CrossWorks for ARM

Welcome to CrossWorks for ARM!

CrossWorks for ARM is a streamlined integrated development environment, compilation tools, and libraries for building, testing, and deploying applications on ARM7, ARM9, and XScale microcontrollers.

Documentation overview

A comprehensive collection of technical documentation, including reference material, release notes, sample code, technical notes, and Q&As. Each of the links below leads to the resources for a specific topic. Key resources also include getting started documents, API references, and cross-references for related topics.

If you have a question or need some help working with CrossStudio, please check our frequently asked questions page or use CrossStudio's **Help window** (page 124). If the problem is not covered in the documentation, see **Requesting support and reporting problems** (page 18) for more information.

Introduction

This guide is divided into a number of sections:

- **Introduction (page 2).** 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 (page 19).** Describes how to get started with CrossStudio and runs through all the steps from creating a project to debugging it on hardware.
- **CrossStudio Reference (page 41).** Contains information on how to use the CrossStudio development environment to manage your projects, build, and debug your applications.
- **Tasking Library Tutorial (page 200).** Contains documentation on using the CrossWorks tasking library to write multi-threaded applications.
- **ARM Library Reference (page 221).** Contains documentation for the functions that are specific to the ARM.
- **Standard C Library Reference (page 258).** Contains documentation for the functions in the standard C library supplied in the package.
- **GCC Users Guide.** Contains an htmlised version of the GCC user documentation.
- **ARM Target Support (page 148).** Contains a description of system files used for startup and debugging of ARM executables.

- **ARM Target Interfaces (page 144).** Contains a description of the support ARM target interfaces.

What is CrossWorks?

CrossWorks for ARM is a complete C development system for ARM 7 microprocessors. It comprises of the ARM GCC C compiler, the CrossWorks C Library and the CrossStudio integrated development environment.

In order to use CrossWorks for ARM you will need:

- Windows 98, Windows Me, Windows NT 4.0, Windows 2000 or Windows XP.
- A Macgraigor Wiggler for ARM (WNPJ-ARM-20/WNPJ-ARM-14) or compatible parallel port to JTAG interface.
- An ARM 7 target board with 20 or 14 pin JTAG connector. CrossWorks for ARM provides support for several ARM based microcontrollers out of the box in the form of examples and target configurations. CrossWorks can also be easily modified to support other ARM 7 targets, see **ARM Target Support** (page 148) for more information.

GCC

CrossWorks for ARM comes with a pre-built version of the GCC C and C++ compiler, assembler, linker and other tools to enable you to immediately begin developing applications for ARM.

CrossWorks C Library

CrossWorks for ARM has it's own royalty-free ANSI and ISO C compliant C library that has been specifically designed for use within embedded systems.

CrossStudio IDE

CrossStudio for ARM is a streamlined integrated development environment (IDE) for building, testing, and deploying ARM 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 organises 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 developer card or into the debugger.
- **ARM Hardware Debug** With the Macgraigor Wiggler attached, you can use the integrated debugger to step through and diagnose problems in your software on your target board.

- **Integrated Debugger** The debugger will help you to quickly find problems in your ARM and THUMB applications.
- **ARM Flash Programming and Debug** You can download your programs directly into Flash and debug them seamlessly from within the IDE.
- **Integrated Help system** The built-in help system provides context-sensitive help and a complete reference to the CrossStudio IDE and tools.

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 ARM 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. For Microsoft Windows development environment we recommend Windows 2000 or Windows XP, but you can use Windows NT 4, Windows 95, Windows 98, or Windows Me if you wish.

C programming guides

- 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 ANCI C (1990 version).
- Harbison, S.P. and Steele, G.L., *A C 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. Written by Guy Steele, a noted language expert.

ANSI C reference

- 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 www.iso.ch.

ARM

- ARM technical reference manuals, specifications, user guides and white papers for can be found at http://www.arm.com/Documentation/.

GCC

- The latest GCC documentation, news and downloads can be be found at http://gcc.gnu.org/.

Release notes

Changes in Release 1.6 Build 1

General

- Added support for **Cortex-M3** (ADIv5) in Wiggler (or compatible) and CrossConnect JTAG adapters.
- New package-based target support. CrossWorks now ships without any target support. Support packages for various targets are installed after CrossWorks installation.
- Updated versions of the C/C++ compilers from the GNU Compiler Collection and assembler, linker, librarian from GNU Binutils that support Thumb-2 code generation. These are based on the CodeSourcery arm-2005q3-2 release with updates for the ARMv7M architecture.

CrossStudio

- Added **Windows** docking window (**Ctrl+Alt+R**) which replaces the **Window > Windows** dialog.
- Re-worked **Debug Windows** menu organisation.
- Added a quick document selector on **Ctrl+Tab** and **Ctrl+Shift+Tab** which mimics Windows Explorer Alt-tabbing.
- Now **Ctrl+Tab** and **Ctrl+Shift+Tab** follow Visual Studio tabbing behaviour so that you can quickly alternate between the same two documents.
- New **Paste As String**, **Paste As HTML**, and **Paste As Comment** to quickly paste copied content into program source code.
- Dynamic visual brace, parenthesis, and bracket matching automatically which highlights the mate if it is visible on the screen.
- New **Bookmarks** window (**Ctrl+Alt+K** or **View > Bookmarks**): bookmarks are now permanent and the **Edit > Bookmarks** menu is updated to reflect the new bookmark capability.
- Numbered (permanent) bookmarks 1 through 9 can be dropped (**Ctrl+K, 1** through **Ctrl+K, 9**) and jumped to (**Ctrl+Q, 1** through **Ctrl+Q, 9**).
- New **Find and Replace** window (**Ctrl+Alt+F** or **Search > Find And Replace**) which contains a much enhanced find and replace capability, including project-wide, solution-wide, all-open-document, and directory (and subdirectory) find and replace.

- Exception trapping support is moved from **Debug > Exceptions** to the **Breakpoints** window to better highlight debugger and simulator capabilities and state.
- **Help > Keyboard Map** now has a **Report** feature to generate an HTML keyboard map report to an editor for saving or printing.
- New **Autos** window (**Debug > Autos**) that displays automatic variable and expression values for the current context. Note that this is not the same as the **Locals** window—the **Locals** window displays the values of parameters and local variables in the currently selected frame, the **Autos** window displays globals, locals, and expressions for the context around the current and previous execution points.
- New environment option to hide the **Output** window after a successful build (which is now the default).
- New option to hide the **Output** window after a successful download (which is now the default).
- Fixed phantom windows reappearing in a dock site after the final dock window in a dock site was closed.
- Added new **Undo** and **Redo** grouping styles in **Tools > Options**: **Individual words** (now the default), **Individual characters** (the default up to v1.5), and **Whole of last insertion** (like Microsoft Word and many other Office applications).
- New code editor key sequences: Delete Word (**Ctrl+K, T**) to delete the word under the cursor, Delete to Start of Line (**Ctrl+K, Backspace**), Delete to End of Line (**Ctrl+K, Ctrl+K**), and Select Word (**Ctrl+Q, T**).
- In addition to the middle mouse button bringing up the **Go To Function** menu, **Alt-Middle** will bring up the **Go To Header** menu.
- **Go To Definition** (**Ctrl+Q, D**) will move the cursor to the definition of the variable or function under the cursor and drop a navigation marker.
- **Go To Declaration** (**Ctrl+Q, E**) will move the cursor to the declaration of the variable or function under the cursor and drop a navigation marker.
- The code editor now allows additional per-language user-defined keywords. Set these up in the **Languages** pane of the **Tools > Options** dialog.
- **Tools > Options** now opens at the previously-selected page rather than always at Environment/General.
- Added **Install Package** and **Remove Package** to **Tools** menu. This is used to install and remove target support files.

- Added **Import Section Placement** and **View Section Placement** actions to project explorer.
- Number of projects displayed in Solution name fixed in project explorer.
- Added **Start Debugging** and variants from the project explorer context menu.
- Added new options to **Tools > Options** to connect to target on start debugging and disconnect on stop debugging.
- New linker property **Treat Warnings As Errors**. Since linker warnings are usually fatal this is set to **Yes** by default.
- Linker property **Entry Point** now defaults to **reset_handler** rather than 0x00000000.
- Linker property **Keep Symbols** now defaults to **_vector**.
- Compiler property **Enforce ANSI Checking** now works with C++ files.
- New compiler property **Keep Assembly Code** which will keep the assembly code output of the compiler.
- Compiler now defines the symbol **__CROSSWORKS_ARM**.
- New compiler property **Generate Static call_via_rX** which works around a restriction in the implementation of long calls when using Thumb code generation.
- New staging property **Post Stage Command**.
- New section property **Vector Section Name**.
- Fixed **debug_break** on ARM7TDMI.
- Fixed crash when the debugger displayed variables that it couldn't find a type for.
- Addresses in memory map files that are preceeded by a + are treated as offsets from the enclosing address.

Target Interfaces

- Simulator now uses a DLL file to implement the memory system of the simulated target. Target-specific DLL files are shipped with target specific packages.
- Simulator now runs the loader executables if appropriate for target.
- Segger J-Link DLL file is now not shipped with CrossWorks. You must install the Segger software and modify the appropriate Segger J-Link target property to point to the jlinkarm.dll file.
- Added support for XScale devices with 7 bit JTAG instruction registers.

- Added support for the Cortex-M3 debug inteface in Wiggler and CrossConnect targets.
- **Erase All** now supported.

Libraries

- Libraries are now built for V4, V4T, V5TE and V7M architectures. The V3 architecture is not supported in this release.

CTL

- CTL projects are now created that reference the source code of CTL. This simplifies debugging and end user customisation of the CTL source code.
- New variable **ctl_timeslice_period**, when non-zero implements timeslicing.
- New byte queues that are a specialisation of message queues.
- The **use_timeout** parameter to blocking functions can now specify an absolute or a delay time period.
- Replaced usage of **swi** with **msr** when changing from system to supervisor mode in a co-operative task switch.
- Updated default CTL application.

Known Problems

- **Replace in Files** is not yet implemented.

Changes in Release 1.5 Build 2

CrossStudio

- Fixed crash when disassembling address ranges that wrap.
- Simulator modified to avoid crash due to memory allocation based on project memory map.
- First release of **Disk Explorer** window.

ARM target support

- Fixed STR7 and SAM7 header files.
- Fixed problem when unplugging the CrossConnect.

Changes in Release 1.5

- Support for redesigned CrossConnect for ARM.
- GCC version 3.4.4 of gcc.exe, cc1.exe and cc1plus.exe are supplied.
- Binutils version 2.16.1 of ar.exe, as.exe, ld.exe, nm.exe, objcopy.exe, objdump.exe, ranlib.exe and strip.exe are supplied.

ARM target support

- Target support header files now contain bit field defines.

CrossStudio

- Fixed crash when locating to disassembly mode.
- General improvements to disassembly/intermixed modes.
- Fixed remove and solution rename bugs in project explorer.
- Fixed problems with upper case project filename.
- Workaround for ELF files that don't have .pubnames and .aranges section.
- Find in files and find in project files now save open files.
- Added default workspace layout option to Window menu.
- Fixed rebuild bug when additional output files are generated.
- Improved support for C++ variable/symbol display.

Changes in Release 1.4

ARM target support

- Support for TI TMS470.
- Support for theARMPatch AT91-SBC.
- Support for theARMPatch LPC-SBC2.
- Support for LogicPD SDKLH79520.
- Enhanced Philips LPC support - improved loader and memory map files.
- JTAG interface now supports daisychaining in order to support multi-core devices.
- Improved wiggler performance.
- Can now alter J-Link JTAG clock speed.

CrossStudio

- Added address and size display to memory map editor.
- New file type Linker Script that will be used for linkage in preference to the section placement and memory map files.
- Added Import Memory Map function on projects that don't have a processor type property.
- The View Memory Map function is now only available on projects that have a processor type property.
- Added Processor and Import nodes to the memory map file - these currently can only be displayed in the memory map editor.
- Debugger can now display VFP and FPA floating point format numbers.

C/C++ Library

- Added new option to enable or disable linking of the GCC libraries.

- Now supports RTTI and exceptions.

Build 2 Changes

- Fixed missing floating point libraries.

Build 3 Changes

- Added support for Freescale MC9328MXL Dragonball including examples for M9328MXLADS board

Build 4 Changes

- Added CVS configuration management support.
- Added support for ATMEL AT91SAM7A1, AT91SAM7A2 and AT91SAM7A3 including examples for AT91SAM7A1-EK board.

Build 5 Changes

- Wiggler target interface now works with ARM9EJS.

Changes in Release 1.3

- Support for CrossConnect for ARM.
- Added new program crossbuild that enables command line building.
- Added new program crossload that enables command line loading.
- Version 3.4.2 of gcc.exe, cc1.exe and cc1plus.exe are shipped.

ARM target support

- Support for XScale processors.
- Support for cache flushing on breakpoint (required for 920T and 740T cores).
- Support for STMicroelectronics STR71x parts.
- Support for ATMEL AT91SAM7 parts.
- Support for latest Philips LPC2xxx parts and faster flash loader.
- Support for GamePark GP32.
- Added Processor type property for Analog Devices ADuC702x parts.
- Added fast FLASH verification.

CrossStudio

- Disassembly is intermixed with source code when debug is enabled.
- Properties, configurations and system files are now selectable at project creation time.
- Default executable project will now run on an ARM with RAM mapped at 0x00000000.
- The Symbols Window can be printed.
- Added linkage map generation to the Linker property group and display in the project explorer.

- Added remove ununsed symbol capability to the Build property group.
- Input/Output options have been renamed Printf/Scanf options and can be more finely controlled.
- Added support for SourceOffSite 3.5.1 to source code integration.
- Added new source code control window that displays a filtered list of the project files.
- Fixed problem with memory map editor sorting section placement files.
- Built-in commands (cp, chmod etc) now work relative to the project directory.

CrossStudio Debugging

- Variable display, pointers now have an expand button.
- Variable display, arrays not fetched until expand button is pressed.
- Variable display, pointers to structs displayed as one level.
- Debugger now displays bool and bitfields types correctly.
- Added support for bitfields in many of the processor register displays.
- Fixed problem printing global variables when not defined in the current compilation unit.
- Fixed problem printing enumeration variables.
- Environment option to break on main (or other symbol) if no breakpoints are set.

C Library

- Faster implementations of memset, strlen and strcpy functions - improves Dhrystone numbers.
- Fixed **fmod** looping when given two value whose relative magnitude is greater than 2^23.
- Fixed **tanh** using bad polynomial for numbers >= ~0.5.
- **printf** formats 0.0 in %g format as "0" rather than "0e+00".

ARM Library

- Added header file __debug_stdio.h that enables C stdio functions (e.g. printf) to be used.
- DebugI/O library now has debug_exit and debug_time functions.
- CTL has been extensively (unfortunately not compatible with the previous release) revised and now includes support for integer valued priority semaphores and message queues.
- ARMLib has support for re-enabling interrupts from an ISR.

Changes in Release 1.2

CrossStudio

- Integrated the new fast floating point routines from GCC 3.4.0.
- Board specific CTL source code now shipped.
- Fixed printing of arrays of structs in debugger.
- Segger J-LINK ARM JTAG interface now supported.
- Post build step now possible after link.
- Support for the Revely (Sharp MCU) boards.
- More LPC2000 boards supported (Olimex LPC-P1, Keil MCB2100 and IAR LPC210x KickStart).
- Executable files now have the .elf extension.
- The LPC2000 project type now has a processor property.
- Fixed problem with the THUMB build of the maths library.
- Added a new linker property to enable ARM or THUMB versions of the library to be selected independently of the application build type e.g. THUMB app using ARM library.
- Modified LPC2000 FLASH loader. The FLASH loader no longer needs to be rebuilt in order to support boards running at different oscillator frequencies, the frequency can now be specified in the **Target | Loader Parameter** project property.
- Version 3.3.3 of gcc.exe, cc1.exe and cc1plus.exe are shipped.
- Improvements to Visual SourceSafe integration - now detects writing of source controlled files and prompts for checkout.
- The Wiggler JTAG clock frequency can now be reduced in order to support boards with unreliable target interface connections.

Changes in Release 1.1

CrossStudio

- New icons for target interface connections.
- Code templates can now be edited and are remembered.
- Assembly code files now have their own indentation settings in the text editor and environment options.
- Support for Philips LPC210x parts.

- Added **Print Preview** capability, now found on the **File** menu and in the standard tool bar.
- Printing now works for both HTML and text editor documents.
- The **Print** tool button on the toolbar prints immediately to the default printer, as in Microsoft Office, without bringing up a **Print** dialog. The default printer is shown in the tool tip of the **Print** tool button.
- The **Project** menu has been split into **Project** and **Build** menus to reduce the size of a combined menu.
- The **Edit | Find** menu has been promoted to the menu bar and renamed **Search**.
- A new environment property (Environment Options | Build | General | Before Debugging | Build before Debug) will automatically build a project when out of date rather than displaying a dialog.
- Added the **Clipboard Ring** which operates rather like the Office Clipboard in Microsoft Office and identically to the Clipboard Ring in Microsoft Visual Studio .NET.
- Added **Auto Step** to the **Debug** menu to animate program stepping.
- The **SFR Window** has been combined into the **Registers Window**. There are now four general register windows that can each be configured to display one or more groups of SFR and CPU registers.
- The mouse middle button brings up the **Goto Function** menu.
- The **Goto Function** menu now works on assembly language files and displays the list of labels in the source file.
- The way that errors are highlighted in the code editor can be configured as no highlighting, underline error, flag error in the margin, or underline and flag the error.
- For Windows, the IDE now stores its settings in the registry under the current user key rather the local machine key.
- The **Build Log** and **Target Log** have been rewritten to display relevant errors, warnings, and notes in a nicer form.
- The **Call Stack** window can optionally display the calling source file, line number, and call address.
- Added **Enable Interrupt Processing** and **Disable Interrupt Processing** tool buttons to the **Debug** toolbar.
- The properties window dialog doesn't stay focused when other selections are made.

- **Register** window now saves the radix when it is changed for a given entry.
- Fixed problem exiting when the session file was read only.
- The **debug_putchar** function now outputs a single byte.
- Additional assembler/compiler/linker properties are now held as a string list so the property inheritance system applies to them.
- Fixed problem with date check and string list properties.
- Support for file differencing.
- Support for **Visual SourceSafe** integration.
- **Registers** window can now display bitfields.
- Implemented **Disassemble** function on project explorer right click.
- Can build C++ programs - C++ library currently not supported.
- Debugger handles large programs better.
- Debugger expressions have limited support for the C++ :: operator.
- Source navigator now just reparses files that have changed.
- Debugger threads window that enables RTOS threads to be displayed by executing a JavaScript program.
- JavaScript console window that enables JavaScript expressions to be evaluated.
- Wiggler download speed has increased.
- Memory window has an option to access memory by display width.
- Breakpoints on addresses now set an execute breakpoint not a data write.
- Removed target specific files from the target system. These are now put into the project at project creation time. Existing projects are automatically upgraded when they are loaded.
- Instruction set simulator included to enable evaluation of CrossWorks without hardware.
- CrossWorks tasking library included in distribution.
- Project system now creates ARM and THUMB configurations for executable projects.
- Project system now creates configurations for library builds.
- Support for ARM9 debug interface.
- Target specific header file supplied in targets subdirectory of include.

- Version 3.3.2 of gcc.exe, cc1.exe and cc1plus.exe are shipped.
- memcpy has been written in ARM assembly code to speed it up.
- Improved ARM and THUMB disassembly.
- Support for Aeroflex AX07CF192.
- Support for MPE ARM Development Kit.

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.
- From the **Help** menu, click **About CrossStudio**.
- Click the **Product Activation** tab.
- Using e-mail, send the contents of the **Registration Key** field 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.
- From the **Help** menu, click **About CrossStudio**.
- Click the **Product Activation** tab.
- Type in or paste the returned activation key into the **Activation Key** field.
- The **License Details** field will change to indicate the type of activation key entered and how long the evaluation lasts for.

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, follow these instructions:

- If you have not already done so, install CrossWorks on your computer using the CrossWorks installer and accept the license agreement.
- Run the **CrossStudio** application.
- From the **Help** menu, click **About CrossStudio**.
- Click the **Product Activation** tab.
- Type or paste your product key into the **Product Key** field.
- Using e-mail, send the contents of the **Registration Key** field to the e-mail address **license@rowley.co.uk**.

By return you will receive an **activation key**. To activate CrossWorks:

- Run the **CrossStudio** application.
- From the **Help** menu, click **About CrossStudio**.
- Click the **Product Activation** tab.
- Type in or paste the returned activation key into the **Activation Key** field.
- The **License Details** field will change to indicate the type of activation key entered.

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

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 dialogue with the computer using the format of the compilation command given above:

```
c:\crossworks\examples>hcl -v myprog.c
CrossWorks MSP430 Compiler Driver   Release 1.0.0
Copyright (c) 1997-2004 Rowley Associates Ltd.
```

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.

Standard syntactic metalanguage

In a formal description of a computer language, it is often convenient to use a more precise language than English. This language-description language is referred to as a *metalanguage*. The metalanguage which will be used to describe the C language is that specified by British Standard 6154. A tutorial introduction to the standard syntactic metalanguage is available from the National Physical Laboratory.

The BS6154 standard syntactic metalanguage is similar in concept to many other metalanguages, particularly those of the well-known Backus-Naur family. It therefore suffices to give a very brief informal description here of the main points of BS6154; for more detail, the standard itself should be consulted.

- Terminal strings of the language—those built up by rules of the language—are enclosed in quotation marks.
- Non-terminal phrases are identified by names, which may consist of several words.
- When numbers are used in the text they will usually be decimal. When we wish to make clear the base of a number, the base is used as a subscript, for example 15_8 is the number 15 in base eight and 13 in decimal, $2F_{16}$ is the number 2F in hexadecimal and 47 in decimal.
- A sequence of items may be built up by connecting the components with commas.
- Alternatives are separated by vertical bars ('|').
- Optional sequences are enclosed in square brackets ('[' and ']').

- Sequences which may be repeated zero or more times are enclosed in braces (‘{’ and ‘}’).
- Each phrase definition is built up using an equals sign to separate the two sides, and a semicolon to terminate the right hand side.

Requesting support and reporting problems

With software as complex as CrossWorks, it’s it’s almost inevitable that you’ll need assistance at some point. Here are some pointers on what to do when you think you’ve found a problem.

Requesting help

If you need some help working with CrossWorks, please contact our support department by e-mail, **support@rowley.co.uk**.

Reporting a bug

Should you have a problem with this product which you consider a bug, please report it by e-mail to our support department, **bugs@rowley.co.uk**.

Support and suggestions

If you have any comments or suggestions regarding the software or documentation, please send these in an e-mail to **support@rowley.co.uk** or in writing to:

CrossWorks Customer Support
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CrossStudio Tutorial

CrossStudio allows you to organize your collection of projects into a workspace or *solution*. We provide a number of project templates for popular evaluation and demonstration boards with the product which you can use as a springboard to start your application development. A project is typically organized into groups, where each group gathers together files that are related—for example, header files, source files, and documentation files can all have their own group in a project.

This section will take you through creating, compiling, and debugging a simple application using the build-in simulator to prepare you for starting your own projects using CrossStudio.

In this section

- **Creating a project (page 20).** Describes how to start a project, select your target processor, and other common options.
- **Managing files in a project (page 22).** Describes how to add existing and new files to a project and how to remove items from a project.
- **Setting project options (page 26).** Describes how to set options on project items and how project option inheritance works.
- **Building projects (page 28).** Describes how to build the project, correct compilation and linkage errors, and find out how big your applications are.

- **Exploring projects (page 30).** Describes how to use the Project Explorer, Symbol Browser, and Source Navigator to find out how much memory your project takes and navigate around the files that make up the project. It also describes the similarities and differences between the three windows.
- **Using the debugger (page 35).** Describes the debugger and how to find and fix problems at a high level when executing your application.
- **Low-level debugging (page 38).** Describes how to use debugger features to debug your program at the machine level by watching registers and tracing instructions.

Creating a project

To start developing an application, you create a new project. To create a new project, do the following:

- From the **File** menu, click **New** then **New Project...**

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

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

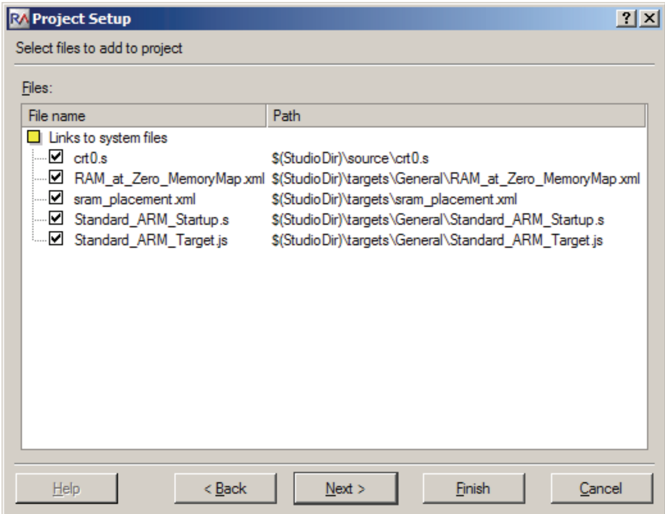
- Click the **Executable** icon in the **Templates** pane which selects the type of project to add.
- Type `Tutorial` in the **Name** edit box, which names the project.
- You can use the **Location** edit box or the **Browse** button to locate where you want the project to be created.
- Click **OK**.

This will create a project for a generic ARM target that has RAM mapped at address 0x00000000, as we are going to run this example on the simulator this is fine. ARM hardware however is rarely so accommodating as memory will be mapped at different addresses, target specific startup code may be required to initialize peripherals, different techniques need to be employed to reset the target and target specific loader applications are required to program FLASH. To create a project to run on hardware you should instead select a template from the project type matching your target, this will create a project with the memory maps, startup code, reset script and FLASH loader for your target.

Once created, the project setup wizard prompts you to set some common options for the project.

Here you can specify an additional file format to be output when the application is linked, and what library support to include if you use **printf** and **scanf**. You can change these settings after the project is created using the Project Explorer.

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



The **Links to system files** group shows the links that will be created in the project to CrossStudio system files. Project links are fully explained in **Project management** (page 48), and we can ignore these for now.

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

Here you can specify the default configurations that will be added to the project. Project configurations are fully explained in **Project management** (page 48), and we can ignore these for now.

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

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

- From the **View** menu, click **Project Explorer**.

or

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

or

- Right click the tool bar area.

- From the popup menu, select **Project Explorer**.

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

You'll notice that the project name is shown in bold which indicates that it is the active project (and in our case, the only project). If you have more than one project then you can set the active project using the dropdown box on the build tool bar or the context menu of the project explorer.

The files are arranged into two groups:

- **Source Files** contains the main source files for your application which will typically be 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 yet are required when the project is built and run. In this case, the system files are `crt0.s` which is the C runtime startup written in assembly code, `RAM_at_Zero_MemoryMap.xml` a memory map file that describes a target with RAM located at address 0x00000000, `sram_placement.xml` which directs the linker on how to arrange program sections in memory, `Standard_ARM_Startup.s` which contains the target specific start code and exception vectors and `Standard_ARM_Target.js` which contains the target specific target script which instructs the debugger on how to reset the target and what to do when the processor stops or starts. Files which are stored outside of the projects home directory are shown by 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 together in the project explorer. You can create new folders and specify filters based on the file extension so that when you add a new file to the project it will be placed in the folder whose filter matches the file extension.

Managing files in a project

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

Adding an existing file to a project

We will add one of the tutorial files to the project. To add an existing file to the project, do the following:

- From the **File** menu, click **Add Existing File**.

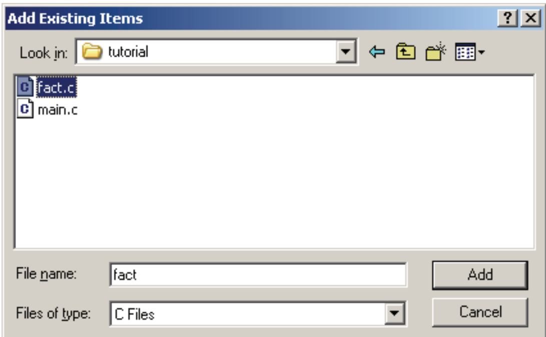
or

- Type **Ctrl+D**.

or

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

When you've done this, CrossStudio displays a standard file locator dialog. Navigate to the CrossStudio installation directory, then to the `tutorial` folder, select the `fact.c`.

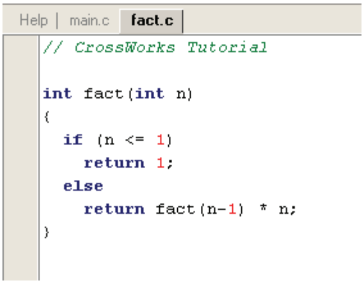


Now click **OK** to add the file to the project. The Project Explorer will show `fact.c` with a shortcut arrow because the file is not in the project's home directory. Rather than edit the file in the tutorial directory, we'll take a copy of it and put it into the project home directory:

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

The shortcut arrow disappears from the `fact.c` node which indicates that the file is now in our home directory.

We can open a file for editing by double clicking the node in the Project Explorer. Double clicking `fact.c` brings it into the code editor:



Adding a new file to a project

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

- From the **Project** menu, click **New File**.

or

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

or

- In the **Project Explorer**, right click the `Tutorial` node.
- From the context menu, click **Add New File**.

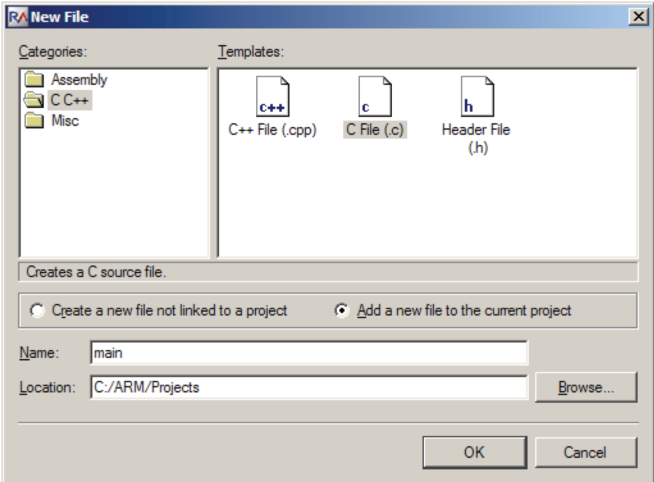
or

- Type **Ctrl+N**.

The **New File** dialog appears.

- Ensure that the **C File (.c)** icon is selected.
- In the **Name** edit box, type `main`.

The dialog box will now look like this:

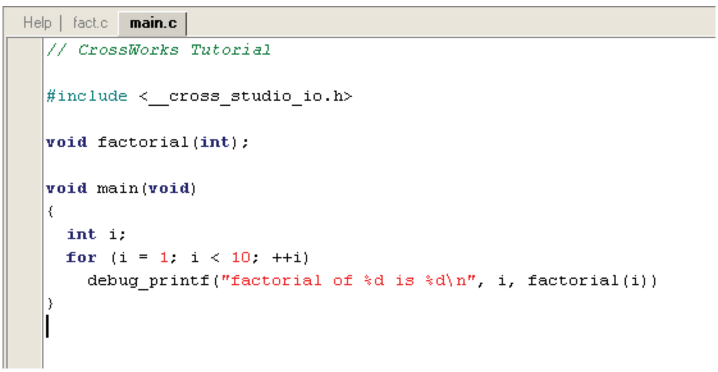


Click **OK** to add the new file.

CrossStudio opens an editor with the new file ready for editing. Rather than type in the program from scratch, we'll add it from a file stored on disk.

- From the **Edit** menu, click **Insert File** or type **Ctrl+K**, **Ctrl+I**.
- Using the file browser, navigate to the `tutorial` directory.
- Select the `main.c` file.
- Click **OK**.

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



Next, we'll set up some project options.

Setting project options

You have now created a simple project, and in this section we will set some options for the project.

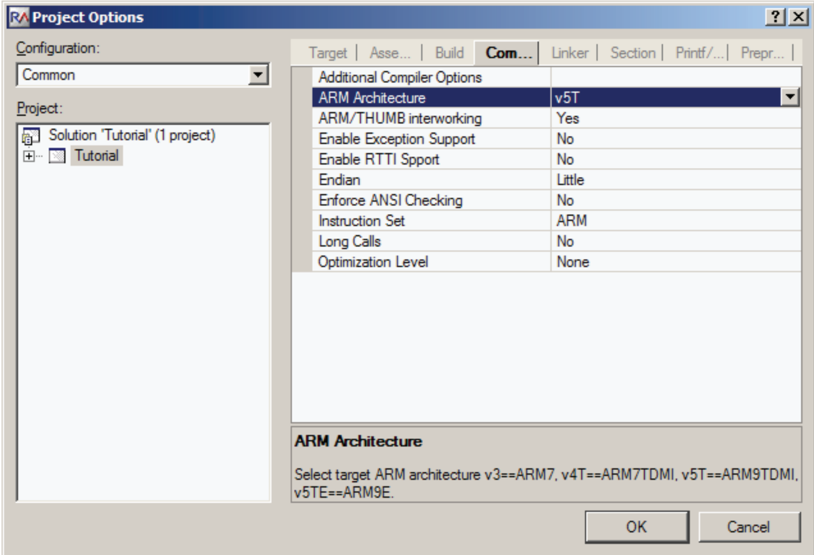
You can set project options on any node of the solution. That is, you can set options on a solution-wide basis, on a project-wide basis, on a project group basis, or on an individual file basis. For instance, options that you set on a solution are inherited by all projects in that solution, by all groups in each of those projects, and then 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) that node. The way that options are inherited provides a very powerful way to customize and manage your projects.

Changing the ARM architecture

In this instance, we will set up the targeted ARM architecture to be v5T. As we will be running the example on the simulator it doesn't matter which architecture we target as the simulator will simulate the architecture specified in the project. To change the targeted ARM architecture:

- Right click the **Tutorial** project in the Project Explorer and select **Properties** from the menuthe **Project Options** dialog appears.
- Click the **Configuration** dropdown and change to the **Common** configuration.
- Click the **Compiler** tab to display the code generation options.
- Click the **ARM Architecture** option and change this from **v4T** to **v5T**.

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 which options are used when building a project (or anything in a project) in a given configuration. Because we have set the target processor in the **Common** configuration, both **Debug** and **Release** configurations will use this setting. We could, however, set the processor type to be different in **Debug** and **Release** configurations, allowing us to develop on a processor with a large amount of code memory and hardware emulation support, but elect to deploy on a smaller, more cost effective variant.

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 projectthese have all been inherited from the solution. If you modify a property when the project node is selected then youll find that its value is highlighted because you have overridden the property value that was inherited from the solution. You can restore the inherited value of a property by right clicking the property and selecting **Use Inherited Value** from the menu.

Next, we'll build the project.

Building projects

Now that the project is created and set up, it's time to build it. Unfortunately, there are some deliberate errors in the program which we need to correct.

Building the project

To buld the project, do the following:

- From the **Project** menu, click **Build**.

—or—

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

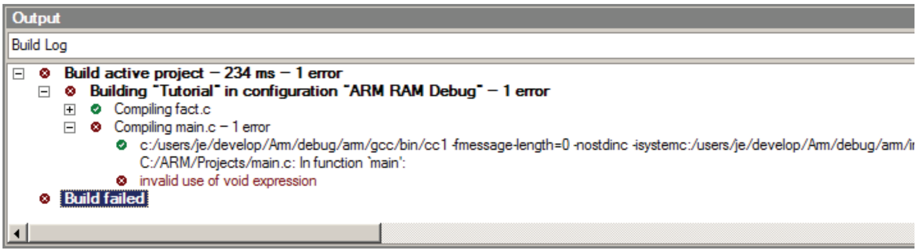
—or—

- Type **F7**.

Alternatively, to build the **Tutorial** project using a context menu, do the following:

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

CrossStudio starts compiling the project files but finishes after detecting an error. The Output Window shows the Build Log which contains the errors found in the project:



Correcting compilation and linkage errors

CrossStudio compiled `fact.c` without errors, but `main.c` contains two errors. After compilation, CrossStudio moves the cursor to the line containing the first reported error. As well as this, the line is marked in the gutter and highlighted by underlining it red. (You can change this behaviour using the **Environment Options** dialog.)

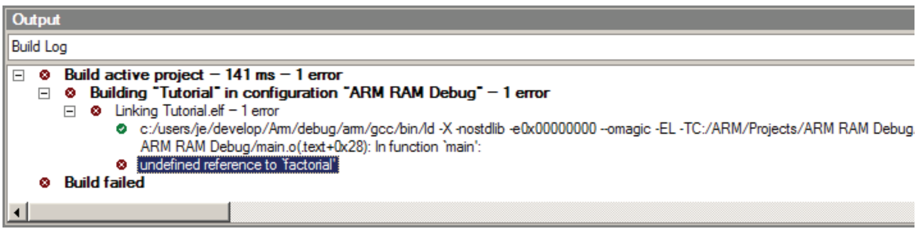
```
int i;
for (i = 1; i < 10; ++i)
  debug_printf("factorial of %d is %d\n", i, factorial(i))
}
```

The status bar also updates to indicate two build errors and shows the first error message.

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 from the **Search** menu, click **Next Location**. The cursor is now positioned at the **debug_printf** statement which is missing a terminating semicolonadd the semicolon to the end of the line. Using **F4** again indicates 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 **Previous Location** in the **Search** menu to move back through errors. Now that the errors are corrected, compile the project again. The build log still shows that we have a problem.



Notice that `fact.c` has not been recompiled because it was compiled correctly before and is up to date. The remaining error is a linkage error. Double click on `fact.c` in the Project Explorer to open it for editing and change the two occurrences of `fact` to `factorial`. Recompile the project—this time, the project compiles correctly:

Exploring projects

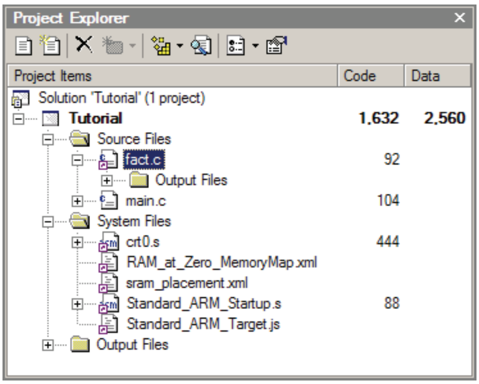
Now that the project has no errors and builds correctly, we can turn our attention to uncovering exactly how our application fits in memory and how to navigate around it.

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 the features that 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 take up, and with small embedded microcontrollers this is especially true. The Project Explorer can display the code and data sizes for each project and individual source file that is successfully compiled. To do this, click the **Options** dropdown on the **Project Explorer** tool bar and make sure that **Show Code/Data Size** is checked. Once checked, the Project Explorer displays two additional columns, **Code** and **Data**.



The **Code** column displays the total code space required for the project and the **Data** column displays the total data space required. The code and data sizes for each C and assembly source file are *estimates*, but good estimates nontheless. 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 before, 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 the project as a whole, you can also configure the Project Explorer to show the *dependencies* for a file. As part of the compilation process, CrossStudio finds and records the relationships between filesthat is, it finds which files are dependent upon other files. CrossStudio uses these relationships when it comes to build the project again so that it does the minimum amount of work to bring the project up to date.

To show the dependencies for a project, click the **Options** button on the **Project Explorer** tool bar and ensure that **Show Dependencies** is checked in the menu. Once checked, dependent files are shown as sub-nodes of the file which depends upon them.

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

Output files

Another useful piece of information is knowing the files output files when compiling and linking the application. Needless to say, CrossStudio can display this information too. To turn on output file display, click the **Options** button on the **Project Explorer** tool bar and ensure that **Show Output Files** is checked in the menu. Once checked, output files are shown in an **Output Files** folder underneath the node that generates them.

In the above figure, we can see that the object files `fact.o`, `main.o`, and `crt0.o` are object files produced by compiling their corresponding source files; the map file `Tutorial.map` and the linked executable `Tutorial.elf` 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 as described above, or you can use the Disassemble tool to do it.

To disassemble a project or file, do one of the following:

- Click the appropriate project or file in the **Project Explorer** view.
- On the **Project Explorer** tool bar, click the **Disassemble** tool button .

or

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

CrossStudio opens a new read-only editor and places a disassembled listing into it. If you change your project and rebuild it, causing a change in the object or executable file, the disassembly updates to keep the display up-to-date with the file on disk.

Using Symbol Browser features

Whilst a map file produced by the linker is *traditionally* the best way (and in some cases, the only way) to see how your application is laid out in memory, CrossStudio provides a much better way to examine and navigate your application: the *Symbol Browser*. You can use the Symbol Browser 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.

Displaying the Symbol Browser

To display the **Symbol Browser** window if it is hidden, do one of the following:

- From the **View** menu, click **Symbol Browser**.

or

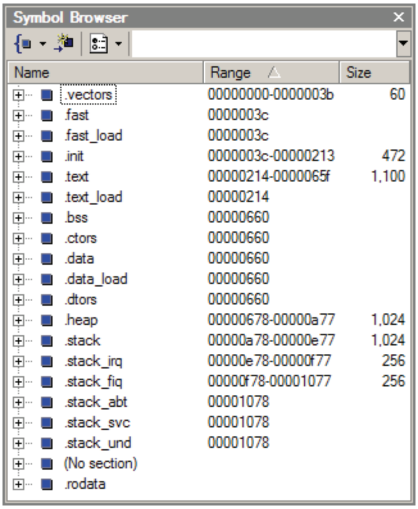
- Type **Ctrl+Alt+Y**.

or

- Right click the tool bar area to display the **View** menu.
- From the popup menu, click **Symbol Browser**.

Drilling down into the application

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



Symbol Browser

Name	Range	Size
.vectors	00000000-0000003b	60
.fast	0000003c	
.fast_load	0000003c	
.init	0000003c-00000213	472
.text	00000214-0000065f	1,100
.text_load	00000214	
.bss	00000660	
.ctors	00000660	
.data	00000660	
.data_load	00000660	
.dtors	00000660	
.heap	00000678-00000a77	1,024
.stack	00000a78-00000e77	1,024
.stack_irq	00000e78-00000f77	256
.stack_fiq	00000f78-00001077	256
.stack_abt	00001078	
.stack_svc	00001078	
.stack_und	00001078	
(No section)		
.rodata		

From this you can see:

- The **.vectors** section containing the ARM exception vectors is placed in memory between address 0x00000000 and 0x0000003B.
- The **.fast** section containing performance critical code and data is empty.
- The **.init** section containing the system startup code is placed in memory between address 0x0000003C and 0x00000213.
- The **.text** section containing the program code is placed in memory between address 0x00000214 and 0x0000065F.
- The **.text_load** section which is the section that the **.text** section image is loaded from is at the same address as **.text**. If the **.text** and **.text_load** section start addresses differ then the startup code will copy the contents of the **.text_load** section to the **.text** section before the program enters main. This feature allows the **.text** section to run from RAM in ROM based applications.
- The **.bss** section containing zeroed data is empty.
- The **.ctors** containing the global constructor table is empty.
- The **.data** section containing initialized data is empty.
- The **.data_load** section which is the section that the **.data** section image is loaded from is at the same address as **.data**. If the **.data** and **.data_load** section start addresses differ then the startup code will copy the contents of the **.data_load** section to the **.data** section before the program enters main. This feature is required for ROM based applications so that data can be initialized in RAM on startup.

- The **.dtors** section containing the global destructor table is empty.
- The **.heap** section is 1024 bytes in length and located at 0x00000678. Note that the size of the heap can be adjusted by modifying the size of the **.heap** section in the section placement file (sram_placement.xml in this example).
- The **.stack** section which contains the User/System mode stack is 1024 bytes in length and located at 0x00000A78. Note that the sizes of the stacks can be adjusted by modifying the size of the **.stack** sections in the section placement file (sram_placement.xml in this example).
- The **.stack_irq** section which contains the IRQ mode stack is 256 bytes in length and located at 0x00000E78.
- The **.stack_fiq** section which contains the FIQ mode stack is 256 bytes in length and located at 0x00000F78.
- The **.stack_abt** section which contains the Abort mode stack is 0 bytes in length.
- The **.stack_svc** section which contains the Supervisor mode stack is 0 bytes in length.
- The **.stack_und** section which contains the Undefined mode stack is 0 bytes in length.

To drill down, open the **.text** 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 104 bytes in size and is placed in memory between addresses 0x00000270 and 0x000002D7 inclusive. Just as in the Project Explorer, you can double click a function and CrossStudio moves the cursor to the line containing the definition of that function, so you can easily navigate around your application using the Symbol Browser.

Printing Symbol Browser contents

You can print the contents of the Symbol Browser by focusing the Symbol Browser window and selecting **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 that you have selected for display, and prints items in the same order they are displayed in the Symbol Browser, so you can choose which columns to print and how to print symbols by configuring the Symbol Browser display before you print.

We have touched on only some of the features that the Symbol Browser offers; to find out more, refer to **Symbol browser** (page 132) 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 using the features of CrossStudio to see how it performs.

Getting set up

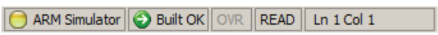
Before running your application, you need to select the target to run it on. The Targets window lists each target interface that is defined, as does the Targets menu, and you use these to connect CrossStudio to a target. For this tutorial, you'll be debugging on the simulator, not hardware, to simplify matters. To connect to the simulator, do one of the following:

- From the **Target** menu, click **Connect ARM Simulator**.

—or—

- From the **View** menu, click **Targets** to focus the Targets window.
- In the Targets window, double click **ARM Simulator**.

After connecting, the connected target is shown in the status bar:



The color of the LED in the Target Status panel 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.

Setting a breakpoint

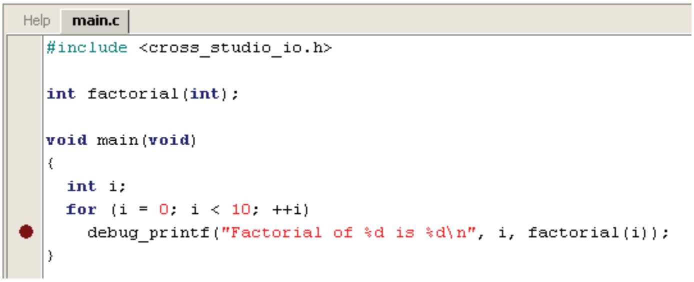
CrossStudio will run a program until it hits a breakpoint. We'll place a breakpoint on the call to `debug_printf` in **main.c**. To set the breakpoint, Move the cursor to the line containing `debug_printf` and do one of the following:

- On the **Build** tool bar, click the **Toggle Breakpoint** button — .

—or—

- Type **F9**.

Alternatively, you can set a breakpoint without moving the cursor by clicking in the gutter of the line to set the breakpoint on.



The gutter displays an icon on lines where the 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** (page 100) section. The breakpoints that you set are stored in the session file associated with the project which means that your breakpoints are remembered if you exit and re-run CrossStudio.

Starting the application

You can now start the program in one of these ways:

- From the **Debug** menu, click **Start Debugging**.

—or—

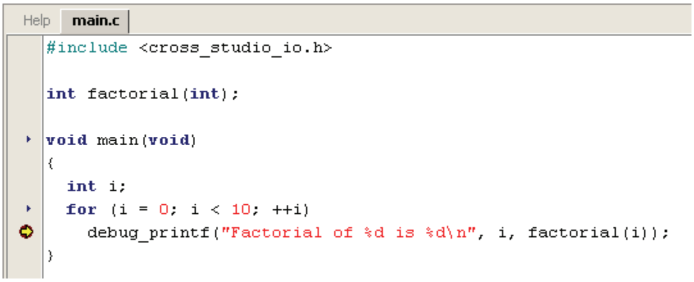
- On the **Build** tool bar, click the **Start Debugging** button — .

—or—

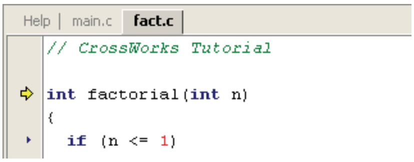
- Type **F5**.

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

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



You can step over a statement by selecting **Debug > Step Over**, by typing **F10** or by clicking the **Step Over** button on the **Debug** tool bar. Right now, we'll step into the next function, `factorial`, and trace its execution. To step into `factorial`, select **Debug > Step Into**, type **F11**, or click the **Step Into** button on the **Debug** tool bar. Now the display changes to show that you have entered `factorial` and execution is paused there.

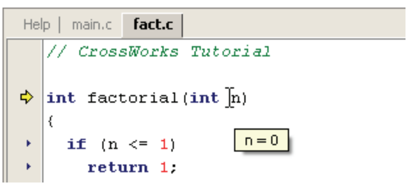


You can also step to a specific statement using **Debug > Run To Cursor**. To restart your application to run to the next breakpoint use **Debug > Go**.

Note that when single stepping you may step into a function that the debugger cannot locate source code for. In this case 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 are may be cases in which the debugger cannot display the instructions, in these cases you will 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 pointer 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.

The Call Stack window shows the function calls that have been made but have not yet finished, i.e. the active set of functions. To display the Call Window, select **Debug > Debug Windows > Call Stack**, or type **Ctrl+Alt+S**.

You can find out about the call stack window in the **Call stack window** (page 105) section.

Program output

The tutorial application uses the function `debug_printf` to output a string to the Debug Console in the Output Window. The Debug Console appears automatically whenever something is written to it—pressing **F5** to continue program execution and you will notice that the Debug Console 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 all very well, but there are occasions where you need to look a little more closely into the way that your program executes to track down the causes of difficult-to-find bugs and CrossStudio provides the tools you need to do just this.

Setting up again

What we'll now do is run the sample application, but 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 **Stop Debugging** from the **Debug** menu, or clicking the **Stop Debugging** button on the **Debug** tool bar. Now run the program so that it stops at the first breakpoint again.

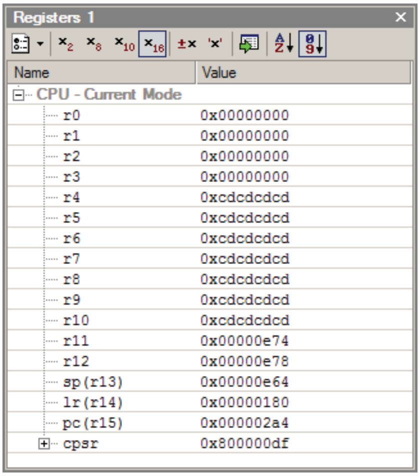
You can see the current processor state in the **Register** windows. To show the first registers window, do one of the following:

- From the **Debug** menu, click **Debug Windows** then **Registers 1**.

—or—

- Type **Ctrl+T, R, 1**.

Your registers window will look something like this:



This register view is displaying the registers for the active processor mode. You can also display the entire set of ARM registers, to do this select **CPU - ALL** from the **Groups** menu on the toolbar.

There are four register windows so you can open and display four sets of peripheral registers at the same time.

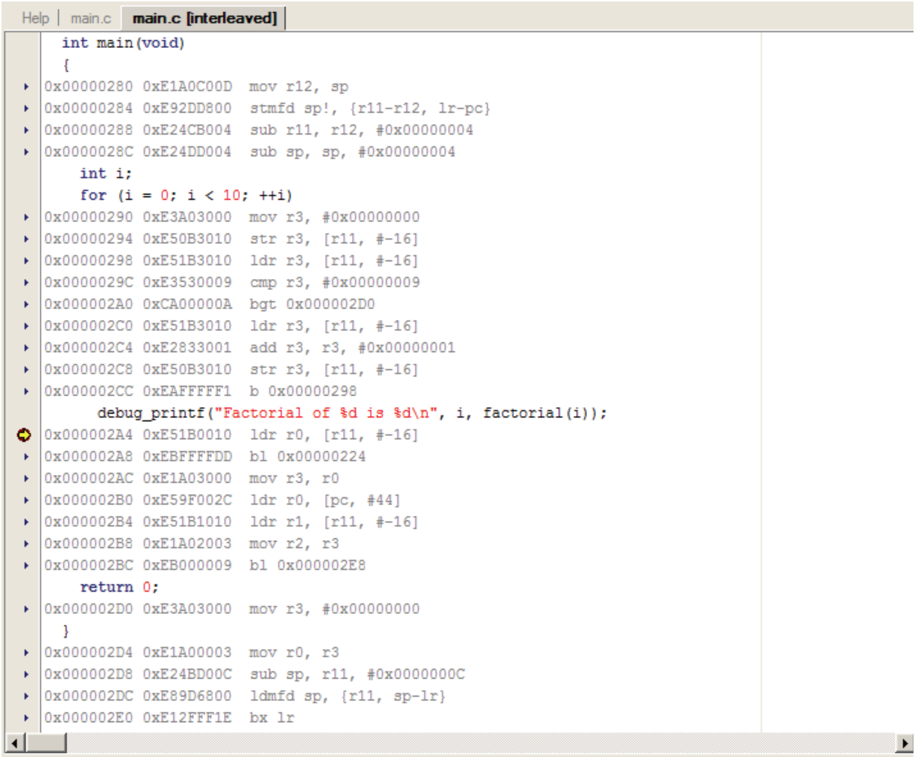
You can configure which registers and peripherals to display in the Registers windows individually. As you single step the program, the contents of the Registers window updates automatically and any change in a register value is highlighted in red.

Debugging modes

The debugger supports three modes of debug

- **Source mode** where the source code is displayed in a code editor.
- **Interleaved mode** where the editor displays an interleaved listing of the currently located source code. All single stepping is done an instruction at a time.
- **Assembly mode** where a disassembly of the instructions around the currently located instruction is shown in the editor. All single stepping is done an instruction at a time.

You have already seen debugging at the source level. To single step at the assembly level, from the **Debug** menu click **Control** then **Interleaved Mode**. The editor window now interleaves the source code of the application with the assembly language generated by the compiler:



In interleaved mode, debugging controls such as single step, step into, and step out work at the instruction level, not the source level. To return to high-level source debugging, select **Debug > Control > Source Mode**.

There are other windows that help you with debugging, such as the memory view and the watch windows, and the CrossStudio Window Reference describes these.

Stopping and starting debugging

You can stop debugging using **Debug | Stop.** If you wish to restart debugging without reloading the program then you can use **Debug > Debug From Reset**. Note that when you debug from reset no loading takes place so it is expected that your program is built in a way such that any resetting of data values is done as part of the program startup. You can also attach the debugger to a running target using the **Debug > Attach Debugger.**

CrossStudio Reference

This section is a reference to the CrossStudio integrated development environment.

In this section

- **CrossStudio menu summary (page 169).** Summarizes each of the menus presented in CrossStudio.

Overview

This section introduces the overall layout and operation of the CrossStudio integrated development environment.

CrossStudio standard layout

The following figure shows the standard layout of CrossStudio. The main window is divided into the following areas:

- **Title bar** Displays the name of the current file being edited and the active workspace.
- **Menu bar** Dropdown 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 or MDI view of multiple editors and the HTML viewer.
- **Docked windows** CrossStudio has many windows which can be docked to the left of, to the right of, or below the editing area. You can configure which windows are visible when editing and debugging. The figure shows the project explorer, targets window, and output window.
- **Status bar** At the bottom of the window, the status bar contains useful information about the current editor, build status, and debugging environment.

The title bar

CrossStudio’s title bar displays the name of the active editor tab if in **Tabbed Document Workspace** mode or the active MDI window if in **Multiple Document Workspace** mode.

Title bar format

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

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

After the file name, 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 the CrossStudio's inbuilt debugger
- **[break].** The debugger is stopped at a breakpoint.
- **[autostep].** The debugger is single stepping the application without user interaction—this is called *autostepping*.

The **Target Status** panel in the status bar also shows CrossStudio's state—see **The status bar** (page 45).

Configuring the title bar

You can configure whether the full path of the file or just its file name is shown in the title bar.

Displaying the full file path in the title bar

To display the full file path in the title bar, do the following:

- From the **Tools** menu, click **Options**.
- In the **Appearance** group, check **Show full path in title bar**.

Displaying only the file name in the title bar

To display only the file name in the title bar, do the following:

- From the **Tools** menu, click **Options**.
- In the **Appearance** group, uncheck **Show full path in title bar**.

The menu bar

The menu bar conatins dropdown menus for editing, building, and debugging your program. You can navigate menu items using the keyboard or using the mouse. You'll find a complete description of each menu and its contents in **CrossStudio menu summary** (page 169).

Navigating menus using the mouse

To navigate menus using the mouse, do the following;

- Click the required menu title in the menu bar; the menu appears.
- Click the required menu item in the dropdown menu.

—or—

- Click and hold the mouse on the required menu title in the menu bar; the menu appears.
- Drag the mouse to the required menu item on the dropdown menu.
- Release the mouse.

Navigating menus using the keyboard

To navigate menus using the keyboard, do the following:

- Tap the **Alt** key which focuses the menu bar.
- Use the **Left** and **Right** keys to navigate to the required menu.
- Use the **Up** or **Down** key to activate the requied menu
- Type **Alt** or **Esc** to cancel menu selection at any time.

Each menu on the menu bar has one letter underlined, its shortcut, so to activate the menu using the keyboard:

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

Once the menu has dropped down you can navigate it using the cursor keys:

- Use **Up** and **Down** to move up and down the menu.
- Use **Esc** to cancel a dropdown 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 menu item to activate that menu item.
- Type **Enter** to activate the selected menu item.

The 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 that contains a set of fixed panels and the other that is used for messages.

The message area

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

The 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 name and, if applicable, the processor that the target interface is connected to. The LED icon flashes green when programs are running, is solid red when stopped at a breakpoint, and is yellow when connected but not running a program. Double clicking this panel displays the Targets window and ight clicking it brings up the Target menu.
Cycle count panel	Displays the number of processor cycles run by the executing program. This panel is only visible if the currently connected target supports performance counters which can report the total number of cycles executed. Double clicking this panel resets the cycle counter to zer, and right clicking this panel beings up the Cycle Count menu.
Insert/overwrite status	Indicates whether the current editor is in insert or overwrite mode. If the editor is in overwrite mode the OVR panel is highlighted otherwise it is dimmed.
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 READ panel is highlighted otherwise it is dimmed.

Panel	Description
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 "Build OK" otherwise it contains the number of errors and warnings reported. Right clicking this panel displays the Build Log in the Output window.
Caret position	Indicates the cursor position of the current editor. For text editors, the caret position pane displays the line number and column number of the cursor; for binary editors it displays the address where the
Caps lock status	Indicates the Caps Lock state. If the Caps Lockis on, CAPS is highlighted, otherwise it is dimmed.
Num lock status	Indicates the Num Lock state. If the Num Lock is on, NUM is highlighted, otherwise it is dimmed.
Scroll lock status	Indicates the Scroll Lock state. If the Scroll Lock is on, SCR is highlighted, otherwise it is dimmed.
Time panel	Displays the current time.

Configuring the status bar panels

To configure which panels are shown on the status bar, do the following:

- From the **View** menu, click **Status Bar**.
- From the status bar menu, check the panels that you want displayed and uncheck the ones you want hidden.

—or—

- Right click on the status bar.
- From the status bar menu, check the panels that you want displayed and uncheck the ones you want hidden.

You can also select the panels to display from the **Tools > Options** dialog in the **Environment > More...** folder.

- From the **Tools** menu, click **Options**.
- In the tree view **Environment** folder, click **More...**
- In the **Status bar** group, check the panels that you want displayed and uncheck the ones you want hidden.

Hiding the status bar

To hide the status bar, do the following:

- From the **View** menu, click **Status Bar**.
- From the status bar menu, uncheck the **Status Bar** menu item.

—or—

- Right click on the status bar.
- From the status bar menu, uncheck the **Status Bar** menu item.

Showing the status bar

To show the status bar, do the following:

- From the **Tools** menu, click **Options**.
- In the tree view **Environment** folder, click **More...**
- In the **Status bar** group, check **(visible)**.

Showing or hiding the size grip

You can choose to hide or display the size grip when the CrossStudio main window is not maximized—the size grip is never shown in full screen mode or when maximized. To do this:

- From the **View** menu, click **Status Bar**.
- From the status bar menu, uncheck the **Size Grip** menu item.

—or—

- Right click on the status bar.
- From the status bar menu, uncheck the **Size Grip** menu item.

You can also choose to hide or display the size grip from the **Tools > Options** dialog in the **Environment > More...** folder.

- From the **Tools** menu, click **Options**.
- In the tree view **Environment** folder, click **More...**
- In the **Status bar** group, check or uncheck the **Size grip** item.

The editing workspace

The main area of CrossStudio is the editing workspace. This area contains files that are being edited by any of the editors in CrossStudio, and also the HTML Browser that's used by the online help system.

You can organize the windows in the editing area either into tabs or as separate windows. In **Tabbed Document Workspace** mode, only one window is visible at any one time, and each of the tabs displays the file's name. In **Multiple Document Workspace** mode, many overlapping windows are displayed in the editing area.

By default, CrossStudio starts in **Tabbed Document Workspace** mode, but you can change at any time between the two.

Changing to Multiple Document Workspace mode

To change to Multiple Document Workspace mode, do the following:

- From the **Window** menu, click **Multiple Document Workspace**.

Changing to Tabbed Document Workspace mode

To change to Tabbed Document Workspace mode, do the following:

- From the **Window** menu, click **Tabbed Document Workspace**.

The document mode is remembered between invocations of CrossStudio.

Project management

CrossWorks has a project system that enables you to manage the source files and build instructions of your solution. The **Project Explorer** and the **Properties Window** are the standard ways to edit and view your solution. You can also edit and view the project file which contains your solution using the text editor—this can be used for making large changes to the solution.

In this section

- **Project properties (page 54).** Describes what properties are, how they relate to a project, and how to change them.
- **Project configurations (page 57).** Describes what project build configurations are, to to create them, and how to use them**Project configurations** (page 57).
- **Project dependencies and build order (page 58).** Describes project dependencies, how to edit them, and how they are used to define the order projects build in.
- **Project macros (page 59).** Describes what project macros are and what they are used for.

Related sections

- **Project explorer (page 127).** Describes the project explorer and how to use it.
- **Project property reference (page 352).** A complete reference to the properties used in the project system.
- **Project file format (page 348).** Describes the XML format CrossStudio uses for project files.

Project system

A solution is a collection of projects, and all projects are contained in solutions. Organizing your projects into a solution allows you to build all the projects in a solution with a single keystroke, load them onto the target ready for debugging with another.

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

The **Project Explorer** organizes your projects and files and provides quick access to the commands that operate on them. A tool bar at the top of the window offers quick access to commonly used commands for the item selected in the **Project Explorer**.

Projects

The projects you create within a solution have a project type which CrossStudio uses to determine how to build the project. The project type is selected when you use the **New Project** dialog. The particular set of project types can vary depending upon the variant of CrossWorks you are using, however the following project types are standard to most CrossWorks variants:

- **Executable** — a program that can be loaded and executed.
- **Externally Built Executable** — an executable that is not built by CrossWorks.
- **Library** — a group of object files that collected into a single file (sometimes called an archive).
- **Object File** — the result of a single compilation.
- **Staging** — a project that can be used to apply a user defined command (for example cp) 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 data that are attached to project nodes. They are usually used in the build process for example to define C preprocessor symbols. You can have different values of the same property based on a configuration, for example you can change the value of a C preprocessor symbol for a release or a debug build.

Folders

Projects can contain folders which are used to group related files together. This grouping can be done using the file extension of the file or it can be done by explicitly creating a file within a folder. Note that folders do not map onto directories in the file store they are solely used to structure the project explorer display.

Files

The source files of your project can be placed either in folders or directly in the project. Ideally files placed in project should be relative to the project directory, however there are cases when you might want to refer to a file in an absolute location and this is supported by the project system. The project system will allow (with a warning) duplicate files to be put into a project.

The project system uses the extension of the file to determine the appropriate build action to perform on the file. So

- a file with the extension **.c** will be compiled by a C compiler.
- a file with the extension **.s** or **.asm** will be compiled 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 it's file type determined by the XML document type.
- other file extensions will not be compiled/linked with.

You can modify this behaviour by setting the **File Type** property of the file 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 then link to this solution (by right clicking on the solution node of the project explorer and selecting **Add Existing Project**) to be able to use the library from a project in the current solution.

Project and session files

When you have created a solution it is stored in a project file. Project files are text files with the file extension **hzp** that contain an XML description of your project. 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 files you have opened in the editor and breakpoints you set in the breakpoint window.

Creating a project

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

To create a new project in an existing solution, do the following:

- From the **Project** menu, click **New** then **New Project...** to display the **New Project** wizard.
- In the **New Project** wizard, select the type of project you wish to create and where it will be placed.
- Ensure that the "Add the project to current solution" radio button is checked.
- Click **OK** to go to next stage of project creation or **Cancel** to cancel the creation.

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

Creating a new project in a new solution

To create a new project in a new solution, do the following:

- From the **File** menu, click **New** then **New Project...** to display the **New Project** dialog.
- In the **New Project** dialog, select the type of project you wish to create and where it will be placed.
- Click **OK**.

Adding existing files to a project

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

Adding existing files to the active project

You can add one or more files to the active project quickly using the standard **Open File** dialog.

To add existing files to the active project do one of the following:

- From the **Project** menu, select **Add Existing File...**

—or—

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

—or—

- Type **Ctrl+D**.

Using the **Open File** dialog, navigate to the directory containing the existing files, select the ones to add to the project, then click **OK**. The selected files are added to the folders whose filter matches the extension of the each of the files. If no filter matches a file's extension, the file is placed underneath the project node.

Adding existing files to any project

To add existing files a project without making it active:

- In the **Project Explorer**, right click on the project to add a new file to.

- From the popup menu, select **Add Existing File...**

The procedure for adding existing files is the same as above.

Adding existing files to a specific folder

To add existing files directly to a folder bypassing the file filter do the following:

- In the **Project Explorer**, right click on the folder to add a new file to.
- From the popup menu, select **Add Existing File...**

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

Adding new files to a project

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

Adding a new file to the active project

To add new files to the active project, do one of the following:

- From the **Project** menu, click **Add New File...**

—or—

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

—or—

- Type **Ctrl+N**.

Adding a new file to any project

To add a new file to a project without making it active, do one of the following:

- In the **Project Explorer**, right click on the project to add a new file to.
- From the popup menu, select **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 file name, 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.

Adding a new file to a specific folder

To add new files directly to a folder bypassing the file filter do the following:

- In the **Project Explorer**, right click on the folder to add a new file to.

- From the popup menu, select **Add New File...**

The new file is added to the folder without using any 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** tool button on the project explorer's toolbar. Removing a source file from a project does not remove it from disk.

Removing an item

To remove an item from the solution do one of the following:

- Click on the project item to remove from the **Project Explorer** tree view.
- On the **Project Explorer** toolbar, click the **Remove** button (or type **Delete**).

—or—

- Right click on the the project item to remove from the **Project Explorer** tree view.
- From the popup menu, click **Remove**.

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 using the properties window in conjunction with the project explorer. As you select an item in the project explorer the properties window will list the set of properties that are applicable.

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 the solution, project or individual file. By setting properties at the solution level you enable all files of the solution to use this property 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 a example particular source file may have warnings that you decide are allowable so you set the **Treat Warnings As Errors** to **No** for this 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

Aggregating properties

An aggregating property collects all of the values that are defined for it in the project hierarchy. For example when a C file is compiled the **Preprocessor Definitions** property will take all of the values defined at the file, project and solution level. 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

project1/file1	SolutionDef
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.

There is a special configuration named **Common** that is always inherited by a configuration. The **Common** configuration enables property values to be set that will apply to all configurations that 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 it's almost certain that you want each configuration to inherit these values - so ensure that the **Common** configuration has been selected.

If the property is unique then it will use the one defined for the particular configuration. If the property isn't defined for this configuration then it uses an arbitrary one from the set of inherited configurations. If the property still isn't defined it uses the value for the **Common** configuration. If it still isn't defined then it tries the to find the value in the next 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

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

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

Project configurations

Project configurations are used to create different software builds for your projects. A configuration is used to define different project property values, for example the output directory of a compilation can be put into different directories which are dependent upon the configuration. By default when you create a solution you'll get some default project configurations created.

Selecting a configuration

You can set the configuration that you are building and debugging with using the combo box of the **Build** tool bar or the **Build > Set Active Build Configuration** menu option.

Creating a configuration

You can create your own configurations using **Build > Build Configurations** which will show the **Configurations** dialog. The **New** button will produce a dialog that allows you name your configuration. You can now specify which existing configurations your new configuration will inherit values from.

Deleteing a configuration

You can delete a configuration by selecting it and pressing the **Remove** button. Note that this operation cannot be undone or cancelled so beware.

Hidden configurations

There are some configurations that are defined purely for inheriting and as such shouldn't appear in the build combo box. When you select a configuration in the configuration dialog you can specify if you want that configuration to be hidden.

Project 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 manage loading and deleting applications and libraries in the correct order. A typically usage of project dependencies is to make an executable project dependent upon a library executable. When you elect to build the executable then the build system will ensure that the library it is dependent upon is up to date. In the case of a dependent library then the output file of the library build is supplied as an input to the executable build so you don't have to worry about this.

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.

Making a project dependent upon another

To make one project dependent upon another, do the following:

- From the **Project** menu, click **Dependencies** to display the **Project Dependencies** dialog.
- From the **Project** dropdown, select the target project which depends upon other projects.
- In the **Depends Upon** list box, check the projects that the target project depends upon and uncheck the projects that it does not depend upon.

Some items in the **Depends Upon** list box may be disabled, which indicates that if the project were checked, a circular dependency would result. Studio prevents you from constructing circular dependencies using the **Project Dependencies** dialog.

Finding the project build order

To display the project build order, do the following:

- From the **Project** menu, click **Build Order** to display the **Project Dependencies** dialog with the **Build Order** tab selected.
- The projects build in order from top to bottom.

If your target supports loading of multiple projects, then 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 applications that use them, and you can ensure that this happens by making the application dependent upon the library. With this a dependency set, the library gets built before the application and loaded before the application.

Applications are deleted from a target in reverse build order, and as such applications are removed before the libraries that they depend upon.

Project macros

You can use macros to modify the way that the project system refers to files. Macros are divided into four classes:

- **System Macros.** These are provided by the Studio application and are used to relay information from the environment, such as paths to common directories.
- **Global Macros.** These macros are saved in the environment and are shared across all solutions and projects. Typically, you would set up paths to library or external items here.
- **Project Macros.** These macros are saved in the project file as project properties and can define macro values specific to the solution/project they are defined in.
- **Build Macros.** These macros are generated by the project system whenever a build occurs.

System macros

The following macro values are defined by the system

Macro	Description
StudioDir	The install directory of the CrossStudio application.

System macros can be used in build properties and also for environment settings.

Global macros

To define a global macro

- Select **Macros** from the **Project** menu.
- Click on the the **Global** tab.
- Set the macro using the syntax *name = replacement text*.

Project macros

To define a project macro

- Select **Macros** from the **Project** menu.
- Click on the **Project** tab.
- Select the solution or project the macro should apply to.
- Set the macro using the syntax *name = replacement text*.

Alternatively you can set the project macros from the properties window:

- Select the appropriate solution/project in the Project Explorer.
- In the properties window, select the **Macros** property in the **General Options** group.
- Click on the the ellipsis button on the right.
- Set the macro using the syntax *name = replacement text*.

Build macros

The following macro values are defined by the project system for a build of a given project node.

Macro	Description
ProjectDir	The project directory.

Macro	Description
ProjectName	The project name.
Configuration	The selected build configuration.
SolutionDir	The directory containing the solution file.
SolutionName	The solution name.
InputFileName	The name of an input file relative to its project directory.
InputName	The name of an input file relative to its project directory without its extension.
InputExt	The extension of an input file.
IntDir	The macro-expanded value of the **Intermediate Directory** property.
OutDir	The macro-expanded value of the **Output Directory** property.
EXE	The default file extension for an executable file including the dot.
LIB	The default file extension for a library file including the dot.
OBJ	The default file extension for an object file including the dot.
LibExt	A platform specific library extension that is generated based on project property values.

Using macros

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

To enable debugging of builds you should use the **Build Information...** dialog that is on the context menu of the project explorer. This dialog will give a full list of the macros that are specified for the project node selected together with the macro expanded property values.

Building projects

CrossStudio provides a facility to build projects in various configurations.

Build configurations and their uses

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

Configurations inherit properties from other configurations. This provides a single point of change for definitions that are common to 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 using **Build > Build Configurations**. Before you build, ensure that the appropriate configuration is set using **Project > Set Active Build Configuration** or alternatively the configuration box in the build tool bar. You should also ensure that the appropriate build properties are set in the properties window.

Building your applications

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. If you are copying files then 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 is using by setting the **Environment Properties | Build Settings | Show Build Information** property and the build commands themselves by setting the **Environment Properties | Build Settings | Echo Build Command** property.

You may have a solution that contains several projects that are dependent upon each. Typically you might have several executable project and some library projects. The **Project > Dependencies** dialog specifies the dependencies between projects and to see the affect those dependencies have 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 new folders titled Dependencies has appeared in the project explorer. These folder contains the list of newly generated files and the files that they where generated from. These files can be decoded and displayed in the editor by right clicking on the file and seeing if it supports the **View** operation.

If you have the symbols window displayed then it will be updated with the symbol and section information of all executable files that have been built in the solution.

When CrossStudio builds projects it uses the values set in the properties window. To generalise 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, these systems can become complicated. To enable you to understand the implications of changing build settings, right clicking a node in the project explorer and selecting **Properties** brings up a dialog that shows the macros and build steps that apply to that project node.

Building all projects

To build all projects in the solution, do one of the following:

- On the **Build** toolbar, click the **Build Solution** button.

—or—

- From the **Build** menu, select **Build Solution**.

—or—

- Type **Alt+F7**.

—or—

- Right click the solution in the **Project Explorer** window.
- From the menu, click **Build**.

Building a single project

To build a single project only, do one of the following:

- Select the required project in the **Project Explorer**.
- On the **Build** tool bar, click the **Build** tool button.

—or—

- Select the required project in the **Project Explorer**.
- From the the **Project** menu, click **Build**.

—or—

- Right-click on the required project in the **Project Explorer** window.
- From the menu, click **Build**.

Compiling a single file

To compile a single file, do one of the following:

- In the **Project Explorer**, right click the source file to compile.
- From the menu, click **Compile**.

—or—

- In the **Project Explorer**, click the source file to compile.
- From the **Build** menu, click **Compile**.

—or—

- In the **Project Explorer**, click the source file to compile.
- Type **Ctrl+F7**.

Correcting errors after building

The results of a build are displayed in the **Build Log** in the **Output** window. Errors are highlighted in red, and warnings are highlighted in yellow. Double-clicking an error, warning, or note will move the cursor to the appropriate source line.

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

Source code control

CrossWorks supports team development of applications using *source code control*. At present CrossWorks integrates with Microsoft Visual SourceSafe, SourceGear SourceOffSite 3.5.1, and CVS. The source code control integration capability provides:

- Connecting to the source control database (sometimes called a repository).

- Mapping files in the project system to those in the source code control system
- Showing the source control status of files and projects
- Adding and removing files and projects from source control
- Typical source control operations such as Add to source control, Remove from source control, and so on.

Configuring source control

You need to configure CrossStudio to use source control in your projects. This section describes how to configure CrossStudio and your projects for source control.

Connecting to the source control system

Before you can check files in and out of source code control, you must connect to the source control system. To connect to the source control system, do the following:

- From the **Project** menu, click **Source Control** then **Connect...**

This displays a source control system specific dialog that enables you specify which source control database to connect to and to enter passwords etc. This dialog will reappear each time you load the solution to provide you with the opportunity to cancel source control connection.

Mapping files

In order to map local files to those in the source control database, the project file is taken to be the root of the project hierarchy. The first time CrossWorks tries to check the source control status of the project file it will prompt you to specify the location of this file in the source control database. This mapping will be stored in the session file so you won't need to specify the mapping each time the project is loaded. If you cancel at the prompt to specify the location of a project file in the source control database, use **Project | Source Control | Add To Source Control** to make CrossWorks prompt again.

If a project directory is defined for a project file then this will be prepended to the filename in the project when mapping to files in the source control system. Note that only relative project directories (and filenames) are supported.

Using source control

Once you have configured source control in CrossStudio, you can use the CrossStudio features to manipulate files in the source control system.

Adding files to source control

To add a file to the source control system so that it can be controlled, checked in, checked out, and so on, do the following:

- In the **Project Explorer**, right click the file to add to source control.
- From the menu, click **Source Control** then **Add To Source Control**.

Checking files out

To check a file out of the source control system, do the following:

- In the **Project Explorer**, right click the file to check out.
- From the menu, click **Source Control** then **Check Out**.

—or—

- In the **Project Explorer**, click the file to check out.
- From the **Project** menu, click **Source Control** then **Check Out**.

—or—

- In the **Project Explorer**, click the file to check out.
- On the **Source Control** tool bar, click the **Check Out** button.

Checking files in

To check a file into the source control system, do the following:

- In the **Project Explorer**, right click the file to check in.
- From the menu, click **Source Control** then **Check In**.

—or—

- In the **Project Explorer**, click the file to check out.
- From the **Project** menu, click **Source Control** then **Check In**.

—or—

- In the **Project Explorer**, click the file to check out.
- On the **Source Control** tool bar, click the **Check In** button.

Undoing check outs

To under a check out and return a file on disk to its previous checked in state, do the following:

- In the **Project Explorer**, right click the file to undo the check out of.
- From the menu, click **Source Control** then **Undo Check Out**.

Getting the latest version of a file

To retrieve the latest version of a file from source control, do the following:

- In the **Project Explorer**, right click the file to check out.
- From the menu, click **Source Control** then **Get Latest Version**.

Showing the differences between files

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

- In the **Project Explorer**, right click the file to show the differences of.
- From the menu, click **Source Control** then **Show Differences**.

Removing a file from source control

To remove a file from being managed by the source control system, do the following:

- In the **Project Explorer**, right click the file to remove from source control.
- From the menu, click **Source Control** then **Remove From Source Control**.

Note that this deletes the file from the source code control system but does not touch the working file on disk and does not remove the file from the project.

Source control properties

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

- **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 one held in the source control system; if **No**, they are identical.
- **File Path.** The file path of the file in the source control system.
- **Old Version.** If **Yes**, the file in the project location is an old version compared to the latest version in the source control system.

- **Status. Controlled** indicates that the file is controlled by the source code control system.

Source control status

By selecting **Project > Source Control > Show Status** a window is displayed that shows the current source control state of each file in the project. If a local file has been changed then this file is displayed in red. You can use this window to do multiple source control operations e.g. add several files to the source control. You can restrict the file list to a node in the project hierarchy e.g. all files of a folder, and supply a filter which enables the file list to be restricted to the source control status e.g. all files that are different.

When a given file or solution is selected in the project explorer, the source control properties appear in the properties window—these properties reflect the local checkout status of the file and whether or not it has been modified.

Debug expressions

The debugger can evaluate simple expressions that can be subsequently displayed in the watch window or as a tool-tip in the code editor.

The simplest expression is an identifier which 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 an @.

The standard programming language operators !, ~, *, /, %, +, -, >>, <<, <, <=, >, >=, ==, |=, &, ^, |, &&, || are supported on number types.

The standard assignment operators =, +=, -=, *=, /=, %=, >>=, <<=, &=, |=, ^= are supported on number 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 the -> works similarly.

The dereference operator (prefix *) is supported on pointers, the addressof (prefix &) and sizeof operators are supported.

Casting to basic pointer types is supported. For example (unsigned char *)0x300 can be used to display the memory at a given location.

Operators have the precedence and associativity that one would expect of a C like programming language.

Source code editor

The Code Editor is a text editor which allows you to edit text, but has features that make it particularly well suited to editing code and is referred to as either the Text Editor or the Code Editor, based on its content.

You can open multiple code editors to view or edit the code in projects and 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 that 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 on a file in the **Project Explorer** or by right clicking on a file and selecting **Open** from the context menu.
- Using the **File** menu **New** or **Open** commands.
- Right clicking in a source file and selecting a file from the **Open Include File** menu.

Elements of the code editor

The code editor is divided into several elements which are described here.

- **Code Pane** The area where you edit your code. You can set options that affect the behavior of text in the code pane as it relates to indenting, tabbing, dragging and dropping of text, and so forth. For more information, see General, All Languages, Text Editor, Options Dialog Box.
- **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. You can hide or display the Margin Indicator bar in General, Tools, Text Editor, Options dialog box.
- **Horizontal and vertical scroll bars** Allows you to scroll the code pane horizontally and vertically so that you can view the code that extends beyond the viewable edges of the code pane. You can hide or display the horizontal and vertical scroll bars using the General, Tools, Text Editor, Options dialog box.

Navigation

There are several ways to move around code editors:

- Mouse and cursor motion keys
- Bookmarks
- The **Go To Line** command
- The **Navigate Backward** and **Navigate Forward** buttons

Navigating with the mouse and keyboard

The most common way to navigate text is with the mouse and cursor motion keys:

- Click a location with the mouse.
- Use the arrow keys to move one character at a time, or the arrow keys in combination with the Ctrl key to move one word at a time.
- Use the scroll bars or scroll wheel on the mouse to move through the text.
- Use the **Home**, **End**, **PageUp**, and **PageDown** keys.
- Use **Alt+PageUp** and **Alt+PageDown** to move the insertion point to the top or bottom of the window, respectively.
- Use **Ctrl+Up** and **Ctrl+Down** to scroll the view without moving the insertion point.

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

Keystroke	Description
Up	Moves the cursor up one line.
Down	Moves the cursor down one line.
Left	Moves the cursor left one character.
Right	Moves the cursor right one character.
Home	Moves the cursor to the first character on the line. Pressing Home a second time moves the cursor to the first column.
End	Moves the cursor to the end of the line.
PageUp	Moves the cursor up one page.
PageDown	Moves the cursor down one page.

Keystroke	Description
Ctrl+Left	Moves the cursor left one word.
Ctrl+Right	Moves the cursor right one word.
Ctrl+Up	Moves the cursor to the previous function.
Ctrl+Down	Moves the cursor to the next function.
Ctrl+Home	Moves the cursor to the start of the document.
Ctrl+End	Moves the cursor to the end of the document.
Alt+Up	Scrolls the document up by one line.
Alt+Down	Scrolls the document down by one line.

Go To Line

To move the cursor to a particular line number, do one of the following:

- From the **Edit** menu, click **Advanced** then **Go To Line**.
- Enter the line number to move the cursor to.

—or—

- Type **Ctrl+G**, **Ctrl+L**.
- Enter the line number to move the cursor to.

Selecting Text

Selecting text with the keyboard

You can select text using the keyboard by using **Shift** with the navigation keys.

- Hold **Shift** key down while using the Navigation Keys.

Selecting text with the mouse

- Move mouse cursor to the point in the document that you want to start selecting.
- Hold down left mouse button and drag mouse to mark selection.
- Release left mouse button to end selection.

Matching Delimiters

The editor can find the matching partner for delimiter characters such as (), [], {}, <>.

To match a delimiter

- Move cursor to the left of the delimiter character to be matched.
- Select **Edit | Advanced | Match Delimiter** menu item or use **Ctrl+]** keys.

To select a delimited range

- Move cursor to the left of the delimiter character to be matched.
- Use **Ctrl+Shift+]** keys.

Bookmarks

To edit a document elsewhere and then return to your current location, add a bookmark. The bookmarks presented in this section are *temporary bookmarks* and their positions are not saved when the file is closed nor when the solution is closed.

Adding a bookmark

To add a temporary bookmark, move to the line you want to bookmark and do one of the following:

- On the **Text Edit** tool bar, click the **Toggle Bookmark** button.

—or—

- From the **Edit** menu, click **Bookmarks** then **Toggle Bookmark**.

—or—

- Type **Ctrl+F2**.

A temporary bookmark symbol appears next to the line in the indicator margin which shows that the bookmark has been set.

Moving through bookmarks

To navigate forward through temporary bookmarks, do one of the following:

- On the **Text Edit** tool bar, click the **Next Bookmark** button.

—or—

- From the **Edit** menu, click **Bookmarks** then **Next Bookmark**.

—or—

- Type **F2**.

The editor moves the cursor to the next bookmark set in the document. If there is no following bookmark, the cursor is moved to the first bookmark in the document.

To navigate backward through temporary bookmarks, do one of the following:

- On the **Text Edit** tool bar, click the **Previous Bookmark** button.

—or—

- From the **Edit** menu, click **Bookmarks** then **Previous Bookmark**.

—or—

- Type **Shift+F2**.

The editor moves the cursor to the previous bookmark set in the document. If there is no previous bookmark, the cursor is moved to the last bookmark in the document.

Moving to the first or last bookmark

To move to the first bookmark set in a document, do one of the following:

- From the **Edit** menu, click **Bookmarks** then **First Bookmark**.

—or—

- Type **Ctrl+K**, **F2**.

To move to the last bookmark set in a document, do one of the following:

- From the **Edit** menu, click **Bookmarks** then **Last Bookmark**.

—or—

- Type **Ctrl+K**, **Shift+F2**.

Removing bookmarks

To remove a temporary bookmark, move to the line you want to remove the bookmark from and do one of the following:

- On the **Text Edit** tool bar, click the **Toggle Bookmark** button.

—or—

- From the **Edit** menu, click **Bookmarks** then **Toggle Bookmark**.

—or—

- Type **Ctrl+F2**.

The temporary bookmark symbol disappears whoch shows that the bookmark has been removed.

To remove all temporary bookmarks set in a document, do the following:

- From the **Edit** menu, click **Bookmarks** then **Clear All Bookmarks**.

—or—

- Type **Ctrl+Shift+F2**.

Changing text

Whether you are editing code, HTML, or plain text, the Code Editor is just line 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.

Adding text

The editor has two text input modes:

- **Insertion mode** As text is entered it is inserted at the current cursor position and any text to the right of the cursor is shifted along. A visual indication of inserion mode is a that the cursor is a flashing line.
- **Overstrike mode** As text is entered it replaces any text to the right of the cursor. A visual indication of inserion 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 set to insert mode.. You can configure the cursor appearance in both insertion and overstrike modes using the **Tools > Options dialog** in the **Text Editor > General** pane.

Changing to insertion or overstrike mode

To toggle between insertion and overstrike mode, do the following:

- Press the **Insert** button to toggle between insert and overwrite mode.
- If overstike mode is enabled, the **OVR** status indicator will be enabled and the overstrike cursor will be visible.

Adding or inserting text

To add or insert text, do the following:

- Either click somewhere in the document or move the cursor to the desired location.

- Enter the text.
- If your cursor is between existing characters, the text is inserted between them.

To overwrite characters in an existing line, press the **Insert** key to put the editor in Overstrike mode.

Deleting text

The text editor supports the following common editing keystrokes:

Key	Description
Backspace	Deletes one character to the left of the cursor
Delete	Deletes one character to the right of the cursor
Ctrl+Backspace	Deletes one word to the left of the cursor
Ctrl+Delete	Deletes one word to the right of the cursor

Deleting characters

To delete characters or a words in a line, do the following:

- Place the cursor immediately before the word or letter you want to delete.
- Press the **Delete** key as many times as needed to delete the characters or words.

—or—

- Place your cursor at the end of the letter or word you want to delete.
- Press the **Backspace** key as many times as needed to delete the characters or words.

Note You can double-click a word and then press **Delete** or **Backspace** to delete it.

Deleting lines or paragraphs

To delete text which spans more than a few characters, do the following:

- Highlight the text you want to delete by selecting it. You can select text by holding down the left mouse button and dragging over the text, or by using the **Shift** key with the either the arrow keys or the **Home**, **End**, **Page Up**, **Page Down** keys.
- Press **Delete** or **Backspace**.

Using the clipboard

Copying text

To copy the selected text to the clipboard, do one of the following:

- From the **Edit** menu, select **Copy**.

—or—

- Type **Ctrl+C**.

—or—

- Type **Ctrl+Ins**.

To append the selected text to the clipboard, do the following:

- From the **Edit** menu, click **Clipboard** then **Copy Append**.

To copy whole lines from the current editor and place them onto the clipboard

- Select **Edit** | **Clipboard** | **Copy Lines** menu item.

To copy whole lines from the current editor and append them onto the end of the clipboard

- Select **Edit** | **Clipboard** | **Copy Lines Append** menu item.

To copy bookmarked lines from the current editor place them onto the clipboard

- Select **Edit** | **Clipboard** | **Copy Marked Lines** menu item.

To copy bookmarked lines from the current editor and append them onto the end of the clipboard

- Select **Edit** | **Clipboard** | **Copy Marked Lines Append** menu item.

Cutting text

To cut the selected text to the clipboard, do one of the following:

- From the **Edit** menu, click **Cut**.

—or—

- Type **Ctrl+X**.

—or—

- Type **Shift+Del**.

To cut selected text from the current editor and append them onto the end of the clipboard

- Select **Edit** | **Clipboard** | **Cut Append** menu item.

To cut whole lines from the current editor and place them onto the clipboard

- Select **Edit** | **Clipboard** | **Cut Lines** menu item.

To cut whole lines from the current editor and append them onto the end of the clipboard

- Select **Edit** | **Clipboard** | **Cut Lines Append** menu item.

To cut bookmarked lines from the current editor and place them onto the clipboard

- Select **Edit** | **Clipboard** | **Cut Marked Lines** menu item.

To cut bookmarked lines from the current editor and append them onto the end of the clipboard

- Select **Edit** | **Clipboard** | **Cut Marked Lines Append** menu item.

Pasting text

To paste text into current editor from clipboard, do one of the following:

- From the **Edit** menu, click **Paste**.

—or—

- Type **Ctrl+V**.

—or—

- Type **Shift+Ins**.

To paste text into a new editor from clipboard, do the following:

- From the **Edit** menu, click **Clipboard** then **Paste As New Document**.

Clearing the clipboard

To clear the clipboard, do the following:

- From the **Edit** menu, click **Clipboard** then **Clear Clipboard**.

Drag and drop editing

You can select text and then drag and drop it in another location. You can drag text to a different location in the same text editor or to another text editor.

Dragging and dropping text

To drag and drop text, do the following:

- Select the text you want to move, either with the mouse or with the keyboard.
- Click on the highlighted text and keep the mouse button pressed.
- Move the mouse cursor to where you want to place the text.
- Release the mouse button to drop the text.

Dragging text moves it to the new location. You can copy the text to a new location by holding down the **Ctrl** key while moving the text: the mouse cursor changes to indicate a copy. Pressing the **Esc** key while dragging text will cancel a drag and drop edit.

Enabling drag and drop editing

To enable or disable drag and drop editing, do the following:

- From the **Tools** menu, click **Options**.
- Under **Text Editor**, click **General**.
- In the **Editing** section, check **Drag/drop editing** to enable drag and drop editing or uncheck it to disable drag and drop editing.

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 editing actions.

Undoing one edit

To undo one editing action, do one of the following:

- From the **Edit** menu, click **Undo**.

—or—

- On the **Standard** toolbar, click the **Undo** tool button.

—or—

- Type **Ctrl+Z** or **Alt+Backspace**.

Undoing multiple edits

To undo multiple editing actions, do the following:

- On the **Standard** toolbar, click the arrow next to the **Undo** tool button.
- From the menu, select the editing operations to undo.

Undoing all edits

To undo all edits, do one of the following:

- From the **Edit** menu, click **Advanced** then **Undo All**.

—or—

- Type **Ctrl+K, Ctrl+Z**.

Redoing one edit

To redo one editing action, do one of the following:

- From the **Edit** menu, click **Redo**.

—or—

- On the **Standard** toolbar, click the **Redo** tool button.

—or—

- Type **Ctrl+Y** or **Alt+Shift+Backspace**.

Redoing multiple edits

To redo multiple editing actions, do the following:

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

Redoing all edits

To redo all edits, do one of the following:

- From the **Edit** menu, click **Advanced** then **Redo All**.

—or—

- Type **Ctrl+K, Ctrl+Y**.

Indentation

The editor uses the **Tab** key to increase or decrease the indentation level. The indentation size can be altered in the editor's **Language Properties** window.

Changing indentation size

To change the indentation size, do the following:

- Select the **Properties Window**.
- Select the **Language Properties** pane.

- 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 Properties** window.

Selecting tab or space fill when indenting

To enable or disable the use of tab characters when indenting, do the following:

- Select the **Properties Window**.
- Select the **Language Properties** pane.
- Set the **Use Tabs** property for the required language. Note that changing this setting does not add or remove existing tabs from files, the change will only effect new indents.

The editor can provide assistance 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 **Return** or **Enter** is pressed, the editor automatically moves the cursor to the indentation level of the previous line.
- **Smart** The editor analyses the source code to compute the appropriate indentation level for the line. The number of lines before the current cursor position that are analysed for context can be altered. The smart indent mode can be configured to either indent open and closing braces or the lines following the braces.

Changing indentation options

To change the indentation mode, do the following:

- Select the **Properties Window**.
- Select the **Language Properties** pane.
- Set the **Indent Mode** property for the required language.

To change whether opening braces are indented in smart indent mode, do the following:

- Select the **Properties Window**.
- Select the **Language Properties** pane.
- Set the **Indent Opening Brace** property for the required language.

To change whether closing braces are indented in smart indent mode, do the following:

- Select the **Properties Window**.
- Select the **Language Properties** pane.
- Set the **Indent Closing Brace** property for the required language.

Changing indentation context

To change number of previous line used for context in smart indent mode, do the following:

- Select the **Properties Window**.
- Select the **Language Properties** pane.
- Set the **Indent Context Lines** property for the required language.

File management

To create a file

- Select **File | New | New File** menu item.

Opening an existing file

To open an existing file, do one of the following:

- From the File **menu**, click **Open...**
- Choose the file to open from the dialog.
- Click **Open**.

—or—

- Type **Ctrl+O**.
- Choose the file to open from the dialog.
- Click **Open**.

Opening multiple files

To open multiple existing files in the same directory, do one of the following

- Select **File | Open** menu item.
- Choose multiple files to open from the dialog. Hold down **Ctrl** key to add individual files or hold down **Shift** to select a range of files.
- Select **Open** from the dialog.

Saving a file

To save a file, do one of the following:

- Activate the editor to save.
- From the **File** menu, click **Save**.

—or—

- Activate the editor to save.
- Type **Ctrl+S.**

—or—

- Right click the tab of the editor to save.
- From the popup menu, click **Save**.

Saving a file to a different name

:To save a file, do one of the following:

- Select editor to save.
- From the **File** menu, click **Save As...**
- Enter the new file name and click **Save**.

—or—

- Right click the tab of the editor to save.
- From the popup menu, click **Save As...**
- Enter the new file name and click **Save**.

Printing a file

:To print a file, do one of the following:

- Select editor to print.
- From the **File** menu, click **Print...**
- Select the printer to print to and click **OK**.

—or—

- Right click the tab of the editor to print.
- From the popup menu, click **Print...**
- Select the printer to print to and click **OK**.

To insert a file at the current cursor position

- Select the editor to insert file into.
- Move the cursor to the required insertion point.
- Select **Edit | Insert File** menu item.
- Select file to insert.
- Click **Open** button.

To toggle a file's write permission

- Select the editor containing the file.
- Select **Edit | Advanced | Toggle Read Only**.

Find and replace

To find text in a single file

- Select **Edit | Find and Replace | Find...** menu item.
- Enter the string to be found in the **Find what** 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, the beginning or the end of line on either side of the string being searched for, set the **Match whole word** option.
- If the search string is a **Regular expressions** (page 85), set the **Use regular expression** option.
- If the search should move up the document from the current cursor position rather than down the document, set the **Search up** option.
- Click **Find** button to find next occurrence of the string or click **Mark All** to bookmark all lines in the file containing the string.

To find text within a selection

- Select text to be searched.
- Select **Edit | Find and Replace | Find...** menu item.
- Enter the string to be found in the **Find what** 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, the beginning or the end of line on either side of the string being searched for, set the **Match whole word** option.
- If the search string is a **Regular expressions** (page 85), set the **Use regular expression** option.
- If the search should move up the document from the current cursor position rather than down the document, set the **Search up** option.
- Click **Mark All** to bookmark all lines in the selection containing the string.

To find and replace text

- Select **Edit | Find and Replace | Replace...** menu item.
- Enter the string to be found in the **Find what** input.
- Enter the string to replace the found string with in the **Replace with** input. If the search string is a **Regular expressions** (page 85) then the *n* backreference can be used in the replace 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, the beginning or the end of line on either side of the string being searched for, set the **Match whole word** option.
- If the search string is a **Regular expressions** (page 85), set the **Use regular expression** option.
- If the search should move up the document from the current cursor position rather than down the document, set the **Search up** option.
- Click **Find** button to find next occurrence of string and then **Replace** button to replace the found string with replacement string or click **Replace All** to replace all occurrences of the string without prompting.

To find text in multiple files

- Select **Edit | Find and Replace | Find in Files...** menu item.
- Enter the string to be found in the **Find what** input.
- Enter the wildcard to use to filter the files in the **In file types** input.
- Enter the folder to start search in the **In folder** 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, the beginning or the end of line on either side of the string being searched for, set the **Match whole word** option.

- If the search string is a **Regular expressions** (page 85), set the **Use regular expression** option.
- If the search will be carried out in the root folder's sub-folders, set the **Look in subfolders** option.
- The output of the search results can go into two separate panes. If the output should go into the second pane, select **Output to pane 2** option.
- Click **Find** button.

Regular expressions

The editor can search and replace test 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 modelled 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 that the CrossStudio editor supports.

Characters	Meaning
\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 character is 0, 1, 2, 7 8 or 9. A range can be negated using the '^' character, e.g. [^a-z] matches if character is anything other than a lower case alphabetic character.
c	The literal character *c*. For example to match the character * you would use *.
\a	Match ASCII bell character.

Characters	Meaning
\f	Match ASCII form feed character.
\n	Match ASCII line feed character.
\r	Match ASCII carriage return character.
\t	Match ASCII horizontal tab character.
\v	Match ASCII vertical tab character.
\x*hhhh*	Match Unicode character specified by hexadecimal number *hhhh*.
.	Match any character.
*	Match zero or more occurrences of the preceding expression.
+	Match one or more occurrences of the preceding expression.
?	Match zero or one occurrences of the preceding expression.
{*n*}	Match *n* occurrences of the preceding expression.
{*n*,}	Match at least *n* occurrences of the preceding expression.
{,*m*}	Match at most *m* occurrences of the preceding expression.
{*n*,*m*}	Match at least *n* and at most *m* occurrences of the preceding expression.
^	Beginning of line.
$	End of line.
\b	Word boundary.
\B	Non-word boundary.
(*e*)	Capture expression *e*.
n	Backreference 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** check box must be set in the search and replace dialog. Once enabled, the regular expressions can be used in the **Find what** search string. The **Replace with** strings can use the "*n*" backreference string to reference any captured strings.

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

Advanced editor features

Code Templates

The editor provides the ability to use code templates. A code template is a block of frequently used source code that can be inserted automatically by using a particular key sequence. A '|' character is used in the template to indicate the required position of the cursor after the template has been expanded.

To view code templates

- Select **Edit | Advanced | View Code Templates** menu item.

Code templates can either be expanded manually or automatically when the **Space** key is pressed.

To expand a code template manually

- Type a key sequence, for example the keys **c** followed by **b** for the comment block template.
- Select **Edit | Advanced | Expand Template** or type **Ctrl+J** to expand the template.

To expand the template automatically

- Ensure the **Expand Templates On Space** editor property is enabled.

- Type a key sequence, for example the keys **c** followed by **b** for the comment block template.
- Now type **Space** key to expand the template.

Editing Macros

The editor has a number of built-in macros for carrying out common editing actions.

To declare a type

- Select **Edit | Editing Macros | Declare Or Cast To**menu item for required type.

To cast to a type

- Select text in the editor containing expression to cast.
- Select **Edit | Editing Macros | Declare Or Cast To**menu item for required type cast.

To insert a qualifier

- Select **Edit | Editing Macros | Insert** menu item for required qualifier.

Tab Characters

The editor can either use tab characters or only use space characters to fill whitespace. The use of tabs or spaces when indenting can be specified in the editor's language properties. The editor can also add or remove tabs characters in blocks of selected text.

To replace spaces with tab characters in selected text

- Select text.
- Select **Edit | Advanced | Tabify Selection** menu item

To replace tab characters with spaces in selected text

- Select text.
- Select **Edit | Advanced | Untabify Selection** menu item

Changing Case

The editor can change the case of selected areas of text.

To change case of selected text to uppercase

- Select text.
- Select **Edit | Advanced | Make Selection Uppercase** menu item.

To change case of selected text to lowercase

- Select text.
- Select **Edit | Advanced | Make Selection Lowercase** menu item.

Commenting

The editor can add or remove language specific comment characters to areas of text.

To comment out an area of selected text

- Select text to comment out.
- Select **Edit | Advanced | Comment** menu item.

To uncomment an area of selected text

- Select text to remove comment characters from.
- Select **Edit | Advanced | Uncomment** menu item.

Indentation

The editor can increase or decrease the indentation level of an area of selected text.

To increase indentation of selected text

- Select text.
- Select **Edit | Advanced | Increase Line Indent** menu item.

To decrease indentation of selected text

- Select text.
- Select **Edit | Advanced | Decrease Line Indent** menu item.

Sorting

The editor can sort areas of selected text in ascending or descending ASCII order.

To sort selected lines into ascending order

- Select text to sort.
- Select **Edit | Advanced | Sort Ascending** menu item.

To sort selected lines into descending order

- Select text to sort.
- Select **Edit | Advanced | Sort Descending** menu item.

Text Transposition

The editor can transpose word or line pairs.

To transpose the word at the current cursor position with the previous word

- Select **Edit | Advanced | Transpose Words** menu item.

To transpose the current line with the previous line

- Select **Edit | Advanced | Transpose Lines** menu item.

Whitespace

To make whitespace visible

- Select **Edit | Advanced | Visible Whitespace** menu item.

Code templates

The editor provides the ability to use code templates. A code template is a block of frequently used source code that can be inserted automatically by using a particular key sequence. A '|' character is used in the template to indicate the required position of the cursor after the template has been expanded.

Editing code templates

To edit code templates, do the following:

- From the **Edit** menu, click **Advanced** then **View Code Templates**.

Code templates can either be expanded manually or automatically when the **Space** key is pressed.

Manually expanding a template

To expand a code template manually, do the following:

- Type a key sequence, for example the keys **c** followed by **b** for the comment block template.
- From the Edit menu, click **Advanced** then **Expand Template** or type **Ctrl+J** to expand the template.

Automatically expanding templates

To expand the template automatically, do the following:

- Ensure the **Expand Templates On Space** editor property is enabled.
- Type a key sequence, for example the keys **c** followed by **b** for the comment block template.
- Now type **Space** key to expand the template.

Memory map editor

Memory map files are tree structured descriptions of the target memory map. Memory map files are used by the compiler to ensure correct placement of program sections. Memory map files are used by the debugger so that it knows which memory addresses are valid on the target and which program sections to load. You can also use the memory 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 that CrossStudio supports but it is useful to view them with the memory map editor.

You can open memory map files using **File > Open** and selecting the XML file that contains the memory map or alternatively using the **View Memory Map** option on the context 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 that are 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 that the linker knows where sections should be placed. Additionally the debugger uses the information in memory map files to enable register display and memory display.

The memory map editor supports the following node types:

- **Root.** The top most node of the memory map.

- **Memory Segment.** A range of addresses that represents a memory region in the target.
- **Program Section.** Represents a program section of your application.
- **Register Group.** Represents an area of 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.
- Bit Fields can be within registers.

All nodes have mandatory and optional properties associated with them. All nodes have a mandatory Name property. This name should be unique within the memory map.

Memory segment and register group properties

- **Start Address.** A hexadecimal number stating where the memory begins (lowest address).
- **Start Address Symbol.** The name of a linker symbol to generate that has the value of the Start Address.
- **Size.** A hexadecimal number that defines the size in bytes of the memory segment.
- **Size Symbol.** The name of a linker symbol to generate that has the value of the Size.
- **Access Type.** Specifies if the memory segment is read only or read/write.

Program section properties

- **Start Address.** An optional hexadecimal value that is the absolute load position of the section. If this isn't set then the relative placement of the program section within the memory segment will determine the load position of the section.
- **Size.** An optional decimal value that is the size in bytes of the program section.

- **Load.** Specifies whether or not the section should be loaded by the debugger.
- **Alignment.** An optional decimal value that specifies the alignment requirements of the section.
- **Section To Run In.** An optional name of another program section that this program section will be copied to.
- **Input Section Names.** The optional names of the files that will be placed into 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 that has the value of the Start Address.
- **Register Type.** Optional, a C type specifying how you want the register to be displayed. The 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 is 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 editor has many of the attributes of the text editor and the same key-bindings for example cut, copy and paste are all accessible from the **Edit** menu. In addition to the standard editor capabilities the memory map editor supports the movement up and down of nodes within a hierarchy. This enables the sequencing of program sections to be achieved.

Section placement

To describe the desired layout of your program in memory the CrossWorks project system uses a memory map file and an optional linker placement file. These files are both xml files and can be edited either with the text editor or with the built-in memory map editor. The principle usage of the memory map file is to describe the physical location of memory segments on the target. The specification of where to place program sections is done in terms of these memory map segments.

Using a single file

In this scheme the sections are explicitly placed in the memory segments of the memory map file

```
ROOT
  PERIPHERALS1 (0x70000000)
  PERIPHERALS2 (0x60000000)
  FLASH (0x400000000)
    .text
    .vectors
  SRAM (0x00000000)
    .stack
```

In this system the sections .text and .vectors are placed in the FLASH segment and the .stack section is placed in the SRAM section.

The memory map file to use for the linkage can either be included as a part of the project or alternatively it can be specified in the Memory Map File project property.

Using two files

In this scheme a separate section placement file is used to specify the section placement by referring to the memory segments of another file. This 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. The format of a section placement is very similar to a memory map file - however no addresses are needed for the memory segments.

```
ROOT
  FLASH
    .text
    .vectors
  SRAM
    .stack
```

The memory map file can just contain the memory segment descriptions

```
ROOT
  PERIPHERALS1 (0x70000000)
  PERIPHERALS2 (0x60000000)
  FLASH (0x400000000)
  SRAM (0x00000000)
```

The section placement file to use for linkage can either be included as a part of the project or alternatively it can be specified in the Section Placement File project property.

Adding a new section

To add a new section you must create one using the either the assembler or the compiler. For the CrossWorks C compiler this can be achieved using the #pragma codeseg("name") directive. For the GNU C compiler this can be achieved using the __attribute__((section("name")) on the functions. For both compilers CrossWorks supports renaming of the code, constant, data and zero'd data using the Section Options properties.

Once you have created a section you can then place it into one of the memory segments of either the memory map file or the section placement file. Note that the placement order is kept when the linker command line is generated unless you specify explicitly an address that the section should be placed at.

Specifying load sections and run sections

If the section you have created is a code section then you should set the Load property of the section to "Yes". This makes the linker include the section in the program. For example a new code section called .text2 can be placed into the program using

```
ROOT
   FLASH
      .text2
      .text
      .vectors
   SRAM
      .stack
```

If you specify a new data section then you will need to instruct the linker to put the initialisation information about the section into the program and you will need to modify the startup code to initialise the contents of this section from the program.

Data sections using the CrossWorks linker

For the CrossWorks linker you can specify that initialisation data is stored in the program 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

```
   data_init_begin2
   .init "IDATA2"
   data_init_end2
```

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

memcpy(SFB(IDATA2), data_init_begin2, data_init_end2-data_init_end2)

Data sections using the GNU linker

For the GNU linker you have to specify a load section in the program where the initialisation data will be stored and the run section where it will be copied to. For example

```
ROOT
  FLASH
    .data2
    ...
  SRAM
    .data2_run
    ...
```

The **.data2** section will have the load attribute set to "Yes" and the "section to run in" attribute set to **.data2_run**, the **.data2_run** section will have the load attribute set to "No".

CrossWorks generates a GNU linker script containing three symbols for each section marking the load address, start run address and end run address. These symbols can be used to copy the sections from their load positions to their run positions.

memcpy(__data2_start__, __data2_load_start__, __data2_end__ - __data2_start__);

CrossStudio Windows

This section is a reference to each of the windows in the CrossStudio environment.

In this section

- **Execution counts window (page 110) and Trace window (page 121).** Describes how to gather useful profiling statistics on your application on the simulator and targets that support execution profiling and tracing.
- **Globals window (page 110), Locals window (page 112), and Watch window (page 121).** Describes how to examine your application's local and global variables and how to watch specific variables.
- **Memory window (page 114).** Describes how to look at target memory in raw hexadecimal form.
- **Register windows (page 116).** Describes how to examine processor registers and peripherals defined by the project's memory map file.
- **Threads window (page 119).** Describes how CrossStudio can display thread-local data, tasks and objects when you run your application under a real-time operating system.
- **Help window (page 124).** Describes how the CrossSudio help system works and how to get answers to your questions.
- **Output window (page 126).** Describes the output window and the logs it contains.
- **Project dependencies and build order (page 58).** Describes the project explorer and how to manage your projects.
- **Properties window (page 129).** Describes the property window and how to change environment and project properties using it.
- **Source code control (page 64).** Describes how to use the Source Navigator to easily browse your project's functions, methods, and variable.
- **Symbol browser (page 132).** Describes how you can use the Symbol browser to find out how much code and data your application requires.
- **Targets window (page 139).** Describes how to manage your target connections by creating new ones, editing existing ones, and deleteing unused ones.

Clipboard ring window

The code editor captures all **Cut** and **Copy** operations and stores the the cut or copied item on the **Clipboard Ring**. The clipboard ring stores the last 20 text items that were cut or copied, but you can configure the maximum number of items stored on the clipboard ring 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.

Showing the clipboard ring

To display the **Clipboard Ring** window if it is hidden, do one of the following:

- From the **View** menu, click **Clipboard Ring**.

—or—

- Type **Ctrl+Alt+C**.

—or—

- Right click the tool bar area to display the **View** menu.
- From the popup menu, click **Clipboard Ring**.

Pasting an item by cycling the clipboard ring

To paste from the clipboard ring, do the following:

- 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.
- Type **Ctrl+Shift+V** to paste the clipboard ring's current item to the current document.
- Repeatedly type **Ctrl+Shift+V** to cycle through the entries in the clipboard ring until you get to the one you want to permanently paste in the document. Each time you press **Ctrl+Shift+V**, the editor replaces the last entry you pasted from the clipboard ring so that you end up with only the last one you selected. The item you stop on then becomes the current item.
- Move to another location or cancel the selection. You can use **Ctrl+Shift+V** to paste the current item again or cycle the clipboard ring to a new item.

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

Pasting a specific item into a document

To paste an item on the clipboard ring directly into the current document, do one of the following:

- Move the cursor to the position where you want to paste the item into the document.
- Display the dropdown menu of the item to paste by clicking the arrow to its right.
- From the menu, click **Paste**.

—or—

- Make the item you want to paste the current item by clicking it.

- Move the cursor to the position where you want to paste the item into the document.
- Type **Ctrl+Shift+V**.

Pasting all items into a document

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

- From the **Edit** menu, click **Clipboard Ring** then **Paste All**.

—or—

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

—or—

- Type **Ctrl+R**, **Ctrl+V**.

Removing a specific item from the clipboard ring

To remove an item from the clipboard ring, do the following:

- Display the dropdown menu of the item to delete by clicking the arrow at the right of the item.
- From the menu, click **Delete**.

Removing all items from the clipboard ring

To remove all items from the clipboard ring, do one of the following:

- From the **Edit** menu, click **Clipboard Ring** then **Clear Clipboard Ring**.

—or—

- On the **Clipboard Ring** tool bar, click the **Clear Clipboard Ring** button.

—or—

- Type **Ctrl+R**, **Delete**.

Configuring the clipboard ring

To configure the clipboard ring, do the following:

- From the **Tools** menu, select **Options**.
- Under **Environment**, select **Even More...**
- Check **Preserve Contents** to save the content of the clipboard ring between runs, or uncheck it to start with an empty clipboard ring.

- Change **Maximum Items** to configure the maximum number of items stored on the clipboard ring.

Build log window

The Build window contain the results of the last build, it is cleared on each rebuild.

If there are any errors in the build then they are displayed in red. Clicking on such a line will locate the editor to the errant source line.

The command lines used to do the build can be echoed to the build log using the tools/options/build/echo checkbox.

Breakpoints window

The **Breakpoints** window manages the list of currently set breakpoints on the solution. Using the breakpoint window you can:

- Enable, disable and delete existing breakpoints.
- Add new breakpoints.
- Show the status of existing breakpoints.
- Chain breakpoints together.

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 breakpoint window for the duration of the debug run but are not saved when you stop debugging.

When a breakpoint is hit then the matched breakpoint will be highlighted in the breakpoint window.

Breakpoints window layout

The **Breakpoints** window is divided into a tool bar and the main breakpoint display.

The Breakpoint tool bar

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 that the selected breakpoint is set at.
	Deletes all breakpoints.
	Disables all breakpoints.
	Enables all breakpoints.
	Creates a new breakpoint group and makes it active.

The Breakpoints window display

The main part of the **Breakpoints** window displays the breakpoints that have been set and what 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 breapoint** 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 there is no executable code associated with the source code line where the breakpoint is set or the processor does not have enough hardware breakpoints.
	**Chained breakpoint** The breakpoint is linked to its parent and is enabled when its parent is hit.

Showing the Breakpoints window

To display the **Breakpoints** window if it is hidden, do one of the following:

- From the **View** menu, click **Other Windows** then **Breakpoints**.

—or—

- From the **Debug** menu, click **Debug Windows** then **Breakpoints**.

—or—

- Type **Ctrl+Alt+B**.

—or—

- On the **Debug** tool bar, click the **Breakpoints** icon.

—or—

- Right click the tool bar area to display the **View** menu.
- From the popup menu, click **Other Windows** then **Breakpoints**.

Managing single breakpoints

You can manage breakpoints in the **Breakpoint** window.

Deleting a breakpoint

To delete a breakpoint, do the following:

- In the **Breakpoints** window, click the breakpoint to delete.
- From the **Breakpoints** window tool bar, click the **Delete Breakpoint** button.

Editing a breakpoint

To edit the properties of a breakpoint, do the following:

- In the **Breakpoints** window, right click the breakpoint to edit.
- From the popup menu, click **Edit Breakpoint**.
- Edit the breakpoint in the Breakpoint dialog.

Enabling or disabling a breakpoint

To toggle the enable state of a breakpoint, do one of the following:

- In the **Breakpoints** window, right click the breakpoint to enable or disable.
- From the popup menu, click **Enable/Disable Breakpoint**.

—or—

- In the **Breakpoints** window, click the breakpoint to enable or disable.
- Type **Ctrl+F9**.

Chaining breakpoints

You can chain breakpoints together using the **Chain Breakpoint From** dialog. When a breakpoint is chained from another breakpoint it will not be hit until the breakpoint it has been chained from has been hit. Note that when a breakpoint is chained to another breakpoint then that breakpoint will not stop your application executing it is there simply to activate the breakpoint (actually breakpoints) it is chained to.

Chained breakpoints have the breakpoint they are chained from displayed as child nodes in the tree display you can remove the chain with the right click context menu.

Note that when you delete or disable a breakpoint that other breakpoints are chained from then those breakpoints are always activated. The chain will also remain in case you wish to reset it.

Managing 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.

Creating a new breakpoint group

To create a new breakpoint group, do one of the following:

- From the **Breakpoints** window tool bar, click the **New Breakpoint Group** button.

—or—

- From the **Debug** menu, click **Breakpoints** then **New Breakpoint Group**.

—or—

- Right click anywhere in the **Breakpoints** window.
- From the popup menu, click **New Breakpoint Group**.

In the **New Breakpoint Group Dialog**, enter the name of the breakpoint group.

Selecting a new active breakpoint group

When you create a breakpoint, it is added to the active breakpoint group. To make a group the active group, do the following:

- In the **Breakpoints** window, click the breakpoint group to make active.
- From the popup menu, click **Set as Active Group**.

Deleting a breakpoint group

To delete a breakpoint group, do the following:

- In the **Breakpoints** window, right click the breakpoint group to delete.
- From the popup menu, click the **Delete Breakpointt Group** button.

Enabling all breakpoints in a breakpoint group

You can enable all breakpoints within a group as a whole. To enable all breakpoints in a group, do the following:

- In the **Breakpoints** window, right click the breakpoint group to enable.
- From the popup menu, click **Enable Breakpoint Group.**

Disabling all breakpoints in a breakpoint group

You can disable all breakpoints within a group as a whole. To disable all breakpoints in a group, do the following:

- In the **Breakpoints** window, right click the breakpoint group to disable.
- From the popup menu, click **Disable Breakpoint Group.**

Managing all breakpoints

You can delete, enable, or disable all breakpoints.

Deleting all breakpoints

To delete all breakpoints, do one of the following:

- From the **Debug** menu, click **Breakpoints** then **Delete All Breakpoints**.

—or—

- From the **Breakpoints** window tool bar, click the **Delete All Breakpoints** button.

—or—

- Type **Ctrl+Shift+F9**.

Enabling all breakpoints

To enable all breakpoints, do one of the following:

- From the **Debug** menu, click **Breakpoints** then **Enable All Breakpoints**.

—or—

- From the **Breakpoints** window tool bar, click the **Enable All Breakpoints** button.

Disabling all breakpoints

To disable all breakpoints, do one of the following:

- From the **Debug** menu, click **Breakpoints** then **Disable All Breakpoints**.

—or—

- From the **Breakpoints** window tool bar, click the **Disable All Breakpoints** button.

Call stack window

The **Call Stack** window displays the list of function calls (stack frames) that are active at the point that program execution halted. When program 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 do 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** (page 119).

Call Stack user interface

The **Call Stack** window is divided into a tool bar and the main breakpoint display.

Call Stack tool bar

Button	Description
	Moves the cursor to where the call to the selected frame was made.
	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.

Call Stack display

The main part of the **Call Stack** window displays each unfinished function call (active stack frame) at the point that program execution halted. The most recent stack frame is displayed at the bottom of the list and the eldest 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 display the **Call Stack** window if it is hidden, do one of the following:

- From the **View** menu, click **Other Windows** then **Call Stack**.

—or—

- From the **Debug** menu, click **Debug Windows** then **Call Stack**.

—or—

- Type **Ctrl+Alt+S**.

—or—

- On the **Debug** tool bar, click the **Call Stack** icon.

—or—

- Right click the tool bar area to display the **View** menu.
- From the popup menu, click **Other Windows** then **Breakpoints**.

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** to display varying amounts of information for each stack frame. By default, CrossStudio displays all information.

Displaying or hiding parameter names

To display or hide the name of each parameter in the call stack, do the following:

- On the **Call Stack** tool bar, click the **Fields** button.
- From the dropdown menu, check or uncheck **Parameter Names**.

Displaying or hiding parameter values

To display or hide the value of each parameter in the call stack, do the following

- On the **Call Stack** tool bar, click the **Fields** button.
- From the dropdown menu, check or uncheck **Parameter Value**v.

Displaying or hiding parameter types

To display or hide the type of each parameter in the call stack, do the following:

- On the **Call Stack** tool bar, click the **Fields** button.
- From the dropdown menu, check or uncheck **Parameter Types**.

Displaying or hiding file names and source line numbers

To display or hide the file name and source line number columns of each frame in the call stack, do the following:

- On the **Call Stack** tool bar, click the **Fields** button.
- From the dropdown menu, check or uncheck **Call Sourrce Location**.

Displaying or hiding call addresses

To display or hide the call address of each frame in the call stack, do the following:

- On the **Call Stack** tool bar, click the **Fields** button.
- From the dropdown menu, check or uncheck **Call Address**.

Changing the debugger context

You can select the stack frame for the debugger context from the **Call Stack** window.

Selecting a specific stack frame

To move the debugger context to a specific stack frame, do one of the following:

- In the **Call Stack** window, double click the stack frame to move to.

—or—

- In the **Call Stack** window, click the stack frame to move to.
- On the **Call Stack** window's tool bar, click the **Switch To Frame** button.

—or—

- In the **Call Stack** window, right click the stack frame to move to.
- From the popup menu, select **Switch To Frame**.

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.

Moving up one stack frame

To move the debugger context up one stack frame to the calling function, do one of the following:

- On the **Call Stack** window's tool bar, click the **Up One Stack Frame** button.

—or—

- On the **Debug Location** tool bar, click the **Up One Stack Frame** button.

—or—

- Type **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.

Moving down one stack frame

To move the debugger context down one stack frame to the called function, do one of the following:

- On the **Call Stack** window's tool bar, click the **Down One Stack Frame** button.

—or—

- On the **Debug Location** tool bar, click the **Down One Stack Frame** button.

—or—

- Type **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, do one of the following:

- In the **Call Stack** window, click the stack frame on the function to stop at when it is returned to.
- From the **Build** tool bar, click the **Toggle Breakpoint** button.

—or—

- In the **Call Stack** window, click the stack frame on the function to stop at when it is returned to.
- Type **F9**.

—or—

- In the **Call Stack** window, right click the function to stop at when it is returned to.
- From the popup menu, click **Toggle Breakpoint**.

Execution counts window

The Execution Counts 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.

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.

The counts window can be sorted by any column (counts, source file, or function name) by clicking on the appropriate column header. Double clicking on an entry will locate the source display to the appropriate source code location.

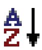
Globals window

The globals window displays a list of all variables that are global to the program. The operations available on the entries in the globals window are the same as the **Watch window** (page 121) except that variables cannot be added to or deleted from the globals window.

Globals window user interface

The **Globals** window is divided into a tool bar and the main data display.

Globals tool bar

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 displayed range in the active memory window to the where the selected item is stored.
	Sorts the global variables alphabetically by name.
	Sorts the global 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 automatically updates to show the active stack frame and new variable values. Items that have changed since they that were previously displayed are highlighted in red.

Showing the Globals window

To display the **Globals** window if it is hidden, do one of the following:

- From the **View** menu, click **Other Windows** then **Globals**.

—or—

- From the **Debug** menu, click **Debug Windows** then **Globals**.

—or—

- Type **Ctrl+Alt+G**.

—or—

- Right click the tool bar area to display the **View** menu.
- From the popup menu, click **Other Windows** then **Globals**.

Changing display format

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

To change the display format of a global variable, do one of the following:

- Right click the item to change.
- From the popup menu, select the format to display the item in.

—or—

- Click the item to change.
- On the Globals window tool bar, select the format to display the item in.

Modifying global variable values

To modify the value of a global variable, do one of the following:

- 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**'.

—or—

- Right click the value of the global variable to modify.
- From the popup menu, select one of the operations to modify the global variable value.

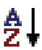
Locals window

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

Locals window user interface

The **Locals** window is divided into a tool bar and the main data display.

Locals tool bar

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 displayed range in the active memory window to the where the selected item is stored.
	Sorts the local variables alphabetically by name.
	Sorts the local 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** tool bar items or select a new frame in the Call Stack window. When the program stops at a breakpoint or is stepped, the Locals window automatically updates to show the active stack frame. Items that have changed since they that were previously displayed are highlighted in red.

Showing the Locals window

To display the **Locals** window if it is hidden, do one of the following:

- From the **View** menu, click **Other Windows** then **Locals**.

—or—

- From the **Debug** menu, click **Debug Windows** then **Locals**.

—or—

- Type **Ctrl+Alt+L**.

—or—

- Right click the tool bar area to display the **View** menu.
- From the popup menu, click **Other Windows** then **Locals**.

Changing display format

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

To change the display format of a local variable, do one of the following:

- Right click the item to change.
- From the popup menu, select the format to display the item in.

—or—

- Click the item to change.
- On the Locals window tool bar, select the format to display the item in.

Modifying local variable values

To modify the value of a local variable, do one of the following:

- 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 popup menu, select one of the operations to modify the local variable value.

Memory window

The memory window shows the contents of the connected target's memory areas. The memory window does not show the complete address space of the target and instead you must enter both the start address and the number of bytes for the memory window to display. You can specify the start address and the size using **Debug expressions** (page 68) which enables you to position the memory display at the start address of a variable or use a value in a register. You can also specify if 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 window updates

The memory window updates each time the debugger locates to source code. So it will update each time your program stops on a breakpoint or single step and whenever you traverse the call stack. If any values that were previously displayed have changed they will be displayed in red.

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 change the number of columns that are displayed.

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.

Saving memory

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, do the following:

- Selects the start address and number of bytes to save by editing the **Start Address** and **Size** fields in the memory window tool bar.
- Right click the main memory display.
- From the popup memu, select **Save As** then select the format from the submenu.

Exporting memory

To export the current state of memory to a binary editor, do the following:

- Selects the start address and number of bytes to save by editing the **Start Address** and **Size** fields in the memory window tool bar.
- Right click the main memory display.
- From the popup memu, select **Export to Binary Editor**.

Note that subsequent modifications in the binary editor will not modify memory in the target.

Register windows

The register windows can 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.

Register window user interface

The **Registers** window is divided into a tool bar and the main data display.

Register tool bar

Button	Description
	Displays the CPU, special function register, and periheral 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.
	Sets the displayed range in the active memory window to the where the selected item is stored.
	Sorts the registers alphabetically by name.
	Sorts the registers numerically by address or register number (default).

Using the register 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 Register windows automatically update to show the current values of the registers. Items that have changed since they that were previously displayed are highlighted in red.

Showing the Registers window

To display register window *n* if it is hidden, do one of the following:

- From the **View** menu, click **Other Windows** then **Registers *n***.

—or—

- From the **Debug** menu, click **Debug Windows** then **Registers *n***.

—or—

- Type **Ctrl+T, R, *n***.

—or—

- Right click the tool bar area to display the **View** menu.
- From the popup menu, click **Other Windows** then **Registers *n***.

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 selected using the Call Stack window.
- The register state of the currently selected thread using the the Threads window.
- The register state that you have supplied using the **Debug > Locate** operation.

To display a group of CPU registers, do the following:

- On the Registers window tool bar, click the Groups button — .

- From the dropdown menu, check the register groups to display and uncheck the ones to hide.

You can uncheck all CPU register groups to allow more space in the display for special function 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 that have been defined in the memory map file that 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, do the following:

- On the Registers window tool bar, click the Groups button — .

- From the dropdown menu, check the register groups to display and uncheck 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 tool bar changes to show the item's display format.

To change the display format of a register, do one of the following:

- Right click the item to change.
- From the popup menu, select the format to display the item in.

—or—

- Click the item to change.
- On the Registers window tool bar, select the format to display the item in.

Modifying register values

To modify the value of a register, do one of the following:

- 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 popup menu, select one of the operations to modify the register value.

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

Threads window

The threads window displays the set of executing contexts on the target processor structured as a set of queues. The executing contexts are supplied to the threads window using a JavaScript program called threads.js that must be in the current active project. When the JavaScript program executes (when the application stops) it creates entries in the threads window that contain the name, priority and status of the thread together with the saved execution context (register state) of the thread. By double clicking on one of the entries in the threads window the debugger is located to it's saved execution context - you can put the debugger back into the default execution context using **Show Next Statement**.

Writing threads.js

The JavaScript program contained in threads.js must be have a named function called **update** which is called when the threads window is refreshed. The threads window is updated using the following JavaScript interface

```
Threads.newqueue("queuename")
Threads.add("threadname", threadpriority, "threadstate", registers)
```

The **Threads.newqueue** function takes a string argument and creates a new top level entry in the threads window. Subsequent threads that are added to this window will go under this.

The **Threads.add** function takes a string argument for the thread name, an integer argument for the thread priority, a string argument for the current state of the thread and finally an array (or null) containing the execution context of the thread (registers). The array containing the registers should contain the entries in the order they are displayed in the CPU registers display—typically this will be in register number order e.g. **r0**, **r1**, and so on.

To generate the thread lists you need to access the debugger from the JavaScript program. To do this you can use the JavaScript interface

```
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 an structure then each field can be accessed using the JavaScript array notation, for example:

```
c = Debug.evaluate("complex");
i = c["i"];
j = c["j"];
```

Because JavaScript is a dynamic language, you can write the above in a more natural fashion:

```
c = Debug.evaluate("complex");
i = c.i;
j = c.j;
```

You can access arbitrary memory locations using C style casts, for example:

```
v = Debug.evaluate("*(unsigned*)0x200");
```

and similarly you can cast to user-defined types:

```
v = Debug.evaluate("*(Complex*)0x200");
```

Note that you should ensure that the JavaScript program will terminate as if it goes into an endless loop then the debugger, and consequently CrossStudio, will become unresponsive and you will need to kill CrossStudio using a task manager.

Trace window

The trace window displays historical information on the instructions executed by the target. 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 right click context 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 on 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.

Watch window

The watch window provides a means to evaluate expressions and display the values of those expressions. Typically expressions are just the name of the variable to be displayed, but can be considerably more complex see **Debug expressions** (page 68). Note that the 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.

Watch window user interface

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

Watch tool bar

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 displayed range in the active memory window to the where the selected item is stored.
	Sorts the global variables alphabetically by name.
	Sorts the global variables numerically by address or register number (default).

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) then you can open the structure see its contents.

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

Showing the Watch window

To display watch window *n* if it is hidden, do one of the following:

- From the **View** menu, click **Other Windows** then **Watch *n***.

—or—

- From the **Debug** menu, click **Debug Windows** then **Watch *n***.

—or—

- Type **Ctrl+T, W, *n***.

—or—

- Right click the tool bar area to display the **View** menu.
- From the popup menu, click **Other Windows** then **Watch *n***.

Changing display format

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

To change the display format of a local variable, do one of the following:

- Right click the item to change.
- From the popup menu, select the format to display the item in.

—or—

- Click the item to change.
- On the Watch window tool bar, select the format to display the item in.

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

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

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

Modifying watched values

To modify the value of a local variable, do one of the following:

- 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 popup menu, select one of the operations to modify the variable's value

Help window

The help viewer is located in the HTML viewer in the main tab window. It displays the currently selected help topic.

Context sensitive help

CrossStudio provides four types of context sensitive help with increasing detail:

- **Tool tips.** When you move your mouse pointer over a tool button and keep it still, a small window appears with a very brief description of the tool button and its keyboard shortcut if it has one.
- **Status tips.** In addition to tool tips, CrossStudio provides a longer description in the status bar when you hover over a tool button or when you move over a menu item.
- **What's This?** For even more detail, What's This? help provides a description of tool buttons and menu items in an expanded form.
- **Online Manual.** CrossStudio has links from all windows to the online help system.

What's This? help

To quickly find out what a menu item or tool button does, you can use "What's This?" help. To do this:

- From the **Help** menu, click **What's This?** or type **Shift+F1**
- Click on the tool button or menu item of interest.

CrossStudio will then display a small window containing the name and a brief description of the tool button or menu item.

Help in the online manual

CrossStudio provides an extensive HTML-based help system which is available at all times. To go to the help information for a particular window or user interface element:, do the following:

- Focus the appropriate element by clicking it.
- From the **Help** menu, click **CrossStudio Help** or type **F1**.

You can return to the **Welcome** page at any time:

- From the **View** menu, click **HTML Browser** then **Home**

—or—

- Type **Alt+Home**.

Help from 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**, that word is looked up in the help system index and the most likely page displayed in the HTML browser—it's a great way to quickly find the reference help pages for functions provided in the library.

Using the Contents window

The **Contents** view provides a list of all the topics and sub-topics within the help system.

The highlighted entry indicates the current help topic. Other topics can be selected and the help viewer will update accordingly.

To move to the next topic

- From the **Help** menu, click **Next Topic**

—or—

- Click the **Next Topic** tool button on the **Contents** window toolbar.

To move to the previous topic

- From the **Help** menu, click **Previous Topic**

—or—

- Click the **Previous Topic** tool button on the **Contents** window toolbar.

Using the Search window

Using the **Search** window you can search for multiple words or phrases. When the search button is pressed the matching pages are listed in order of relevance.

When you select a topic in the **Search** window, the corresponding help topic is shown in the HTML browser.

Using the Index window

The index view allows single keywords to be located. Keywords can either be typed, or selected from the list. As the selected keyword changes the topic with the highest number of hits is displayed. Other topics can be selected and the help viewer will update accordingly.

Output window

The **Output** window contains logs and transcripts from various systems within CrossStudio. Most notably, it contains the **Build Log**, **Target Log** and **Find in Files** results.

Output window user interface

The **Output** window is divided into a tool bar and the log display.

Output tool bar

Button	Description
	**Tree view** Shows the log as a tree view.
	**Flat view** Shows the log as a flat view.

Showing the Output window

To display the **Output** window if it is hidden, do one of the following:

- From the **View** menu, click **Output**.

—or—

- Type **Ctrl+Alt+O**.

—or—

- Right click the tool bar area to display the **View** menu.
- From the popup menu, click **Output**.

Using the output window

Showing a specific log

To display a specific log, do one of the following:

- On the **Output** window tool bar, click the **Output Pane List**.
- From the list, click the log to display.

—or—

- From the **View** menu, click **Logs** and then the log to display.

—or—

- Right click the tool bar area to display the **View** menu
- From the popup menu, click **Logs** and then the log to display.

Showing the Build Log

To display the build log in the output window, do one of the following:

- From the **Build** menu, click **Show Build Log**.

—or—

- Double click the **Target Status** panel in the status bar.

Showing the Target Log

To display the target log in the output window, do the following:

- From the **Target** menu, click **Show Target Log**.

Project explorer

The **Project Explorer** organizes your projects and files and provides quick access to the commands that operate on them. A tool bar at the top of thw window offers quick access to commonly used commands for the item selected in the **Project Explorer**.

This section gives a brief overview of the project explorer window and its operation, but for a complete description of how to work with projects and how to manage them, please refer to **Project management** (page 48).

The Project Explorer tool bar

Button	Description
	Adds a new file to the project using the **New File** dialog.
	Adds an existing files to the project.
	Removes files, folders, projects, and links from the project.
	Creates a new folder in the project.
	Builds the active project.
	Disassembles the selected project item.
	Sets project explorer options.
	Displays the properties dialog for the selected item.

Showing the Project Explorer

To activate the **Project Explorer** if it is hidden, do one of the following:

- From the **View** menu, click **Project Explorer**.

—or—

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

—or—

- On the **Standard** tool bar, click the **Project Explorer** icon.

—or—

- Right click the tool bar area to display the **View** menu.
- From the popup menu, click **Project Explorer**.

Setting project properties

When you select an item in the project explorer, the properties window displays the properties that can be set for the item. This allows you to set compilation options for source files, for instance.

Opening files for editing

Double clicking a source file will load it into the code editor for editing. As you switch between files in the editor, the selection in the project explorer changes to highlight the file that you're currently editing.

Source code control

Using the the project explorer you can check files into and out of a source code control system. Right clicking on a source file brings up a context menu with the following source code control operations:

- **Check In** checks a file into source code control.
- **Check Out** checks a source file out of the repository and makes it writable.
- **Undo Check Out** undoes a check out and reverts the file on disk to the one in the source code control system.
- **Add To Source Control** adds a file to source control.
- **Remove From Source Control** removes a file from source control and deletes it from the source code control database.

For more information on source code control, see **Source code control** (page 64).

Related sections

See the **Project management** (page 48) section.

Properties window

The properties window displays properties of the current focused CrossStudio object. Using the properties window you can set build properties of your project, modify the editor defaults and change target settings.

The properties window is organised as a set of key value pairs. As you select one of the keys then a help display explains the purpose of the property. Because the properties are numerous and can be specific to a particular product build you should consider this help to be the definitive help on the property.

You can organise the property display so that it is divided into categories or alternatively display it as a flat list that is sorted alphabetically.

The combo-box enables you to change the properties yourself and explains which properties you are looking at.

Some properties have actions associated with them - you can find these by right clicking on the property key. Most properties that represent filenames can be opened this way.

When the properties window is displaying project properties you'll find that some properties are displayed in **bold**. This means that the property value hasn't been inherited. If you wish to inherit rather than define such a property then on the right click context menu you'll find an action that enables you to inherit the property.

Source navigator window

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

Source navigator user interface

The **Source Navigator** window is divided into a tool bar and the main breakpoint display.

Source Navigator tool bar

Button	Description
	Sorts the objects alphabetically.
	Sorts the objects by type.
	Sorts the objects by access (public, protected, private).
	Groups objects by type (functions, classes, structures, variables).
	Move the cursor to the statement where the object is defined.
	Move the cursor to the statement where the object is declared. If more than one declaration exists, an arbitrary one is chosen.
	Manually re-parses any changed files in the project.

Source navigator display

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

CrossStudio displays these icons to the left of each object:

Icon	Description
	**Structure or namespace** A C or C++ structure or a C++ namespace.
	**C++ class** A C++ class.
	**Private function** A C++ member function that is declared **private** or a function that is declared with **static** linkage.
	**Protected function** A C++ member function that is declared **protected**.
	**Public function** A C++ member function that is declared **public** or a function that is declared with **extern** linkage.
	**Private variable** A C++ member variable that is declared **private** or a variable declared with **static** linkage.
	**Protected variable** A C++ member variable that is declared **protected**.
	**Public variable** A C++ member variable that is declared **public** or a variable that is declared with **extern** linkage.

Showing the Source Navigator window

To display the **Source Navigator** window if it is hidden, do one of the following:

- From the **View** menu, click **Source Navigator**.

—or—

- Type **Ctrl+Alt+N**.

—or—

- Right click the tool bar area to display the **View** menu.
- From the popup menu, click **Source Navigator**.

Using the source navigator

Parsing source files manually

To parse source files manually, do one of the following:

- From the **Tools** menu, click **Source Navigator** then **Refresh**.

—or—

- On the **Source Navigator** tool bar, click **Refresh**.

CrossStudio re-parses any changed files and updates the source navigator display with the changes. Progress information and any errors are sent to the **Source Navigator Log** in the Output window when parsing.

Grouping objects by type

You can group object 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 in the source browser by type, do one of the following:

- From the **Tools** menu, click **Source Navigator** then **Group By Type**.

—or—

- On the **Source Navigator** tool bar, click the arrow to the right of the **Cycle Grouping** button.
- From the dropdown menu, click **Group By Type**.

Symbol browser

The Symbol Browser window 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 as a whole. You can use the symbol browser to *drill down* to see how big each part of your program is and where it's placed. The way that symbols are sorted and grouped is saved between runs. When you rebuild an application, CrossStudio automatically updates the symbol browser so you can see the effect your changes are making to the memory layout of your program.

Symbol browser user interface

The symbol browser is divided into a tool bar and the main symbol display.

Symbol Browser tool bar

Button	Description
	Groups symbols by source file name.
	Groups symbols by symbol type (equates, functions, labels, sections, and variables)
	Groups symbols by the section that they are defined in.
	Moves the cursor to the statement that defined the symbol.
	Chooses the columns to display in the symbol browser.

Symbol Browser display

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

Icon	Description
	**Private Equate** A private symbol that is 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.

Symbol browser columns

You can choose to display the following fields against 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 addreses 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, that the code or data item covers. 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, then **Size** is calculated as the difference between the start and end address of the range. If a symbol has no range, the size column is left blank.
- **Section.** The section in which the symbol is defined. If the symbol is not defined within a section, the **Section** column is left 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 left blank.

Showing the Symbol Browser window

To display the **Symbol Browser** window if it is hidden, do one of the following:

- From the **View** menu, click **Symbol Browser**.

—or—

- Type **Ctrl+Alt+Y**.

—or—

- Right click the tool bar area to display the **View** menu.
- From the popup menu, click **Symbol Browser**.

Configuring the Symbol Browser

Choosing fields to display

Initially the **Range** and **Size** columns are shown in the symbol browser. You can select which columns to display using the **Field Chooser** on the **Symbol Browser** tool bar.

To select the fields to display in the Symbol Browser, do one of the following:

- Click the **Field Chooser** button on the **Symbol Browser**tool bar.
- Check the fields that you wish to display and uncheck the fields that you wish to hide.

—or—

- From the **Tools** menu, select **Symbol Browser** then **Fields**.
- Check the fields that you wish to display and uncheck the fields that you wish to hide.

Grouping symbols by section

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

To group symbols by section, do the following:

- On the **Symbol Browser** tool bar, click the arrow next to the **Cycle Grouping** tool button.
- From the popup menu, click **Group By Section**.

—or—

- From the **Tools** menu, click **Symbol Browser** then **Group By Section**.

The **Cycle Grouping** tool button icon will change to indicate that the symbol browser is now grouping symbols by section.

Grouping symbols by type

When you group symbols by type, each symbol is grouped underneath the type of symbol that it is. 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 a symbol that is defined by a high-level code sequence.
- A **Variable** is defined by a high-level data declaration.
- A **Label** is a symbol that is defined by an assembly language module. **Label** is also used when high-level modules are compiled with debugging information turned off.

To group symbols by source type, do the following:

- On the **Symbol Browser** tool bar, click the arrow next to the **Cycle Grouping** tool button.

- From the popup menu, click **Group By Type**.

—or—

- From the **Tools** menu, click **Symbol Browser** then **Group By Type**.

The **Cycle Grouping** tool button icon will change to indicate that the symbol browser is now grouping symbols by type.

Grouping symbols by source file

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

To group symbols by source file, do one of the following:

- On the **Symbol Browser** tool bar, click the arrow next to the **Cycle Grouping** tool button.
- From the popup menu, click **Group By Source File**.

—or—

- From the **Tools** menu, click **Symbol Browser** then **Group By Source File**.

The **Cycle Grouping** tool button icon will change to indicate that the symbol browser is now grouping symbols by source file.

Sorting symbols alphabetically

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

To group symbols alphabetically, do one of the following:

- On the **Symbol Browser** tool bar, click the arrow next to the **Cycle Grouping** tool button.
- From the popup menu, click **Sort Alphabetically**.

—or—

- From the **Tools** menu, click **Symbol Browser** then **Sort Alphabetically**.

The **Cycle Grouping** tool button icon will change to indicate that the symbol browser is now grouping symbols alphabetically.

Filtering, finding, and watching symbols

When you're dealing with big projects with hundreds, or even thousands, of symbols, a way to filter the display of those symbols and drill down to the ones you need is very useful. The symbol browser provides an editable combo box in the toolbar which you can use to specify the symols you'd like displayed. The symbol browser uses "*" 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. One thing to note is that 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 browseruses the low-level symbol name when displaying and filtering, so you must type the leading underscore to match high-level symbols.

Finding symbols with a common prefix

To display symbols that start with a common prefix, do the following:

- Type the required prefix into the combo box, optionally followed by a "*".

For instamce, 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 as it is implied.

Finding symbols with a common suffix

To display symbols that end with a common suffix, do the following:

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

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

Jumping to the definition of a symbol

Once 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 the definition of a symbol using the **Go To Definition** tool button.

To go to the definition of a symbol, do one of the following:

- Select the symbol from the list of symbols.
- On the **Symbol Browser** tool bar, click **Go To Definition**.

—or—

- Right click the symbol in the list of symbols.

- From the popup menu, click **Go To Definition**.

Adding symbol to watch and memory windows

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, do the following:

- In the **Symbol Browser**, right click on the the symbol you wish to add to the watch window.
- From the popup menu, click **Add To Watch**.

To add a symbol to the memory window, do the following:

- In the **Symbol Browser**, right click on the the symbol you wish to add to the memory window.
- From the popup menu, click **Locate Memory**.

Working with the Symbol Browser

Here are a few common ways to use the symbol browser:

What function takes up the most code space or what takes the most data space?

- Show the symbol browser by selecting **Symbol Browser** from the **Tools** menu.
- Group symbols by type by choosing **Symbol Browser > Group By Type** from the **Tools** menu.
- Make sure that the **Size** field is checked in **Symbol Browser > Fields** on the **Tools** menu.
- Ensure that the filter on the symbol browser tool bar is empty.
- Click on the **Size** field in the header to sort by data size.
- Read off the the sizes of variables under the **Variable** group and functions under the **Functions** group.

What's the overall size of my application?

- Show the symbol browser by selecting **Symbol Browser** from the **Tools** menu.
- Group symbols by section by choosing **Symbol Browser > Group By Section** from the **Tools** menu.
- Make sure that the **Range** and **Size** fields are checked in **Symbol Browser > Fields** on the **Tools** menu.

- Read off the section sizes and ranges of each section in the application.

Targets window

The targets window (and associated menu) displays the set of target interfaces that 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.

You can connect, disconnect, and reconnect to a target system. You can also reset and load programs using the target window. If you load a program using the target window and you need to debug it then you will have to use the **Debug > Attach Debugger** operation.

Targets window layout

Targets tool bar

Button	Description
	Connects the selected target interface.
	Disconnects the connected target interface.
	Reconnects the connected target interface.
	Resets the connected target interface.
	Displays the properties of the selected target interface.

Showing the Targets window

To display the **Targets** window if it is hidden, do one of the following:

- From the **View** or **Target** menu, click **Targets**.

—or—

- Type **Ctrl+Alt+T**.

—or—

- Right click the tool bar area to display the **View** menu.
- From the popup menu, click **Targets**.

Managing target connections

Connecting a target

To connect a target, do one of the following:

- In the **Targets** window, double click the target to connect.

—or—

- From the **Target** menu, click the target to connect.

—or—

- In the **Targets** window, click the target to connect.
- On the **Targets** window tool bar, click the **Connect** button

—or—

- In the **Targets** window, right click the target to connect.
- From the popup menu, click **Connect**

—or—

- In the **Targets** window, click the target to connect.
- Type **Ctrl+T**, **C**.

Disconnecting a target

To disconnect a target, do one of the following:

- From the **Target** menu, click **Disconnect**

—or—

- On the **Targets** window tool bar, click the **Disconnect** button

—or—

- Type **Ctrl+T**, **D**.

—or—

- Right click the connected target in the **Targets** window
- From the popup menu, click **Disconnect**.

Alternatively, connecting a different target will automatically disconnect the current target connection.

Reconnecting a target

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 as it forces CrossStudio to resynchronize with the target.

To reconnect a target, do one of the following:

- From the **Target** menu, click **Reconnect**.

—or—

- On the **Targets** window tool bar, click the **Reconnect** button.

—or—

- Type **Ctrl+T**, **E**.

—or—

- In the **Targets** window, right click the target to reconnect.
- From the popup menu, click **Reconnect**.

Automatic target connection

You can configure CrossStudiuo to automatically connect to the last used target interface when loading a solution.

To enable or disable automatic target connection, do the following:

- From the **View** menu, click **Properties Window**.
- In the **Properties Window**, click **Environment Properties** from the combo box.
- In the **Target Settings** section, set the **Enable Auto Connect** property to **Yes** to enable automatic connection or to **No** to disable automatic connection.

Creating a new target interface

To create a new target interface, do the following:

- From the targets window's context menu, click **New Target Interface**. A new menu will be displayed containing the types of target interface that may be created.
- 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 on the target, 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, do the following:

- Select a target.
- Select the **Properties** option from the target's context menu.

Restoring default target definitions

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 and therefore should be used with care.

To restore the default target definitions, do the following:

- Select **Restore Default Targets** from the targets window context menu.
- Click **Yes** when prompted if you want to restore the default targets.

Controlling target connections

Resetting the target

Reset of the target is typically handled automatically by the system when you start debugging. However, the target may be manually reset using the **Targets** window.

To reset the connected target, do one of the following:

- On the **Targets** window tool bar, click the **Reset** button.

—or—

- From the **Target** menu, click **Reset**

—or—

- Type **Ctrl+T**, **S**.

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, do the following:

- In the **Targets** window, right click the selected target.
- From the popup menu, click **Download File**.
- From the **Download File** menu, select the type of file to download.
- In the **Open File** dialog, select the executable file to download and click **Open** to download the file.

CrossStudio supports the following file formats when downloading a program:

- Binary
- Intel Hex
- Motorola S-record
- CrossWorks native object file
- Texas Instruments text file

Verifying downloaded programs

You can verify a target's contents against a arbitrary programs held on disk using the **Targets** window.

To verify a target's contents against a program, do the following:

- In the **Targets** window, right click the selected target.
- From the popup menu, click **Verify File**.
- From the **Verify File** menu, select the type of file to verify.
- 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 it does for downloading, described above.

Erasing target memory

Usually, erasing target memory is done automatically CrossStudio downloads a program, but you can erase a target's memory manually.

To completely erase target memory, do the following:

- In the **Targets** window, right click the target to erase.
- From the popup menu, click **Erase All**.

To erase part of target memory, do the following:

- In the **Targets** window, right click the target to erase.
- From the popup menu, click **Erase Range**.

Target definition file

The target interface information in the targets window is stored in an XML file called the target definition file.

To change the target definition file used by the targets window, do the following:

- From the Tools menu, click **Options.**
- In the **Environment Options**, select the **Target** section.
- Edit the **Target definition file** entry to change the path to the target definition file.
- Click **OK** to apply the change, the targets window should load the new target definition file.

ARM Target Interfaces

A target interface is a mechanism for communicating with and controlling a target. A target maybe be a physical hardware device or a simulator.

CrossStudio has a targets window for viewing and manipulating target interfaces. For more information on the targets window, see **Targets window** (page 139).

Before a target interface can be used, it must be connected. CrossStudio permits connection to only one target at a time. For more information on connecting to target interfaces, 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 on viewing and editing target properties, see Viewing and editing target properties.

CrossWorks for ARM can connect to the following targets and target interfaces:

- USB CrossConnect for ARM
- Macraigor System's Wiggler for ARM
- Segger J-Link
- CrossStudio ARM Simulator

USB CrossConnect for ARM Target Interface

The USB CrossConnect for ARM target interface provides access to ARM targets via the Rowley Associates USB CrossConnect for ARM. This target interface supports program loading and debugging of both RAM and FLASH based applications.

CrossConnect Properties

- **Firmware Variant** The variant of the firmware running on the currently connected CrossConnect. Some early CrossConnects requires a different variant of the firmware for ARM7, ARM9 and XScale, each target also has a maximum and variable speed variant of the firmware making six variants in total. You should use the CrossConnect configuration utility (**xcconf**) to configure your CrossConnect with the required firmware variant.
- **Firmware Version** The version number of the firmware running on the currently connected CrossConnect.
- **Serial Number** The serial number of the currently connected CrossConnect device.
- **Use Serial Number** The serial number of the CrossConnect you want to connect to. If multiple USB CrossConnects are connected to your system, this property allows you to specify which one to use. If no serial number is specified, the first available CrossConnect will be used.

Current Device Properties

- **Device Type** The JTAG device ID of the currently connected device.

JTAG Properties

- **Adaptive Clocking** Specifies whether JTAG adaptive clocking using the RTCK signal should be used. This option requires the variable speed variant of the CrossConnect firmware.
- **Identify Target** Specifies whether the target should be identified on connection.
- **JTAG Clock Divider** The value to divide the JTAG clock frequency. The variable speed variant of the CrossConnect firmware is required if this value is set greater than 1.

Loader Properties

- **Erase All** If set to **Yes**, all of the target's FLASH memory will be erased prior to downloading the application. This can be used to speed up download of large programs as it generally quicker to erase a whole device rather than individual segments. If set to **No**, only the areas of FLASH containing the program being downloaded will be erased.

Target Properties

- **Processor Endian** Specifies the byte order of the target processor. Note that the value of this property will be automatically set to a project's **Endian**property when a project is downloaded or attached to.
- **Processor Stop Time** The timeout period, in milliseconds, to allow when stopping the processor.

Macraigor Wiggler (20 and 14 pin) Target Interface

The Macraigor Wiggler target interface provides access to ARM targets via Macraigor System's Wiggler for ARM (or compatible device). This target interface supports program loading and debugging of both RAM and FLASH based applications. There are two variants of the Wiggler, one with 20 pins and one with 14 pins, and both are supported.

Connection Properties

- **Parallel Port** The parallel port connection to use to connect to the target.
- **Parallel Port Address** The base address of the currently connected parallel port (if available).
- **Parallel Port Sharing** If set to **Yes**, parallel port may be shared with other device drivers and programs. If set to **No**, the target interface will demand exclusive use of the port.

Current Device Properties

- **Device Type** The JTAG device ID of the currently connected device.

JTAG Properties

- **Identify Target** Specifies whether the target should be identified on connection.
- **Invert nSRST** Specifies whether the **nSRST** signal should be inverted.

- **JTAG Clock Divider** The value to divide the JTAG clock frequency. This feature allows the JTAG clock frequency to be reduced in order to allow CrossStudio to communicate with boards with unreliable target interfaces.

Loader Properties

- **Erase All** If set to **Yes**, all of the target's FLASH memory will be erased prior to downloading the application. This can be used to speed up download of large programs as it generally quicker to erase a whole device rather than individual segments. If set to **No**, only the areas of FLASH containing the program being downloaded will be erased.

Target Properties

- **Processor Endian** Specifies the byte order of the target processor. Note that the value of this property will be automatically set to a project's **Endian**property when a project is downloaded or attached to.
- **Processor Stop Time** The timeout period, in milliseconds, to allow when stopping the processor.

Segger J-Link

The Segger J-Link target interface provides access to ARM targets via the Segger USB J-Link ARM JTAG interface. This target interface supports program loading and debugging of both RAM and FLASH based applications.

Current Device Properties

- **Device Type** The JTAG device ID of the currently connected device.

J-Link Properties

- **Speed** The JTAG clock frequency.
- **Version** The firmware version.

Loader Properties

- **Erase All** If set to **Yes**, all of the target's FLASH memory will be erased prior to downloading the application. This can be used to speed up download of large programs as it generally quicker to erase a whole device rather than individual segments. If set to **No**, only the areas of FLASH containing the program being downloaded will be erased.

Target Properties

- **Processor Endian** Specifies the byte order of the target processor. Note that the value of this property will be automatically set to a project's **Endian**property when a project is downloaded or attached to.
- **Processor Stop Time** The timeout period, in milliseconds, to allow when stopping the processor.

CrossStudio ARM Simulator Target Interface

The ARM Simulator target interface provides access to CrossStudio's ARM simulator. This target interface supports program loading and debugging. The simulator's memory configuration is determined by the memory map file of the current project/configuration.

ARM Target Support

When a target specific executable project is created using the **Creating a project** (page 20), the following default files are added to the project:

- *Target*_Startup.s - The **Target Startup Code** (page 149)code.
- crt0.s - The CrossWorks standard **crt0.s** (page 150) code.
- *Target*_MemoryMap.xml - The **ARM Memory Map Files** (page 152) file for the board. Note that for some target's a general linker placement file may not be suitable. In these cases there will be two memory map files, one for a Flash build and one for a RAM build.
- flash_placement.xml - The linker placement file for a Flash build.
- sram_placement.xml - The linker placement file for a RAM build.
- *Target*_Target.js - The **ARM Target Script File** (page 154)

Initially, shared versions of these files are added to the project, if you want to modify any these files you should select the file in the project explorer and then click the **Import** option from the context menu. This will copy a writeable version of the file into your project directory and change the path in the project explorer to be that of the local file. You will then be able to make changes to the local file without effecting the shared copy of the file.

The following list describes the typical flow of a C program created using CrossStudio's project templates:

- The processor starts executing at address 0x0000000 which is the reset exception vector. The exception vector table can be found in the **Target Startup Code** (page 149) code, it is put into the program section *.vectors*which is positioned at address 0x00000000 by the **ARM Memory Map Files** (page 152) file.
- The processor jumps to the *reset_handler* label in the **Target Startup Code** (page 149) code which configures the target.
- When the target is configured the **Target Startup Code** (page 149)code jumps to the *_start* entry point in the **crt0.s** (page 150)code which sets up the C runtime environment.
- When the C runtime environment has been set up the **crt0.s** (page 150) code jumps to the C entry point function *main*.
- When the program returns from main, it re-enters the **crt0.s** (page 150)code, executes the destructors and then finally enters an endless loop.

Target Startup Code

The following section describes the role of the target specific startup code.

When you create a new project to produce an executable file using a target specific project template, a file containing the default startup code for the target will be added to the project. Initially a shared version of this file will be added to the project, if you want to modify this file you should select the file in the project explorer and then select **Import** to copy the file to your project directory.

The target startup file typically consists of the following:

- *_vectors* - This is the exception vector table. It is put into it's own *.vectors* section in order to ensure that it is always placed at address 0x00000000.
- *reset_handler* - This is the main reset handler function and typically the main entry point of an executable. The reset handler will usually carry out any target specific initialisation and then jump to the *_start*entry point. In a C system the *_start* entry point is in the **crt0.s** (page 150)file.
- *undef_handler* - This is the default undefined instruction exception handler. This has been declared as a weak symbol to allow the user the override the implementation.
- *swi_handler* - This is the default software interrupt exception handler. This has been declared as a weak symbol to allow the user the override the implementation.

- *pabort_handler* - This is the default prefetch abort exception handler. This has been declared as a weak symbol to allow the user the override the implementation.
- *dabort_handler* - This is the default data abort exception handler. This has been declared as a weak symbol to allow the user the override the implementation.
- *irq_handler* - This is the default IRQ exception handler. This has been declared as a weak symbol to allow the user the override the implementation.
- *fiq_handler* - This is the default FIQ exception handler. This has been declared as a weak symbol to allow the user the override the implementation.

crt0.s

The following section describes the role of the C runtime startup code.

When you create a new project to produce an executable file using a target specific project template, the *crt0.s* file will be added to the project. Initially a shared version of this file will be added to the project, if you want to modify this file you should select the file in the project explorer and then select **Import** to copy the file to your project directory.

The entry point of the C runtime startup code is *_start*. In a typical system this will be called by the **Target Startup Code** (page 149) code after it has initialized the target.

The C runtime carries out the following actions:

- Initialize the stacks.
- Copy the contents of the .data (initialized data) section from non-volatile memory should it be required.
- Copy the contents of the .fast section from non-volatile memory to SRAM should it be required.
- Initialize the .bss section.
- Initialize the heap.
- Call constructors.
- Jump to the *main* entry point.
- Call destructors.
- Wait in exit loop.

Stacks

The ARM maintains six separate stacks. The position and size of these stacks are specified in the project's section placement or memory map file by the following program sections:

- .stack - System and User mode stack.
- .stack_svc - Supervisor mode stack
- .stack_irq - IRQ mode stack
- .stack_fiq - FIQ mode stack
- .stack_abt - Abort mode stack.
- .stack_und - Undefined mode stack.

The crt0.s startup code references these sections and initializes each of the stack pointer registers to point to the appropriate memory location. To change the location in memory of a particular stack, the section should be moved to the required position in the section placement or memory map file.

There is a **Stack Size** linker project property for each stack, you can modify this property in order to alter each stack maximum size. For compatibility with earlier versions of CrossStudio you can also specify the stack size using the stack section's **Size** property in the section placement or memory map file.

Should your application not require one or more of these stacks to be set up you can remove the sections from the memory map file or set the size to 0 and remove the initialization code from the crt0.s file.

.data Section

The **.data** section contains the initialized data. If the run address is different from the load address, as it would be in a FLASH based application in order to allow the program to run from reset, the crt0.s startup code will copy the **.data** section from the load address to the run address before calling the **main** entry point.

.fast Section

For performance reasons it is a common requirement with embedded systems to have critical code running from fast memory, the **.fast** section can be used to simplify this. If the **.fast** section's run address is different from the load address the crt0.s startup code will copy the **.fast** section from the load address to the run address before calling the **main** entry point.

.bss Section

The **.bss** section contains the zero initialized data. The crt0.s startup code references the **.bss** section and sets its contents to zero.

Heap

The position and size of the heap is specified in the project's section placement or memory map file by the **.heap** program section.

The crt0.s startup code references this section and initializes the heap. To change the position of the heap, the section should be moved to the required position in the section placement or memory map file.

There is a **Heap Size** linker project property, you can modify this property in order to alter the heap size. For compatibility with earlier versions of CrossStudio you can also specify the heap size using the heap section's **Size** property in the section placement or memory map file.

Should your application not require the heap functions, you can remove the heap section from the memory map file or set the size to 0 and remove the heap initialization code from the crt0.s file.

ARM Memory Map Files

CrossStudio's memory map files are XML files that are used for the following purposes:

- *Linking*- Memory map files are used by the linker to describe how to lay out a program in memory.
- *Loading*- Memory map files are used by the loader to check that a program being downloaded will actually fit into the target's memory.
- *Debugging*- Memory map files are used by the debugger to describe the location and types of memory a target has. This information is used to decide how to debug the program, for example whether to set hardware or software breakpoints on particular memory location.

There are two types of memory map files:

- *Board Memory Definition* - This type of memory map file is used to describe a target's memory segments. If no *Linker Placement* file is defined, a *Board Memory Definition* file can also describe how program sections should be laid out within the memory segments.
- *Linker Placement* - This type of memory map file is used to describe how program sections should be laid out in the memory segments described by a *Board Memory Definition* file. As the *Linker Placement* file does not describe

memory addresses, only the mapping between memory segments and program sections, it can be used as a general means to describe the layout of a program not tied to a particular target. A *Linker Placement* file does not need to be used if the *Board Memory Definition* file contains all the program section information.

Memory map files can be viewed and edited using CrossStudio's memory map editor, for more information see **Memory map editor** (page 91).

To use a memory map file, simply add the memory file to a project. You may have configuration specific memory map files by excluding memory map files from configurations as you would any other source file.

ARM Project Configurations

The following table describes the default set of **Project configurations** (page 57) when you create a new project:

Configuration Name	Description
ARM Flash Debug	Compile/assemble for ARM instruction set. Link ARM version of libraries. Load into and run from Flash memory. Compile/assemble with debug information and with optimization disabled.
ARM Flash Release	Compile/assemble for ARM instruction set. Link ARM version of libraries. Load into and run from Flash memory. Compile/assemble without debug information and with optimization enabled.
ARM RAM Debug	Compile/assemble for ARM instruction set. Link ARM version of libraries. Load into and run from RAM. Compile/assemble with debug information and with optimization disabled.
ARM RAM Release	Compile/assemble for ARM instruction set. Link ARM version of libraries. Load into and run from RAM. Compile/assemble without debug information and with optimization enabled.
THUMB Flash Debug	Compile/assemble for THUMB instruction set. Link THUMB version of libraries. Load into and run from Flash memory. Compile/assemble with debug information and with optimization disabled.
THUMB Flash Release	Compile/assemble for THUMB instruction set. Link THUMB version of libraries. Load into and run from Flash memory. Compile/assemble without debug information and with optimization enabled.

Configuration Name	Description
THUMB RAM Debug	Compile/assemble for THUMB instruction set. Link THUMB version of libraries. Load into and run from RAM. Compile/assemble with debug information and with optimization disabled.
THUMB RAM Release	Compile/assemble for THUMB instruction set. Link THUMB version of libraries. Load into and run from RAM. Compile/assemble without debug information and with optimization enabled.

ARM Target Script File

The target interface system uses CrossStudio's JavaScript (ECMAScript) interpreter to support board and target specific behaviour.

The main use for this is to support non-standard target and board reset schemes and also to configure the target after reset, see Reset Script for more information.

The target script system can also be used to carry out target specific operations when the debugger attaches, stops or starts the target. This can be useful when debugging with caches enabled as it provides a mechanism for the debugger to FLUSH and disable caches when the processor enters debug state and then re-enable the caches when the processor is released into run state. See Attach Script, Stop Script, and Run Script for more information.

In order to reduce script duplication, when the target interface runs a reset, attach, run or stop script it first looks in the current active project for a file marked with a project property **File Type** set to **Reset Script**. If a file of this type is found it will be loaded prior to executing the scripts, each of the scripts can then call functions within this script file.

Reset Script

The **Reset Script** property held in the **Target** project property group is used to define a script to execute to reset and configure the target.

The aim of the reset script is to get the processor into a known state. When the script has executed the processor should be reset, stopped on the first instruction and configured appropriately.

As an example, the following script demonstrates the reset script for an Evaluator 7T target board with a memory configuration that re-maps SRAM to start from 0x00000000. The **Evaluator7T_Reset** function carries out the standard ARM reset and stops the processor prior to executing the first instruction. The **Evaluator7T_ResetWithRamAtZero** function calls this reset function and then configures the target memory by accessing the configuration registers directly. See TargetInterface Object for a description of the TargetInterface object which is used by the reset script to access the target hardware.

```
function Evaluator7T_Reset()
{
 TargetInterface.setNSRST(0);
 TargetInterface.setICEBreakerBreakpoint(0, 0x00000000, 0xFFFFFFFF,
0x00000000, 0xFFFFFFFF, 0x100, 0xF7);
 TargetInterface.setNSRST(1);
 TargetInterface.waitForDebugState(1000);
 TargetInterface.trst();
}

function Evaluator7T_ResetWithRamAtZero()
{
 Evaluator7T_Reset();
 /***********************************************************************
  * Register settings for the following memory configuration:           *
  *                                                                     *
  *  ----------------------                                             *
  * | ROMCON0 - 512K FLASH | 0x01800000 - 0x0187FFFF                    *
  * |----------------------|                                            *
  * | ROMCON2 - 256K SRAM  | 0x00040000 - 0x0007FFFF                    *
  * |----------------------|                                            *
  * | ROMCON1 - 256K SRAM  | 0x00000000 - 0x0003FFFF                    *
  *  ----------------------                                             *
  *                                                                     *
  ***********************************************************************/
 TargetInterface.pokeWord(0x03FF0000, 0x07FFFFA0); // SYSCFG
 TargetInterface.pokeWord(0x03FF3000, 0x00000000); // CLKCON
 TargetInterface.pokeWord(0x03FF3008, 0x00000000); // EXTACON0
 TargetInterface.pokeWord(0x03FF300C, 0x00000000); // EXTACON1
 TargetInterface.pokeWord(0x03FF3010, 0x0000003E); // EXTDBWIDTH
 TargetInterface.pokeWord(0x03FF3014, 0x18860030); // ROMCON0
 TargetInterface.pokeWord(0x03FF3018, 0x00400010); // ROMCON1
 TargetInterface.pokeWord(0x03FF301C, 0x00801010); // ROMCON2
 TargetInterface.pokeWord(0x03FF3020, 0x08018020); // ROMCON3
 TargetInterface.pokeWord(0x03FF3024, 0x0A020040); // ROMCON4
 TargetInterface.pokeWord(0x03FF3028, 0x0C028040); // ROMCON5
 TargetInterface.pokeWord(0x03FF302C, 0x00000000); // DRAMCON0
 TargetInterface.pokeWord(0x03FF3030, 0x00000000); // DRAMCON1
 TargetInterface.pokeWord(0x03FF3034, 0x00000000); // DRAMCON2
```

```
  TargetInterface.pokeWord(0x03FF3038, 0x00000000); // DRAMCON3
  TargetInterface.pokeWord(0x03FF303C, 0x9C218360); // REFEXTCON
}
```

Attach Script

The **Attach Script** property held in the **Target** project property group is used to define a script that is executed when the debugger first attaches to an application. This can be after a download or reset before the program is run or after an attach to a running application. The aim of the attach script is to carry out any target specific configuration before the debugger first attaches to the application being debugged.

See TargetInterface Object for a description of the TargetInterface object which is used by the attach script to access the target hardware.

Stop Script

The **Stop Script** property held in the **Target** project property groups is used to define a script that is executed when the target enters debug/stopped state. This can be after the application hits a breakpoint or when the **Debug | Break** operation has been carried out. The aim of the stop script is to carry out any target specific operations before the debugger starts accessing target memory. This is particularly useful when debugging applications that have caches enabled as the script can disable and flush the caches enabling the debugger to access the current memory state.

See TargetInterface Object for a description of the TargetInterface object which is used by the stop script to access the target hardware.

Run Script

This **Run Script** property held in the **Target** project property group is used to define a script that is executed when the target enters run state. This can be when the application is run for the first time or when the **Debug | Go** operation has been carried out after the application has hit a breakpoint or been stopped using the **Debug | Break** operation. The aim of the run script is to carry out any target specific operations after the debugger has finished accessing target memory. This can be useful to re-enable caches previously disabled by the stop script.

See TargetInterface Object for a description of the TargetInterface object which is used by the run script to access the target hardware.

TargetInterface Object

The **TargetInterface** object is used to access the currently connected target interface. The following section describes the **TargetInterface** object's member functions.

TargetInterface.beginDebugAccess

Synopsis

```
TargetInterface.beginDebugAccess()
```

Description

Put target into debug state if it is not already in order to carry out a number of debug operations. The idea behind **beginDebugAccess** and **endDebugAccess**is to minimize the number of times the target enters and exits debug state when carrying out a number of debug operations. Target interface functions that require the target to be in debug state (such as peek and poke) also use **beginDebugAccess**and **endDebugAccess** to get the target into the correct state. A nesting count is maintained, incremented by **beginDebugAccess** and decremented by **endDebugAccess**. The initial processor state is recorded on the first nested call to **beginDebugAccess**and this state is restored when the final **endDebugAccess** is called causing the count to return to it initial state.

TargetInterface.delay

Synopsis

```
TargetInterface.delay(milliseconds)
```

Description

TargetInterface.delay waits for **milliseconds** milliseconds

TargetInterface.endDebugAccess

Synopsis

```
TargetInterface.endDebugAccess(alwaysRun)
```

Description

Restore the target run state recorded at the first nested call to **beginDebugAccess.**See **beginDebugAccess** for more information. If **alwaysRun** is non-zero the processor will exit debug state on the last nested call to **endDebugAccess**.

TargetInterface.eraseBytes

Synopsis

```
TargetInterface.eraseBytes(address, length)
```

Description

TargetInterface.eraseBytes erases a block of erasable memory. **address**is the start address of the block to erase and length is the number of bytes to erase.

TargetInterface.executeFunction

Synopsis

```
TargetInterface.executeFunction(address, r0, timeout)
```

Description

TargetInterface.executeFunction executes a function on the target.**address**is the address of the function entry point, **r0** is the value to set register r0 on entry to the function (in effect the first parameter to the function), and **timeout** is the timeout value in milliseconds to wait for the function to complete.

TargetInterface.getRegister

Synopsis

```
TargetInterface.getRegister(register)
```

Description

TargetInterface.getRegister gets the value of a CPU register. Note that the set of register values are only updated when the CPU stops. **register** is a string specifying the register to get and must be one of r0, r1, r2, r3, r4, r5, r6, r7, r8, r9, r10, r11, r12, r13, r14, r15, sp, lr, pc, cpsr, r8_fiq, r9_fiq, r10_fiq, r11_fiq, r12_fiq, r13_fiq, r14_fiq, spsr_fiq, r13_svc, r14_svc, spsr_svc, r13_abt, r14_abt, spsr_abt, r13_irq, r14_irq, spsr_irq, r13_und, r14_und, spsr_und. **TargetInterface.getRegister** returns the register's value.

TargetInterface.peekByte

Synopsis

```
TargetInterface.peekByte(address)
```

Description

TargetInterface.peekByte reads a byte of target memory from **address**and returns it.

TargetInterface.peekBytes

Synopsis

```
TargetInterface.peekBytes(address, length)
```

Description

TargetInterface.peekBytes reads a block of bytes from target memory starting at **>address** for **length** bytes and returns the result as an array containing the bytes read.

TargetInterface.peekUint16

Synopsis

```
TargetInterface.peekUint16(address)
```

Description

TargetInterface.peekUint16 reads a 16-bit unsigned integer from target memory from **address** and returns it.

TargetInterface.peekUint32

Synopsis

```
TargetInterface.peekUint32(address)
```

Description

TargetInterface.peekUint32 reads a 32-bit unsigned integer from target memory from **address** and returns it.

TargetInterface.peekWord

Synopsis

```
TargetInterface.peekWord(address)
```

Description

TargetInterface.peekWord reads a word as an unsigned integer from target memory from **address** and returns it.

TargetInterface.pokeByte

Synopsis

```
TargetInterface.pokeByte(address, data)
```

Description

TargetInterface.pokeByte writes the byte **data** to **address** in target memory.

Synopsis

TargetInterface.pokeUint16

```
TargetInterface.pokeUint16(address, data)
```

Description

TargetInterface.pokeUint16 writes **data** as a 16-bit value to **address**in target memory.

Synopsis

TargetInterface.pokeUint32

```
TargetInterface.pokeUint32(address, data)
```

Description

TargetInterface.pokeUint32 writes **data** as a 32-bit value to **address**in target memory.

Synopsis

TargetInterface.pokeWord

```
TargetInterface.pokeWord(address, data)
```

Description

TargetInterface.pokeWord writes **data** as a word value to **address**in target memory.

TargetInterface.pokeBytes

Synopsis

TargetInterface.pokeBytes

```
TargetInterface.pokeBytes(address, data)
```

Description

TargetInterface.pokeBytes writes the array **data** containing 8-bit data to target memory at **address**.

TargetInterface.peekMultUint16

Synopsis
```
TargetInterface.peekMultUint16(address, length)
```

Description

TargetInterface.peekMultUint16 reads **length** unsigned 16-bit integers from target memory starting at **address** and returns them as an array.

TargetInterface.peekMultUint32

Synopsis
```
TargetInterface.peekMultUint32(address, length)
```

Description

TargetInterface.peekMultUint32 reads **length** unsigned 32-bit integers from target memory starting at **address** and returns them as an array.

TargetInterface.pokeMultUint16

Synopsis
```
TargetInterface.pokeMultUint16(address, data)
```

Description

TargetInterface.pokeBytes writes the array **data** containing 16-bit data to target memory at **address**.

TargetInterface.pokeMultUint32

Synopsis
```
TargetInterface.pokeMultUint32(address, data)
```

Description

TargetInterface.pokeBytes writes the array **data** containing 32-bit data to target memory at **address**.

TargetInterface.setICEBreakerBreakpoint

Synopsis
```
TargetInterface.setICEBreakerBreakpoint(n, addressValue, addressMask,
dataValue, dataMask controlValue, controlMask)
```

Description

TargetInterface.setICEBreakerBreakpoint sets an ICEBreaker breakpoint. **n**is the number of the watchpoint unit to use, **addressValue** is the address value, **addressMask** is the address mask, **dataValue** is the data value, **dataMask** is the data mask, **controlValue** is the control value, and **controlMask** is the control mask.

TargetInterface.setNSRST

Synopsis
```
TargetInterface.setNSRST(state)
```

Description

TargetInterface.setNSRST sets the level of the target's nSRST reset signal high if state is non-zero.

TargetInterface.setRegister

Synopsis

```
TargetInterface.setRegister(register, value)
```

Description

TargetInterface.setRegister sets the CPU regsister **register** to **value**.

registeris a string describing the register to set and must be one of r0, r1, r2, r3, r4, r5, r6, r7, r8, r9, r10, r11, r12, r13 or sp, r14 or lr, r15 or pc, cpsr, r8_fiq, r9_fiq, r10_fiq, r11_fiq, r12_fiq, r13_fiq, r14_fiq, spsr_fiq, r13_svc, r14_svc, spsr_svc, r13_abt, r14_abt, spsr_abt, r13_irq, r14_irq, spsr_irq, r13_und, r14_und, spsr_und.

Note that this function will only change the CPU register state if the CPU is stopped.

TargetInterface.trst

Synopsis

```
TargetInterface.trst()
```

Description

TargetInterface.trst performs a JTAG TAP reset.

TargetInterface.waitForDebugState

Synopsis

```
TargetInterface.waitForDebugState(timeout)
```

Description

TargetInterface.waitForDebugState waits for the target to enter debug state with a timeout of **timeout**milliseconds. If the timeout period expires and exception is thrown which is caught by the debugger.

ARM Program Loader

CrossStudio for ARM supports Flash programming (and subsequent debugging) by loading a program into the RAM of the target and transmitting it the data to be programmed.

The use of a target loader is determined by the value of the **Loader File Path** project property defined for the appropriate configuration of the project. The **Loader File Path** property specifies the location of the loader executable to use, if this is defined the loader executable will be downloaded onto the target an run prior to download of the main application.

In addition to the **Loader File Path** property, the **Loader File Type** project property must be specified. This tells CrossStudio how to communicate with the loader program. The various communication mechanisms available are explained in more detail later. The **Load File Type**property may be set to one of the following:

- **Comms Channel Loader** - The ARM debug comms channel is used to communicate with the loader.
- **Fast Comms Channel Loader** - The ARM debug comms channel is used to communicate with the loader. This scheme is significantly faster at downloading than **Comms Channel Loader** because it makes the assumption that the loader program is always ready to read data and therefore does not check the ARM comms channel status before transmitting data. This may not be suitable for all targets or loaders. If you experience reliability problems downloading and verifying programs using this setting, you should revert to the **Comms Channel Loader**setting.
- **RAM Loader** - The target's RAM is used to communicate with the loader.

The functionality a loader provides to CrossStudio is:

- Erase all non-volatile memory.
- Erase a block of non-volatile memory.
- Write a block of data into volatile or non-volatile memory.
- Read a block of data from volatile or non-volatile memory.
- Set a block of volatile or non-volatile memory to a specific value.
- Verify a block of volatile or non-volatile memory.

CrossStudio can communicate with the loader running on the ARM in one of two ways:

- ARM Debug Comms Port - All transactions with the loader are carried out over the ARM debug comms port. This is generally quicker than using RAM communication, however the ARM debug comms port is not supported on all targets.
- RAM - All transactions with the loader are carried out by the host writing data to target RAM, executing code and then reading the results out of target RAM. This system has the advantage that it will run on all targets, however it is not necessarily as quick as using the ARM debug comms port and can be hard to use if RAM is scarce.

To simplify the creation of a new loader program, a number of files have been supplied in the *target/loader* directory:

- *loader.h* - This file contains prototypes for all the loader functions and a number of useful macros.
- *loader_main.c* - This file contains the main entry point of a loader. It handles the reading of commands from the host and calling the appropriate loader entry points.

- *loader_comm.c* & *loader_ram.c* - These files implement the ARM debug comms port and RAM communication mechanisms used by the loader. Each file implements a version of the *waitForCommand*, *loaderReadWord* and *loaderWriteWord* functions. A loader that uses the ARM debug comms port should link in *loader_comm.c* and a loader that uses RAM should link in *loader_ram.c*. A loader using *loader_comm.c*should have the **Loader File Type** project property set to either **Comms Channel Loader** or **Fast Comms Channel Loader**. A loader using *loader_ram.c*should have the **Loader File Type** project property set to **RAM Loader**.

In order to implement a loader, the following loader entry points should be implemented:

- *void loaderBegin()* - This function is called before the loader enters it main loop, it can be used to initialize the loader if required.
- *void loaderEnd()*- This function is called when the loader exits it main loop, it can be used to clean up after the loader if required.
- *int loaderPoke(unsigned char *address, unsigned int length)* - This function is called when the host requests a write to memory. The *address* parameter specifies the address to start writing to, the *length* parameter specifies the number of bytes to write. The data to write should be read from the host using the *loaderReadWord*function, the bytes are stored in each word in little endian order. A non-zero value should be returned on success.
- *int loaderMemset(unsigned char *address, unsigned int length, unsigned char c)* - This function is called when the host request memory to be set to particular value. The *address* parameter specifies the address to start writing to, the *length* parameter specifies the number of bytes to write and the *c* parameter specifies the value to write. A non-zero value should be returned on success.
- *int loaderErase(unsigned char *address, unsigned int length)* - This function is called when the host requests a block of non-volatile memory to be erased. The *address* parameter specifies the starting address of the block to erase, the *length* parameter specifies the length of the block in bytes. A non-zero value should be returned on success.
- *int loaderEraseAll()* - This function is called when the host requests all non-volatile memory to be erased. A non-zero value should be returned on success.
- *int loaderSetParameter(unsigned int parameter, unsigned int value)* - This function is called when the host attempts to set a loader specific property. The *parameter* parameter specifies the parameter to set, this is currently always set to zero. The *value* parameter specifies the value being set. The parameter value to be passed to the loader can be specified in the **Loader Parameter** project property.

A loader that uses *loader_ram.c* must also define the program section in RAM called *.comm_buffer*. The RAM this section occupies is used to write the data sent to and from the loader. The size to set the *.comm_buffer* section to is dependent on how much RAM you have free, however the larger you set the .comm_buffer the faster the loader will run.

The loader projects and source code for all the supported targets can be found in the target-specific directories contained in the *targets*directory

The following code demonstrates the structure of a loader implementation:

```
#include "../loader/loader.h"

void
loaderBegin()
{
}

void
loaderEnd()
{
}

int
loaderPoke(unsigned char *address, unsigned int length)
{
  while (length)
    {
      unsigned int data = loaderReadWord();
      int i;
      for (i = 4; i && length; --i)
        {
          if (ADDRESS_IN_FLASH(address))
            flash_write_byte(address++, (unsigned char)data);
          else
            *address++ = (unsigned char)data;
          data >>= 8;
          length--;
        }
    }
  return 1;
}

int
loaderMemset(unsigned char *address, unsigned int length,  unsigned char c)
{
  while(length--)
```

```
    {
      if (ADDRESS_IN_FLASH(address))
        flash_write_byte(address++, (unsigned char)c);
      else
        *address++ = (unsigned char)c;
    }
  return 1;
}

int
loaderErase(unsigned char *address, unsigned int length)
{
  if (!is_erased(address, length))
    flash_erase(address, length);
  return 1;
}

int
loaderEraseAll()
{
  if (!is_erased(FLASH_START_ADDRESS, FLASH_END_ADDRESS))
    flash_erase_all(FLASH_START_ADDRESS);
  return 1;
}
```

The *targets* directory contains a directory for each supported target. The loader source code for each target can be found in these directories. In order to view, edit and build a loader project open the *Loader.hzp* solution for the required target. By default CrossStudio picks the loaders from the *Release/Loader.exe* directory of each target directory.

ARM Device Specific Target Support

Dialogs

Debug file search editor

When a program is built with debugging enabled the debugging information contains paths describing where the source files that went into the program are located in order to allow the debugger to find them. If a program or libraries linked into the program are being run on a different machine to the one they were compiled on or if the source files have moved since the program was compiled, the debugger will unable to find the source files.

In this situation the simplest way to help CrossStudio find the moved source files is to add the directory containing the source file to one of it's source file search paths. Alternatively, if CrossStudio cannot find a source file it will prompt you for it's location and record it's new location in it's source file map.

Debug source file search paths

The debug source file search paths can be used to help the debugger locate source files that are no longer in the same location as 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 set in the current project session and does not apply to all projects.
- **The global search path** This path is set system wide and applies to all projects.

The project session search path is checked before the global search path.

To view and edit the debug search paths

- From the **Debug** menu, click **Edit Search Paths**

Debug source file map

If a source file cannot be found whilst 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 is simply a mapping between the original file name and it's new location. 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 for the file has been recorded or if the user has specified that the file does not exist. Each project session maintains it's own source file map, the map is not shared by all projects.

To view the debug source file map

- From the **Debug** menu, click **Edit Search Paths**

To remove individual entries from the debug source file map

- From the **Debug** menu, click **Edit Search Paths**
- Right click on the mapping you want to delete
- From the context menu, click **Delete Mapping**

To remove all entries from the debug source file map

- From the **Debug** menu, click **Edit Search Paths**
- Select **Delete All Mappings** from the context menu

Environment options

Environment General

- **Window menu contains.** Specifies the maximum number of open windows to be listed in the **Window** menu.
- **Most recently used project list contains.** Specifies the maximum number of project files to be listed in the **File > Recent Projects** menu.
- **Most recently used files list contains.** Specifies the maximum number of files to be listed in the **File > Recent Files** menu.
- **Use large icons in toolbars.** Enables large icons in tool bars.
- **Show status bar.** Enables display of status bar.
- **Show full path in title bar.** Enables display in title bar of full file path of current file being edited.

- **Show dock window contents when moving.** Enables display of docking window contents when window is being moved.
- **Docking windows show toolbars.** Configures docking window toolbar display.
- **Projects location.** Specifies the default directory location of projects.

Environment Workspace

The workspaces dialog provides the ability to specify which windows and toolbars are displayed in Full Screen, Normal and Debug run states.

Text Editor General

- **Vertical scroll bar.** Enables display of vertical scroll bar.
- **Horizontal scroll bar.** Enables display of horizontal scroll bar.
- **Indicator margin.** Enables display of indicator margin.
- **Margins enabled.** Enables margins.
- **Top margin.** Size in lines of top margin.
- **Left margin.** Size in columns of left margin.
- **Bottom margin.** Size in lines of bottom margin.
- **Right margin.** Size in columns of right margin.
- **Hide mouse cursor when typing.** Enables hiding of mouse cursor when typing.
- **Use I-beam text cursor.** Enables I-beam cursor when mouse is moved over editor.
- **Allow editing or read only files.** Enables the editing of read only files.
- **Insert mode style.** Specifies the caret style when the editor is in insert mode.
- **Overtype mode style.** Specifies the caret style when the editor is in overwrite mode.

Text Editor Indent

- **File type.** The type of file to configure the indent options for.
- **Insert spaces.** Enables insertion of spaces only.
- **Tab size.** Specifies the tab size in characters.
- **Keep tabs.** Enables use of tab characters.

- **Indent size.** Specifies the default indentation size in characters.
- **Auto indent.** Specifies indent mode.
- **Indent open brace.** Enables indentation of open braces when in smart indent mode.
- **Indent closing brace.** Enables indentation of closing braces when in smart indent mode.
- **Previous lines used for context.** Specifies the maximum number of lines prior to the current line to start parsing when in smart indent mode.

Build General

- **Echo command lines to log.** Enables echoing of build command lines to output window.
- **Show build information in log.** Enables build avoidance logic to be displayed.

Debugger General

- **Default data display.** Specifies the default data display format.
- **Source file search path.** Comma separated list of directories to use to locate source files.

Debugger Data Tips

- **Limit data tip array display to *n* elements.** Specifies the maximum number of array elements to display when showing array data tips.
- **Display extended data tips.** Enables display of extended data tips. Extended data tips display the data in a number of formats.
- **Extended data tip formats.** Specifies the formats to display when displaying extended data tips is enabled.

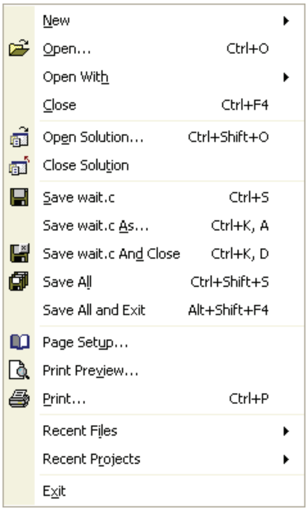
CrossStudio menu summary

The following sections describe each menu and each menu item.

File menu

The **File** menu provides commands to create, open, and close files, and to print them.

The File menu



File commands

Menu command	Keystroke	Description
New		Displays the **New** menu.
Open	Ctrl+O	Opens an existing file for editing.
Open With		Displays the **Open With** menu.
Close	Ctrl+F4	Closes the active editor. If you have made changes to the file, CrossStudio prompts you to save the file.
Open Solution	Ctrl+Shift+O	Opens an existing solution for editing. If you already have an open solution, CrossStudio will close it before opening the new solution and, if you have made changes to any of the files in your solution, you are prompted to save each of them.
Close Solution		Closes the current solution. If you have made changes to any of the files in your solution, you are prompted to save each of them.

Menu command	Keystroke	Description
Save *file*	Ctrl+S	Saves the contents of the active editor to disk. If it is a new file without a name, CrossStudio opens a file browser for you to choose where to save the file and what to call it.
Save *file* As...	Ctrl+K, A	Saves the contents of the active editor to disk using a different name. CrossStudio opens a file browser for you to choose where to save the file and what to call it. After saving, the editor is set to edit the newly saved file, not the previous file.
Save *file* And Close	Ctrl+K, D	Saves the contents of the active editor to disk and then closes the editor. If it is a new file without a name, CrossStudio opens a file browser for you to choose where to save the file and what to call it.
Save All	Ctrl+Shift+S	Saves all edited files to disk. For each new file without a name, CrossStudio opens a file browser for you to choose where to save the file and what to call it. Cancelling a save at any time will return you to CrossStudio without saving the remainder of the files.
Save All And Exit	Alt+Shift+F4	Saves all edited files to disk and then exits CrossStudio. For each new file without a name, CrossStudio opens a file browser for you to choose where to save the file and what to call it. Cancelling a save at any time will return you to CrossStudio without exiting.
Page Setup...		Steps into the next statement or instruction and enters C functions and assembly language subroutines. If a breakpoint is hit when stepping, the debugger immediately stops at that breakpoint.
Print Preview...		Opens the **Print Preview** dialog and shows the document as it will appear when it is printed.
Recent Files		Opens the **Recent Files** menu which contains a list of files that have been recently opened, with the most recently opened file first in the list. You can configure the number of files retained in the **Recent Files** menu in the **Environment Options** dialog. You can clear the list of recent files by selecting **Clear Recent Files List** from the **Recent Files** menu.
Recent Projects		Opens the **Recent Projects** menu which contains a list of projects that have been recently opened, with the most recently opened project first in the list. You can configure the number of projects retained in the **Recent Projects** menu in the **Environment Options** dialog. You can clear the list of recent projects by selecting **Clear Recent Projects List** from the **Recent Projects** menu.
Exit	Alt+F4	Saves all edited files, closes the solution, and exits CrossStudio. For each new file without a name, CrossStudio opens a file browser for you to choose where to save the file and what to call it. Cancelling a save at any time will return you to CrossStudio without exiting.

New menu

The **New** menu provides commands to create files and folders.

The New menu

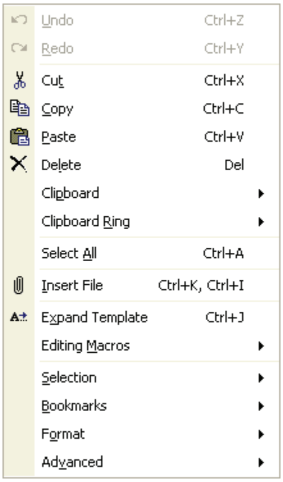
New menu commands

Menu command	Keystroke	Description
New File...		Creates a new file using the **New File** dialog
New Blank File	Ctrl+K, Ctrl+N	Creates a new, unnamed document.
New Project...		Creates a new project using the **New Project** dialog.
New Blank Solution	Ctrl+K, Ctrl+Shift+N	Creates a new solution containing no projects.
New File Comparison	Ctrl+T, F	Creates a new file comparison window.
New Folder...		Creates a new folder underneath the currently selected item in the **Project Explorer**.

Edit menu

The **Edit** menu provides commands to edit files.

The Edit menu



Edit menu commands

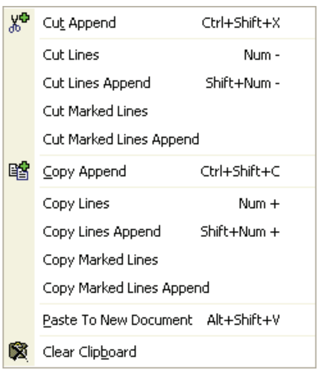
Menu command	Keystroke	Description
Undo	Ctrl+Z —or— Alt+Backspace	Undoes the last editing action.
Redo	Ctrl+Y —or— Alt+Shift+Backsp ace	Redoes the last undone editing action.
Cut	Ctrl+X —or— Shift+Delete	Cuts the selected text to the clipboard. If no text is selected, cuts the current line to the clipboard.
Copy	Ctrl+C —or— Ctrl+Insert	Cuts the selected text to the clipboard. If no text is selected, copies the current line to the clipboard.
Paste	Ctrl+V —or— Shift+Insert	Pastes the clipboard into the document.
Delete	Delete	Deletes the selection. If no text is selected, deletes the character to the right of the cursor.
Clipboard		Displays the **Clipboard** menu.

Menu command	Keystroke	Description
Clipboard Ring		Displays the **Clipboard Ring** menu.
Select All	Ctrl+A	Selects all text or items in the document.
Insert File	Ctrl+K, Ctrl+I	Inserts a file into the document at the cursor position.
Expand Template	Ctrl+J	Forces expansion of a template.
Editing Macros		Displays the **Editing Macros** menu.
Selection		Displays the **Edit Selection** menu. See **Edit Selection menu** (page 177).
Bookmarks		Displays the **Bookmarks** menu.
Format		Displays the **Formatting** menu.
Advanced		Displays the **Advanced Editing** menu.

Clipboard menu

The **Clipboard** menu provides commands to edit files using the clipboard.

The Clipboard menu



Clipboard menu commands

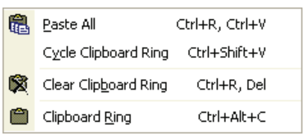
Menu command	Keystroke	Description
Cut Append	Ctrl+Shift+X	Cuts the selected text and appends it to the clipboard. If no text is selected, cuts and appends the current line to the clipboard.

Menu command	Keystroke	Description
Cut Lines	Num -	Converts the selection to complete lines then cuts the selected text lines them to the clipboard. If no text is selected, cuts and appends the current line to the clipboard.
Cut Lines Append	Shift+Num -	Converts the selection to complete lines then cuts the selected text lines and appends them to the clipboard. If no text is selected, cuts and appends the current line to the clipboard.
Cut Marked Lines		Cuts all bookmarked lines in the current document to the clipboard.
Cut Marked Lines Append		Cuts all bookmarked lines in the current document and appends them to the clipboard.
Copy Append		Copies the selected text and appends it to the clipboard. If no text is selected, copies and appends the current line to the clipboard.
Copy Lines		Converts the selection to complete lines then copies the selected text lines them to the clipboard. If no text is selected, copies and appends the current line to the clipboard.
Copy Lines Append		Converts the selection to complete lines then copies the selected text lines and appends them to the clipboard. If no text is selected, copies and appends the current line to the clipboard.
Copy Marked Lines		Copies all bookmarked lines in the current document to the clipboard.
Copy Marked Lines Append		Copies all bookmarked lines in the current document and appends them to the clipboard.
Paste to New Document	Alt+Shift+V	Creates a new, unnamed document and pastes the clipboard into it.
Clear Clipboard		Clears the contents of the clipboard.

Clipboard Ring menu

The **Clipboard Ring** menu provides commands to edit files using the clipboard ring.

The Clipboard Ring menu



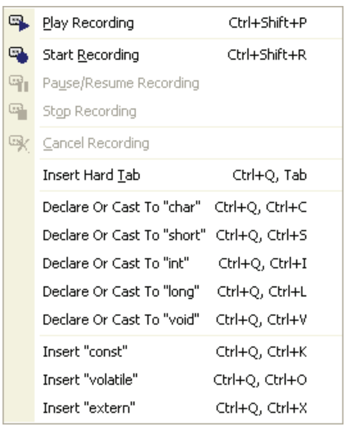
Clipboard Ring menu commands

Menu command	Keystroke	Description
Paste All	Ctrl+Shift+X	Pastes the contents of the clipboard ring to the current document.
Cycle Clipboard Ring	Num -	Cycles the clipboard ring.
Clear Clipboard Ring	Ctrl+R, Del	Clears the contents of the clipboard ring.
Clipboard Ring	Ctrl+Alt+C	Displays the Clipboard Ring window. See **Clipboard ring window** (page 97).

Macros menu

The **Macros** menu provides additional commands to record and play key sequences as well as provide some fixed macros.

The Macros menu



Macros menu commands

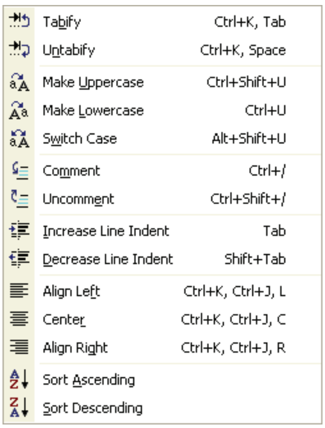
Menu command	Keystroke	Description
Play Recording	Ctrl+Shift+P	Plays the last recorded keyboard macro.
Start Recording	Ctrl+Shift+R	Starts recording a keyboard macro.

Menu command	Keystroke	Description
Pause/Resume Recording		Temporarily pauses a recording a keyboard macro. If already paused, recommences recording of the keyboard macro.
Stop Recording		Stops recording a keyboard macro and saves it. Note that when recording has commenced, the keystroke to stop recording the keyboard macro is Ctrl+Shift+R.
Cancel Recording		Cancels recording without changing the current keyboard macro.
Insert Hard Tab	Ctrl+Q, Tab	Inserts a tab character into the document even if the document's language settings inserts tabs as spaces.
Declare Or Cast to *type*		If there is a selection, parentheses are placed around the selection and that expression is cast to *type*. If there is no selection, *type* is inserted into the document.
Insert *keyword*		Inserts *keyword* into the document, followed by a space.

Edit Selection menu

The **Edit > Selection** menu provides commands to operate on the selection.

The Edit Selection menu



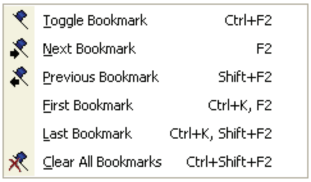
Edit Selection menu commands

Menu command	Keystroke	Description
Tabify	Ctrl+K, Tab	Convert space characters in the selection to tabs according to the tab settings for the language.
Untabify	Ctrl+K, Space	Convert tab characters in the selection to spaces according to the tab settings for the language.
Make Uppercase	Ctrl+Shift+U	Convert the letters in the selection to uppercase. If there is no selection, CrossStudio converts the character to the right of the cursor to uppercase and moves the cursor right one character.
Switch Case	Ctrl+U	Switches the letter case of letters in the selection; that is, uppercase characters become lowercase, and lowercase become uppercase. If there is no selection, CrossStudio switches the letter case of the character to the right of the cursor and moves the cursor right one character.
Comment	Ctrl+/	Prefixes lines in the selection with language-specific comment characters. If there is no selectiom, CrossStudio comments the cursor line.
Uncomment	Ctrl+Shift+/	Removes the prefixed from lines in the selection that contains language-specific comment characters. If there is no selectiom, CrossStudio uncomments the cursor line.
Increase Line Indent	Tab	Increases the line indent of the selection. If there is no selection, the cursor is moved to the next tab stop by inserting spaces or a tab character according to the tab settings for the document.
Decrease Line Indent	Shift+Tab	Decreases the line indent of the selection. If there is no selection, the cursor is moved to the previous tab stop.
Align Left	Ctrl+K, Ctrl+J, L	Aligns all text in the selection to the leftmost non-blank character in the selection.
Align Center	Ctrl+K, Ctrl+J, C	Centers all text in the selection between the leftmost and rightmost non-blank characters in the selection.
Align Right	Ctrl+K, Ctrl+J, R	Aligns all text in the selection to the rightmost non-blank character in the selection.
Sort Ascending		Sorts the selection into ascending lexicographic order.
Sort Descending		Sorts the selection into decending lexicographic order.

Bookmarks menu

The **Bookmarks** menu provides commands to drop and find temporary bookmarks.

The Bookmarks menu



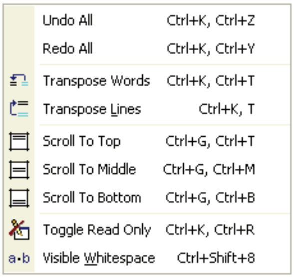
Bookmarks menu commands

Menu command	Keystroke	Description
Toggle Bookmark	Ctrl+F2	Inserts or removes a bookmark on the cursor line.
Next Bookmark	F2	Moves the cursor to the next bookmark in the document. If there is no following bookmark, the cursor is placed at the first bookmark in the document.
Previous Bookmark	Shift+F2	Moves the cursor to the previous bookmark in the document. If there is no previous bookmark, the cursor is placed at the last bookmark in the document.
First Bookmark	Ctrl+K, F2	Moves the cursor to the first bookmark in the document.
Last Bookmark	Ctrl+K, Shift+F2	Moves the cursor to the last bookmark in the document.
Clear All Bookmarks	Ctrl+Shift+F2	Removes all bookmarks from the document.

Advanced menu

The **Advanced** menu provides additional commands to edit your document.

The Advanced menu



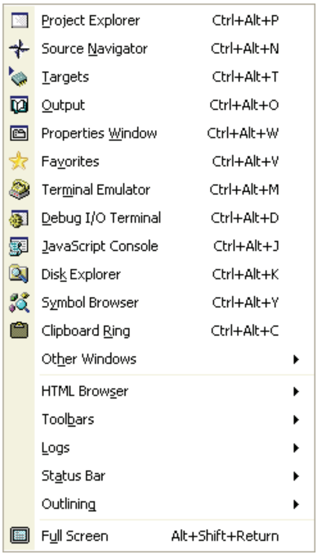
Advanced menu commands

Menu command	Keystroke	Description
Undo All	Ctrl+K, Ctrl+Z	Undoes all editing actions in the document.
Redo All	Ctrl+K, Ctrl+Y	Redoes all editing actions in the document.
Transpose Words	Ctrl+K, Ctrl+T	Swaps the word at the cursor position with the preceding word.
Transpose Lines	Ctrl+K, T	Swaps the cursor line with the preceding line.
Scroll To Top	Ctrl+G, Ctrl+T	Moves the cursor line to the top of the window.
Scroll To Middle	Ctrl+G, Ctrl+M	Moves the cursor line to the middle of the window.
Scroll To Bottom	Ctrl+G, Ctrl+B	Moves the cursor line to the bottom of the window.
Toggle Read Only	Ctrl+K, Ctrl+R	Toggles the read only bit of the document.
Visible Whitespace	Ctrl+Shift+8	Toggles the document display between non-visible whitespace and visible whitespace where tabs and spaces are shown with special characters.

View menu

The **View** menu provides commands to control the way that windows and their contents are seen within CrossStudio.

The View menu



View menu commands

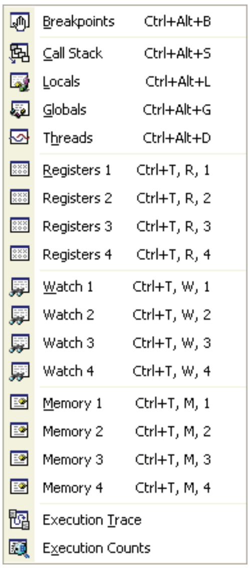
Menu command	Keystroke	Description
Project Explorer	Ctrl+Alt+P	Activates the **Project Explorer**. See **Project explorer** (page 127).
Source Navigator	Ctrl+Alt+N	Activate the **Source Navigator**. See Source Navigator.
Targets	Ctrl+Alt+T	Activates the **Targets** window. See **Targets window** (page 139).
Output	Ctrl+Alt+O	Activates the **Output** window. See **Output window** (page 126).
Properties Window	Ctrl+Alt+W	Activates the **Properties** window. See **Properties window** (page 129).
Favorites	Ctrl+Alt+V	Activates the **Favorites** window. See Favorites Window.
Terminal Emulator	Ctrl+Alt+M	Activates the **Terminal Emulator** window. See Terminal Emulator Window.
Debug Console	Ctrl+Alt+D	Activates the **Debug Console** window.
JavaScript Console	Ctrl+Alt+J	Activates the **JavaScript Console** window.
Symbol Browser	Ctrl+Alt+Y	Activates the **Symbol Browser** window. See **Symbol browser** (page 132).

Menu command	Keystroke	Description
Clipboard Ring	Ctrl+Alt+C	Activates the **Clipboard Ring** window.
Other Windows		Displays the **Other Windows** menu.
HTML Browser		Displays the **HTML Browser** menu.
Logs		Displays the **Logs** menu.
Status Bar		Displays the **Status Bar** menu.
Outlining		Displays the **Outlining** menu.
Full Screen	Alt+Shift+Return	Activates the **Full Screen** workspace.

Other Windows menu

The **Other Windows** menu provides commands to activate additional windows in CrossStudio.

The Other Windows menu



Other Windows commands

Menu command	Keystroke	Description
Breakpoints	Ctrl+Alt+B	Activates the **Breakpoints** window. See **Breakpoints window** (page 100).
Call Stack	Ctrl+Alt+S	Activates the **Call Stack** window. See **Call stack window** (page 105).
Locals	Ctrl+Alt+L	Activates the **Locals** window. See **Locals window** (page 112).
Globals	Ctrl+Alt+G	Activates the **Globals** window. See **Globals window** (page 110).
Threads	Ctrl+Alt+D	Activates the **Threads** window. See **Threads window** (page 119).
Registers 1	Ctrl+T, R, 1	Activates the first **Register** window. See **Register windows** (page 116).
Registers 2	Ctrl+T, R, 2	Activates the second **Register** window. See **Register windows** (page 116).
Registers 3	Ctrl+T, R, 3	Activates the third **Register** window. See **Register windows** (page 116).
Registers 4	Ctrl+T, R, 4	Activates the fourth **Register** window. See **Register windows** (page 116).
Watch 1	Ctrl+T, W, 1	Activates the first **Watch** window. See **Watch window** (page 121).
Watch 2	Ctrl+T, W, 2	Activates the second **Watch** window. See **Watch window** (page 121).
Watch 3	Ctrl+T, W, 3	Activates the third **Watch** window. See **Watch window** (page 121).
Watch 4	Ctrl+T, W, 4	Activates the fourth **Watch** window. See **Watch window** (page 121).
Memory 1	Ctrl+T, M, 1	Activates the first **Memory** window. See **Memory window** (page 114).
Memory 2	Ctrl+T, M, 2	Activates the second **Memory** window. See **Memory window** (page 114).
Memory 3	Ctrl+T, M, 3	Activates the third **Memory** window. See **Memory window** (page 114).
Memory 4	Ctrl+T, M, 4	Activates the fourth **Memory** window. See **Memory window** (page 114).
Execution Trace		Activates the **Execution Trace** window. See **Trace window** (page 121).
Execution Counts		Activates the **Execution Counts** window. See **Execution counts window** (page 110).

Browser menu

The **Browser** menu provides commands nagivate through the browser history.

The Browser menu

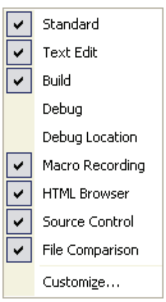
Browser commands

Menu command	Keystroke	Description
Show Browser	Ctrl+Alt+H	Activates the **Browser** window.
Back	Ctrl+Alt+Left	Displays the previous page in the browser history.
Forward	Ctrl+Alt+Right	Displays the following page in the browser history.
Home	Ctrl+Alt+Home	Displays the home page.
Text Size		Displays the **Browser Text Size** menu.

Toolbars menu

The **Toolbars** menu provides commands to display or hide CrossStudio tool bars.

The Toolbars menu



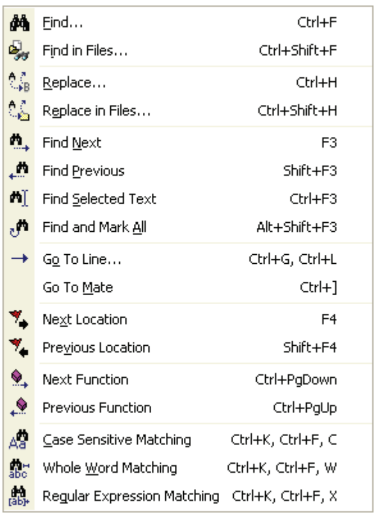
Toolbar menu commands

Menu command	Keystroke	Description
Standard		Displays the **Standard** tool bar.
Text Edit		Displays the **Text Edit** tool bar.
Build		Displays the **Build** tool bar.
Debug		Displays the **Debug** tool bar.
Debug Location		Displays the **Debug Location** tool bar.
Macro Recording		Displays the **Macro Recording** tool bar.
HTML Browser		Displays the **HTML Browser** tool bar.
Source Control		Displays the **Source Control** tool bar.
File Comparison		Displays the **File Comparison** tool bar.
Customize...		Displays the **Toolbar Configuration** dialog.

Search menu

The **Search** menu provides commands to search in files.

The Search menu



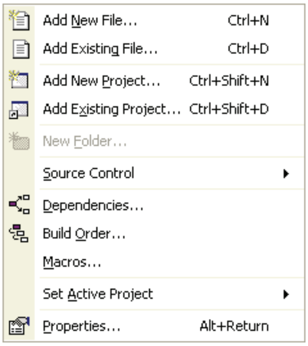
Search menu commands

Menu command	Keystroke	Description
Find	Ctrl+F	Searches documents for strings.
Find in Files	Ctrl+Shift+F	Searches for a string in multiple files.
Replace	Replace	Replaces text with different text.
Replace in Files	Ctrl+Shift+H	Replaces text with different text in multiple files.
Find Next	F3	Searches for the next occurrence of the specified text.
Find Previous	Shift+F3	Searches for the previous occurrence of the specified text.
Find Selected Text	Ctrl+F3	Searches for the next occurrence of the selection.
Find and Mark All	Alt+Shift+F3	Searches the document for all occurrences of the specified text and marks them with bookmarks.
Go To L:ine	Ctrl+G, Ctrl+L	Moves the cursor to a specified line in the document.
Go To Mate	Ctrl+]	Moves the cursor to the bracket, parenthesis, or brace that matches the one at the cursor.
Next Location	F4	Moves the cursor to the line containing the next error or tag.
Previous Location	Shift+F4	Moves the cursor to the line containing the previous error or tag.
Next Function	Ctrl+PgDn	Moves the cursor to the declaration of the next function.
Previous Function	Ctrl+PgUp	Moves the cursor to the declaration of the previous function.
Case Sensitive Matching	Ctrl+K, Ctrl+F, C	Enables or disables the case sensitivity of letters when searching.
Whole Word Matching	Ctrl+K, Ctrl+F, W	Enables or disables whole word matching when searching.
Regular Expression Matching	Ctrl+K, Ctrl+F, X	Enables or disables expression matching rather than plain text matching.

Project menu

The **Project** menu provides commands to manipulate the project.

The Project menu



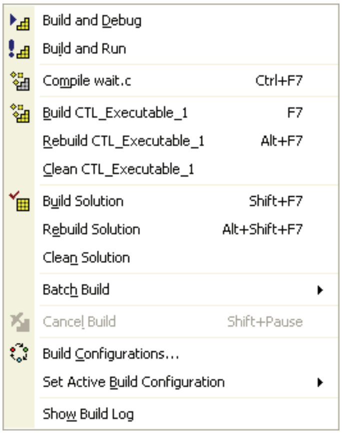
Project menu commands

Menu command	Keystroke	Description
Add New File...	Ctrl+N	Adds a new file to the active project.
Add Existing File...	Ctrl+D	Adds an existing file to the active project.
Add New Project...	Ctrl+Shift+N	Adds a new project to the solution.
Add Existing Project	Ctrl+Shift+D	Adds a link to an existing project to the solution.
New Folder...		Adds a new folder to the current project or folder.
Source Control		Displays the **Source Control** menu.
Dependencies...		Displays the **Project Dependencies** dialog to alter project dependencies.
Build Order...		Displays the **Build Order** tab of the **Project Dependencies** dialog.
Macros...		Displays the **Project Macros** dialog to edit the macros defined in a project.
Set Active Project		Displays a menu which allows you to select the active project.
Properties	Alt+Return	Displays the **Project Properties** dialog for the current project item.

Build menu

The **Build** menu provides commands to build projects and solutions.

The Build menu



Build menu commands

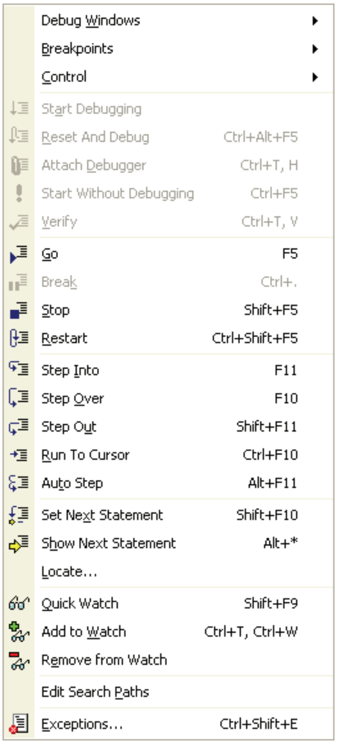
Menu command	Keystroke	Description
Build and Debug		Builds the active project and starts debugging it.
Build and Run		Builds the active project and runs it without debugging.
Compile *file*	Ctrl+F7	Compiles the selected project file.
Build *project*	F7	Builds the active project.
Rebuild *project*	Alt+F7	Rebuilds the active project.
Clean *project*		Removes all output and temporary files generated by the active project.
Build Solution	Shift+F7	Builds all projects in the solution.
Rebuild Solution	Alt+Shift+F7	Rebuilds all projects in the solution.
Clean Solution		Removes all output and temporary files generated by all projects in the solution.
Batch Build		Displays the **Batch Build** menu.
Cancel Build	Shift+Pause	Stops any build in progress.
Build Configurations...		Displays the **Build Configurations** dialog.
Set Active Build Configuration		Displays a menu which allows you to select the active build configuration.

Menu command	Keystroke	Description
Show Build Log		Displays the **Build Log** in the **Output** window.

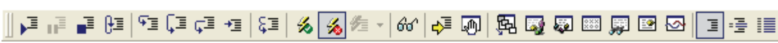
Debug menu

The **Debug** menu provides commands to download, run, and debug your application. You can find common debug actions as tool buttons on the **Debug** toolbar.

The Debug menu



The Debug toolbar



Debug commands

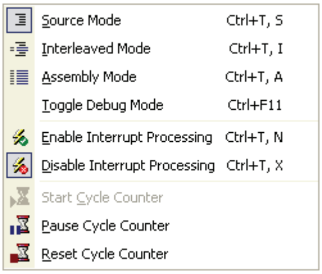
Menu command	Keystroke	Description
Debug Windows		Displays the **Debug Windows** menu. See **Debug Windows menu** (page 194).
Breakpoints		Displays the **Breakpoints** menu. See **Breakpoint menu** (page 193).
Control		Displays the **Debug Control** menu. See **Debug Control menu** (page 191).
Start Debugging	F5	Downloads the program to the selected target interface and starts running the program under control of the debugger.
Reset and Debug	Ctrl+Alt+F5	Resets the selected target interface without downloading the project and starts running the program.
Attach Debugger	Ctrl+T, H	Attaches the debugger to the program running on the selected target interface.
Start Without Debugging	Ctrl+F5	Downloads the program to the selected target interface and starts running the program without the debugger.
Go	F5	Continues running the program until a breakpoint is hit or a hardware exception is raised.
Break	Ctrl+.	Stops the program running and returns control to the debugger.
Stop	Shift+F5	Stops debugging the program and returns to the editing workspace.
Restart	Ctrl+Shift+F5	Resets the selected target interface and starts debugging the program.
Step Into	F11	Steps into the next statement or instruction and enters C functions and assembly language subroutines. If a breakpoint is hit when stepping, the debugger immediately stops at that breakpoint.
Step Over	F10	Steps over the next statement or instruction without entering C functions and assembly language subroutines. If a breakpoint is hit when stepping, the debugger immediately stops at that breakpoint.
Step Out	Shift+F11	Steps out of the function or subroutine by executing up to the instruction following the call to the current function or subroutine. If a breakpoint is hit when stepping, the debugger immediately stops at that breakpoint.
Run To Cursor	Ctrl+F10	Runs the program to the statement or instruction the cursor is at. If a breakpoint is hit when stepping, the debugger immediately stops at that breakpoint.

Menu command	Keystroke	Description
Auto Step	Alt+F11	Animates program execution by running the program and updates all debugger windows after each statement or instruction executed.
Set Next Statement	Shift+F10	Sets the program counter to the statement or instruction that the cursor is on. Note that doing this may lead to unpredictable or incorrect execution of your program.
Show Next Statement	Alt+*	Displays the source line or instruction associated with the program counter. You can use this to show the execution point after navigating through files.
Locate...		
Quick Watch	Shift+F9	Opens a viewer on the variable or expression at the cursor position. If no text is selected, CrossStudio opens a viewer using the word at the cursor position as the expression. If some text is selected, CrossStudio opens a viewer using the selected text as the expression.
Add To Watch	Ctrl+T, Ctrl+W	Adds the variable or expression at the cursor position to the last activated watch window. If no text is selected, CrossStudio adds the word at the cursor position to the watch window. If some text is selected, CrossStudio adds the selected text as the expression to the watch window.
Remove From Watch		Removes the variable or expression at the cursor position to the last activated watch window. If no text is selected, CrossStudio removes any expression matching the word at the cursor position from the watch window. If some text is selected, CrossStudio removes any expression matching the selected text from the watch window.
Edit Search Paths		Opens the **Debug Search File** dialog. See **Debug file search editor** (page 166).
Exceptions		Opens the **Exceptions** dialog.

Debug Control menu

The **Debug Control** menu provides commands to control how you debug your program. The **Debug Control** menu is a submenu of the **Debug** menu.

The Debug Control menu



Debug Control commands

Menu command	Keystroke	Description
Source Mode	Ctrl+T, S	Switches the debugger into **Source Debugging** mode where code is stepped a statement at a time.
Interleaved Mode	Ctrl+T, I	Switches the debugger into **Interleaved Debugging** mode where code is stepped one instruction at a time and source code is intermixed with the generated assembly code.
Assembly Mode	Ctrl+T, A	Switches the debugger into **Assembly Debugging** mode where code is stepped one instruction at a time with a simple disassembly of memory.
Toggle Debug Mode	Ctrl+F11	Toggles between **Source Debugging** and **Interleaved Debugging** modes.
Enable Interrupt Processing	Ctrl+T, N	Enables global interrupts in the processor by writing to the appropriate register.
Disable Interrupt Processing	Ctrl+T, X	Disables global interrupts in the processor by writing to the appropriate register.
Start Cycle Counter		Restarts the cycle counter after it has been paused.
Pause Cycle Counter		Pauses the cycle counter so that it does not incremement and count cycles even though code executes.
Reset Cycle Counter		Resets the cycle counter to zero.

Breakpoint menu

The **Breakpoint** menu provides commands to create, modifiy, and remove breakpoints. The **Breakpoint** menu is a submenu of the **Debug** menu.

The Breakpoint menu

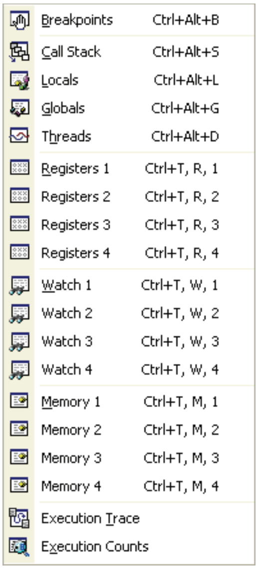
Breakpoint commands

Menu command	Keystroke	Description
New Breakpoint...	Ctrl+Alt+F9	Activates the **New Breakpoint** menu which allows you to create complex breakpoints on code or data. See **Breakpoints window** (page 100).
New Breakpoint Group...		Creates a new breakpoint group in the **Breakpoints** window. You can manage breakpoints individually or as a group.
Disable All Breakpoints		Disables all breakpoints so that they are never hit.
Enable All Breakpoints		Enables all breakpoints so that they can be hit.
Clear All Breakpoints	Ctrl+Shift+F9	Removes all breakpoints set in the **Breakpoints** window.
Next Breakpoint	Alt+F9	Selects the next breakpoint in the **Breakpoint** window and moves the cursor to the statement or instruction associated with that breakpoint.
Previous Breakpoint	Alt+Shift+F9	Selects the previous breakpoint in the **Breakpoint** window and moves the cursor to the statement or instruction associated with that breakpoint.

Debug Windows menu

The **Debug Windows** menu provides commands to activate debugging windows. The **Debug Windows** menu is a submenu of the **Debug** menu.

The Debug Windows menu



Debug Windows commands

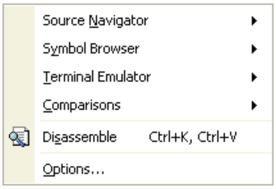
Menu command	Keystroke	Description
Breakpoints	Ctrl+Alt+B	Activates the **Breakpoints** window. See **Breakpoints window** (page 100).
Call Stack	Ctrl+Alt+S	Activates the **Call Stack** window. See **Call stack window** (page 105).
Locals	Ctrl+Alt+L	Activates the **Locals** window. See **Locals window** (page 112).
Globals	Ctrl+Alt+G	Activates the **Globals** window. See **Globals window** (page 110).
Threads	Ctrl+Alt+D	Activates the **Threads** window. See **Threads window** (page 119).
Registers 1	Ctrl+T, R, 1	Activates the first **Register** window. See **Register windows** (page 116).
Registers 2	Ctrl+T, R, 2	Activates the second **Register** window. See **Register windows** (page 116).

Menu command	Keystroke	Description
Registers 3	Ctrl+T, R, 3	Activates the third **Register** window. See **Register windows** (page 116).
Registers 4	Ctrl+T, R, 4	Activates the fourth **Register** window. See **Register windows** (page 116).
Watch 1	Ctrl+T, W, 1	Activates the first **Watch** window. See **Watch window** (page 121).
Watch 2	Ctrl+T, W, 2	Activates the second **Watch** window. See **Watch window** (page 121).
Watch 3	Ctrl+T, W, 3	Activates the third **Watch** window. See **Watch window** (page 121).
Watch 4	Ctrl+T, W, 4	Activates the fourth **Watch** window. See **Watch window** (page 121).
Memory 1	Ctrl+T, M, 1	Activates the first **Memory** window. See **Memory window** (page 114).
Memory 2	Ctrl+T, M, 2	Activates the second **Memory** window. See **Memory window** (page 114).
Memory 3	Ctrl+T, M, 3	Activates the third **Memory** window. See **Memory window** (page 114).
Memory 4	Ctrl+T, M, 4	Activates the fourth **Memory** window. See **Memory window** (page 114).
Execution Trace		Activates the **Execution Trace** window. See **Trace window** (page 121).
Execution Counts		Activates the **Execution Counts** window. See **Execution counts window** (page 110).

Tools menu

The **Tools** menu provides setup and configuration of CrossStudio.

The Tools menu



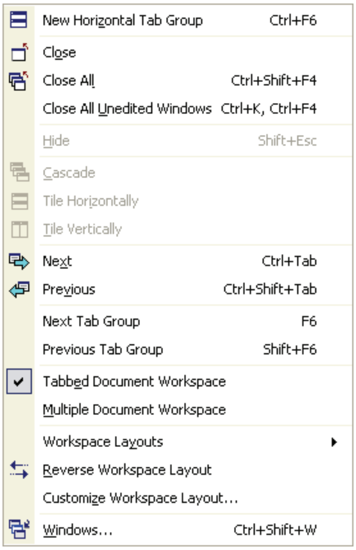
Tools menu commands

Menu command	Keystroke	Description
Source Navigator		Displays the **Source Navigator** configuration menu.
Symbol Browser		Displays the **Symbol Browser** configuration menu.
Terminal Emulator		Displays the **Terminal Emulator** configuration menu.
Comparisons		Displays the **Comparisons** menu.
Disassemble	Ctrl+K, Ctrl+V	Disassembles the selected project item.
Options...		Displays the **Environment Options** dialog.

Window menu

The **Window** menu provides commands to control windows within CrossStudio.

The Window menu



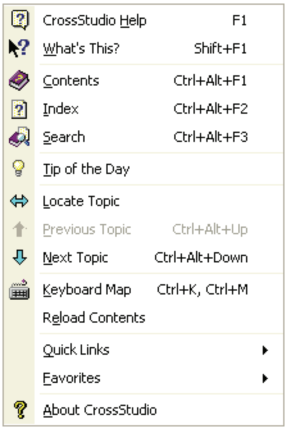
Window menu commands

Menu command	Keystroke	Description
New Horizontal Tab Group	Ctrl+F6	Splits the tab group in two at the active tab and creates two tab groups in tabbed document workspace mode.
Close	Ctrl+F4	Closes the active document window.
Close All	Ctrl+Shift+F4	Closes all document windows.
Close All Unedited Windows	Ctrl+K, Ctrl+F4	Closes all document windows that have not been changed.
Hide *window*		Hides the focused dock window.
Cascade		Cascades windows in multiple document interface mode.
Tile Horizontally		Tiles windows horizontally in multiple document interface mode.
Next	Ctrl+Tab	Activates the next window in the tab group or window stack.
Previous	Ctrl+Shift+Tab	Activates the previous window in the tab group or window stack.
Next Tab Group	F6	Activates the next tab group in tabbed document interface mode.
Previous Tab Group	Shift+F6	Activates the next tab group in tabbed document interface mode.
Tabbed Document Workspace		Enables the tabbed document workspace.
Multiple Document Workspace		Enables the multiple document workspace.
Workspace Layouts		Displays the **Workspace Layout** menu which allows selection of various workspace layouts.
Reverse Workspace Layout		Reverses the left and right dock areas.
Customize Workspace Layout...		Displays the **Document Workspace Layout** dialog.
Windows...		Displays the **Windows** dialog.

Help menu

The **Help** menu provides access to online help for CrossStudio.

The Help menu



Help menu commands

Menu command	Keystroke	Description
CrossStudio Help	F1	Displays online help for the focused GUI element.
What's This	Shift+F1	Enters What's This? mode which provides a short description of each GUI element.
Contents	Ctrl+Alt+F1	Activates the **Contents** window.
Index	Ctrl+Alt+F2	Activates the **Index** window.
Search	Ctrl+Alt+F3	Activates the **Search** window.
Tip of the Day		Activates the **Tip of the Day** window.
Locate Topic		Locates the help page displayed by the browser in the **Contents** window.
Previous Topic	Ctrl+Alt+Up	Moves to the previous topic in the Contents window and updates the browser.
Next Topic	Ctrl+Alt+Down	Moves to the next topic in the Contents window and updates the browser.
Keyboard Map	Ctrl+K, Ctrl+M	Displays the **Keyboard Map** dialog.

Menu command	Keystroke	Description
Quick Links		Displays the **Quick Links** menu which contains useful shortcuts to the online manual.
Favorites		Displays the web pages from the **Favorites** window.
About CrossStudio		Displays information on CrossStudio, the license agreement, and activation status.

Tasking Library Tutorial

This section describes the CrossWorks Tasking Library which will be subsequently referred to as the CTL. The CTL provides a multi-priority, preemptive, task switching and synchronisation facility. Additionally the library provides timer, interrupt service routine and memory block allocation support.

In this section

- **Timer support (page 217).** Describes the timer facilities that the CTL provides.
- **Programmable interrupt handling (page 218).** Describes how you can use CTL functions on systems that have programmable interrupt controller hardware.
- **Low-level interrupt handling (page 219).** Describes how to write interrupt service routines that co-exist with the CTL.
- **Memory areas (page 220).** Describes how you can use the CTL to allocate fixed sized memory blocks.

Related sections

- **<ctl_api.h> - Tasking functions (page 221).** The reference for each of the functions and variables defined by the CTL.
- **Threads window (page 119).** A scriptable debugger window that displays the threads of a running program together with their state.

Overview

The CTL enables your application to have multiple tasks. You will typically use a task when you have some algorithmic or protocol processing that suspend it's execution whilst other activities occur. For example you may have a protocol processing task and a user interface task.

Tasks

A task (sometimes called a thread) is a CPU execution context which is typically a subset of the CPU register state. When a task switch occurs the CPU execution context is saved on to the stack of the current task, a new task is selected to run and its saved CPU execution context is restored. The process of selecting a new task to run is called task switching or (re)scheduling.

A task has a priority associated with it, the lowest priority is 0 the highest is 255. A task is either executing (the current task) or it is queued in the task list. The task list is kept in priority order with the highest priority task at the head of the list. The current task will always have a priority that is greater than or equal to the first runnable task in the task list.

Task switching can be *cooperative* or *preemptive*.

Cooperative task switching occurs when the current task calls a CTL function which checks for rescheduling and the next task ready to run is of the same or higher priority than the current task.

Preemptive task switching occurs when an interrupt service routine calls a CTL function which checks for rescheduling and the next task ready to run is of a higher priority then the current task.

Preemptive task switching can also occur when an interrupt service routine calls a CTL function which checks for rescheduling, time slicing is enabled, the time slice period has been exceeded and the next task ready to run is of the same priority as the current task.

There is one executing task and there must always be a task ready to execute i.e. the task list must have a runnable task queued on it. Typically there will always be an idle task that loops and perhaps puts the CPU into a power save mode. A task on the task list is either runnable or waiting for something (e.g. timeout).

When a task switch occurs global interrupts will be enabled. So you can safely call the tasking library functions with interrupts disabled.

Task synchronization and resource allocation

The CrossWorks tasking library provides several mechanisms to synchronize execution of tasks and to serialise resource allocation.

- **Event Sets** — An event set is a word sized variable which tasks can wait for specific bits (events) to be set to 1. You can wait for any specified events in an event set or for all of the specified events. You can also specify that the events the task are waiting on are automatically cleared (set to 0) when the task has completed its wait.
- **Counting Semaphores** — A counting semaphore is a word size variable which tasks can wait for to be non-zero. Counting semaphores are useful when serialising access to fixed sized buffers i.e. the count value can represent the number of free or used elements in the buffer.
- **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 between tasks.
- **Byte Queues** — A byte queue is a specialisation of a message queue i.e. it's a message queue where the messages are 1 byte in size.
- **Interrupt enable/disable** — The tasking library provides functions that enable and disable the global interrupt enables state of the processor. These functions can be used to provide a time critical mutual exclusion facility.

Note that all waits on task synchronization objects are priority based i.e. the highest priority task waiting will be scheduled first.

Timer support

If your application can provide a periodic timer interrupt (for example one that keeps a watch dog alive) then you can use the timer wait facility of the library. This is a simple software counter that is incremented by your timer interrupt. You can use this to specify a wakeup time and to prevent your program waiting forever for something to happen.

Interrupt service routine support

On systems that have programmable interrupt controllers the CTL provides functions that enable you to install interrupt service routines as C functions and associate the required hardware priority to their execution. On systems that have fixed interrupt schemes functions are provided that enable you to create interrupt service routines that co-operate with the CTL.

Tasks can synchronize with interrupt service routines using either event sets, semaphores or message queues. Interrupt service routines are allowed to set (and clear) events in an event set, to signal a semphore and to do a non blocking post to a message queue. Interrupt service routines cannot wait for events, wait for a semaphore or use blocking message queue functions.

Memory block allocation support

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

C library support

The CTL provides a task specific errno as well as exclusion mechanisms to enable usage of malloc/free functions in a multi-tasking envrionment.

Tasks

Each task has a corresponding task structure that holds information such as the priority and the saved register state. You allocate task structures by declaring them as C variables.

```
CTL_TASK_t mainTask;
```

You create the first task using the ctl_task_init function which turns the main program into a task. This function takes a pointer to the task structure that represents the main task, it's priority and a name as parameters.

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

This function must be called before any other CrossWorks tasking library calls are made. 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 the main task to create other tasks without being descheduled. The name should point to a zero terminated ASCII string for debug purposes. When this function has been called global interrupts will be enabled, so you must ensure that any interrupt sources are disabled before calling this function.

You can create other tasks using the function `ctl_task_run` which initialises a task structure and may cause a context switch. You supply the same arguments as `task_init` together with the function that the task will run and the memory that the task will use as its stack.

The function that 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 when a task function returns the ctl_task_die function is called which terminates the task.

You have to allocate the stack for the task as an C array of unsigned.

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

The size of the stack you need depends on the CPU type (the number of registers that have to be saved), the function calls that the task will make and (depending upon the CPU) the stack used for interrupt service routines. Running out of stack space is common problem with multi-tasking systems and the error behaviour is often misleading. It is recommended that you initialise the stack to known values so that you can check the stack with the CrossWorks debugger if problems 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) the task will start executing at. The third parameter is a pointer to the function to execute (in this case `task1Fn`). The fourth parameter is the value that is supplied to the task function (in this case zero). 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 seperate call stack and is the number of words to reserve for the call stack.

You can change the priority of a task using the ctl_task_set_priority function call which takes a pointer to a task structure and the new priority as parameters.

```
ctl_task_set_priority(&mainTask, 0);
```

Example

The following example turns main into a task and creates another task. The main task ultimately will be the lowest priority task that switches the CPU into a power save 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_api.h>

void task1(void *p)
{
  //  task code, on return 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");

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

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

  //  Now all the tasks have been created go to lowest priority.
  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 created at the highest priority whilst it creates the other tasks, it then changes it's priority to the lowest task. This technique can be used when multiple tasks are created to enable all of the tasks to be created before they start to execute.

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

Event sets

An event set is a means to synchronise tasks with other tasks and interrupt service routines. An event set contains a set of events (one per bit) which tasks can wait to become set (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 then the task can still execute. If they don't match, the task is put on the task list together with details of the event set and the events that the task is waiting for.

You allocate an event set by declaring it as C variable

```
CTL_EVENT_SET_t e1;
```

An **CTL_EVENT_SET_t** is a synonym for an **unsigned** type. Thus, when an **unsigned** is naturally 16 bits an event set will contain 16 events and when it is naturally 32 bits an event set will contain 32 events.

You can initialise an event set using the **ctl_events_init** (page 226) function.

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

Note that initialisation should be done before any tasks can use an event set.

You can set and clear events of an event set using the **ctl_events_set_clear** (page 226) function.

```
ctl_events_set_clear(&e1, 1, 0x80);
```

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 the **ctl_events_wait** (page 227) function. 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 indefinately.

```
ctl_events_wait(CTL_EVENT_WAIT_ANY_EVENTS, &e1, 0x80, 0, 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, 0x80, 1,
ctl_get_current_time()+1000)==0)
  {
    //  timeout occured
  }
```

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

Task synchronisation in an interrupt service routine

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

```
CTL_EVENT_SET_t e1;
CTL_TASK_s t1;

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

```
void task1(void *p)
{
  while (1)
    {
      ctl_events_wait(CTL_EVENT_WAIT_ANY_EVENTS, &e1, 1, 0, 0);
      ...
      ctl_events_set_clear(&e1, 0, 1);
    }
}
```

Task synchronisation with more than one interrupt service routine

The following example illustrates synchronising 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);
}
void ISRfn2(void)
{
  //  do work, and then...
  ctl_events_set_clear(&e1, 2, 0);
}
void task1(void *p)
{
  for (;;
    {
      unsigned e;
      e = ctl_events_wait(CTL_EVENT_WAIT_ANY_EVENTS_AUTO_CLEAR,
                      &e1,
  1 | 2,
  0, 0);
      if (e & 1)
        {
          //  ISRfn1 completed
        }
      else if (e & 2)
        {
          //  ISRfn2 completed
        }
      else
        {
          //  error
        }
    }
}
```

Resource serialisation

The following example illustrates resource serialisation of two tasks.

```
CTL_EVENT_SET_t e1;

void task1(void)
{
  for (;;)
    {
      ctl_events_wait(CTL_EVENT_WAIT_ANY_EVENTS_AUTO_CLEAR, &e1, 1, 0,
0);
      //  resource has now been acquired
      ctl_events_set_clear(&e1, 1, 0);
      //  resource has now been released
    }
}

void task2(void)
{
  for (;;)
    {
      ctl_events_wait(CTL_EVENT_WAIT_ANY_EVENTS_AUTO_CLEAR, &e1, 1, 0,
0);
      // resource has now been acquired
      ctl_events_set_clear(&e1, 1, 0);
      // resource has now been released
    }
}
....
void main(void)
{
  ....
  ctl_events_init(&e1, 1);
  ....
}
```

Note that **e1** is initialised with the event set—without this neither task would acquire the resource.

Semaphores

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 then the semaphore value is decremented and the task continues execution. When a semaphore is zero and a task waits on it then the task will be suspended until the semaphore is signalled. When a semaphore is signalled and no tasks are waiting for it then the semaphore value is incremented. When a semaphore is signalled and tasks are waiting then one of the tasks is made runnable.

You allocate a semaphore by declaring it as a C variable

```
CTL_SEMAPHORE_t s1;
```

An **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 (either 16 or 32 bits).

You can initialise a semaphore using the **ctl_semaphore_init** (page 235) function.

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

Note that initialisation should be done before any tasks can use a semaphore.

You can signal a semaphore using the **ctl_semaphore_signal** (page 235) function.

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

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

You can wait for a semaphore with an optional timeout using the **ctl_semaphore_wait** (page 235) function.

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

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

```
if (ctl_semaphore_wait(&s1, 1, ctl_get_current_time()+1000)==0)
  {
    //  timeout occured
  }
```

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

Task synchronisation in an interrupt service routine.

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

```
CTL_SEMAPHORE_t s1;

void ISRfn()
{
  //  do work
  ctl_semaphore_signal(&s1);
}

void task1(void *p)
{
  while (1)
    {
      ctl_semaphore_wait(&s1, 0, 0);
      …
```

```
    }
}
```

Resource serialisation

The following example illustrates resource serialisation of two tasks.

```
CTL_SEMAPHORE_t s1=1;

void task1(void)
{
  for (;;)
    {
      ctl_semaphore_wait(&s1, 0, 0);
      /*  resource has now been acquired  */
      …
      ctl_semaphore_signal(&s1);
      /*  resource has now been released  */
    }
}

void task2(void)
{
  for (;;)
    {
      ctl_semaphore_wait(&s1);
      /*  resource has now been acquired  */
      …
      ctl_semaphore_signal(&s1);
      /*  resource has now been released  */
    }
}

int
main(void)
{
  …
  ctl_semaphore_init(&s1, 1);
  …
}
```

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

Message queues

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 (2 or 4 bytes depending upon processor word size) or can be used to pass a pointer to a block of memory. The message queue has a buffer that enables a number of posts to be completed without receives occuring. The buffer keeps the posted messages in a 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.

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

```
CTL_MESSAGE_QUEUE_t m1;
```

A message queue is initialised using the **ctl_message_queue_init** (page 233) function.

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

This example uses an 20 element array for the message queue. Note that the array is a `void *` which enables pointers to memory or (cast) integers to be communicated via a message queue.

You can post a message to a message queue with an optional timeout using the **ctl_message_queue_post** (page 233) function.

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

This example posts the integer `45` onto the message queue.

```
if (ctl_message_queue_post(&m1, (void *)45, 1,
ctl_get_current_time()+1000) == 0)
  {
    //  timeout occured
  }
```

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

If you want to post a message and you don't want to block (e.g from an interrupt service routine) you can use the **ctl_message_queue_post_nb** (page 234) function.

```
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.

You can receive a message with an optional timeout using the **ctl_message_queue_receive** (page 234) function.

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

This example receives the oldest message in the message queue.

```
if (ctl_message_queue_receive(&m1, &msg, 1,
ctl_get_current_time()+1000) == 0)
  {
    //  timeout occured
  }
```

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

If you want to receive a message and you don't want to block (e.g from an interrupt service routine) you can use the **ctl_message_queue_receive_nb** (page 234) function.

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

Example

The following example illustrates usage of 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, 0, 0);
  …
}

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

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

Byte queues

A byte queue is a structure that enables tasks to post and receive data bytes. The byte queue has a buffer that enables a number of posts to be completed without receives occuring. The buffer keeps the posted bytes in a 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.

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

```
CTL_BYTE_QUEUE_t m1;
```

A byte queue is initialised using the **ctl_byte_queue_init** (page 224) function.

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

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

You can post a byte to a byte queue with an optional timeout using the **ctl_byte_queue_post** (page 224) function.

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

This example posts the byte `45` onto the byte queue.

```
if (ctl_byte_queue_post(&m1, 45, 1, ctl_get_current_time()+1000) == 0)
  {
    //  timeout occured
  }
```

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

If you want to post a byte and you don't want to block (e.g from an interrupt service routine) you can use the **ctl_byte_queue_post_nb** (page 225) function

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

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

You can receive a byte with an optional timeout using the **ctl_byte_queue_receive** (page 225) function.

```
void *msg;
  ctl_byte_queue_receive(&m1, &msg, 0, 0);
```

This example receives the oldest byte in the byte queue.

```
if (ctl_byte_queue_receive(&m1, &msg, 1, ctl_get_current_time()+1000)
== 0)
  {
    //  timeout occured
  }
```

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

If you want to receive a byte and you don't want to block (e.g from an interrupt service routine) you can use the **ctl_byte_queue_receive_nb** (page 225) function.

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

Example

The following example illustrates usage of 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, 0, 0);
  …
}

void task2(void)
{
  void *msg;
  …
  ctl_byte_queue_receive(&m1, &msg, 0, 0);
  …
}

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

Global interrupts control

The CrossWorks tasking library provides functions that lock and unlock the global interrupt enables. These functions can be used (sparingly) to provide a fast mutual exclusion facility for time critical uses.

You can disable interrupts using the **ctl_global_interrupts_disable** (page 228) function call.

```
int en=ctl_global_interrupts_disable();
```

This function returns the previous global interrupts enabled state.

You can enable interrupts using the **ctl_global_interrupts_enable** (page 229) function call.

```
int en=ctl_global_interrupts_enable();
```

This function returns the previous global interrupts enabled state.

You can restore the previous global interrupts enabled state you the **ctl_global_interrupts_set** (page 229) function call.

```
int en = ctl_global_interrupts_disable();
...
ctl_set_interrupts(en);
```

Note that you can call a tasking library function that causes a task switch with global interrupts disabled. The tasking library will ensure that when a task is scheduled that global interrupts are enabled.

You can re-enable global interrupt enables from within an interrupt service routine using the **ctl_global_interrupts_re_enable_from_isr** (page 229) function call in order to permit higher priority interrupts to occur. A call to this function must be matched with a call to the **ctl_global_interrupts_un_re_enable_from_isr** (page 230) function.

```
//  code of interrupt service routine
...
ctl_global_interrupts_re_enable_from_isr();
...
//  global interrupts are now enabled so another interrupt can be
handled.
...
ctl_global_interrupts_un_re_enable_from_isr();
...
```

Timer support

The current time is held as a 32 bit value in the **ctl_current_time** (page 226) variable. This variable is incremented by a periodic interrupt that is started using the **ctl_timeout_wait** (page 236) function. When you start the timer you must pass it a function to call when the periodic interrupt occurs. The interrupt function can be a user defined function that calls **ctl_increment_tick_from_isr** (page 230).

```
void myfn{void)
  {
    ...
    ctl_increment_tick_from_isr();
    ...
  }
void main(...)
  ..
  ctl_start_timer(myfn);
  ..
```

Alternatively you can pass the **ctl_increment_tick_from_isr** (page 230) function as the parameter

```
void main(...)
{
  ..
  ctl_start_timer(ctl_increment_tick_from_isr);
  ..
```

You can atomically read **ctl_current_time** (page 226) using the **ctl_get_current_time** (page 228) function on systems whose word size is not 32 bit.

You can find out the resolution of the timer using the **ctl_get_ticks_per_second** (page 228)function.

You can suspend execution of a task for a fixed period using the **ctl_timeout_wait** (page 239) function.

Note that this function takes the timeout not the duration as a parameter, so you should 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 increments of the **ctl_current_time** variable.

Programmable interrupt handling

The CTL provides an optional set of functions for establishing C functions as interrupt service routines. These functions are available on systems that have programmable interrupt controller hardware. On systems that have fixed interrupt schemes you should use the facilities described in **Low-level interrupt handling** (page 219) when you create your interrupt service routines.

The function **ctl_set_isr** (page 236) is used to establish a C function as an interrupt service routine.

You must enable an interrupt source using **ctl_umask_isr** (page 240) and you can disable an interrupt source using **ctl_mask_isr** (page 231).

The C function you have established is called when the interrupt occurs. On entry to this function interrupts will still be disabled. To allow interrupts of a higher priority to occur you should enable interrupts on entry by calling **ctl_global_interrupts_re_enable_from_isr** (page 229) and disable interrupts on exit by calling **ctl_global_interrupts_un_re_enable_from_isr** (page 230). Note that the pending interrupt flag in the interrupt controller hardware will be cleared by the CTL when your interrupt service routine returns.

Interrupt service routine example

```
void isr(void)
{
  ctl_global_interrupts_re_enable_from_isr();
  …
  //  do interrupt handling stuff in here
  //  including clearing the source of the interrupt
  …
  ctl_global_interrupts_un_re_enable_from_isr();
}


int main(void)
{
  …
  ctl_set_isr(11, 11, CTL_ISR_TRIGGER_FIXED, isr, 0);
  ctl_unmask_isr(11);
  …
}
```

The **isr** function is triggered from interrupt vector 11 and will run at priority 11. When the function is run it enables interrupts which will allow higher priority interrupts to trigger whilst it is executing.

Low-level interrupt handling

If your system doesn't support a programmable interrupt controller and you want tasks to be rescheduled when interrupts occur, you must save the register state of the CPU on entry to an interrupt service routine and increment the global variable **ctl_interrupt_count** (page 231).

When you are executing an interrupt service routine you must not call the tasking library functions that may block (**task_wait_events, task_wait_semaphore, task_post_message, task_receive_message, task_wait_timeout**) — you can call other tasking library functions, but a task switch will only occur when the last interrupt handler has completed execution.

Whilst you are executing an interrupt service routine you can allow interrupts of a higher priority to occur by calling **ctl_global_interrupts_re_enable_from_isr** (page 229). You must also disable interrupts before exit from the interrupt service routine by calling **ctl_global_interrupts_un_re_enable_from_isr** (page 230).

In order to achieve a task switch from an interrupt service routine the **ctl_exit_isr** (page 227) function must be jumped to as the last action of an interrupt service routine. This function must be passed a pointer to the saved registers.

Interrupt service routine (ARM example)

This example declares an ISR using the GCC syntax for declaring naked functions and accessing assembly code instructions.

```
void irq_handler(void) __attribute__((naked));

void
irq_handler(void)
{
  asm("stmfd sp!, {r0-r12, lr}");
  asm("mrs r0, spsr");
  asm("stmfd sp!, {r0}");
  ctl_interrupt_count++;
  ....
  // do interrupt handling stuff in here
  ....
  asm("mov r0, sp");
  asm("b ctl_exit_isr");
}
```

Note that the registers **SPSR**, **R0** through **R12** and **R14** (user mode program counter) must be saved on the stack. The user mode **R13** and **R14** registers don't need to be saved because they are held in banked registers.

Note that FIQ handlers are not supported on the ARM.

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 (or interrupt service routine) cannot block.

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

```
CTL_MEMORY_AREA_t m1;
```

A message queue is initialised using the **ctl_memory_area_init** (page 232) function.

```
unsigned mem[20];
…
ctl_message_queue_init(&m1, mem, 2, 10);
```

This example uses an 20 element array for the memory. The array is split into 10 blocks of each of which two words in size.

You can allocate a memory block from a memory area using the **ctl_memory_area_allocate** (page 232) function. If the memory block cannot be allocated then 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 you should return it to the memory area from which it was allocated using **ctl_memory_area_free** (page 232):

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

ARM Library Reference

In addition to the Standard C Library, CrossWorks for ARM provides an additional set of library routines that you can use.

In this section

- **<ctl_api.h> - Tasking functions (page 221).** Describes the C tasking library, a library of functions that enable you to run multiple tasks in a real-time system.
- **<cross_studio_io.h> - Debug I/O library (page 240).** Describes the virtual console services and semi-hosting support that CrossStudio provides to help you when developing your applications.
- **<__armlib.h> - Misc ARM functions (page 253).** Describes the ARM specific facilities which you can build into your application.

<ctl_api.h> - Tasking functions

The header file **<ctl_api.h>** defines functions and macros that you can use to write multi-threaded applications. For more information on how to use the tasking library, please see the **Tasking Library Tutorial** (page 200).

Task management functions

ctl_task_die	Terminate the executing task
ctl_task_executing	Active task
ctl_task_init	Create initial task
ctl_task_list	Priority-ordered list of runnable tasks
ctl_task_run	Create a task
ctl_task_remove	Remove a task from waiting task list
ctl_task_reschedule	Cause a reschedule
ctl_task_set_priority	Set the priority of a task

Event Set functions

ctl_events_init	Initialise an event set
ctl_events_set_clear	Set and clear events
ctl_events_wait	Wait for events or timeout

Semaphore functions

ctl_semaphore_init	Initialise a semaphore
ctl_semaphore_signal	Signal a semaphore
ctl_semaphore_wait	Wait for a semaphore or timeout

Message queue functions

ctl_message_queue_init	Initialise a message queue
ctl_message_queue_post	Post a message to a message queue or timeout
ctl_message_queue_post_nb	Post a message to a message queue without blocking
ctl_message_queue_receive	Receive a message from a message queue or timeout
ctl_message_queue_receive_nb	Receive a message from a message queue without blocking

Byte queue functions

ctl_byte_queue_init	Initialise a byte queue
ctl_byte_queue_post	Post a byte to a byte queue or timeout

ctl_byte_queue_post_nb	Post a byte to a byte queue without blocking
ctl_byte_queue_receive	Receive a byte from a byte queue or timeout
ctl_byte_queue_receive_nb	Receive a message from a byte queue without blocking

Global interrupts control

ctl_global_interrupts_disable	Disable global interrupts
ctl_global_interrupts_enable	Enable global interrupts
ctl_global_interrupts_set	Set global interrupts to saved state
ctl_global_interrupts_re_enable_from_isr	Reenable global interrupts from an interrupt service routine
ctl_global_interrupts_un_re_enable_from_isr	Redisable global interrupts from an interrupt service routine

Timer support

ctl_timeout_wait	Start the timer ticking.
ctl_current_time	The current time in ticks.
ctl_get_ticks_per_second	Return the number of ticks in a second.
ctl_get_current_time	Atomically return the current time in ticks.
ctl_increment_tick_from_isr	Increment tick timer.
ctl_timeout_wait	Wait until timeout has occured.
ctl_timeslice_period	The timeslice period - zero means no time slicing.

Programmable interrupt controller support

ctl_set_isr	Install an interrupt service routine
ctl_mask_isr	Mask an interrupt source
ctl_umask_isr	Unmask an interrupt source

Low level interrupt service routine support

ctl_exit_isr	Exit from ISR and check for reschedule
ctl_interrupt_count	Nested interrupt count

Memory areas

ctl_memory_area_init	Initialise a memory area
ctl_memory_area_allocate	Allocate a block from a memory area
ctl_memory_area_free	Return a block to a memory area

Miscellaneous functions and variables

ctl_handle_error	Handle an error condition
ctl_libc_mutex	C library mutex

ctl_byte_queue_init

Synopsis

```
#include <ctl_api.h>
void ctl_byte_queue_init(CTL_BYTE_QUEUE_t *m,
                         unsigned char *queue,
                         unsigned queue_size);
```

Description

The function **ctl_byte_queue_init** is given a pointer to the byte queue to initialise in **m**. The array that will be used to implement the byte queue pointed to by **queue** and its size in **queue_size** are also supplied.

Portability

ctl_byte_queue_init is provided in every implementation of the CrossWorks tasking library.

See Also

Byte queues (page 214)

ctl_byte_queue_post

Synopsis

```
#include <ctl_api.h>
unsigned ctl_byte_queue_post(CTL_BYTE_QUEUE_t *m,
                             unsigned char byte,
                             CTL_TIMEOUT_t timeoutType,
                             CTL_TIME_t timeout);
```

Description

The **ctl_byte_queue_post** function posts the **byte** to the byte queue pointed at by **m**. 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 the **timeout** value. This function returns zero if the timeout occured otherwise it returns one.

Restrictions

This function should not be called from an interrupt service routine.

Portability

ctl_byte_queue_post is provided in every implementation of the CrossWorks tasking library.

See Also **Byte queues** (page 214)

ctl_byte_queue_post_nb

Synopsis

```
#include <ctl_api.h>
unsigned ctl_byte_queue_post_nb(CTL_BYTE_QUEUE_t *m,
                                unsigned char byte);
```

Description The **ctl_byte_queue_post_nb** function posts the **byte** to the byte queue pointed at by **m**. If the byte queue is full then the function will return zero otherwise it will return one.

Portability **ctl_byte_queue_post_nb** is provided in every implementation of the CrossWorks tasking library.

See Also **Byte queues** (page 214)

ctl_byte_queue_receive

Synopsis

```
#include <ctl_api.h>
unsigned ctl_byte_queue_receive(CTL_BYTE_QUEUE_t *m,
                                unsigned char *byte,
                                CTL_TIMEOUT_t timeoutType,
                                CTL_TIME_t timeout);
```

Description The function **ctl_byte_queue_receive** pops the oldest byte in the byte queue pointed at by **m** into the memory pointed at by **byte**. This function will block if no bytes are available unless **timeoutType** is non-zero and the current time reaches the **timeout** value. If the timeout occured the function returns zero otherwise it will return one.

Restrictions This function should not be called from an interrupt service routine.

Portability **ctl_byte_queue_receive** is provided in every implementation of the CrossWorks tasking library.

See Also **Byte queues** (page 214)

ctl_byte_queue_receive_nb

Synopsis

```
#include <ctl_api.h>
unsigned ctl_byte_queue_receive_nb(CTL_BYTE_QUEUE_t *m,
                                   unsigned char *byte);
```

Description The function **ctl_byte_queue_receive_nb** pops the oldest byte in the byte queue pointed at by **m** into the memory pointed at by **byte**. If no bytes are available then the function returns zero otherwise it will return one.

Portability **ctl_byte_queue_receive_nb** is provided in every implementation of the CrossWorks tasking library.

See Also **Byte queues** (page 214)

ctl_current_time

Synopsis

```
#include <ctl_api.h>
extern 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**.

Portability **ctl_current_time** is provided in every implementation of the CrossWorks tasking library.

ctl_events_init

Synopsis

```
#include <ctl_api.h>
int ctl_events_init(CTL_EVENT_SET_t *event_set,
                    CTL_EVENT_SET_t set);
```

Description **ctl_events_init** initializes the **event_set** with the **set** values.

Portability **ctl_events_init** is provided in every implementation of the CrossWorks tasking library.

See Also **Event sets** (page 206)

ctl_events_set_clear

Synopsis

```
#include <ctl_api.h>
void ctl_events_set_clear(CTL_EVENT_SET_t *eventSet,
                          CTL_EVENT_SET_t set,
  CTL_EVENT_SET_t clear);
```

Description This will set the events defined by **set** and clear the events defined by **clear** of the event set pointed to by **eventSet**. This function will then search the task list, matching tasks that are waiting on the **eventSet**, and make them runnable if the match is successful.

Portability **ctl_events_set_clear** is provided in every implementation of the CrossWorks tasking library.

See Also **Event sets** (page 206)

ctl_events_wait

Synopsis

```
#include <ctl_api.h>
unsigned ctl_events_wait(CTL_EVENT_WAIT_TYPE_t waitType,
                         CTL_EVENT_SET_t *eventSet,
                         CTL_EVENT_SET_t events,
                         CTL_TIMEOUT_t timeoutType,
                         CTL_TIME_t timeout);
```

Description

The **ctl_events_wait** function 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 the following:

- **CTL_EVENT_WAIT_ANY_EVENTS** — wait for any of the **events** in ***eventSet** to be set.
- **CTL_EVENT_WAIT_ANY_EVENTS_WITH_AUTO_CLEAR** — wait for any of the **events** in ***eventSet** to be set and reset (value 0) them.
- **CTL_EVENT_WAIT_ALL_EVENTS** — wait for all of the **events** in ***eventSet** to be set.
- **CTL_EVENT_WAIT_ALL_EVENTS_WITH_AUTO_CLEAR** — wait for all of the **events** in ***eventSet** to be set and reset (value 0) them.

The **ctl_events_wait** function returns the value pointed to by **eventSet** before any auto-clearing occurred or zero if the **timeout** occured.

Restrictions

This function should not be called from an interrupt service routine.

Portability

ctl_events_wait is provided in every implementation of the CrossWorks tasking library.

See Also

Event sets (page 206)

ctl_exit_isr

Synopsis

```
#include <ctl_api.h>
void ctl_exit_isr(void *savedRegisters);
```

Description

The **ctl_exit_isr** function must be jumped to from an interrupt service routine with global interrupts disabled. This function will decrement the **ctl_interrupt_count** variable and if zero it will check if a task switch is required. The **savedRegisters** parameter points to the registers saved on the stack on entry to the interrupt service routine. If a task switch is needed then the register state in **savedRegisters** will be stored in the **ctl_task_executing** and a new task will be made the executing task. If a context switch isn't required or the **ctl_interrupt_count** is non-zero then the register state in **savedRegisters** is restored and the interrupt handler returns.

Restrictions

Portability **ctl_exit_isr** is provided in every implementation of the CrossWorks tasking library.

See Also **Low-level interrupt handling** (page 219)

ctl_get_current_time

Synopsis
```
#include <ctl_api.h>
CTL_TIME_t ctl_get_current_time(void);
```

Description Atomically returns the value of **ctl_current_time** (page 226).

Portability **ctl_get_current_time** is provided in every implementation of the CrossWorks tasking library.

ctl_get_ticks_per_second

Synopsis
```
#include <ctl_api.h>
unsigned long ctl_get_ticks_per_second(void);
```

Description Returns the number of ticks in a second.

Portability **ctl_get_ticks_per_second** is provided in every implementation of the CrossWorks tasking library.

ctl_global_interrupts_disable

Synopsis
```
#include <ctl_api.h>
int ctl_global_interrupts_disable(void);
```

Description **ctl_global_interrupts_disable** disables global interrupts and returns the return the enabled state of interrupts before they were enabled. You can pass the return value of **ctl_global_interrupts_disable** to **ctl_global_interrupts_set** to restore the previous global interrupt enable state.

Portability **ctl_global_interrupts_disable** is provided in every implementation of the CrossWorks tasking library.

See Also

Global interrupts control (page 216)

ctl_global_interrupts_enable

Synopsis

```
#include <ctl_api.h>
int ctl_global_interrupts_enable(void);
```

Description

ctl_global_interrupts_enable enables global interrupts and returns the return the enabled state of interrupts before they were enabled. You can pass the return value of **ctl_global_interrupts_enable** to **ctl_global_interrupts_set** to restore the previous global interrupt enable state.

Portability

ctl_global_interrupts_enable is provided in every implementation of the CrossWorks tasking library.

See Also

Global interrupts control (page 216)

ctl_global_interrupts_re_enable_from_isr

Synopsis

```
#include <ctl_api.h>
void ctl_global_interrupts_re_enable_from_isr(void);
```

Description

ctl_global_interrupts_re_enable_from_isr does what is required to re-enable global interrupts from an interrupt service routine.

Restrictions

This function should only be invoked by an interrupt service routine and must be matched with a call to **ctl_global_interrupts_un_re_enable_from_isr** before the interrupt service routine completes.

Portability

ctl_global_interrupts_re_enable_from_isr is provided in every implementation of the CrossWorks tasking library.

See Also

Global interrupts control (page 216),
ctl_global_interrupts_un_re_enable_from_isr (page 230)

ctl_global_interrupts_set

Synopsis

```
#include <ctl_api.h>
void ctl_global_interrupts_set(int enable);
```

Description

ctl_global_interrupts_set disables or enables global interrupts according to rhe state **enable**. If **enable** is zero, interrupts are disabled and if **enable** is non-zero, interrupts are enabled.

Portability

ctl_global_interrupts_set is provided in every implementation of the CrossWorks tasking library.

See Also

Global interrupts control (page 216)

ctl_global_interrupts_un_re_enable_from_isr

Synopsis

```
#include <ctl_api.h>
void ctl_global_interrupts_un_re_enable_from_isr(void);
```

Description

ctl_global_interrupts_un_re_enable_from_isr undoes whatever **ctl_global_interrupts_re_enable_from_isr** had to do resulting in global interrupts being disabled whilst in an interrupt service routine.

Restrictions

This function should only be invoked by an interrupt service routine.

Portability

ctl_isr_disable_interrupts is provided in every implementation of the CrossWorks tasking library.

See Also

Global interrupts control (page 216), **ctl_global_interrupts_re_enable_from_isr** (page 229)

ctl_handle_error

Synopsis

```
#include <ctl_api.h>
void ctl_handle_error(CTL_ERROR_CODE_t error);
```

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 are:

- **CTL_ERROR_NO_TASKS_TO_RUN** — a reschedule has occured but there are no tasks which are runnable.
- **CTL_WAIT_CALLED_FROM_ISR** — an interrupt service routine has called a tasking library function that could block.
- **CTL_SUICIDE_IN_ISR** — the **ctl_task_die** (page 237) function has been called from an interrupt service routine.

Portability

ctl_handle_error is used in every implementation of the CrossWorks tasking library

ctl_increment_tick_from_isr

Synopsis

```
#include <ctl_api.h>
void ctl_increment_tick_from_isr(void);
```

Description

ctl_increment_tick_from_isr increments the **ctl_current_time** and does rescheduling. This function must be called from a periodic interrupt service routine with interrupts disabled. This function enables the timer service of the CrossWorks tasking library to be used.

Restrictions This function should only be invoked by an interrupt service routine.

Portability **ctl_increment_tick_from_isr** is provided in every implementation of the CrossWorks tasking library.

See Also **Timer support** (page 217)

ctl_interrupt_count

Synopsis

```
#include <ctl_api.h>
extern unsigned ctl_interrupt_count;
```

Description The **ctl_interrupt_count** variable contains a count of the interrupt nesting level. This variable must be incremented on entry to an interrupt service routine and will be decremented when **ctl_exit_isr** is invoked.

Portability **ctl_interrupt_count** is provided in every implementation of the CrossWorks tasking library.

See Also **Low-level interrupt handling** (page 219), **ctl_exit_isr** (page 227)

ctl_libc_mutex

Synopsis

```
#include <ctl_api.h>
extern CTL_EVENT_SET_t ctl_libc_mutex;
```

Description **ctl_libc_mutex** is the event set used to serialise access to C library resources. The event set is used as follows:

- **bit 0** — used by **malloc** and **free**
- **bit 1** — used by **printf**
- **bit 2** — used by **scanf**
- **bit 3** — used by debug input and ouput operations

Portability **ctl_libc_mutex** is provided in every implementation of the CrossWorks tasking library.

ctl_mask_isr

Synopsis

```
#include <ctl_api.h>
  int ctl_mask_isr(unsigned int vector);
```

Description The function **ctl_mask_isr** disables an interrupt source. The **vector** argument specifies the interrupt source to mask.

Portability **ctl_disable_interrupts** is provided in every implementation of the CrossWorks tasking library.

See Also **Programmable interrupt handling** (page 218)

ctl_memory_area_allocate

Synopsis

```
#include <ctl_api.h>
unsigned *ctl_memory_area_allocate(CTL_MEMORY_AREA_t *memory_area);
```

Description The function **ctl_memory_area_allocate** is given a pointer to the **memory_area** which has been initialised. This function returns a block of the size specified in the call to **ctl_memory_area_init** or zero if no blocks are available.

Portability **ctl_memory_area_allocate** is provided in every implementation of the CrossWorks tasking library.

See Also **Memory areas** (page 220), **ctl_memory_area_init** (page 232)

ctl_memory_area_free

Synopsis

```
#include <ctl_api.h>
void ctl_memory_area_free(CTL_MEMORY_AREA_t *memory_area,
                          unsigned *block);
```

Description The function **ctl_memory_area_free** is given a pointer to a **memory_area** which has been initialised 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.

Portability **ctl_memory_area_free** is provided in every implementation of the CrossWorks tasking library.

See Also **Memory areas** (page 220), **ctl_memory_area_allocate** (page 232)

ctl_memory_area_init

Synopsis

```
#include <ctl_api.h>
void ctl_memory_area_init(CTL_MEMORY_AREA_t *memory_area,
                          unsigned *memory,
                          unsigned block_size_in_words,
                          unsigned num_blocks);
```

Description The function **ctl_memory_area_init** is given a pointer to the memory area to initialise in **memory_area**. The array that will be 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 that **memory** must point to a block of memory that is at least **block_size_in_wordsnum_blocks** words long.

Portability **ctl_memory_area_init** is provided in every implementation of the CrossWorks tasking library.

See Also **Memory areas** (page 220)

ctl_message_queue_init

Synopsis

```
#include <ctl_api.h>
void ctl_message_queue_init(CTL_MESSAGE_QUEUE_t *m,
                            void **queue,
                            unsigned queue_size);
```

Description The function **ctl_message_queue_init** is given a pointer to the message queue to initialise in **m**. The array that will be used to implement the message queue pointed to by **queue** and its size in **queue_size** are also supplied.

Portability **ctl_message_queue_init** is provided in every implementation of the CrossWorks tasking library.

See Also **Message queues** (page 211)

ctl_message_queue_post

Synopsis

```
#include <ctl_api.h>
unsigned ctl_message_queue_post(CTL_MESSAGE_QUEUE_t *m,
                                void *message,
                                CTL_TIMEOUT_t timeoutType,
                                CTL_TIME_t timeout);
```

Description The **ctl_message_queue_post** function posts the **message** to the message queue pointed at by **m**. 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 the **timeout** value. This function returns zero if the timeout occured otherwise it returns one.

Restrictions This function should not be called from an interrupt service routine.

Portability **ctl_message_queue_post** is provided in every implementation of the CrossWorks tasking library.

See Also **Message queues** (page 211)

ctl_message_queue_post_nb

Synopsis

```
#include <ctl_api.h>
unsigned ctl_message_queue_post_nb(CTL_MESSAGE_QUEUE_t *m,
                                   void *message);
```

Description

The **ctl_message_queue_post_nb** function posts the **message** to the message queue pointed at by **m**. If the message queue is full then the function will return zero otherwise it will return one.

Portability

ctl_message_queue_post_nb is provided in every implementation of the CrossWorks tasking library.

See Also

Message queues (page 211)

ctl_message_queue_receive

Synopsis

```
#include <ctl_api.h>
unsigned ctl_message_queue_receive(CTL_MESSAGE_QUEUE_t *m,
                                   void **message,
                                   CTL_TIMEOUT_t timeoutType,
                                   CTL_TIME_t timeout);
```

Description

The function **ctl_message_queue_receive** pops the oldest message in the message queue pointed at by **m** into the memory pointed at by **message**. This function will block if no messages are available unless **timeoutType** is non-zero and the current time reaches the **timeout** value. If the timeout occured the function returns zero otherwise it returns 1.

Restrictions

This function should not be called from an interrupt service routine.

Portability

ctl_message_queue_receive is provided in every implementation of the CrossWorks tasking library.

See Also

Message queues (page 211)

ctl_message_queue_receive_nb

Synopsis

```
#include <ctl_api.h>
unsigned ctl_message_queue_receive_nb(CTL_MESSAGE_QUEUE_t *m,
                                      void **message);
```

Description

The function **ctl_message_queue_receive_nb** pops the oldest message in the message queue pointed at by **m** into the memory pointed at by **message**. If no messages are available the function returns zero otherwise it returns 1.

Portability

ctl_message_queue_receive_nb is provided in every implementation of the CrossWorks tasking library.

See Also **Message queues** (page 211)

ctl_semaphore_init

Synopsis

```
#include <ctl_api.h>
void ctl_semaphore_init(CTL_SEMAPHORE_t *s,
                        unsigned value);
```

Description The function **ctl_semaphore_init** initialises the semaphore pointed at by **s** to the **value**.

Portability **ctl_semaphore_init** is provided in every implementation of the CrossWorks tasking library.

See Also **Semaphores** (page 209)

ctl_semaphore_signal

Synopsis

```
#include <ctl_api.h>
void ctl_signal_semaphore(CTL_SEMAPHORE_t *s);
```

Description The **ctl_signal_semaphore** signals the semaphore pointed at 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.

Portability **ctl_signal_semaphore** is provided in every implementation of the CrossWorks tasking library.

See Also **Semaphores** (page 209)

ctl_semaphore_wait

Synopsis

```
#include <ctl_api.h>
unsigned ctl_wait_semaphore(CTL_SEMAPHORE_t *s,
                            CTL_TIMEOUT_t timeoutType,
                            CTL_TIME_t timeout);
```

Description The **ctl_wait_semaphore** waits for the semaphore pointed at 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 occured the function returns zero otherwise it returns one.

Restrictions This function should not be called from an interrupt service routine.

Portability **ctl_wait_semaphore** is provided in every implementation of the CrossWorks tasking library.

See Also **Semaphores** (page 209)

ctl_timeout_wait

Synopsis

```
#include <ctl_api.h>
void ctl_start_timer(CTL_ISR_FN_t timerFn);
```

Description

The **ctl_start_timer** function starts a periodic timer interrupt that calls the **timerFn** function.

Restrictions

This function should only be called once.

Portability

ctl_start_timer is provided in every implementation of the CrossWorks tasking library.

ctl_set_isr

Synopsis

```
#include <ctl_api.h>
void ctl_set_isr(unsigned int vector,
                 unsigned int priority,
                 CTL_ISR_TRIGGER_t trigger,
                 CTL_ISR_FN_t isr,
                 CTL_ISR_FN_t *oldisr);
```

Description

The function **ctl_set_isr** takes the interrupt **vector** number and **priority** as arguments. These number will vary from system to system - check the data sheet of the system you are using for information. The **trigger** defines the type of interrupt that will trigger the interrupt service routine.

- **CTL_ISR_TRIGGER_FIXED** — the trigger type is not programmable.
- **CTL_ISR_TRIGGER_LOW_LEVEL** — generates an interrupt when the signal is low.
- **CTL_ISR_TRIGGER_HIGH_LEVEL** — generates an interrupt when the signal is high.
- **CTL_ISR_TRIGGER_NEGATIVE_EDGE** — generates an interrupt on a falling edge.
- **CTL_ISR_TRIGGER_POSITIVE_EDGE** — generates an interrupt on a rising edge.
- **CTL_ISR_TRIGGER_DUAL_EDGE** — generates an interrupt on either a falling or a rising edge.

On many systems the interrupt controller lacks a programmable trigger type—use **CTL_ISR_TRIGGER_FIXED** on these systems.

The **isr** parameter is the C function to call on interrupt and if **oldisr** is non zero then the existing interrupt handler is returned in ***oldisr**.

Portability — The **ctl_set_isr** function is provided on systems that have programmable interrupt controller hardware.

See Also — **Programmable interrupt handling** (page 218)

ctl_task_die

Synopsis

```
#include <ctl_api.h>
void ctl_task_die(void);
```

Description — **ctl_task_die** terminates the currently executing task and schedules the next ready task. You cannot remove the currently executing task from an interrupt service routine; if you do, the error handler is called with the reason code **CTL_SUICIDE_IN_ISR**.

Portability — **ctl_task_die** is provided in every implementation of the CrossWorks tasking library.

ctl_task_executing

Synopsis

```
#include <ctl_api.h>
extern CTL_TASK_t *ctl_task_executing;
```

Description — The **ctl_task_executing** variable points to the **CTL_TASK_t** structure of the currently executing task. The **priority** field is the only one of the **CTL_TASK_t** structure that is defined for the task that is executing. It is an error is **ctl_task_executing** takes the **NULL** value.

Portability — **ctl_task_executing** is provided in every implementation of the CrossWorks tasking library.

ctl_task_init

Synopsis

```
#include <ctl_api.h>
void ctl_task_init(CTL_TASK_t *task,
                   unsigned char priority,
                   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, it's **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.

Restrictions The function must be called before any other CrossWorks tasking library calls are made.

Portability **ctl_task_init** is provided in every implementation of the CrossWorks tasking library.

ctl_task_list

Synopsis

```
#include <ctl_api.h>
extern CTL_TASK_t *ctl_task_list;
```

Description **ctl_task_list** points to the **CTL_TASK_t** structure of the highest priority task that isn't executing. It is an error if **ctl_task_list** takes the **NULL** value.

Portability **ctl_task_list** is provided in every implementation of the CrossWorks tasking library.

ctl_task_remove

Synopsis

```
#include <ctl_api.h>
void ctl_task_remove(CTL_TASK_t *task);
```

Description **ctl_task_remove** removes the task **task** from the waiting task list. Once you you have removed a task the only way to re-introduce it to the system is to call **ctl_task_run**.

You can remove the currently executing task by passing **ctl_task_executing** to **ctl_task_remove** which is the same as calling **ctl_task_die**. You cannot remove the currently executing task from an interrupt service routine; if you do, the error handler is called with the reason code **CTL_SUICIDE_IN_ISR**.

Portability **ctl_task_remove** is provided in every implementation of the CrossWorks tasking library.

ctl_task_reschedule

Synopsis

```
#include <ctl_api.h>
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.

Restrictions This function should not be called from an interrupt service routine.

Portability **ctl_task_reschedule** is provided in every implementation of the CrossWorks tasking library.

ctl_task_run

Synopsis

```
#include <ctl_api.h>
void ctl_task_run(CTL_TASK_t *task,
                  unsigned char priority,
                  void (*entrypoint)(void *),
                  void *parameter,
                  char *name,
                  unsigned stack_size_in_words,
                  unsigned *stack,
                  unsigned call_size_in_words);
```

Description

This function 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. The **name** is a pointer to a zero terminated string used for debug purposes. The start of the memory used to implement 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.

Portability

ctl_task_run is provided in every implementation of the CrossWorks tasking library.

ctl_task_set_priority

Synopsis

```
#include <ctl_api.h>
void 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.

Portability

ctl_task_set_priority is provided in every implementation of the CrossWorks tasking library.

ctl_timeout_wait

Synopsis

```
#include <ctl_api.h>
void ctl_timeout_wait(CTL_TIME_t timeout);
```

Description

The **ctl_timeout_wait** function takes the **timeout** (not the duration) as a parameter and suspends the calling task until the current time is less than the timeout.

Restrictions
This function should not be called from an interrupt service routine.

Portability
ctl_task_set_priority is provided in every implementation of the CrossWorks tasking library.

ctl_timeslice_period

Synopsis
```
#include <ctl_api.h>
extern 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.

Portability
ctl_timeslice_period is provided in every implementation of the CrossWorks tasking library.

ctl_umask_isr

Synopsis
```
#include <ctl_api.h>
int ctl_unmask_isr(unsigned int vector);
```

Description
The function **ctl_unmask_isr** enables an interrupt source. The **vector** argument specifies the interrupt source to unmask.

Portability
ctl_unmask_isr is provided on systems that have programmable interrupt controller hardware.

See Also
Programmable interrupt handling (page 218)

<cross_studio_io.h> - Debug I/O library

The header file **<cross_studio_io.h>** defines functions that enable the target program to perform input and output using **Virtual Console Services**.

These functions are closely modelled on the standard C **<stdio.h>** functions.

Output functions

debug_printf	Formatted output to the virtual console
debug_putchar	Write one character to the virtual console

debug_puts	Write string to the virtual console

Input functions

debug_getchar	Read one character from the virtual console
debug_getd	Read a double floating value from the virtual console
debug_getf	Read a floating value from the virtual console
debug_geti	Read an integer from the virtual console
debug_getl	Read a long integer from the virtual console
debug_getll	Read a long long integer from the virtual console
debug_gets	Read a string from the virtual console
debug_getu	Read an unsigned integer from the virtual console
debug_getul	Read an unsigned long integer from the virtual console
debug_getull	Read an unsigned long long integer from the virtual console

File functions

debug_fopen	Open a file
debug_fflush	Flush a file
debug_fclose	Close a file
debug_fprintf	Formatted output to a file
debug_fgetc	Read one character from a file
debug_fgets	Read a string from a file
debug_fputc	Write one character to a file
debug_fputs	Write a string to a file
debug_fread	Read from a file
debug_fwrite	Write to a file
debug_fseek	Position a file
debug_ftell	Remember position of a file
debug_rewind	Reposition to start of a file
debug_filesize	Get the size of a file
debug_clearerr	Clear error flags associated with a file

debug_feof	Test for end of file
debug_ferror	Test a file for errors

Debug functions

debug_runtime_error	Stop debugger and display a runtime error string
debug_break	Programmed breakpoint that stops the debugger

Miscellaneous functions

debug_time	Returns the number of seconds elapsed since midnight (00:00:00), January 1, 1970, coordinated universal time (UTC)

debug_break

Synopsis

```
#include <cross_studio_io.h>
void debug_break();
```

Description

debug_break causes the the debugger to stop the target and position the cursor on the line that called **debug_break**.

Portability

debug_break is an extension provided by CrossWorks C.

debug_clearerr

Synopsis

```
#include <cross_studio_io.h>
void debug_clearerr(DEBUG_FILE *stream);
```

Description

debug_clearerr clear any error or end of file conditions on **stream**.

Portability

debug_clearerr is an extension provided by CrossWorks C.

debug_fclose

Synopsis

```
#include <cross_studio_io.h>
void debug_fclose(DEBUG_FILE *stream);
```

Description

debug_fclose flushes any buffered output to **stream** and then closes the stream.

Portability

debug_fclose is an extension provided by CrossWorks C.

debug_feof

Synopsis

```
#include <cross_studio_io.h>
int debug_feof(DEBUG_FILE *stream);
```

Description

debug_feof returns non-zero if the end of file condition is set for **stream**.

Portability

debug_feof is an extension provided by CrossWorks C.

debug_ferror

Synopsis

```
#include <cross_studio_io.h>
int debug_ferror(DEBUG_FILE *stream);
```

Description

debug_ferror returns a non-zero value if the error indicator is set for **stream**.

Portability

debug_ferror is an extension provided by CrossWorks C.

debug_fflush

Synopsis

```
#include <cross_studio_io.h>
int debug_fflush(DEBUG_FILE *stream);
```

Description

debug_fflush flushes any buffered output to the **stream**.

debug_fflush returns 0 on success and **EOF** if there was an error.

Portability

debug_fflush is an extension provided by CrossWorks C.

debug_fgetc

Synopsis

```
#include <cross_studio_io.h>
int debug_fgetc(DEBUG_FILE *stream);
```

Description

debug_fgetc reads and returns the next character on **stream** or EOF if no character is available.

Portability

debug_fgetc is an extension provided by CrossWorks C.

debug_fgets

Synopsis

```
#include <cross_studio_io.h>
char *debug_fgets(char *s, int n DEBUG_FILE *stream);
```

Description

debug_fgets reads at most **n**?1 characters from **stream** into the array pointed to by **s**.

debug_fgets returns **s** on success, or 0 on error or end of file.

Portability

debug_fgets is an extension provided by CrossWorks C.

debug_filesize

Synopsis

```
#include <__cross_studio_io.h>
int debug_filesize(DEBUG_FILE *stream);
```

Description

debug_filesize returns the size of the file associated with the stream **stream** in bytes.

debug_filesize returns **EOF** on error.

Portability

debug_filesize is an extension provided by CrossWorks C.

debug_fopen

Synopsis

```
#include <cross_studio_io.h>
DEBUG_FILE *debug_fopen(const char *filename, const char *mode);
```

Description

debug_fopen opens the named file and returns a stream or **NULL** if the open fails. 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

The **mode** should then include either “**t**” or “**b**” to specify if carriage return, linefeed combinations are translated into newline characters e.g. “**rt**”, “**a+b**”.

Portability

debug_fopen is an extension provided by CrossWorks C.

debug_fprintf

Synopsis

```
#include <cross_studio_io.h>
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 actual formatting is performed on the host by CrossStudio and therefore **debug_fprintf** is very small and consumes almost no 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 number of characters transmitted, or a negative value if an output or encoding error occurred.

Portability

debug_fprintf is an extension provided by CrossWorks C.

debug_fputc

Synopsis

```
#include <cross_studio_io.h>
int debug_fputc(int c, DEBUG_FILE *stream);
```

Description

debug_fputc writes the character **c** to the stream **stream**.

debug_fputc returns the character written. If a write error occurs, **debug_fputc** returns **EOF**.

Portability

debug_fputc is an extension provided by CrossWorks C.

debug_fputs

Synopsis

```
#include <cross_studio_io.h>
int debug_fputs(const char *s, DEBUG_FILE *stream);
```

Description

debug_fputs writes the string pointed to by **s** to the stream **stream** and appends a new-line character to the output. The terminating null character is not written.

debug_fputs returns **EOF** if a write error occurs; otherwise it returns a nonnegative value.

Portability

debug_fputs is an extension provided by CrossWorks C.

debug_fread

Synopsis

```
#include <cross_studio_io.h>
int debug_fread(void *ptr, int size, int nobj, DEBUG_FILE *stream);
```

Description
debug_fread reads from **stream** into the array **ptr** at most **nobj** objects of size **size** and returns the number of objects read. **debug_feof** and **debug_ferror** can be used to determine status.

Portability
debug_fread is an extension provided by CrossWorks C.

debug_printf

Synopsis

```
#include <cross_studio_io.h>
int debug_fscanf(DEBUG_FILE *file, const char *format, ...);
```

Description
debug_fscanf reads from the **file**, under control of the string pointed to by **format** that specifies how subsequent arguments are converted for input. The actual formatting is performed on the host by CrossStudio and therefore **debug_fscanf** is very small and consumes almost no 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.

Portability
debug_fscanf is an extension provided by CrossWorks C.

debug_fseek

Synopsis

```
#include <cross_studio_io.h>
int debug_fseek(DEBUG_FILE *stream, long offset, int origin);
```

Description
debug_fseek sets the file position for **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 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 non-zero on error.

Portability
debug_fseek is an extension provided by CrossWorks C.

debug_ftell

Synopsis

```
#include <cross_studio_io.h>
int debug_ftell(DEBUG_FILE *stream, long *offset);
```

Description

debug_ftell writes the current file position of **stream** to the object pointed to by **offset**.

debug_ftell returns **EOF** on error:

Portability

debug_ftell is an extension provided by CrossWorks C.

debug_fwrite

Synopsis

```
#include <cross_studio_io.h>
int debug_fwrite(void *ptr, int size, int nobj, DEBUG_FILE *stream);
```

Description

debug_fwrite writes from the array pointed to by **ptr**, **nobj** objects of size **size** on **stream** and returns the number of objects written. **debug_feof** and **debug_ferror** can be used to determine status.

Portability

debug_fwrite is an extension provided by CrossWorks C.

debug_getch

Synopsis

```
#include <cross_studio_io.h>
int debug_getch(void);
```

Description

debug_getch prompts the user for character input and returns the character supplied or a negative value if no character is available.

Portability

debug_getch is an extension provided by CrossWorks C.

debug_getchar

Synopsis

```
#include <cross_studio_io.h>
int debug_getchar(void);
```

Description

debug_getchar prompts the user for character input and returns the character supplied or a negative value if no character is available.

Portability

debug_getchar is an extension provided by CrossWorks C.

debug_getd

Synopsis

```
#include <cross_studio_io.h>
int debug_getd(double *d);
```

Description

debug_getd prompts the user to enter an real value. The number is written to the **double** object pointed to by **d**.

debug_getd returns zero on success and **EOF** on error.

Portability

debug_getd is an extension provided by CrossWorks C.

debug_getf

Synopsis

```
#include <cross_studio_io.h>
int debug_getf(float *f);
```

Description

debug_getf prompts the user to enter an real value. The number is written to the **float** object pointed to by **f**.

debug_getf returns zero on success and **EOF** on error.

Portability

debug_getf is an extension provided by CrossWorks C.

debug_geti

Synopsis

```
#include <cross_studio_io.h>
int debug_geti(int *i);
```

Description

debug_geti prompts the user to enter an integer. 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 **int** object pointed to by **i**.

debug_geti returns zero on success and **EOF** on error.

Portability

debug_geti is an extension provided by CrossWorks C.

debug_getl

Synopsis

```
#include <cross_studio_io.h>
int debug_getl(long *l);
```

Description **debug_getl** prompts the user to enter an integer. 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 and **EOF** on error.

Portability **debug_getl** is an extension provided by CrossWorks C.

debug_getll

Synopsis

```
#include <cross_studio_io.h>
int debug_getl(long *ll);
```

Description **debug_getll** prompts the user to enter an integer. 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 and **EOF** on error.

Portability **debug_getll** is an extension provided by CrossWorks C.

debug_gets

Synopsis

```
#include <cross_studio_io.h>
int debug_gets(char *s, int n);
```

Description **debug_gets** prompts the user for string input and writes at most **n**?1 characters into the array pointed to be **s** which is null terminated.

debug_gets returns the number of characters read or **EOF** on error. .

Portability **debug_gets** is an extension provided by CrossWorks C.

debug_getu

Synopsis

```
#include <cross_studio_io.h>
int debug_getu(unsigned *u);
```

Description **debug_getu** prompts the user to enter an integer. 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** object pointed to by **u**.

debug_getu returns zero on success and **EOF** on error.

Portability **debug_getu** is an extension provided by CrossWorks C.

debug_getul

Synopsis
```
#include <cross_studio_io.h>
int debug_getul(unsigned long *ul);
```

Description **debug_getul** prompts the user to enter an integer. 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 long** object pointed to by **ul**.

debug_getul returns zero on success and **EOF** on error.

Portability **debug_getul** is an extension provided by CrossWorks C.

debug_getull

Synopsis
```
#include <cross_studio_io.h>
int debug_getul(unsigned long *ull);
```

Description **debug_getull** prompts the user to enter an integer. 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 long long**object pointed to by **ull**.

debug_getull returns zero on success and **EOF** on error.

Portability **debug_getull** is an extension provided by CrossWorks C.

debug_kbhit

Synopsis
```
#include <cross_studio_io.h>
int debug_kbhit(void);
```

Description **debug_kbhit** return a non-zero value if a character is available or 0 is not.

Portability **debug_kbhit** is an extension provided by CrossWorks C.

debug_printf

Synopsis

```
#include <cross_studio_io.h>
int debug_printf(const char *format, ...);
```

Description

debug_printf writes to the **Target I/O Console Window**, under control of the string pointed to by **format** that specifies how subsequent arguments are converted for output. The actual formatting is performed on the host by CrossStudio and therefore **debug_printf** is very small and consumes almost no 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 number of characters transmitted, or a negative value if an output or encoding error occurred.

Portability

debug_printf is an extension provided by CrossWorks C.

debug_putchar

Synopsis

```
#include <cross_studio_io.h>
int debug_putchar(int c);
```

Description

debug_putchar writes the character **c** to the **Target I/O Console Window**.

debug_putchar returns the character written. If a write error occurs, **putchar** returns **EOF**.

Portability

debug_printf is an extension provided by CrossWorks C.

debug_puts

Synopsis

```
#include <cross_studio_io.h>
int debug_puts(const char *s);
```

Description

debug_puts writes the string pointed to by **s** to the **Target I/O Console Window** and appends a new-line character to the output. The terminating null character is not written.

debug_puts returns **EOF** if a write error occurs; otherwise it returns a nonnegative value.

Portability

debug_puts is an extension provided by CrossWorks C.

debug_rewind

Synopsis

```
#include <cross_studio_io.h>
void debug_rewind(DEBUG_FILE *stream);
```

Description

debug_rewind sets the current file position of the stream **stream** to the beginning of the file and clears any error and end of file conditions.

Portability

debug_rewind is an extension provided by CrossWorks C.

debug_runtime_error

Synopsis

```
#include <cross_studio_io.h>
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**.

Portability

debug_runtime_error is an extension provided by CrossWorks C.

debug_scanf

Synopsis

```
#include <cross_studio_io.h>
int debug_scanf(const char *format, ...);
```

Description

debug_scanf reads from the **Target I/O Console Window**, under control of the string pointed to by **format** that specifies how subsequent arguments are converted for input. The actual formatting is performed on the host by CrossStudio and therefore **debug_scanf** is very small and consumes almost no 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.

Portability

debug_scanf is an extension provided by CrossWorks C.

debug_time

Synopsis

```
#include <cross_studio_io.h>
unsigned long debug_ftell(unsigned long *ptr);
```

Description

debug_time writes the current file position of **stream** to the object pointed to by **offset**.

debug_ftell returns **EOF** on error:

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.

Portability

debug_time is an extension provided by CrossWorks C.

<__armlib.h> - Misc ARM functions

The header **<__armlib.h>** defines a number of useful ARM specific functions.

Interrupt functions	
__ARMLIB_enableIRQ (page 254)	Enable IRQ interrupts.
__ARMLIB_disableIRQ (page 254)	Disable IRQ interrupts.
__ARMLIB_isrEnableIRQ (page 254)	Re-enable IRQ interrupts from within an IRQ ISR.
__ARMLIB_isrDisableIRQ (page 255)	Re-disable IRQ interrupts from within an IRQ ISR.
__ARMLIB_enableFIQ (page 255)	Enable FIQ interrupts.
__ARMLIB_disableFIQ (page 256)	Disable FIQ interrupts.
Debug I/O functions	
__ARMLIB_commTX (page 256)	Send a word of data down the ARM debug communications channel.
__ARMLIB_commRX (page 256)	Read a word of data from the ARM debug communications channel.

Interrupt functions	
__ARMLIB_runCommPortServer (page 257)	Serve ARMCPS commands from the ARM's debug communications channel.
Miscellaneous Functions	
__ARMLIB_crc32 (page 257)	Compute a CRC-32 checksum of a block of data.

__ARMLIB_enableIRQ

Synopsis

```
#include <__armlib.h>
void __ARMLIB_enableIRQ(void);
```

Description

__ARMLIB_enableIRQ globally enables the ARM's IRQ interrupts by clearing the I bit of the CPSR register.

Portability

__ARMLIB_enableIRQ is an ARM specific extension provided by CrossWorks C.

See also

__ARMLIB_disableIRQ (page 254)**__ARMLIB_enableFIQ** (page 255)**__ARMLIB_disableFIQ** (page 256)**__ARMLIB_isrEnableIRQ** (page 254)**__ARMLIB_isrDisableIRQ** (page 255)

__ARMLIB_disableIRQ

Synopsis

```
#include <__armlib.h>
void __ARMLIB_disableIRQ(void);
```

Description

__ARMLIB_disableIRQ globally disables the ARM's IRQ interrupts by setting the I bit of the CPSR register.

Portability

__ARMLIB_disableIRQ is an ARM specific extension provided by CrossWorks C.

See also

__ARMLIB_enableIRQ (page 254)**__ARMLIB_enableFIQ** (page 255)**__ARMLIB_disableFIQ** (page 256)**__ARMLIB_isrEnableIRQ** (page 254)**__ARMLIB_isrDisableIRQ** (page 255)

__ARMLIB_isrEnableIRQ

Synopsis

```
#include <__armlib.h>
void __ARMLIB_isrEnableIRQ(void);
```

Description

__ARMLIB_isrEnableIRQ re-enables the ARM's global interrupts from within an ISR enabling reentrant IRQ interrupt handlers.

Calls to **__ARMLIB_isrEnableIRQ** should be accompanied with a call to **__ARMLIB_isrDisableIRQ** (page 255)prior to completion of the ISR.

Portability

__ARMLIB_isrEnableIRQ is an ARM specific extension provided by CrossWorks C.

See also

__ARMLIB_enableIRQ (page 254)**__ARMLIB_disableIRQ** (page 254)**__ARMLIB_isrDisableIRQ** (page 255)

__ARMLIB_isrDisableIRQ

Synopsis

```
#include <__armlib.h>
void __ARMLIB_isrDisableIRQ(void);
```

Description

__ARMLIB_isrDisableIRQ re-disables the ARM's global interrupts from within an ISR.

__ARMLIB_isrDisableIRQ should only be called after a previous call to **__ARMLIB_isrEnableIRQ** (page 254).

Portability

__ARMLIB_isrDisableIRQ is an ARM specific extension provided by CrossWorks C.

See also

__ARMLIB_enableIRQ (page 254)**__ARMLIB_disableIRQ** (page 254)**__ARMLIB_isrEnableIRQ** (page 254)

__ARMLIB_enableFIQ

Synopsis

```
#include <__armlib.h>
void __ARMLIB_enableFIQ(void);
```

Description

__ARMLIB_enableFIQ globally enables the ARM's FIQ interrupts by clearing the F bit of the CPSR register.

Portability

__ARMLIB_enableFIQ is an ARM specific extension provided by CrossWorks C.

See also

__ARMLIB_disableFIQ (page 256)**__ARMLIB_enableIRQ** (page 254)**__ARMLIB_disableIRQ** (page 254)**__ARMLIB_isrEnableIRQ** (page 254)**__ARMLIB_isrDisableIRQ** (page 255)

__ARMLIB_disableFIQ

Synopsis

```
#include <__armlib.h>
void __ARMLIB_disableFIQ(void);
```

Description

__ARMLIB_disableFIQ globally disables the ARM's FIQ interrupts by setting the F bit of the CPSR register.

Portability

__ARMLIB_disableFIQ is an ARM specific extension provided by CrossWorks C.

See also

__ARMLIB_enableFIQ (page 255)**__ARMLIB_enableIRQ** (page 254)**__ARMLIB_disableIRQ** (page 254)**__ARMLIB_isrEnableIRQ** (page 254)**__ARMLIB_isrDisableIRQ** (page 255)

__ARMLIB_commTX

Synopsis

```
#include <__armlib.h>
void __ARMLIB_commTX(unsigned long n);
```

Description

__ARMLIB_commTX transmits the word of data **n** down the ARM's debug communications channel. This function will block until the operation is complete.

Portability

__ARMLIB_commTX is an ARM specific extension provided by CrossWorks C.

See also

__ARMLIB_commRX (page 256)

__ARMLIB_commRX

Synopsis

```
#include <__armlib.h>
unsigned long __ARMLIB_commRX(void);
```

Description

__ARMLIB_commRX reads a word of data from the ARM's debug communications channel. This function will block until the operation is complete.

Portability

__ARMLIB_commRX is an ARM specific extension provided by CrossWorks C.

See also

__ARMLIB_commTX (page 256)

__ARMLIB_runCommPortServer

Synopsis

```
#include <__armlib.h>
void __ARMLIB_runCommPortServer(void);
```

Description

__ARMLIB_runCommPortServer serves ARMCPS commands from the ARM's debug communication channel until terminated by the host.

Portability

__ARMLIB_runCommPortServer is an ARM specific extension provided by CrossWorks C.

__ARMLIB_crc32

Synopsis

```
#include <__armlib.h>
void __ARMLIB_crc32(const unsigned char *src, unsigned long length);
```

Description

__ARMLIB_crc32 computes a CRC-32 checksum of a block of data. The parameter **src** points to the start of the data block and **length**specifies the size of the data block in bytes.

Portability

__ARMLIB_crc32 is an ARM specific extension provided by CrossWorks C.

Standard C Library Reference

CrossWorks C provides a library that conforms to the ANSI and ISO standards for C.

In this section

- **<stdio.h> - Input/output functions (page 298).** Describes the general utility functions provided by the C library.
- **<string.h> - String handling (page 330).** Describes the string handling functions provided by the C library.

<assert.h> - Diagnostics

The header file **<assert.h>** defines the **assert** macro under control of the **NDEBUG** macro, which the library *does not define*.

Macros

assert (page 259)	Assert that a condition is true

assert

Synopsis

```
#include <assert.h>
void assert(expression);
```

Description

assert allows you to place assertions and diagnostic tests into programs.

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**. When such an **assert** is executed and **expression** 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__**.

The prototype for **__assert** is:

```
extern void __assert(const char *, const char *, int);
```

There is no default implementation of **__assert**. Keeping **__assert** out of the library means that you can can customize its behaviour without rebuilding the library.

Important notes

The **assert** macro is redefined according to the current state of **NDEBUG** each time that **<assert.h>** is included.

Portability

assert conforms to ISO/IEC 9899:1990 (C90).

<ctype.h> - Character handling

The header **<ctype.h>** declares several functions useful for classifying and mapping characters.

The character argument to all functions is an **int**, the value of which is representable as an unsigned char or is the value of the macro **EOF**. If the argument has any other value, the behavior is undefined.

Only the "C" locale is supported by CrossWorks C, and thus the functions in this header are not affected by locales.

The term printing character refers to a member of a set of characters, each of which occupies one printing position on a display device; the term control character refers to a member of a set of characters that are not printing characters. All letters and digits are printing characters.

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?
isupper	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 letter?

Conversion functions

tolower	Convert uppercase character to lowercase
toupper	Convert lowercase character to uppercase

isalnum

Synopsis

```
#include <ctype.h>
int isalnum(int c);
```

Description **isalnum** returns nonzero (true) if and only if **isalpha** or **isdigit** return true for value of the argument **c**.

Portability **isalnum** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See also **isalpha** (page 261) **isdigit** (page 262)

isalpha

Synopsis

```
#include <ctype.h>
int isalpha(int c);
```

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

Portability **isalpha** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See also **isupper** (page 263) **isupper** (page 262)

isblank

Synopsis

```
#include <ctype.h>
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'`).

Portability **isblank** ISO/IEC 9899:1999 (C99).

See also **isspace** (page 263)

iscntrl

Synopsis

```
#include <ctype.h>
int iscntrl(int c);
```

Description **iscntrl** returns nonzero (true) if and only if the value of the argument **c** is a control character. Control characters have values 0 through 31 and the single value 127.

Portability **iscntrl** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

isdigit

Synopsis
```
#include <ctype.h>
int isdigit(int c);
```

Description **isdigit** returns nonzero (true) if and only if the value of the argument **c** is a decimal digit 0 through 9.

Portability **isdigit** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

isgraph

Synopsis
```
#include <ctype.h>
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 (`' '`).

Portability **isgraph** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

isupper

Synopsis
```
#include <ctype.h>
int islower(int c);
```

Description **islower** returns nonzero (true) if and only if the value of the argument **c** is an uppercase letter a through z.

Portability **islower** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

isprint

Synopsis
```
#include <ctype.h>
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 (`' '`).

Portability **isprint** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

ispunct

Synopsis

```
#include <ctype.h>
int ispunct(int c);
```

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

Portability **ispunct** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See also **isspace** (page 263) **isalnum** (page 261)

isspace

Synopsis

```
#include <ctype.h>
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'`).

Portability **isspace** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See also **isblank** (page 261)

isupper

Synopsis

```
#include <ctype.h>
int isupper(int c);
```

Description **isupper** returns nonzero (true) if and only if the value of the argument **c** is an uppercase letter A through Z.

Portability **isupper** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

isxdigit

Synopsis

```
#include <ctype.h>
int isxdigit(int c);
```

Description **isxdigit** returns nonzero (true) if and only if the value of the argument **c** is a hexadecimal digit 0 through 9, a through f, or A through F.

Portability **isxdigit** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

tolower

Synopsis

```
#include <ctype.h>
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.

Portability

tolower conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

toupper

Synopsis

```
#include <ctype.h>
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.

Portability

toupper conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

<errno.h> - Errors

The header file **<errno.h>** defines macros defines several macros, all relating to the reporting of error conditions.

Macros

errno	Error number

errno

Synopsis

```
#include <errno.h>
int errno;
```

Description

errno expands to a modifiable lvalue of type **int**, the value of which is set to a positive error number by several library functions.

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**.

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 functio that does so.

The header file **<errno.h>** defines the macros **EDOM**, **EILSEQ**, and **ERANGE** which expand to integer constant expressions with type **int**, distinct positive values, and which are suitable for use in **#if** preprocessing directives.

Portability

errno conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

<limits.h> - Integer numerical limits

The header file **<limits.h>** defines macros that expand to various limits and parameters of the standard integer types.

Type sizes

CHAR_BIT	Number of bits in a **char**

Character minimum and maximum values

CHAR_MIN	Minimum value of a **char**
CHAR_MAX	Maximum value of a **char**
SCHAR_MIN	Minimum value of a **signed char**
SCHAR_MAX	Maximum value of a **signed char**
UCHAR_MAX	Maximum value of an **unsigned char**

Short minimum and maximum values

SHRT_MIN	Minimum value of a **short**
SHRT_MAX	Maximum value of a **short**
USHRT_MAX	Maximum value of an **unsigned short**

Integer minimum and maximum values

INT_MIN	Minimum value of an **int**
INT_MAX	Maximum value of an **int**

UINT_MAX	Maximum value of an **unsigned int**

Long integer minimum and maximum values

LONG_MIN	Minimum value of a **long**
LONG_MAX	Maximum value of a **long**
ULONG_MAX	Maximum value of an **unsigned long**

Long long integer minimum and maximum values

LLONG_MIN	Minimum value of a **long long**
LLONG_MAX	Maximum value of a **long long**
ULLONG_MAX	Maximum value of an **unsigned long long**

CHAR_BIT

Synopsis

```
#include <limits.h>
#define CHAR_BIT 8
```

Description

CHAR_BIT is the number of bits for smallest object that is not a bit-field (byte).

Portability

CHAR_BIT conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

CHAR_MIN

Synopsis

```
#include <limits.h>
#define CHAR_MIN 0
```

Description

CHAR_MIN is the minimum value for an object of type **char**.

Portability

CHAR_MIN conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

CHAR_MAX

Synopsis

```
#include <limits.h>
#define CHAR_MAX 255
```

Description

CHAR_MAX is the maximum value for an object of type **char**.

Portability

CHAR_MAX conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

INT_MIN

Synopsis

```
#include <limits.h>
#define INT_MIN  processor-dependent-value
```

Description

INT_MIN is the minimum value for an object of type **int**.

For processors where an integer is held in 16 bits, **INT_MIN** is -32768, and for processors where an integer is held in 32 bits, **INT_MIN** is -2147483648.

Portability

INT_MIN conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

INT_MAX

Synopsis

```
#include <limits.h>
#define INT_MAX  processor-dependent-value
```

Description

INT_MAX is the maximum value for an object of type **int**.

For processors where an integer is held in 16 bits, **INT_MAX** is 32767, and for processors where an integer is held in 32 bits, **INT_MAX** is 2147483647.

Portability

INT_MAX conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

LLONG_MIN

Synopsis

```
#include <limits.h>
#define LLONG_MIN (-9223372036854775807-1)
```

Description

LLONG_MIN is the minimum value for an object of type **long long int**.

Portability

LLONG_MIN conforms to ISO/IEC 9899:1999 (C99).

LLONG_MAX

Synopsis

```
#include <limits.h>
#define LLONG_MAX (-9223372036854775807-1)
```

Description

LLONG_MAX is the maximum value for an object of type **long long int**.

Portability

LLONG_MAX conforms to ISO/IEC 9899:1999 (C99).

LONG_MIN

Synopsis

```
#include <limits.h>
#define LONG_MIN (-2147483647-1)
```

Description **LONG_MIN** is the minimum value for an object of type **long int**.

Portability **LONG_MIN** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

LONG_MAX

Synopsis

```
#include <limits.h>
#define LONG_MAX 2147483647
```

Description **LONG_MAX** is the maximum value for an object of type **long int**.

Portability **LONG_MAX** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

SCHAR_MIN

Synopsis

```
#include <limits.h>
#define SCHAR_MIN -127
```

Description **SCHAR_MIN** is the minimum value for an object of type **signed char**.

Portability **SCHAR_MIN** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

SCHAR_MAX

Synopsis

```
#include <limits.h>
#define SCHAR_MAX 127
```

Description **SCHAR_MAX** is the maximum value for an object of type **signed char**.

Portability **SCHAR_MAX** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

SHRT_MIN

Synopsis

```
#include <limits.h>
#define SHRT_MIN (-32767-1)
```

Description **SHRT_MIN** is the minimum value for an object of type **short int**.

Portability **SHRT_MIN** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

SHRT_MAX

Synopsis

```
#include <limits.h>
#define SHRT_MAX 32767
```

Description **SHRT_MAX** is the maximum value for an object of type **short int**.

Portability **SHRT_MAX** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

UCHAR_MAX

Synopsis

```
#include <limits.h>
#define UCHAR_MAX 255
```

Description **UCHAR_MAX** is the maximum value for an object of type **unsigned char**.

Portability **UCHAR_MAX** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

UINT_MAX

Synopsis

```
#include <limits.h>
#define UINT_MAX  processor-dependent-value
```

Description **UINT_MAX** is the maximum value for an object of type **unsigned int**.

For processors where an unsigned integer is held in 16 bits, **UINT_MAX** is 65535, and for processors where an unsigned integer is held in 32 bits, **UINT_MAX** is 4294967295.

Portability **UINT_MAX** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

ULLONG_MAX

Synopsis

```
#include <limits.h>
#define ULLONG_MAX 18446744073709551615
```

Description **ULLONG_MAX** is the maximum value for an object of type **unsigned long long int**.

Portability **ULLONG_MAX** conforms to ISO/IEC 9899:1999 (C99).

ULONG_MAX

Synopsis

```
#include <limits.h>
#define ULONG_MAX 2147483647
```

Description **ULONG_MAX** is the maximum value for an object of type **unsigned long int**.

Portability **ULONG_MAX** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

USHRT_MAX

Synopsis

```
#include <limits.h>
#define USHRT_MAX 65535
```

Description **USHRT_MAX** is the maximum value for an object of type **unsigned short int**.

Portability **USHRT_MAX** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

<math.h> - Mathematics

The header file **<math.h>** defines a number of types, macros, and mathematical functions.

Classification functions

isfinite	Is floating value finite?
isinf	Is floating value an infinity?
isnan	Is floating value a NaN?

Trigonometric functions

sin	Compute sine of a **double**
sinf	Compute sine of a **float**
cos	Compute cosine of a **double**
cosf	Compute cosine of a **float**

tan	Compute tangent of a **double**
tanf	Compute tangent of a **float**

Inverse trigonometric functions

asin	Compute inverse sine of a **double**
asinf	Compute inverse sine of a **float**
acos	Compute inverse cosine of a **double**
acosf	Compute inverse coside of a **float**
atan	Compute inverse tangent of a **double**
atanf	Compute inverse tangent of a **float**
atan2	Compute inverse tangent of a ratio of **double**s
atan2f	Compute inverse tangent of a ratio of **float**s

Inverse hyperbolic functions

acosh	Compute inverse hyperbolic cosine of a **double**
acoshf	Compute inverse hyperbolic cosine of a **float**
asinh	Compute inverse hyperbolic sine of a **double**
asinhf	Compute inverse hyperbolic sine of a **float**
atanh	Compute inverse hyperbolic tangent of a **double**
atanhf	Compute inverse hyperbolic tangent of a **float**

Hyperbolic functions

cosh	Compute hyperbolic cosine of a **double**
coshf	Compute hyperbolic cosine of a **float**
sinh	Compute hyperbolic sine of a **double**
sinhf	Compute hyperbolic sine of a **float**
tanh	Compute hyperbolic tangent of a **double**
tanhf	Compute hyperbolic tangent of a **float**

Exponential and logarithmic functions

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**
ldexpf	Adjust exponent of a **float**
log	Compute natural logarithm of a **double**
logf	Compute natural logarithm of a **float**
log10	Compute common logarithm of a **double**
log10f	Compute common logarithm of a **float**

Power functions

sqrt	Compute square root of a **double**
sqrtf	Compute square root of a **float**
cbrt	Compute cube root of a **double**
cbrtf	Compute cube root of a **float**
pow	Raise a **double** to a power
powf	Raise a **float** to a power

Absolute value functions

fabs	Compute absolute value of a **double**
fabsf	Compute absolute value of a **float**
hypot	Compute complex magnitude of two **double**s
hypotf	Compute complex magnitude of two **float**s

Remainder functions

fmod	Compute remainder after division of two **double**s
fmodf	Compute remainder after division of two **float**s
modf	Break a **double** to integer and fractional parts
modff	Break a **float** to integer and fractional parts

Maximum, minimum, and positive difference functions

fmax	Compute maximum of two **double**s
fmaxf	Compute maximum of two **float**s

fmin	Compute minimum of two **double**s
fminf	Compute minimum of two **float**s

Nearest integer functions

ceil	Compute smallest integer not greater than a **double**
ceilf	Compute smallest integer not greater than a **float**
floor	Compute largest integer not greater than a **double**
floorf	Compute largest integer not greater than a **float**

acos

Synopsis

```
#include <math.h>
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.

Fast math library behavior

If |**x**| > 1, **errno** is set to **EDOM** and **acos** returns **HUGE_VAL**.

IEC 60559 math library behavior

If **x** is NaN, **acos** returns **x**.
If |**x**| > 1, **acos** returns NaN with invalid signal.

Portability

acos conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

acosf

Synopsis

```
#include <math.h>
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.

Fast math library behavior

If |**x**| > 1, **errno** is set to **EDOM** and **acosf** returns **HUGE_VAL**.

IEC 60559 math behavior

If **x** is NaN, **acosf** returns **x**.
If |**x**| > 1, **acosf** returns NaN with invalid signal.

Portability

acosf conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

acosh

Synopsis

```
#include <math.h>
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.

Fast math library behavior

If **x**< 1, **errno** is set to **EDOM** and **acosh** returns **HUGE_VAL**.

IEC 60559 math library behavior

If **x** < 1, **acosh** returns NaN with signal.
If **x** is NaN, **acosh** returns NaN without signal .

Portability

acosh conforms to ISO/IEC 9899:1999 (C99).

acoshf

Synopsis

```
#include <math.h>
float acoshf(float x);
```

Description

acoshf returns the non-negative inverse hyperbolic cosine of **x**.

Fast math library behavior

If **x**< 1, **errno** is set to **EDOM** and **acoshf** returns **HUGE_VALF**.

IEC 60559 math library behavior

If **x** < 1, **acoshf** returns NaN with signal.
If **x** is NaN, **acoshf** returns NaN without signal.

Portability

acoshf conforms to ISO/IEC 9899:1999 (C99).

asin

Synopsis

```
#include <math.h>
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 [-PI/2, +PI/2] radians.

Fast math library behavior

If |**x**| > 1, **errno** is set to **EDOM** and **asin** returns **HUGE_VAL**.

IEC 60559 math library behavior

If **x** is NaN, **asin** returns **x**.
If |**x**| > 1, **asin** returns NaN with invalid signal.

Portability

asin conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

asinf

Synopsis
```
#include <math.h>
float asinf(float val);
```

Description

asinf returns the principal value, in radians, of the inverse circular sine of **val**. The principal value lies in the interval [-PI/2, +PI/2] radians.

Fast math library behavior

If |**x**| > 1, **errno** is set to **EDOM** and **asinf** returns **HUGE_VALF**.

IEC 60559 math library behavior

If **x** is NaN, **asinf** returns **x**.
If |**x**| > 1, **asinf** returns NaN with invalid signal.

Portability

asinf conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

asinh

Synopsis
```
#include <math.h>
double asinh(double x);
```

Description

asinh returns the inverse hyperbolic sine of **x**.

Portability

asinh conforms to ISO/IEC 9899:1999 (C99).

asinhf

Synopsis
```
#include <math.h>
float asinhf(float x);
```

Description

asinhf returns the inverse hyperbolic sine of **x**.

Portability

asinhf conforms to ISO/IEC 9899:1999 (C99).

atan

Synopsis
```
#include <math.h>
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 [-¾?, +¾?] radians.

Portability

atan conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See Also

atan2 (page 276)

atan2

Synopsis

```
#include <math.h>
double atan2(double y, double x);
```

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 [-PI/2, +PI/2] radians.

Fast math library behavior

If **x** = **y** = 0, **errno** (page 264) is set to **EDOM** and **atan2** returns **HUGE_VAL**.

IEC 60559 math library behavior

atan2f(*x*, NaN) is NaN
atan2f(NaN, *x*) is NaN
atan2f(0, +(anything but NaN)) is 0
atan2f(0, -(anything but NaN)) is ?
atan2f((anything but 0 and NaN), 0) is ?/2
atan2f((anything but Infinity and NaN), +Infinity) is 0
atan2f((anything but Infinity and NaN), -Infinity) is ?
atan2f(Infinity, +Infinity) is ?/4
atan2f(Infinity, -Infinity) is 3?/4
atan2f(Infinity, (anything but 0, NaN, and Infinity)) is ?/2

Portability

atan2 conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See Also

atan (page 275)

atan2f

Synopsis

```
#include <math.h>
float atan2f(float y, float x);
```

Description

atan2f returns the value, in radians, of the inverse circular tangent of **y** divided by **x** using the signs of **x** and **y** to compute the quadrant of the return value. The principal value lies in the interval [-PI/2, +PI/2] radians.

Fast math library behavior

If **x** = **y** = 0, **errno** (page 264) is set to **EDOM** and **atan2f** returns **HUGE_VALF**.

IEC 60559 math library behavior

atan2f(*x*, NaN) is NaN
atan2f(NaN, *x*) is NaN
atan2f(0, +(anything but NaN)) is 0
atan2f(0, -(anything but NaN)) is ?
atan2f((anything but 0 and NaN), 0) is ?/2
atan2f((anything but Infinity and NaN), +Infinity) is 0
atan2f((anything but Infinity and NaN), -Infinity) is ?

atan2f(Infinity, +Infinity) is ?/4
atan2f(Infinity, -Infinity) is 3?/4
atan2f(Infinity, (anything but 0, NaN, and Infinity)) is ?/2

Portability **atan2f** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See Also **atanf** (page 277)

atanf

Synopsis

```
#include <math.h>
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 [-¾?, +¾?] radians.

Portability **atanf** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

atanh

Synopsis

```
#include <math.h>
double atanh(double x)
```

Description **atanh** returns the inverse hyperbolic tangent of **x**.

Fast math library If |**x**| ? 1, **errno** is set to **EDOM** and **atanh** returns **HUGE_VAL**.

IEC 60559 math library behavior If |**x**| > 1 **atanh** returns NaN with signal.
If **x** is NaN, **atanh** returns that NaN with no signal.
If **x** is 1, **atanh** returns Infinity with signal.
If **x** is -1, **atanh** returns -Infinity with signal.

Portability **atanh** conforms to ISO/IEC 9899:1999 (C99).

atanhf

Synopsis

```
#include <math.h>
float atanhf(float val)
```

Description **atanhf** returns the inverse hyperbolic tangent of **val**.

Fast math library behavior If |**x**| ? 1, **errno** is set to **EDOM** and **atanhf** returns **HUGE_VALF**.

IEC 60559 math library behavior

If |**val**| > 1 **atanhf** returns NaN with signal.
If **val** is NaN, **atanhf** returns that NaN with no signal.
If **val** is 1, **atanhf** returns Infinity with signal.
If **val** is -1, **atanhf** returns -Infinity with signal.

Portability

atanhf conforms to ISO/IEC 9899:1999 (C99).

cbrt

Synopsis

```
#include <math.h>
double cbrt(double x);
```

Description

cbrt computes the cube root of **x**.

Portability

cbrt conforms to ISO/IEC 9899:1999 (C99).

cbrtf

Synopsis

```
#include <math.h>
float cbrt(float x);
```

Description

cbrtf computes the cube root of **x**.

Portability

cbrtf conforms to ISO/IEC 9899:1999 (C99).

ceil

Synopsis

```
#include <math.h>
double ceil(double x);
```

Description

ceil computes the smallest integer value not less than **x**.

IEC 60559 math library behavior

ceil(0) is 0.
ceil(Infinity) is Infinity.

Portability

ceil conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

ceilf

Synopsis

```
#include <math.h>
float ceilf(float x);
```

Description

ceilf computes the smallest integer value not less than **x**.

IEC 60559 math library behavior

ceilf(0) is 0.
ceilf(Infinity) is Infinity.

Portability

ceilf conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

cos

Synopsis

```
#include <math.h>
double cos(double x);
```

Description

cos returns the radian circular cosine of **x**.

Fast math library behavior

If |**x**| > 10^9, **errno** is set to **EDOM** and **cos** returns **HUGE_VAL**.

IEC 60559 math library behavior

If **x** is NaN, **cos** returns **x**.
If |**x**| is Infinity, **cos** returns NaN with invalid signal.

Portability

cos conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

cosf

Synopsis

```
#include <math.h>
float cosf(float x);
```

Description

cosf returns the radian circular cosine of **x**.

Fast math library behavior

If |**x**| > 10^9, **errno** is set to **EDOM** and **cosf** returns **HUGE_VALF**.

IEC 60559 math library behavior

If **x** is NaN, **cosf** returns **x**.
If |**x**| is Infinity, **cosf** returns NaN with invalid signal .

Portability

cosf conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

cosh

Synopsis

```
#include <math.h>
double cosh(double x);
```

Description

cosh calculates the hyperbolic cosine of **x**.

Fast math library behavior

If |**x**| >~ 709.782, **errno** is set to **EDOM** and **cosh** returns **HUGE_VAL**.

IEC 60559 math library behavior

If **x** is +Infinity, -Infinity, or NaN, **cosh** returns |**x**|.
If |**x**| >~ 709.782, **cosh** returns +Infinity or -Infinity depending upon the sign of **x**.

Portability

cosh conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

coshf

Synopsis
```
#include <math.h>
float coshf(float x);
```

Description
coshf calculates the hyperbolic sine of **x**.

Fast math library behavior
If |**x**| >~ 88.7228, **errno** is set to **EDOM** and **coshf** returns **HUGE_VALF**.

IEC 60559 math library behavior
If **x** is +Infinity, -Infinity, or NaN, **coshf** returns |**x**|.
If |**x**| >~ 88.7228, **coshf** returns +Infinity or -Infinity depending upon the sign of **x**.

Portability
coshf conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

exp

Synopsis
```
#include <math.h>
double exp(double x);
```

Description
exp computes the base-*e* exponential of **x**.

Fast math library behavior
If |**x**| >~ 709.782, **errno** is set to **EDOM** and **exp** returns **HUGE_VAL**.

IEC 60559 math library behavior
If **x** is NaN, **exp** returns NaN.
If **x** is Infinity, **exp** returns Infinity
If **x** is -Infinity, **exp** returns 0.

Portability
exp conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

expf

Synopsis
```
#include <math.h>
float expf(float x);
```

Description
expf computes the base-*e* exponential of **x**.

Fast math library behavior
If |**x**| >~ 88.722, **errno** is set to **EDOM** and **expf** returns **HUGE_VALF**.

IEC 60559 math library behavior
If **x** is NaN, **expf** returns NaN.
If **x** is Infinity, **expf** returns Infinity
If **x** is -Infinity, **expf** returns 0.

Portability
expf conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

fabs

Synopsis

```
#include <math.h>
double fabs(double x);
```

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

Portability **fabs** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

fabsf

Synopsis

```
#include <math.h>
float fabs(float x);
```

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

Portability **fabsf** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

floor

Synopsis

```
#include <math.h>
double floor(double x);
```

Description **floor** computes the largest integer value not greater than **x**.

IEC 60559 math library behavior

floor(0) is0.
floor(Infinity) is Infinity.

Portability **floor** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

floorf

Synopsis

```
#include <math.h>
double floor(double x);
```

Description **floorf** computes the largest integer value not greater than **x**.

IEC 60559 math library behavior

floorf(0) is0.
floorf(Infinity) is Infinity.

Portability **floorf** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

fmax

Synopsis

```
#include <math.h>
double fmax(double x, double y);
```

Description

fmax determines the minimum of **x** and **y**.

IEC 60559 math library behavior

fmax(NaN, **y**) is **y**.
fmax(**x**, NaN) is **x**.

Portability

fmax conforms to ISO/IEC 9899:1999 (C99).

---

fmaxf

Synopsis

```
#include <math.h>
float fmaxf(float x, float y);
```

Description

fmaxf determines the minimum of **x** and **y**.

IEC 60559 math library behavior

fmaxf(NaN, **y**) is **y**.
fmaxf(**x**, NaN) is **x**.

Portability

fmaxf conforms to ISO/IEC 9899:1999 (C99).

---

fmin

Synopsis

```
#include <math.h>
double fmin(double x, double y);
```

Description

fmin determines the minimum of **x** and **y**.

IEC 60559 math library behavior

fmin(NaN, **y**) is **y**.
fmin(**x**, NaN) is **x**.

Portability

fmin conforms to ISO/IEC 9899:1999 (C99).

---

fminf

Synopsis

```
#include <math.h>
float fminf(float x, float y);
```

Description

fminf determines the minimum of **x** and **y**.

IEC 60559 math library behavior

fminf(NaN, **y**) is **y**.
fminf(**x**, NaN) is **x**.

Portability

fminf conforms to ISO/IEC 9899:1999 (C99).

fmod

Synopsis

```
#include <math.h>
double fmod(double x, double y);
```

Description

fmod computes the floating-point remainder of **x** divided by **y**. fmod 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**.

Fast math library behavior

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

IEC 60559 math library behavior

fmod(0, **y**) is 0 for **y** not zero.
fmod(Infinity, **y**) is NaN and raises the "invalid" floating-point exception.
fmod(**x**, 0) is NaN and raises the "invalid" floating-point exception.
fmod(x, Infinity) is **x** for **x** not infinite.

Portability

fmod conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

fmodf

Synopsis

```
#include <math.h>
float fmod(float x, float y);
```

Description

fmod computes the floating-point remainder of **x** divided by **y**. fmod 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**.

Fast math library behavior

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

IEC 60559 math library behavior

fmodf(0, **y**) is 0 for **y** not zero.
fmodf(Infinity, **y**) is NaN and raises the "invalid" floating-point exception.
fmodf(**x**, 0) is NaN and raises the "invalid" floating-point exception.
fmodf(x, Infinity) is **x** for **x** not infinite.

Portability

fmodf conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

frexp

Synopsis

```
#include <math.h>
double frexp(double x, int *exp);
```

Description

frexp breaks a floating-point number into a normalized fraction and an integral power of 2.

frexp stores power of two in the **int** object pointed to by **exp** and returns the value **x**, such that **x** has a magnitude in the interval [1/2, 1) or zero, and value equals **x** * 2^**exp**.

If **x** is zero, both parts of the result are zero.

IEC 60559 math library behavior

If **x** is Infinity or NaN, **frexp** returns **x** and stores zero into the int object pointed to by **exp**.

Portability

frexp conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

frexpf

Synopsis

```
#include <math.h>
float frexp(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 **exp** and returns the value **x**, such that **x** has a magnitude in the interval [1/2, 1) or zero, and value equals **x** * 2^**exp**.

If **x** is zero, both parts of the result are zero.

IEC 60559 math library behavior

If **x** is Infinity or NaN, **frexpf** returns **x** and stores zero into the int object pointed to by **exp**.

Portability

frexpf conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

hypot

Synopsis

```
#include <math.h>
double hypot(double x, double y);
```

Description

hypot compute 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..

IEC 60559 math library behavior

If **x** or **y** is +Infinity or -Infinity, **hypot** returns Infinity.
If **x** or **y** is NaN, **hypot** returns NaN.

Portability

hypot conforms to ISO/IEC 9899:1999 (C99).

hypotf

Synopsis

```
#include <math.h>
float hypotf(float x, float y);
```

Description

hypotf compute 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..

IEC 60559 math library behavior

If **x** or **y** is +Infinity or -Infinity, **hypotf** returns Infinity.
If **x** or **y** is NaN, **hypotf** returns NaN.

Portability

hypotf conforms to ISO/IEC 9899:1999 (C99).

isfinite

Synopsis

```
#include <math.h>
int isfinite(floating-type  x);
```

Description

isfinite determines whether **x** is a fiinite 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.

Fast math library behavior

As the fast math library does not support NaN and infinite values, **isfinite** always returns a non-zero value.

Portability

isfinite conforms to ISO/IEC 9899:1999 (C99).

isinf

Synopsis

```
#include <math.h>
int isinf(floating-type  x);
```

Description

isinf determines whether its argument value is an infinity (positive or negative). The determination is based on the type of the argument.

Portability

isinf confirms to ISO/IEC 9899:1999 (C99).

isnan

Synopsis

```
#include <math.h>
int isnan(floating-type  x);
```

Description — **isnan** determines whether its argument value is a NaN. The determination is based on the type of the argument.

Portability — **isnan** confirms to ISO/IEC 9899:1999 (C99).

ldexp

Synopsis

```
#include <math.h>
double ldexp(double x, int exp);
```

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

ldexp returns **x** * 2^**exp**.

Fast math library behavior — If the result overflows, **errno** is set to **ERANGE** and **ldexp** returns **HUGE_VAL**.

IEC 60559 math library behavior — If **x** is Infinity or NaN, **ldexp** returns **x**.
If the result overflows, **ldexp** returns Infinity.

Portability — **ldexp** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

ldexpf

Synopsis

```
#include <math.h>
float ldexpf(float x, int exp);
```

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

ldexpf returns **x** * 2^**exp**.

Fast math library behavior — If the result overflows, **errno** is set to **ERANGE** and **ldexpf** returns **HUGE_VALF**.

IEC 60559 math library behavior — If **x** is Infinity or NaN, **ldexpf** returns **x**.
If the result overflows, **ldexpf** returns Infinity.

Portability — **ldexpf** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

log

Synopsis

```
#include <math.h>
double log(double x);
```

Description — **log** computes the base-*e* logarithm of **x**.

Fast math library behavior — 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**.

IEC 60559 math library behavior

If **x** < 0 or **x** = -Infinity, **log** returns NaN with signal.
If **x** = 0, **log** returns -Infinity with signal.
If **x** = Infinity, **log** returns Infinity.
If **x** = NaN, **log** returns **x** with no signal.

Portability

log conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

log10

Synopsis

```
#include <math.h>
double log10(double x);
```

Description

log10 computes the base-10 logarithm of **x**.

Fast math library behavior

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**.

IEC 60559 math library behavior

If **x** < 0 or **x** = -Infinity, **log10** returns NaN with signal.
If **x** = 0, **log10** returns -Infinity with signal.
If **x** = Infinity, **log10** returns Infinity.
If **x** = NaN, **log10** returns **x** with no signal.

Portability

log10 conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

log10f

Synopsis

```
#include <math.h>
float log10f(float x);
```

Description

log10f computes the base-10 logarithm of **x**.

Fast math library behavior

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**.

IEC 60559 math library behavior

If **x** < 0 or **x** = -Infinity, **log10f** returns NaN with signal.
If **x** = 0, **log10f** returns -Infinity with signal.
If **x** = Infinity, **log10f** returns Infinity.
If **x** = NaN, **log10f** returns **x** with no signal.

Portability

log10f conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

logf

Synopsis

```
#include <math.h>
float logf(float x);
```

Description

logf computes the base-*e* logarithm of **x**.

Fast math library behavior

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**.

IEC 60559 math library behavior

If **x** < 0 or **x** = -Infinity, **logf** returns NaN with signal.
If **x** = 0, **logf** returns -Infinity with signal.
If **x** = Infinity, **logf** returns Infinity.
If **x** = NaN, **logf** returns **x** with no signal.

Portability

logf conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

modf

Synopsis

```
#include <math.h>
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**.

Portability

modf conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

modff

Synopsis

```
#include <math.h>
float modff(float x, double *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**.

Portability

modff conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

pow

Synopsis

```
#include <math.h>
double pow(double x, double y);
```

Description

pow computes **x** raised to the power **y**.

Fast math library behavior

If **x** < 0 and **y** <= 0, **errno** is set to **EDOM** and **pow** returns -**HUGE_VAL**.
If **x** <= 0 and **y** is not an integer value, **errno** is set to **EDOM** and **pow** returns -**HUGE_VAL**.

IEC 60559 math library behavior

If **y** = 0, **pow** returns 1.
If **y** =1, **pow** returns **x**.
If **y** = NaN, **pow** returns NaN.
If **x** = NaN and **y** is anything other than 0, **pow** returns NaN.
If **x** < -1 or 1 < **x**, and **y** = +Infinity, **pow** returns +Infinity.
If **x** < -1 or 1 < **x**, and **y** =-Infinity, **pow** returns 0.
If -1 < **x** < 1 and **y** = +Infinity, **pow** returns +0.
If -1 < **x** < 1 and **y** = -Infinity, **pow** returns +Infinity.
If **x** = +1 or **x** = -1 and **y** = +Infinity or **y** = -Infinity, **pow** returns NaN.
If **x** = +0 and **y** > 0 and **y** <> NaN, **pow** returns +0.
If **x** = -0 and **y** > 0 and **y** <> NaN or **y** not an odd integer, **pow** returns +0.
If **x** = +0 and **y** <0 and **y** <> NaN, **pow** returns +Infinity.
If **x** = -0 and **y** > 0 and **y** <> NaN or **y** not an odd integer, **pow** returns +Infinity.
If **x** = -0 and **y** is an odd integer, **pow** returns -0.
If **x** = +Infinity and **y** > 0 and **y** <> NaN, **pow** returns +Infinity.
If **x** = +Infinity and **y** < 0 and **y** <> NaN, **pow** returns +0.
If **x** = -Infinity, **pow** returns **pow**(-0, **y**)
If **x** < 0 and **x** <> Infinity and **y** is a non-integer, **pow** returns NaN.

Portability

pow conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

---

powf

Synopsis

```
#include <math.h>
float powf(float x, float y);
```

Description

powf computes **x** raised to the power **y**.

Fast math library behavior

If **x** < 0 and **y** <= 0, **errno** (page 264) is set to **EDOM** and **powf** returns -**HUGE_VALF**.
If **x** <= 0 and **y** is not an integer value, **errno** (page 264) is set to **EDOM** and **pow** returns -**HUGE_VALF**.

IEC 60559 math library behavior

If **y** = 0, **powf** returns 1.
If **y** =1, **powf** returns **x**.
If **y** = NaN, **powf** returns NaN.
If **x** = NaN and **y** is anything other than 0, **powf** returns NaN.
If **x** < -1 or 1 < **x**, and **y** = +Infinity, **powf** returns +Infinity.
If **x** < -1 or 1 < **x**, and **y** =-Infinity, **powf** returns 0.
If -1 < **x** < 1 and **y** = +Infinity, **powf** returns +0.
If -1 < **x** < 1 and **y** = -Infinity, **powf** returns +Infinity.
If **x** = +1 or **x** = -1 and **y** = +Infinity or **y** = -Infinity, **powf** returns NaN.
If **x** = +0 and **y** > 0 and **y** <> NaN, **powf** returns +0.
If **x** = -0 and **y** > 0 and **y** <> NaN or **y** not an odd integer, **powf** returns +0.
If **x** = +0 and **y** <0 and **y** <> NaN, **powf** returns +Infinity.
If **x** = -0 and **y** > 0 and **y** <> NaN or **y** not an odd integer, **powf** returns +Infinity.

If **x** = -0 and **y** is an odd integer, **powf** returns -0.
If **x** = +Infinity and **y** > 0 and **y** <> NaN, **powf** returns +Infinity.
If **x** = +Infinity and **y** < 0 and **y** <> NaN, **powf** returns +0.
If **x** = -Infinity, **powf** returns **powf**(-0, **y**)
If **x** < 0 and **x** <> Infinity and **y** is a non-integer, **powf** returns NaN.

Portability

powf conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

scalbn

Synopsis

```
#include <math.h>
double scalbn(double x, int exp);
```

Description

scalbn multiplies a floating-point number by an integral power of **FLT_RADIX**.

As floating-point aritmetic conforms to IEC 60559, **FLT_RADIX** is 2 and **scalbn** is (in this implementation) identical to **ldexp**.

scalbn returns **x** * **FLT_RADIX^exp**.

Fast math library behavior

If the result overflows, **errno** is set to **ERANGE** and **scalbn** returns **HUGE_VAL**.

IEC 60559 math library behavior

If **x** is Infinity or NaN, **scalbn** returns **x**.
If the result overflows, **scalbn** returns Infinity.

Portability

scalbn conforms to ISO/IEC 9899:1999 (C99).

See Also

ldexp (page 286)

scalbnf

Synopsis

```
#include <math.h>
float scalbnf(float x, int exp);
```

Description

scalbnf multiplies a floating-point number by an integral power of **FLT_RADIX**.

As floating-point aritmetic conforms to IEC 60559, **FLT_RADIX** is 2 and **scalbnf** is (in this implementation) identical to **ldexpf**.

scalbnf returns **x** * **FLT_RADIX^exp**.

Fast math library behavior

If the result overflows, **errno** (page 264) is set to **ERANGE** and **scalbnf** returns **HUGE_VALF**.

IEC 60559 math library behavior

If **x** is Infinity or NaN, **scalbnf** returns **x**.
If the result overflows, **scalbnf** returns Infinity.

Portability **scalbnf** conforms to ISO/IEC 9899:1999 (C99).

See Also **ldexpf** (page 286)

sin

Synopsis
```
#include <math.h>
double sin(double x);
```

Description **sin** returns the radian circular sine of **x**.

Fast math library behavior If |**x**| > 10^9, **errno** (page 264) is set to **EDOM** and **sin** returns **HUGE_VAL**.

IEC 60559 math library behavior **sin** returns **x** if **x** is NaN.
sin returns NaN with invalid signal if |**x**| is Infinity.

Portability **sin** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

sinf

Synopsis
```
#include <math.h>
float sinf(float x);
```

Description **sinf** returns the radian circular sine of **x**.

Fast math library special cases If |**x**| > 10^9, **errno** (page 264) is set to **EDOM** and **sin** returns **HUGE_VALF**.

IEC 60559 math library special cases **sinf** returns **x** if **x** is NaN.
sinf returns NaN with invalid signal if |**x**| is Infinity.

Portability **sinf** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

sinh

Synopsis
```
#include <math.h>
double sinh(double x);
```

Description **sinh** calculates the hyperbolic sine of **x**.

Fast math library behavior If |**x**| >~ 709.782, **errno** (page 264) is set to **EDOM** and **sinh** returns **HUGE_VAL**.

IEC 60559 math library behavior If **x** is +Infinity, -Infinity, or NaN, **sinh** returns |**x**|.
If |**x**| >~ 709.782, **sinh** returns +Infinity or -Infinity depending upon the sign of **x**.

Portability **sinh** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

sinhf

Synopsis

```
#include <math.h>
float sinhf(float x);
```

Description **sinhf** calculates the hyperbolic sine of **x**.

Fast math library behavior If |**x**| >~ 88.7228, **errno** (page 264) is set to **EDOM** and **sinhf** returns **HUGE_VALF**.

IEC 60559 math library behavior If **x** is +Infinity, -Infinity, or NaN, **sinhf** returns |**x**|.
If |**x**| >~ 88.7228, **sinhf** returns +Infinity or -Infinity depending upon the sign of **x**.

Portability **sinhf** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

sqrt

Synopsis

```
#include <math.h>
double sqrt(double val);
```

Description **sqrt** computes the nonnegative square root of **val**. 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.

Special cases If **val** is +0, **sqrt** returns +0.
If **val** is -0, **sqrt** returns -0.
If **val** is Infinity, **sqrt** returns Infinity.
If **val** < 0, **sqrt** returns NaN with invalid signal.
If **val** is NaN, **sqrt** returns that NaN with invalid signal for signaling NaN.

Portability **sqrt** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99) except in the case of domain errors.

sqrtf

Synopsis

```
#include <math.h>
float sqrtf(float val);
```

Description **sqrt**f computes the nonnegative square root of **val**. 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.

Special cases

If **val** is +0, **sqrt** returns +0.
If **val** is -0, **sqrt** returns -0.
If **val** is Infinity, **sqrt** returns Infinity.
If **val** < 0, **sqrt** returns NaN with invalid signal.
If **val** is NaN, **sqrt** returns that NaN with invalid signal for signaling NaN.

Portability

sqrtf conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99) except in the case of domain errors.

tan

Synopsis

```
#include <math.h>
double tan(double x);
```

Description

tan returns the radian circular tangent of **x**.

Fast math library behaviour

If |**x**| > 10^9, **errno** (page 264) is set to **EDOM** and **tan** returns **HUGE_VAL**.

IEC 60559 math library behaviour

If **x** is NaN, **tan** returns **x**.
If |**x**| is Infinity, **tan** returns NaN with invalid signal.

Portability

tan conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

tanf

Synopsis

```
#include <math.h>
float tanf(float x);
```

Description

tanf returns the radian circular tangent of **x**.

Fast math library special cases

If |**x**| > 10^9, **errno** is set to **EDOM** and **tanf** returns **HUGE_VALF**.

IEC 60559 math library special cases

If **x** is NaN, **tanf** returns **x**.
If |**x**| is Infinity, **tanf** returns NaN with invalid signal.

Portability

tanf conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

tanh

Synopsis

```
#include <math.h>
double tanh(double x);
```

Description

tanh calculates the hyperbolic tangent of **x**.

IEC 60559 math library behavior

If **x** is NaN, **tanh** returns NaN.

Portability — **tanh** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

tanhf

Synopsis

```
#include <math.h>
float tanhf(float x);
```

Description — **tanhf** calculates the hyperbolic tangent of **x**.

IEC 60559 math library behavior — If **x** is NaN, **tanhf** returns NaN.

Portability — **tanhf** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

<setjmp.h> - Non-local jumps

The header file **<setjmp.h>** defines macros and functions for non-local flow of control, commonly used to implement exception handling in a C program.

Types

jmp_buf	Structure to hold processor state

Functions

longjmp	Non-local jump to saved state
setjmp	Save state for non-local jump

jmp_buf

Synopsis

```
#include <setjmp.h>
typedef  implementation-defined-type  jmp_buf[];
```

Description — The type **jmp_buf** is an array type suitable for holding the information needed to restore a calling environment. The environment of 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. It does not include the state of the floating-point status flags, of open files, or of any other component of the machine.

Portability — **jmp_buf** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See also — **longjmp** (page 295), **setjmp** (page 295)

longjmp

Synopsis

```
#include <setjmp.h>
void longjmp(jmp_buf env, int val);
```

Description

longjmp restores the environment saved by the most recent invocation of **setjmp** with the corresponding **jmp_buf** 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 iof **longjmp** undefined.

When the environment is restored, all accessible objects have values have state as of the time the **longjmp** function was called.

After **longjmp** is completed, program execution continues as if the corresponding invocation of **setjmp** had just returned the value specified by **val**. Note that **longjmp** cannot cause **setjmp** to return the value 0; if **val** is 0, **setjmp** returns the value 1.

Important notes

Objects of automatic storage duration 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 **longjmp** call are indeterminate.

Portability

longjmp conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See also

setjmp (page 295)

setjmp

Synopsis

```
#include <setjmp.h>
int setjmp(jmp_buf env);
```

Description

setjmp saves its calling environment in the **jmp_buf** argument **env** for later use by the **longjmp** function.

On return is from a direct invocation, **setjmp** returns the value zero. If the return is from a call to the **longjmp** function, the **setjmp** macro returns a nonzero value determined by the call to **longjmp**.

The ISO standard does not specify whether **setjmp** is a macro or an identifier declared with external linkage. If a macro definition is suppressed in order to access an actual function, or a program defines an external identifier with the name **setjmp**, the behavior of **setjmp** is undefined.

Portability

setjmp conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See also

longjmp (page 295)

<stdarg.h> - Variable arguments

The header file **<stdarg.h>** defines a number of macros to access variable parameter lists.

Functions

va_end	Start access to variable arguments
va_arg	Get variable argument value
va_end	Finish access to variable arguments
va_copy	Copy **va_arg** structure

va_arg

Synopsis

```
#include <stdarg.h>
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.

Examples

When calling **va_arg**, you must ensure that **type** is the *promoted type* of the argument, not the argument type. The following will not work as you expect:

```
char x = va_arg(ap, char);
```

Because characters are promoted to integers, the above must be written:

```
char ch = (char)va_arg(ap, int);
```

Portability **va_arg** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See also **va_copy** (page 297), **va_end** (page 297), **va_end** (page 297)

va_copy

Synopsis

```
#include <stdarg.h>
void va_copy(va_list dest, va_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**.

Portability **va_copy** conforms to ISO/IEC 9899:1999 (C99).

See also **va_arg** (page 296), **va_end** (page 297), **va_end** (page 297)

va_end

Synopsis

```
#include <stdarg.h>
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.

Portability **va_end** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See also **va_arg** (page 296), **va_copy** (page 297), **va_end** (page 297)

va_end

Synopsis

```
#include <stdarg.h>
void va_start(va_list ap,  parmN);
```

Description **va_start** initializes **ap** for subsequent use by the **va_arg** and **va_end** macros.

The parameter **parmN** 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 **parmN** 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 be invoked to reinitialize **ap** without an intervening invocation of the **va_end** macro for the same **ap**.

Portability

va_start conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See also

va_arg (page 296), **va_copy** (page 297), **va_end** (page 297)

<stdio.h> - Input/output functions

The header file **<stdio.h>** defines a number of functions to format and output values. The format-control directives that for the formatted input and output function are described in **Formatted input control strings** (page 304) and **Formatted output control strings** (page 299).

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 input functions

scanf	Read formatted text from standard input
sscanf	Read formatted text from a string
vscanf	Read formatted text from standard input using a **va_list** argument
vsscanf	Read formatted text from a string using a **va_list** argument

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 a **va_list** argument
vsnprintf	Write formatted text to a string with truncation using a **va_list** argument
vsprintf	Write formatted text to a string using a **va_list** argument

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.

Overview

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 [-]*dddd*. 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.ddd*e*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 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 conjuction with the '`c`' and '`s`' conversion specifiers is not supported and nor are the conversion specifiers '`a`' and '`A`'.

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.

Overview

Each conversion specification is introduced by the character '**%**'. After the '**%**', the following appear in sequence:

- An optional assignment-suppressing character '*****'.
- An optional nonzero decimal integer that specifies the maximum field width (in characters).
- An optional length modifier that specifies the size of the receiving object.
- A conversion specifier character that specifies the type of conversion to be applied.

The formatted input function executes each directive of the format in turn. If a directive fails, the function returns. Failures are described as input failures (because of the occurrence of an encoding error or the unavailability of input characters), or matching failures (because of inappropriate input).

A directive composed of white-space character(s) is executed by reading input up to the first non-white-space character (which remains unread), or until no more characters can be read.

A directive that is an ordinary character is executed by reading the next characters of the stream. If any of those characters differ from the ones composing the directive, the directive fails and the differing and subsequent characters remain unread. Similarly, if end-of-file, an encoding error, or a read error prevents a character from being read, the directive fails.

A directive that is a conversion specification defines a set of matching input sequences, as described below for each specifier. A conversion specification is executed in the following steps:

- Input white-space characters (as specified by the **isspace** function) are skipped, unless the specification includes a '**[**', '**c**', or '**n**' specifier.
- An input item is read from the stream, unless the specification includes an n specifier. An input item is defined as the longest sequence of input characters which does not exceed any specified field width and which is, or is a prefix of, a matching input sequence. The first character, if any, after the input item remains unread. If the length of the input item is zero, the execution of the directive fails; this condition is a matching failure unless

end-of-file, an encoding error, or a read error prevented input from the stream, in which case it is an input failure.

- Except in the case of a '**%**' specifier, the input item (or, in the case of a %n directive, the count of input characters) is converted to a type appropriate to the conversion specifier. If the input item is not a matching sequence, the execution of the directive fails: this condition is a matching failure. Unless assignment suppression was indicated by a '*****', the result of the conversion is placed in the object pointed to by the first argument following the format argument that has not already received a conversion result. If this object does not have an appropriate type, or if the result of the conversion cannot be represented in the object, the behavior is undefined.

Length modifiers

The length modifiers and their meanings are:

- **'hh'.** Specifies that a following '**d**', '**i**', '**o**', '**u**', '**x**', '**X**', or '**n**' conversion specifier applies to an argument with type pointer to **signed char** or pointer to **unsigned char**.
- **'h'.** Specifies that a following '**d**', '**i**', '**o**', '**u**', '**x**', '**X**', or '**n**' conversion specifier applies to an argument with type pointer to **short int** or **unsigned short int**.
- **'l'.** Specifies that a following '**d**', '**i**', '**o**', '**u**', '**x**', '**X**', or '**n**' conversion specifier applies to an argument with type pointer to **long int** or **unsigned long int**; that a following '**e**', '**E**', '**f**', '**F**', '**g**', or '**G**' conversion specifier applies to an argument with type pointer to **double**. Some 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 conjuction with the '**c**', '**s**', and '**[**' conversion specifiers is not supported and nor are the conversion specifiers '**a**' and '**A**'.

getchar

Synopsis

```
#include <stdio.h>
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, **getc** returns **EOF**.

Portability

getchar conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

gets

Synopsis

```
#include <stdio.h>
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.

Portability

gets conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See also

getchar (page 307)

printf

Synopsis

```
#include <stdio.h>
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 number of characters transmitted, or a negative value if an output or encoding error occurred.

Portability

printf conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See Also

Formatted output control strings (page 299)

putchar

Synopsis

```
#include <stdio.h>
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**.

Portability **putchar** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See also Customizing putchar, **puts** (page 309)

puts

Synopsis

```
#include <stdio.h>
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.

Portability **puts** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See also **putchar** (page 308)

scanf

Synopsis

```
#include <stdio.h>
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.

Portability **scanf** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See Also **Formatted input control strings** (page 304)

snprintf

Synopsis

```
#include <stdio.h>
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**.

Portability

snprintf conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See Also

Formatted output control strings (page 299)

sprintf

Synopsis

```
#include <stdio.h>
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.

Portability **sprintf** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See Also **Formatted output control strings** (page 299)

sscanf

Synopsis

```
#include <stdio.h>
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.

Portability **sscanf** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See Also **Formatted input control strings** (page 304)

vprintf

Synopsis

```
#include <stdio.h>
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 number of characters transmitted, or a negative value if an output or encoding error occurred.

Notes **vprintf** is equivalent to **printf** with the variable argument list replaced by **arg**.

Portability **vprintf** conforms to ISO/IEC 9899:1999 (C99).

See Also **Formatted output control strings** (page 299)

vscanf

Synopsis

```
#include <stdio.h>
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.

Notes

vscanf is equivalent to **scanf** with the variable argument list replaced by **arg**.

Portability

vscanf conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See Also

Formatted input control strings (page 304)

vsnprintf

Synopsis

```
#include <stdio.h>
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**.

Notes — **vsnprintf** is equivalent to **snprintf** with the variable argument list replaced by **arg**.

Portability — **vsnprintf** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See Also — **Formatted output control strings** (page 299)

vsprintf

Synopsis

```
#include <stdio.h>
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.

Notes — **vsprintf** is equivalent to **sprintf** with the variable argument list replaced by **arg**,

Portability — **vsprintf** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See Also — **Formatted output control strings** (page 299)

vsscanf

Synopsis

```
#include <stdio.h>
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.

Notes

vsscanf is equivalent to **sscanf** with the variable argument list replaced by **arg**.

Portability

vsscanf conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See Also

Formatted input control strings (page 304)

<stdlib.h> - General utilities

The header file **<stdlib.h>** defines a number of types, macros, and functions of general utility.

Types

div_t	Structure containing quotient and remainder after division of **int**s
ldiv_t	Structure containing quotient and remainder after division of **long**s
lldiv_t	Structure containing quotient and remainder after division of **long long**s

String to number conversions

atoi	Convert string to **int**
atol	Convert string to **long**
atoll	Convert string to **long long**
strtol	Convert string to **long**
strtoll	Convert string to **long long**
strtoul	Convert string to **unsigned long**

strtoull	Convert string to **unsigned long long**

Number to string conversions

itoa	Convert **int** to string
ltoa	Convert **long** to string
lltoa	Convert **long long** to string
utoa	Convert **unsigned** to string
ultoa	Convert **unsigned long** to string
ultoa	Convert **unsigned long long** to string

Integer arithmetic functions

div	Divide two **int**s returning quotient and remainder
ldiv	Divide two **long**s returning quotient and remainder
lldiv	Divide two **long long**s returning quotient and remainder

Pseudo-random sequence generation functions

RAND_MAX	Maximum value returned by **rand**
rand	Return next random number in sequence
srand	Set seed of random number sequence

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

atof

Synopsis

```
#include <stdlib.h>
int atof(const char *nptr);
```

Description

atof converts the initial portion of the string pointed to by **nptr** to an **int** 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)`.

atoi returns the converted value.

Portability

atoi conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See Also

strtol (page 322)

atoi

Synopsis

```
#include <stdlib.h>
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.

Portability

atoi conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See Also

strtol (page 324)

atol

Synopsis

```
#include <stdlib.h>
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.

Portability

atol conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See Also

strtol (page 324)

atoll

Synopsis

```
#include <stdlib.h>
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.

Portability

atoll conforms to ISO/IEC 9899:1999 (C99).

See Also

strtoll (page 325)

calloc

Synopsis

```
#include <stdlib.h>
void *calloc(size_t nmemb, 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.

Portability

calloc conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

div

Synopsis

```
#include <stdlib.h>
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** (page 318) 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.

Portability

div conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See also **div_t** (page 318)

div_t

Synopsis

```
#include <stdlib.h>
typedef struct {
  int quot;
  int rem;
} div_t;
```

Description **div_t** stores the quotient and remainder returned by **div** (page 317).

Portability **div_t** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See also **div** (page 317)

free

Synopsis

```
#include <stdlib.h>
void free(void *ptr);
```

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.

Notes 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 behaviour is undefined.

Portability **free** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

itoa

Synopsis

```
#include <stdlib.h>
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.

Portability **itoa** is an extension to the standard C library provided by *CrossWorks C*.

See Also **ltoa** (page 320), **lltoa** (page 320), **ultoa** (page 329), **ultoa** (page 329), **utoa** (page 330)

ldiv

Synopsis

```
#include <stdlib.h>
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** (page 319) 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.

Portability

ldiv conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See also

ldiv_t (page 319)

ldiv_t

Synopsis

```
#include <stdlib.h>
typedef struct
{
  long int quot;
  long int rem;
} ldiv_t;
```

Description

ldiv_t stores the quotient and remainder returned by **ldiv** (page 319).

Portability

ldiv_t conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See also

ldiv (page 319)

lldiv

Synopsis

```
#include <stdlib.h>
lldiv_t lldiv(long long int numer, long long int denom);
```

Description

lldiv computes **numer** / **denom** and **numer** % **denom** in a single operation.

lldiv returns a structure of type **lldiv_t** (page 320) 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.

Portability

lldiv conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See also **lldiv_t** (page 320)

lldiv_t

Synopsis

```
#include <stdlib.h>
typedef struct
{
  long long int quot;
  long long int rem;
} lldiv_t;
```

Description **lldiv_t** stores the quotient and remainder returned by **lldiv** (page 319).

Portability **lldiv_t** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See also **lldiv** (page 319)

lltoa

Synopsis

```
#include <stdlib.h>
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.

Portability **lltoa** is an extension to the standard C library provided by *CrossWorks C*.

See Also **itoa** (page 318) **ltoa** (page 320) **ultoa** (page 329) **ultoa** (page 329) **utoa** (page 330)

ltoa

Synopsis

```
#include <stdlib.h>
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.

Portability

ltoa is an extension to the standard C library provided by *CrossWorks C*.

See Also

itoa (page 318) **lltoa** (page 320) **ultoa** (page 329) **ultoa** (page 329) **utoa** (page 330)

malloc

Synopsis

```
#include <stdlib.h>
void *malloc(size_t size);
```

Description

malloc allocates space for an object whose size is specified by **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.

Portability

malloc conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

rand

Synopsis

```
#include <stdlib.h>
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.

Portability

rand conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See Also

srand (page 322) **RAND_MAX** (page 321)

RAND_MAX

Synopsis

```
#include <stdlib.h>
#define RAND_MAX 32767
```

Description

RAND_MAX expands to an integer constant expression that is the maximum value returned by **rand**.

Portability

RAND_MAX conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See Also

rand (page 321) **srand** (page 322)

realloc

Synopsis

```
#include <stdlib.h>
void *realloc(void *ptr, 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 function 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.

Notes

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 behaviour is undefined.

Portability

realloc conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

srand

Synopsis

```
#include <stdlib.h>
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.

Portability

srand conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See Also

rand (page 321) **RAND_MAX** (page 321)

strtol

Synopsis

```
#include <stdlib.h>
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** (page 263)), a subject sequence resembling a floating-point constant, and a final string of one or more unrecognized characters, including the terminating null character of the input string. **strtod** then attempts to convert the subject sequence to a floating-point number, and return the result.

The subject sequence is defined as the longest initial subsequence of the input string, starting with the first non-white-space character, that is of the expected form. The subject sequence contains no characters if the input string is empty or consists entirely of white space, or if the first non-white-space character is other than a sign or a permissible letter or digit.

The expected form of the subject sequence is an optional plus or minus sign followed by a nonempty sequence of decimal digits optionally containing a decimal-point character, then an optional exponent part.

If the subject sequence begins with a minus sign, the value resulting from the conversion is negated.

A pointer to the final string is stored in the object pointed to by **endptr**, provided that **endptr** is not a null pointer.

If the subject sequence is empty or does not have the expected form, no conversion is performed, the value of **nptr** is stored in the object pointed to by **endptr**, provided that **endptr** is not a null pointer.

strtod returns the converted value, if any. If no conversion could be performed, zero is returned. If the correct value is outside the range of representable values, **HUGE_VAL** is returned according to the sign of the value, if any, and the value of the macro **errno** (page 264) is stored in **errno** (page 264).

Portability

strtod conforms to ISO/IEC 9899:1990 (C90).

strtof

Synopsis

```
#include <stdlib.h>
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** (page 263)), 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** (page 264) is stored in **errno** (page 264).

Portability

strtof conforms to ISO/IEC 9899:1990 (C90).

strtol

Synopsis

```
#include <stdlib.h>
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** (page 263)), 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** (page 268) or **LONG_MAX** (page 268) is returned according to the sign of the value, if any, and the value of the macro **errno** (page 264) is stored in **errno** (page 264).

Portability

strtol conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

strtoll

Synopsis

```
#include <stdlib.h>
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** (page 263)), 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** (page 267) or **LLONG_MAX** (page 267) is returned according to the sign of the value, if any, and the value of the macro **ERANGE** is stored in **errno** (page 264).

Portability

strtoll conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

strtoul

Synopsis

```
#include <stdlib.h>
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** (page 263)), 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** (page 268) or **ULONG_MAX** (page 270) is returned according to the sign of the value, if any, and the value of the macro **ERANGE** is stored in **errno** (page 264).

Portability **strtoul** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

strtoull

Synopsis

```
#include <stdlib.h>
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** (page 263)), 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** (page 267) or **ULLONG_MAX** (page 269) is returned according to the sign of the value, if any, and the value of the macro **ERANGE** is stored in **errno** (page 264).

Portability

strtoull conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

ultoa

Synopsis

```
#include <stdlib.h>
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.

Portability

ulltoa is an extension to the standard C library provided by *CrossWorks C*.

See Also

itoa (page 318) **ltoa** (page 320) **lltoa** (page 320) **ultoa** (page 329) **utoa** (page 330)

ultoa

Synopsis

```
#include <stdlib.h>
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.

Portability

ultoa is an extension to the standard C library provided by *CrossWorks C*.

See Also **itoa** (page 318) **ltoa** (page 320) **lltoa** (page 320) **ultoa** (page 329) **utoa** (page 330)

utoa

Synopsis

```
#include <stdlib.h>
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.

Portability

utoa is an extension to the standard C library provided by *CrossWorks C*.

See Also **itoa** (page 318) **ltoa** (page 320) **lltoa** (page 320) **ultoa** (page 329) **ultoa** (page 329)

<string.h> - String handling

The header file **<string.h>** defines functions that operate on arrays that are interpreted as null-terminated strings.

Various methods are used for determining the lengths of the arrays, but in all cases a **char *** or **void *** argument points to the initial (lowest addressed) character of the array. If an array is accessed beyond the end of an object, the behavior is undefined.

Where an argument declared as **size_t n** specifies the length of an array for a function, **n** can have the value zero on a call to that function. Unless explicitly stated otherwise in the description of a particular function, pointer arguments must have valid values on a call with a zero size. On such a call, a function that locates a character finds no occurrence, a function that compares two character sequences returns zero, and a function that copies characters copies zero characters.

Copying functions

memcpy	Copy memory
memmove	Safely copy overlapping memory
strcpy	Copy string
strncpy	Copy string up to a maximum length

Concatenation functions

strcat	Convert string to **int**
strncat	Convert string to **long**

Comparison functions

memcmp	Compare memory
strcmp	Compare strings
strncmp	Compare strings up to a maximum length
strcoll	Collate strings

Search functions

memchr	Search memory for a character
strchr	Find first occurrence of character within string
strcspn	Compute size of string not prefixed by a set of characters
strpbrk	Find first occurrence of characters within string
strrchr	Find last occurrence of character within string
strspn	Compute size of string prefixed by a set of characters
strstr	Find first occurrence of a string within a string
strtok	Break string into tokens

Miscellaneous functions

memset	Set memory to character
strerror	Return string from error code
strlen	Calculate length of string

memchr

Synopsis

```
#include <string.h>
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.

Portability **memchr** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See also **strchr** (page 333)

memcmp

Synopsis

```
#include <string.h>
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**.

Portability **memcmp** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

memcpy

Synopsis

```
#include <string.h>
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 behaviour of **memcpy** is undefined if copying takes place between objects that overlap.

memcpy returns the value of **s1**.

Portability **memcpy** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

memmove

Synopsis

```
#include <string.h>
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**.

Portability

memmove conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

memset

Synopsis

```
#include <string.h>
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**.

Portability

memset conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

strcat

Synopsis

```
#include <string.h>
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 behaviour of **strcat** is undefined if copying takes place between objects that overlap.

strcat returns the value of **s1**.

Portability

strcat conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

strchr

Synopsis

```
#include <string.h>
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.

Portability

strchr conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See also

memchr (page 331)

strcmp

Synopsis

```
#include <string.h>
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**.

Portability

strcmp conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

strcoll

Synopsis

```
#include <string.h>
int strcoll(const char *s1, const char *s2);
```

Description

strcoll compares the string pointed to by **s1** to the string pointed to by **s2**. **strcoll** 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**.

strcoll is not affected by the locale as *CrossWorks C* provides no locale capability.

Portability

strcoll is provided for compaibility only and is not required in a freestanding implementation according to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

strcpy

Synopsis

```
#include <string.h>
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 behaviour of **strcpy** is undefined if copying takes place between objects that overlap.

strcpy returns the value of **s1**.

Portability

strcpy conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

strcspn

Synopsis

```
#include <string.h>
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.

Portability

strcspn conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

strerror

Synopsis

```
#include <string.h>
char *strerror(int errnum);
```

Description

strerror maps the number in **errnum** to a message string. Typically, the values for **errnum** 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**.

Portability

strerror conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

strlen

Synopsis

```
#include <string.h>
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.

Portability

strlen conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

strncat

Synopsis

```
#include <string.h>
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 behaviour of **strncat** is undefined if copying takes place between objects that overlap.

strncat returns the value of **s1**.

Portability

strncat conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

strncmp

Synopsis

```
#include <string.h>
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**.

Portability

strncmp conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

strncpy

Synopsis

```
#include <string.h>
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 **s1** are not copied. The behaviour 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**.

Portability

strncpy conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

strpbrk

Synopsis

```
#include <string.h>
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**.

Portability **strpbrk** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

strrchr

Synopsis

```
#include <string.h>
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.

Portability **strrchr** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

See also **strchr** (page 333)

strspn

Synopsis

```
#include <string.h>
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.

Portability **strspn** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

strstr

Synopsis

```
#include <string.h>
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**.

Portability **strstr** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

strtok

Synopsis

```
#include <string.h>
char *strtok(char *s1, const char *s2);
```

Description 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.

Portability **strtok** conforms to ISO/IEC 9899:1990 (C90) and ISO/IEC 9899:1999 (C99).

CrossBuild

The command line program **crossbuild** enables your software to be built without using **CrossStudio**. This tool can be used for production build purposes but isn't designed to be used for development. The tool works from a crossstudio project file (.hzp) and options that specify what is to be built.

```
crossbuild [options] project.hzp
```

You must specify a configuration to build in using the **-config** option.

```
crossbuild -config "V5T THUMB LE Release" arm.hzp
```

This example will build all projects in the solution contained in **arm.hzp** in the configuration **"V5T THUMB LE Release"**.

If you want to build a specific project in the solution then you can specify it using the **-project** option.

```
crossbuild -config "V5T THUMB LE Release" -project "libm" libc.hzp
```

This example will build the project **libm** contained in **libc.hzp** in the configuration **"V5T THUMB LE Release"**.

If your project file imports other project files (using the <import..> mechanism) then denoting projects requires you to specify the solution names as a comma seperated list in brackets after the project name.

```
crossbuild -config "V5T THUMB LE Release" -project "libc(C Library)"
arm.hzp
```

With this example **libc(C Library)** specifies the **libc** project in the **C Library** solution that has been imported by the project file **arm.hzp**.

If you want 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 seperated list.

```
crossbuild -config "ARM Debug" -solution "ARM Targets,EB55" arm.hzp
```

With this example **ARM Targets,EB55** specifies the **EB55** solution imported by the **ARM Targets** solution which in turn was imported by the project file **arm.hzp**.

You can do a batch build using the **-batch** option.

```
crossbuild -config "ARM Debug" -batch libc.hzp
```

With this example the projects in **libc.hzp** which are marked to batch build in the configuration **"ARM Debug"** will be built.

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 file is up to date. You can force a complete build by using the **-rebuild** option. Alternatively you can remove all output files using the **-clean** option.

You can see the commands that are being used in the build if you use the **-echo** option and you can also see why commands are being executed using the **-verbose** option. You can see what commands will be executed without executing them using the **-show** option.

CrossBuild Options	
-batch	Do a batch build.
-config 'name'	Specify the configuration to build in. If the 'name' configuration can’t be found crossbuild will list the set of configurations that are available.
-clean	Remove all the output files of the build process.
-D macro=value	Define a macro value for the build process.
-echo	Show the command lines as they are executed.
-project 'name'	Specify the name of the project to build. If crossbuild can’t find the specified project then a list of project names is shown.
-rebuild	Always execute the build commands.
-show	Show the command lines but don’t execute them.

CrossBuild Options	
-solution 'name'	Specify the name of the solution to build. If crossbuild can’t find the specified solution then a list of solution names is shown.
-verbose	Show build information.

CrossLoad

CrossLoad is a command line program that allows you to download and verify applications without using **CrossStudio**. This tool can be used for production purposes but is not designed to be used for development.

Usage	
crossload [options] [files...]	
Options	
-target*target*	Specify the target interface to use. Use the **-listtargets** option to display the list of supported target interfaces.
-listtargets	List all of the supported target interfaces.
-solution*file*	Specify the CrossWorks solution file to use.
-project*name*	Specify the name of the project to use.
-config*configuration*	Specify the build configuration to use.
-filetype*filetype*	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. Use the **-listfiletypes** option to display the list of supported file types.

Usage	
-listfiletypes	List all of the supported file types.
-setprop*property***=***value*	Set the target property *property* to *value*.
-listprops	List the target properties of the target specified by the **-target** option.
-noverify	Do not carry out verification of download.
-nodownload	Do not carry out download, just verify.
-nodisconnect	Do not disconnect the target interface when finished.
-help	Display the command line options.
-verbose	Produce verbose output.
-quiet	Do not output any progress messages.

In order to carry out a download or verify **CrossLoad** needs to know what target interface to use. The supported target interfaces vary between systems, to produce a list of the currently supported target interfaces use the *-listtargets* option.

crossload -listtargets

This command will produce a list of target interface names and descriptions:

```
usb                 USB CrossConnect
parport             Parallel Port Interface
sim                 Simulator
```

Use the *-target* option followed by the target interface name to specify which target interface to use:

crossload -target usb ...

CrossLoad is normally used to download and/or verify projects created and built with **CrossStudio**. To do this you need to 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 USBCrossConnect:

crossload -target usb -solution MySolution.hzp -project MyProject -config Debug

In some cases it is useful to download a program that might not have been created using **CrossStudio** using the settings from an existing **CrossStudio** project. You might want to do this if your existing project describes specific loaders or scripts that are required in order to download the application. To do this you simply need to add the name of the file you want to download to the command line. For example the following command line will download the HEX file *ExternalApp.hex* using the release settings of the project *MyProject* using a USB CrossConnect:

crossload -target usb -solution MySolution.hzp -project MyProject -config Release ExternalApp.hex

CrossLoad is able to download and verify a range of file types. The supported file types vary between systems, to display a list of the file types supported by **CrossLoad** use the *-listfiletypes* option:

crossload -listfiletypes

This command will produce a list of the supported file types, for example:

```
  hzx                   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 carry out a download without the need to specify a **CrossStudio** project. In this case all you need to specify is the target interface and the load file. For example the following command line will download **myapp.s19** using a USB CrossConnect:

crossload -target usb myapp.s19

Each target interface has a range of configurable properties that allow you to customize the default behaviour. To produce a list of the target properties and their current value use the **-listprops** option:

crossload -target parport -listprops

This command will produce a list of the *parport* target interfaces properties, a description of what the properties are and their current value:

```
  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" ...

Appendicies

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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.
- From the **Help** menu, click **About CrossStudio**.
- Click the **Product Activation** tab.
- Using e-mail, send the contents of the **Registration Key** field 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.
- From the **Help** menu, click **About CrossStudio**.
- Click the **Product Activation** tab.
- Type in or paste the returned activation key into the **Activation Key** field.

- The **License Details** field will change to indicate the type of activation key entered and how long the evaluation lasts for.

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, follow these instructions:

- If you have not already done so, install CrossWorks on your computer using the CrossWorks installer and accept the license agreement.
- Run the **CrossStudio** application.
- From the **Help** menu, click **About CrossStudio**.
- Click the **Product Activation** tab.
- Type or paste your product key into the **Product Key** field.
- Using e-mail, send the contents of the **Registration Key** field to the e-mail address **license@rowley.co.uk**.

By return you will receive an **activation key**. To activate CrossWorks:

- Run the **CrossStudio** application.
- From the **Help** menu, click **About CrossStudio**.
- Click the **Product Activation** tab.
- Type in or paste the returned activation key into the **Activation Key** field.
- The **License Details** field will change to indicate the type of activation key entered.

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.

Project file format

CrossStudio project files are held in text files with the .hzp extension. We anticipate that you may want to edit project files and perhaps generate them so they are structured using XML syntax to enable simple construction and parsing.

The first entry of the project file defines the XML document type which is 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 name of solution displayed in the project explorer and also has a version attribute which defines the file format version of the project file. Solutions can contain projects, projects can contain folder and /files, and folders can contain folder 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, names of folder elements must be unique to the project however names of files do not need to 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 you cannot have file paths containing the $ character. For example

```
<file file_name="$(StudioDir)/source/crt0.s" Name="crt0.s" />
```

will be expanded using the value of the $(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 (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 link projects together using the import element.

```
<import file_name="target/libc.hzp" />
```

Project Templates file format

The CrossStudio New Project Dialog works from a file called `project_templates.xml` which is held in the `targets` subdirectory of the CrossStudio installation directory. We anticipate that you may want to add your own new project types so they are structured using XML syntax to enable simple construction and parsing.

The first entry of the project file defines the XML document type which is 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 project entry has a project element that contains the class of the project (attribute `caption`), the name of the project (attribute `name`), it's type (attribute `type`) and a description (attribute `description`).

```
<project caption="ARM Evaluator7T" name="Executable" description=An
executable for an ARM Evaluator7T." type="Executable"/>
```

The project type can be one of

- "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 that are to be created for the project are defined using the `configuration`element. The configuration element 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 then you can specify this using the `value` attribute and optionally set the property in a defined `configuration`.

```
<property name="target_reset_script" configuration="RAM"
value="Evaluator7T_ResetWithRamAtZero()"/>
```

Alternatively you can include a property that will be shown to the user who can 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.

```
<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 **Project macros** (page 59) to specify files that are in the CrossStudio installation directory. Files will be copied to the project directory or just left as references based 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 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.

```
<configuration name="Debug">
  <property name="build_debug_information" value="Yes">
```

Project property reference

Assembler and Compiler Properties

These properties are applicable to C and assembly code source files.

Property	Description
Additional Assembler Options	Additional command line options to be supplied to the assembler.
Additional Compiler Options	Additional command line options to be supplied to the compiler.
ARM Architecture	Specifies the versions of the ARM or THUMB instruction set to generate code for and the library variant the linker should use. The options are **v3**, **v4T**, **v5T**, **v5TE**.
ARM Floating Point Format	Specifies the ARM floating point format. This value is currently only used by the debugger to describe how to display floating point values, it does not affect code generation.
ARM/THUMB interworking	Specifies that the code generated can be called either from ARM or THUMB code and the library variant the linker should use.
Endian	Specifies the endianness to build for. Note that the value of this property at project level will be used to automatically set the **Endian** target property when a project is downloaded or attached to.

Property	Description
Enforce ANSI Checking	Enable additional checking to ensure programs conform to the ANSI-C99 standard.
Instruction Set	Specifies the instruction set the compiler should generate code for. The options are **ARM** or **THUMB**.
Long Calls	Specifies whether function calls are made using absolute addresses.
Object File Name	Specifies the name of the object file produced by the compiler/assembler. This property will have macro expansion applied to it.
Optimization Level	Specifies the optimization level to use for compliation.

External Build Properties

These properties are applicable to **Externally Built Executable** project types.

Property	Description
Build Command	The command line that will build the executable.
Clean Command	The command line that will clean the executable.
Executable File	The name of the externally built executable file. This property will have macro expansion applied to it.
Load Address	The address to load the file at. This is required if the load address isn't contained in the executable file - for example a binary file.
Load File Type	The type of the executable file. The default is to detect the file type based on the file extension.

Folder Properties

These properties are applicable to project folders.

Property	Description
Filter	A list of file extensions that are matched when a file is added to the project.

Build Properties

These properties are applicable to a range of project types.

Property	Description
Build Quietly	Suppress the display of the startup banners and information messages.
Enable Unused Symbol Removal	If this option is set then any unreferenced symbols will be removed from your program.
Exclude From Build	Specifies whether or not to exclude the project/file from the build.
File Type	Use this property to change the file type of the selected file. This can be used to be able to compile or assemble a file that has no recognised file type.
Include Debug Information	Specifies whether symbolic debug information is generated.
Macros	Defines macro values that are used for filename generation
Intermediate Directory	Specifies a relative path from the project directory to the intermediate file directory. This property will have macro expansion applied to it.
Optimize Output	Specifies whether the application should be optimized for size and speed.
Output Directory	Specifies a relative path from the project directory to the output file directory. This property will have macro expansion applied to it.

Property	Description
Project Directory	Specifies the project directory. This can be either relative to the solution directory (recommended) or can be an absolute directory.
Project Type	Specifies the type of project to build.
Suppress Warnings	Specifies whether the display of warning messages should be suppressed.
Target Processor	Select a set of target specific options based on the target processor.
Treat Warnings as Errors	Specifies whether warning messages should be treated as errors.

Preprocessor Options

These properties are applicable to C and assembly code source files.

Property	Description
Ignore Includes	If set to **Yes**, the **System Include Directories** and **User Include Directories** properties are ignored.
Preprocessor Definitions	Specifies one or more preprocessor definitions.
Preprocessor Undefinitions	Specifies one or more preprocessor undefinitions.
System Include Directories	Specifies the system include path. This property will have macro expansion applied to it.
Undefine All Preprocessor Definitions	If set to **Yes**, no standard preprocessor definitions will be defined.
User Include Directories	Specifies the user include path. This property will have macro expansion applied to it.

Section Properties

These properties are applicable to C and assembly code source files.

Property	Description
Code Section Name	Specifies the default section name to use for the program code section.
Constant Section Name	Specifies the default section name to use for the read-only constant section.
Data Section Name	Specifies the default section name to use for the initialised, writable data section.
Zeroed Section Name	Specifies the default section name to use for the zero-initialised, writable data section.

Input/Output Properties

These properties define what the printf/scanf support is to be used.

Property	Description
Floating Point I/O Supported	Specifies whether the version of the printf and scanf functions that support floating point numbers should be linked into the application.
Integer I/O Support	Specifies the largest integer type supported by the printf and scanf function group.
Scanf Classes Supported	Enables support for %[...] and %[^...] character class matching in the scanf functions.

Staging Properties

These properties are applicable to **Staging** project types.

Property	Description
Output File Path	Specifies the name the file will be copied to. This property will have macro expansion applied to it.

Property	Description
Set Readonly	Specifies that the output file will have it's permissions set to readonly.
Stage Command	Specifies the command be used to do the staging operation. This property will have macro expansion applied to it.

Combining Properties

These properties are applicable to **Combining** project types.

Property	Description
Output File Path	Specifies the name the file will be copied to. This property will have macro expansion applied to it.
Set Readonly	Specifies that the output file will have it's permissions set to readonly.
Combine Command	Specifies the command be used to do the combining operation. This property will have macro expansion applied to it.

Library Properties

These properties are applicable to **Library** project types.

Property	Description
Library File Name	Specifies the name of the output file produced by the librarian. This property will have macro expansion applied to it.

Linker Properties

These properties are applicable to **Executable** project types.

Property	Description
Additional Input Files	Additional object and library files to be supplied to the linker. This property will have macro expansion applied to it.
Additional Linker Options	Additional command line options to be supplied to the linker.
Additional Output Format	Specifies an additional file format to be generated by the linker. For example an s-record output may be generated as well as the .hzx file.
Check For Memory Segment Overflow	Specifies that the linker should check whether program sections fit into the memory segments they have been placed in.
Entry Point	Specifies the entry point of the program. This may be a symbol or an absolute address.
Executable File Name	Specifies the name of the output file produced by the linker.
Generate Map File	Specifies whether or not a linker map file is generated.
Heap Size	Specifies the heap size in bytes to be used by the application.
Include Standard Libraries	Specifies whether the standard libraries should be linked into the application.
Include Startup Code	Specifies whether the standard C startup code is linked into the application.
Library Instruction Set	Specifies the library variant the linker should use. The options are *ARM* or *THUMB*.
Linker Script File	Use specified linker script file rather than auto generating one from the section placement and memory map files.
Memory Map File	The name of the file containing the memory map description. This property will have macro expansion applied to it. Note that a memory map file in the project will be used in preference to this setting.

Property	Description
Post Build Command	Specifies a command to run after the link command has executed.
Section Placement File	The name of the file containing the section placement description. This property will have macro expansion applied to it. Note that a section placement file in the project will be used in preference to this setting.
Stack Size (Abort Mode)	Specifies the size of the **Abort** mode stack in bytes.
Stack Size (FIQ Mode)	Specifies the size of the **FIQ** mode stack in bytes.
Stack Size (IRQ Mode)	Specifies the size of the **IRQ** mode stack in bytes.
Stack Size (Supervisor Mode)	Specifies the size of the **Supervisor** mode stack in bytes.
Stack Size (Undefined Mode)	Specifies the size of the **Undefined** mode stack in bytes.
Stack Size (User/System Mode)	Specifies the size of the **User/System** mode stack in bytes.
Stack Size (User/System Mode)	Specifies the size of the **User/System** mode stack in bytes.
Use GCC Libraries	Use GCC floating point, exception and rtti libraries.
Use Multi Threaded Libraries	Specifies that multi-threaded (re-entrant) versions of the libraries should be linked in.

Target Properties

These properties are applicable to "**executable**" project types.

Property	Description
Attach Script	The script that is executed when the debugger attaches to the target.
Reset Script	The script that is executed when the target is reset. This script is typically responsible for resetting the target and configuring memory.

Property	Description
Run Script	The script that is executed when the target is released into run state. This script is typically responsible for re-enabling caches previously disabled by the stop script.
Stop Script	The script that is executed when the target enters debug state. This script is typically responsible for disabling or flushing caches.
ARM Debug Interface	Specifies whether the target's debug interface is ARM7TDI, ARM7DI, ARM9TDMI or XScale compliant.
JTAG Data Bits After	Specifies the number of bits to pad the JTAG data register after the data for the ARM processor being targeted. As the width of the BYPASS register is normally 1 bit this value is usually equal to the number of devices in the scan chain after the device being targeted.
JTAG Data Bits Before	Specifies the number of bits to pad the JTAG data register before the data for the ARM processor being targeted. As the width of the BYPASS register is normally 1 bit this value is usually equal to the number of devices in the scan chain before the device being targeted.
JTAG Instruction Bits After	Specifies the number of bits to pad the JTAG instruction register with the BYPASS instruction (all bits set) after the instruction for the ARM processor being targeted. This value should be the combined length of the instruction registers for all devices in the scan chain after the ARM processor being targeted.
JTAG Instruction Bits Before	Specifies the number of bits to pad the JTAG instruction register with the BYPASS instruction (all bits set) before the instruction for the ARM processor being targeted. This value should be the combined length of the instruction registers for all devices in the scan chain before the ARM processor being targeted.

Property	Description
First Loader Program Section	The name of the loader's first program section. This value is used to tell CrossStudio the area of memory occupied by the loader in order to prevent it from being overwritten during download. This parameter is only required if the program being downloaded overwrites the loader.
Last Loader Program Section	The name of the loader's last program section. This parameter is only required if the program section specified by *First Loader Program Section* is not the loader's only program section.
Loader File Path	Specifies the file path of the loader program to use. This is typically used by targets that support FLASH download. It is not possible to download programs to FLASH using only the ARM's debug interface. A loader program therefore has to be downloaded and run from RAM prior to the download of the main application.
Loader File Type	Specifies the communication mechanism used to communicate with the loader.
Loader Parameter	This field allows a parameter to be passed to the loader. The parameter is loader specific.
Reset After Download	Specifies whether the target should be reset after a download using a loader.
Stop CPU Using DBGRQ	Specifies whether the CPU should be stopped by asserting **DBGRQ** rather than by using breakpoints.

Code editor command summary

The following table summarizes the keystrokes and corresponding menu items for code editor commands:

Keystrokes	Menu	Description
Up		Move the caret one line up.
Down		Move the caret one line down.

Keystrokes	Menu	Description
Left		Move the caret one character to the left.
Right		Move the caret one character to the right.
Home		Move the caret to the start of the current line.
End		Move the caret to the end of the current line.
PageUp		Move the caret on page up.
PageDown		Move the caret one page down.
Ctrl+Up		Scroll the document down one line.
Ctrl+Down		Scroll the document up one line.
Ctrl+Left		Move the caret to the start of the previous word.
Ctrl+Right		Move the caret to the start of the next word.
Ctrl+Home		Move the caret to the start of the document.
Ctrl+End		Move the caret to the end of the document.
Ctrl+PageUp		Move the caret to the top of the window.
Ctrl+PageDown		Move the caret to the bottom of the window.
Enter Return		Insert a new line and move the caret to an appropriate position on the next line dependant on the indent settings.
Shift+Up		Extend the current selection up by one line.
Shift+Down		Extend the current selection down by one line.
Shift+Left		Extend the current selection left by one character.
Shift+Right		Extend the current selection right by one character.
Shift+Home		Extend the current selection to the beginning of the current line.
Shift+End		Extend the current selection to the end of the current line.
Shift+PageUp		Extend the current selection up by one page.

Keystrokes	Menu	Description
Shift+PageDown		Extend the current selection down by one page.
Ctrl+Shift+Left		Extend the current selection to the beginning of the previous word.
Ctrl+Shift+Right		Extend the current selection to the end of the next word.
Ctrl+Shift+Home		Extend the current selection to the beginning of the file.
Ctrl+Shift+End		Extend the current selection to the end of the file.
Ctrl+Shift+Page Up		Extend the current selection to the top of the window.
Ctrl+Shift+Page Down		Extend the current selection to the end of the window.
Ctrl+Shift+]		Select the text contained within the nearest delimiter pair.
Ctrl+A		Select the entire document.
Ctrl+F8		Select the current line.
	Edit | Advanced | Sort Ascending	Sort the lines contained within the current selection into ascending order.
	Edit | Advanced | Sort Descending	Sort the lines contained within the current selection into descending order.
Ctrl+C Ctrl+Insert	Edit | Copy	Copy the current selection into the clipboard.
Ctrl+X Shift+Delete	Edit | Cut	Copy the current selection into the clipboard and remove the selected text from the document.
Ctrl+V Shift+Insert	Edit | Paste	Insert the contents of the clipboard into the document at the current caret position.
Ctrl+L		Cut the current line *or selection.*
Ctrl+Shift+L		Delete the current line *or selection.*

Keystrokes	Menu	Description
	Edit | Clipboard | Clear Clipboard	Empty the current contents of the clipboard.
Ctrl+F2	Edit | Bookmarks | Toggle Bookmark	Add or remove a bookmark to the current line.
F2	Edit | Bookmarks | Next Bookmark	Move the caret to the next bookmark.
Shift+F2	Edit | Bookmarks | Previous Bookmark	Move the caret to the previous bookmark.
	Edit | Bookmarks | First Bookmark	Move the caret to the first bookmark in the document.
	Edit | Bookmarks | Last Bookmark	Move the caret to the last bookmark in the document.
Ctrl+Shift+F2	Edit | Bookmarks | Clear All Bookmarks	Remove all bookmarks from the document.
Alt+F2		Add a permanent bookmark on the current line.
Ctrl+F	Edit | Find	Display the find dialog.
Ctrl+H	Edit | Replace	Display the replace dialog.
F3		Find the next occurrence of the previous search ahead of the current caret position.
Shift+F3		Find the next occurrence of the previous search behind the current caret position.
Ctrl+]		Find the matching delimiter character for the nearest delimiter character on the current line.
Ctrl+F3		Search up the document for currently selected text.

Keystrokes	Menu	Description
Ctrl+Shift+F3		Search down the document for the currently selected text.
Ctrl+G, Ctrl+L		Display the goto line dialog.
Backspace		Delete the character to the left of the caret position.
Delete		Delete the character to the right of the caret position.
Ctrl+Backspace		Delete from the caret position to the start of the current word.
Ctrl+Delete		Delete from the caret position to the end of the current word.
Ctrl+L		Delete current line.
Ctrl+Alt+L		Delete from the caret position to the end of the line.
Alt+Shift+L		Delete from the caret position to the next blank line.
Tab	Edit | Advanced | Increase Line Indent	Either advance the caret to the next indent position or, if there is selected text, indent each line of the selection.
Shift+Tab	Edit | Advanced | Decrease Line Indent	Either move the caret to the previous indent position or, if there is selected text, unindent each line of the selection.
Alt+Right		Indent the current line.
Alt+Left		Unindent the current line.
Ctrl+S	File | Save	Save the current file.
	File | Save As	Save the current file under a different file name.
Ctrl+Shift+S	File | Save All	Save all the files.
Ctrl+P	File | Print	Print the current file.
Ctrl+U	Edit | Advanced | Make Selection Lowercase	Either change the current character to lowercase or, if there is selected text, change all characters within the selection to lowercase.

Keystrokes	Menu	Description
Ctrl+Shift+U	Edit | Advanced | Make Selection Uppercase	Either change the current character to uppercase or, if there is selected text, change all characters within the selection to uppercase.
Ctrl+/	Edit | Advanced | Comment	If there is a selection, adds a comment to the start of each selected line. If there is no selection, adds a comment to the start of the line the caret is on.
Ctrl+Shift+/	Edit | Advanced | Uncomment	If there is a selection, removes any comment from the start of each selected line. If there is no selection, removes any comment fro the start of the line the caret is on.
Ctrl+Z or Alt+Backspace	Edit | Undo	Undoes the last operation.
Ctrl+Y	Edit | Redo	Redoes the last operation.
Insert		Enable or disable overwrite mode.
Ctrl+Shift+T		Swap the current word with the previous word or, if there is no previous word, the next word.
Alt+Shift+T		Swap the current line with the previous line or, if there is no previous line, the next line.
Ctrl+Alt+J		Appends the line below the caret onto the end of the current line.
	Edit | Advanced | Tabify Selection	Replace whitespace with appropriate tabs within the current selection.
	Edit | Advanced |Untabify Selection	Remove tabs from within the current selection.
	Edit | Advanced |Visible Whitespace	Enable or disable visible whitespace.
	Edit | Advanced | Toggle Read Only	Toggle the write permissions of the current file.

Binary editor command summary

The following table summarizes the keystrokes and corresponding menu items for binary editor commands:

Keystrokes	Menu	Action
Up		Move the caret 16 bytes back.
Down		Move the caret 16 bytes forward.
Left		Move the caret one byte back.
Right		Move the caret one byte forward.
Home		Move the caret to the start of the current line of bytes.
End		Move the caret to the end of the current line of bytes.
Page Up		Move the caret one page up.
Page Down		Move the caret one page down.
Ctrl+Home		Move the caret to address 0.
Ctrl+End		Move the caret to the address of the last byte in the file.
Ctrl+Up		Move the view up one line.
Down		Move the view down one line.
Ctrl+Left		Move the caret 4 bytes back.
Ctrl+Right		Move the caret 4 bytes forward.
Ctrl+F	Edit | Find	Display the find dialog.
F3		Find the next occurrence of the value most recently searched for.
Backspace		Removes the byte in the address before the caret position.
Delete		Removes the currently selected byte.
Ctrl+S	File | Save	Save the current file.

Keystrokes	Menu	Action
	File | Save As	Save the current file under a different file name. **WARNING** the current version of the binary editor continues to display the original file name after a "Save as" operation.
Ctrl+Z	Edit | Undo	Undoes the last operation.
Ctrl+Y	Edit | Redo	Redoes the last undone operation.
Insert		Enable or disable overwrite mode.
Ctrl+T		When in text input mode the currently selected byte will be replaced with the ASCII character code for the input key. e.g. 0F would become 66 when 'f' is pressed. When not in text input mode the currently selected byte is replaced with the HEX value of the input keys. e.g. 00 would become 0F when 'f' is pressed. 00 would become FA if the 'f' then 'a' keys were pressed.
	Edit | Advanced | Toggle Read Only	Toggle the write permissions of the current file.
Ctrl+E		Allows the file to be a fixed size or a variable size
Down or Right		Extends the file when the last address is selected and the file is write enabled. the new bytes will be initialised to 00.

Glossary

The following terms are in common use and are used throughout the CrossWorks documentation:

- **Active project.** The project that is currently selected in the **Project Explorer**. The **Build** tool bar contains a dropdown and the **Project > Set Active Project** menu contains an item that display the active project. You can change the active project using either of these elements.
- **Active configuration.** The configuration that is currently selected for building. The **Build** too bar contains a dropdown and the **Build > Set**

Active Build Configuration menu display the active configuration. You can change the active configuration using either of these elements.

- **Assembler.** A program that translates low-level assembly language statements into executable machine code. See Assembler Reference.
- **Compiler.** A program that translates high-level statement into executable machine code. See C Compiler Reference.
- **Integrated development environment.** A program that supports editing, managing, building, and debugging your programs within a single environment.
- **Linker.** A program that combines multiple relocatable object modules and resolves inter-module references to produce an executable program. See Linker Reference.
- **Project explorer.** A docking indow that contains a visual representation of the project. See **Project explorer** (page 127).