for programmable interrupt handler

The following functions have been removed from CTL V2:

- `ctl_set_isr`
- `ctl_unmask_isr`
- `ctl_mask_isr`

These functions are now declared in `ctl_api.h` and are implemented in board- and CPU-support packages.

Removed CPU-specific timer functions

The following functions have been removed from CTL V2:

- **ctl_start_timer**
- **ctl_get_ticks_per_second**

These functions are now declared in **ctl_api.h** and are implemented in support packages for the board and CPU.

Removed board-specific functions

The following functions have been removed from CTL V2:

- **ctl_board_init**
- **ctl_board_set_leds**
- **ctl_board_on_button_pressed**

These functions are now declared in **ctl_api.h** and are implemented in board-support packages.

Moved libc mutex

The declaration of the event set **ctl_libc_mutex** has been moved into the implementation of the libc multi-threading helper functions.

Byte-queue and message-queue additions

Functions to post and receive multiple bytes/messages.

Functions to query the state of byte/message queues.

Function to associate events that are set when byte or message queues are not empty or not full.

Usage of **ctl_global_interrupts_set**

In CTL V2.1, the usage of **ctl_global_interrupts_set** has been replaced with usage of **ctl_global_interrupts_disable** and **ctl_global_interrupts_enable**. These functions are now implemented using compiler intrinsics in the default CTL build. You can rebuild with the C preprocessor symbol **__NO_USE_INTRINSICS__** defined if your application requires **ctl_global_interrupts_set** to be used.

Complete API reference

This section contains a complete reference to the CrossWorks Tasking Library (CTL) API.

<ctl.h>

API Summary

Tasks	
ctl_task_die	Terminate the executing task
ctl_task_init	Create the initial task
ctl_task_remove	Remove a task from the task list
ctl_task_reschedule	Cause a reschedule
ctl_task_restore	Put back a task on to the task list
ctl_task_run	Start a task
ctl_task_set_priority	Set the priority of a task
Timer	
ctl_get_current_time	Atomically return the current time
ctl_increment_tick_from_isr	Increment tick timer
ctl_timeout_wait	Wait until timeout has occurred
Event sets	
ctl_events_init	Initialize an event set
ctl_events_pulse	Pulse events in an event set
ctl_events_set_clear	Set and clear events in an event set
ctl_events_wait	Wait for events in an event set
Semaphores	
ctl_semaphore_init	Initialize a semaphore
ctl_semaphore_signal	Signal a semaphore
ctl_semaphore_wait	Wait for a semaphore
Message queues	
ctl_message_queue_init	Initialize a message queue
ctl_message_queue_num_free	Return number of free elements in a message queue
ctl_message_queue_num_used	Return number of used elements in a message queue
ctl_message_queue_post	Post message to a message queue
ctl_message_queue_post_multi	Post messages to a message queue
ctl_message_queue_post_multi_nb	Post messages to a message queue without blocking
ctl_message_queue_post_nb	Post message to a message queue without blocking
ctl_message_queue_receive	Receive message from a message queue
ctl_message_queue_receive_multi	Receive messages from a message queue

ctl_message_queue_receive_multi_nb	Receive messages from a message queue without blocking
ctl_message_queue_receive_nb	Receive message from a message queue without blocking
ctl_message_queue_setup_events	Associate events with the not-full and not-empty state of a message queue
Bytes queues	
ctl_byte_queue_init	Initialize a byte queue
ctl_byte_queue_num_free	Return number of free bytes in a byte queue
ctl_byte_queue_num_used	Return number of used bytes in a byte queue
ctl_byte_queue_post	Post byte to a byte queue
ctl_byte_queue_post_multi	Post bytes to a byte queue
ctl_byte_queue_post_multi_nb	Post bytes to a byte queue without blocking
ctl_byte_queue_post_nb	Post byte to a byte queue without blocking
ctl_byte_queue_receive	Receive a byte from a byte queue
ctl_byte_queue_receive_multi	Receive multiple bytes from a byte queue
ctl_byte_queue_receive_multi_nb	Receive multiple bytes from a byte queue without blocking
ctl_byte_queue_receive_nb	Receive a byte from a byte queue without blocking
ctl_byte_queue_setup_events	Associate events with the not-full and not-empty state of a byte queue
Mutexes	
ctl_mutex_init	Initialize a mutex
ctl_mutex_lock	Lock a mutex
ctl_mutex_unlock	Unlock a mutex
Interrupts	
ctl_global_interrupts_disable	Disable global interrupts
ctl_global_interrupts_enable	Enable global interrupts
ctl_global_interrupts_set	Enable/disable interrupts
Error handling	
ctl_handle_error	Handle a CTL error condition
Memory areas	
ctl_memory_area_allocate	Allocate a block from a memory area
ctl_memory_area_free	Free a memory area block
ctl_memory_area_init	Initialize a memory area
ctl_memory_area_setup_events	Set memory area events

Types	
CTL_BYTE_QUEUE_t	Byte queue struct definition
CTL_ERROR_CODE_t	Error cause
CTL_EVENT_SET_t	Event set definition
CTL_EVENT_WAIT_TYPE_t	Event set wait types
CTL_MEMORY_AREA_t	Memory area struct definition
CTL_MESSAGE_QUEUE_t	Message queue struct definition
CTL_MUTEX_t	Mutex struct definition
CTL_SEMAPHORE_t	Semaphore definition
CTL_STATE_t	Task states
CTL_TASK_t	Task struct definition
CTL_TIMEOUT_t	Type of wait
CTL_TIME_t	Time definition
System state variables	
ctl_current_time	The current time in ticks
ctl_interrupt_count	Nested interrupt count
ctl_last_schedule_time	The time (in ticks) of the last task schedule
ctl_reschedule_on_last_isr_exit	Reschedule is required on last ISR exit
ctl_task_executing	The task that is currently executing
ctl_task_list	List of tasks sorted by priority
ctl_task_switch_callout	A function pointer called on a task switch
ctl_time_increment	Current time tick increment
ctl_timeslice_period	Time slice period in ticks

CTL_BYTE_QUEUE_t

Synopsis

```
typedef struct {
    unsigned char *q;
    unsigned s;
    unsigned front;
    unsigned n;
    CTL_EVENT_SET_t *e;
    CTL_EVENT_SET_t notempty;
    CTL_EVENT_SET_t notfull;
} CTL_BYTE_QUEUE_t;
```

Description

CTL_BYTE_QUEUE_t defines the byte queue structure. The byte queue structure contains:

Member	Description
q	pointer to the array of bytes
s	size of the array of bytes
front	the next byte to leave the byte queue
n	the number of elements in the byte queue
e	the event set to use for the not empty and not full events
notempty	the event number for a not empty event
notfull	the event number for a not full event

CTL_ERROR_CODE_t

Synopsis

```
typedef enum {  
    CTL_ERROR_NO_TASKS_TO_RUN,  
    CTL_UNSUPPORTED_CALL_FROM_ISR,  
    CTL_MUTEX_UNLOCK_CALL_ERROR,  
    CTL_UNSPECIFIED_ERROR  
} CTL_ERROR_CODE_t;
```

Description

CTL_ERROR_CODE_t defines the set of errors that are detected by the CrossWorks tasking library; the errors are reported by a call to **ctl_handle_error**.

Constant	Description
CTL_ERROR_NO_TASKS_TO_RUN	A reschedule has occurred but there are no tasks which are runnable.
CTL_UNSUPPORTED_CALL_FROM_ISR	An interrupt service routine has called a tasking library function that could block or is otherwise unsupported when called from inside an interrupt service routine.
CTL_MUTEX_UNLOCK_CALL_ERROR	A task called ctl_mutex_unlock passing a mutex which it has not locked, or which a different task holds a lock on. Only the task that successfully acquired a lock on a mutex can unlock that mutex.
CTL_UNSPECIFIED_ERROR	An unspecified error has occurred.

CTL_EVENT_SET_t

Synopsis

```
typedef unsigned CTL_EVENT_SET_t;
```

Description

CTL_EVENT_SET_t defines an event set. Event sets are word sized 16 or 32 depending on the machine.

CTL_EVENT_WAIT_TYPE_t

Synopsis

```
typedef enum {  
    CTL_EVENT_WAIT_ANY_EVENTS,  
    CTL_EVENT_WAIT_ANY_EVENTS_WITH_AUTO_CLEAR,  
    CTL_EVENT_WAIT_ALL_EVENTS,  
    CTL_EVENT_WAIT_ALL_EVENTS_WITH_AUTO_CLEAR  
} CTL_EVENT_WAIT_TYPE_t;
```

Description

CTL_EVENT_WAIT_TYPE_t defines how to wait for an event set.

Constant	Description
CTL_EVENT_WAIT_ANY_EVENTS	Wait for any of the specified events to be set in the event set.
CTL_EVENT_WAIT_ANY_EVENTS_WITH_AUTO_CLEAR	Wait for any of the specified events to be set in the event set and reset (clear) them.
CTL_EVENT_WAIT_ALL_EVENTS	Wait for all of the specified events to be set in the event set.
CTL_EVENT_WAIT_ALL_EVENTS_WITH_AUTO_CLEAR	Wait for all of the specified events to be set in the event set and reset (clear) them.

See Also

[ctl_events_wait](#)

CTL_MEMORY_AREA_t

Synopsis

```
typedef struct {  
    unsigned *head;  
    CTL_EVENT_SET_t *e;  
    CTL_EVENT_SET_t blockavailable;  
} CTL_MEMORY_AREA_t;
```

Description

CTL_MEMORY_AREA_t defines the memory area structure. The memory area structure contains:

Member	Description
head	the next free memory block
e	the event set containing the blockavailable event
blockavailable	the blockavailable event

CTL_MESSAGE_QUEUE_t

Synopsis

```
typedef struct {  
    void ** q;  
    unsigned s;  
    unsigned front;  
    unsigned n;  
    CTL_EVENT_SET_t *e;  
    CTL_EVENT_SET_t notempty;  
    CTL_EVENT_SET_t notfull;  
} CTL_MESSAGE_QUEUE_t;
```

Description

CTL_MESSAGE_QUEUE_t defines the message queue structure. The message queue structure contains:

Member	Description
q	pointer to the array of message queue objects
s	size of the array of message queue objects
front	the next element to leave the message queue
n	the number of elements in the message queue
e	the event set to use for the not empty and not full events
notempty	the event number for a not empty event
notfull	the event number for a not full event

CTL_MUTEX_t

Synopsis

```
typedef struct {  
    unsigned lock_count;  
    CTL_TASK_t *locking_task;  
    unsigned locking_task_priority;  
} CTL_MUTEX_t;
```

Description

CTL_MUTEX_t defines the mutex structure. The mutex structure contains:

Member	Description
lock_count	number of times the mutex has been locked
locking_task	the task that has locked the mutex
locking_task_priority	the priority of the task at the time it locked the mutex

CTL_SEMAPHORE_t

Synopsis

```
typedef unsigned CTL_SEMAPHORE_t;
```

Description

CTL_SEMAPHORE_t defines the semaphore type. Semaphores are held in one word, 16 or 32 bits depending on the machine.

CTL_STATE_t

Synopsis

```
typedef enum {
    CTL_STATE_RUNNABLE,
    CTL_STATE_TIMER_WAIT,
    CTL_STATE_EVENT_WAIT_ALL,
    CTL_STATE_EVENT_WAIT_ALL_AC,
    CTL_STATE_EVENT_WAIT_ANY,
    CTL_STATE_EVENT_WAIT_ANY_AC,
    CTL_STATE_SEMAPHORE_WAIT,
    CTL_STATE_MESSAGE_QUEUE_POST_WAIT,
    CTL_STATE_MESSAGE_QUEUE_RECEIVE_WAIT,
    CTL_STATE_MUTEX_WAIT,
    CTL_STATE_SUSPENDED
} CTL_STATE_t;
```

Description

CTL_STATE_t defines the states the task can be on.

Constant	Description
CTL_STATE_RUNNABLE	Task can run.
CTL_STATE_TIMER_WAIT	Waiting for a time value.
CTL_STATE_EVENT_WAIT_ALL	Waiting for all events to be set.
CTL_STATE_EVENT_WAIT_ALL_AC	Waiting for all events to be set with auto clear.
CTL_STATE_EVENT_WAIT_ANY	Waiting for any events to be set.
CTL_STATE_EVENT_WAIT_ANY_AC	Waiting for any events to be set with auto clear.
CTL_STATE_SEMAPHORE_WAIT	Task is waiting for a semaphore.
CTL_STATE_MESSAGE_QUEUE_POST_WAIT	Task is waiting to post to a message queue.
CTL_STATE_MESSAGE_QUEUE_RECEIVE_WAIT	Task is waiting to receive from a message queue.
CTL_STATE_MUTEX_WAIT	Task is waiting for a mutex.
CTL_STATE_SUSPENDED	Task cannot run.

CTL_TASK_t

Synopsis

```
typedef struct {
    unsigned *stack_pointer;
    unsigned char priority;
    unsigned char state;
    unsigned char timeout_occured;
    CTL_TIME_t timeout;
    void *wait_object;
    CTL_EVENT_SET_t wait_events;
    int thread_errno;
    void *data;
    CTL_TIME_t execution_time;
    unsigned *stack_start;
    const char *name;
} CTL_TASK_t;
```

Description

CTL_TASK_t defines the task structure. The task structure contains:

Member	Description
stack_pointer	the saved register state of the task when it is not scheduled
priority	the priority of the task
state	the state of task CTL_STATE_RUNNABLE or (CTL_STATE_*_WAIT_* CTL_STATE_TIMER_WAIT) or CTL_STATE_SUSPENDED
timeout_occured	1 if a wait timed out otherwise 0 - when state is CTL_RUNNABLE
next	next pointer for wait queue
timeout	wait timeout value or time slice value when the task is executing
wait_object	the event set, semaphore, message queue or mutex to wait on
wait_events	the events to wait for
thread_errno	thread specific errno
data	task specific data pointer
execution_time	number of ticks the task has executed for
stack_start	the start (lowest address) of the stack
name	task name

CTL_TIMEOUT_t

Synopsis

```
typedef enum {  
    CTL_TIMEOUT_NONE,  
    CTL_TIMEOUT_INFINITE,  
    CTL_TIMEOUT_ABSOLUTE,  
    CTL_TIMEOUT_DELAY,  
    CTL_TIMEOUT_NOW  
} CTL_TIMEOUT_t;
```

Description

CTL_TIMEOUT_t defines the type of timeout for a blocking function call.

Constant	Description
CTL_TIMEOUT_NONE	No timeout — block indefinitely.
CTL_TIMEOUT_INFINITE	Identical to CTL_TIMEOUT_NONE .
CTL_TIMEOUT_ABSOLUTE	The timeout is an absolute time.
CTL_TIMEOUT_DELAY	The timeout is relative to the current time.
CTL_TIMEOUT_NOW	The timeout happens immediately — no rescheduling occurs.

CTL_TIME_t

Synopsis

```
typedef unsigned long CTL_TIME_t;
```

Description

CTL_TIME_t defines the base type for times that CTL uses.

ctl_byte_queue_init

Synopsis

```
void ctl_byte_queue_init(CTL_BYTE_QUEUE_t *q,  
                        unsigned char *queue,  
                        unsigned queue_size);
```

Description

ctl_byte_queue_init is given a pointer to the byte queue to initialize in **q**. The array that will be used to implement the byte queue pointed to by **queue** and its size in **queue_size** are also supplied.

ctl_byte_queue_num_free

Synopsis

```
unsigned ctl_byte_queue_num_free(CTL_BYTE_QUEUE_t *q);
```

Description

ctl_byte_queue_num_free returns the number of free bytes in the byte queue **q**.

ctl_byte_queue_num_used

Synopsis

```
unsigned ctl_byte_queue_num_used(CTL_BYTE_QUEUE_t *q);
```

Description

ctl_byte_queue_num_used returns the number of used elements in the byte queue **q**.

ctl_byte_queue_post

Synopsis

```
unsigned ctl_byte_queue_post(CTL_BYTE_QUEUE_t *q,  
                             unsigned char b,  
                             CTL_TIMEOUT_t t,  
                             CTL_TIME_t timeout);
```

Description

ctl_byte_queue_post posts **b** to the byte queue pointed to by **q**. If the byte queue is full then the caller will block until the byte can be posted or, if **timeoutType** is non-zero, the current time reaches **timeout** value.

ctl_byte_queue_post returns zero if the timeout occurred otherwise it returns one.

Note

ctl_byte_queue_post must not be called from an interrupt service routine.

ctl_byte_queue_post_multi

Synopsis

```
unsigned ctl_byte_queue_post_multi(CTL_BYTE_QUEUE_t *q,  
                                   unsigned n,  
                                   unsigned char *b,  
                                   CTL_TIMEOUT_t t,  
                                   CTL_TIME_t timeout);
```

Description

ctl_byte_queue_post_multi posts **n** bytes to the byte queue pointed to by **q**. The caller will block until the bytes can be posted or, if **timeoutType** is non-zero, the current time reaches **timeout** value. **ctl_byte_queue_post_multi** returns the number of bytes that were posted.

Note

ctl_byte_queue_post_multi must not be called from an interrupt service routine.

ctl_byte_queue_post_multi does not guarantee that the bytes will be all be posted to the byte queue atomically. If you have multiple tasks posting (multiple bytes) to the same byte queue then you may get unexpected results.

ctl_byte_queue_post_multi_nb

Synopsis

```
unsigned ctl_byte_queue_post_multi_nb(CTL_BYTE_QUEUE_t *q,  
                                     unsigned n,  
                                     unsigned char *b);
```

Description

ctl_byte_queue_post_multi_nb posts **n** bytes to the byte queue pointed to by **q**.

ctl_byte_queue_post_multi_nb returns the number of bytes that were posted.

ctl_byte_queue_post_nb

Synopsis

```
unsigned ctl_byte_queue_post_nb(CTL_BYTE_QUEUE_t *q,  
                               unsigned char b);
```

Description

ctl_byte_queue_post_nb posts **b** to the byte queue pointed to by **q**. If the byte queue is full then the function will return zero otherwise it will return one.

ctl_byte_queue_receive

Synopsis

```
unsigned ctl_byte_queue_receive(CTL_BYTE_QUEUE_t *q,  
                               unsigned char *b,  
                               CTL_TIMEOUT_t t,  
                               CTL_TIME_t timeout);
```

Description

ctl_byte_queue_receive pops the oldest byte in the byte queue pointed to by **q** into the memory pointed to by **b**. **ctl_byte_queue_receive** will block if no bytes are available unless **timeoutType** is non-zero and the current time reaches the **timeout** value.

ctl_byte_queue_receive returns zero if a timeout occurs otherwise 1.

Note

ctl_byte_queue_receive must not be called from an interrupt service routine.

ctl_byte_queue_receive_multi

Synopsis

```
unsigned ctl_byte_queue_receive_multi(CTL_BYTE_QUEUE_t *q,  
                                     unsigned n,  
                                     unsigned char *b,  
                                     CTL_TIMEOUT_t t,  
                                     CTL_TIME_t timeout);
```

Description

ctl_byte_queue_receive_multi pops the oldest **n** bytes in the byte queue pointed to by **q** into the memory pointed at by **b**. **ctl_byte_queue_receive_multi** will block until the number of bytes are available unless **timeoutType** is non-zero and the current time reaches the **timeout** value.

ctl_byte_queue_receive_multi returns the number of bytes that have been received.

Note

ctl_byte_queue_receive_multi must not be called from an interrupt service routine.

ctl_byte_queue_receive_multi_nb

Synopsis

```
unsigned ctl_byte_queue_receive_multi_nb(CTL_BYTE_QUEUE_t *q,  
                                         unsigned n,  
                                         unsigned char *b);
```

Description

ctl_byte_queue_receive_multi_nb pops the oldest **n** bytes in the byte queue pointed to by **q** into the memory pointed to by **b**. **ctl_byte_queue_receive_multi_nb** returns the number of bytes that have been received.

ctl_byte_queue_receive_nb

Synopsis

```
unsigned ctl_byte_queue_receive_nb(CTL_BYTE_QUEUE_t *q,  
                                   unsigned char *b);
```

Description

ctl_byte_queue_receive_nb pops the oldest byte in the byte queue pointed to by **m** into the memory pointed to by **b**. If no bytes are available the function returns zero otherwise it returns 1.

ctl_byte_queue_setup_events

Synopsis

```
void ctl_byte_queue_setup_events(CTL_BYTE_QUEUE_t *q,  
                                CTL_EVENT_SET_t *e,  
                                CTL_EVENT_SET_t notempty,  
                                CTL_EVENT_SET_t notfull);
```

Description

ctl_byte_queue_setup_events registers events in the event set **e** that are set when the byte queue **q** becomes **notempty** or becomes **notfull**. No scheduling will occur with this operation, you need to do this before waiting for events.

ctl_current_time

Synopsis

```
CTL_TIME_t ctl_current_time;
```

Description

ctl_current_time holds the current time in ticks. **ctl_current_time** is incremented by **ctl_increment_ticks_from_isr**.

Note

For portable programs without race conditions you should not read this variable directly, you should use **ctl_get_current_time** instead. As this variable is changed by an interrupt, it cannot be read atomically on processors whose word size is less than 32 bits without first disabling interrupts. That said, you can read this variable directly in your interrupt handler as long as interrupts are still disabled.

ctl_events_init

Synopsis

```
void ctl_events_init(CTL_EVENT_SET_t *e,  
                    CTL_EVENT_SET_t set);
```

Description

ctl_events_init initializes the event set **e** with the **set** values.

ctl_events_pulse

Synopsis

```
void ctl_events_pulse(CTL_EVENT_SET_t *e,  
                     CTL_EVENT_SET_t set_then_clear);
```

Description

ctl_events_pulse will set the events defined by **set_then_clear** in the event set pointed to by **e**.

ctl_events_pulse will then search the task list, matching tasks that are waiting on the event set **e**, and make them runnable if the match is successful. The events defined by **set_then_clear** are then cleared.

See Also

[ctl_events_set_clear](#).

ctl_events_set_clear

Synopsis

```
void ctl_events_set_clear(CTL_EVENT_SET_t *e,  
                        CTL_EVENT_SET_t set,  
                        CTL_EVENT_SET_t clear);
```

Description

ctl_events_set_clear sets the events defined by **set** and clears the events defined by **clear** of the event set pointed to by **e**. **ctl_events_set_clear** will then search the task list, matching tasks that are waiting on the event set **e** and make them runnable if the match is successful.

See Also

[ctl_events_pulse](#).

ctl_events_wait

Synopsis

```
unsigned ctl_events_wait(CTL_EVENT_WAIT_TYPE_t type,  
                        CTL_EVENT_SET_t *eventSet,  
                        CTL_EVENT_SET_t events,  
                        CTL_TIMEOUT_t t,  
                        CTL_TIME_t timeout);
```

Description

ctl_events_wait waits for **events** to be set (value 1) in the event set pointed to by **eventSet** with an optional **timeout** applied if **timeoutType** is non-zero.

The **waitType** can be one of:

- **CTL_EVENT_WAIT_ANY_EVENTS** — wait for any of **events** in **eventSet** to be set.
- **CTL_EVENT_WAIT_ANY_EVENTS_WITH_AUTO_CLEAR** — wait for any of **events** in **eventSet** to be set and reset (clear) them.
- **CTL_EVENT_WAIT_ALL_EVENTS** — wait for all **events** in ***eventSet** to be set.
- **CTL_EVENT_WAIT_ALL_EVENTS_WITH_AUTO_CLEAR** — wait for all **events** in **eventSet** to be set and reset (clear) them.

ctl_events_wait returns the value pointed to by **eventSet** before any auto-clearing occurred or zero if the **timeout** occurred.

Note

ctl_events_wait must not be called from an interrupt service routine.

ctl_get_current_time

Synopsis

```
CTL_TIME_t ctl_get_current_time(void);
```

Description

ctl_get_current_time atomically reads the value of **ctl_current_time**.

ctl_global_interrupts_disable

Synopsis

```
int ctl_global_interrupts_disable(void);
```

Description

ctl_global_interrupts_disable disables global interrupts. If **ctl_global_interrupts_disable** is called and interrupts are already disabled then it will return 0. If **ctl_global_interrupts_disable** is called and interrupts are enabled then it will return non-zero which may or may not represent the true interrupt disabled state. **ctl_global_interrupts_disable** is used to provide exclusive access to CTL data structures the implementation of it may or may not disable global interrupts.

ctl_global_interrupts_enable

Synopsis

```
void ctl_global_interrupts_enable(void);
```

Description

ctl_global_interrupts_enable enables global interrupts. **ctl_global_interrupts_enable** is used to provide exclusive access to CTL data structures the implementation of it may or may not disable global interrupts.

ctl_global_interrupts_set

Synopsis

```
int ctl_global_interrupts_set(int enable);
```

Description

ctl_global_interrupts_set disables or enables global interrupts according to the state **enable**. If **enable** is zero, interrupts are disabled and if **enable** is non-zero, interrupts are enabled. If **ctl_global_interrupts_set** is called and interrupts are already disabled then it will return 0. If **ctl_global_interrupts_set** is called and interrupts are enabled then it will return non-zero which may or may not represent the true interrupt disabled state. **ctl_global_interrupts_set** is used to provide exclusive access to CTL data structures the implementation of it may or may not disable global interrupts.

ctl_handle_error

Synopsis

```
void ctl_handle_error(CTL_ERROR_CODE_t e);
```

Description

ctl_handle_error is a function that you must supply in your application that handles errors detected by the CrossWorks tasking library.

The errors that can be reported in **e** are described in [CTL_ERROR_CODE_t](#).

ctl_increment_tick_from_isr

Synopsis

```
void ctl_increment_tick_from_isr(void);
```

Description

ctl_increment_tick_from_isr increments **ctl_current_time** by the number held in **ctl_time_increment** and does rescheduling. This function should be called from a periodic interrupt service routine.

Note

ctl_increment_tick_from_isr must only be invoked by an interrupt service routine.

ctl_interrupt_count

Synopsis

```
unsigned char ctl_interrupt_count;
```

Description

ctl_interrupt_count contains a count of the interrupt nesting level. This variable must be incremented immediately on entry to an interrupt service routine and decremented immediately before return from the interrupt service routine.

ctl_last_schedule_time

Synopsis

```
CTL_TIME_t ctl_last_schedule_time;
```

Description

ctl_last_schedule_time contains the time (in ticks) of the last task schedule.

Description

ctl_last_schedule_time contains the time of the last reschedule in ticks.

ctl_memory_area_allocate

Synopsis

```
unsigned *ctl_memory_area_allocate(CTL_MEMORY_AREA_t *memory_area);
```

Description

ctl_memory_area_allocate allocates a block from the initialized memory area **memory_area**.

ctl_memory_area_allocate returns a block of the size specified in the call to [ctl_memory_area_init](#) or zero if no blocks are available.

ctl_memory_area_allocate executes in constant time and is very fast. You can call **ctl_memory_area_allocate** from an interrupt service routine, from a task, or from initialization code.

ctl_memory_area_free

Synopsis

```
void ctl_memory_area_free(CTL_MEMORY_AREA_t *memory_area,  
                          unsigned *block);
```

Description

ctl_memory_area_free is given a pointer to a memory area **memory_area** which has been initialized and a **block** that has been returned by [ctl_memory_area_allocate](#). The block is returned to the memory area so that it can be allocated again.

ctl_memory_area_init

Synopsis

```
void ctl_memory_area_init(CTL_MEMORY_AREA_t *memory_area,  
                          unsigned *memory,  
                          unsigned block_size_in_words,  
                          unsigned num_blocks);
```

Description

ctl_memory_area_init is given a pointer to the memory area to initialize in **memory_area**. The array that is used to implement the memory area is pointed to by **memory**. The size of a memory block is given supplied in **block_size_in_words** and the number of block is supplied in **num_blocks**.

Note

memory must point to a block of memory that is at least **block_size_in_words** × **num_blocks** words long.

ctl_memory_area_setup_events

Synopsis

```
void ctl_memory_area_setup_events(CTL_MEMORY_AREA_t *m,  
                                CTL_EVENT_SET_t *e,  
                                CTL_EVENT_SET_t blockavailable);
```

Description

ctl_memory_area_setup_events registers the events **blockavailable** in the event set **e** that are set when a block becomes available in the the memory area **m**.

ctl_message_queue_init

Synopsis

```
void ctl_message_queue_init(CTL_MESSAGE_QUEUE_t *q,  
                           void **queue,  
                           unsigned queue_size);
```

Description

ctl_message_queue_init is given a pointer to the message queue to initialize in **q**. The array that will be used to implement the message queue pointed to by **queue** and its size in **queue_size** are also supplied.

ctl_message_queue_num_free

Synopsis

```
unsigned ctl_message_queue_num_free(CTL_MESSAGE_QUEUE_t *q);
```

Description

ctl_message_queue_num_free returns the number of free elements in the message queue **q**.

ctl_message_queue_num_used

Synopsis

```
unsigned ctl_message_queue_num_used(CTL_MESSAGE_QUEUE_t *q);
```

Description

ctl_message_queue_num_used returns the number of used elements in the message queue **q**.

ctl_message_queue_post

Synopsis

```
unsigned ctl_message_queue_post(CTL_MESSAGE_QUEUE_t *q,  
                               void *message,  
                               CTL_TIMEOUT_t t,  
                               CTL_TIME_t timeout);
```

Description

ctl_message_queue_post posts **message** to the message queue pointed to by **q**. If the message queue is full then the caller will block until the message can be posted or, if **timeoutType** is non-zero, the current time reaches **timeout** value. **ctl_message_queue_post** returns zero if the timeout occurred otherwise it returns one.

Note

ctl_message_queue_post must not be called from an interrupt service routine.

ctl_message_queue_post_multi

Synopsis

```
unsigned ctl_message_queue_post_multi(CTL_MESSAGE_QUEUE_t *q,  
                                     unsigned n,  
                                     void **messages,  
                                     CTL_TIMEOUT_t t,  
                                     CTL_TIME_t timeout);
```

Description

ctl_message_queue_post_multi posts **n messages** to the message queue pointed to by **q**. The caller will block until the messages can be posted or, if **timeoutType** is non-zero, the current time reaches **timeout** value. **ctl_message_queue_post_multi** returns the number of messages that were posted.

Note

ctl_message_queue_post_multi must not be called from an interrupt service routine.

ctl_message_queue_post_multi function does not guarantee that the messages will be all be posted to the message queue atomically. If you have multiple tasks posting (multiple messages) to the same message queue then you may get unexpected results.

ctl_message_queue_post_multi_nb

Synopsis

```
unsigned ctl_message_queue_post_multi_nb(CTL_MESSAGE_QUEUE_t *q,  
                                         unsigned n,  
                                         void **messages);
```

Description

ctl_message_queue_post_multi_nb posts **n messages** to the message queue pointed to by **m**.

ctl_message_queue_post_multi_nb returns the number of messages that were posted.

ctl_message_queue_post_nb

Synopsis

```
unsigned ctl_message_queue_post_nb(CTL_MESSAGE_QUEUE_t *q,  
                                   void *message);
```

Description

ctl_message_queue_post_nb posts **message** to the message queue pointed to by **q**. If the message queue is full then the function will return zero otherwise it will return one.

ctl_message_queue_receive

Synopsis

```
unsigned ctl_message_queue_receive(CTL_MESSAGE_QUEUE_t *q,  
                                   void **message,  
                                   CTL_TIMEOUT_t t,  
                                   CTL_TIME_t timeout);
```

Description

ctl_message_queue_receive pops the oldest message in the message queue pointed to by **q** into the memory pointed to by **message**. **ctl_message_queue_receive** will block if no messages are available unless **timeoutType** is non-zero and the current time reaches the **timeout** value.

ctl_message_queue_receive returns zero if a timeout occurs otherwise 1.

Note

ctl_message_queue_receive must not be called from an interrupt service routine.

ctl_message_queue_receive_multi

Synopsis

```
unsigned ctl_message_queue_receive_multi(CTL_MESSAGE_QUEUE_t *q,  
                                         unsigned n,  
                                         void **messages,  
                                         CTL_TIMEOUT_t t,  
                                         CTL_TIME_t timeout);
```

Description

ctl_message_queue_receive_multi pops the oldest **n** messages in the message queue pointed to by **q** into the memory pointed to by **message**. **ctl_message_queue_receive_multi** will block until all the messages are available unless **timeoutType** is non-zero and the current time reaches the **timeout** value.

ctl_message_queue_receive_multi returns the number of messages that were received.

Note

ctl_message_queue_receive_multi must not be called from an interrupt service routine.

ctl_message_queue_receive_multi_nb

Synopsis

```
unsigned ctl_message_queue_receive_multi_nb(CTL_MESSAGE_QUEUE_t *q,  
                                           unsigned n,  
                                           void **messages);
```

Description

ctl_message_queue_receive_multi_nb pops the oldest **n** messages in the message queue pointed to by **q** into the memory pointed to by **message**.

ctl_message_queue_receive_multi_nb returns the number of messages that were received.

ctl_message_queue_receive_nb

Synopsis

```
unsigned ctl_message_queue_receive_nb(CTL_MESSAGE_QUEUE_t *q,  
                                     void **message);
```

Description

ctl_message_queue_receive_nb pops the oldest message in the message queue pointed to by **q** into the memory pointed to by **message**. If no messages are available the function returns zero otherwise it returns 1.

ctl_message_queue_setup_events

Synopsis

```
void ctl_message_queue_setup_events(CTL_MESSAGE_QUEUE_t *q,  
                                   CTL_EVENT_SET_t *e,  
                                   CTL_EVENT_SET_t notempty,  
                                   CTL_EVENT_SET_t notfull);
```

Description

ctl_message_queue_setup_events registers events in the event set **e** that are set when the message queue **q** becomes **notempty** or becomes **notfull**. No scheduling will occur with this operation, you need to do this before waiting for events.

ctl_mutex_init

Synopsis

```
void ctl_mutex_init(CTL_MUTEX_t *m);
```

Description

ctl_mutex_init initializes the mutex pointed to by **m**.

ctl_mutex_lock

Synopsis

```
unsigned ctl_mutex_lock(CTL_MUTEX_t *m,  
                       CTL_TIMEOUT_t t,  
                       CTL_TIME_t timeout);
```

Description

ctl_mutex_lock locks the mutex pointed to by **m** to the calling task. If the mutex is already locked by the calling task then the mutex lock count is incremented. If the mutex is already locked by a different task then the caller will block until the mutex is unlocked. In this case, if the priority of the task that has locked the mutex is less than that of the caller the priority of the task that has locked the mutex is raised to that of the caller whilst the mutex is locked. If **timeoutType** is non-zero and the current time reaches the **timeout** value before the lock is acquired the function returns zero otherwise it returns one.

Note

ctl_mutex_lock must not be called from an interrupt service routine.

ctl_mutex_unlock

Synopsis

```
void ctl_mutex_unlock(CTL_MUTEX_t *m);
```

Description

ctl_mutex_unlock unlocks the mutex pointed to by **m**. The mutex must have previously been locked by the calling task. If the calling task's priority has been raised (by another task calling **ctl_mutex_unlock** whilst the mutex was locked), then the calling tasks priority will be restored.

Note

ctl_mutex_unlock must not be called from an interrupt service routine.

ctl_reschedule_on_last_isr_exit

Synopsis

```
unsigned char ctl_reschedule_on_last_isr_exit;
```

Description

ctl_reschedule_on_last_isr_exit is set to a non-zero value if a CTL call is made from an interrupt service routine that requires a task reschedule. This variable is checked and reset on exit from the last nested interrupt service routine.

ctl_semaphore_init

Synopsis

```
void ctl_semaphore_init(CTL_SEMAPHORE_t *s,  
                        unsigned value);
```

Description

ctl_semaphore_init initializes the semaphore pointed to by **s** to **value**.

ctl_semaphore_signal

Synopsis

```
void ctl_semaphore_signal(CTL_SEMAPHORE_t *s);
```

Description

ctl_semaphore_signal signals the semaphore pointed to by **s**. If tasks are waiting for the semaphore then the highest priority task will be made runnable. If no tasks are waiting for the semaphore then the semaphore value will be incremented.

ctl_semaphore_wait

Synopsis

```
unsigned ctl_semaphore_wait(CTL_SEMAPHORE_t *s,  
                           CTL_TIMEOUT_t t,  
                           CTL_TIME_t timeout);
```

Description

ctl_semaphore_wait waits for the semaphore pointed to by **s** to be non-zero. If the semaphore is zero then the caller will block unless **timeoutType** is non-zero and the current time reaches the **timeout** value. If the timeout occurred **ctl_semaphore_wait** returns zero otherwise it returns one.

Note

ctl_semaphore_wait must not be called from an interrupt service routine.

ctl_task_die

Synopsis

```
void ctl_task_die(void);
```

Description

ctl_task_die terminates the currently executing task and schedules the next runnable task.

ctl_task_executing

Synopsis

```
CTL_TASK_t *ctl_task_executing;
```

Description

ctl_task_executing points to the **CTL_TASK_t** structure of the currently executing task. The **priority** field is the only field in the **CTL_TASK_t** structure that is defined for the task that is executing. It is an error if **ctl_task_executing** is **NULL**.

ctl_task_init

Synopsis

```
void ctl_task_init(CTL_TASK_t *task,  
                  unsigned char priority,  
                  const char *name);
```

Description

ctl_task_init turns the main program into a task. This function takes a pointer in **task** to the **CTL_TASK_t** structure that represents the main task, its **priority** (0 is the lowest priority, 255 the highest), and a zero-terminated string pointed by **name**. On return from this function global interrupts will be enabled.

The function must be called before any other CrossWorks tasking library calls are made.

ctl_task_list

Synopsis

```
CTL_TASK_t *ctl_task_list;
```

Description

ctl_task_list points to the **CTL_TASK_t** structure of the highest priority task that is not executing. It is an error if **ctl_task_list** is **NULL**.

ctl_task_remove

Synopsis

```
void ctl_task_remove(CTL_TASK_t *task);
```

Description

ctl_task_remove removes the task **task** from the waiting task list. Once you have removed a task the only way to re-introduce it to the system is to call **ctl_task_restore**.

ctl_task_reschedule

Synopsis

```
void ctl_task_reschedule(void);
```

Description

ctl_task_reschedule causes a reschedule to occur. This can be used by tasks of the same priority to share the CPU without using timeslicing.

ctl_task_restore

Synopsis

```
void ctl_task_restore(CTL_TASK_t *task);
```

Description

ctl_task_restore adds a task **task** that was removed (using **ctl_task_remove**) onto the task list and do scheduling.

ctl_task_run

Synopsis

```
void ctl_task_run(CTL_TASK_t *task,
                  unsigned char priority,
                  void (*entrypoint)(void *),
                  void *parameter,
                  const char *name,
                  unsigned stack_size_in_words,
                  unsigned *stack,
                  unsigned call_size_in_words);
```

Description

ctl_task_run takes a pointer in **task** to the **CTL_TASK_t** structure that represents the task. The **priority** can be zero for the lowest priority up to 255 which is the highest. The **entrypoint** parameter is the function that the task will execute which has the **parameter** passed to it.

name is a pointer to a zero-terminated string used for debug purposes.

The start of the memory used to hold the stack that the task will execute in is **stack** and the size of the memory is supplied in **stack_size_in_words**. On systems that have two stacks (e.g. Atmel AVR) then the **call_size_in_words** parameter must be set to specify the number of stack elements to use for the call stack.

ctl_task_set_priority

Synopsis

```
unsigned char ctl_task_set_priority(CTL_TASK_t *task,  
                                   unsigned char priority);
```

Description

ctl_task_set_priority changes the priority of **task** to **priority**. The priority can be 0, the lowest priority, to 255, which is the highest priority.

You can change the priority of the currently executing task by passing **ctl_task_executing** as the **task** parameter. **ctl_task_set_priority** returns the previous priority of the task.

ctl_task_switch_callout

Synopsis

```
void (*ctl_task_switch_callout)(CTL_TASK_t *);
```

Description

ctl_task_switch_callout contains a pointer to a function that is called (if it is set) when a task schedule occurs. The task that will be scheduled is supplied as a parameter to the function (**ctl_task_executing** will point to the currently scheduled task).

Note that the callout function is called from the CTL scheduler and as such any use of CTL services whilst executing the callout function has undefined behavior.

Note

Because this function pointer is called in an interrupt service routine, you should assign it before interrupts are started or with interrupts turned off.

ctl_time_increment

Synopsis

```
unsigned ctl_time_increment;
```

Description

ctl_time_increment contains the value that **ctl_current_time** is incremented when **ctl_increment_tick_from_isr** is called.

ctl_timeout_wait

Synopsis

```
void ctl_timeout_wait(CTL_TIME_t timeout);
```

Description

ctl_timeout_wait takes the **timeout** (not the duration) as a parameter and suspends the calling task until the current time reaches the timeout.

Note

ctl_timeout_wait must not be called from an interrupt service routine.

ctl_timeslice_period

Synopsis

```
CTL_TIME_t ctl_timeslice_period;
```

Description

ctl_timeslice_period contains the number of ticks to allow a task to run before it will be preemptively rescheduled by a task of the same priority. The variable is set to zero by default so that only higher priority tasks will be preemptively scheduled.



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
```

-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

-D*name*

-D*name=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
- **-Ttxt** — 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

-K*name*

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`.

-l- (Do not link standard libraries)

Syntax

-l-

Description

The **-l** option instructs the compiler driver not to link standard libraries. If you use this option you must supply your own library functions or libraries.

-mboot (Generate boot loader code)

Syntax

-mboot

Description

Linker option to generate code that can only execute in memory above 128K bytes in length e.g a bootloader for a mega2560.

-msize (Set code size)

Syntax

-m8k -m128k -m8m

Description

Specifies the code size of the device to generate code for. The options are:

- **-m8k** — up to 8 kilobytes of code
- **-m128k** — up to 128 kilobytes of code
- **-m8m** — up to 8 megabytes of code

-mmpy (Generate multiplier instructions)

Syntax

-mmpy

Description

Compiler option that specifies if multiplier instructions are generated.

-mxmega (Generate xmega code)

Syntax

-mxmega

Description

Compiler option that specifies that xmega code sequences are generated to access sfrw's.

-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.

-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.

-nstderr (No stderr output)

Syntax

-nstderr

Description

When **-nstderr** 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
- **-Rk** *name* — change the default name of the const 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

-W*tool 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
- **-Wl** — 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

-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

-D*name*

-D*name=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
- **-Ttxt** — 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

-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.

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

-K*name*

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.

-l (Link library)

Syntax

-l*x*

Description

Link the library **lib*x*.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
```


Linker

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
- **-Ftek** — Tektronix hex format
- **-Ttxt** — Texas Instruments hex format
- **-Flst** — Hexadecimal listing
- **-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.

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

-l (Link library)

Syntax

-l*x*

Description

Link the library **lib*x*.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*.

-m8k (Generate for 8K part)

Syntax

-m8k

Description

This option instructs the linker to generate code for parts with no more than 8 kilobytes of code memory. In particular, the linker will always use

RJMP instructions for relative branches which can wrap around the 8K memory space. Even if you are using less than 8K of memory for your application on devices with more than 8K of memory, you should still *not use this switch* as your application will fail.

-m128k (Generate for 128K part)

Syntax

-m128k

Description

This option instructs the linker to generate code for parts with between 8K and 128 kilobytes of code memory. For devices that have 8K of code memory or less, you should use the **-m8k** switch so that **RJMP** instructions are always used, and for devices with more than 128K of memory you should use the **-m8m** switch so that the wider program counter of these devices is correctly supported.

-m8m (Generate for 8M part)

Syntax

-m8m

Description

This option instructs the linker to generate code for parts with between 128K and 8M of code memory. For devices that have 8K of code memory or less, you should use the **-m8k** switch so that **RJMP** instructions are always used and for devices with 128K of code memory or less, you should use the **-m128k** switch so that the 16-bit program counter of these devices is supported correctly.

-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.

-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.

-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.

-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.

-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.

-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.

-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.

-Ojt (Enable jump threading 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.

-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 0xffff inclusive and with **CONST** placed before **CODE**:

```
-TCONST, CODE=0x1000-0xffef+0x10000-0xffff
```

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.

Hex extractor

The hex extractor **hex** prepares images in a number of formats to burn into EPROM or flash memory. Although the linker is capable of writing all the formats described here, it doesn't have the capability of splitting files for different bus or device sizes.

When you prepare to download applications to a monitor held in ROM, you usually need the application in a single industry-standard format such as S-records or Intel hex format. What you don't need to do is split high and low bytes, and you won't need to split across ROMs. The extractor generates files in this format by default—all you need to provide is the format you need the file in.

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.

-W (Set bus width)

Syntax

-W1

-W2

-W4

Description

The **-W** option splits a file into multiple streams. You can use this if your EPROM programmer cannot split files into different devices when programming.

Example

```
hex -W2 app.hzx -Fhex
```

This splits the application file **app.hzx** into high and low bytes for a processor with a 16-bit bus. The bytes at even addresses are placed in the file **app.hzx.0.hex** and the bytes at odd addresses in the file **app.hzx.1.hex**.

-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
- **-Ftek** — Tektronix hex format
- **-Ttxt** — Texas Instruments hex format
- **-Flst** — Hexadecimal listing

-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 -W2 app.hzx -Fhex -o app
```

This splits the application file **app.hzx** into high and low bytes for a processor with a 16-bit bus. The bytes at even addresses are placed in the file **app.0.hex** and the bytes at odd addresses in the file **app.1.hex**.

-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
```

CrossBuild

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.

-define (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.

-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.

CrossLoad

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"="Ltp2" ...
```

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 be 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)")
[0xeaffffe, 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")
0x00000770
```

```
> 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 *framenumbers* which can be supplied to the **Debug.locate(framenumbers)** method. Framenumbers start at zero and are incremented for each function call. So framenumbers zero is the current location, framenumbers 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.

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.

-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.

CrossScript

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.
-d	Remove files from a package.
-r	Replace files in a package.
-t	List the contents of a package.
-v	Be chatty.
-V	Show version information.



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 the CrossWorks IDE.

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" />
      </Register>
    </RegisterGroup>
  </MemorySegment>
</Root>
```

`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" />
    </Register>
  </RegisterGroup>
</Root>
```

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:

- *alignment*: The required alignment of the program section; a decimal number specifying the byte alignment.
- *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.
- *runoffset*: This specifies an offset from the load address that the section will be run from (**ARM only**).
- *start*: The optional start address of the program section, a hexadecimal number with a 0x prefix.
- *size*: The optional size of the program section in bytes, a hexadecimal number with a 0x prefix.
- *address_symbol*: A symbolic name for the start address of the section.
- *end_symbol*: A symbolic name for the end address of the section.
- *size_symbol*: A symbolic name for the size of the section.

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 `.hzip` 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.hzip" />
```

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>
  <grouphdots
    ?
  <grouphdots
</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>
</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>).

<code>version</code>	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
<code>name</code>	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 CrossWorks 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>&amp;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 shortcut 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) $(INCLUDES) -D__GNUC__ -u -b +macros -w2 -e537 +fie +ffn -width(0,4) -hF1
  &quot;-format=%f:%l:%C:s%t:s%m&quot; &quot;$(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 Options

Property	Description
Always Rebuild <code>build_always_rebuild</code> – Boolean	Specifies whether or not to always rebuild the project/folder/file.
Build Quietly <code>build_quietly</code> – Boolean	Suppress the display of startup banners and information messages.
Enable Unused Symbol Removal <code>build_remove_unused_symbols</code> – Boolean	Enable the removal of unused symbols from the executable.
Exclude From Build <code>build_exclude_from_build</code> – Boolean	Specifies whether or not to exclude the project/folder/file from the build.
Include Debug Information <code>build_debug_information</code> – Boolean	Specifies whether symbolic debug information is generated.
Intermediate Directory <code>build_intermediate_directory</code> – FileName	Specifies a relative path to the intermediate file directory. This property will have macro expansion applied to it. The macro <code>\$(IntDir)</code> is set to this value.
Memory Map File <code>linker_memory_map_file</code> – ProjFileName	The name of the file containing the memory map description.
Memory Map Macros <code>linker_memory_map_macros</code> – StringList	Macro values to substitute in memory map nodes. Each macro is defined as name=value and are separated by <code>;</code> .
Output Directory <code>build_output_directory</code> – FileName	Specifies a relative path to the output file directory. This property will have macro expansion applied to it. The macro <code>\$(OutDir)</code> is set to this value. The macro <code>\$(RootRelativeOutDir)</code> is set relative to the Root Output Directory if specified.
Project Dependencies <code>project_dependencies</code> – StringList	Specifies the projects the current project depends upon.
Project Directory <code>project_directory</code> – String	Path of the project directory relative to the directory containing the project file. The macro <code>\$(ProjectDir)</code> is set to the absolute path of this property.
Project Macros <code>macros</code> – StringList	Specifies macro values which are expanded in project properties. Each macro is defined as name=value and are separated by <code>;</code> .
Project Type <code>project_type</code> – Enumeration	Specifies the type of project to build. The options are Executable , Library , Object file , Staging , Combining , Externally Built Executable .

Property Groups File <code>property_groups_file_path</code> – 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 <code>build_root_output_directory</code> – FileName	Allows a common root output directory to be specified that can be referenced using the <code>\$(RootOutDir)</code> macro.
Suppress Warnings <code>build_suppress_warnings</code> – Boolean	Don't report warnings.
Treat Warnings as Errors <code>build_treat_warnings_as_errors</code> – Boolean	Treat all warnings as errors.

General Options

Property	Description
Batch Build Configurations <code>batch_build_configurations</code> – StringList	The set of configurations to batch build.
Inherited Configurations <code>inherited_configurations</code> – StringList	The list of configurations that are inherited by this configuration.

Package Options

Property	Description
Package Dependencies <code>package_dependencies</code> – StringList	Specifies the packages the current project depends upon.

Combining Project Properties

Combining Options

Property	Description
Combine Command <code>combine_command</code> – String	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 <code>combine_command_wd</code> – String	The working directory in which the combine command is run. This property will have macro expansion applied to it.
Output File Path <code>combine_output_filepath</code> – String	The output file path the stage command will create. This property will have macro expansion applied to it.
Set To Read-only <code>combine_set_readonly</code> – Boolean	Set the output file to read only or read/write.

Compilation Properties

Assembler Options

Property	Description
Additional Assembler Options <code>asm_additional_options</code> – StringList	Enables additional options to be supplied to the assembler. This property will have macro expansion applied to it.
Additional Assembler Options From File <code>asm_additional_options_from_file</code> – ProjFileName	Enables additional options to be supplied to the assembler from a file. This property will have macro expansion applied to it.

Code Generation Options

Property	Description
Architecture <code>avr_architecture</code> – Enumeration	The AVR instruction set architecture revision.
Block Localization Optimization <code>optimize_block_locality</code> – Boolean	Reduce spand-dependent jumps by rearranging basic blocks to improve their locality.
Code Factoring Optimization <code>optimize_cross_calling</code> – Enumeration	Reduces code size at the expense of execution speed by factoring common code sequences into subroutines.
Code Factoring Passes <code>linker_cross_call_maximum_passes</code> – IntegerRange	The maximum number of passes to perform when code factoring (0=unlimited).
Code Factoring Subroutine Size <code>linker_cross_call_minimum_subroutine_size</code> – Integer	The minimum size of subroutine created by code factoring.
Code Motion Optimization <code>optimize_code_motion</code> – Boolean	Rearrange code to reduce the number of jump instructions.
Copy Propagation Optimization <code>optimize_copy_propagation</code> – Boolean	Tries to eliminate copy instructions and reduce code size.
Cross Jumping Optimization <code>optimize_cross_jumping</code> – Boolean	Always reduces code size at the expense of a single jump instruction.
Dead Code Elimination <code>optimize_dead_code</code> – Boolean	Remove code that is not referenced by the application.
Enable Exception Support <code>cpp_enable_exceptions</code> – Boolean	Specifies whether exception support is enabled for C++ programs.
Enable RTTI Support <code>cpp_enable_rtti</code> – Boolean	Specifies whether RTTI support is enabled for C++ programs.
Flash Size <code>avr_flash_size</code> – Enumeration	The maximum size of flash memory.

Flattening Optimization <code>optimize_flattening</code> – Boolean	Subroutines that are just a call followed by a return are flattened into a jump.
Jump Chaining Optimization <code>optimize_jump_chaining</code> – Boolean	Reduce spand-dependent jump sizes by chaining jumps together.
Jump Threading Optimization <code>optimize_jump_threading</code> – Boolean	Follow jump chains and retarget jumps to jump instructions.
Optimization Strategy <code>compiler_optimization_strategy</code> – Enumeration	Minimize code size or maximize execution speed (positive values).
Peephole Optimization <code>optimize_peepholes</code> – Boolean	Find instruction sequences that can be replaced with faster, smaller code.
Register Allocation <code>optimize_register_allocation</code> – Enumeration	Whether to allocate registers to locals or locals and global addresses.
Tail Merging Optimization <code>optimize_tail_merging</code> – Boolean	Always reduces code size at the expense of a single jump instruction.
Treat 'double' as 'float' <code>double_is_float</code> – Boolean	Forces the compiler to make 'double' equivalent to 'float'.
Use Hardware Multiplier <code>build_use_hardware_multiplier</code> – Enumeration	Enables code generation for the hardware multiplier.

Compiler Options

Property	Description
Additional C Compiler Only Options <code>c_only_additional_options</code> – 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 <code>c_only_additional_options_from_file</code> – 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 <code>c_additional_options</code> – 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 <code>c_additional_options_from_file</code> – 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 <code>cpp_only_additional_options</code> – 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 <code>cpp_only_additional_options_from_file</code> – ProjFile	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 <code>c_enforce_ansi_checking</code> – Boolean	Ensure programs conform to the ANSI-C/C++ standard.
Object File Name <code>build_object_file_name</code> – FileName	Specifies a name to override the default object file name.

Preprocessor Options

Property	Description
Ignore Includes <code>c_ignore_includes</code> – Boolean	Ignore the include directories properties.
Preprocessor Definitions <code>c_preprocessor_definitions</code> – StringList	Specifies one or more preprocessor definitions. This property will have macro expansion applied to it.
Preprocessor Undefinitions <code>c_preprocessor_undefinitions</code> – StringList	Specifies one or more preprocessor undefinitions. This property will have macro expansion applied to it.
System Include Directories <code>c_system_include_directories</code> – StringList	Specifies the system include path. This property will have macro expansion applied to it.
Undefine All Preprocessor Definitions <code>c_undefine_all_preprocessor_definitions</code> – Boolean	Does not define any standard preprocessor definitions.
User Include Directories <code>c_user_include_directories</code> – StringList	Specifies the user include path. This property will have macro expansion applied to it.

Section Options

Property	Description
Code Section Name <code>default_code_section</code> – String	Specifies the default name to use for the program code section.
Constant Section Name <code>default_const_section</code> – String	Specifies the default name to use for the read-only constant section.
Data Section Name <code>default_data_section</code> – String	Specifies the default name to use for the initialized, writable data section.
ISR Section Name <code>default_isr_section</code> – String	Specifies the default name to use for the ISR code.
Vector Section Name <code>default_vector_section</code> – String	Specifies the default name to use for the interrupt vector section.
Zeroed Section Name <code>default_zeroed_section</code> – String	Specifies the default name to use for the zero-initialized, writable data section.

User Build Step Options

Property	Description
Post-Compile Command <code>compile_post_build_command</code> – String	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 <code>compile_post_build_command_wd</code> – String	The working directory where the post-compile command is run. This property will have macro expansion applied to it.
Pre-Compile Command <code>compile_pre_build_command</code> – String	A command to run before the compile command. This property will have macro expansion applied to it.
Pre-Compile Command Output File Path <code>compile_pre_build_command_output_file_name</code>	The pre-compile generated file name. This property will have macro expansion applied to it.
Pre-Compile Working Directory <code>compile_pre_build_command_wd</code> – String	The working directory where the pre-compile command is run. This property will have macro expansion applied to it.

Debugging Properties

Debugger Options

Property	Description
Additional Load File <code>debug_additional_load_file</code> – ProjFileName	Additional file to load on debug load. This property will have macro expansion applied to it.
Additional Load File Address <code>debug_additional_load_file_address</code> – String	The address to load the additional load file.
Additional Load File Type <code>debug_additional_load_file_type</code> – Enumeration	The file type of the additional load file. The options are Detect , hzx , bin , ihex , hex , tihex , srec .
Command Arguments <code>debug_command_arguments</code> – String	The command arguments passed to the executable. This property will have macro expansion applied to it.
Debug Dependent Projects <code>debug_dependent_projects</code> – Boolean	Debugger will debug dependent projects.
Entry Point Symbol <code>debug_entry_point_symbol</code> – String	Debugger will start execution at symbol if defined.
Startup Completion Point <code>debug_startup_completion_point</code> – String	Specifies the point in the program where startup is complete. Software breakpoints and debugIO will be enabled after this point has been reached.
Working Directory <code>debug_working_directory</code> – DirPath	The working directory for a debug session.

JTAG Chain Options

Property	Description
JTAG Data Bits After <code>arm_linker_jtag_pad_post_dr</code> – IntegerRange	Specifies the number of bits to pad the JTAG data register after the target.
JTAG Data Bits Before <code>arm_linker_jtag_pad_pre_dr</code> – IntegerRange	Specifies the number of bits to pad the JTAG data register before the target.
JTAG Instruction Bits After <code>arm_linker_jtag_pad_post_ir</code> – IntegerRange	Specifies the number of bits to pad the JTAG instruction register with the BYPASS instruction after the target.
JTAG Instruction Bits Before <code>arm_linker_jtag_pad_pre_ir</code> – IntegerRange	Specifies the number of bits to pad the JTAG instruction register with the BYPASS instruction before the target.

Target Loader Options

Property	Description
Erase All <code>target_loader_erase_all</code> – 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.
No Load Sections <code>target_loader_no_load_sections</code> – StringList	Names of (loadable) sections not to load.

Target Script Options

Property	Description
Attach Script <code>target_attach_script</code> – String	The script that is executed when the target is attached to.
Connect Script <code>target_connect_script</code> – String	The script that is executed when the target is connected to.
Debug Begin Script <code>target_debug_begin_script</code> – String	The script that is executed when the debugger begins a debug session.
Debug End Script <code>target_debug_end_script</code> – String	The script that is executed when the debugger ends a debug session.
Debug Interface Reset Script <code>target_debug_interface_reset_script</code> – String	The script that is executed to reset the debug interface. If not specified the default debug interface reset will be carried out instead.
Disconnect Script <code>target_disconnect_script</code> – String	The script that is executed when the target is disconnected from.
Reset Script <code>target_reset_script</code> – String	The script that is executed when the target is reset.
Run Script <code>target_go_script</code> – String	The script that is executed when the target is run.
Stop Script <code>target_stop_script</code> – String	The script that is executed when the target is stopped.
Target Extras Script <code>target_extras_script</code> – String	The script that is executed to supply extra menu entries in the targets window context menu.
Target Script File <code>target_script_file</code> – FileName	The target script file.

Externally Built Executable Project Properties

External Build Options

Property	Description
Build Command <code>external_build_command</code> – String	The command line to build the executable.
Clean Command <code>external_clean_command</code> – String	The command line to clean the executable.
Debug Symbols File <code>external_debug_symbols_file_name</code> – ProjFileName	The name of the debug symbols file. This property will have macro expansion applied to it.
Debug Symbols Load Address <code>external_debug_symbols_load_address</code> – String	The (code) address to be added to the debug symbol (code) addresses.
Executable File <code>external_build_file_name</code> – ProjFileName	The name of the externally built executable. This property will have macro expansion applied to it.
Load Address <code>external_load_address</code> – String	The address to load the externally built executable.
Load File Type <code>external_load_file_type</code> – Enumeration	The file type of the externally built executable. The options are Detect , hxx , bin , ihex , hex , tihex , srec .
Start Address <code>external_start_address</code> – String	The address to start the externally built executable running from.

File and Folder Properties

(Information)

Property	Description
File Name <code>file_name</code> – 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: <code>\$(InputDir)</code> relative directory of file, <code>\$(InputName)</code> file name without directory or extension, <code>\$(InputFileName)</code> file name, <code>\$(InputExt)</code> file name extension, <code>\$(InputPath)</code> absolute path to the file name, <code>\$(RelInputPath)</code> relative path from project directory to the file name.
Name <code>Name</code> – String	Names the item. The macro <code>\$(ProjectNodeName)</code> is set to this value.
Platform <code>Platform</code> – String	Specifies the platform for the project. The macro <code>\$(Platform)</code> is set to this value.

File Options

Property	Description
File Encoding <code>file_codec</code> – Enumeration	Specifies the encoding to use when reading and writing the file.
File Open Action <code>file_open_with</code> – Enumeration	Specifies how to open the file when it is double clicked.
File Type <code>file_type</code> – Enumeration	The type of file. Default setting uses the file extension to determine file type.
Flag <code>file_flag</code> – Enumeration	Flag which you can use to draw attention to important files in your project.

Folder Options

Property	Description
Dynamic Folder Directory <code>path</code> – DirPath	Dynamic folder directory specification.
Dynamic Folder Filter <code>filter</code> – String	Dynamic folder directory specification.

Dynamic Folder Recurse <code>recurse</code> – Boolean	Dynamic folder recurse into subdirectories.
Filter <code>filter</code> – StringList	A filter used when adding new files to the project.

Project Options

Property	Description
Flag <code>project_flag</code> – Enumeration	Flag which you can use to draw attention to important projects in your solution.

Solution Options

Property	Description
Flag <code>solution_flag</code> – Enumeration	Flag which you can use to draw attention to important projects in your solution.

Library Project Properties

Library Options

Property	Description
Library File Name <code>build_output_file_name</code> – FileName	Specifies a name to override the default library file name.

Executable Project Properties

Library Options

Property	Description
I/O Library Name <code>link_IOLibraryName</code> – Enumeration	Specifies the IO library (printf etc) to use.
Include Standard Libraries <code>link_include_standard_libraries</code> – Boolean	Specifies whether the standard libraries should be linked into your application.
Standard Libraries Directory <code>link_standard_libraries_directory</code> – String	Specifies where to find the standard libraries
Use Multi Threaded Libraries <code>link_use_multi_threaded_libraries</code> – Boolean	Specifies whether to use thread safe standard libraries.

Linker Options

Property	Description
Additional Input Files <code>linker_additional_files</code> – StringList	Enables additional object and library files to be supplied to the linker.
Additional Linker Options <code>linker_additional_options</code> – StringList	Enables additional options to be supplied to the linker.
Additional Linker Options From File <code>linker_additional_options_from_file</code> – ProjFile	Enables additional options to be supplied to the linker from a file.
Additional Output Format <code>linker_output_format</code> – Enumeration	The format used when creating an additional linked output file.
Build BootLoader <code>avr_build_boot_loader</code> – Boolean	Build a bootloader executable
Call Stack Size <code>linker_call_stack_size</code> – IntegerRange	The number of bytes to allocate for the application's call stack.
Checksum Algorithm <code>linker_checksum_algorithm</code> – Enumeration	The algorithm used to checksum sections.
Checksum Sections <code>linker_checksum_sections</code> – StringList	The list of sections to checksum using the set checksum algorithm.
Data Stack Size <code>linker_data_stack_size</code> – IntegerRange	The number of bytes to allocate for the application's data stack.
DebugIO Supported <code>linker_DebugIO_enabled</code> – Boolean	Is DebugIO supported.
Executable File Name <code>build_output_file_name</code> – FileName	Specifies a name to override the default executable file name.

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.
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 substitute in section placement nodes - MACRO1=value1;MACRO2=value2.
Stack Size linker_stack_size – IntegerRange	The number of bytes to allocate for the application's stack.

Printf/Scanf Options

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 Supported linker_printf_enabled – Boolean	Is printf supported.
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 – Boolean	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.
Scanf Supported linker_scanf_enabled – Boolean	Is scanf supported.

User Build Step Options

Property	Description
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Link Patch Command <code>linker_patch_build_command</code> – String	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 <code>linker_patch_build_command_wd</code> – String	The working directory where the link patch command is run. This property will have macro expansion applied to it.
Post-Link Command <code>linker_post_build_command</code> – String	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.
Post-Link Working Directory <code>linker_post_build_command_wd</code> – String	The working directory where the post-link command is run. This property will have macro expansion applied to it.
Pre-Link Command <code>linker_pre_build_command</code> – String	A command to run before the link command. This property will have macro expansion applied to it.
Pre-Link Working Directory <code>linker_pre_build_command_wd</code> – String	The working directory where the pre-link command is run. This property will have macro expansion applied to it.

Staging Project Properties

Staging Options

Property	Description
Output File Path <code>stage_output_filepath</code> – String	The output file path the stage command will create. This property will have macro expansion applied to it.
Set To Read-only <code>stage_set_readonly</code> – Boolean	Set the output file to read only or read/write.
Stage Command <code>stage_command</code> – String	The command to execute. This property will have macro expansion applied to it with the additional <code>\$(StageOutputFilePath)</code> macro set to the output filepath of the stage command.
Stage Command Working Directory <code>stage_command_wd</code> – String	The working directory in which the stage command is run. This property will have macro expansion applied to it.
Stage Post-Build Command <code>stage_post_build_command</code> – String	The command to execute after staging commands have executed. This property will have macro expansion applied to it.
Stage Post-Build Command Working Directory <code>stage_post_build_command_wd</code> – String	The working directory where the post build command runs. This property will have macro expansion applied to it.

System Macros

System Macro Values

Property	Description
\$(Date) \$(Date) – String	Day Month Year e.g. 21 June 2011.
\$(DateDay) \$(DateDay) – String	Year e.g. 2011.
\$(DateMonth) \$(DateMonth) – String	Month e.g. June.
\$(DateYear) \$(DateYear) – String	Day e.g. 21.
\$(DesktopDir) \$(DesktopDir) – String	Path to users desktop directory e.g. c:/users/mpj/Desktop.
\$(DocumentsDir) \$(DocumentsDir) – String	Path to users documents directory e.g. c:/users/mpj/Documents.
\$(HomeDir) \$(HomeDir) – String	Path to users home directory e.g. c:/users/mpj.
\$(HostArch) \$(HostArch) – String	The CPU architecture that CrossStudio is running on e.g. x86.
\$(HostDLL) \$(HostDLL) – String	The file extension for dynamic link libraries on the CPU that CrossStudio is running on e.g. .dll.
\$(HostDLLExt) \$(HostDLLExt) – String	The file extension for dynamic link libraries used by the operating system that CrossStudio is running on e.g. .dll, .so, .dylib.
\$(HostEXE) \$(HostEXE) – String	The file extension for executables on the CPU that CrossStudio is running on e.g. .exe.
\$(HostOS) \$(HostOS) – String	The name of the operating system that CrossStudio is running on e.g. win.
\$(Micro) \$(Micro) – String	The CrossWorks target e.g. ARM.
\$(PackagesDir) \$(PackagesDir) – String	Path to the users packages directory e.g. c:/users/mpj/AppData/Local/Rowley Associates Limited/CrossWorks for ARM/packages.
\$(Platform) \$(Platform) – String	The CrossWorks target e.g. arm

\$(SamplesDir) \$(SamplesDir) – String	Path to the samples subdirectory of the packages directory e.g. c:/users/mpj/AppData/Local/Rowley Associates Limited/CrossWorks for ARM/packages/samples.
\$(StudioDir) \$(StudioDir) – String	The install directory of CrossStudio e.g. c:/Program Files(x86)/Rowley Associates Limited/CrossWorks for ARM 2.0.
\$(StudioMajorVersion) \$(StudioMajorVersion) – String	The major release version of CrossStudio e.g. 2.
\$(StudioMinorVersion) \$(StudioMinorVersion) – String	The minor release version of CrossStudio e.g. 0.
\$(StudioName) \$(StudioName) – String	The name of CrossStudio e.g. CrossStudio for ARM.
\$(StudioRevision) \$(StudioRevision) – String	The release revision of CrossStudio e.g. 11.
\$(StudioUserDir) \$(StudioUserDir) – String	The directory containing the packages directory e.g. c:/users/mpj/AppData/Local/Rowley Associates Limited/CrossWorks for ARM.
\$(TargetID) \$(TargetID) – String	ID number representing the CrossWorks target.
\$(TargetsDir) \$(TargetsDir) – String	Path to the targets subdirectory of the packages directory e.g. c:/users/mpj/AppData/Local/Rowley Associates Limited/CrossWorks for ARM/packages/targets.
\$(Time) \$(Time) – String	Hour:Minutes:Seconds e.g. 15:34:03.
\$(TimeHour) \$(TimeHour) – String	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>\$(CombiningOutputFilePath)</code> <code>\$(CombiningOutputFilePath) - String</code>	The full path of the output file of the combining command.
<code>\$(CombiningRelInputPaths)</code> <code>\$(CombiningRelInputPaths) - String</code>	The relative inputs to the combining command.
<code>\$(Configuration)</code> <code>\$(Configuration) - String</code>	The build configuration e.g. ARM Flash Debug.
<code>\$(EXE)</code> <code>\$(EXE) - String</code>	The default file extension for an executable file including the dot e.g. .elf.
<code>\$(InputDir)</code> <code>\$(InputDir) - String</code>	The absolute directory of the input file.
<code>\$(InputExt)</code> <code>\$(InputExt) - String</code>	The extension of an input file not including the dot e.g. cpp.
<code>\$(InputFileName)</code> <code>\$(InputFileName) - String</code>	The name of an input file relative to the project directory.
<code>\$(InputName)</code> <code>\$(InputName) - String</code>	The name of an input file relative to the project directory without the extension.
<code>\$(InputPath)</code> <code>\$(InputPath) - String</code>	The absolute name of an input file including the extension.
<code>\$(IntDir)</code> <code>\$(IntDir) - String</code>	The macro-expanded value of the Intermediate Directory project property.
<code>\$(LIB)</code> <code>\$(LIB) - String</code>	The default file extension for a library file including the dot e.g. .lib.
<code>\$(OBJ)</code> <code>\$(OBJ) - String</code>	The default file extension for an object file including the dot e.g. .o.
<code>\$(OutDir)</code> <code>\$(OutDir) - String</code>	The macro-expanded value of the Output Directory project property.
<code>\$(PackageExt)</code> <code>\$(PackageExt) - String</code>	The file extension of a CrossWorks package file e.g. hzq.
<code>\$(ProjectDir)</code> <code>\$(ProjectDir) - String</code>	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> <code>\$(ProjectName) - String</code>	The project name of the current project.
<code>\$(ProjectNodeName)</code> <code>\$(ProjectNodeName) - String</code>	The name of the selected project node.

<code>\$(RelInputPath)</code> <code>\$(RelInputPath) – String</code>	The relative path of the input file to the project directory.
<code>\$(RootOutDir)</code> <code>\$(RootOutDir) – String</code>	The macro-expanded value of the Root Output Directory project property.
<code>\$(RootRelativeOutDir)</code> <code>\$(RootRelativeOutDir) – String</code>	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> <code>\$(SolutionDir) – String</code>	The absolute path of the directory containing the solution file.
<code>\$(SolutionExt)</code> <code>\$(SolutionExt) – String</code>	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.

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.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.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.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.getlineumber() 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.