

Motorola HC12 Compiler

Revision 1.2, 9/9/03

The information in this document is based on
HC12 Compiler V5.0.23
or higher

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Using the Compiler

Introduction

This document describes the ANSI-C/C++ Compiler. The Compiler consists of a **Front End**, which is language dependent, and a **Back End** that depends on the target processor.

Application Programs

If you installed the software in 'C:\Metrowerks' on a PC, all application programs are in 'C:\Metrowerks\PROG' (for details see installation guide).

The following list provides an overview of the applications used for C/C++ programming.

ide.exe	CodeWarrior IDE
chc12.exe	Motorola HC12 Compiler
ahc12.exe	Motorola HC12 Assembler
libmaker.exe	Librarian Tool to build libraries
linker.exe	Link Tool to build applications (absolute files)
decoder.exe	Decoder Tool to generate assembly listings
maker.exe	Make Tool for automatically rebuild
burner.exe	Batch and interactive Burner (S-Records, ...)
hiwave.exe	Multi-Purpose Simulation/Debugging Environment
piper.exe	Utility to redirect messages to stdout

NOTE Depending on your license configuration, not all programs listed above may be installed, or there may be additional programs!

Startup Command Line Options

There are some special tool options. These tools are specified at tool startup (while launching the tool). They cannot be specified interactively:

- `-Prod` specifies the current project directory or file. For example:

```
linker.exe -Prod=c:\Metrowerks\demo\myproject.pjt
```

There are other options that launch the tool, and open its special dialogs. Those dialogs are available in compiler/assembler/burner/maker/linker/decoder/libmaker:

- `ShowOptionDialog`: This startup option opens the tool option dialog.
- `ShowMessageDialog`: This startup option opens the tool message dialog.
- `ShowConfigurationDialog`: This opens the File->Configuration dialog.
- `ShowBurnerDialog`: This option is for the Burner only and opens the Burner dialog.
- `ShowSmartSliderDialog`: This option is for the compiler only and opens the smart slider dialog.
- `ShowAboutDialog`: This option opens the tool about box.

The above options open a modal dialog where you can specify tool settings. If the OK button is pressed in the dialog, the settings are stored in the current project settings file. Example for use:

```
c:\Metrowerks\prog\linker.exe -ShowOptionDialog  
-Prod=c:\demos\myproject.pjt
```

Literature

Refer to the documentation listed below for details about programming languages.

- “American National Standard for Programming Language – C”, ANSI/ISO 9899–1990 (see also <http://www.x3.org> or ANSI X3.159-1989, X3J11)
- “The C Programming Language”, second edition, Prentice-Hall 1988
- “C: A Reference Manual”, second edition, Prentice-Hall 1987, Harbison and Steele
- “C Traps and Pitfalls”, Andrew Koenig, AT&T Bell Laboratories, Addison-Wesley Publishing Company, Nov. 1988, ISBN 0-201-17928-8
- “Data Structures and C Programs”, Van Wyk, Addison-Wesley 1988
- “How to Write Portable Programs in C”, Horton, Prentice-Hall 1989

- “The UNIX Programming Environment”, Kernighan and Pike, Prentice-Hall 1984
- “The C Puzzle Book”, Feuer, Prentice-Hall 1982
- “C Programming Guidelines”, Thomas Plum, Plum Hall Inc., Second Edition for Standard C, 1989, ISBN 0-911537-07-4
- “DWARF Debugging Information Format”, UNIX International, Programming Languages SIG, Revision 1.1.0 (October 6, 1992), UNIX International, Waterview Corporate Center, 20 Waterview Boulevard, Parsippany, NJ 07054
- “DWARF Debugging Information Format”, UNIX International, Programming Languages SIG, Revision 2.0.0 (July 27, 1993), UNIX International, Waterview Corporate Center, 20 Waterview Boulevard, Parsippany, NJ 07054
- “System V Application Binary Interface”, UNIX System V, 1992, 1991 UNIX Systems Laboratories, ISBN 0-13-880410-9
- 'Programming Microcontroller in C', Ted Van Sickle, ISBN 1878707140
- 'C Programming for Embedded Systems', Kirk Zurell, ISBN 1929629044
- 'Programming Embedded Systems in C and C ++', Michael Barr, ISBN 1565923545
- 'Embedded C' Michael J. Pont ISBN 020179523X
- “Single- and Multi-Chip Microcontroller Interfacing for the Motorola 68HC12”, G. Jack Lipovski, 1999, Academic Press Series in Engineering, ISBN 0-12-451830-3

Programmers not familiar with C++ should read the additional documentation listed below.

- “C++ Programming Guidelines”, Thomas Plum, Dan Saks, Plum Hall Inc., 1989, ISBN 0-911537-07-4
- "Ellis/Stroustrup: The Annotated C++ Reference Manual", ANSI Base Document, 1995, Addison-Wesley, ISBN 0-201-51459-1
- “Bjarne Stroustrup: The C++ Programming Language”, 1987, Addison-Wesley, ISBN 0-201-12078-X
- “Bjarne Stroustrup: The Design and Evolution of C++”, 1994, ISBN 0-201-54330-3
- “P.J. Plauger: The Draft Standard C++ Library”, 1995, Prentice Hall, ISBN 0-13-117003-1

Highlights

- Powerful User Interface

- Online Help
- Flexible Type Management
- Flexible Message Management
- 32-Bit Application
- Support for Encrypted Files
- High Performance Optimizations
- Conforms to ANSI/ISO 9899-1990

Structure of this Document

- [User Interface](#): Description of the Compiler GUI
- [Compiler Options](#): Detailed description of the full set of Compiler options
- [Compiler Predefined Macros](#): List of all macros predefined by the Compiler
- [Compiler Pragmas](#): List of possible pragmas
- [ANSI-C Front End](#): Description of the ANSI-C implementation
- [C++ Front End](#): C++ language extension compared with ANSI-C with some hints about using C++ in embedded programming (compactC++)
- **Compiler Back End**: Description of code generator and basic type implementation, also hints about hardware oriented programming (optimizations, interrupt functions)
- **High Level Inline Assembler**: Description of the HLI Assembler
- **Compiler Messages**: Description with examples of messages produced by the Compiler
- **Migration hints**: Hints about porting applications from other Compiler vendors to this Compiler
- **Appendix**: FAQ's, Trouble shooting, Technical Notes
- Index

Specific Configuration Markers

Some parts of this document are marked with a special indicator box in the upper right corner. Each section that contains an indicator box applies to just the configuration identified by that box. Please check your license configuration.

[Table 1.1](#) lists each type of indicator box.

Table 1.1 Documentation Indicator Boxes

Indicator Box	Description
C++	This section is only available for Compiler with the C++ feature.
ICG	This marker indicates sections of the ICG (Intermediate Code Generator) Optimization Engine.
HC12	Only available for Motorola HC12.
PC	Only available for the IBM-PC operating system.
UNIX	Only available for the UNIX operating system.

CodeWarrior Integration

All required plug-ins are installed together with the CodeWarrior IDE. The CodeWarrior IDE is installed in the 'bin' directory (usually `C:\CodeWarrior\bin`). The plug-ins are installed in the 'bin\plugins' directory.

Combined/Separated Installations

The installation script enables you to install several CPUs in one single installation path. This saves disk space and enables switching from one processor family to another without leaving the IDE.

NOTE Additionally, it is possible to have separate installations on one machine. There is only one point to consider: The IDE is using COM files, and for COM the IDE installation path is written into the registry. This registration is done in the installation setup. However, if there is a problem with the COM registration using several installations on one machine, the COM registration is done by starting a small batch file located in the 'bin' (usually `C:\CodeWarrior\bin`) directory. To do this, start the `regservers.bat` batch file.

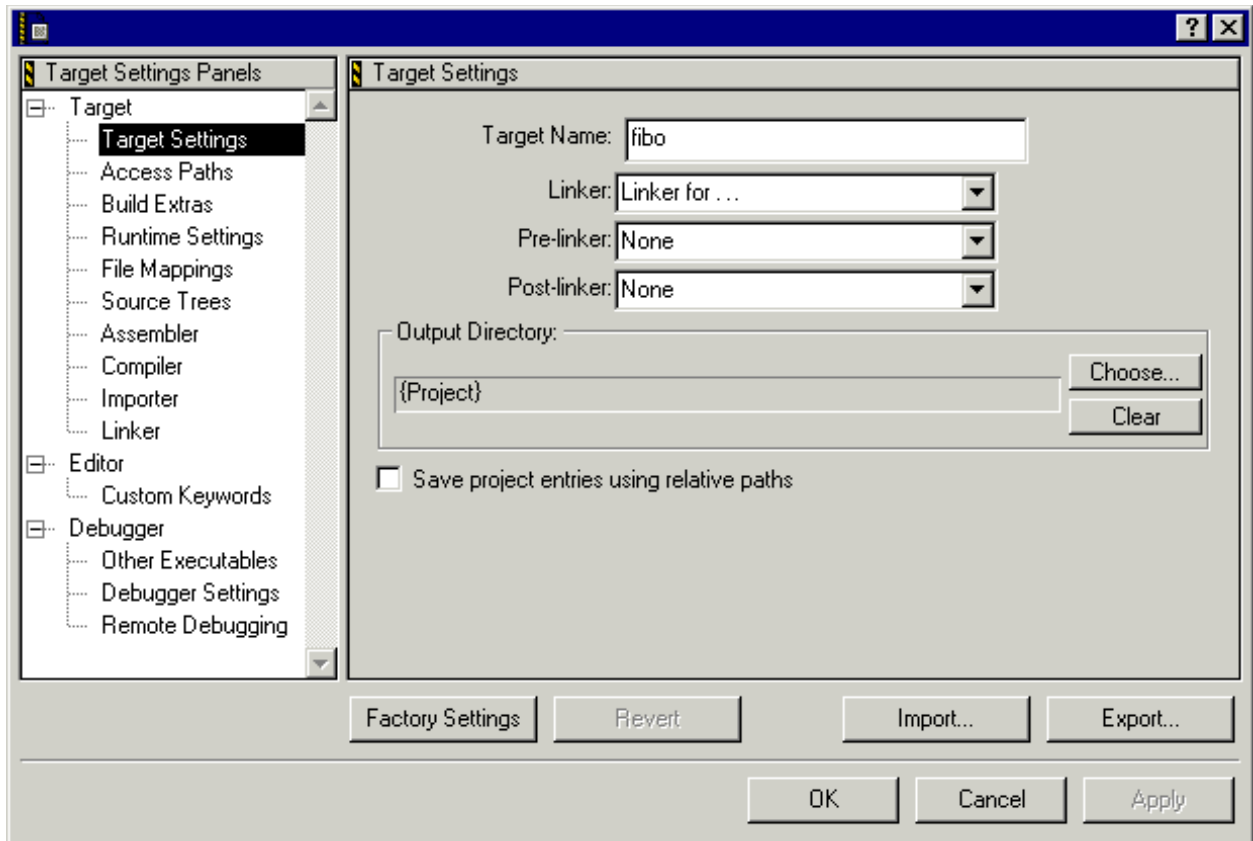
To combine two installations into one, copy the following files from one installation to the other. <target> denotes here a CPU target, for example, 'hc12', 'st7' or 'xa'.

- Copy the target specific files from/to `bin\plugins\compiler:`
`hw_<target>_importer.dll`

hw_<target>_compiler.dll
hw_<target>_assembler.dll

- Copy the target specific files from/to bin\plugins\linker:
hw_<target>_linker.dll
hw_<target>_burner.dll
hw_<target>_libmaker.dll
- Copy the target specific files from/to bin\plugins\preference panel:
hw_<target>_linker_panel.dll
hw_<target>_libmaker_panel.dll
hw_<target>_importer_panel.dll
hw_<target>_compiler_panel.dll
hw_<target>_assembler_panel.dll
hw_<target>_burner_panel.dll
- Copy from/to the stationery files:
stationery\<target>
- Copy the needed files from/to the prog directory:
c<target>.exe
c<target>.dll
c<target>.hlp
a<target>.exe
a<target>.dll
a<target>.hlp
<target>.sim
<target>.cpu
all the needed target interfaces for the simulator/debugger
mem files from prog/mem directory
- Copy the library from/to the library directory:
lib\<target>c
- Copy from/to the demo files:
demo\<target>

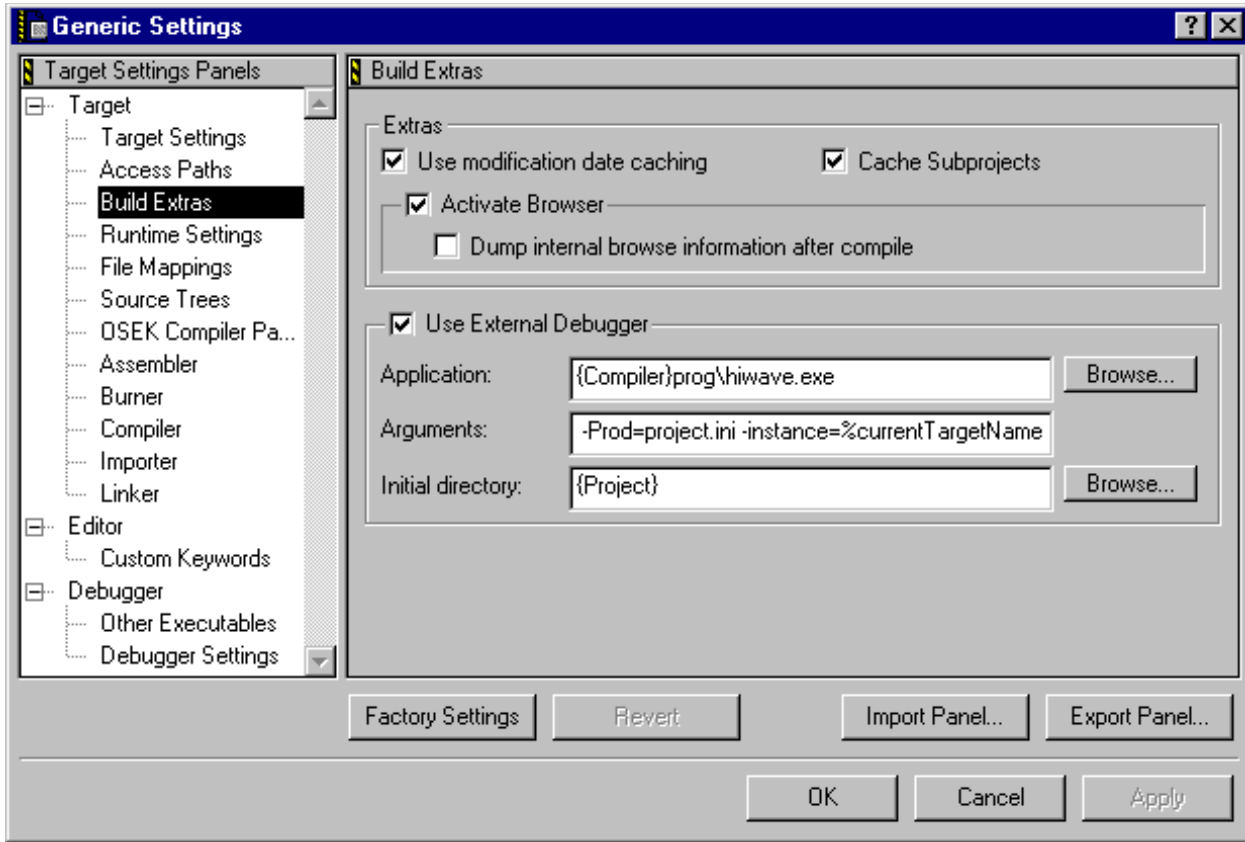
Target Settings



The linker builds an absolute (.abs) file. Before working with a project, set up the linker for the selected CPU in the Target Settings Preference Panel. Depending on the CPU targets installed, you can choose from various linkers available in the linker drop box.

You can also select a libmaker. When a libmaker is set up, the build target is a library (.lib) file.

Build Extras Panel



Use the Build Extras Preference Panel to get the compiler to generate browse information (Activate Browser).

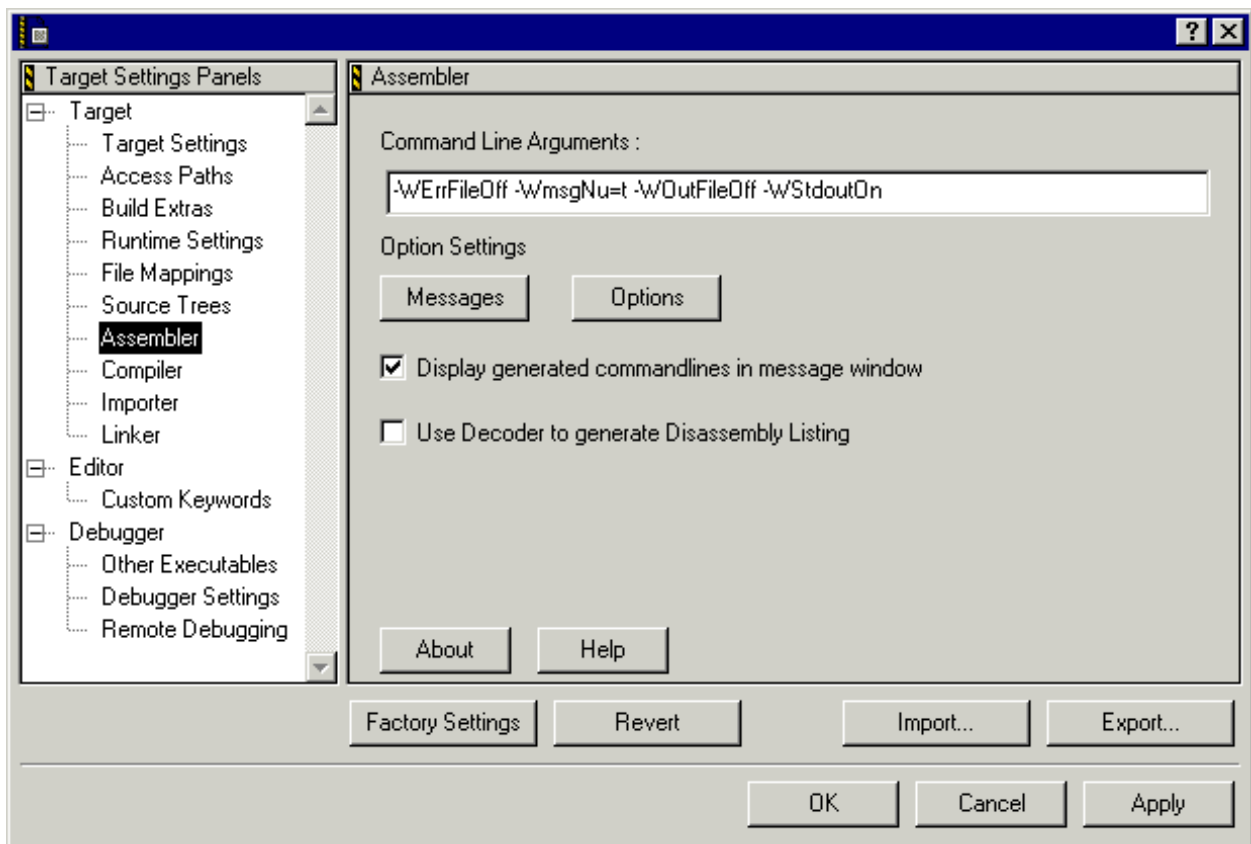
Enable the 'Use third party debugger' checkbox to use the external simulator/debugger. Define the path to the debugger, which is either absolute (for example, 'C:\metrowerks\prog\hiwave.exe'), or installation-relative (for example, '{Compiler}prog\hiwave.exe').

Additional command line arguments passed to the debugger are specified in the Arguments box. Beside the normal arguments (refer to your simulator/debugger documentation), the following '% macros' can also be specified:

- %sourceFilePath
- %sourceFileDir
- %sourceFileName
- %sourceLineNumber
- %sourceSelection
- %sourceSelUpdate
- %projectFilePath

%projectFileDir
%projectFileName
%projectSelectedFiles
%targetFilePath
%targetFileDir
%targetFileName
%currentTargetName
%symFilePath
%symFileDir
%symFileName

Assembler Preference Panel

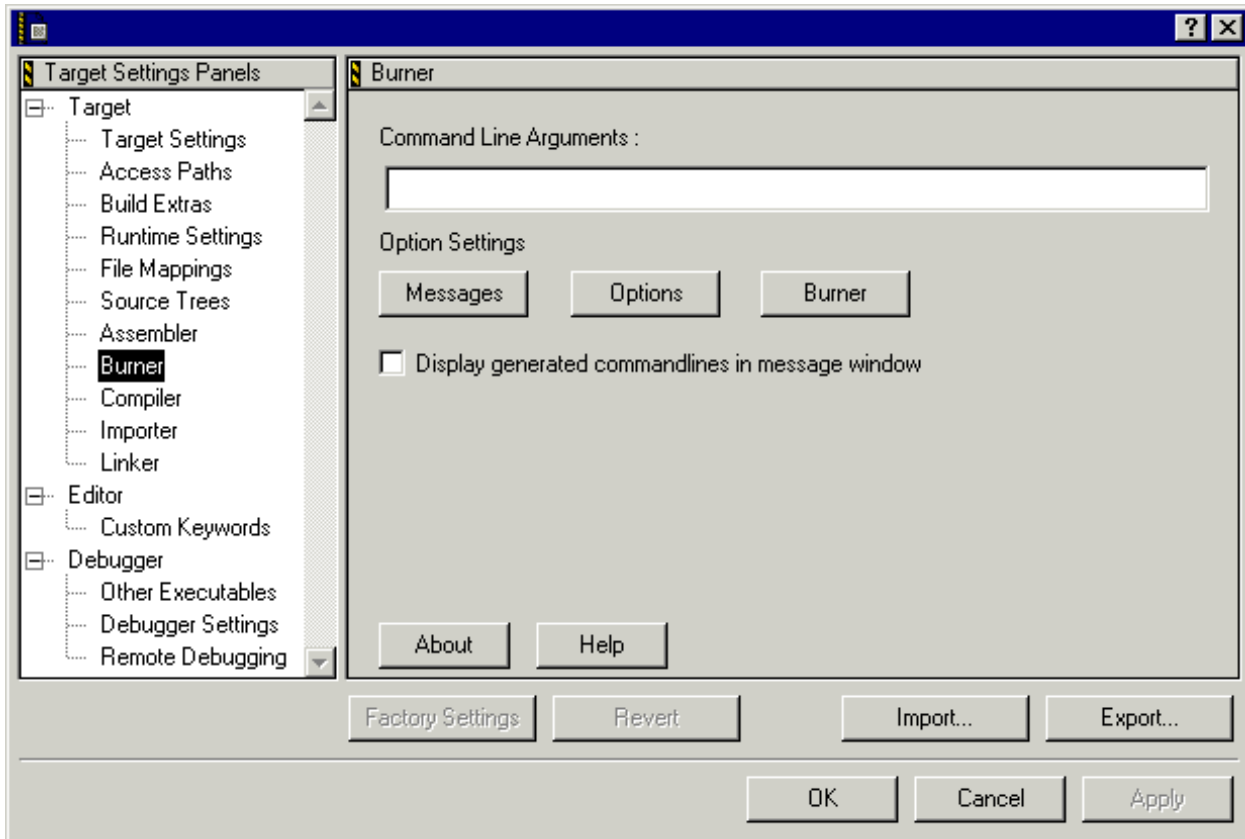


The plug-in preference panel contains the following:

- Command Line Arguments: Command line options are displayed. You can add/delete/modify the options by hand, or by using the Messages and Options buttons below.
- Messages: Button to open the Messages dialog

- Options: Button to open the Options dialog
- Display generated command lines in message window: The plug-in filters the messages produced, so that only Warning/Information/Error messages are displayed in the 'Errors & Warnings' window. With this check box set, the complete command line is passed to the tool.
- Use Decoder to generate Disassembly Listing: The built-in listing file generator is used to produce the disassembly listing. If this check box is set, the external decoder is enabled.
- About: Provides status and version information.
- Help: Opens the help file.

Burner Preference Panel

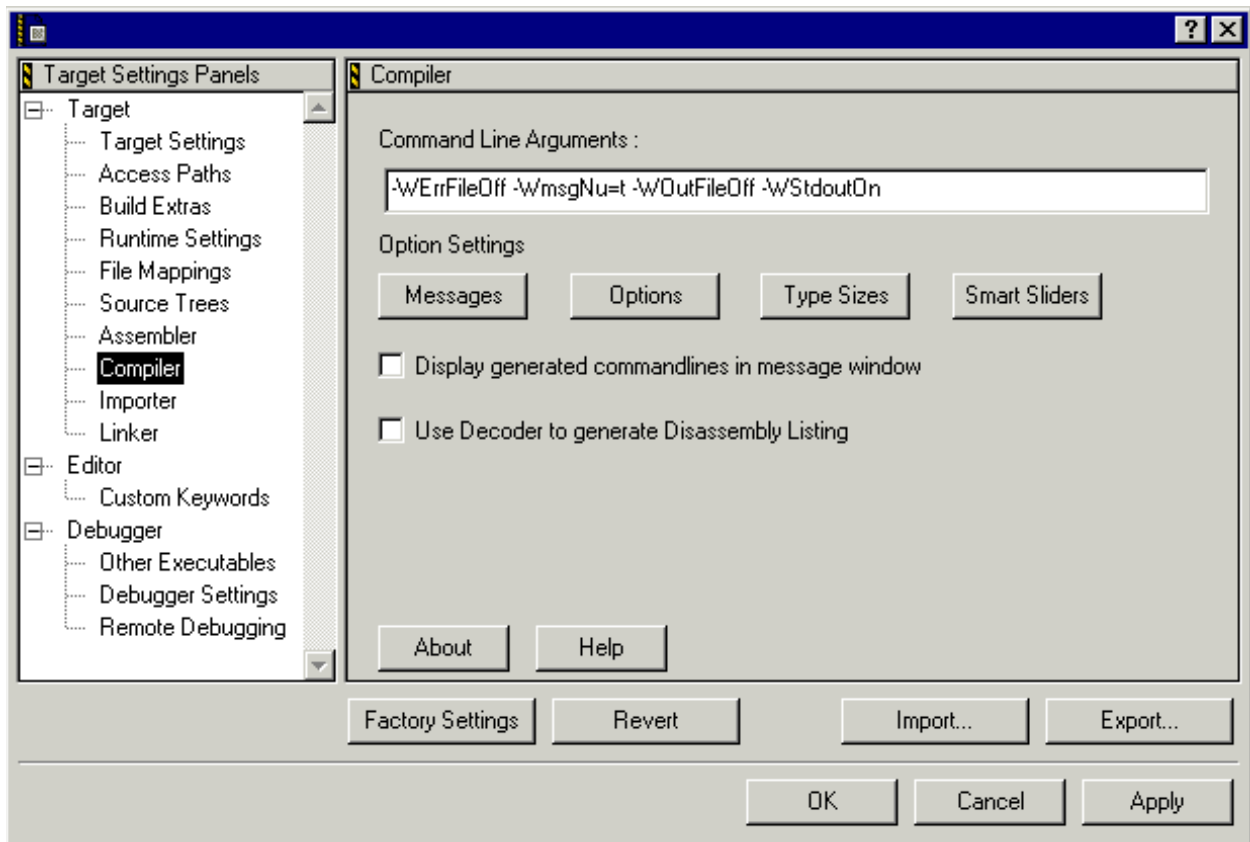


The Burner Plug-In Function: The *.bbl (batch burner language) files are mapped to the Burner Plug-In in the File Mappings Preference Panel. Whenever a *.bbl file is in the project file, the *.bbl file is processed during the post-link phase using the settings in the Burner Preference-Panel.

The plug-in preference panel contains the following:

- Command Line Arguments: The actual command line options are displayed. You can add/delete/modify the options manually, or use the Messages, Options, and Burner buttons listed below.
 - Messages: Opens the Messages dialog
 - Options: Opens the Options dialog
 - Burner: Opens the Burner dialog
- Display generated command lines in message window: The plug-in filters the messages produced, so that only Warning/Information/Error messages are displayed in the 'Errors & Warnings' window. With this check box set, the complete command line is passed to the tool.
- About: Provides status and version information.
- Help: Opens the help file.

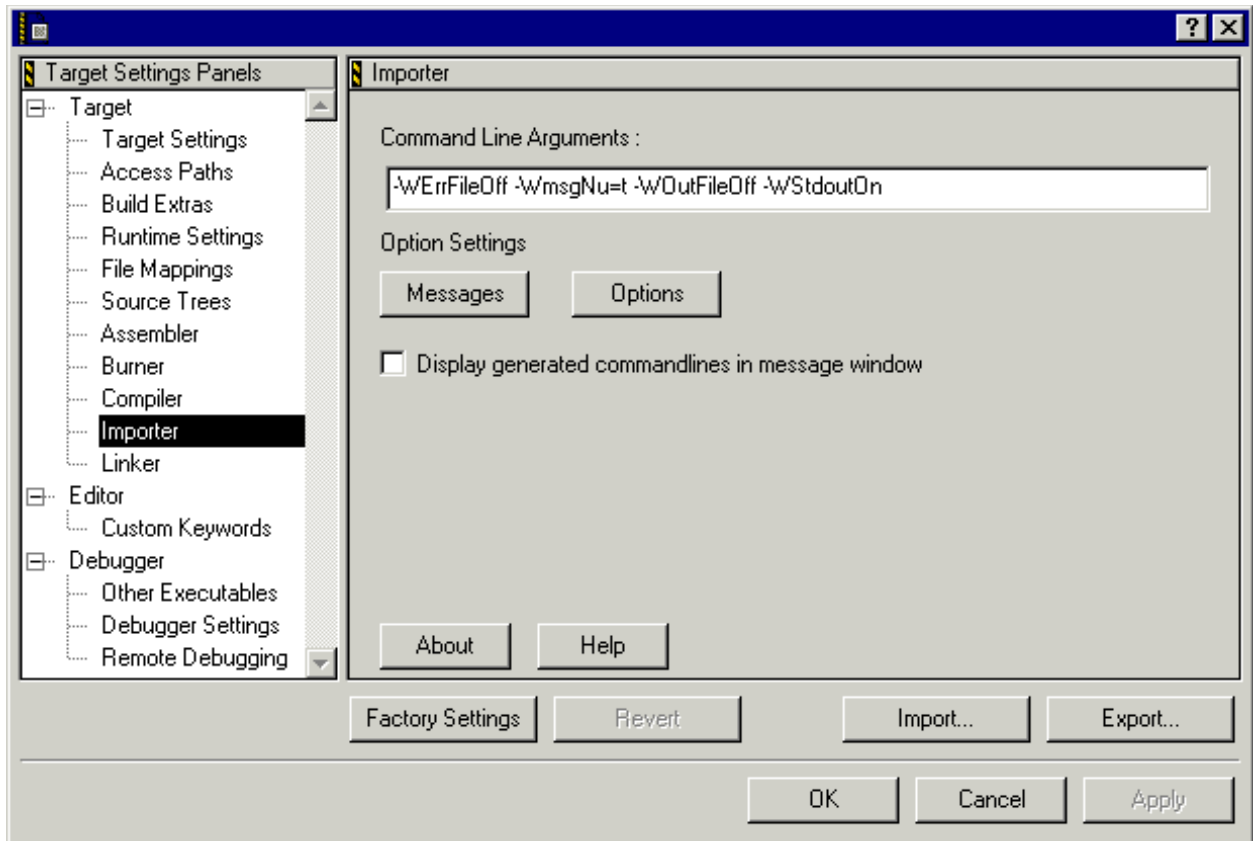
Compiler Preference Panel



The plug-in preference panel contains the following:

- **Command Line Arguments:** Command line options are displayed. You can add/delete/modify the options by manually, or use the Messages, Options, Type Sizes, and Smart Sliders buttons listed below.
 - Messages: Opens the Messages dialog
 - Options: Opens the Options dialog
 - Type Sizes: Opens the Standard Type Size dialog
 - Smart Sliders: Opens the Smart Slider dialog
- **Display generated command lines in message window:** The plug-in filters the messages produced, so that only Warning/Information/Error messages are displayed in the 'Errors & Warnings' window. With this check box set, the complete command line is passed to the tool.
- **Use Decoder to generate Disassembly Listing:** Checking this check box enables the external decoder to generate a disassembly listing.
- **About:** Provides status and version information.
- **Help:** Opens the help file.

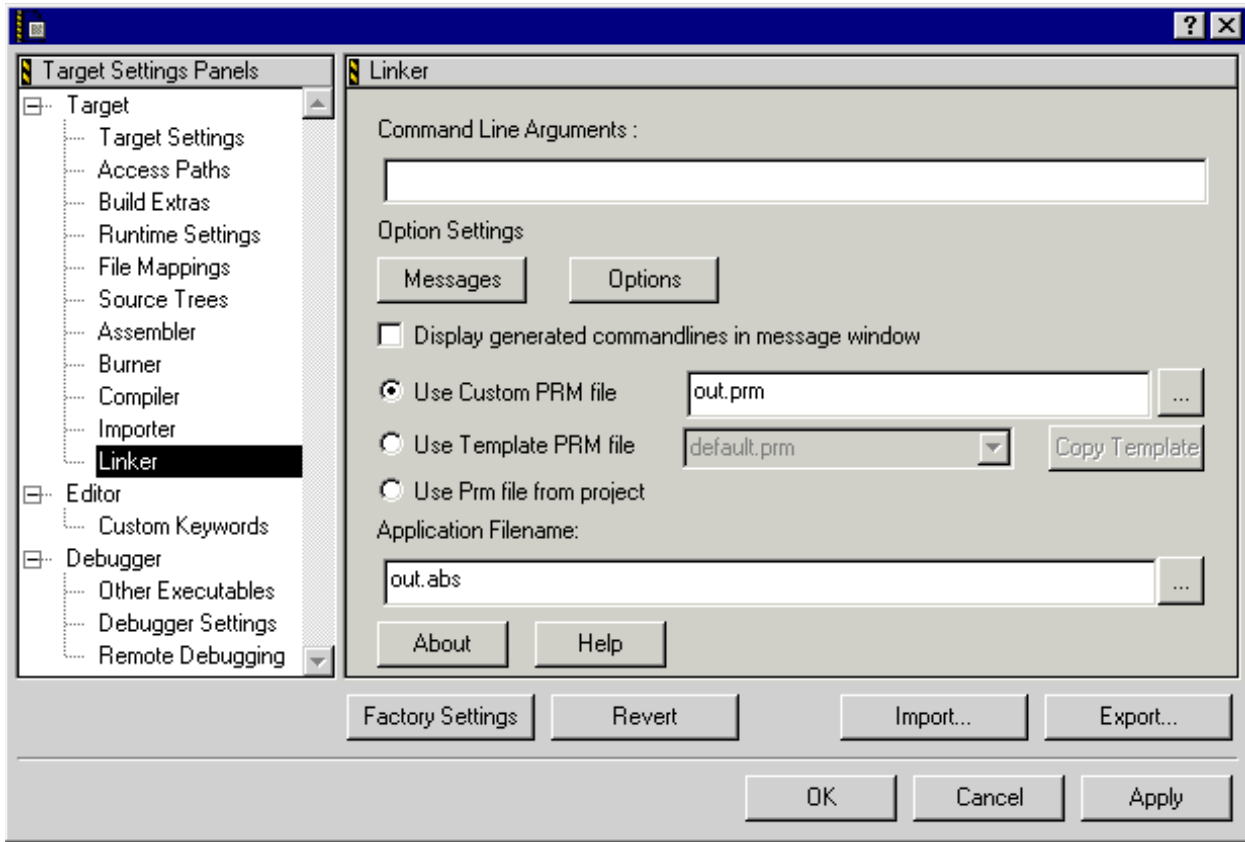
Importer Preference Panel



The plug-in preference panel contains the following controls:

- **Command Line Arguments:** Command line options are displayed. You can add/delete/modify the options manually, or use the Messages or Options buttons listed below.
 - **Messages:** Opens the Messages dialog
 - **Options:** Opens the Options dialog
- **Display generated command lines in message window:** The plug-in filters the messages produced so that only Warning/Information/Error messages are displayed in the 'Errors & Warnings' window. With this check box set, the complete command line is passed to the tool.
- **About:** Provides status and version information.
- **Help:** Opens the help file.

Linker Preference Panel



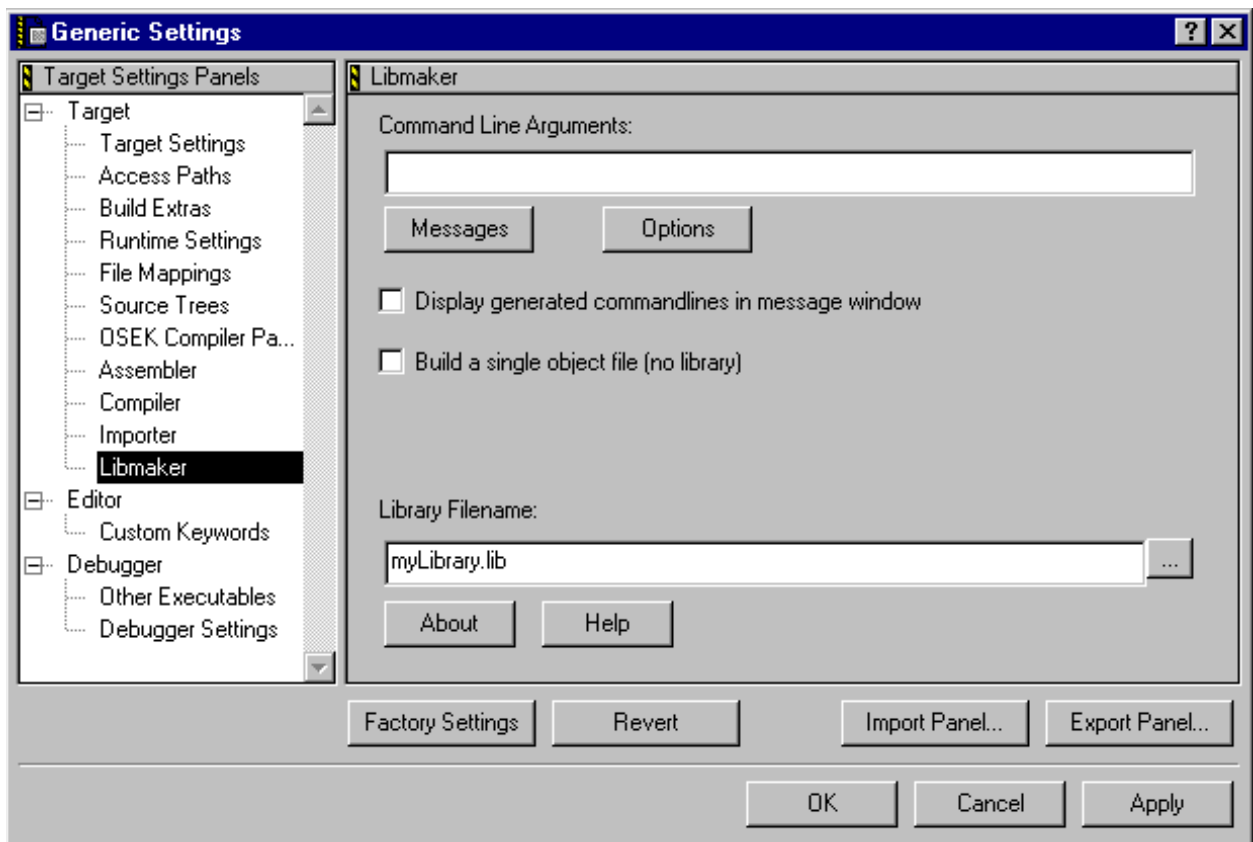
This preference panel displays in the Target Settings Panel if a Linker is selected. The plug-in preference panel contains following controls:

- **Command Line Arguments:** Command line options are displayed. You can add/delete/modify the options manually, or use the Messages or Options buttons listed below.
 - Messages: Opens the Messages dialog
 - Options: Opens the Options dialog
- **Display generated command lines in message window:** The plug-in filters the messages produced, so that only Warning/Information/Error messages are displayed in the 'Errors & Warnings' window. With this check box set, the complete command line is passed to the tool.
- **Use custom PRM file:** Specifies a custom linker parameter file in the edit box. Use the browse button (...) to browse for a file.
- **Use the template PRM file:** With this radio control set, you can select one of the pre-made prm files located in the templates directory (usually

c:\metrowerks\templates\

- Application File Name: The output file name is specified.
- About: Provides status and version information.
- Help: Button to open the tool help file directly.

Libmaker Preference Panel



This preference panel displays in the Target Settings Panel if a Libmaker is selected. The plug-in preference panel contains the following:

- Command Line Arguments: Command line options are displayed. You can add/delete/modify the options manually, or by using the Messages or Options buttons listed below.
 - Messages: Opens the Messages dialog
 - Options: Opens the Options dialog

- Display generated command lines in message window: The plug-in filters the messages produced, so that only Warning/Information/Error messages are displayed in the 'Errors & Warnings' window. With this check box set, the complete command line is passed to the tool.
- Build a single object file (no library): With this checkbox set, only a single object file is generated. This is useful to generate a startup object file to be linked later, or to create an absolute assembly application.
- Library File Name: The output file name is specified. Use the browse button (directly to the right of the entry field) to locate the directory where the output file is stored.
- About: Provides status and version information.
- Help: Opens the help file.

CodeWarrior Tips and Tricks

- If the simulator debugger can not be launched, check the settings in the Build Extras Preference Panel.
- If the data folder of the project is deleted, then some project-related settings may also have been deleted. One of these settings determines whether the debugger/simulator is enabled. Check the menu Project->Enable/Disable Debugger.
- If a file can not be added to the project, the file extension may be present in the File Mappings Preference Panel.
- If it is suspected that project data is corrupted, export and re-import the project using File->Export Project and File->Import Project.

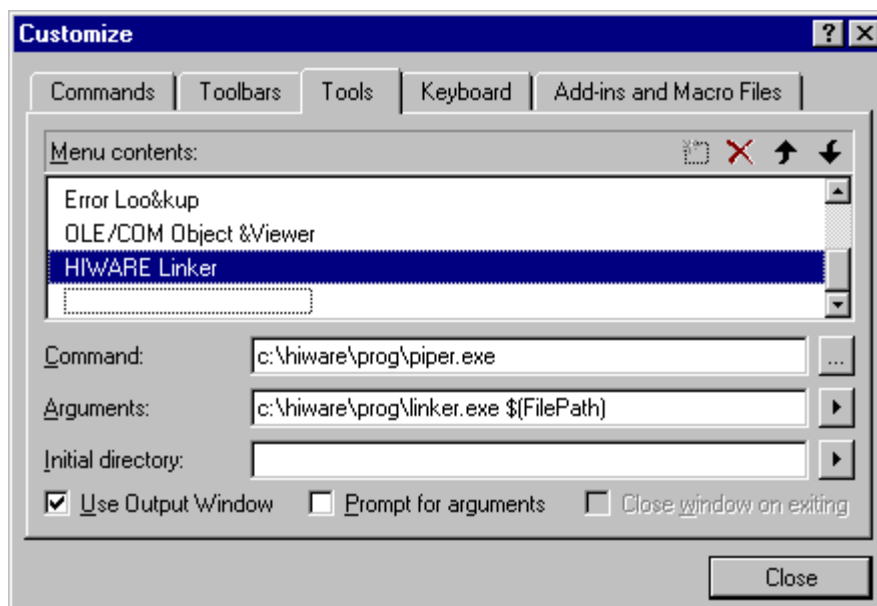
Integration into Microsoft Visual Studio (Visual C++ V5.0 or later)

Use the following procedure to integrate the Tools into the Microsoft Visual Studio (Visual C++).

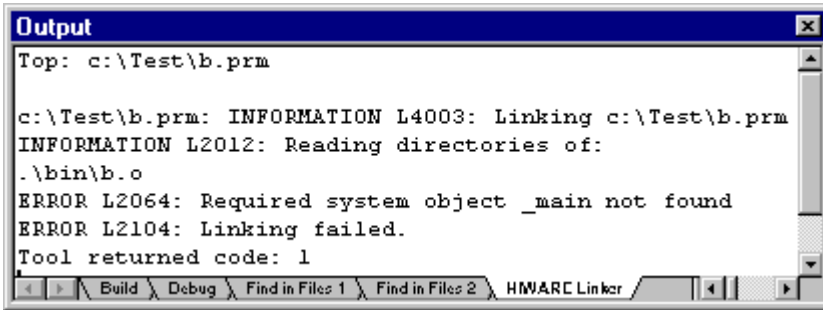
Integration as Additional Tools

1. Start Visual Studio.
2. Select the menu Tools->Customize.
3. Select the 'Tools' Tab.

4. Add a new tool using the 'New' button, or by double-clicking on the last empty entry in the 'Menu contents' list.
5. Type in the name of the tool to display in the menu (for example, 'Linker').
6. In the 'Command' field, type in the name and path of the piper tool (for example, 'c:\Metrowerks\prog\piper.exe').
7. In the 'Arguments' field, type in the name of the tool to be started with any command line options (for example, -N) and the \$(FilePath) Visual variable (for example, 'c:\Metrowerks\prog\linker.exe -N \$(FilePath)').
8. Check 'Use Output Window'.
9. Uncheck 'Prompt for arguments'.
10. Proceed as above for all other tools (for example, compiler, decoder).
11. Close the 'Customize' dialog.



This allows the active file to be compiled or linked in the Visual Editor ('\$(FilePath)'). Tool messages are reported in a separate Visual output window. Double click on the output entries to jump to the right message position (message feedback).



The screenshot shows a window titled "Output" with a blue title bar and a close button. The text inside the window is as follows:

```
Top: c:\Test\b.prm  
  
c:\Test\b.prm: INFORMATION L4003: Linking c:\Test\b.prm  
INFORMATION L2012: Reading directories of:  
. \bin\b.o  
ERROR L2064: Required system object _main not found  
ERROR L2104: Linking failed.  
Tool returned code: 1
```

At the bottom of the window, there is a toolbar with several icons and labels: "Build", "Debug", "Find in Files 1", "Find in Files 2", and "HMARC Linker".

Integration with Visual Studio Tool Bar

1. Start Visual Studio.
2. Make sure that all tools are integrated as 'Additional Tools'.
3. Select the menu Tools->Customize.
4. Select the 'Toolbars' Tab.
5. Select 'New' and enter a name (for example, Metrowerks Tools). A new empty toolbar named 'Metrowerks Tools' appears on your screen.
6. Select the 'Commands' Tab.
7. In the 'Category' drop down box, select 'Tools'.
8. On the right side many 'hammer' tool images appear, each with a number. The number corresponds to the entry in the Tool menu. Usually the first user defined tool is tool number 7 (The Linker was set up in 'Additional Tools' above).
9. Drag the selected tool image to the Metrowerks Tools tool bar.
10. All default tool image look the same, making it difficult to know which tool has been launched. It is recommended to associate a name with them:
11. Right-Click on a tool in the Metrowerks Tool bar to open the context menu of the button.
12. Select 'Button Appearance...' in the context menu.
13. Select 'Image and Text'.
14. Enter the tool name to associate with the image in 'Button text:' (for example, 'Linker').
15. Repeat for all tools to appear in the tool bar.
16. Close the 'Customize' Dialog.

This enables the tools to be started from the tool bar.

C++, EC++, compactC++

The Compiler supports the C++ language, if the C++ feature is enabled with a license file.

Some features of the C++ language are not designed for embedded controllers. If they are used, they may produce a excess code and occupy a lot of runtime.

Avoid this situation by providing compactC++ and EC++ images, which are subsets of the C++ language. Each subset is adapted for embedded application programming.

This subset of the C++ language avoids implicit and explicit overhead of the C++ language (for example, virtual member functions, multiple inheritance). The EC++ is a restricted subset, where the cC++ (compact C++) includes features which are not in the EC++ definition. This makes it more flexible.

Another key aspect of cC++ is its flexible configuration of the language (for example, allowed keywords, code generation behavior, message management). The Compiler is adapted for the special needs for embedded programming.

The Compiler provides the following language settings:

- ANSI-C: The compiler behaves as an ANSI-C compiler. It is possible to force the compiler into a strict ANSI-C compliant mode, or to use language extensions designed for efficient embedded systems programming.
- EC++: The compiler behaves as a C++ compiler. The following features are not allowed in EC++:
 - Mutable specifier
 - Exception handling
 - Runtime type identification
 - Namespace
 - Template
 - Multiple inheritance
 - Virtual inheritance
 - Library support for w_char and long double
- cC++, compactC++: In this mode, the compiler behaves as a full C++ compiler that allows the C++ language to be configured to provide compact code. This enables developers to enable/disable and configure the following C++ features:
 - Multiple inheritance

- Virtual inheritance
- Templates
- Trigraph and bigraph

Compact means:

- No mutable qualifier
- No exception handling
- No runtime type identification
- No namespaces
- No library support for `w_char` and `long double`
- C++: The compiler behaves as a full C++ compiler. However, because the C++ language provides some features not usable for embedded systems programming, such features may be not usable.

Object File Formats

The Compiler supports two different object file formats: ELF/DWARF and the vendor specific HIWARE object file format. The object file format specifies the format of the object files (extension `.o`), the library files (extension `.lib`), and the absolute files (extension `.abs`).

NOTE Be careful and do not mix object file formats. *Both the HIWARE and the ELF/DWARF object files use the same extensions.*

HIWARE Object File Format

The HIWARE Object File Format is a vendor-specific object file format defined by HIWARE AG. This object file format is very compact. The object file sizes are smaller than the ELF/DWARF object files. This smaller size enables faster file operations on the object files. The object file format is also easy to support by other tool vendors (for example, emulators from Abatron, Lauterbach or iSYSTEM). The object file format supports ANSI-C and Modula-2. The C++ language is supported with restrictions.

Each other tool vendor must support this object file format explicitly. Note that there is also a lack of extensibility, amount of debug information, and C++ support. For example, using the full flexibility of the Compiler Type Management is not supported in the HIWARE Object File Format.

Using HIWARE object file format results may also result in slower source/debug info loading. In the HIWARE object file format, the source position information is provided as position information (offset in file), and not directly in a file/line/column format. The debugger must translate this HIWARE object file source information format into a file/line/column format. This has the tendency to slow down the source file/debugging info loading process.

ELF/DWARF Object File Format

The ELF/DWARF object file format originally comes from the UNIX world. This format is very flexible and is able to support extensions.

Many chip vendors define this object file format as the standard for tool vendors supporting their devices. This standard allows inter-tool operability making it possible to use the compiler from one tool vendor, and the linker from another. The developer has the choice to select the best tool in the tool chain. Additionally, other third parties (for example, emulator vendors) only have to support this object file to support a wide range of tool vendors.

Object file sizes are large compared with the HIWARE object file format. This in more file I/O to generate those object files.

NOTE ANSI-C, C++ and Modula-2 are supported in this object file format.

Tools

Compiler

The Compiler supports both object file formats. The default format is the HIWARE object file format (Compiler option [-Fh](#), [-F1](#) or [-F2](#) to switch to ELF/DWARF).

Decoder

Use the same executable 'decoder.exe' for both the HIWARE and the ELF/Dwarf object file format.

Linker

Use the same executable 'linker.exe' for both the HIWARE and the ELF/Dwarf object file formats.

Simulator/Debugger

The Simulator/Debugger supports both object file formats.

Mixing Object File Formats

Mixing HIWARE and ELF object files is not possible. Mixing ELF object files with DWARF 1.1 and DWARF 2.0 debug information is possible. However, the final generated application does not contain any debug data.

Graphical User Interface

The Graphical User Interface (GUI) tool provides both a simple and a powerful user interface:

- Graphical User Interface
- Command-Line User Interface
- Online Help
- Error Feedback
- Easy integration into other tools (for example, CodeWarrior, CodeWright, MS Visual Studio, WinEdit, ...)

This section describes the user interface and provides useful hints.

Launching a Tool

Start the tools (compiler/linker/assembler/decoder/...) using:

- The Windows Explorer
- An Icon on the desktop
- An Icon in a program group
- Batch/command files
- Other tools (Editor, Visual Studio)

Interactive Mode

If the application (for example, compiler or linker) is started with no input (that means no options and no input files), then the graphical user interface (GUI) is active (interactive mode). This is usually the case if the tool is started using the Explorer or using an Icon.

Batch Mode

If the tool is started with arguments (options and/or input files), then the tool is started in batch mode. Specify the following line associated with an icon on the desktop:

```
C:\Metrowerks\PROG\linker.exe -W2 fibo.prm
```

In batch mode, the tool does not open a window. It is displayed in the taskbar only for the time it processes the input, and terminates afterwards.

Because it is possible to start 32-bit applications from the command line (for example, DOS prompt under Windows NT/95/98), commands are entered to execute as shown below:

```
C:\> C:\Metrowerks\PROG\linker.exe -W2 fibo.prm
```

Message output (stdout) of a tool is redirected using the normal redirection operators (for example, '>' to write the message output to a file), as shown below:

```
C:\> C:\Metrowerks\PROG\linker.exe -W2 fibo.prm >
myoutput.txt
```

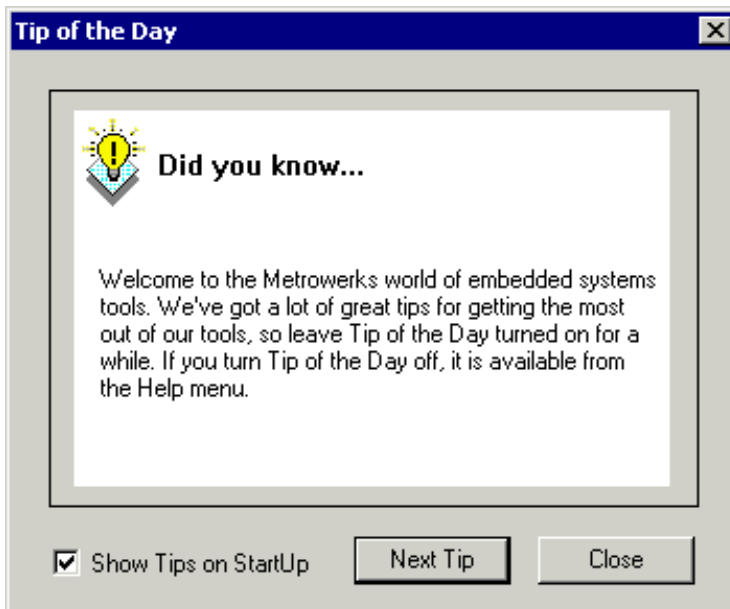
The command line process returns after starting the tool process. It does not wait until the started process has terminated. To start a process and wait for termination (for example, for synchronization), use the 'start' command under Windows NT/95/98, or use the '/wait' options (see windows help ('help start')):

```
C:\> start /wait C:\Metrowerks\PROG\linker.exe -W2 fibo.prm
```

Using 'start /wait' you can write perfect batch files (for example, to process your files).

Tip of the Day

When the application is started, a standard *Tip of the Day* window is opened containing the last news and tips.



The *Next Tip* button displays the next tip about the application.

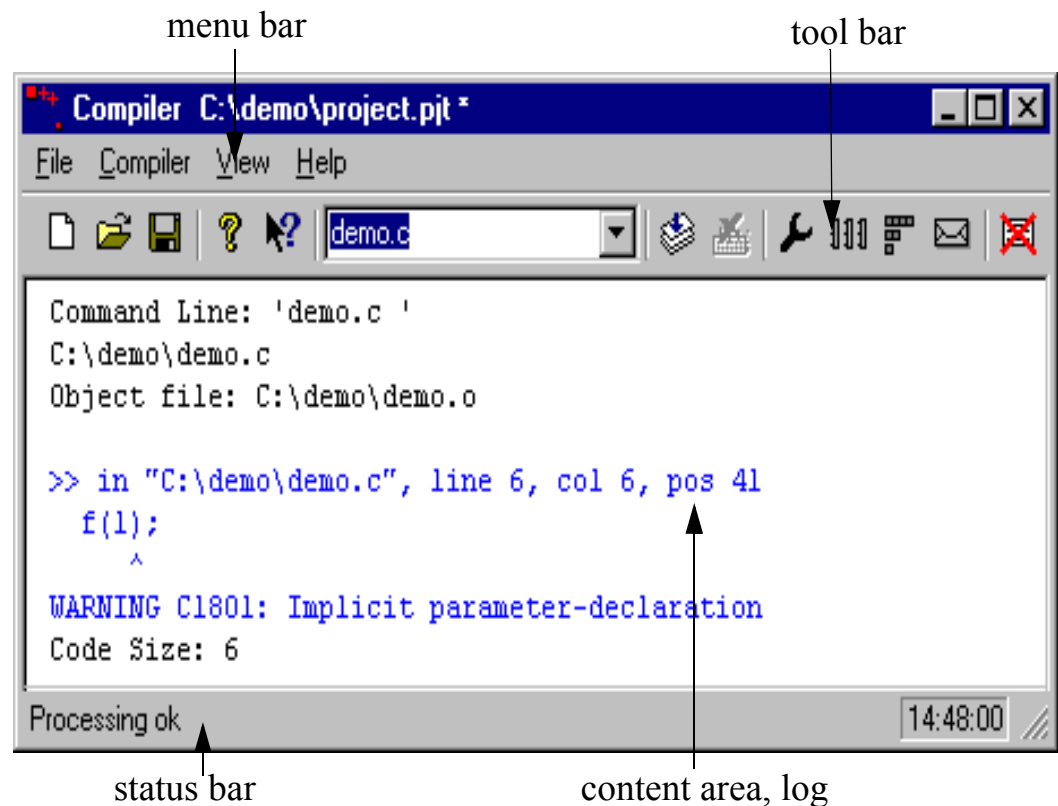
If it is not desired for the *Tip of the Day* window to open automatically when the application is started, uncheck the check box *Show Tips on StartUp*.

NOTE This configuration entry is stored in the local project file.

To enable automatic display from the standard *Tip of the Day* window when the application is started, select the entry *Help / Tip of the Day....* The *Tip of the Day* window will be open. Check the box *Show Tips on StartUp*.

Click *Close* to close the *Tip of the Day* window.

Main Window



This window is only visible on the screen when a file name is not specified while starting the application. The application window provides a window title, a menu bar, a tool bar, a content area, and a status bar.

Window Title

The window title displays the application name and the project name. If there is no project currently loaded, the “Default Configuration” is displayed. An asterisk (“*”) after the configuration name indicates if any values have been changed.

NOTE Changes to options, the editor configuration, and the application appearance can make the “*” appear.

Content Area

The content area is used as text container, where logging information about the process session is displayed. This logging information consists of:

- The name of the file being processed
- The whole names (including full path specifications) of the files processed (main C file and all files included)
- An error, warning and information message list
- The size of the code generated during the process session

When a file is dropped into the application window content area, the corresponding file is either loaded as configuration data, or processed. It is loaded as configuration data if the file has the extension “ini”. If the file does not contain this extension, the file is processed with the current option settings.

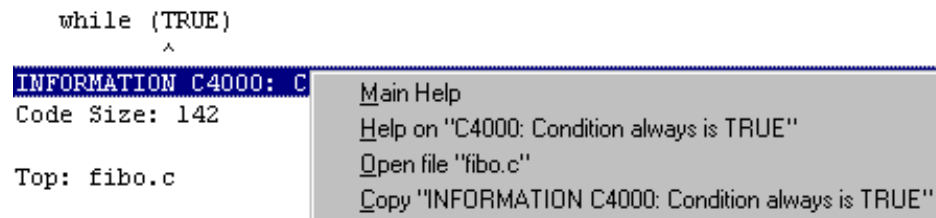
All text in the application window content area can contain context information. The context information consists of two items:

- A file name including a position inside of a file
- A message number

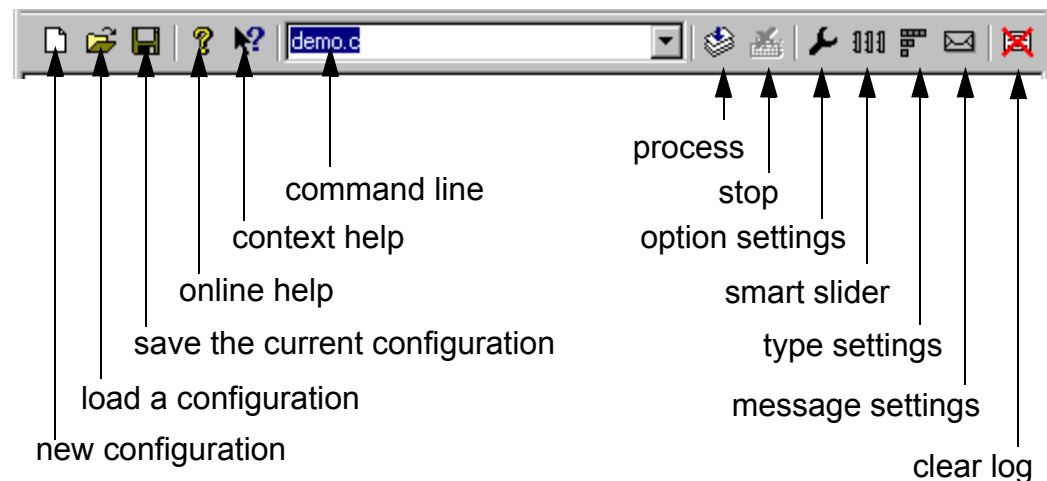
File context information is available for all output where a text file is considered. It is also available for all source and include files, and for messages which do concern a specific file. If a file context is available, double-clicking on the text or message opens this file in an editor, as specified in the editor configuration. The right mouse button can also be used to open a context menu. The context menu contains an “Open ...” entry if a file context is available. If a file can not be opened although a context menu entry is present, refer to the section [Editor Configuration](#).

The message number is available for any message output. There are three ways to open the corresponding entry in the help file.

- Select one line of the message and press F1.
If the selected line does not have a message number, the main help is displayed.
- Press Shift-F1 and then click on the message text.
If the point clicked at does not have a message number, the main help is displayed.
- Click with the right mouse at the message text and select “Help on ...”.
This entry is available only if a message number is available.

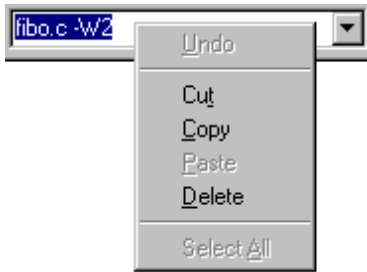


Tool Bar



The three buttons on the left are linked with the corresponding entries of the *File* menu. The next button opens the *About* dialog. After pressing the context help button (or the shortcut Shift F1), the mouse cursor changes its form and displays a question mark beside the arrow. The help file is called for the next item which is clicked. It is clicked on menus, toolbar buttons and on the window area to get help specific for the topic that is clicked on.

The command line history contains a list of the commands executed. Once a command is selected or entered in history, clicking *Process* starts the execution of the command. Use the keyboard shortcut key F2 to jump directly to the command line. Additionally there is a context menu associated with the command line:

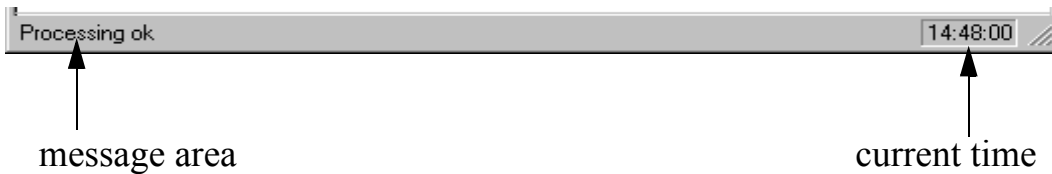


The *Stop* button enables stops the current process session.

The next four buttons open the option setting, the smart slider, type setting, and the message setting dialog.

The last button clears the content area.

Status Bar



When pointing to a button in the tool bar or a menu entry, the message area displays the function of the button or menu entry being pointed to.

Menu Bar



[Table 1.2](#) lists and describes the menus available in the menu bar:

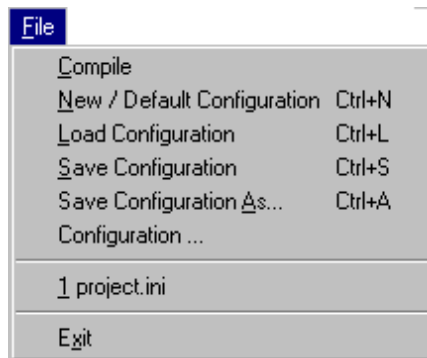
Table 1.2 Menus in the Menu Bar

Menu Entry	Description
File	Contains entries to manage application configuration files.
Compiler	Contains entries to set the application options.

Table 1.2 Menus in the Menu Bar

Menu Entry	Description
View	Contains entries to customize the application window output.
Help	A standard Windows Help menu.

File Menu



Save or load configuration files from the File Menu. A configuration file contains the following information:

- The application option settings specified in the application dialog boxes
- The Message settings that specify which messages to display and which messages to treat as error messages
- The list of the last command line executed and the current command line being executed
- The window position
- The Tips of the Day settings, including if enabled at startup and which is the current entry

[Configuration files](#) are text files, which use the standard extension `.ini`. A developer can define as many configuration files as required for a project. The developer can also switch between the different configuration files using the *File / Load Configuration* and *File / Save Configuration* menu entry or the corresponding tool bar buttons.

[Table 1.3](#) describes all commands that are available from the File Menu.

Table 1.3 File Menu Commands

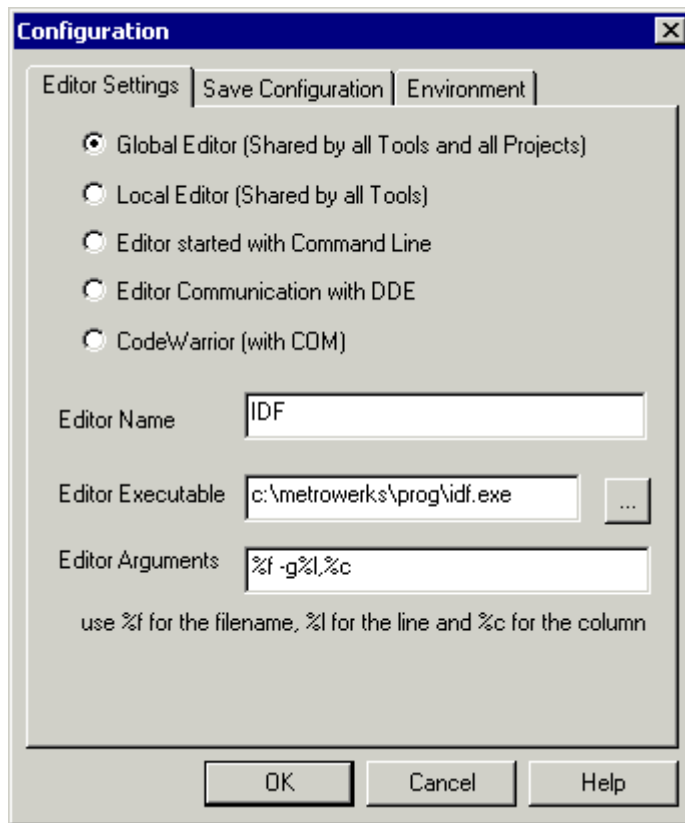
Menu entry	Description
Compile	Opens a standard Open File box. The configuration data stored in the selected file is loaded and will be used by a further session.
New/Default Configuration	Resets the application option settings to the default value. The application options which are activated per default are specified in section <i>Command Line Options</i> from this document
Load Configuration	Opens a standard Open File box. The configuration data stored in the selected file is loaded and will be used by a further session.
Save Configuration	Saves the current settings.
Save Configuration as...	Opens a standard Save As box. The current settings are saved in a configuration file which has the specified name.
Configuration...	Opens the <i>Configuration</i> dialog box to specify the editor used for error feedback and which parts to save with a configuration.
1. project.ini 2.	Recent project list. This list is accessed to open a recently opened project again.
Exit	Closes the application.

Edit Settings Dialog

The Editor Setting dialog has a main selection entry. Depending on the main type of editor selected, the content below changes.

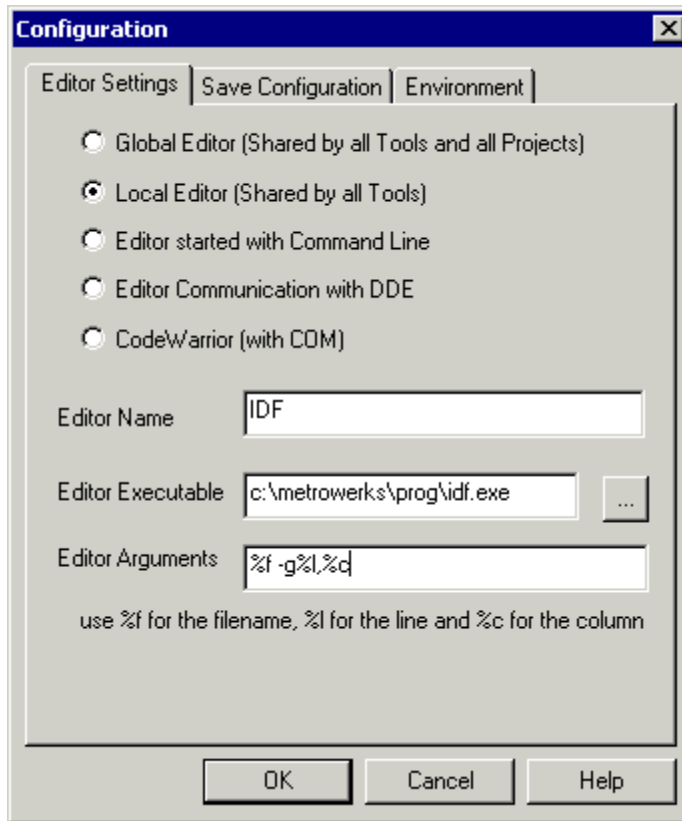
There main entries are described on the following pages.

- Global Editor



The Global Editor is shared among all tools and projects on one work station. It is stored in the global initialization file "MCUTOOLS.INI" in the "[Editor]" section. Some [Modifiers](#) are specified in the editor command line.

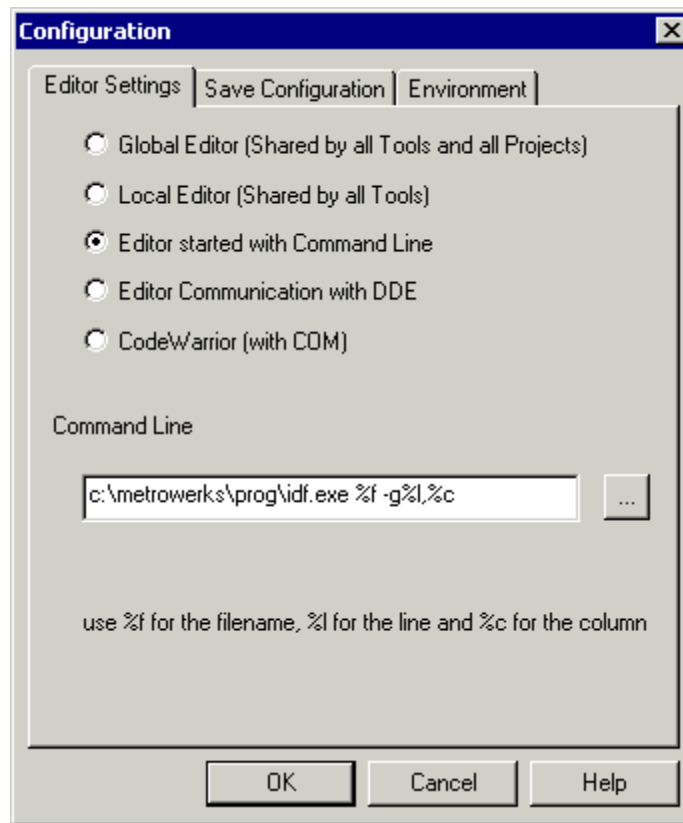
- Local Editor



The local editor is shared among all tools using the same project file. Some [Modifiers](#) are specified in the editor command line

Edit the Global and Local Editor configuration. However, when these entries are stored, the behavior of the other tools using the same entry also change when they are re-started.

- Editor started with Command Line



When this editor type is selected, a separate editor is associated with the application for error feedback. The configured editor is not used for error feedback.

Enter the command, that starts the editor.

The format of the editor command depends on the syntax. Some [Modifiers](#) are specified in the editor command line to refer to a file name or a line number (See the Modifiers section below).

The format of the editor command depends on the syntax that is used to start the editor.

Examples: (also look at the notes below)

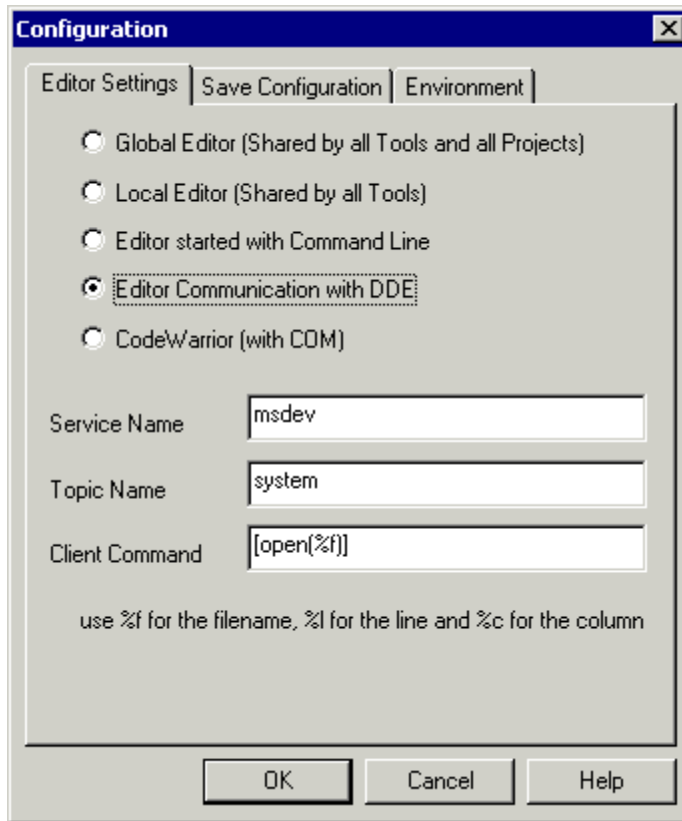
For Premia CodeWright V6.0 version use (with an adapted path to the cw32.exe file):

```
C:\Premia\cw32.exe %f -g%l
```

For Winedit 32 bit version use (with an adapted path to the winedit.exe file):

```
C:\WinEdit32\WinEdit.exe %f /#:%l
```

- Editor started with DDE



Enter the service, topic and client name for the DDE connection to the editor. The entries for Topic and ClientCommand can have modifiers for file name, line number and column number as explained below.

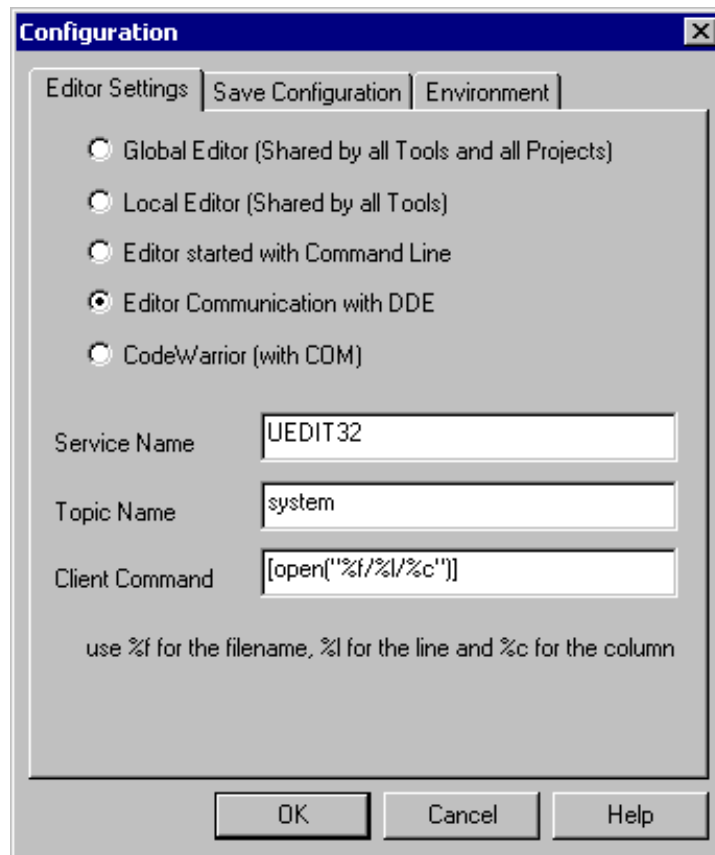
For Microsoft Developer Studio, use the following setting:

```
Service Name      : msdev
Topic Name        : system
ClientCommand     : [open(%f)]
```

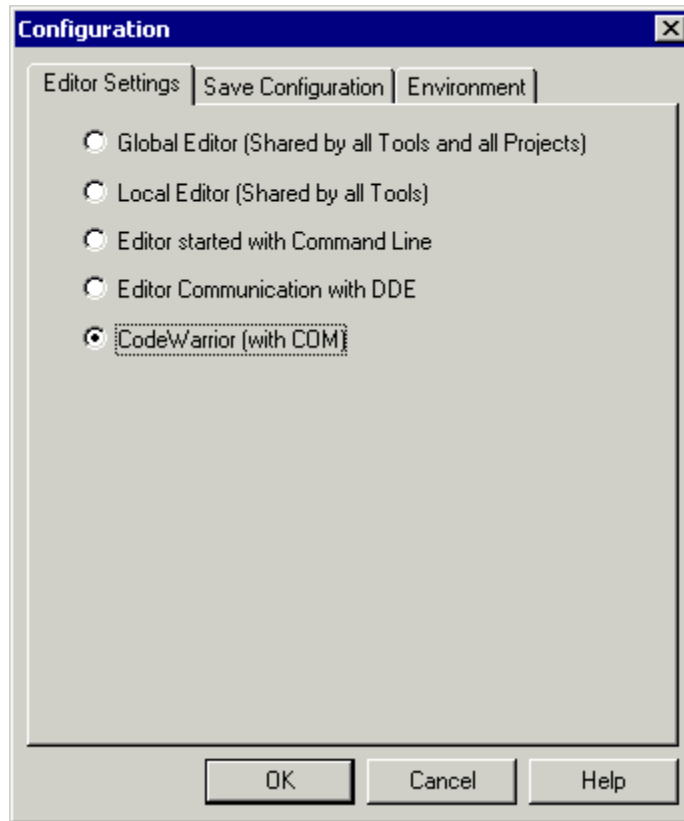
UltraEdit is a powerful shareware editor. It is available from www.idmcomp.com or www.ultraedit.com, email idm@idmcomp.com. The latest version of UltraEdit is also on the CD-ROM in the 'addons' directory. For UltraEdit use the following setting:

```
Service Name      : UEDIT32
Topic Name        : system
ClientCommand     : [open( "%f/%l/%c" )]
```

NOTE The DDE application (Microsoft Developer Studio, UltraEdit) has to be started, otherwise the DDE communication will fail.



- CodeWarrior with COM



If CodeWarrior with COM is enabled, the CodeWarrior IDE (registered as COM server by the installation script) is used as the editor.

Modifiers

The configuration must contain modifiers that instruct the editor which file to open and at which line.

- The `%f` modifier refers to the name of the file (including path) where the message has been detected.
- The `%l` modifier refers to the line number where the message has been detected.
- The `%c` modifier refers to the column number where the message has been detected.

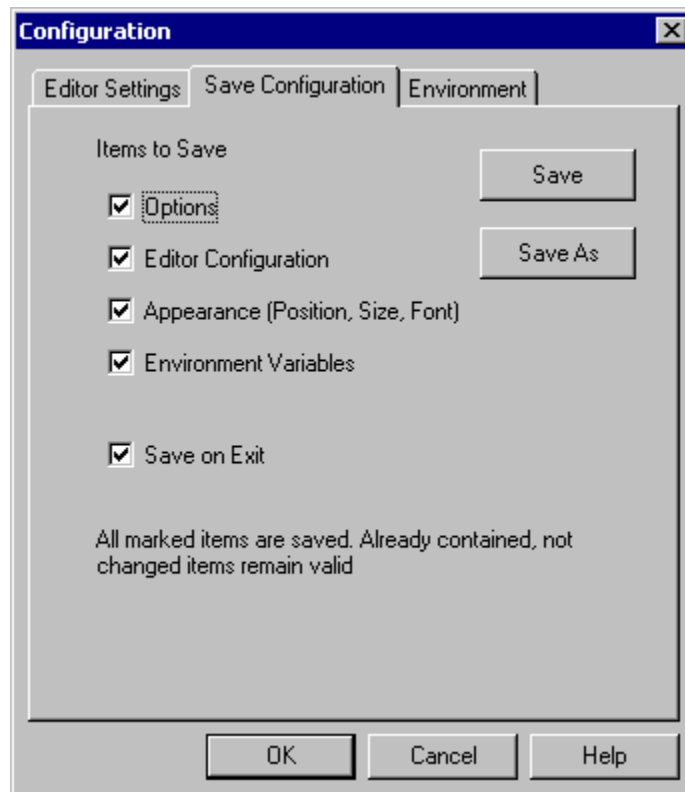
NOTE The `%l` modifier can only be used with an editor which is started with a line number as parameter. This is not the case for WinEdit version 3.1 or lower or for the Notepad. When working with such an editor, start it with the file name as parameter and then select the menu entry

'Go to' to jump on the line where the message has been detected. *In that case the editor command looks like:*

`C:\WINAPPS\WINEDIT\Winedit.EXE %f`

Please check the editor manual to define the command line which should be used to start the editor.

Save Configuration Dialog



All save options are located on the second page of the configuration dialog.

Use the In the Save Configuration dialog to configure which parts of your configuration will be stored into a project file.

This Save Configuration dialog offers the following options:

- Options

The current option and message setting is saved when a configuration is written. By disabling this option, the last saved content remains valid.

- Editor Configuration

The current editor setting is saved when a configuration is written. By disabling this option, the last saved content remains valid.

- Appearance

This saves topics consisting of many parts such as the window position (only loaded at startup time) and the command line content and history. These settings are saved when a configuration is written.

- *Environment Variables*

The environment variable changes done in the Environment property sheet are saved.

NOTE By disabling selective options only some parts of a [configuration file](#) are written. For example when the best options are found, the save option mark is removed. Then future save commands will not modify the options any more.

- Save on Exit

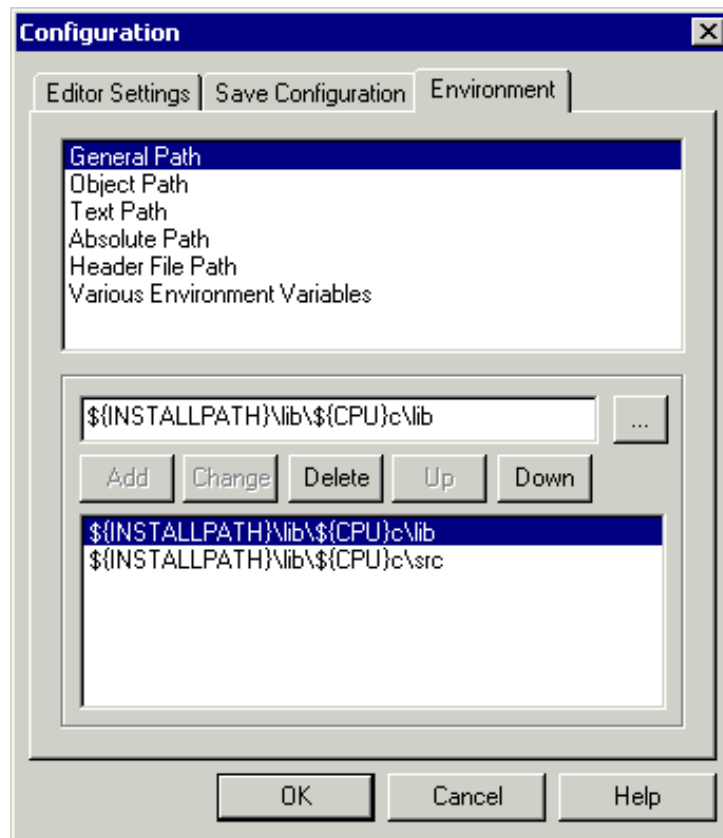
The application writes the configuration on exit. No question appears to confirm this operation. If this option is not set, the application will not write the configuration at exit, even if options or another part of the configuration have changed. No confirmation appears in either case when closing the application.

NOTE Almost all settings are stored in the [configuration file](#) only. The only exceptions are:

- The recently used configuration list.
- All settings in this dialog.

NOTE The application configurations can (and in fact are intended to) coexist in the same file as the project configuration of CodeWright. When an editor is configured by the shell, the application reads this content out of the project file, if present. The project configuration file of the shell is named project.ini. This file name is also suggested (but not mandatory) to the application.

Environment Configuration Dialog



This Environment Configuration dialog is used to configure the environment. The content of the dialog is read from the actual project file out of the section [Environment Variables]. The following variables are available:

General Path: GENPATH

Object Path: OBJPATH

Text Path: TEXTPATH

Absolute Path: ABSPATH

Header File Path: LIBPATH

Various Environment Variables: other variables not covered by the above list.

The following buttons are available:

Add: Adds a new line/entry

Change: changes a line/entry

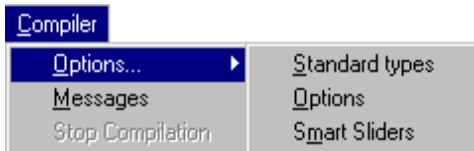
Delete: deletes a line/entry

Up: Moves a line/entry up

Down: Moves a line/entry down

The variables are written to the project file only if the Save Button is pressed (or use File->Save Configuration, or CTRL-S). Additionally, the environment is specified if it is to be written to the project in the Save Configuration dialog.

Compiler Menu

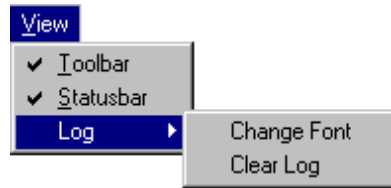


This menu enables the application to be customized. Application options are graphically set as well as defining the optimization level. [Table 1.4](#) defines the Compiler Menu options.

Table 1.4 Compiler Menu Options

Menu entry	Description
Options...	Allows you to customize the application. You can graphically set/reset options. Following entries are available when <i>Options...</i> is selected:
Standard Types	Allows you to specify the size you want to associate with each ANSI C standard type (See <i>Standard Types Dialog Box</i> below).
Advanced	Allows you to define the options which must be activated when processing an input file (See <i>Option Settings Dialog Box</i> below).
Smart Slider	Allows you to define the optimization level you want to reach, when processing the input file (See <i>Compiler Smart Control Dialog Box</i> below).
Messages	Opens a dialog box, where the different error, warning or information messages are mapped to another message class (See <i>Message Setting Dialog Box</i> below).
Stop Compilation	Stops immediately the current processing session.

View Menu

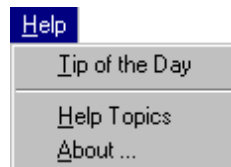


The View Menu enables you to customize the application window. You can define things such as displaying or hiding the status or tool bar. You can also define the font used in the window, or clear the window. [Table 1.5](#) lists the View Menu options.

Table 1.5 View Menu Options

Menu entry	Description
Tool Bar	Switches display from the tool bar in the application window.
Status Bar	Switches display from the status bar in the application window.
Log...	Allows you to customize the output in the application window content area. Following entries are available when <i>Log...</i> is selected:
Change Font	Opens a standard font selection box. The options selected in the font dialog box are applied to the application window content area.
Clear Log	Allows you to clear the application window content area.

Help Menu



The Help Menu enables you to either display or not display the Tip of the Day dialog application startup. Additionally, it provides a standard Windows Help entry and an entry to an About box. [Table 1.6](#) defines the Help Menu options.

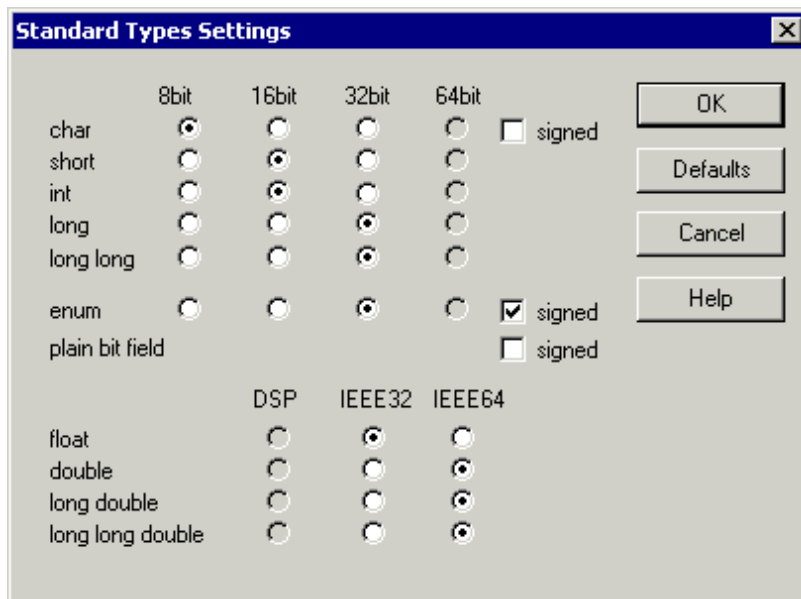
Table 1.6 Help Menu Options

Menu entry	Description
Tip of the Day	Switches on or off the display of a Tip of the Day during startup.

Table 1.6 Help Menu Options

Menu entry	Description
Help Topics	Standard Help topics.
About...	Displays an About box with some version and license information.

Standard Types Dialog Box



The Standard Types Dialog Box enables you to define the size you want to associate to each ANSI C standard type. You can also use the command line option `-T` to configure ANSI C standard type sizes.

NOTE Not all formats may be available for a target. Additionally there has to be at least one type for each size. For example, it is illegal to specify all types to a size of 32bits. There is no type for 8bit and 16bit available for the Compiler. Note that if the HIWARE Object File Format is used instead the ELF/DWARF Object File Format, the HIWARE Format does not support a size greater than 1 for the char type.

The following rules apply when you modify the size associated with an ANSI C standard type:

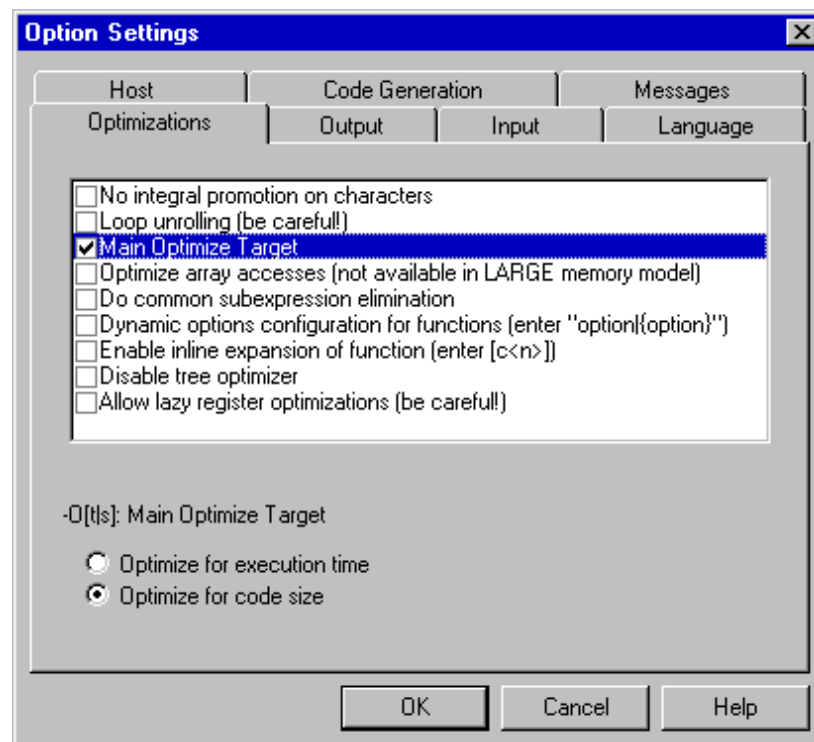
```
sizeof(char)  <= sizeof(short)
sizeof(short) <= sizeof(int)
sizeof(int)   <= sizeof(long)
sizeof(long)  <= sizeof(long long)
sizeof(float) <= sizeof(double)
sizeof(double)<= sizeof(long double)
```

Enumerations must be smaller or equal than 'int'.

The check box *signed* enables you to specify if type char must be considered as signed or unsigned for your application.

The button *Default* resets the size of the ANSI C standard types to their default values. The ANSI C standard type default values depend on the target processor.

Options Dialog Box



The Options Dialog Box enables you to set or reset application options. The possible command line option is also displayed in the lower display area. The available options

are arranged into different groups. A sheet is available for each of these groups. The content of the list box depends on the selected sheet (not all groups may be available). [Table 1.7](#) lists the Options Dialog Box selections.

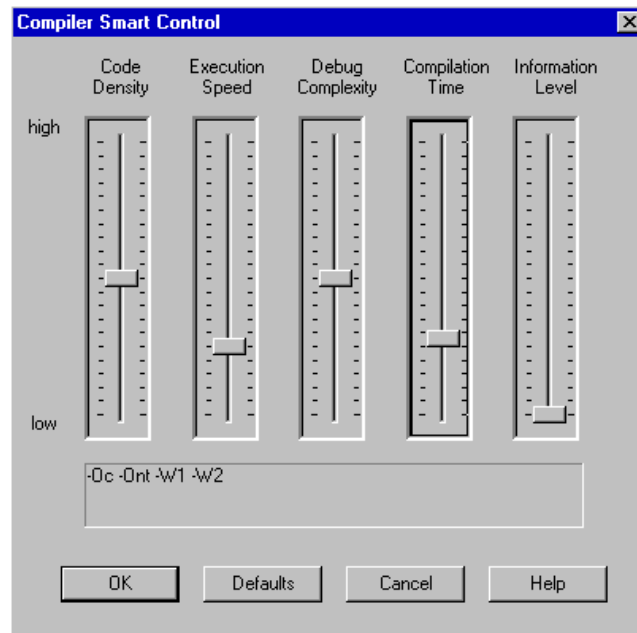
Table 1.7 Options Dialog Box Selections

Group	Description
Optimization	Lists optimization options.
Output	Lists options related to the output files generation (which kind of file should be generated).
Input	Lists options related to the input file.
Language	Lists options related to the programming language (ANSI C, C++)
Target	Lists options related to the target processor.
Host	Lists options related to the host operating system.
Code Generation	Lists options related to code generation (memory models, float format, ...).
Messages	Lists options controlling the generation of error messages.
Various	Lists options not related to the above options.

An application option is set when its check box is checked. To obtain a more detailed explanation about a specific option, select the option and press the F1 key or the help button. To select an option, click once on the option text. The option text is then displayed color-inverted. When the dialog is opened and no option is selected, pressing the key F1 or the help button shows the help for this dialog.

NOTE When options requiring additional parameters are selected, you can open an edit box or an additional sub window where the additional parameter is set. For example for the option ‘Write statistic output to file...’, available in the Output sheet.

Compiler Smart Control Dialog Box



The Compiler Smart Control Dialog Box enables you to define the optimization level you want to reach during compilation of the input file. Five sliders are available to define the optimization level. See [Table 1.8](#).

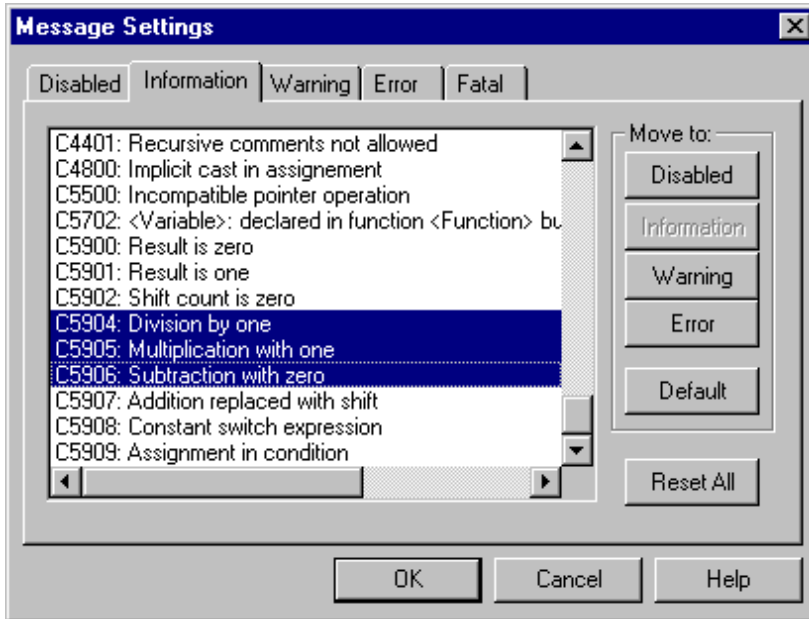
Table 1.8 Compiler Smart Control Dialog Box Controls

Slider	Description
Code Density	Displays the code density level expected, a high value indicates highest code efficiency (smallest code size).
Execution Speed	Displays the execution speed level expected, a high value indicates fastest execution of the code generated.
Debug Complexity	Displays the debug complexity level expected, a high value indicates complex debugging e.g. assembly code corresponds directly to the high level language code.
Compilation Time	Displays the compilation time level expected, a high value indicates long compilation time to produce the object file, e.g. due high optimization.
Information Level	Displays the level of information messages which is displayed during a Compiler session, a high value indicates a verbose behavior of the Compiler e.g. it will inform with warnings and information messages.

There is a direct link between the first four sliders in this window. When you move one slider, the positions of the other three are updated according to the modification.

The command line is automatically updated with the options set in accordance with the settings of the different sliders.

Message Settings Dialog Box



The Message Settings Dialog Box enables you to map messages to a different message class.

Some buttons in the dialog may be disabled (e.g. if an option cannot be moved to an Information message, the ‘Move to: Information’ button is disabled). [Table 1.9](#) lists and describes the buttons available in this dialog.

Table 1.9 Message Settings Dialog Box Buttons

Button	Description
Move to: Disabled	The messages selected will be disabled. The message will not occur any longer.
Move to: Information	The messages selected will be changed to information messages.
Move to: Warning	The messages selected will be changed to warning messages.
Move to: Error	The messages selected will be changed to error messages.

Table 1.9 Message Settings Dialog Box Buttons

Button	Description
Move to: Default	The messages selected will be changed to their default message kind.
Reset All	Resets all messages to their default message kind.
Ok	Exits this dialog and accepts the changes made.
Cancel	Exits this dialog without accepting the changes made.
Help	Displays online help about this dialog.

A sheet is available for each error message class. The content of the list box depends on the selected sheet:

Table 1.10 Message Group Definitions

Message group	Description
Disabled	Lists all disabled messages. That means messages displayed in the list box will not be displayed by the application.
Information	Lists all information messages. Information messages informs about action taken by the application.
Warning	Lists all warning messages. When a warning message is generated, processing of the input file continues.
Error	Lists all error messages. When an error message is generated, processing of the input file continues.
Fatal	Lists all fatal error messages. When fatal error message is generated, processing of the input file stops immediately. Fatal messages can not be changed and are only listed to call context help.

Each message has its own character (e.g. 'C' for Compiler message, 'A' for Compiler messages, 'L' for Linker messages, 'M' for Maker messages, 'LM' for Libmaker messages) followed by a 4-5 digit number. This number allows an easy search for the message both in the manual or on-line help.

Changing the Class Associated with a Message

You can configure your own mapping of messages in the different classes. In that purpose you can use one of the buttons located on the right hand of the dialog box. Each button refers to a message class. To change the class associated with a message,

you have to select the message in the list box and then click the button associated with the class where you want to move the message.

Example:

To define a warning message as an error message:

1. Click the *Warning* sheet, to display the list of all warning messages in the list box.
2. Click on the message you want to change in the list box to select the message.
3. Click *Error* to define this message as an error message.

NOTE Messages cannot be moved to or from the fatal error class.

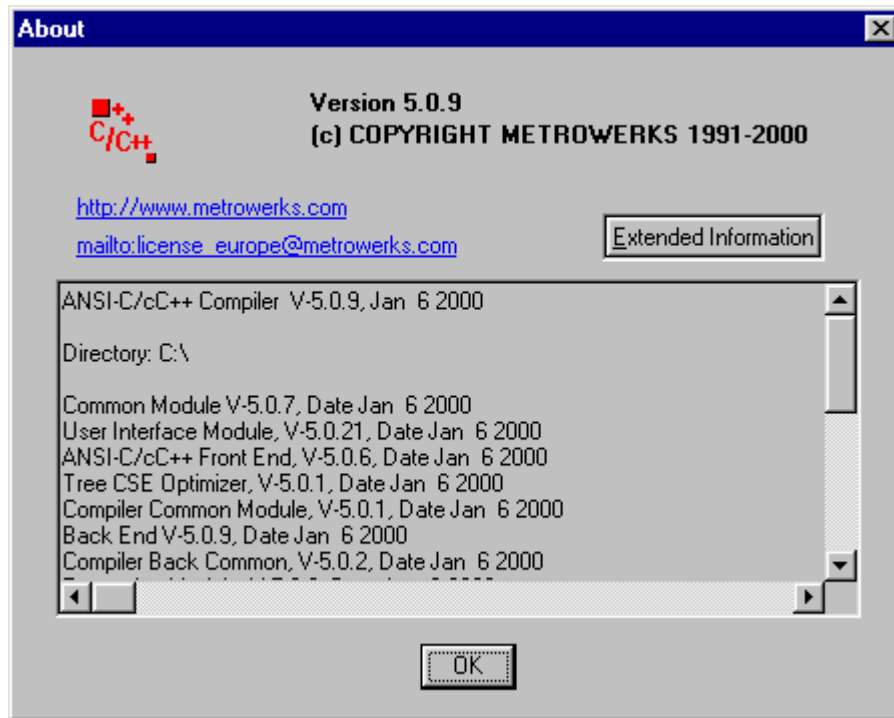
NOTE The 'move to' buttons are active only when messages that can be moved are selected. When one message is marked which can not be moved to a specific group, the corresponding 'move to' button is disabled (grayed).

If you want to validate the modification you have performed in the error message mapping, close the 'Message settings' dialog box using the 'OK' button. If you close it using the 'Cancel' button, the previous message mapping remains valid.

Retrieving Information About an Error Message

You can access information about each message displayed in the list box. Select the message in the list box and then click *Help* or the F1 key. An information box is opened. The information box contains a more detailed description of the error message, as well as a small example of code that may have generated the error message. If several messages are selected, a help for the first is shown. When no message is selected, pressing the F1 key or the help button shows the help for this dialog.

About Box



The About box is opened by selecting Help->About. The About box contains information regarding your application. The current directory and the versions of subparts of the application are also shown. The main version is displayed separately on top of the dialog.

Use the 'Extended Information' button to get license information about all software components in the same directory as that of the executable file.

Click OK to close this dialog.

NOTE During processing, the sub-versions of the application parts can not be requested. They are only displayed if the application is inactive.

Specifying the Input File

There are different ways to specify the input file. During the compilation, the options will be set according to the configuration established in the different dialog boxes.

Before starting to compile a file make sure you have associated a working directory with your editor.

Use the Command Line in the Tool Bar to Compile

Compiling a New File

A new file name and additional Compiler options are entered in the command line. The specified file will be compiled as soon as the button *Compile* in the tool bar is selected or the enter key is pressed.

Compiling a File which has already been compiled

The previously executed command is displayed using the arrow on the right side of the command line. A command is selected by clicking on it. It appears in the command line. The specified file is compiled as soon as the *Compile* button in the tool bar is clicked.

Use the Entry File - Compile...

When the menu entry *File / Compile...* is selected, a standard open file box is displayed. Use this to locate the file you want to compile. The selected file is compiled as soon as the standard open file box is closed using the *OK* button.

Use Drag and Drop

A file name is dragged from an external application (for example the File Manager/ Explorer) and dropped into the Compiler window. The dropped file is compiled as soon as the mouse button is released in the Compiler window. If a file being dragged has the extension “ini”, it is considered to be a configuration and it is immediately loaded and not compiled. To compile a C file with the extension “ini”, use one of the other methods to compile it.

Message/Error Feedback

There are several ways to check where different errors or warnings have been detected after compilation. The format of the error message is:

```
>> <FileName>, line <line number>, col <column number>, pos  
<absolute position in file>  
<Portion of code generating the problem>  
<message class><message number>: <Message string>
```

Example

```
>> in "C:\DEMO\fibo.c", line 30, col 10, pos 428
    EnableInterrupts
    WHILE (TRUE) {
        (
    INFORMATION C4000: Condition always TRUE
```

See also Compiler options [-WmsgFi](#) and [-WmsgFb](#) for different message formats.

Use Information from the Compiler Window

Once a file has been compiled, the Compiler window content area displays the list of all the errors or warnings that were detected.

Use your usual editor to open the source file and correct the errors.

Use a User-Defined Editor

You must first configure the editor you want to use for message/error feedback in the *Configuration* dialog box, before you begin the compile process. Once a file has been compiled, double-click on an error message. The selected editor is automatically activated and points to the line containing the error.

Environment

This section describes all environment variables. Some environment variables are also used by other tools (e.g. Linker/Assembler). Consult the respective manual for more information.

Parameters are set in an environment using environment variables. There are three ways to specify your environment:

1. The current project file with the section [Environment Variables]. This file may be specified on Tool startup using the [-Prod](#) option.
2. An optional 'default.env' file in the current directory. This file is supported for backwards compatibility. The file name is specified using the [ENVIRONMENT](#) variable. Using the default.env file is not recommended.
3. Setting environment variables on system level (DOS level). This is not recommended.

The syntax is:

```
Parameter = KeyName "=" ParamDef.
```

NOTE *Normally no* blanks are allowed in the definition of an environment variable.

Example:

```
GENPATH=C:\INSTALL\LIB;D:\PROJECTS\TESTS;/usr/local/lib;  
/home/me/my_project
```

Parameters may be defined in several ways:

- Using system environment variables supported by your operating system.
- Putting the definitions into the actual project file in the section named [Environment Variables].
- Putting the definitions in a file called DEFAULT.ENV in the default directory.

NOTE The maximum length of environment variable entries in the DEFAULT.ENV is 4096 characters.

- Putting the definitions in a file given by the value of the system environment variable ENVIRONMENT.

NOTE The default directory mentioned above is set using the system environment variable [DEFAULTDIR](#).

When looking for an environment variable, all programs first search the system environment, then the DEFAULT.ENV file, and finally the global environment file defined by ENVIRONMENT. If no definition is found, a default value is assumed.

NOTE The environment may also be changed using the [-Env](#) option.

NOTE Ensure there are no spaces at the end of any environment variable declaration.

The Current Directory

The most important environment for all tools is the current directory. The current directory is the base search directory where the tool starts to search for files (e.g. for the DEFAULT.ENV)

The current directory of a tool is determined by the operating system, or by the program which launches another one.

For the UNIX operating system, the current directory of an launched executable is also the current directory from where the binary file has been started.

- For MS Windows based operating systems, the current directory definition is defined as follows:
- If the tool is launched using a File Manager/Explorer, the current directory is the location of the launched executable.
- If the tool is launched using an Icon on the Desktop, the current directory is the one specified and associated with the Icon.
- If the tool is launched by dragging a file on the icon of the executable under Windows 95 or Windows NT 4.0, the desktop is the current directory.
- If the tool is launched by another launching tool with its own current directory specification (e.g. an editor), the current directory is the one specified by the launching tool (e.g. current directory definition).
- For the tools, the current directory is where the local project file is located. Changing the current project file also changes the current directory, if the other project file is in a different directory. Note that browsing for a C file does not change the current directory.

To overwrite this behavior, use the [DEFAULTDIR](#) environment variable.

The current directory is displayed, with other information, using the option “[-V](#)” and in the About box.

Environment Macros

You can use macros in your environment settings.

Example:

```
MyVAR=C:\test
TEXTPATH=$(MyVAR)\txt
OBJPATH=${MyVAR}\obj
```

In the example above, TEXTPATH is expanded to ‘C:\test\txt’ and OBJPATH is expanded to ‘C:\test\obj’. You can use \$() or \${ }. However, the referenced variable must be defined.

Special variables are also allowed (special variables are always surrounded by { } and they are case sensitive). Additionally the variable content contains a the directory separator ‘\’. The special variables are:

- {Compiler}

That is the path of the executable one directory level up if the executable is ‘c:\metrowerks\prog\linker.exe’, and the variable is ‘c:\metrowerks\’.

- {Project}

Path of the current project file. This is used if the current project file is ‘C:\demo\project.ini’, and the variable contains ‘C:\demo\’.

- {System}

This is the path where your Windows system is installed, e.g. ‘C:\WINNT\’.

Global Initialization File (MCUTOOLS.INI) (PC only)

All tools store some global data into the file MCUTOOLS.INI. The tool first searches for the MCUTOOLS.INI file in the directory of the tool itself (path of the executable). If there is no MCUTOOLS.INI file in this directory, the tool looks for a MCUTOOLS.INI file in the MS Windows installation directory (e.g. C:\WINDOWS).

Example:

```
C:\WINDOWS\MCUTOOLS.INI
```

```
D:\INSTALL\PROG\MCUTOOLS.INI
```

If a tool is started in the `D:\INSTALL\PROG\DIRECTORY`, the project file located in the same directory as the tool is used (`D:\INSTALL\PROG\MCUTOOLS.INI`).

If the tool is started outside the `D:\INSTALL\PROG` directory, the project file in the Windows directory is used (`C:\WINDOWS\MCUTOOLS.INI`).

[“Global Configuration File Entries” on page 1025](#) documents the sections and entries you can include in the `MCUTOOLS.INI` file.

Local Configuration File (usually `project.ini`)

The compiler only reads the `default.env`. All the configuration properties are stored in the configuration file. The same configuration file is used by different applications.

The shell uses the configuration file with the name “`project.ini`” in the current directory only. When the shell uses the same file as the compiler, the editor configuration is written and maintained by the shell and is used by the compiler. Apart from this, the compiler can use any file name for the project file. The configuration file has the same format as the `windows.ini` files. The compiler stores its own entries with the same section name as those in the global `mcutools.ini` file. The compiler backend is encoded into the section name, so that a different compiler backend can use the same file without any overlapping. Different versions of the same compiler use the same entries. This plays a role when options, only available in one version, must be stored in the configuration file. In such situations, two files must be maintained for each different compiler version. If no incompatible options are enabled when the file is last saved, the same file may be used for both compiler versions.

The current directory is always the directory where the configuration file is located. If a configuration file in a different directory is loaded, the current directory also changes. When the current directory changes, the entire `default.env` file is reloaded. When a configuration file is loaded or stored, the options in the environment variable `COMPOPTIONS` are reloaded and added to the project options. This behavior is noticed when in different `default.env` files exist in different directories, each containing incompatible options in the `COMPOPTIONS` variable.

When a project is loaded using the first `default.env`, its `COMPOPTIONS` are added to the configuration file. If this configuration is stored in a different directory

where a `default.env` exists with incompatible options, the compiler adds options and remarks the inconsistency. A message box appears to inform you that the `default.env` options were not added. You can either remove the option from the configuration file with the option settings dialog. You can also remove the option from the `default.env` with the shell or a text editor, depending which options will be used in the future.

At startup, there are two ways to load a configuration:

- Use the command line option [-Prod](#)
- The file `project.ini` in the current directory

If the [-Prod](#) option is used, the current directory is the directory the project file is in. If the [-Prod](#) option is used with a directory, the `project.ini` file in this directory is loaded.

[“Local Configuration File Entries” on page 1033](#) documents the sections and entries you can include in a `project.ini` file.

Paths

Most environment variables contain path lists directing where to look for files. A path list is a list of directory names separated by semicolons. Path names are declared using the following syntax:

```
PathList = DirSpec {";" DirSpec}.
DirSpec  = ["*"] DirectoryName.
```

Example:

```
GENPATH=C:\INSTALL\LIB;D:\PROJECTS\TESTS;/usr/local/lib;/
home/me/my_project
```

If a directory name is preceded by an asterisk ("`*`"), the programs recursively search that entire directory tree for a file, not just the given directory itself. The directories are searched in the order they appear in the path list.

Example:

```
LIBPATH=*C:\INSTALL\LIB
```

NOTE Some DOS environment variables (like `GENPATH`, `LIBPATH`, etc.) are used.

If you work with CodeWright, you can set the environment using a `<project>.pjt` file in your project directory. This enables you to have different projects in different directories, each with its own environment.

NOTE When using WinEdit, do *not* set the system environment variable [DEFAULTDIR](#). If you do so, and this variable does not contain the project directory given in WinEdit's project configuration, files might not be placed where you expect them to.

Line Continuation

It is possible to specify an environment variable in an environment file (default.env) over different lines using the line continuation character '\

Example:

```
OPTIONS=\
-W2 \
-Wpd
```

This is the same as

```
OPTIONS=-W2 -Wpd
```

But this feature may not work well using it together with paths, e.g.

```
GENPATH=.\
TEXTFILE=.\txt
```

will result in

```
GENPATH= .TEXTFILE=.\txt
```

To avoid such problems, use a semicolon';' at the end of a path if there is a '\

```
GENPATH=.\;
TEXTFILE=.\txt
```

Environment Variable Details

The remainder of this section describes each of the available environment variables. [Table 1.11](#) lists these options in alphabetical order. Each is divided into several sections.

Table 1.11 Environment Variables—Documentation Topics

Topic	Description
Tools	Lists tools that use this variable
Synonym	A synonym exists for some environment variables. Those synonyms may be used for older releases of the Compiler and will be removed in the future. A synonym has lower precedence than the environment variable.
Syntax	Specifies the syntax of the option in a EBNF format.
Arguments	Describes and lists optional and required arguments for the variable.
Default	Shows the default setting for the variable or none.
Description	Provides a detailed description of the option and how to use it.
Example	Gives an example of usage, and the effects of the variable where possible. The examples shows an entry in the default.env for PC.
See also	Names related sections.

COMPOPTIONS: Default Compiler Options

Tools

Compiler

Synonym

HICOMPOPTIONS

Syntax

"COMPOPTIONS=" {<option>}

Arguments

<option>: Compiler command line option

Default

None

Description

If this environment variable is set, the Compiler appends its contents to its command line each time a file is compiled. It is used to globally specify options that should always be set. This frees you from having to specify them at every compilation.

NOTE	It is not recommended to use this environment variable if the Compiler is used (V5.x), because the Compiler adds the options specified in the COMPOPTIONS variable to the options stored in the project.ini.
-------------	--

Example

```
COMPOPTIONS=-W2 -Wpd
```

See also

[Compiler options](#)

COPYRIGHT: Copyright Entry in Object File

Tools

Compiler, Assembler, Linker, Librarian

Synonym

None

Syntax

"COPYRIGHT=" <copyright>

Arguments

<copyright>: copyright entry

Default

None

Description

Each object file contains an entry for a copyright string. This information is retrieved from the object files using the decoder.

Example

COPYRIGHT=Copyright by Metrowerks

See also

[Environment variable USERNAME](#)

[Environment variable INCLUDETIME](#)

DEFAULTDIR: Default Current Directory

PC

Tools

Compiler, Assembler, Linker, Decoder, Debugger, Librarian, Maker, Burner

Synonym

None

Syntax

"DEFAULTDIR=" <directory>

Arguments

<directory>: Directory to be the default current directory

Default

None

Description

Specifies the default directory for all tools. All the tools indicated above will take the specified directory as their current directory instead of the one defined by the operating system or launching tool (e.g. editor).

NOTE This is an environment variable on a system level (global environment variable). It can not be specified in a default environment file (DEFAULT.ENV).

Example

```
DEFAULTDIR=C:\INSTALL\PROJECT
```

See also

[Section 'The Current Directory'](#)

[Section MCUTOOLS.INI File](#)

ENVIRONMENT: Environment File Specification

PC

Tools

Compiler, Linker, Decoder, Debugger, Librarian, Maker, Burner

Synonym

HIENVIRONMENT

Syntax

"ENVIRONMENT=" <file>

Arguments

<file>: file name with path specification, without spaces

Default

None

Description

This variable is specified on a system level. The application looks in the [current directory](#) for a environment file named default.env. Using ENVIRONMENT (e.g. set in the autoexec.bat (DOS) or .cshrc (UNIX)), a different file name may be specified.

NOTE This is an environment variable on a system level (global environment variable). It can not be specified in a default environment file (DEFAULT.ENV).

Example

```
ENVIRONMENT=\Metrowerks\prog\global.env
```

See also

None

ERRORFILE: Error File Name Specification

Tools

Compiler, Assembler, Linker, Burner

Synonym

None

Syntax

"ERRORFILE=" <file name>

Arguments

<file name>: File name with possible format specifiers

Description

The ERRORFILE environment variable specifies the name for the error file.

Possible format specifiers are:

'%n': Substitute with the file name, without the path.

'%p': Substitute with the path of the source file.

'%f': Substitute with the full file name, i.e. with the path and name (the same as '%p%n').

A notification box is shown in the event of an illegal error file name.

Example

```
ERRORFILE=MyErrors.err
```

Lists all errors into the file MyErrors.err in the current directory.

```
ERRORFILE=\tmp\errors
```

Lists all errors into the file errors in the directory \tmp.

```
ERRORFILE=%f.err
```

Lists all errors into a file with the same name as the source file, but with extension .err, into the same directory as the source file. If you compile a file such as \sources\test.c, an error list file, \sources\test.err, is generated.

```
ERRORFILE=\dir1\%n.err
```

For a source file such as test.c, an error list file \dir1\test.err is generated.

```
ERRORFILE=%p\errors.txt
```

For a source file such as \dir1\dir2\test.c, an error list file \dir1\dir2\errors.txt is generated.

If the environment variable ERRORFILE is not set, the errors are written to the file EDOUT in the current directory.

Example

Another example shows the usage of this variable to support correct error feedback with the WinEdit Editor. The editor looks for an error file named EDOUT, as shown:

```
Installation directory: E:\INSTALL\PROG
```

```
Project sources: D:\MEPHISTO
```

```
Common Sources for projects: E:\CLIB
```

```
Entry in default.env (D:\MEPHISTO\DEFAULT.ENV):
```

```
ERRORFILE=E:\INSTALL\PROG\EDOUT
```

```
Entry in WINEDIT.INI (in Windows directory):
```

```
OUTPUT=E:\INSTALL\PROG\EDOUT
```

NOTE	Be careful to set this variable if the WinEdit Editor is use, otherwise the editor cannot find the EDOUT file.
-------------	--

See also

None

GENPATH: #include “File” Path

Tools

Compiler, Linker, Decoder, Debugger, Burner

Synonym

HIPATH

Syntax

```
"GENPATH=" {<path>}
```

Arguments

<path>: Paths separated by semicolons, without spaces

Default

Current directory

Description

If a header file is included with double quotes, the Compiler searches first in the current directory, then in the directories listed by GENPATH, and finally in the directories listed by [LIBPATH](#).

NOTE	If a directory specification in this environment variable starts with an asterisk (“*”), the whole directory tree is searched recursively depth first, i.e. all subdirectories and <i>their</i> subdirectories and so on are searched. Search order of the subdirectories is indeterminate within one level in the tree.
-------------	--

Example

```
GENPATH=\sources\include;..\..\headers;\usr\local\lib
```

See also

[Environment variable LIBPATH](#)

INCLUDETIME: Creation Time in Object File

Tools

Compiler, Assembler, Linker, Librarian

Synonym

None

Syntax

"INCLUDETIME=" ("ON" | "OFF")

Arguments

"ON": Include time information into object file

"OFF": Do not include time information into object file

Default

"ON"

Description

Each object file contains a time stamp indicating the creation time and data as strings. Whenever a new file is created by one of the tools, the new file gets a new time stamp entry.

This behavior may be undesired if (for Software Quality Assurance reasons) a binary file compare has to be performed. Even if the information in two object files is the same, the files do not match exactly as the time stamps are not identical. To avoid such problems, set this variable to OFF. In this case, the time stamp strings in the object file for date and time are “none” in the object file.

The time stamp is retrieved from the object files using the decoder.

Example

```
INCLUDETIME=OFF
```

See also

[Environment variable COPYRIGHT](#)

[Environment variable USERNAME](#)

LIBRARYPATH: 'include <File>' Path

Tools

Compiler, ELF tools (Burner, Linker, Decoder)

Synonym

LIBPATH

Syntax

```
"LIBRARYPATH=" {<path>}
```

Arguments

<path>: Paths separated by semicolons, without spaces

Default

Current directory

Description

If a header file is included with double quotes, the Compiler searches first in the current directory, then in the directories given by [GENPATH](#) and finally in the directories given by LIBRARYPATH.

NOTE	If a directory specification in this environment variable starts with an asterisk ("*"), the whole directory tree is searched recursively depth first, i.e. all subdirectories and <i>their</i> subdirectories and so on are searched. Search order of the subdirectories is indeterminate within one level in the tree.
-------------	--

Example

```
LIBRARYPATH=\sources\include;..\headers;\usr\local\lib
```

See also

[Environment variable GENPATH](#)

[Environment variable USELIBPATH](#)

[Section "Input Files"](#)

OBJPATH: Object File Path

Tools

Compiler, Linker, Decoder, Debugger, Burner

Synonym

None

Syntax

"OBJPATH=" <path>

Default

Current directory

Arguments

<path>: Path without spaces

Description

If the Compiler generates an object file, the object file is placed into the directory specified by OBJPATH. If this environment variable is empty or does not exist, the object file is stored into the path where the source has been found.

If the Compiler tries to generate an object file specified in the path specified by this environment variable but fails (e.g. because the file is locked), the Compiler will issue an error message.

If a tool looks for an object file (e.g. the Linker), it first checks for an object file specified by this environment variable, then in [GENPATH](#), and finally in HIPATH.

Example

```
OBJPATH=\sources\obj
```

See also

[Section “Output Files”](#)

TEXTPATH: Text File Path

Tools

Compiler, Linker, Decoder

Synonym

None

Syntax

"TEXTPATH=" <path>

Arguments

<path>: Path without spaces

Default

Current directory

Description

If the Compiler generates a textual file, the file is placed into the directory specified by TEXTPATH. If this environment variable is empty or does not exist, the text file is stored into the current directory.

Example

```
TEXTPATH=\sources\txt
```

See also

[Section "Output Files"](#)

[Compiler option -Ll](#)

[Compiler option -Lm](#)

[Compiler option -Lo](#)

TMP: Temporary Directory

PC

Tools

Compiler, Assembler, Linker, Debugger, Librarian

Synonym

None

Syntax

"TMP=" <directory>

Arguments

<directory>: Directory to be used for temporary files

Default

None

Description

If a temporary file must be created, the ANSI function, `tmpnam()`, is used. This library function stores the temporary files created in the directory specified by this environment variable. If the variable is empty or does not exist, the current directory is used. Check this variable if you get the error message "Cannot create temporary file".

NOTE This is an environment variable on a system level (global environment variable). It can not be specified in a default environment file (DEFAULT.ENV).

Example

```
TMP=C:\TEMP
```

See also

[Section 'The Current Directory'](#)

USELIBPATH: Using LIBPATH Environment Variable

Tools

Compiler, Linker, Debugger

Synonym

None

Syntax

"USELIBPATH=" ("OFF" | "ON" | "NO" | "YES").

Arguments

"ON", "YES": The environment variable [LIBPATH](#) is used by the Compiler to look for system header files <*.h>.

"NO", "OFF": The environment variable [LIBPATH](#) is not used by the Compiler.

Default

ON

Description

This environment variable allows a flexible usage of the [LIBPATH](#) environment variable as the [LIBPATH](#) variable might be used by other software (e.g. version management PVCS).

Example

```
USELIBPATH=ON
```

See also

[Environment variable LIBPATH](#)

USERNAME: User Name in Object File

Tools

Compiler, Assembler, Linker, Librarian

Synonym

None

Syntax

"USERNAME=" <user>

Arguments

<user>: Name of user

Default

None

Description

Each object file contains an entry identifying the user who created the object file. This information is retrievable from the object files using the decoder.

Example

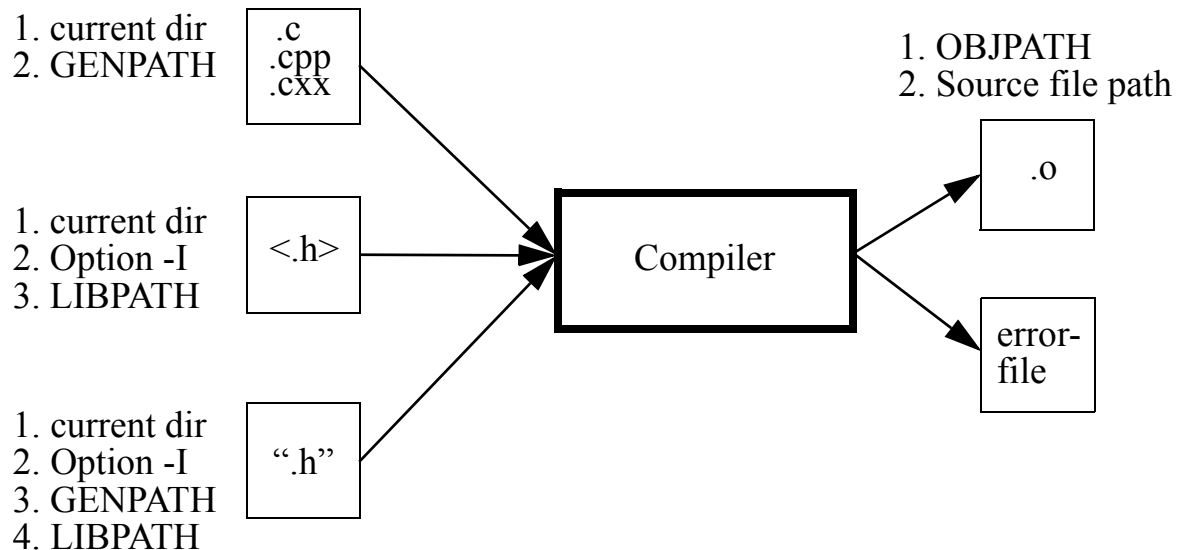
USERNAME=The Master

See also

[Environment variable COPYRIGHT](#)
[Environment variable INCLUDETIME](#)

Files

The following figure shows how file processing occurs with the Compiler:



Input Files

Source Files

The front end takes any file as input. It does not require the file name to have a special extension. However, it is suggested that all your source file names have the `.c` extension, and all header files the `.h` extension. The C++ files normally have the extension `.cpp` or `.cxx`. Source files are searched first in the [current directory](#) and then in the [GENPATH](#) directory.

Include File

The search for include files is governed by two environment variables: [GENPATH](#) and [LIBRARYPATH](#). Include files that are included using double quotes as in

```
#include "test.h"
```

are searched first in the directory specified by the [-I option](#), then in the current directory, then in the directories given in the environment variable [GENPATH](#), and finally in those listed in [LIBPATH](#) or [LIBRARYPATH](#). The current directory is set using the IDE, the Program Manager, or the [DEFAULTDIR](#) environment variable.

Include files that are included using angular brackets as in

```
#include <stdio.h>
```

are searched for first in the current directory, then in the directory specified by the `-I` option, and then in the directories given in [LIBPATH](#) or [LIBRARYPATH](#). The current directory is set using the IDE, the Program Manager, or the environment variable [DEFAULTDIR](#).

Output Files

Object Files

After successful compilation, the Compiler generates an object file containing the target code as well as some debugging information. This file is written to the directory listed in the [OBJPATH](#) environment variable. If that variable contains more than one path, the object file is written in the first listed directory. If this variable is not set, the object file is written in the directory the source file was found. Object files always get the extension `.o`.

Error Listing

If the Compiler detects any errors, it does not create an object file. Rather, it creates an error listing file named `ERR.TXT`. This file is generated in the directory the source file was found (also see *Environment*, [Environment Variable `ERRORFILE`](#)).

If the Compiler's window is open, it displays the full path of all header files read. After successful compilation the number of code bytes generated and the number of global objects written to the object file are also displayed.

If the Compiler is started from a IDE (with `'%f'` given on the command line) or Codewright (with `'%b%e'` given on the command line), this error file is not produced. Instead, it writes the error messages in a special format in a file called `EDOUT` using the Microsoft format by default. You may use the CodeWrights's *Find Next Error* command to display both the error positions and the error messages.

Interactive Mode (Compiler Window Open)

If `ERRORFILE` is set, the Compiler creates a message file named as specified in this environment variable.

If `ERRORFILE` is not set, a default file named `ERR.TXT` is generated in the current directory.

Batch Mode (Compiler Window Not Open)

If ERRORFILE is set, the Compiler creates a message file named as specified in this environment variable.

If ERRORFILE is not set, a default file named EDOUT is generated in the current directory.

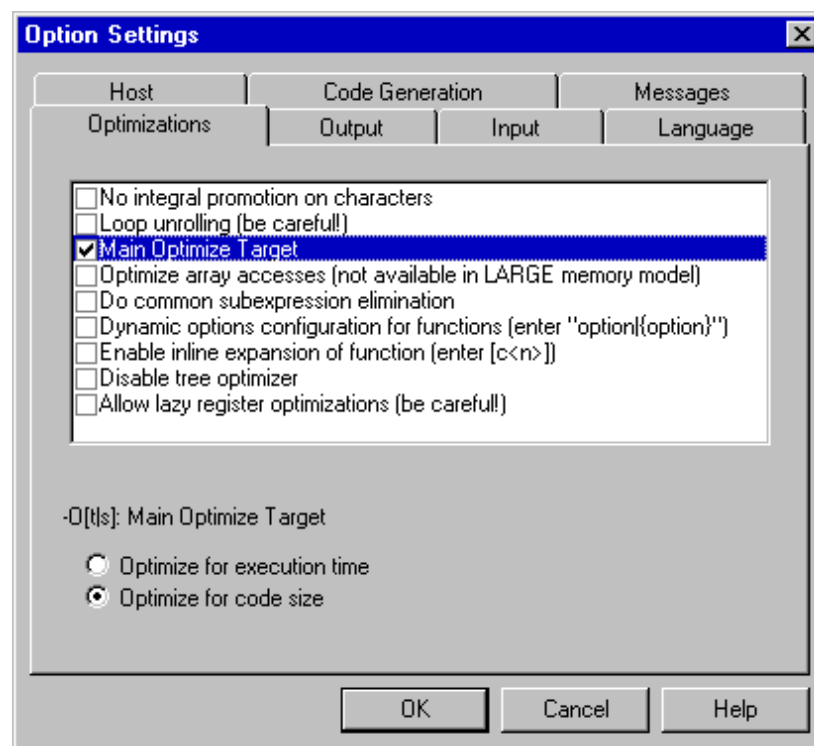
Compiler Options

The Compiler provides a number of Compiler options that control the Compiler's operation. Options consist of a minus/dash ('-'), followed by one or more letters or digits. Anything not starting with a dash/minus is the name of a source file to be compiled. You can specify Compiler options on the command line or in the COMPOPTIONS variable. Each Compiler option is specified only once per compilation.

Command line options are not case sensitive, e.g. "-Li" is the same as "-li".

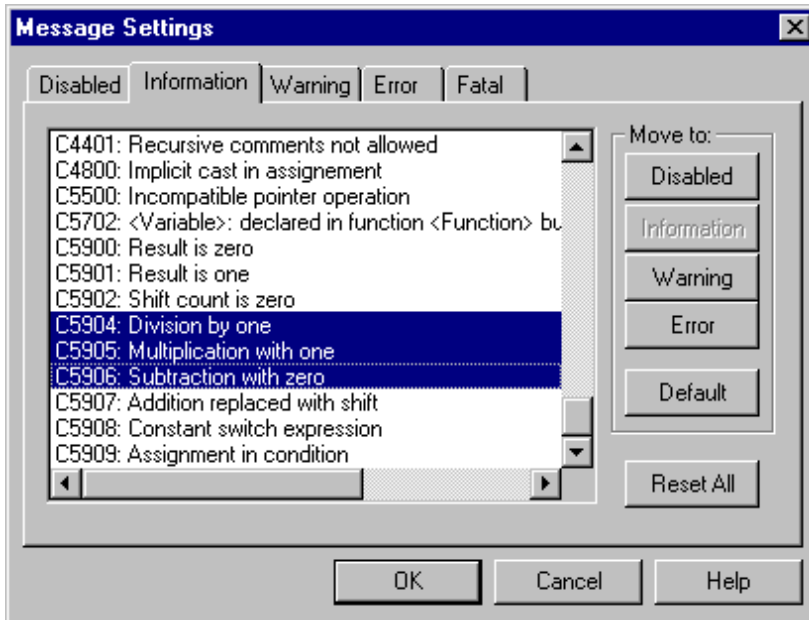
NOTE It is not possible to coalesce options in different groups, e.g. "-Cc -Li" *cannot* be abbreviated by the terms "-Cci" or "-CcLi"!

Another way to set the Compiler options is to use the GUI.



NOTE Do not use the COMPOPTIONS environment variable if the GUI is used. The Compiler stores the options in the project.ini, not in the default.env.

The dialog, shown below, may also be used to move messages (options -Wmsg).



Option Recommendation

Depending on the compiled sources, each Compiler optimization may have its advantages or disadvantages. The following is recommended:

- [-Cc](#) (allocate constant objects into ROM), remembering to specify ROM_VAR in the Linker parameter file
- [-Wpd](#) (error for implicit parameter declaration)
- Enable register optimizations ([-Or](#)) whenever available or possible

By default, most optimizations are enabled in the Compiler. If they cause problems in your code (e.g. they make the code hard to debug), switch them off (the options usually have the prefix [-On](#)). Candidates for such optimizations are peephole optimizations.

Some optimizations may produce more code for some functions than for others (e.g. inlining ([-Oi](#)), loop unrolling ([-Cu](#))). Try those options to get the best result for each.

To acquire the best results for each function, compile each module with the [-OdocF](#). An example for the this option is [-OdocF="-Or"](#).

If you do have a Compiler with the ICG optimization engine, the following option combination provides the best results:

[-Ona -OdocF="-Onca|-One"](#)

Compiler Option Details

Option Groups

Compiler options are grouped by:

- HOST
- LANGUAGE
- OPTIMIZATION
- OUTPUT
- INPUT
- CODE
- TARGET
- MESSAGE VARIOUS.

See [Table 1.12](#).

A special group is the STARTUP group: The options in this group cannot be specified interactively; they can only be specified on the command line to start the tool.

Table 1.12 Compiler Option Groups

Group	Description
HOST	Lists options related to the host
LANGUAGE	Lists options related to the programming language (ANSI C, C++, ...)
OPTIMIZATION	Lists optimization options
OUTPUT	Lists options related to the output files generation (which kind of file should be generated)
INPUT	Lists options related to the input file
CODE	Lists options related to code generation (memory models, float format, ...)
TARGET	Lists options related to the target processor
MESSAGES	Lists options controlling the generation of error messages
VARIOUS	Lists various options
STARTUP	Options which only are specified on tool startup

The group corresponds to the property sheets of the graphical option settings.

NOTE Not all command line options are accessible through the property sheets as they have a special graphical setting (e.g. the option to set the type sizes).

Option Scopes

Each option has also a scope. See [Table 1.13](#)

Table 1.13 Option Scopes

Scope	Description
Application	The option has to be set for all files (Compilation Units) of an application. A typical example is an option to set the memory model. Mixing object files will have unpredictable results.
Compilation Unit	This option is set for each compilation unit for an application differently. Mixing objects in an application is possible.
Function	The option may be set for each function differently. Such an option may be used with the option: -OdocF .
None	The option scope is not related to a specific code part. A typical example are the options for the message management.

The available options are arranged into different groups. A sheet is available for each of these groups. The content of the list box depends on the selected sheets.

Option Detail Description

The remainder of this section describes each of the Compiler options available for the Compiler. The options are listed in alphabetical order. Each is divided into several sections listed in [Table 1.14](#).

Table 1.14 Compiler Option—Documentation Topics

Topic	Description
Group	HOST, LANGUAGE, OPTIMIZATION, OUTPUT, INPUT, CODE GENERATION, MESSAGE or VARIOUS.
Scope	Application, Compilation Unit, Function or None
Syntax	Specifies the syntax of the option in a EBNF format
Arguments	Describes and lists optional and required arguments for the option

Table 1.14 Compiler Option—Documentation Topics

Topic	Description
Default	Shows the default setting for the option
Defines	List of defines related to the Compiler option
Pragma	List of pragmas related to the Compiler option
Description	Provides a detailed description of the option and how to use it
Example	Gives an example of usage, and effects of the option where possible. Compiler settings, source code and/or Linker PRM files are displayed where applicable. The examples shows an entry in the <code>default.env</code> for PC.
See also	Names related options

Using Special Modifiers

With some options, it is possible to use special modifiers. However, some modifiers may not make sense for all options. This section describes those modifiers.

[Table 1.15](#) lists the supported modifiers.

Table 1.15 Compiler Option Modifiers

Modifier	Description
%p	Path including file separator
%N	File name in strict 8.3 format
%n	File name without extension
%E	Extension in strict 8.3 format
%e	Extension
%f	Path + file name without extension
%"	A double quote (") if the file name, the path or the extension contains a space
%'	A single quote (') if the file name, the path or the extension contains a space
%(ENV)	Replaces it with the contents of an environment variable
%%	Generates a single '%'

Examples:

For your examples it is assumed that the actual file name (base file name for the modifiers) is:

```
c:\Metrowerks\my demo\TheWholeThing.myExt
```

%p gives the path only with a file separator:

```
c:\Metrowerks\my demo\
```

%N results in the file name in 8.3 format, that is the name with only 8 characters:

```
TheWhole
```

%n returns just the file name without extension:

```
TheWholeThing
```

%E gives the extension in 8.3 format, that is the extension with only 3 characters:

```
myE
```

%e is used for the whole extension:

```
myExt
```

%f gives the path plus the file name:

```
c:\Metrowerks\my demo\TheWholeThing
```

Because the path contains a space, using %" or %' is recommended: Thus %"%f%" gives:

```
"c:\Metrowerks\my demo\TheWholeThing"
```

where %'%f%' gives:

```
'c:\Metrowerks\my demo\TheWholeThing'
```

Using %(envVariable) an environment variable may be used. A file separator following after %(envVariable) is ignored if the environment variable is empty or does not exist. In other words, the \$(TEXTSPATH)\myfile.txt is replaced with

```
c:\Metrowerks\txt\myfile.txt
```

if TEXTSPATH is set to

```
TEXTSPATH=c:\Metrowerks\txt
```

But is set to

```
myfile.txt
```

if TEXTSPATH is does not exist or is empty.

A %% may be used to print a percent sign. The %e%% gives:

```
myExt%
```

-!: File Names to DOS Length

Group

INPUT

Scope

Compilation Unit

Syntax

"-!"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

This option, named *cut*, is very useful when compiling files copied from an MS-DOS file system. File names are clipped to DOS length (8 characters).

Example

-!

This truncates the following include directive

```
#include "mylongfilename.h"
```

to

```
#include "mylongfi.h"
```

See also

None

-AddIncl: Additional Include File

Group

INPUT

Scope

Compilation Unit

Syntax

"-AddIncl="<fileName>

Arguments

<fileName>: name of file to be included

Default

None

Defines

None

Pragmas

None

Description

The specified file is included at the beginning of the compilation unit. It has the same effect as it would if written at the beginning of the compilation unit using double quotes (".."):

```
#include "my headerfile.h"
```

Example

```
-AddIncl="my headerfile.h"
```

See also

[Option -I](#)

-Ansi: Strict ANSI

Group

LANGUAGE

Scope

Function

Syntax

"-Ansi"

Arguments

None

Default

None

Defines

__STDC__

Pragmas

None

Description

The `-ANSI` option forces the Compiler to follow strict ANSI C language conversions. When `-ANSI` is specified, all non ANSI-compliant keywords (e.g. `asm`, `far` and `near`) are not accepted by the Compiler, and the Compiler generates an error.

The compiler also does not allow C++ style comments (started with `//`). To allow C++ comments even with `-Ansi` set, the [option `-Cppc`](#) must be set.

The `asm` keyword is also not allowed if `-Ansi` is set. To use inline assembly even with `-Ansi` set, you have to use `__asm` instead the `asm` keyword.

The Compiler defines `__STDC__` as 1 if this option is set, and as 0 if this option is not set.

Example

-ANSI

See also

[Option -Cppc](#)

-BfaB: Bit Field Byte Allocation

Group

CODE GENERATION

Scope

Application

Syntax

"-BfaB" ("MS" | "LS")

Arguments

"MS": Most significant bit in byte first (left to right)

"LS": Least significant bit in byte first (right to left)

Default

HC12: -BfaBLS

Defines

```
__BITFIELD_MSWORD_FIRST__  
__BITFIELD_LSWORD_FIRST__  
__BITFIELD_MSBYTE_FIRST__  
__BITFIELD_LSBYTE_FIRST__  
__BITFIELD_MSBIT_FIRST__  
__BITFIELD_LSBIT_FIRST__
```

Pragmas

None

Description

Normally, bits in byte bitfields are allocated from the least significant bit to the most significant bit. This produces less code overhead if a byte bitfield is allocated only partially.

Example

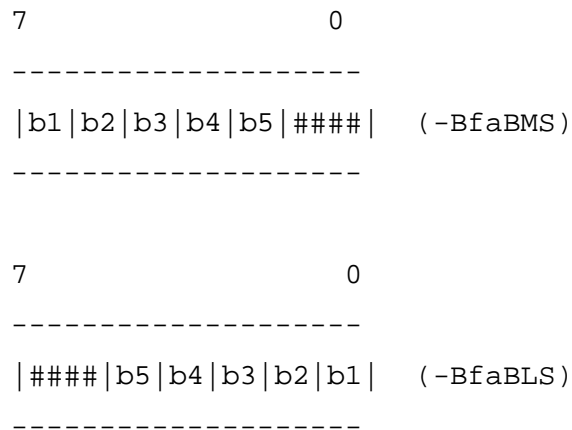
```
struct {unsigned char b: 3; } B;  
// by default the 3 least significant bits are used
```


This allows just a mask operation without any shift to access the bit field.

To change this allocation order, use the following option, shown in the example below.

Example

```
struct{
    char b1:1;
    char b2:1;
    char b3:1;
    char b4:1;
    char b5:1;
} myBitfield;
```



Example

```
-BfaBMS
```

See also

[Bit Field Allocation Defines](#)

-BfaGapLimitBits: Bit Field Gap Limit

Group

CODE GENERATION

Scope

Application

Syntax

"-BfaGapLimitBits" <number>

Arguments

<number>: positive number specifying the maximum number of bits for a gap

Default

HC12: 3

Defines

None

Pragmas

None

Description

The bit field allocation tries to avoid crossing a byte boundary whenever possible. To achieve optimized accesses, the compiler may insert some padding/gap bits to reach this. This option enables you to affect the maximum number of gap bits allowed.

Example

```
struct {  
    unsigned char a: 7;  
    unsigned char b: 5;  
    unsigned char c: 4;  
} B;
```

In the above example, it is assumed that you have specified a 3-bit gap. The compiler allocates the struct B with 3 bytes. First the compiler allocates the 7 bits of a. Then it tries to allocate the 5 bits of b, but this would cross a byte boundary. Because the gap of 1 bit is smaller than the specified gap of 3 bits, the b is allocated in the next byte. Then allocation starts for c. After allocation of b, there are 3 bits left. Because the gap is 3 bits, c is allocated in the next byte. If the maximum gap size is specified to 0, all bits would be allocated in two bytes.

Example

```
-BfaGapLimitBits3
```

See also

[Bit Field Allocation Defines](#)

-BfaTSR: Bit Field Type Size Reduction

Group

CODE GENERATION

Scope

Application

Syntax

"-BfaTSR" ("ON" | "OFF")

Arguments

"ON": Enable Type Size Reduction

"OFF": Disable Type Size Reduction

Default

HC12: -BfaTRSon

Defines

__BITFIELD_TYPE_SIZE_REDUCTION__
__BITFIELD_NO_TYPE_SIZE_REDUCTION__

Pragmas

None

Description

This option is configurable if the compiler uses type size reduction, or not, for bit fields. Type size reduction means that the compiler can reduce the type of an int bit field to a char bit field if it fits into a character. This allows the compiler to allocate memory only for one byte instead of for an integer.

Example

```
struct{  
    long b1:4;
```

```
    long b2:4;
} myBitfield;

31                                     7 3 0
-----
|#####|b2|b1| -BfaTSRoff
-----

7      3 0
-----
|b2 | b1 | -BfaTSRon
-----
```

Example

-BfaTSRon

See also

[Bit Field Type Reduction Defines](#)

-C++ (-C++f, -C++e, -C++c): C++ Support



Group

LANGUAGE

Scope

Compilation Unit

Syntax

"-C++" ("f"|"e"|"c")

Arguments

"f": Full ANSI Draft C++ support
"e": Embedded C++ support (EC++)
"c": compactC++ support (cC++)

Default

None

Defines

`__cplusplus`

Pragmas

None

Description

With this option enabled, the Compiler behaves as a C++ Compiler. You can choose between 3 different types of C++:

- Full ANSI Draft C++ supports the whole C++ language.
- Embedded C++ (EC++) supports a constant subset of the C++ language. EC++ does not support inefficient stuff like templates, multiple inheritance, virtual base classes and exception handling.
- compactC++ (cC++) supports a configurable subset of the C++ language. You can configure this subset with the option [-Cn](#).

If the option is not set, the Compiler behaves as an ANSI-C Compiler.

If the option is enabled and the source file name extension is `*.c`, the Compiler behaves as a C++ Compiler.

If the option is not set, but the source-filename extension is `*.cpp` or `*.cxx`, the Compiler behaves as if the `-C++f` option were set.

Example

```
COMPOTIONS=-C++f
```

See also

[C++ Front End](#)
[Option -Cn](#)

-Cc: Allocate Constant Objects into ROM

Group

OUTPUT

Scope

Compilation Unit

Syntax

"-Cc"

Arguments

None

Default

None

Defines

None

Pragmas

[#pragma INTO_ROM](#)

Description

Variables declared as `const` are treated just like any other variable, unless the command line option "-Cc" has been given. In that circumstance, the `const` objects are put into segment `ROM_VAR`, which is then assigned to a ROM section in the Linker parameter file (please see document *Linker*).

For objects allocated into a read-only section, the Linker prepares no initialization. The startup code does not have to copy the constant data.

You may also put variables into segment `ROM_VAR` by using the segment pragma (please see document *Linker*).

With the `#pragma CONST_SECTION` for constant segment allocation, variables declared as `const` are allocated in this segment.

If the current data segment is not the default segment, `const` objects in that user-defined segment are not allocated in the segment `ROM_VAR` but remain in the segment defined by the user. If that data segment happens to contain *only* `const` objects, it may be allocated in a ROM memory section (refer to the *Linker* chapter for more information).

NOTE This option is useful only for HIWARE object file formats. Constants are allocated into the ELF section `".rodata"` in the ELF/DWARF object file format.

NOTE The Compiler uses the default addressing mode for the constants specified by the memory model.

Example

```
-Cc
SECTION
    MY_ROM READ_ONLY    0x1000 TO 0x2000
PLACEMENT
    DEFAULT_ROM, ROM_VAR INTO MY_ROM
```

See also

[Segmentation](#)
[Linker Manual](#)
[Option -F2](#)
[#pragma INTO_ROM](#)

-Ccx: Cosmic compatibility mode for space modifiers

Group

LANGUAGE

Scope

Compilation Unit

Syntax

"-Ccx"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

This option allows Cosmic style `@near`, `@far` and `@tiny` space modifiers in your C code. The option `-ANSI` must be switched off. There is no need anymore to remove the Cosmic space modifiers from your application code. It is also no need to place the objects to sections addressable by the Cosmic space modifiers.

Following is done when a Cosmic space modifier is parsed:

- The objects declared with the space modifier are always allocated in a special Cosmic compatibility (`_CX...`) section (regardless which section pragma is set)

depending on the space modifier, on the `const` qualifier or if it is a function or a variable:

Table 1.16 Cosmic Space Modifier Handling

Definition	Placement to <code>_cx</code> section
<code>@tiny int my_var</code>	<code>_CX_DATA_TINY</code>
<code>@near int my_var</code>	<code>_CX_DATA_NEAR</code>
<code>@far int my_var</code>	<code>_CX_DATA_FAR</code>
<code>const @tiny int my_cvar</code>	<code>_CX_CONST_TINY</code>
<code>const @near int my_cvar</code>	<code>_CX_CONST_NEAR</code>
<code>const @far int my_cvar</code>	<code>_CX_CONST_FAR</code>
<code>@tiny void my_fun(void)</code>	<code>_CX_CODE_TINY</code>
<code>@near void my_fun(void)</code>	<code>_CX_CODE_NEAR</code>
<code>@far void my_fun(void)</code>	<code>_CX_CODE_FAR</code>

- Space modifiers on the left hand side of a pointer declaration specify the pointer type and `-size`, depending on the target.

See example for a `prm` file below how to place the sections mentioned in the table above.

For further information about porting applications from Cosmic to CodeWarrior please refer to the technical note TN 234.

Example

`-Ccx`

See [Listing 1.1](#)

Listing 1.1 Cosmic Space Modifiers

```
volatile @tiny char tiny_ch;
extern @far const int table[100];
static @tiny char * @near ptr_tab[10];
typedef @far int (*@far funptr)(void);
funptr my_fun; /* banked and far calling conv. */

char @tiny *tptr = &tiny_ch;
char @far *fptr = (char @far *)&tiny_ch;
```

Using the Compiler

Compiler Options

Example for a prm file:
(16 and 24 bit addressable ROM;
8, 16 and 24 bit addressable RAM)

```
SEGMENTS
MY_ROM   READ_ONLY       0x2000 TO 0x7FFF;
MY_BANK  READ_ONLY       0x508000 TO 0x50BFFF;
MY_ZP    READ_WRITE      0xC0 TO 0xFF;
MY_RAM   READ_WRITE      0xC000 TO 0xCFFF;
MY_DBANK READ_WRITE      0x108000 TO 0x10BFFF;
END
PLACEMENT
DEFAULT_ROM, ROM_VAR,
_CX_CODE_NEAR, _CX_CODE_TINY, _CX_CONST_TINY,
_CX_CONST_NEAR          INTO MY_ROM;
_CX_CODE_FAR, _CX_CONST_FAR INTO MY_BANK;
DEFAULT_RAM, _CX_DATA_NEAR INTO MY_RAM;
_CX_DATA_FAR          INTO MY_DBANK;
_ZEROPAGE, _CX_DATA_TINY INTO MY_ZP;
END
```

See also

Cosmic Manuals, Linker Manual, TN 234

-Cf: Float IEEE32, doubles IEEE64

HC12

Group

CODE GENERATION

Scope

Application

Syntax

"-Cf"

Arguments

None

Default

By default, float and doubles are IEEE32

Defines

`__FLOAT_IS_IEEE32__`

`__DOUBLE_IS_IEEE64__`

`__LONG_DOUBLE_IS_IEEE64__`

`__LONG_LONG_DOUBLE_IS_IEEE64__`

Pragmas

None

Description

This option sets the standard type `float` to the IEEE32 format and all double types (`double`, `long double`, `long long double`) to the IEEE64 format.

This option is the same as `-Tf4d8Ld8LLd8`.

Example

`-Cf`

See also

[Option -T](#)

-Ci: Tri- and Bigraph Support

Group

LANGUAGE

Scope

Function

Syntax

"-Ci"

Arguments

None

Default

None

Defines

___TRIGRAPHS___

Pragmas

None

Description

If certain tokens are not available on your keyboard, they are replaced with the following keywords See [Table 1.17](#).

Table 1.17 Keyword Alternatives for Unavailable Tokens

Bigraph		Trigraph		Additional Keyword	
<%	}	??=	#	and	&&
%>	}	??/	\	and_eq	&=
<:	[??'	^	bitand	&
:>]	??([bitor	

Table 1.17 Keyword Alternatives for Unavailable Tokens

Bigraph		Trigraph		Additional Keyword	
?:	#	??)]	compl	~
?:%:	##	??!		not	!
		??<	{	or	
		??>	}	or_eq	=
		??~	~	xor	^
				xor_eq	^=
				not_eq	!=

NOTE Additional keywords are not allowed as identifiers if this option is enabled.

Example

-Ci

The example in [Listing 1.2](#) shows the use of trigraphs, bigraphs and the additional keywords with the corresponding ‘normal’ C-source.

Listing 1.2 Trigraphs, Bigraphs, and Additional Keywords

```
int Trigraphs(int argc, char * argv??(??)) ??<
  if (argc<1 ??!?! *argv??(1??)=='??/0') return 0;
  printf("Hello, %s??/n", argv??(1??));
??>

%:define TEST_NEW_THIS 5
%:define cat(a,b) a%:%:b
??=define arraycheck(a,b,c) a??(i??) ??!?! b??(i??)

int i;
int cat(a,b);
char a<:10:>;
char b<:10:>;

void Trigraph2(void) <%
  if (i and ab) <%
```

```

    i and_eq TEST_NEW_THIS;
    i = i bitand 0x03;
    i = i bitor 0x8;
    i = compl i;
    i = not i;
%> else if (ab or i) <%
    i or_eq 0x5;
    i = i xor 0x12;
    i xor_eq 99;
%> else if (i not_eq 5) <%
    cat(a,b) = 5;
    if (a??(i??) || b[i])<%%>
    if (arraycheck(a,b,i)) <%
        i = 0;
    %>
%>
%>
%>

/* is the same as ... */
int Trigraphs(int argc, char * argv[]) {
    if (argc<1 || *argv[1]!='\0') return 0;
    printf("Hello, %s\n", argv[1]);
}

#define TEST_NEW_THIS 5
#define cat(a,b) a##b
#define arraycheck(a,b,c) a[i] || b[i]

int i;
int cat(a,b);
char a[10];
char b[10];

void Trigraph2(void){
    if (i && ab) {
        i &= TEST_NEW_THIS;
        i = i & 0x03;
        i = i | 0x8;
        i = ~i;
        i = !i;
    } else if (ab || i) {
        i |= 0x5;
        i = i ^ 0x12;
        i ^= 99;
    }
}

```

```
} else if (i != 5) {  
  cat(a,b) = 5;  
  if (a[i] || b[i]){}  
  if (arraycheck(a,b,i)) {  
    i = 0;  
  }  
}  
}
```

See also

None

-Cn: Disable compactC++ features

C++

Group

LANGUAGE

Scope

Compilation Unit

Syntax

```
"-Cn" ["=" {"Vf"|"Tpl"|"Ptm"|"Mih"|"Ctr"|"Cpr"}].
```

Arguments

"Vf": Do not allow virtual functions

"Tpl": Do not allow templates

"Ptm": Do not allow pointer to member

"Mih": Do not allow multiple inheritance and virtual base classes

"Ctr": Do not create compiler defined functions

"Cpr": Do not allow class parameters and class returns

Default

None

Defines

None

Pragmas

None

Description

If the [-C++c](#) option is enabled, you can disable following compactC++ features:

"Vf" Virtual functions are not allowed.

Avoid having virtual tables consuming a lot of memory.

"Tpl" Templates are not allowed.

Avoid having many generated functions performing similar operations.

"Ptm" Pointer to member not allowed.

Avoid having pointer-to-member objects consuming a lot of memory.

"Mih" Multiple inheritance is not allowed.

Avoid having complex class hierarchies.

Because virtual base classes are logical only when used with multiple inheritance, they are also not allowed.

"Ctr" The C++ Compiler can generate several kinds of functions, if necessary:

- Default Constructor,
- Copy Constructor,
- Destructor,
- Assignment operator.

With this option enabled, the Compiler does not create those functions. This is useful when compiling C sources with the C++ Compiler, assuming you do not want C structures to acquire member functions.

"Cpr" Class parameters and class returns are not allowed.

Avoid having overhead with Copy-Constructor and Destructor calls at passing parameters, and passing return values of class type.

Example

```
-C++c -Cn=Ctr
```

See also

[Option -C++c](#)

[C++ Front End](#)

-Cni: No Integral Promotion

Group

OPIMIZATION

Scope

Function

Syntax

"-Cni"

Arguments

None

Default

None

Defines

__CNI__

Pragmas

None

Description

Enhances code density of character operations by omitting integral promotion. This option enables a none ANSI-C compliant behavior.

In ANSI-C operations with data types, anything smaller than int must be promoted to int (integral promotion). With this rule, adding two unsigned character variables results in a zero-extension of each character operand, and then adding them back in as int operands. If the result must be stored back into a character, this integral promotion is not necessary. When this option is set, promotion is avoided where possible.

Because operations may be performed on character base instead on integer base with this option set, code size will be decreased.

The `-Cni` option enhances character operation code density by omitting integral promotion.

Consider the following:

In most expressions, ANSI-C requires char type variables to be extended to the next larger type int, which is required to be at least 16-Bit in size by the ANSI standard.

The `-Cni` option suppresses this ANSI-C behavior and thus allows 'characters' and 'character sized constants' to be used in expressions. This option does not conform to ANSI standards. Code compiled with this option is not portable.

The ANSI standard requires that 'old style declarations' of functions using the char parameter be extended to int. The `-Cni` option disables this extension saving additional RAM. See the example below.

Example

```
old_style_func (a, b, c)
    char a, b, c;
{
    ...
}
```

The space reserved for a, b, c is just one byte each, instead of two.

For expressions containing different types of variables, the following conversion rules apply:

If both variables are of type signed char, the expression is evaluated signed.

If one of two variables is of type unsigned char, the expression is evaluated unsigned, regardless of whether the other variable is of type signed or unsigned char.

If one operand is of another type than signed or unsigned char, the usual ANSI-C arithmetic conversions are applied.

If constants are in the character range, they are treated as characters. Remember that the char type is unsigned and applies to the constants `-128 - 127`. All constants greater than 127, i.e. 128, 129 ... are treated as integer. If you want them treated as characters, they must be casted.

Example

```
signed char a, b;
if (a > b * (signed char) - 129)
```

NOTE This option is ignored with the `-ANSI` Compiler switch active.

NOTE With this option set, the code that is generated does not conform to the ANSI standard. In other words: the code generated is wrong if you apply the ANSI standard as reference. Using this option is not recommended in most cases.

Example

`-Cni`

See also

None

-Cppc: C++ Comments in ANSI-C

Group

LANGUAGE

Scope

Function

Syntax

"-Cppc"

Arguments

None

Default

By default, the Compiler does not allow C++ comments if [-Ansi](#) is set.

Defines

None

Pragmas

None

Description

The `-Ansi` option forces the compiler to conform to the ANSI-C standard. Because a strict ANSI-C compiler rejects any C++ comments (started with `//`), this option may be used to allow C++ comments.

Example

```
-Cppc
```

This allows the following code to be compiled with the `-Ansi` option set:

```
void foo(void) // this is a c++ comment
```


See also

[Option -Ansi](#)

-CpDPAGE: Specify DPAGE Register

HC12

Group

CODE GENERATION

Scope

Application

Syntax

```
"-CpDPAGE" ["=" (<hexAddr> | "RUNTIME")]
```

Arguments

<hexAddr>: address of DPAGE register in hex format (e.g. 0x34)
"RUNTIME": if runtime routine must be used

Default

By default, the Compiler assumes 0x34 for <hexAddr>

Defines

```
__DPAGE__  
__NO_DPAGE__
```

Pragmas

None

Description

See Back End for details

Example

```
-CpDPAGE=RUNTIME
```

See also

[Option -CpEPAGE](#)
[Option -CpPPAGE](#)

-CpEPAGE: Specify EPAGE Register

HC12

Group

CODE GENERATION

Scope

Application

Syntax

"-CpEPAGE" ["=" (<hexAddr> | "RUNTIME")].

Arguments

<hexAddr>: address of EPAGE register in hex format (e.g. 0x36)
"RUNTIME": if runtime routine must be used

Default

By default, the Compiler assumes 0x36 for <hexAddr>

Defines

__EPAGE__

__NO_EPAGE__

Pragmas

None

Description

See Back End for details

Example

```
-CpEPAGE=0x36
```

See also

[Option -CpDPAGE](#)

[Option -CpPPAGE](#)

-CpPPAGE: Specify PPAGE Register

HC12

Group

CODE GENERATION

Scope

Application

Syntax

"-CpPPAGE" ["="(<hexAddr> | "RUNTIME")].

Arguments

<hexAddr>: address of PPAGE register in hex format (e.g. 0x35)
"RUNTIME": if runtime routine must be used

Default

By default, the Compiler assumes 0x35 for <hexAddr>

Defines

__PPAGE__

__NO_PPAGE__

Pragmas

None

Description

See Back End for details

Example

```
-CpPPAGE
```

See also

[Option -CpDPAGE](#)

[Option -CpEPAGE](#)

-Cq: Propagate const and volatile Qualifiers for structs

Group

LANGUAGE

Scope

Application

Syntax

"-Cq"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

This option propagates const and volatile qualifiers for structures. That means, if all members of a structure are constant, the structure itself is constant as well. The same happens with the volatile qualifier. If the structure is declared as constant/volatile, all members are constant/volatile. Consider the following example:

```
struct {
    const field;
} s1, s2;

void foo(void) {
    s1 = s2; // struct copy
    s1.field = 3; // error: modifiable lvalue expected
}
```

In the above example, the field in the struct is constant, but not the struct itself. Thus the struct copy 's1 = s2' is legal, even if the field of the struct is constant. But, a write access to the struct field causes an error message. Using the -Cq option propagates the qualification (const) of the fields to the whole struct or array. In the above example, the struct copy would cause an error message.

Example

-Cq

See also

None

-CswMaxLF: Maximum Load Factor for Switch Tables

Group

CODE GENERATION

Scope

Function

Syntax

"-CswMaxLF<number>"

Arguments

<number>: a number in the range of 0 – 100 denoting the maximum load factor.

Default

Back End dependent.

Defines

None

Pragmas

None

Description

Allows changing the default strategy of the Compiler to use tables for switch statements.

NOTE This option is only available if the compiler supports switch tables.

Normally the Compiler uses a table for switches with more than about 8 labels if the table is filled between 80% (minimum load factor of 80) and 100% (maximum load factor of 100). If there are not enough labels for a table or the table is not filled, a branch tree is generated (tree of if-elseif-else). This branch tree is like an ‘unrolled’ binary search in a table which quickly evaluates the associated label for a switch expression.

Using a branch tree instead a table improves code execution speed, but may increase code size. Additionally, because the branch tree itself uses no special runtime routine for switch expression evaluation, debugging may be more seamless.

Specifying a load factor means that tables are generated in specific ‘fuel’ status:

```
switch(i) {
  case 0: ...
  case 1: ...
  case 2: ...
  case 3: ...
  case 4: ...
  // case 5: ...
  case 6: ...
  case 7: ...
  case 8: ...
  case 9: ...
  default
}
```

The above table is filled to 90% (labels for ‘0’ to ‘9’, except for ‘5’). Assumed that the minimum load factor is set to 50% and setting the maximum load factor for the above case to 80%, a branch tree is generated instead a table. But setting the maximum load factor to 95% will produce a table.

To guarantee that tables are generated for switches with full tables only, set the table minimum and maximum load factors to 100: `-CswMinLF100 -CswMaxLF100`.

Example

```
-CswMaxLF50
```

See also

[Option -CswMinLB](#)
[Option -CswMinSLB](#)
[Option -CswMinLF](#)

-CswMinLB: Minimum Number of Labels for Switch Tables

Group

CODE GENERATION

Scope

Function

Syntax

"-CswMinLB<number>"

Arguments

<number>: a positive number denoting the number of labels.

Default

Back End dependent

Defines

None

Pragmas

None

Description

This option allows changing the default strategy of the Compiler using tables for switch statements.

NOTE This option is only available if the compiler supports switch tables.

Normally the Compiler uses a table for switches with more than about 8 labels (case entries) (actually this number is highly backend dependent). If there are not enough labels for a table, a branch tree is generated (tree of if-elseif-else). This branch tree is like an 'unrolled' binary search in a table which evaluates very fast the associated label for a switch expression.

Using a branch tree instead a table may increase the code execution speed, but it probably increase the code size. Additionally because the branch tree itself uses no special runtime routine for switch expression evaluation, debugging may be much easier.

To disable any tables for switch statements, just set the minimum number of labels needed for a table to a high value (e.g. 9999): `-CswMinLB9999 -CswMinSLB9999`.

When disabling simple tables it makes usually sense also to disable search tables with option `-CswMinSLB`.

Example

```
-CswMinLB5
```

See also

[Option -CswMinLF](#)

[Option -CswMinSB](#)

[Option -CswMaxLF](#)

-CswMinSLB: Minimum Number of Labels for Search Switch Tables

Group

CODE GENERATION

Scope

Function

Syntax

"-CswMinSLB<number>"

Arguments

<number>: a positive number denoting the number of labels

Default

Back End dependent

Defines

None

Pragmas

None

Description

Allows the Compiler to use tables for switch statements.

NOTE This option is only available if the compiler supports search tables.

Switch tables are implemented in different ways. When almost all case entries in some range are given, a table containing only branch targets is used. Using such a dense table is efficient because only the correct entry is accessed. When large holes exist in some areas, a table form can still be used.

But now the case entry and its corresponding branch target are encoded in the table. This is called a search table. A complex runtime routine must be used to

access a search table. This routine checks all entries until it finds the matching one. Search tables execute slowly.

Using a search table improves code density, but the execution time increases. Every time an entry in a search table must be found, all previous entries must be checked first. For a dense table, the right offset is computed and accessed. Additionally note that all backends implement search tables (if at all) by using a complex runtime routine. This may make debugging more complex.

To disable search tables for switch statements, set the minimum number of labels needed for a table to a high value (e.g. 9999): `-CswMinSLB9999`.

Example

```
-CswMinSLB9999
```

See also

[Option -CswMinLB](#)

[Option -CswMinLF](#)

[Option -CswMaxL](#)

-CswMinLF: Minimum Load Factor for Switch Tables

Group

CODE GENERATION

Scope

Function

Syntax

"-CswMinLF<number>".

Arguments

<number>: a number in the range of 0 – 100 denoting the minimum load factor

Default

Back End dependent

Defines

None

Pragmas

None

Description

Allows the Compiler to use tables for switch statements.

NOTE This option is only available if the compiler supports switch tables.

Normally the Compiler uses a table for switches with more than about 8 labels and if the table is filled between 80% (minimum load factor of 80) and 100% (maximum load factor of 100). If there are not enough labels for a table or the table is not filled, a branch tree is generated (tree of if-elseif-else). This branch tree is like an ‘unrolled’ binary search in a table which quickly evaluates the associated label for a switch expression.

Using a branch tree instead a table improves code execution speed, but may increase code size. Additionally, because the branch tree itself uses no special runtime routine for switch expression evaluation, debugging is more seamless.

Specifying a load factor means that tables are generated in specific ‘fuel’ status:

```
switch(i) {  
    case 0: ...  
    case 1: ...  
    case 2: ...  
    case 3: ...  
    case 4: ...  
    // case 5: ...  
    case 6: ...  
    case 7: ...  
    case 8: ...  
    case 9: ...  
    default  
}
```

The above table is filled to 90% (labels for ‘0’ to ‘9’, except for ‘5’). Assuming that the maximum load factor is set to 100% and the minimum load factor for the above case is set to 90%, this still generates a table. But setting the minimum load factor to 95% produces a branch tree.

To guarantee that tables are generated for switches with full tables only, set the minimum and maximum table load factors to 100: `-CswMinLF100`
`-CswMaxLF100`.

Example

```
-CswMinLF50
```

See also

[Option -CswMinLB](#)
[Option -CswMinSLB](#)
[Option -CswMaxLF](#)

-Cu: Loop Unrolling

Group

OPTIMIZATION

Scope

Function

Syntax

"-Cu [=i" <number>]"

Arguments

<number>: number of iterations for unrolling, between 0 and 1024

Default

None

Defines

None

Pragmas

[#pragma LOOP_UNROLL](#)

[#pragma NO_LOOP_UNROLL](#)

Description

Enables loop unrolling with the following restrictions:

- Only simple `for` statements are unrolled, e.g.
`for (i=0; i<10; i++)`
- Initialization and test of the loop counter must be done with a constant.
- Only `<`, `>`, `<=`, `>=` are permitted in a condition.
- Only `++` or `--` are allowed for the loop variable increment or decrement.
- The loop counter must be integral.
- No change of the loop counter is allowed within the loop.

- The loop counter must not be used on the left side of an assignment.
- No address operator (&) is allowed on the loop counter within the loop.

Only small loops are unrolled:

- Loops with few statements within the loop.
- Loops with fewer than 16 increments or decrements of the loop counter.
The bound may be changed with the optional argument "=i" <number>. The -Cu=i20 option unrolls loops with a maximum of 20 iterations.

Example

```
-Cu
int i, j;

j = 0;
for (i=0; i<3; i++) {
    j += i;
}
```

With the Compiler option '-Cu' given, the Compiler issues an information message '*Unrolling loop*' and transforms this loop into:

```
j += 1;
j += 2;
i = 3;
```

The Compiler also transforms some special loops, i.e. loops with a constant condition or loops with only one pass:

Example for a loop with a constant condition:

```
for (i=1; i>3; i++) {
    j += i;
}
```

The Compiler issues an information message '*Constant condition found, removing loop*' and transforms the loop into a simple assignment

```
i=1;
```

because the loop body is never executed.

Example for a loop with only one pass:

```
for (i=1; i<2; i++) {
    j += i;
}
```


The Compiler issues a warning '*Unrolling loop*' and transforms the `for` loop into

```
j += 1;  
i = 2;
```

because the loop body is executed only once.

See also

None

-Cx: No Code Generation

Group

CODE GENERATION

Scope

Compilation Unit

Syntax

"-Cx"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

The -Cx Compiler option disables the code generation process of the Compiler. No object code is generated, though the Compiler does perform a syntactical check of the source code. This allows a quick test if the Compiler accepts the source without errors.

Example

-Cx

See also

None

-D: Macro Definition

Group

LANGUAGE

Scope

Compilation Unit

Syntax

"-D" <identifier> ["=" <value>]

Arguments

<identifier>: identifier to be defined

<value>: value for <identifier>, anything except "-" and blank

Default

None

Defines

None

Pragmas

None

Description

The Compiler allows the definition of a macro on the command line. The effect is the same as having a `#define` directive at the very beginning of the source file.

Example

```
-DDEBUG=0
```

This is the same as writing

```
#define DEBUG 0
```

in the source file.

If you need strings with blanks in your macro definition, there are two ways:
escape sequence or double quotes:

```
-dPath="Path\40with\40spaces"
```

```
-d"Path=" "Path with spaces" "
```

NOTE Blanks are *not* allowed after the "-D" option – the first blank terminates this option. Also, macro parameters are not supported.

See also

None

-Ec: Conversion from 'const T*' to 'T*'

Group

LANGUAGE

Scope

Function

Syntax

"-Ec"

Arguments

None

Default

None

Description

If this non ANSI compliant extension is enabled, a pointer to a constant type is treated like a pointer to the non-constant equivalent of the type. Earlier Compilers did not check a store to a constant object through a pointer. This option is useful if some older source has to be compiled.

Examples

```
void f() {
    int *i;
    const int *j;
    i=j; /* C++ illegal, but with -ec ok! */
}

struct A {
    int i;
};

void g() {
    const struct A *a;
    a->i=3; /* ANSI-C/C++ illegal, but with -Ec ok! */
}
```

```
void h() {  
    const int *i;  
    *i=23; /* ANSI-C/C++ illegal, but with -ec ok! */  
}
```

Defines

None

Pragmas

None

Example

-Ec

```
void foo(const int *p){  
    *p = 0; // some Compiler does not issue an error  
}
```

See also

None

-Eencrypt: Encrypt Files

Group

OUTPUT

Scope

Compilation Unit

Syntax

"-Eencrypt" ["=" <filename>]

Arguments

<filename>: The name of the file to be generated

It may contain special modifiers (see [Using Special Modifiers](#)).

Default

The default file name is %f.e%. A file named 'foo.c' creates an encrypted file named 'foo.ec'.

Description

All files passed together with this option are encrypted using the given key with the option [-Ekey](#).

NOTE	This option is only available/working with a license for the following feature: HIxxxx30 were xxxx. This is the feature number of the compiler for a specific target.
-------------	---

Defines

None

Pragmas

None

Example

```
foo.c foo.h -Ekey1234567 -Eencrypt=%n.e%e
```

encrypts the file 'foo.c' using the key 1234567 to file 'foo.ec' and the file 'foo.h' to the file 'foo.eh'.

The encrypted files foo.ec and foo.eh may be passed to a client. The client is able to compile the encrypted files without the key compiling the following file:

```
foo.ec
```

See also

[Option -Ekey](#)

-Env: Set Environment Variable

Group

HOST

Scope

Compilation Unit

Syntax

"-Env" <Environment Variable> "=" <Variable Setting>

Arguments

<Environment Variable>: Environment variable to be set
<Variable Setting>: Setting of the environment variable

Default

None

Description

This option sets an environment variable. This environment variable may be used in the maker, or used to overwrite system environment variables.

Defines

None

Pragmas

None

Example

```
-EnvOBJPATH=\sources\obj
```

This is the same as

```
OBJPATH=\sources\obj
```

in the default.env.

Use the following syntax to use an environment variable using file names with spaces:

```
-Env"OBJPATH=\program files"
```

See also

[Section "Environment"](#)

-Ekey: Encryption Key

Group

OUTPUT

Scope

Compilation Unit

Syntax

"-Ekey<keyNumber>"

Arguments

<keyNumber>

Default

The default encryption key is '0'. Using this default is not recommended.

Description

This option is used to encrypt files with the given key number (option [-Eencrypt](#)).

NOTE	This option is only available/working with a license for the following feature: Hxxxx30 were xxxx. This is the feature number of the compiler for a specific target.
-------------	--

Defines

None

Pragmas

None

Example

```
foo.c -Ekey1234567 -Eencrypt=%n.e%e
```

encrypts the file 'foo.c' using the key 1234567

See also

[Option -Eencrypt](#)

-F (-Fh, -F1, -F1o, -F2, -F2o,-F6, -F7): Object File Format

Group

OUTPUT

Scope

Application

Syntax

"-F" ("h" | "1" | "2" | "2o" | "6" | "7")

Arguments

"h": HIWARE object file format
"1": ELF/Dwarf 1.1 object file format
"1o": compatible ELF/Dwarf 1.1 object file format
"2": ELF/Dwarf 2.0 object file format
"2o": compatible ELF/Dwarf 2.0 object file format
"6": strict HIWARE V2.6 object file format
"7": strict HIWARE V2.7 object file format

NOTE Not all object file formats may be available for a target.

Default

Motorola HC12: -F2

Defines

__HIWARE_OBJECT_FILE_FORMAT__
__ELF_OBJECT_FILE_FORMAT__

Pragmas

None

Description

The Compiler writes the code and debugging info after compilation into an object file.

The Compiler uses a HIWARE-proprietary object file format when the -Fh, -F6 or -F7 options are set.

The HIWARE Object File Format (-Fh) has the following limitations:

- The type char is limited to a size of 1 byte.
- Symbolic debugging for enumerations is limited to 16bit signed enumerations.
- No zero bytes in strings are allowed (zero byte marks the end of the string).

The HIWARE V2.7 Object File Format (option -F7) has some limitations:

- The type char is limited to a size of 1 byte.
- Enumerations are limited to a size of 2 and has to be signed.
- No symbolic debugging for enumerations.
- The standard type short is encoded as int in the object file format.
- No zero bytes in strings allowed (zero byte marks the end of the string).

The Compiler produces an ELF/DWARF object file when the options -F1 or -F2 are set. This object file format may also be supported by other Compiler vendors.

In the Compiler ELF/DWARF 2.0 output, some constructs written in previous versions were not confirming the ELF standard because the standard was not clear enough in this area. Because old versions of the simulator/debugger (V5.2 or earlier) are not able to load the corrected new format, the old behavior can still be produced by using "-f2o" instead of "-f2". Some old versions of the debugger (simulator/debugger V5.2 or earlier) generate a GPF when a new absolute file is loaded. If you want to use the older versions, use "-f2o" instead of "-f2". New versions of the debugger are able to load both formats correctly. Also, some older ELF/DWARF object file loaders from emulator vendors may require you to set the -F2o option.

The -F1o option is only supported if the target supports the ELF/DWARF 1.1 format. This option is only used with older debugger versions as a compatibility option. This option may be discontinued in the future. It is recommended you use -F1 instead.

Note that it is recommended to use the ELF/DWARF 2.0 format instead of the ELF/DWARF 1.1. The 2.0 format is much more generic. Additionally, it

supports multiple include files plus modifications of the basic generic types (e.g. floating point format). Debug information is also more robust.

Example

-Fh

See also

None

-H: Short Help

Group

VARIOUS

Scope

None

Syntax

"-H"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

The -H option causes the Compiler to display a short list (i.e. help list) of available options within the Compiler window. Options are grouped into HOST, LANGUAGE, OPTIMIZATION, OUTPUT, INPUT, CODE GENERATION, MESSAGE and VARIOUS.

No other option or source file should be specified when the -H option is invoked.

Example

-H may produce following list:

```
INPUT:
-!      Filenames ar clipped to DOS length
-I      Include file path
```


VARIOUS:

- H Prints this list of options
- V Prints the Compiler version

See also

None

-I: Include File Path

Group

INPUT

Scope

Compilation Unit

Syntax

"-I" <path>

Arguments

<path>: path, terminated by a space or end-of-line

Default

None

Defines

None

Pragmas

None

Description

Allows you to set include paths in addition to the [LIBPATH](#), [LIBRARYPATH](#) and [GENPATH](#) environment variables. Paths specified with this option have precedence over includes in the current directory, and paths specified in [GENPATH](#), [LIBPATH](#) and [LIBRARYPATH](#).

Example

```
-I. -I..\h -I\src\include
```

This directs the Compiler to search for header files first in the current directory (.), then relative from the current directory in '..\h', and then in '\src\include'. If the file is not found, the search continues with [GENPATH](#), [LIBPATH](#) and [LIBRARYPATH](#) for header files in double quotes

(`#include"headerfile.h"`), and with [LIBPATH](#) and [LIBRARYPATH](#) for header files in angular brackets (`#include <stdio.h>`).

See also

[Section “Input Files”](#)

[Option -AddIncl](#)

[Environment variable LIBPATH](#)

[Environment variable LIBRARYPATH](#)

[Environment variable GENPATH](#)

-Ica: Implicit Comments in HLI-ASM Instructions



Group

LANGUAGE

Scope

Function

Syntax

"-Ica"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

Comments in HLI (High Level Inline) Assembler are either normal High Level Language comments (e.g. using ANSI-C comments `/* */` or C++ comments `//`), or HLI comments beginning with `;`.

If this option is enabled, the Compiler handles all text as comments after a complete assembly statement. It is not necessary to start a HLI comment with a special token (`;`, `/*` or `//`). This is useful when compiling assembly source from other assemblers that allow this option.

Example

-Ica

See also

None

-La: Generate Assembler Include File

Group

OUTPUT

Scope

Function

Syntax

"-La" ["=" <filename>]

Arguments

<filename>: The name of the file to be generated
It may contain special modifiers (see [Using Special Modifiers](#))

Default

No file created

Defines

None

Pragmas

None

Description

The -La option causes the Compiler to generate an assembler include file when the CREATE_ASM_LISTING pragma occurs. The name of the created file is specified by this option. If no name is specified, a default of "%f.inc" is taken. To put the file into the directory specified by the environment variable [TEXTPATH](#), use the option "-la=%n.inc". The %f option already contain the path of the source file. When %f is used, the generated file is in the same directory as the source file.

The content of all modifiers refers to the main input file and not to the actual header file. The main input file is the one specified on the command line.

Example

```
-La=asm.inc
```

See also

[pragma CREATE_ASM_LISTING
Generating an Assembler Include File](#)

-Lasm: Generate Listing File

Group

OUTPUT

Scope

Function

Syntax

```
"-Lasm" ["=" <filename>]
```

Arguments

<filename>: The name of the file to be generated.
It may contain special modifiers (see [Using Special Modifiers](#)).

Default

No file created.

Defines

None

Pragmas

None

Description

The -Lasm option causes the Compiler to generate an assembler listing file directly. All assembler generated instructions are also printed to this file. The name of the file is specified by this option. If no name is specified, a default of "%n.lst" is taken. The environment variable, [TEXTPATH](#), is used if the resulting file name contains no path information.

The syntax does not always conform with the inline assembler or the assembler syntax. Therefore, this option can only be used to review the generated code. It can not currently be used to generate a file for assembly.

Example

```
-Lasm=asm.lst
```

See also

[Option -Lasmc](#)

-Lasmc: Configure Listing File

Group

OUTPUT

Scope

Function

Syntax

```
"-Lasmc" ["=" {"a" | "c" | "i" | "s" | "h" | "p" | "e" | "v"}]
```

Arguments

- a: Do not write the address in front of every instruction
- c: Do not write the hex bytes of the instructions
- i: Do not write the decoded instructions
- s: Do not write the source code
- h: Do not write the function header
- p: Do not write the source prolog
- e: Do not write the source epilog
- v: Do not write the compiler version

Default

All printed together with the source

Defines

None

Pragmas

None

Description

The `-Lasmc` option configures the output format of the listing file generated with the [option `-Lasm`](#). The addresses, the hex bytes, and the instructions are selectively switched off.

The format of the listing file has layout shown below. The letters in brackets ([]) indicate which suboption may be used to switch it off:

```
[v] ANSI-C/cC++ Compiler V-5.0.1
[v]
[p] 1:
[p] 2: void foo(void) {
[h]
[h] Function: foo
[h] Source  : C:\Metrowerks\test.c
[h] Options : -Lasm=%n.lst
[h]
[s] 3: }
[a] 0000 [c] 3d          [i] RTS
[e] 4:
[e] 5: // comments
[e] 6:
```

Example

```
-Lasmc=ac
```

See also

[Option -Lasm](#)

-Li: List of Included Files

Group

OUTPUT

Scope

Compilation Unit

Syntax

"-Li".

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

The `-Li` option causes the Compiler to generate a text file which contains a list of the `#include` files specified in the source. This text file shares the same name as the source file but with the extension, `.INC`. The files are stored in the path specified by the [TEXTPATH](#) environment variable. The generated file may be used in make files.

Example

```
-Li
```

If the source file is `c:\myFiles\b.c`:

```
/* c:\myFiles\b.c */  
include <string.h>
```

Then the generated file is

```
c:\myFiles\b.c : \
c:\Metrowerks\lib\targetc\include\string.h \
c:\Metrowerks\lib\targetc\include\libdefs.h \
c:\Metrowerks\lib\targetc\include\hidef.h \
c:\Metrowerks\lib\targetc\include\stddef.h \
c:\Metrowerks\lib\targetc\include\stdintypes.h
```

See also

[Option -Lm](#)

-Lic: License Information

Group

VARIOUS

Scope

None

Syntax

"-Lic"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

The -Lic option prints the current license information (e.g. if it is a demo version or a full version). This information is also displayed in the about box.

Example

```
-Lic
```

See also

[Option -LicA](#)

-LicA: License Information about every Feature in Directory

Group

VARIOUS

Scope

None

Syntax

"-LicA"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

The -LicA option prints the license information (e.g. if the tool or feature is a demo version or a full version) of every tool or .dll in the directory where the executable is located. This will take some time as every file in the directory is analyzed.

Example

```
-LicA
```

See also

[Option -Lic](#)

-Ldf: Log Predefined Defines to File

Group

OUTPUT

Scope

Compilation Unit

Syntax

"-Ldf ["=" <file>]

Arguments

<file>: file name for the log file, default is 'predef.h'.

Default

default <file> is 'predef.h'.

Defines

None

Pragmas

None

Description

The -Ldf option causes the Compiler to generate a text file that contains a list of the Compiler-defined `#define`. The default file name is 'predef.h', but may be changed (e.g. -Ldf="myfile.h"). The file is generated in the directory specified by the [TEXTPATH](#) environment variable. The defines written to this file depend on the actual Compiler option settings (e.g. type size settings, ANSI compliance, ...).

NOTE The defines specified by the command line (option [-D](#)) are not included.

This option may be very useful for SQA. With this option it is possible to document every `#define` which was used to compile all sources.

NOTE This option only has an effect if a file is compiled. This option is unusable if you are not compiling a file.

Example

`-Ldf`

This generates the file 'predef.h' with the following content:

```
/* resolved by preprocessor: __LINE__ */
/* resolved by preprocessor: __FILE__ */
/* resolved by preprocessor: __DATE__ */
/* resolved by preprocessor: __TIME__ */
#define __STDC__ 0
#define __VERSION__ 5004
#define __VERSION_STR__ "V-5.0.4"
#define __SMALL__
#define __PTR_SIZE_2__
#define __BITFIELD_LSBIT_FIRST__
#define __BITFIELD_MSBYTE_FIRST__
...
```

See also

[Option -D](#)

-LI: Statistics About Each Function

Group

OUTPUT

Scope

Compilation Unit

Syntax

"-LI" ["=" <file Name>]

Arguments

<file Name>: file to be used for the output

Default

The default output file name is `logfile.txt`

Defines

None

Pragmas

None

Description

The `-LI` option causes the Compiler to append statistical information about the compilation session to the specified file. Compiler options, code size (in bytes), stack usage (in bytes) and compilation time (in seconds) are given for each procedure of the compiled file. The information is appended to the specified file name (or the file 'make.txt', if no argument given). If the [TEXTPATH](#) environment variable is set, the file is stored into the path specified by the environment variable. Otherwise it is stored in the current directory.

Example

```
-Ll=mylog.txt  
  
/* foo.c */  
int Func1(int b) {  
    int a = b+3;  
    return a+2;  
}  
  
void Func2(void) {  
}
```

Appends the following two lines into mylog.txt:

```
foo.c Func1 -Ll=mylog.txt 11 4 0.055000  
foo.c Func2 -Ll=mylog.txt 1 0 0.001000
```

See also

None

-Lm: List of Included Files in make Format

Group

OUTPUT

Scope

Compilation Unit

Syntax

"-Lm" ["=" <file Name>]

Arguments

<file Name>: file to be used for the output

Default

The default file name is `Make.txt`

Defines

None

Pragmas

None

Description

The `-Lm` option causes the Compiler to generate a text file which contains a list of the `#include` files specified in the source. The generated list is in a *make* format. The `-Lm` option is useful when creating make files. The output from several source files may be copied and grouped into one make file. The generated list is in the make format. The file names does not include the path. After each entry, an empty line is added. The information is appended to the specified file name (or the file 'make.txt', if no argument given). If the [TEXTPATH](#) environment variable is set, the file is stored into the path specified by the environment variable. Otherwise it is stored in the current directory.

Example

```
COMPOTIONS=-Lm=mymake.txt
```

Compiling the following sources 'foo.c' and 'second.c':

```
/* foo.c */
#include <stddef.h>
#include "myheader.h"
...
/* second.c */
#include "inc.h"
#include "header.h"
...
```

This adds the following entries in the 'mymake.txt':

```
foo.o :      foo.c stddef.h myheader.h
seconde.o : second.c inc.h header.h
```

See also

[Option -Li](#)

[Option -Lo](#)

Make Utility

-LmCfg: Configuration of List of Included Files in make Format

Group

OUTPUT

Scope

Compilation Unit

Syntax

```
"-LmCfg" ["=" {"i" | "l" | "m" | "o" | "u"}]
```

Arguments

i: Write path of included files
l: Use line continuation
m: Write path of main file
o: Write path of object file
u: Update information

Default

None

Defines

None

Pragmas

None

Description

This option is used when configuring the [option -Lm](#). This option is operative only if the -Lm option is also used. The -Lm option produces the ‘dependency’ information for a make file. Each dependency information grouping is structured as shown:

```
<main object file>: <main source file> {<included file>}
```

Example

If you compile a file named `b.c`, which includes `'stdio.h'`, the output of `-Lm` may be:

```
b.o: b.c stdio.h stddef.h stdarg.h string.h
```

The suboption, `'l'`, uses line continuation for each single entry in the dependency list. This improves readability as shown:

```
b.o: \  

  b.c \  

  stdio.h \  

  stddef.h \  

  stdarg.h \  

  string.h
```

With the suboption `'m'`, the full path of the main file is written. The main file is the actual compilation unit (file to be compiled). This is necessary if there are files with the same name in different directories:

```
b.o: c:\test\b.c stdio.h stddef.h stdarg.h string.h
```

The suboption `'o'` has the same effect as `'m'`, but writes the full name of the target object file:

```
c:\test\obj\b.o: b.c stdio.h stddef.h stdarg.h string.h
```

The suboption `'i'` writes the full path of all included files in the dependency list:

```
b.o: b.c c:\Metrowerks\lib\include\stdio.h  

c:\Metrowerks\lib\include\stddef.h  

c:\Metrowerks\lib\include\stdarg.h  

c:\Metrowerks\lib\include\  

c:\Metrowerks\lib\include\string.h
```

The suboption `'u'` updates the information in the output file. If the file does not exist, the file is created. If the file exists and the current information is not yet in the file, the information is appended to the file. If the information is already present, it is updated. This allows you to specify this suboption for each compilation ensuring that the make dependency file is always up to date.

Example

```
COMPOTIONS=-LmCfg=u
```

See also

[Option -Li](#)
[Option -Lo](#)

[Option -Lm](#)
Make Utility

-Lo: Object File List

Group

OUTPUT

Scope

Compilation Unit

Syntax

"-Lo" ["=" <file Name>]

Arguments

<file Name>: file to be used for the output

Default

The default file name is `objlist.txt`

Defines

None

Pragmas

None

Description

The `-Lo` option causes the Compiler to append the object file name to the list in the specified file. The information is appended to the specified file name (or the file 'make.txt', if no argument given). If [TEXTPATH](#) is set, the file is stored into the path specified by the environment variable. Otherwise, it is stored in the current directory.

Example

`-Lo`

See also

[Option -Li](#)
[Option -Lm](#)

-Lp: Preprocessor Output

Group

OUTPUT

Scope

Compilation Unit

Syntax

"-Lp" ["=" <filename>]

Arguments

<filename>: The name of the file to be generated.

It may contain special modifiers (see [Using Special Modifiers](#))

Default

No file created

Defines

None

Pragmas

None

Description

The `-Lp` option causes the Compiler to generate a text file which contains the preprocessor's output. If no file name is specified, the text file shares the same name as the source file but with the extension, `.PRE (%n.pre)`. The `TEXTPATH` environment variable is used to store the preprocessor file.

The resultant file is a form of the source file. All preprocessor commands (i.e. `#include`, `#define`, `#ifdef`, etc.) have been resolved. Only source code is listed with line numbers.

Example

`-Lp`

See also

[Option -LpX](#)

[Option -LpCfg](#)

-LpCfg: Preprocessor Output configuration

Group

OUTPUT

Scope

Compilation Unit

Syntax

"-LpCfg" ["=" {"c" | "f" | "l"}]

Arguments

"c": do not emit line comments

"f": filenames with path

"l": emit #line directives in preprocessor output

Default

If `-LpCfG` is specified, all suboptions (arguments) are enabled

Defines

None

Pragmas

None

Description

The `-LpCfG` option specifies how source file and `-line` information is formatted in the preprocessor output. Switching `-LpCfG` off means that the output is

formatted like in former compiler versions. The effects of the arguments are listed in [Table 1.18](#).

Table 1.18 Effects of Source and Line Information Format Control Arguments

Argument	on	off
"c"	#line 1 #line 10	/* 1 */ /* 2 */ /* 10 */
"f"	c:\lib\hc12c\include\stdlib.h	stdlib.h
"l"	#line 1 "stdlib.h"	**** FILE 'stdlib.h' */
all	#line 1 "c:\lib\hc12c\include\stdlib.h" #line 10	**** FILE 'stdlib.h' */ /* 1 */ /* 2 */ /* 10 */

Example

```
-Lpcfg  
-Lpcfg=lf
```

See also

[Option -Lp](#)

-LpX: Stop After Preprocessor

Group

OUTPUT

Scope

Compilation Unit

Syntax

"-LpX"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

Without this option, the compiler always translates the preprocessor output as C/C++ code. To do only preprocessing, use this option together with the -Lp option. No object file is generated.

Example

```
-LpX
```

See also

[Option -Lp](#)

-M (-Ms, -Mb, -MI): Memory Model

HC12

Group

CODE GENERATION

Scope

Application

Syntax

"-M" ("s" | "b" | "I").

Arguments

"s": small memory model

"b": banked memory model

"I": large memory model

Default

-Ms

Defines

__SMALL__

__BANKED__

__LARGE__

Pragmas

None

Description

See Back End for details ([Memory Models](#))

Example

-Ms

See also

See Back End for details ([Memory Models](#))

-N: Display Notify Box



Group

MESSAGE

Scope

Function

Syntax

"-N"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

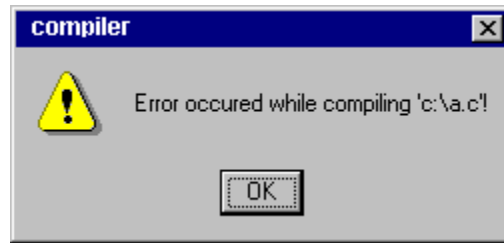
Makes the Compiler display an alert box if there was an error during compilation. This is useful when running a make file (please see *Make Utility*) since the Compiler waits for you to acknowledge the message, thus suspending make file processing. The 'N' stands for "Notify".

This feature is useful for halting and aborting a build using the Make Utility.

Example

-N

If during compilation an error occurs, a dialog box similar to the following one will be opened:



See also

None

-NoBeep: No Beep in Case of an Error

Group

MESSAGE

Scope

Function

Syntax

"-NoBeep"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

There is a 'beep' notification at the end of processing if an error was generated. To implement a silent error, this 'beep' may be switched off using this option.

Example

```
-NoBeep
```

See also

None

-NoDebugInfo: Do Not Generate Debug Information

Group

Output

Scope

None

Syntax

"-NoDebugInfo"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

The compiler generates debug information by default. When this option is used, the compiler does not generate debug information.

NOTE

To generate an application without debug information in ELF, the linker provides an option to strip the debug information. By calling the linker twice, you can generate two versions of the application: one with and one without debug information. This compiler option has to be used only if object files or libraries are to be distributed without debug info.

NOTE This option does not affect the generated code. Only the debug information is excluded.

Example

```
-NoDebugInfo
```

See also

[Option -F](#)

[Option -NoPath](#)

-NoEnv: Do Not Use Environment

Group

Startup. This option can not be specified interactively.

Scope

None

Syntax

"-NoEnv"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

This option can only be specified at the command line while starting the application. It can not be specified in any other way, including via the default.env file, the command line, or processes.

When this option is given, the application does not use any environment (default.env, project.ini or tips file) data.

Example

```
compiler.exe -NoEnv
```

Use the compiler executable name instead of "compiler".

See also

[Section Configuration File](#)

-NoPath: Strip Path Info

Group

OUTPUT

Scope

Compilation Unit

Syntax

"-NoPath"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

With this option set, it is possible to avoid any path information in object files. This is useful if you want to move object files to another file location, or to hide your path structure.

Example

```
-NoPath
```

See also

[Option -NoDebugInfo](#)

-ObjN: Object File Name Specification

Group

OUTPUT

Scope

Compilation Unit

Syntax

"-ObjN=" <file>.

Arguments

<file>: Object file name

Default

-ObjN=%(OBJPATH)\%n.o

Defines

None

Pragmas

None

Description

The object file has the same name as the processed source file, but with the extension “.o”. This option allows a flexible way to define the object file name. It may contain special modifiers (see [Using Special Modifiers](#)). If <file> in the option contains a path (absolute or relative), the OBJPATH environment variable is ignored.

Example

```
-ObjN=a.out
```

The resulting object file is “a.out”. If the OBJPATH environment variable is set to “\src\obj”, the object file is “\src\obj\a.out”.

```
fibonacci.c -ObjN=%n.obj
```

The resulting object file is “fibo.obj”.

```
myfile.c -ObjN=..\objects\_%n.obj
```

The object file is named relative to the current directory to “..\objects_myfile.obj. The OBJPATH environment variable is ignored as the <file> contains a path.

See also

[Environment variable OBJPATH](#)

-Obfv: Optimize Bit Fields and Volatile Bit Fields



Group

OPTIMIZATION

Scope

Function

Syntax

"-Obfv"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

Optimize bit fields as well as bit fields declared as volatile. The compiler is allowed to change the access order or to combine many accesses to one, even if the bitfields are declared as volatile.

Example

```
volatile struct {  
    unsigned int b0:1;  
    unsigned int b1:1;  
    unsigned int b2:1;  
} bf;  
  
void foo(void) {
```

```
    bf.b0 = 1;  bf.b1 = 1;  bf.b2 = 1;  
}
```

using -Obfv:

```
BSET  bf,#7
```

without -Obfv:

```
BSET  bf,#1  
BSET  bf,#2  
BSET  bf,#4
```

See also

None

-Oc: Common Subexpression Elimination (CSE)

Group

OPTIMIZATION

Scope

Function

Syntax

"-Oc"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

Performs common subexpression elimination (CSE). The code for common subexpressions and assignments is generated only once. The result is reused. Depending on available registers, a common subexpression may produce more code due to many spills.

NOTE When the CSE is switched on, changes of variables by aliases may generate incorrect optimizations.

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Example

-Oc

Example where CSE may produce wrong results

```
void main (void) {
    int x;
    int *p;
    x = 7; /* here the value of x is set to 7 */
    p = &x;
    *p = 6; /* here x is set to 6 by the alias *p */
    /* here x is assumed to be equal to 7 and
       Error is called */
    if(x != 6) Error();
}
```

NOTE This error does not occur if x is declared as volatile.

See also

None

-OdocF: Dynamic Option Configuration for Functions

Group

OPTIMIZATION

Scope

Function

Syntax

"-OdocF=" "<option>"

Arguments

<options>: Set of options, separated by '|' to be evaluated for each single function.

Default

None

Defines

None

Pragmas

None

Description

Normally, you must set a specific set of Compiler switches for each compilation unit (file to be compiled). For some files, a specific set of options may decrease the code size, but for other files, the same set of Compiler options may produce more code depending on the sources.

Some optimizations may reduce the code size for some functions, but may increase the code size for other functions in the same compilation unit. Normally it is impossible to vary options over different functions, or to find the best combination of options.

This option solves this problem by allowing the Compiler to choose from a set of options to reach the smallest code size for every function. Without this feature,

you must set some Compiler switches, which are fixed, over the whole compilation unit. With this feature, the Compiler is free to find the best option combination from a user-defined set for every function.

Standard merging rules applies also for this new option, e.g.

```
-Or -OdocF=" -Ocu | -Cu "
```

is the same as

```
-OrDOCF=" -Ouc | -Cu "
```

The Compiler attempts to find the best option combination (of those specified) and evaluates all possible combinations of all specified sets, e.g. for the following option:

```
-W2 -OdocF=" -Or | -Cni -Cu | -Oc "
```

The code sizes for following option combinations are evaluated:

1. -W2
2. -W2 -Or
3. -W2 -Cni -Cu
4. -W2 -Or -Cni -Cu
5. -W2 -Oc
6. -W2 -Or -Oc
7. -W2 -Cni -Cu -Oc
8. -W2 -Or -Cni -Cu -Oc

Thus, if the more sets are specified, the longer the Compiler has to evaluate all combinations, e.g. for 5 sets 32 evaluations.

NOTE No options with scope Application or Compilation Unit (as memory model, float/double format/object file format) or options for the whole compilation unit (like inlining or macro definition) should be specified in this option. The generated functions may be incompatible for linking and executing.

Limitations:

- The maximum set of options set is limited to five, e.g. '-OdocF=" -Or -Ou| -Cni| -Cu| -Oic2| -W2 -Ob"'
- The maximum length of the option is 64 characters.
- The feature is available only for functions and options compatible with functions. Future extensions will also provide this option for compilation units.

Example

```
-Odocf="-Or|-Cni"
```

See also

None

-Of/-Onf: Create Sub-Functions with Common Code

HC12

Group

OPTIMIZATION

Scope

Function

Syntax

"-Onf"

Arguments

None

Default

-Of default or with [“-Os”](#), -Onf with [“-Ot”](#)

Defines

None

Pragmas

None

Description

This option performs the reverse job of inlining. It detects common code parts in the generated code. The common code is moved to a different place and all occurrences are replaced with a JSR to the moved code. At the end of the common code, an RTS instruction is inserted. All SP usages are increased by an address size. This optimization takes care of stack allocation, control flow, and of functions having arguments on the stack. Also, inline assembler code is never treated as common code.

Example

Consider the following function:

```
void f(int);
void g(void);
void h(void);
void main(void) {
    f(1); f(2); f(3);
    h();
    f(1); f(2); f(3);
    g();
    f(1); f(2);
}
```

The compiler first detects that "f(1); f(2); f(3);" occurs twice and places this code separately.

The two code patterns are replaced by a call to the moved code.

This situation can be thought of as the following non-C pseudo code (C does not support local functions):

```
void main(void) {
    void tmp0(void) {
        f(1); f(2); f(3);
    }
    tmp0();
    h();
    tmp0();
    g();
    f(1); f(2);
}
```

In a next step, the Compiler detects that the code "f(1); f(2);" also occur twice.

The Compiler generates a second internal function:

```
void main(void) {
    void tmp1(void) {
        f(1); f(2);
    }
    void tmp0(void) {
        tmp1(); f(3);
    }
    tmp0();
    h();
    tmp0();
    g();
}
```

```
    tmp1();  
}
```

The new code of the function tmp1 (actually tmp1 is not really a function, it is a part of main) is called once directly from main, and once indirectly by using tmp0. These two call chains use a different amount of the stack. Because of this situation, it is not always possible to generate correct debug information. For the local function tmp1, the compiler cannot state both possible SP values. It will only state one of them. While debugging the other state, local variables and the call chain are declared invalid in the debugger. The compiler notes this situation and issues the message:

[“C12056: SP debug info incorrect because of optimization or inline assembler”](#)

Tips

Switch off this optimization to debug your application. The common code makes the control flow more complicated. Also, the debugger cannot distinguish two distinct usages of the same code. Setting a breakpoint in common code stops the application and every use of it. It will also stop the local variables and the call frame if they are not displayed correctly, as explained above.

Switching off this optimization achieves faster code. For code density, there are only a few cases where the code gets worse. This situation may only occur when other optimizations (such as branch tail merging or peepholing) can not find a pattern after this optimization occurs.

See also

[Message “C12056: SP debug info incorrect because of optimization or inline assembler”](#)

-Oi: Inlining

Group

OPTIMIZATION

Scope

Compilation unit

Syntax

"-Oi" ["=" ("c"<code Size> | "OFF")]

Arguments

<code Size>: Limit for inlining in code size

OFF: switching off inlining

Default

None. If no <code Size> is specified, the compiler uses a default code size of 40 bytes

Defines

None

Pragmas

`#pragma INLINE`

Description

This option enables inline expansion. If there is a `#pragma INLINE` before a function definition, or the C++ keyword “inline” is used, all calls of this function are replaced by the code of this function, if possible.

Using the option `-Oi=c0` switches off inlining. Functions marked with the `#pragma INLINE` are still inlined. To disable inlining, use the `-Oi=OFF` option.

Example

```
-Oi

#pragma INLINE
static void f(int i) {
    /* all calls of function f() are inlined */
    /* ... */
}

inline static void g(int i) { /* C++ only! */
    /* all calls of function g() are inlined */
    /* ... */
}
```

The option extension [=c<n>] signifies that all functions with a size smaller than <n> are inlined. For example, compiling with the option `-oi=c100` enables inline expansion for all functions with a size smaller than 100 bytes.

Restrictions

The following functions are not inlined:

- functions with default arguments
- functions with labels inside
- functions with an open parameter list (“void f(int i,...);”)
- functions with inline assembly statements
- functions using local static objects

See also

None

-Oilib: Inline Library Functions

Group

OPTIMIZATION

Scope

Function

Syntax

"-Oilib" ["=" <arguments>]

Arguments

<arguments> are one or multiple of following suboptions:

- a: inline calls to function “strcpy”
- b: inline calls to function “strlen”
- d: inline calls to function “fabs/fabsf”
- e: inline calls to function “memset”
- f: inline calls to function “memcpy”
- g: replace shifts left of 1 by array lookup

Default

None

Defines

None

Pragmas

None

Description

This option enables the compiler, when inlining specific library functions, to reduce execution time. The Compiler frequently uses small functions such as strcpy, strcmp, and so forth. The following functions are inlined:

- strcpy (only available for ICG based back ends)
- strlen (e.g. strlen(“abc”))

- fabs/fabs (e.g. 'f = fabs(f);')
- memset

memset() is inlined only if:

- the result is not used
- memset is used to zero out
- the size for the zero out is in the range 1 – 0xff
- the ANSI library header file <string.h> is included

An example for this is '(void)memset(&buf, 0, 50);' In this case, the call to memset() is replaced with a call to '_memset_clear_8bitCount' present in the ANSI library (string.c)

memcpy() is inlined only if:

- the result is not used
- the size for the copy out is in the range 0 – 0xff
- the ANSI library header file <string.h> is included

An example for this is '(void)memcpy(&buf, &buf2, 30);'

In this case the call to memcpy() is replaced with a call to '_memcpy_8bitCount' present in the ANSI library (string.c)

(char)1 << val is replaced by _PowOfTwo_8[val] if _PowOfTwo_8 is known at compile time. Similarly, for 16 bit and for 32 bit shifts, the arrays _PowOfTwo_16 and _PowOfTwo_32 are used. These constant arrays contain the values 1,2,4,8... . They are declared in hidef.h. This optimization is performed only when optimizing for time.

-Oilib without arguments: inline calls to all supported library functions.

Example

Compiling function f below with option -Oilib=a

```
void f(void) {
    char *s = strcpy(s, ct);
}
```

is translated similar to the following function:

```
void g(void) {
    s2 = s;
    while(*s2++ = *ct++);
}
```

See also

[Option -Oi](#)

[Message C5920](#)

-O1: Try to Keep Loop Induction Variables in Registers

ICG

Group

OPTIMIZATION

Scope

Function

Syntax

"-O1" <number>

Arguments

<number>: number of registers to be used for induction variables

Default

None

Defines

None

Pragmas

None

Description

Try to maintain <number> loop induction variables in registers. Loop induction variables are variables read and written within the loop (e.g. loop counter). The Compiler tries to keep loop induction variables in registers to reduce execution time, and sometimes also code size. This option sets the number of loop induction variables the Compiler is allowed to keep in registers. The range is from 0 (no variable) to infinity. If this option is not given, the Compiler takes the optimal number (code density). Like the option -or, this option may increase code size (spill and merge code) if too many loop induction variables are specified.

NOTE Disable this option (with `-O10`) if there are problems when debugging your code. This optimization could increase the complexity of code debugging on a High Level Language level.

Example (abstract code):

```
void main (char *s) {
    do {
        *s = 0;
    } while (*++s);
}
```

with option `-O10` (no optimization, pseudo code):

```
loop:
    LD  s, Reg0
    ST  #0, [Reg0]
    INC Reg0
    ST  Reg0, s
    CMP [Reg0], #0
    BNE loop
```

without option (optimized, pseudo assembler):

```
loop:
    ST  #0, s
    INC s
    CMP s, #0
    BNE loop
```

the load and stores from/to variable `s` disappears.

Example

`-O11`

See also

None

-Ona: Disable Alias Checking

ICG

Group

OPTIMIZATION

Scope

Function

Syntax

"-Ona"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

Variables that may be written by a pointer indirection or an array access, are redefined after the optimization. This option prevents the Compiler from doing this redefinition, which may allow you to reuse already-loaded variables or equivalent constants. Use this option only if you are sure you will have no real writes of aliases to a memory location of a variable.

Example: do not compile with -Ona.

```
void main (void) {
    int a = 0, *p = &a;

    *p = 1; // real write by the alias *p
    if(a == 0) Error(); // if -Ona is specified,
```

```
        // Error() is called!  
    }
```

Example

-Ona

See also

None

-OnB: Disable Branch Optimizer

HC12

Group

OPTIMIZATION

Scope

Function

Syntax

"-OnB" ["=" <option Char> {<option Char>}]

Arguments

<option Char> is one of the following:

- "a": Short BRA optimization
- "b": Branch JSR to BSR optimization
- "l": Long branch optimization
- "t": Branch tail optimization

Default

None

Defines

None

Pragmas

None

Description

See Back End for details

Example

-OnB
Disables all branch optimizations

See also

None

-Onbf: Disable Optimize Bit Fields

ICG

Group

OPTIMIZATION

Scope

Function

Syntax

"-Onbf"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

A sequence of bitfield assignments with constants is not combined if you use -Onbf. This option simplifies debugging and makes the code more readable.

Example:

```
struct {
    b0:1;
    b1:1;
    b2:1;
} bf;

void main(void) {
    bf.b0 = 0;
    bf.b1 = 0;
```

```
    bf.b2 = 0;  
}
```

without `-Onbf`: (pseudo intermediate code)

```
    BITCLR  bf, #7  // all 3 bits (the mask is 7)  
                // are cleared
```

with `-Onbf`: (pseudo intermediate code)

```
    BITCLR  bf, #1  // clear bit 1 (mask 1)  
    BITCLR  bf, #2  // clear bit 2 (mask 2)  
    BITCLR  bf, #4  // clear bit 3 (mask 4)
```

Example

`-Onbf`

See also

None

-Onbt: Disable ICG Level Branch Tail Merging

ICG

Group

OPTIMIZATION

Scope

Function

Syntax

"-Onbt"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

The ICG level branch tail merging is switched off leading to more readable code and simplified debugging.

Example:

```
void main(void) {  
    if(x > 0) {  
        y = 4;  
    } else {  
        y = 9;  
    }  
}
```

without -Onbt: (pseudo intermediate code)

```
CMP x, 0
BLE else_label

LOAD reg, #4
BRA branch_tail
```

```
else_label: LOAD reg, #9
branch_tail: STORE y, reg
go_on:     ...
```

with -Onbt: (pseudo intermediate code)

```
CMP x, 0
BLE else_label

LOAD reg, #4
STORE y, reg
BRA go_on
```

```
else_label: LOAD reg, #9
STORE y, reg
go_on:     ...
```

Example

-Onbt

See also

None

-Onca: Disable any Constant Folding

ICG

Group

OPTIMIZATION

Scope

Function

Syntax

"-Onca"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

Disables any constant folding over statement boundaries. This option prevents the Compiler from folding constants. All arithmetical operations are coded. This option must be set when the library functions, `setjmp` and `longjmp`, are present. If this option is not set, the Compiler makes wrong assumptions as in the following example:

```
void main(void) {
    jmp_buf env;
    int k = 0;
    if (setjmp(env) == 0) {
        k = 1;
        longjmp(env, 0);
        Err(1);
    }
}
```

```
    } else if (k != 1) { /* assumed always TRUE */  
      Err(0);  
    }  
  }
```

Example

-Onca

See also

None

-Oncn: Disable Constant Folding in Case of a New Constant

ICG

Group

OPTIMIZATION

Scope

Function

Syntax

"-Oncn"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

Disables any constant folding in the case of a new constant. This option prevents the Compiler from folding constants if the resulting constant is new.

The option only has an effect for processors where a constant is difficult to load (e.g. RISC processors).

Example (pseudo code):

```
void main (void) {  
    int a = 1, b = 2, c, d;  
  
    c = a + b;
```

```
    d = a * b;  
}
```

without option `-Oncn` (pseudo code):

```
a MOVE 1  
b MOVE 2  
c MOVE 3  
d MOVE 2
```

with option `-Oncn` (pseudo code):

```
a MOVE 1  
b MOVE 2  
c ADD a,b  
d MOVE 2
```

The constant 3 is a new constant that does not appear in the source. The constant 2 is already present, so it is still propagated.

Example

`-Oncn`

See also

None

-OnCopyDown: Do Generate Copy Down Information for Zero Values

Group

OPTIMIZATION

Scope

Compilation unit

Syntax

"-OnCopyDown"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

With usual startup code, all global variables are first set to 0 (zero out). If the definition contained an initialization value, this initialization value is copied to the variable (copy down). Because of this, it is not necessary to copy zero values unless the usual startup code is modified. If a modified startup code contains a copy down but not a zero out, use this option to prevent the compiler from removing the initialization.

NOTE	The case of a copy down without a zero out is normally not used. Because the copy down needs much more space than the zero out, it usually contains copy down and zero out, zero out alone, or none of them.
-------------	--

In the HIWARE format, the object file format permits the Compiler to remove single assignments in a structure or array initialization. In the ELF format, it is optimized only if the whole array or structure is initialized with 0.

NOTE This option controls the optimizations done in the compiler. However, the linker itself might further optimize the copy down or the zero out.

Example

```
int i=0;
int arr[10]={1,0,0,0,0,0,0,0,0,0};
```

If this option is present, no copy down is generated for `i`. For the array `arr`, the initialization with 0 can only be optimized in the HIWARE format. In ELF it is not possible to separate them from the initialization with 1.

See also

None

-OnCstVar: Disable CONST Variable by Constant Replacement

Group

OPTIMIZATION

Scope

Compilation Unit

Syntax

"-OnCstVar"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

This option provides you with a way to switch OFF the replacement of CONST variable by the constant value.

Example

```
const int MyConst = 5;
int i;
void foo(void) {
    i = MyConst;
}
```

If the option -OnStVar is not set, the compiler replaces each occurrence of 'MyConst' with its constant value 5; that is 'i = MyConst' will be transformed

into 'i = 5;'. The Memory/ROM needed for the 'MyConst' constant variable is optimized as well. With the -OnCstVar option set, this optimization is avoided. This is logical only if you want to have unoptimized code.

See also

None

-One: Disable any Low Level Common Subexpression Elimination

ICG

Group

OPTIMIZATION

Scope

Function

Syntax

"-One"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

This option prevents the Compiler from reusing common subexpressions, such as array indexes and array base addresses. The code size may increase. The low level CSE does not have the alias problems of the front end CSE and is therefore switched on by default.

The two CSE optimizations do not cover the same cases. The low level CSE has a finer granularity, but does not handle all cases of the front end CSE.

Use this option only to generate more readable code for debugging.

Example: (abstract code)

```
void main (int i) {  
    int a[10];  
    a[i] = a[i-1];  
}
```

without option (optimized):

```
tmp1    LD i  
tmp2    LSL tmp1,#1  
tmp3    SUB tmp2,#2  
tmp4    ADR a  
tmp5    ADD tmp3, tmp4  
tmp6    LD (tmp5)  
2(tmp5) ST tmp6
```

-One (not optimized, readable):

```
tmp1    LD i  
tmp2    LSL tmp1,#1  
tmp3    SUB tmp2,#2  
tmp4    ADR a  
tmp5    ADD tmp3,tmp4  
tmp6    LSL tmp1,#1    ;calculated twice  
tmp7    ADR a          ;calculated twice  
tmp8    ADD tmp6,tmp7  
tmp9    LD (tmp5)  
(tmp8) ST tmp9
```

Example

-One

See also

None

-OnP: Disable Peephole Optimization

HC12

Group

OPTIMIZATION

Scope

Function

Syntax

"-OnP" ["=" <option Char> {<option Char>}]

Arguments

<option Char> is one of the following:

- "a": Disable LEAS to PUSH/POP optimization
- "b": Disable POP PULL optimization
- "c": Disable Compare 0 optimizations
- "d": Disable load/store load/store optimization
- "e": Disable LEA LEA optimization
- "f": Disable load/store to POP/PUSH optimization
- "g": Disable load arithm store optimization
- "h": Disable JSR/RTS optimization
- "i": Disable INC/DEC Compare optimizations
- "j": Disable store store optimization
- "k": Disable LEA 0 optimization
- "l": Disable LEA into addressing mode optimization
- "m": Disable RET optimization
- "p": Disable PULL POP optimization
- "q": Disable PSHC PULC optimization
- "t": Disable TFR TFR optimization
- "u": Disable unused optimization

Default

None

Defines

None

Pragmas

None

Description

If `-OnP` is specified, the whole peephole optimizer is disabled. To disable only a single peephole optimization, the optional syntax `-OnP=<char>` may be used, e.g. `-OnP=ef` disables LEA/LEA and POP/PUSH optimization. Refer to Back End for additional details.

Example

`-OnP`

See also

[Backend description of all peephole optimizations](#)

-OnPMNC: Disable Code Generation for NULL Pointer to Member Check

Group

OPTIMIZATION

Scope

Compilation Unit

Syntax

"-OnPMNC"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

Before assigning a pointer to member in C++, you must ensure that the pointer to member is not NULL in order to generate correct and safe code. In embedded systems development, the problem is to generate the denser code while avoiding overhead whenever possible (this NULL check code is a good example). If you can ensure this pointer to member will never be NULL, then this NULL check is useless. This option enables you to switch off the code generation for the NULL check.

Example

-OnPMNC

See also

None

-Ont: Disable Tree Optimizer

Group

OPTIMIZATION

Scope

Function

Syntax

```
"-Ont" ["=" {"%" | "&" | "*" | "+" | "-" | "/" | "0" | "1" | "7" | "8" | "9" | "?" | "^" |  
"a" | "b" | "c" | "d" | "e" | "f" | "h" | "i" | "l" | "m" | "n" | "o" | "p" | "q" | "r" | "s" | "t"  
| "u" | "v" | "w" | "|" | "~"}]
```

Arguments

"%": Disable mod optimization
"&": Disable bit and optimization
"*": Disable mul optimization
"+": Disable plus optimization
"-": Disable minus optimization
"/": Disable div optimization
"0": Disable and optimization
"1": Disable or optimization
"7": Disable extend optimization
"8": Disable switch optimization
"9": Disable assign optimization
"?": Disable test optimization
"^": Disable xor optimization
"a": Disable statement optimization
"b": Disable constant folding optimization
"c": Disable compare optimization
"d": Disable binary operation optimization
"e": Disable constant swap optimization
"f": Disable condition optimization
"h": Disable unary minus optimization
"i": Disable address optimization
"l": Disable label optimization
"m": Disable left shift optimization
"n": Disable right shift optimization

"o": Disable cast optimization
"p": Disable cut optimization
"q": Disable 16-32 compare optimization
"r": Disable 16-32 relative optimization
"s": Disable indirect optimization
"t": Disable for optimization
"u": Disable while optimization
"v": Disable do optimization
"w": Disable if optimization
"|": Disable bit or optimization
"~": Disable bit neg optimization

Default

If `-Ont` is specified, all optimizations are disabled

Defines

None

Pragmas

None

Description

The Compiler contains a special optimizer which optimizes the internal tree data structure. This tree data structure holds the semantic of the program and represents the parsed statements and expressions.

This option disables the tree optimizer. This may be useful for debugging, and to force the Compiler to produce 'straight forward' code. Note that the optimizations below are just examples for the classes of optimizations.

If this option is set, the Compiler will not perform the following optimizations:

-Ont=~

Disable optimization of '`~~i`' into '`i`'

-Ont=|

Disable optimization of '`i|0xffff`' into '`0xffff`'

-Ont=w

Disable optimization of '`if (1) i = 0;`' into '`i = 0;`'

-Ont=v

Disable optimization of 'do ... while(0) into '...'

-Ont=u

Disable optimization of 'while(1) ...;' into '...;'

-Ont=t

Disable optimization of 'for(;;) ...' into 'while(1) ...'

-Ont=s

Disable optimization of '*&i' into 'i'

-Ont=r

Disable optimization of 'L<=4' into 16bit compares if 16bit compares are better

-Ont=q

Reduction of long compares into int compares if int compares are better: (-Ont=q to disable it)

```
if (uL == 0)
```

will be optimized into

```
if ((int)(uL>>16) == 0 && (int)uL == 0)
```

-Ont=p

Disable optimization of '(char)(long)i' into '(char)i'

-Ont=o

Disable optimization of '(short)(int)L' into '(short)L' if short and int have the same size

-Ont=n, -Ont=m:

Optimization of shift optimizations (<<, >>, -Ont=n or -Ont=m to disable it):

Reduction of shift counts to unsigned char:

```
uL = uL1 >> uL2;
```

will be optimized into

```
uL = uL1 >> (unsigned char)uL2;
```

Optimization of zero shift counts:

```
uL = uL1 >> 0;
```

will be optimized into

```
uL = uL1;
```

Optimization of shift counts greater than the object to be shifted:

```
uL = uL1 >> 40;
```

will be optimized into

```
uL = 0L;
```

Strength reduction for operations followed by a cast operation:

```
ch = uL1 * uL2;
```

will be optimized into

```
ch = (char)uL1 * (char)uL2;
```

Replacing shift operations by load/store

```
i = uL >> 16;
```

will be optimized into

```
i = *(int *)(&uL);
```

Shift count reductions:

```
ch = uL >> 17;
```

will be optimized into

```
ch = (*(char *)(&uL)+1)>>1;
```

Optimization of shift combined with binary and:

```
ch = (uL >> 25) & 0x10;
```

will be optimized into

```
ch = ((* (char *)(&uL))>>1) & 0x10;
```

-Ont=l

Disable optimization removal of labels if not used

-Ont=i

Disable optimization of '&*p' into 'p'

-Ont=h

Disable optimization of `'-(-i)'` into `'i'`

-Ont=f

Disable optimization of `'(a==0)'` into `'(!a)'`

-Ont=e

Disable optimization of `'2*i'` into `'i*2'`

-Ont=d

Disable optimization of `'us & ui'` into `'us & (unsigned short)ui'`

-Ont=c

Disable optimization of `'if ((long)i)'` into `'if (i)'`

-Ont=b

Disable optimization of `'3+7'` into `'10'`

-Ont=a

Disable optimization of last statement in function if result is not used

-Ont=^

Disable optimization of `'i^0'` into `'i'`

-Ont=?

Disable optimization of `'i = (int)(cond ? L1:L2);'` into
`'i = cond ? (int)L1:(int)L2;'`

-Ont=9

Disable optimization of `'i=i;'`

-Ont=8

Disable optimization of empty switch statement

-Ont=7

Disable optimization of `'(long)(char)L'` into `'L'`

-Ont=1

Disable optimization of 'a || 0' into 'a'

-Ont=0

Disable optimization of 'a && 1' into 'a'

-Ont=/

Disable optimization of 'a/1' into 'a'

-Ont=-

Disable optimization of 'a-0' into 'a'

-Ont=+

Disable optimization of 'a+0' into 'a'

-Ont=*

Disable optimization of 'a*1' into 'a'

-Ont=&

Disable optimization of 'a&0' into '0'

-Ont=%

Disable optimization of 'a%1' into '0'

Example

```
fibonacci.c -Ont
```

See also

None

-Or: Allocate Local Variables into Registers

ICG

Group

OPTIMIZATION

Scope

Function

Syntax

"-Or"

Arguments

None

Default

None

Defines

__OPTIMIZE_REG__

Pragmas

None

Description

Allocate local variables (char and int) in registers. The number of local variables allocated in registers depends on the number of available registers. This option is useful when using variables as loop counters and switch selectors, or if the processor requires register operands for multiple operations (e.g. RISC processors). Compiling with this option may increase your code size (spill and merge code).

NOTE This optimization may result in code very hard to debug on High Level Language level.

NOTE This optimization has only effects for some backends.
For some backends the code does not change.

Example

-Or

```
int main (void){
    int a,b;
    return a + b;
}
```

without option -Or (pseudo code):

```
tmp1 LD a
tmp2 LD b
tmp3 ADD tmp1,tmp2
RET tmp3
```

with option -Or (pseudo code):

```
tmp1 ADD a,b
RET tmp1
```

See also

None

-O (-Os, -Ot): Main Optimization Target

Group

OPTIMIZATION

Scope

Function

Syntax

"-O" ("s" | "t")

Arguments

"s": Optimization for code size (default)

"t": Optimization for execution speed

Default

-Os

Defines

__OPTIMIZE_FOR_SIZE__

__OPTIMIZE_FOR_TIME__

Pragmas

None

Description

There are various points where the Compiler has to choose between two possibilities: it can either generate fast, but large code, or small but slower code.

The Compiler generally optimizes on code size. It often has to decide between a runtime routine or an expanded code. The programmer can decide whether to choose between the slower and shorter or the faster and longer code sequence by setting a command line switch.

The -Os option directs the Compiler to optimize the code for smaller code size. The Compiler trades faster-larger code for slower-smaller code.

The `-Ot` option directs the Compiler to optimize the code for faster execution time. The Compiler will “trade” slower-smaller code for faster-larger code.

NOTE This option only affects some special code sequences. This option has to be set together with other optimization options (e.g. register optimization) to get best results.

Example

`-Os`

-Ou/-Onu: Optimize Dead Assignments

ICG

Group

OPTIMIZATION

Scope

Function

Syntax

"-O" ("u" | "nu")

Arguments

None

Default

Optimization enabled for functions containing no inline assembler code

Defines

None

Pragmas

None

Description

Optimize dead assignments. Assignments to local variables, not referenced later, are removed by the Compiler.

There are three possible settings for this option: -Ou is given, -Onu is given, or neither of these options is given:

-Ou: Always optimize dead assignments (even if HLI is present in current function). Inline assembler accesses are not considered.

NOTE This option is not safe when accesses to local variables are contained in inline assembler code.

-Onu: The optimization does not take place. This generates the best possible debug information. The code is larger and slower than without -one.

None of the options given: Optimize dead assignments if HLI is not present in the current function.

NOTE The compiler is not aware of longjmp/setjmp calls. These functions, those that are similar, may generate a control flow which is not recognized by the compiler. Therefore, be sure to either not use local variables in functions using longjmp/setjmp, or switch this optimization off by using -Onu.

NOTE Dead assignments to volatile declared global objects are never optimized.

Example

```
-Ou
void main (int x) {
    f(x);
    x = 1; /* this assignment is dead and is
           removed if -Ou is active */
}
```

See also

None

-Pe: Preprocessing Escape Sequences in Strings

Group

LANGUAGE

Scope

Compilation Unit

Syntax

"-Pe"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

If escape sequences are used in macros, they are handled in an include directive similar to the way they are handled in a printf instruction:

```
#define STRING "c:\myfile.h"  
#include STRING
```

produces an error:

```
>> Illegal escape sequence
```

and used in:

```
printf(STRING);
```

produces a carriage return with line feed:

```
c:  
myfile
```

If the `-Pe` option is used, escape sequences are ignored in strings that contain a DOS drive letter ('a' – 'z', 'A' – 'Z') followed by a colon ':' and a backslash '\

When the `-Pe` option is enabled, the Compiler handles strings in include directives differently from other strings. Escape sequences in include directive strings are not evaluated.

The following example:

```
#include "c:\names.h"
```

results in exactly the same include file name as in the source file ("c:\names.h"). If the file name appears in a macro, the Compiler does not distinguish between file name usage and normal string usage with escape sequence. This occurs because the macro `STRING` has to be the same for the include and the `printf` call, as shown:

```
#define STRING "c:\n.h"  
#include STRING /* means: "c:\n.h" */  
  
void main(void) {  
    printf(STRING); /* means: "c:", new line and ".h" */  
}
```

This option may be used to use macros for include files. This prevents escape sequence scanning in strings if the string starts with a DOS drive letter ('a' – 'z', 'A' – 'Z') followed by a colon ':' and a backslash '\'. With the option set, the above example includes the 'c:\n.h' file and calls `printf` with "c:\n.h").

Example

`-Pe`

See also

None

-PEDIV: Use EDIV instruction

Group

CODE GENERATION

Scope

Function

Syntax

```
"-PEDIV" ["=" {"Div" | "Mod"}]
```

Arguments

Div: Use EDIV for divisions

Mod: Use EDIV for modulo instructions

Not specifying Div/Mod “-PEDIV” means the same as specifying both after the assignment (“-PEDIV=DivMod”)

Default

None

Defines

None

Pragmas

None

Description

The HC12 instruction set contains an EDIV and an EDIVS instruction. Each instruction divides a 32 bit value by a 16 bit values giving a 16 bit quotient and a 16 bit remainder. The EDIV instruction handles the unsigned division case and the EDIVS the signed division case.

With this option enabled, the compiler generates an EDIV instructions instead of calling a division runtime routine for matching cases. When a 32 bit value is divided by a 16 bit value, only 16 bits of the result are used.

The EDIV instruction, as implemented in the HC12 hardware, does not calculate a result when an overflow occurs. When using EDIV to calculate $0x100001 \% 0x10$, the EDIV instruction does not return 0x01 as a remainder because the quotient overflows. Therefore, the EDIV instruction cannot be used in a C-compatible code structure. When this option is enabled, the Compiler generates this instruction assuming that no overflow occurs. If an overflow does occur, the Compiler assumes it is insignificant.

Using this option may generate much faster and shorter code. But because this optimization is not ANSI-C compliant, this option must be enabled separately.

Example

Here a small source example:

```
long Divisor;
int Dividend;
int Remainder;
void Div(void) {
    Remainder= Divisor%Quotient;
}
```

Div generates the following code with -PEDIV:

```
LDD    Divisor:0x2
LDX    Dividend
LDY    Divisor
EDIVS
STD    Remainder
```

Div generates the following code without -PEDIV:

```
LDD    Dividend
JSR    _ILSEXT ; calls INT to LONG conversion routine
PSHD
PSHX
LDD    Divisor:0x2
LDX    Divisor
JSR    _LMODS ; calls the slow long division routine
STD    Remainder
```

Example of a usage

```
void main(void) {
    Divisor = 0x12345678;
    Dividend = 0x4567;
    Div(); /* in these case both version work because */
          /* 0x12345678 / 0x4567 == 0x4326 <= 0x7FFF */
    Dividend = 0x10;
```

```
    Div(); /* here the function compiled with -PEDIV */  
          /* does not return 8 in Remainder because */  
          /* 0x12345678 / 0x10 == 0x1234567 > 0x7FFF */  
}
```

See also

None

-Pic: Generate Position Independent Code (PIC)

HC12

Group

CODE

Scope

Function

Syntax

"-Pic"

Arguments

None

Default

None

Defines

__PIC__

Pragmas

None

Description

With this option enabled the Compiler generates PIC (Position Independent Code). PIC is generated only for code (call of functions) and not for data. Instead of using JSR with extended (16bit) addressing mode for function calls, the Compiler uses a PC-relative (IDX2) call. This ensures the branch distance is encoded instead of the absolute address.

Also, the Compiler uses LBRA's instead of JMP's for local unconditional branches.

```
void foo(void);  
void main(void) {  
    foo(); // BSR foo instead JSR foo  
}
```

With -pic:

```
0000 05fa0000    JMP    foo,PCR
```

Without -pic:

```
0000 060000    JMP    foo
```

NOTE With -pic, the code is larger and slower. Therefore this should only be used when necessary.

Example

```
-Pic
```

See also

[Position Independent Code Chapter in the Backend](#)
[Option -PicRTS](#)
[#pragma CODE_SEG](#)

-PicRTS: Call Runtime Support Position Independent

HC12

Group

CODE

Scope

Function

Syntax

"-PicRTS"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

When this option is enabled, the Compiler calls runtime functions independently in position independent code position. This requires one additional byte per call and should only be done when the whole application, including the runtime support, must be position independent. This option only affects position independent functions. Runtime calls that are not position independent functions are still done absolutely. This option is only useful when used together with "#pragma CODE_SEG PIC PicSegName" or with the "-Pic" option.

Example

```
-PicRTS
```

See also

[Position Independent Code Chapter in the Backend](#)

[#pragma CODE_SEG](#)

[Option -Pic](#)

-Pio: Include Files Only Once

Group

INPUT

Scope

Compilation Unit

Syntax

"-Pio"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

Includes every header file only once. Whenever the compiler reaches an `#include` directive, it checks if this file to be included was already read. If so, the compiler ignores the `#include` directive. It is common practice to protect header files from multiple inclusion by conditional compilation, as shown:

```
/* Header file myfile.h */
#ifndef _MY_FILE_H_
#define _MY_FILE_H_

/* .... content .... */
#endif /* _MY_FILE_H_ */
```

When `#ifndef` and `#define` directives are issued, header file content is read only once even when the header file is included several times. This solves many

problems as C-language protocol does not allow you to define structures (such as enums or typedefs) more than once.

When all header files are protected this way, this option can safely accelerate the compilation.

This option must not be used when a header file must be included twice, e.g. the file contains macros which are set differently at the different inclusion times.

In those instances, [#pragma ONCE](#) is used to accelerate the inclusion of safe header files which do not contain macros of that nature.

Example

```
-Pio
```

See also

[#pragma ONCE](#)

-Prod: Specify Project File at Startup

Group

Startup - This option can not be specified interactively.

Scope

None

Syntax

"-Prod=" <file>

Arguments

<file>: name of a project or project directory

Default

None

Defines

None

Pragmas

None

Description

This option can only be specified at the command line while starting the application. It can not be specified in any other circumstances, including the default.env file, the command line or whatever.

When this option is given, the application opens the file as configuration file.

When the file name does only contain a directory, the default name project.ini is appended. When the loading fails, a message box appears.

Example

```
compiler.exe -prod=project.ini
```

Use the compiler executable name instead of "compiler".

See also

[Section Configuration File](#)

-PSeg: Assume Objects are On Same Page

HC12

Group

CODE GENERATION

Scope

Function

Syntax

"-PSeg" ("All" | "NonDef" | "Obj")

Arguments

None

Default

NonDef

Defines

None

Pragmas

None

Description

The compiler has to generate at least two accesses to access objects allocated in the far area. First, the accessed page must be stored in the page register, and then the actual access takes place.

As an optimization, the compiler tries to avoid unnecessary page stores. If two memory accesses are using the same page, the second page store is avoided.

This option controls what the compiler assumes about the page of different objects.

-PSegAll: All objects in the same segment share the same page number. As a special case, all not otherwise allocated objects are in the same default segment.

-PsegNonDef: All objects in the same user-defined segment share the page number. Objects in default segments do not share the page number.

-PsegObj: Any two objects might have different page numbers. The compiler only optimizes page stores for the same object.

NOTE This option is effective only when directly accessing far objects. It does not change accesses with a runtime routine.

Example

Consider the following example in the large memory model:

```
char i0_def_seg;
char i1_def_seg;
#pragma DATA_SEG DPAGE DPAGE_CONTROLLED
char i2_user_seg;
char i3_user_seg;
void main(void) {
    i0_def_seg=56;
    i1_def_seg=56;
    i2_user_seg=56;
    i3_user_seg=56;
}
```

When compiled with the “-PsegAll” option, the i0_def_seg variable is on the same page as i1_def_seg, and the i2_user_seg variable is on the same page as the i3_user_seg variable. Therefore, the compiler sets the page register twice, as shown:

```
Options : -CpDPAGE=0x34 -Ml -PsegAll

0000 c638          LDAB  #56
0002 8600          LDAA  #i0_def_seg:Page
0004 5a34          STAA  52
0006 7b0000       STAB  i0_def_seg
0009 7b0000       STAB  i1_def_seg
000c 8600          LDAA  #i2_user_seg:Page
000e 5a34          STAA  52
0010 7b0000       STAB  i2_user_seg
0013 7b0000       STAB  i3_user_seg
0016 0a           RTC
```

When compiled with the “-PSegNonDef” option, only the `i2_user_seg` variable is on the same page as the `i3_user_seg` variable. Therefore, the compiler sets the page register three times, as shown:

```
Options : -CpDPAGE=0x34 -Ml -PSegNonDef
```

```
0000 c638          LDAB  #56
0002 8600          LDAA  #i0_def_seg:Page
0004 5a34          STAA  52
0006 7b0000        STAB  i0_def_seg
0009 8600          LDAA  #i1_def_seg:Page
000b 5a34          STAA  52
000d 7b0000        STAB  i1_def_seg
0010 8600          LDAA  #i2_user_seg:Page
0012 5a34          STAA  52
0014 7b0000        STAB  i2_user_seg
0017 7b0000        STAB  i3_user_seg
001a 0a           RTC
```

Finally, with the “-PSegObj” option, all variables may be on different pages. The page is set for every variable:

```
Options: -CpDPAGE=0x34 -Ml -PSegObj
```

```
0000 c638          LDAB  #56
0002 8600          LDAA  #i0_def_seg:Page
0004 5a34          STAA  52
0006 7b0000        STAB  i0_def_seg
0009 8600          LDAA  #i1_def_seg:Page
000b 5a34          STAA  52
000d 7b0000        STAB  i1_def_seg
0010 8600          LDAA  #i2_user_seg:Page
0012 5a34          STAA  52
0014 7b0000        STAB  i2_user_seg
0017 8600          LDAA  #i3_user_seg:Page
0019 5a34          STAA  52
001b 7b0000        STAB  i3_user_seg
001e 0a           RTC
```

See also

None

-Px4: Do Not Use ?BNE/?BEQ

HC12

Group

CODE GENERATION

Scope

Function

Syntax

"-Px4"

Arguments

None

Default

None

Defines

___PROCESSOR_X4___

Pragmas

None

Description

Some processors do not support all HC12 instructions. The Compiler does not generate instructions and code patterns which do not work on all available processors when this option is used. The following points are affected by this option:

- None of the instructions below is generated:

TBNE
TBEQ
IBNE
IBEQ
DBNE
DBEQ

- Also, the overflow flag is not used after a COM instruction.
- With this option set, the inline assembler does not allow the use of the instructions listed in Item 1, above.
- The macro `__PROCESSOR_X4__` is defined to allow different inline assembler code with conditional compilation.

Example

`-Px4`

See also

None

-Qvtp: Qualifier for Virtual Table Pointers

C++

Group

CODE GENERATION

Scope

Application

Syntax

"-Qvtp" ("none" | "far" | "near" | "rom" | "uni" | "paged")

Arguments

None

Default

-Qvptnone

Defines

None

Pragmas

None

Description

Using a virtual function in C++ requires an additional pointer to virtual function tables. This pointer is not accessible and is generated by the compiler in every class object when virtual function tables are associated.

NOTE It is useless to specify a qualifier which is not supported by the Back End (see Back End), e.g. using a 'far' qualifier if the Back End or CPU does not support any far data accesses.

Example

-QvtpFar

This sets the qualifier for virtual table pointers to far enabling the virtual tables to be placed into a far segment (if the Back End/CPU supports far segments).

See also

[C++ Front End](#)

-Rp (-Rpe, -Rpt): Large Return Value Type

ICG

Group

OPTIMIZATION

Scope

Application

Syntax

"-Rp" ("t" | "e")

Arguments

"t": Pass the large return value by pointer

"e": Pass the large return value with temporary elimination

Default

-Rpe

Defines

None

Pragmas

None

Description

This option is supported by the Compiler even though returning a ‘large’ return value may be not as efficient as using an additional pointer. The Compiler introduces an additional parameter for the return value if the return value could not be passed in registers.

Consider the following code:

```
typedef struct { int i[10]; } S;  
  
S F(void);  
S s;  
  
void main(void) {
```

```
    s = F();  
}
```

In the above case, with `-Rpt`, the code will look like:

```
void main(void) {  
    S tmp;  
  
    F(&tmp);  
    s = tmp; /* struct copy */  
}
```

The above approach is always correct but not efficient. The better solution is to pass the destination address directly to the callee making it unnecessary to declare and temporary and struct copy in the caller (i.e. `-Rpe`), as shown below:

```
void main(void) {  
    F(&s);  
}
```

The above example may produce incorrect results for rare cases, e.g. if the function `F` returns something overlapping of `'s'`. Because it's not possible for the Compiler to detect such rare cases, two options are provide: the `-Rpt` (always correct, but inefficient), or `-Rpe` (efficient) options.

Example

`-Rpt`

See also

None

-T: Flexible Type Management

Group

LANGUAGE.

Scope

Application

Syntax

"-T" <Type Format>

Arguments

<Type Format>: See below

Default

Depends on target, see Compiler Back End

Defines

To deal with different type sizes, one in the following define groups will be predefined by the Compiler:

```
__CHAR_IS_SIGNED__  
__CHAR_IS_UNSIGNED__  
  
__CHAR_IS_8BIT__  
__CHAR_IS_16BIT__  
__CHAR_IS_32BIT__  
__CHAR_IS_64BIT__  
  
__SHORT_IS_8BIT__  
__SHORT_IS_16BIT__  
__SHORT_IS_32BIT__  
__SHORT_IS_64BIT__  
  
__INT_IS_8BIT__  
__INT_IS_16BIT__  
__INT_IS_32BIT__  
__INT_IS_64BIT__  
  
__ENUM_IS_8BIT__  
__ENUM_IS_16BIT__
```

```
__ENUM_IS_32BIT__  
__ENUM_IS_64BIT__  
  
__ENUM_IS_SIGNED__  
__ENUM_IS_UNSIGNED__  
  
__PLAIN_BITFIELD_IS_SIGNED__  
__PLAIN_BITFIELD_IS_UNSIGNED__  
  
__LONG_IS_8BIT__  
__LONG_IS_16BIT__  
__LONG_IS_32BIT__  
__LONG_IS_64BIT__  
  
__LONG_LONG_IS_8BIT__  
__LONG_LONG_IS_16BIT__  
__LONG_LONG_IS_32BIT__  
__LONG_LONG_IS_64BIT__  
  
__FLOAT_IS_IEEE32__  
__FLOAT_IS_IEEE64__  
__FLOAT_IS_DSP__  
  
__DOUBLE_IS_IEEE32__  
__DOUBLE_IS_IEEE64__  
__DOUBLE_IS_DSP__  
  
__LONG_DOUBLE_IS_IEEE32__  
__LONG_DOUBLE_IS_IEEE64__  
__LONG_DOUBLE_IS_DSP__  
  
__LONG_LONG_DOUBLE_IS_IEEE32__  
__LONG_LONG_DOUBLE_IS_IEEE64__  
__LONG_LONG_DOUBLE_DSP__  
  
__VTAB_DELTA_IS_8BIT__  
__VTAB_DELTA_IS_16BIT__  
__VTAB_DELTA_IS_32BIT__  
__VTAB_DELTA_IS_64BIT__  
  
__PTRMBR_OFFSET_IS_8BIT__  
__PTRMBR_OFFSET_IS_16BIT__  
__PTRMBR_OFFSET_IS_32BIT__  
__PTRMBR_OFFSET_IS_64BIT__
```

Pragmas

None

Description

This option allows configurable type settings. The syntax of the option is: -
 T{<type> <format>}

For <type> one of the keys listed in [Table 1.19](#) may be specified:

Table 1.19 Data Type Keys

Type	Key
char	'c'
short	's'
int	'i'
long	'L'
long long	'LL'
float	'f'
double	'd'
long double	'Ld'
long long double	'LLd'
enum	'e'
sign plain bitfield	'b'
virtual table delta size	'vtd'
pointer to member offset size	'pmo'

NOTE Keys are not case sensitive, e.g. both 'f' and 'F' may be used for the type “float”.

The sign of the type ‘char,’ or of the enumeration type, may be changed with a prefix placed before the key for the char key. See [Table 1.20](#).

Table 1.20 Keys for Signed And Unsigned Prefixes

Sign prefix	Key
signed	's'
unsigned	'u'

The sign of the type 'plain bitfield type' is changed with the options shown in [Table 1.21](#). Plain bitfield are bitfields defined/declared without an explicit signed/unsigned qualifier, e.g. 'int field:3'. Using this option, you can specify if the 'int' in the previous example is handled as 'signed int' or as 'unsigned int'. Note that this option may not be available on all targets. Also the default setting may vary. Refer to [Defines for Plain Bitfield Sign](#).

Table 1.21 Keys for Signed And Unsigned Bitfield Prefixes

Sign prefix	Key
plain signed bitfield	'bs'
plain unsigned bitfield	'bu'

For <format> one of the keys in [Table 1.22](#) can be specified.

Table 1.22 Data Format Specifier Keys

Format:	Key
8 bit integral	'1'
16 bit integral	'2'
24 bit integral	'3'
32 bit integral	'4'
64 bit integral	'8'
IEEE32 floating	'2'
IEEE64 floating	'4'
DSP(32 bit)	'0'

Not all formats may be available for a target. See Back End for supported formats.

NOTE At least one type for each basic size (1, 2, 4 bytes) has to be available. It is illegal if no type of any sort is not set to at least a size of one. See Back End for default settings.

NOTE Enumeration types have the type 'signed int' by default for ANSI-C compliance.

The `-Tpmo` option allows you to change the pointer to a member offset value type. The default setting is 16 bits. The pointer to the member offset is used for C++ pointer to members only.

Example

`-Tsc` sets 'char' to 'signed char'
 and `-Tuc` sets 'char' to 'unsigned char'

Example

`-Tsc1s2i2L4LL4f2d4Ld4LLd4e2`

denotes:

- signed char with 8 bit (sc1)
- short and int with 16 bit (s2i2)
- long, long long with 32 bit (L4LL4)
- float with IEEE32 (f2)
- double, long double and long long double with IEEE64 (d4Ld4LL4)
- enum with 16 bit (signed) (e2)

Restrictions:

For integrity and compliance to ANSI, the following two rules has to be true:

```
sizeof(char)      <= sizeof(short)
sizeof(short)    <= sizeof(int)
sizeof(int)      <= sizeof(long)
sizeof(long)     <= sizeof(long long)

sizeof(float)    <= sizeof(double)
sizeof(double)   <= sizeof(long double)
sizeof(long double) <= sizeof(long long double)
```

NOTE It is illegal to set char to 16 bit and int to 8 bit.

Be careful if you change type sizes. Type sizes must be consistent over the whole application. The libraries delivered with the Compiler are compiled with the standard type settings.

Also be careful if you change the type sizes for under or overflows, e.g. assigning a value too large to an object which is smaller now, as shown in the following example:

```
int i; /* -Til int has been set to 8 bit! */
i = 0x1234; /* i will set to 0x34! */
```

Examples:

Setting the size of char to 16 bit:

```
-Tc2
```

Setting the size of char to 16 bit and plain char is signed:

```
-Tsc2
```

Setting char to 8 bit and unsigned, int to 32 bit and long long to 32 bit

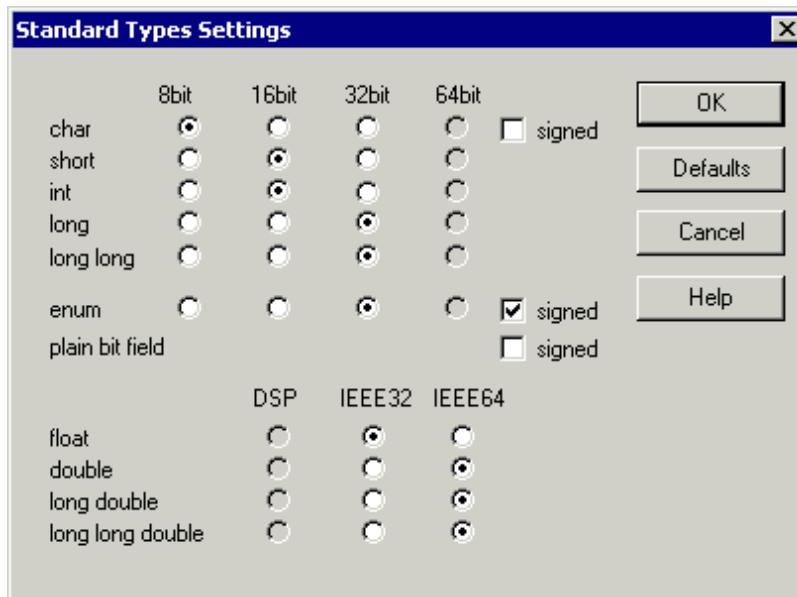
```
-Tuc1i4LL4
```

Setting float to IEEE32 and double to IEEE64:

```
-Tf2d4
```

The -Tvtd option allows you to change the delta value type inside virtual function tables (see also [C++ Front End](#)). The default setting is 16bit.

Another way to set this option is using the dialog in the Graphical User Interface:



See also

[Defines for Plain Bitfield Sign](#)

-V: Prints the Compiler Version

Group

VARIOUS

Scope

None

Syntax

"-V"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

Prints the Compiler version of the internal subversion numbers of the parts the Compiler consists of and the current directory.

NOTE This option can determine the current directory of the Compiler.

Example

-V produces the following list:

```
Directory: \software\sources\c
ANSI-C Front End, V5.0.1, Date Jan 01 1997
```

Tree CSE Optimizer, V5.0.1, Date Jan 01 1997
Back End V5.0.1, Date Jan 01 1997

See also

None

-View: Application Standard Occurrence

PC

Group

HOST

Scope

Compilation Unit

Syntax

"-View" <kind>

Arguments

<kind> is one of:

“Window”: Application window has default window size

“Min”: Application window is minimized

“Max”: Application window is maximized

“Hidden”: Application window is not visible (only if arguments)

Default

Application started with arguments: Minimized

Application started without arguments: Window

Defines

None

Pragmas

None

Description

The application (e.g. linker, compiler, ...) is started as a normal window if no arguments are given. If the application is started with arguments (e.g. from the maker to compile/link a file), then the application runs minimized to allow batch processing.

You can specify the behavior of the application using this option. Using `-ViewWindow`, the application is visible with its normal window. Using `-ViewMin` the application is visible iconified (in the task bar). Using `-ViewMax`

the application is visible maximized (filling the whole screen). Using `-ViewHidden` the application processes arguments (e.g. files to be compiled/linked) completely invisible in the background (no window/icon in the task bar visible). However, if you are using the `-N` option, a dialog box is still possible.

Example

```
c:\Metrowerks\linker.exe -ViewHidden fibo.prm
```

See also

None

-WErrFile: Create "err.log" Error File

Group

MESSAGE

Scope

Compilation Unit

Syntax

"-WErrFile" ("On" | "Off")

Arguments

None

Default

err.log is created/deleted

Defines

None

Pragmas

None

Description

The error feedback to the tools that are called is done with a return code. In 16-bit window environments, this was not possible. In the error case, an "err.log" file, with the numbers of errors written into it, was used to signal an error. To state no error, the "err.log" file was deleted. Using UNIX or WIN32, there is now a return code available. The "err.log" file is no longer needed when only UNIX / WIN32 applications are involved.

NOTE: The error file must be created in order to signal any errors if you use a 16-bit maker with this tool.

Example

```
-WErrFileOn
```

The err.log file is created/deleted when the application is finished.

`-WErrFileOff`

The existing err.log file is not modified.

See also

[Option -WStdout](#)

[Option -WOutFile](#)

-Wmsg8x3: Cut File Names in Microsoft Format to 8.3

PC

Group

MESSAGE

Scope

Compilation Unit

Syntax

"-Wmsg8x3"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

Some editors (e.g. early versions of WinEdit) expect the file name in the Microsoft message format (8.3 format). That means the file name can have, at most, eight characters with not more than a three-character extension. Longer file names are possible when you use Win95 or WinNT. This option truncates the file name to the 8.3 format.

Example

```
x:\mysourcefile.c(3): INFORMATION C2901: Unrolling loop
```

With the option -Wmsg8x3 set, the above message is:

```
x:\mysource.c(3): INFORMATION C2901: Unrolling loop
```

See also

[Option -WmsgFi](#)
[Option -WmsgFb](#)

-WmsgCE: RGB Color for Error Messages

Group

MESSAGE

Scope

Function

Syntax

"-WmsgCE" <RGB>

Arguments

<RGB>: 24bit RGB (red green blue) value

Default

-WmsgCE16711680 (rFF g00 b00, red)

Defines

None

Pragmas

None

Description

This option changes the error message color. The specified value must be an RGB (Red-Green-Blue) value, and must also be specified in decimal.

Example

-WmsgCE255 changes the error messages to blue

See also

None

-WmsgCF: RGB Color for Fatal Messages

Group

MESSAGE

Scope

Function

Syntax

"-WmsgCF" <RGB>

Arguments

<RGB>: 24bit RGB (red green blue) value

Default

-WmsgCF8388608 (r80 g00 b00, dark red)

Defines

None

Pragmas

None

Description

This option changes the color of a fatal message. The specified value must be an RGB (Red-Green-Blue) value, and must also be specified in decimal.

Example

-WmsgCF255 changes the fatal messages to blue

See also

None

-WmsgCI: RGB Color for Information Messages

Group

MESSAGE

Scope

Function

Syntax

"-WmsgCI" <RGB>

Arguments

<RGB>: 24bit RGB (red green blue) value

Default

-WmsgCI32768 (r00 g80 b00, green)

Defines

None

Pragmas

None

Description

This option changes the color of an information message. The specified value must be an RGB (Red-Green-Blue) value, and must also be specified in decimal.

Example

-WmsgCI255 changes the information messages to blue

See also

None

-WmsgCU: RGB Color for User Messages

Group

MESSAGE

Scope

Function

Syntax

"-WmsgCU" <RGB>

Arguments

<RGB>: 24bit RGB (red green blue) value

Default

-WmsgCU0 (r00 g00 b00, black)

Defines

None

Pragmas

None

Description

This option changes the color of a user message. The specified value must be an RGB (Red-Green-Blue) value, and must also be specified in decimal.

Example

-WmsgCU255 changes the user messages to blue

See also

None

-WmsgCW: RGB Color for Warning Messages

Group

MESSAGE

Scope

Function

Syntax

"-WmsgCW" <RGB>.

Arguments

<RGB>: 24bit RGB (red green blue) value

Default

-WmsgCW255 (r00 g00 bFF, blue)

Defines

None

Pragmas

None

Description

This option changes the color of a warning message. The specified value must be an RGB (Red-Green-Blue) value, and must also be specified in decimal.

Example

-WmsgCW0 changes the warning messages to black

See also

None

-WmsgFb (-WmsgFbi, -WmsgFbm): Set Message File Format for Batch Mode

Group

MESSAGE

Scope

Compilation Unit

Syntax

"-WmsgFb" ["v" | "m"]

Arguments

"v": Verbose format

"m": Microsoft format

Default

-WmsgFbm

Defines

None

Pragmas

None

Description

You can start the Compiler with additional arguments (e.g. files to be compiled together with Compiler options). If the Compiler has been started with arguments (e.g. from the Make Tool or with the ‘%f’ argument from the CodeWright IDE), the Compiler compiles the files in a batch mode. No Compiler window is visible and the Compiler terminates after job completion.

If the Compiler is in batch mode, the Compiler messages are written to a file instead of to the screen. This file contains only the compiler messages (see examples below).

The Compiler uses a Microsoft message format to write the Compiler messages (errors, warnings, information messages) if the compiler is in batch mode.

This option changes the default format from the Microsoft format (only line information) to a more verbose error format with line, column, and source information.

NOTE Using the verbose message format may slow down the compilation because the compiler has to write more information into the message file.

Example

```
void foo(void) {
    int i, j;
    for(i=0;i<1;i++);
}
```

The Compiler may produce the following file if it is running in batch mode (e.g. started from the Make tool):

```
X:\C.C(3): INFORMATION C2901: Unrolling loop
X:\C.C(2): INFORMATION C5702: j: declared in function foo
but not referenced
```

Setting the format to verbose, more information is stored in the file:

-WmsgFbv

```
>> in "X:\C.C", line 3, col 2, pos 33
    int i, j;

    for(i=0;i<1;i++);
    ^
INFORMATION C2901: Unrolling loop
>> in "X:\C.C", line 2, col 10, pos 28
void foo(void) {

    int i, j;
    ^
INFORMATION C5702: j: declared in function foo but not
referenced
```

See also

[Environment variable ERRORFILE](#)

[Option -WmsgFi](#)

-WmsgFi (-WmsgFiv, -WmsgFim): Set Message Format for Interactive Mode

Group

MESSAGE

Scope

Compilation Unit

Syntax

"-WmsgFi" ["v" | "m"]

Arguments

"v": Verbose format

"m": Microsoft format

Default

-WmsgFiv

Defines

None

Pragmas

None

Description

The Compiler operates in the interactive mode (that is, a window is visible) if it is started without additional arguments (e.g. files to be compiled together with Compiler options).

The Compiler uses the verbose error file format to write the Compiler messages (errors, warnings, information messages).

This option changes the default format from the verbose format (with source, line and column information) to the Microsoft format (only line information).

NOTE Using the Microsoft format may speed up the compilation because the compiler has to write less information to the screen.

Example

```
void foo(void) {  
    int i, j;  
    for(i=0;i<1;i++);  
}
```

The Compiler may produce the following error output in the Compiler window if it is running in interactive mode:

```
Top: X:\C.C  
Object File: X:\C.O  
  
>> in "X:\C.C", line 3, col 2, pos 33  
    int i, j;  
  
    for(i=0;i<1;i++);  
  
    ^  
INFORMATION C2901: Unrolling loop
```

Setting the format to Microsoft, less information is displayed:

```
-WmsgFim  
  
Top: X:\C.C  
Object File: X:\C.O  
X:\C.C(3): INFORMATION C2901: Unrolling loop
```

See also

[Environment variable ERRORFILE](#)

[Option -WmsgFb](#)

-WmsgFob: Message Format for Batch Mode

Group

MESSAGE

Scope

Function

Syntax

"-WmsgFob"<string>

Arguments

<string>: format string (see below).

Default

-WmsgFob"% "%f%e%"(%l): %K %d: %m\n"

Defines

None

Pragmas

None

Description

This option modifies the default message format in batch mode. The formats listed in [Table 1.23](#) are supported (assuming that the source file is `x:\Metrowerks\mysourcefile.cpph`):

Table 1.23 Message Format Specifiers

Format	Description	Example
%s	Source Extract	
%p	Path	x:\Metrowerks\
%f	Path and name	x:\Metrowerks\mysourcefile
%n	File name	mysourcefile

Table 1.23 Message Format Specifiers

Format	Description	Example
%e	Extension	.cpph
%N	File (8 chars)	mysource
%E	Extension (3 chars)	.cpp
%l	Line	3
%c	Column	47
%o	Pos	1234
%K	Uppercase kind	ERROR
%k	Lowercase kind	error
%d	Number	C1815
%m	Message	text
%%	Percent	%
\n	New line	
%"	A " if the filename, if the path or the extension contains a space	
%'	A ' if the filename, the path or the extension contains a space	

Example

```
-WmsgFob"%f%e(%l): %k %d: %m\n"
```

Produces a message in the following format:

```
X:\C.C(3): information C2901: Unrolling loop
```

See also

- [Environment variable ERRORFILE](#)
- [Option -WmsgFb](#)
- [Option -WmsgFi](#)
- [Option -WmsgFonp](#)
- [Option -WmsgFoi](#)

-WmsgFoi: Message Format for Interactive Mode

Group

MESSAGE

Scope

Function

Syntax

"-WmsgFoi"<string>

Arguments

<string>: format string (See below)

Default

-WmsgFoi"\n>> in \"%f%e\", line %l, col >>%c, pos %o\n%s\n%K %d: %m\n"

Defines

None

Pragmas

None

Description

This option modifies the default message format in interactive mode. The formats listed in [Table 1.24](#) are supported (assuming that the source file is x:\Metrowerks\mysourcefile.cpph):

Table 1.24 Message Format Specifiers

Format	Description	Example
%s	Source Extract	
%p	Path	x:\sources\
%f	Path and name	x:\sources\mysourcefile
%n	File name	mysourcefile

Table 1.24 Message Format Specifiers

Format	Description	Example
%e	Extension	.cpph
%N	File (8 chars)	mysource
%E	Extension (3 chars)	.cpp
%l	Line	3
%c	Column	47
%o	Pos	1234
%K	Uppercase kind	ERROR
%k	Lowercase kind	error
%d	Number	C1815
%m	Message	text
%%	Percent	%
\n	New line	
%"	A " if the filename, if the path or the extension contains a space.	
%'	A ' if the filename, the path or the extension contains a space	

Example

```
-WmsgFoi"%f%e(%l): %k %d: %m\n"
```

Produces a message in following format

```
X:\C.C(3): information C2901: Unrolling loop
```

See also

- [Environment variable ERRORFILE](#)
- [Option -WmsgFb](#)
- [Option -WmsgFi](#)
- [Option -WmsgFonp](#)
- [Option -WmsgFob](#)

-WmsgFonf: Message Format for no File Information

Group

MESSAGE

Scope

Function

Syntax

"-WmsgFonf"<string>

Arguments

<string>: format string (See below)

Default

-WmsgFonf"%K %d: %m\n"

Defines

None

Pragmas

None

Description

Sometimes there is no file information available for a message (e.g. if a message not related to a specific file). Then the message format string defined by MESSAGE is used. [Table 1.25](#) lists the supported formats.

Table 1.25 Message Format Specifiers

Format	Description	Example
%K	Uppercase kind	ERROR
%k	Lowercase kind	error
%d	Number	C1815
%m	Message	text

Table 1.25 Message Format Specifiers

Format	Description	Example
%%	Percent	%
\n	New line	
%"	A " if the filename, if the path or the extension contains a space	
%'	A ' if the filename, the path or the extension contains a space	

Example

```
-WmsgFonf "%k %d: %m\n"
```

Produces a message in following format:

```
information L10324: Linking successful
```

See also

[Environment variable ERRORFILE](#)

[Option -WmsgFb](#)

[Option -WmsgFi](#)

[Option -WmsgFonp](#)

[Option -WmsgFoi](#)

-WmsgFonp: Message Format for no Position Information

Group

MESSAGE

Scope

Function

Syntax

"-WmsgFonp"<string>

Arguments

<string>: format string (See below)

Default

-WmsgFonp"% "%f%e% ": %K %d: %m\n"

Defines

None

Pragmas

None

Description

Sometimes there is no position information available for a message (e.g. if a message not related to a certain position). Then the message format string defined by MESSAGE is used. [Table 1.26](#) lists the supported formats.

Table 1.26 Message Format Specifiers

Format	Description	Example
%K	Uppercase kind	ERROR
%k	Lowercase kind	error
%d	Number	C1815
%m	Message	text

Table 1.26 Message Format Specifiers

Format	Description	Example
%%	Percent	%
\n	New line	
%"	A " if the filename, if the path or the extension contains a space	
%'	A ' if the filename, the path, or the extension contains a space	

Example

```
-WmsgFonf "%k %d: %m\n"
```

Produces a message in following format:

```
information L10324: Linking successful
```

See also

[Environment variable ERRORFILE](#)

[Option -WmsgFb](#)

[Option -WmsgFi](#)

[Option -WmsgFonp](#)

[Option -WmsgFoi](#)

-WmsgNe: Number of Error Messages

Group

MESSAGE

Scope

Compilation Unit

Syntax

"-WmsgNe" <number>

Arguments

<number>: Maximum number of error messages

Default

50

Defines

None

Pragmas

None

Description

This option sets the number of error messages that are to be displayed while the Compiler is processing.

NOTE Subsequent error messages which depend upon a previous error message may not process correctly.

Example

```
-WmsgNe2
```

Stops compilation after two error messages

See also

[Option -WmsgNi](#)

[Option -WmsgNw](#)

-WmsgNi: Number of Information Messages

Group

MESSAGE

Scope

Compilation Unit

Syntax

"-WmsgNi" <number>

Arguments

<number>: Maximum number of information messages

Default

50

Defines

None

Pragmas

None

Description

This option sets the amount of information messages that are logged.

Example

```
-WmsgNi10
```

Ten information messages logged

See also

[Option -WmsgNe](#)

[Option -WmsgNw](#)

-WmsgNu: Disable User Messages

Group

MESSAGE

Scope

None

Syntax

```
"-WmsgNu" ["=" {"a" | "b" | "c" | "d"}]
```

Arguments

- “a”: Disable messages about include files
- “b”: Disable messages about reading files
- “c”: Disable messages about generated files
- “d”: Disable messages about processing statistics
- “e”: Disable informal messages

Default

None

Defines

None

Pragmas

None

Description

The application produces messages that are not in the following normal message categories: WARNING, INFORMATION, WRROR, FATAL. This option disables messages that are not in the normal message category by reducing the amount of messages, and simplifying the error parsing of other tools.

“a”: Disables the application from generating information about all included files.

“b”: Disables messages about reading files (e.g. the files used as input) are disabled.

“c”: Disables messages informing about generated files.

“d”: Disables information about statistics (e.g. code size, RAM/ROM usage and so on).

“e”: Disables informal messages (e.g. memory model, floating point format, ...) .

NOTE Depending on the application, the Compiler may not recognize all suboptions. In this case they are ignored for compatibility.

Example

```
-WmsgNu=c
```

See also

None

-WmsgNw: Number of Warning Messages

Group

MESSAGE

Scope

Compilation Unit

Syntax

"-WmsgNw" <number>

Arguments

<number>: Maximum number of warning messages

Default

50

Defines

None

Pragmas

None

Description

This option sets the number of warning messages.

Example

```
-WmsgNw15
```

Fifteen warning messages logged

See also

[Option -WmsgNe](#)

[Option -WmsgNi](#)

-WmsgSd: Setting a Message to Disable

Group

MESSAGE

Scope

Function

Syntax

"-WmsgSd" <number>

Arguments

<number>: Message number to be disabled, e.g. 1801

Default

None

Defines

None

Pragmas

None

Description

This option disables message from appearing in the error output.
This option cannot be used in a [pragma OPTION](#). Use this option only with [pragma MESSAGE](#).

Example

```
-WmsgSd1801
```

Disables message for implicit parameter declaration

See also

[Option -WmsgSi](#)
[Option -WmsgSw](#)

[Option -WmsgSe](#)
[Pragma MESSAGE](#)

-WmsgSe: Setting a Message to Error

Group

MESSAGE

Scope

Function

Syntax

"-WmsgSe" <number>

Arguments

<number>: Message number to be an error, e.g. 1853

Default

None

Defines

None

Pragmas

None

Description

This option changes a message to an error message.

This option cannot be used in a [pragma OPTION](#). Use this option only with [pragma MESSAGE](#).

Example

```
COMPOTIONS=-WmsgSe1853
```

See also

[Option -WmsgSd](#)

[Option -WmsgSi](#)

[Option -WmsgSw](#)
[Pragma MESSAGE](#)

-WmsgSi: Setting a Message to Information

Group

MESSAGE

Scope

Function

Syntax

"-WmsgSi" <number>

Arguments

<number>: Message number to be an information, e.g. 1853

Default

None

Defines

None

Pragmas

None

Description

This option sets a message to an information message.

This option cannot be used with [pragma OPTION](#). Use this option only with [pragma MESSAGE](#).

Example

```
-WmsgSi1853
```

See also

[Option -WmsgSd](#)

[Option -WmsgSw](#)

[Option -WmsgSe](#)
[Pragma MESSAGE](#)

-WmsgSw: Setting a Message to Warning

Group

MESSAGE

Scope

Function

Syntax

"-WmsgSw" <number>

Arguments

<number>: Error number to be a warning, e.g. 2901

Default

None

Defines

None

Pragmas

None

Description

This option sets a message to a warning message.

This option cannot be used with [pragma OPTION](#). Use this option only with [pragma MESSAGE](#).

Example

```
-WmsgSw2901
```

See also

[Option -WmsgSd](#)

[Option -WmsgSi](#)

[Option -WmsgSe](#)
[Pragma MESSAGE](#)

-WOutFile: Create Error Listing File

Group

MESSAGE

Scope

Compilation Unit

Syntax

"-WOutFile" ("On" | "Off")

Arguments

None

Default

Error listing file is created

Defines

None

Pragmas

None

Description

This option controls whether an error listing file should be created. The error listing file contains a list of all messages and errors that are created during processing. It is possible to obtain this feedback without an explicit file since the text error feedback can now also be handled with pipes to the calling application. The name of the listing file is controlled by the [ERRORFILE](#) environment variable.

Example

```
-WOutFileOn
```

Error file is created as specified with [ERRORFILE](#)

```
-WOutFileOff
```

No error file created

See also

[Option -WErrFile](#)

[Option -WStdout](#)

-Wpd: Error for Implicit Parameter Declaration

Group

MESSAGE

Scope

Function

Syntax

"-Wpd"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

This option prompts the Compiler to issues an *ERROR* message instead of a *WARNING* message when an implicit declaration is encountered. This occurs if the Compiler does not have a prototype for the called function.

This option helps to prevent parameter passing errors, which can only be detected at runtime. It requires that each function that is called, is prototyped before use. The correct ANSI behavior is to assume that parameters are correct for the stated call.

This option is the same as using `-WmsgSe1801`.

Example

```
-Wpd
main() {
    char a, b;
    func(a, b); // <- Error here
}
func(a, b, c)
    char a, b, c;
{
    ...
}
```

See also

[Message C1801](#)

[Option -WmsgSe](#)

[Implicit Parameter Declaration in the Front End](#)

-WStdout: Write to Standard Output

Group

MESSAGE

Scope

Compilation Unit

Syntax

"-WStdout" ("On" | "Off")

Arguments

None

Default

Output is written to stdout

Defines

None

Pragmas

None

Description

The usual standard streams are available with Windows applications. Text written into them does not appear anywhere unless explicitly requested by the calling application. This option determines if error file text to error file is also written into the stdout file.

Example

```
-WStdoutOn
```

All messages written to stdout

```
-WErrFileOff
```

Nothing written to stdout

See also

[Option -WErrFile](#)
[Option -WOutFile](#)

-W1: No Information Messages

Group

MESSAGE

Scope

Function

Syntax

"-W1"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

Inhibits printing INFORMATION messages. Only WARNINGS and ERROR messages are generated.

Example

```
-W1
```

See also

[Option -WmsgNi](#)

-W2: No Information and Warning Messages

Group

MESSAGE

Scope

Function

Syntax

"-W2"

Arguments

None

Default

None

Defines

None

Pragmas

None

Description

Suppresses all messages of type INFORMATION and WARNING. Only ERRORS are generated.

Example

-W2

See also

[Option -WmsgNi](#)
[Option -WmsgNw](#)

Compiler Predefined Macros

The ANSI standard for the C language requires the Compiler to predefine a couple of macros. The Compiler provides the predefined macros listed in [Table 1.27](#).

Table 1.27 Macros Defined by the Compiler

Macro	Description
<code>__LINE__</code>	Line number in the current source file
<code>__FILE__</code>	Name of the source file it appears in
<code>__DATE__</code>	The date of compilation as a string
<code>__TIME__</code>	The time of compilation as a string
<code>__STDC__</code>	Set to 1 if the <code>-Ansi</code> command line option has been given. Otherwise, additional keywords are accepted (not in ANSI standard).

The following tables lists all Compiler defines with their associated names and options.

NOTE If these macros do not have a value, the Compiler treats them as if they had been defined as shown: `#define __HIWARE__`

It is also possible to log all Compiler predefined defines to a file using the `-Ldf` option.

Compiler Vendor Defines

[Table 1.28](#) shows the defines identifying the Compiler vendor. Compilers in the USA may also be sold by ARCHIMEDES.

Table 1.28 Compiler Vendor Identification Defines

Name	Defined
<code>__HIWARE__</code>	always
<code>__MWERKS__</code>	always, set to 1
<code>__ARCHIMEDES__</code>	always

Product Defines

[Table 1.29](#) shows the defines identifying the Compiler. The Compiler may either be a HI-CROSS Compiler (V2.7.x), a Smile~Line Compiler (V3.0.x) or a HI-CROSS+ Compiler (V5.0.x).

Table 1.29 Compiler Identification Defines

Name	Defined
__PRODUCT_HICROSS__	defined for V2.7 Compilers
__PRODUCT_SMILE_LINE__	defined for V3.0 Compilers
__PRODUCT_HICROSS_PLUS__	defined for V5.0 Compilers
__DEMO_MODE__	defined if the Compiler is running in demo mode
__VERSION__	defined and contains the version number, e.g. it is set to 5013 for a Compiler V5.0.13, or set to 3140 for a Compiler V3.1.40

Data Allocation Defines

The Compiler provides two macros that define how data is organized in memory: Little Endian (least significant byte first in memory) or Big Endian (most significant byte first in memory). The ‘Intel World’ uses Little Endian and the ‘Non-Intel World’ uses Big Endian.

The Compiler provides the “endian” macros listed in [Table 1.30](#).

Table 1.30 Compiler Macros for Defining “Endianness”

Name	Defined
__LITTLE_ENDIAN__	defined if the Compiler allocates in Little Endian order
__BIG_ENDIAN__	defined if the Compiler allocates in Big Endian order

Following example illustrates the difference:

```
unsigned long L = 0x87654321;
unsigned short s = *(unsigned short*)&L; //BE: 0x8765,LE: 0x4321
unsigned char c = *(unsigned char*)&L; //BE: 0x87, LE: 0x21
```

Various Defines for Compiler Option Settings

Table 1.31 Defines for Miscellaneous Compiler Option Settings

Name	Defined
__cplusplus	-C++f, -C++e, -C++c
__STDC__	-Ansi
__TRIGRAPHS__	-Ci
__CNI__	-Cni
__OPTIMIZE_FOR_TIME__	-Ot
__OPTIMIZE_FOR_SIZE__	-Os

Option Checking in C Code

You can also check the source to determine if an option is active. The EBNF syntax is:

```
OptionActive = "__OPTION_ACTIVE__" "(" string ")".
```

The above is used in the preprocessor and in C code, as shown:

```
#if __OPTION_ACTIVE__("-W2")
    // option -W2 is set
#endif

void main(void) {
    int i;
    if (__OPTION_ACTIVE__("-or")) {
        i=2;
    }
}
```

You can check all preprocessor-valid options (e.g. options given at the command line, via default.env or project.ini, but not options added with the [#pragma OPTIO](#)). You perform the same check in C code using -Odocf and [#pragma OPTION](#).

As a parameter, only the option itself is tested and not a specific argument of an option.

For example:

```
#if __OPTION_ACTIVE__("-D") /* true if any -d option given */
#if __OPTION_ACTIVE__("-DABS") /* not allowed */
```

To check for a specific define use:

```
#if defined(ABS)
```

If the specified option cannot be checked to determine if it is active (i.e. options that no longer exist), the message “[C1439: illegal pragma __OPTION_ACTIVE__](#)” is issued.

ANSI-C Standard Types 'size_t', 'wchar_t' and 'ptrdiff_t' Defines

ANSI provides some standard defines in 'stddef.h' to deal with the implementation of defined object sizes.

[Listing 1.3](#) show part of the contents of stdtypes.h (included from stddef.h).

Listing 1.3 Type Definitions of ANSI-C Standard Types

```
/* size_t: defines the maximum object size type */
#if defined(__SIZE_T_IS_UCHAR__)
    typedef unsigned char  size_t;
#elif defined(__SIZE_T_IS_USHORT__)
    typedef unsigned short size_t;
#elif defined(__SIZE_T_IS_UINT__)
    typedef unsigned int   size_t;
#elif defined(__SIZE_T_IS_ULONG__)
    typedef unsigned long  size_t;
#else
    #error "illegal size_t type"
#endif

/* ptrdiff_t: defines the maximum pointer difference type */
#if defined(__PTRDIFF_T_IS_CHAR__)
    typedef signed char  ptrdiff_t;
#elif defined(__PTRDIFF_T_IS_SHORT__)
    typedef signed short ptrdiff_t;
#elif defined(__PTRDIFF_T_IS_INT__)
    typedef signed int   ptrdiff_t;
```

```

    #elif defined(__PTRDIFF_T_IS_LONG__)
        typedef signed long ptrdiff_t;
    #else
        #error "illegal ptrdiff_t type"
    #endif
/* wchar_t: defines the type of wide character */
#if defined(__WCHAR_T_IS_UCHAR__)
    typedef unsigned char wchar_t;
#elif defined(__WCHAR_T_IS_USHORT__)
    typedef unsigned short wchar_t;
#elif defined(__WCHAR_T_IS_UINT__)
    typedef unsigned int wchar_t;
#elif defined(__WCHAR_T_IS_ULONG__)
    typedef unsigned long wchar_t;
#else
    #error "illegal wchar_t type"
#endif

```

[Table 1.32](#) lists defines that deal with other possible implementations:

Table 1.32 Defines for Other Implementations

Macro	Description
<code>__SIZE_T_IS_UCHAR__</code>	Defined if the Compiler expects <code>size_t</code> in <code>stddef.h</code> to be 'unsigned char'.
<code>__SIZE_T_IS_USHORT__</code>	Defined if the Compiler expects <code>size_t</code> in <code>stddef.h</code> to be 'unsigned short'.
<code>__SIZE_T_IS_UINT__</code>	Defined if the Compiler expects <code>size_t</code> in <code>stddef.h</code> to be 'unsigned int'.
<code>__SIZE_T_IS_ULONG__</code>	Defined if the Compiler expects <code>size_t</code> in <code>stddef.h</code> to be 'unsigned long'.
<code>__WCHAR_T_IS_UCHAR__</code>	Defined if the Compiler expects <code>wchar_t</code> in <code>stddef.h</code> to be 'unsigned char'.
<code>__WCHAR_T_IS_USHORT__</code>	Defined if the Compiler expects <code>wchar_t</code> in <code>stddef.h</code> to be 'unsigned short'.
<code>__WCHAR_T_IS_UINT__</code>	Defined if the Compiler expects <code>wchar_t</code> in <code>stddef.h</code> to be 'unsigned int'.
<code>__WCHAR_T_IS_ULONG__</code>	Defined if the Compiler expects <code>wchar_t</code> in <code>stddef.h</code> to be 'unsigned long'.
<code>__PTRDIFF_T_IS_CHAR__</code>	Defined if the Compiler expects <code>ptrdiff_t</code> in <code>stddef.h</code> to be 'char'.

Table 1.32 Defines for Other Implementations

Macro	Description
__PTRDIFF_T_IS_SHORT__	Defined if the Compiler expects ptrdiff_t in stddef.h to be 'short'.
__PTRDIFF_T_IS_INT__	Defined if the Compiler expects ptrdiff_t in stddef.h to be 'int'.
__PTRDIFF_T_IS_LONG__	Defined if the Compiler expects ptrdiff_t in stddef.h to be 'long'.

The following tables define the default settings of the for the ANSI-C Compiler standard types size_t and ptrdiff_t.

Macros for HC12

[Table 1.33](#) shows the settings for the HC12 target:

Table 1.33 HC12 Compiler Defines

size_t Macro	Defined
__SIZE_T_IS_UCHAR__	never
__SIZE_T_IS_USHORT__	never
__SIZE_T_IS_UINT__	always
__SIZE_T_IS_ULONG__	never

Table 1.34 HC12 Compiler Pointer Difference Macros

ptrdiff_t Macro	Defined
__PTRDIFF_T_IS_CHAR__	never
__PTRDIFF_T_IS_SHORT__	never
__PTRDIFF_T_IS_INT__	always
__PTRDIFF_T_IS_LONG__	never

Division and Modulus

To ensure that the results of the "/" and "%" operators are defined correctly for signed arithmetic operations, both operands must be defined positive (Refer to the backend chapter). It is implementation-defined if the result is negative or positive when one of the operands is defined negative. This is illustrated in the following example:

```

#ifdef __MODULO_IS_POSITIV__
    22 / 7 == 3;    22 % 7 == 1
    22 /-7 == -3;   22 % -7 == 1
   -22 / 7 == -4;  -22 % 7 == 6
   -22 /-7 == 4;  -22 % -7 == 6
#else
    22 / 7 == 3;    22 % 7 == +1
    22 /-7 == -3;   22 % -7 == +1
   -22 / 7 == -3;  -22 % 7 == -1
   -22 /-7 == 3;   -22 % -7 == -1
#endif
  
```

The following sections show how it is implemented in a back end.

Macros for HC12

Table 1.35 HC12 Compiler Modulo Operator Macros

Name	Defined
__MODULO_IS_POSITIV__	never

Object File Format Defines

The Compiler defines some macros to identify the format (mainly used in the startup code if it is object file specific), depending on the specified object file format option. [Table 1.36](#) lists these defines.

Table 1.36 Object File Format Defines

Name	Defined
__HIWARE_OBJECT_FILE_FORMAT__	-Fh
__ELF_OBJECT_FILE_FORMAT__	-F1 , -F2


```
#else
    #error "undefined bit field allocation strategy!"
#endif
    } MyIOport;
```

If the basic allocation unit for bitfields in the Compiler is a byte, the allocation of memory for bitfields is always from the most significant BYTE to the least significant BYTE. For example, `__BITFIELD_MSBYTE_FIRST__` is defined as shown below:

```
/* example for __BITFIELD_MSBYTE_FIRST__ */
struct {
    unsigned char a:8;
    unsigned char b:3;
    unsigned char c:5;
} MyIOport2;

/* LSBIT_FIRST      */ /* MSBIT_FIRST      */
/* MSByte  LSByte   */ /* MSByte  LSByte   */
/* aaaaaaaa cccccbbb */ /* aaaaaaaa bbbccccc */
```

NOTE There is no standard way to allocate bit fields. Allocation may vary from compiler to compiler even for the same target. Using bit fields for I/O register access to is non-portable and, for the masking involved in unpacking individual fields, inefficient. It is recommended to use regular bit-and (&) and bit-or (|) operations for I/O port access.

Bit Field Type Reduction

The Compiler provides two predefined macros for enabled/disabled type size reduction. With type size reduction enabled, the Compiler is free to reduce the type of a bit field. For example, if the size of a bit field is 3, the Compiler uses the char type.

```
__BITFIELD_TYPE_SIZE_REDUCTION__ /* defined if Type Size
Reduction is enabled */

__BITFIELD_NO_TYPE_SIZE_REDUCTION__ /* defined if Type Size
Reduction is disabled */
```

It is possible to write compatible code over different Compiler vendors and to get optimized bit fields:

```
struct {
    long b1:4;
```

```
    long b2:4;
} myBitfield;

31                                     7 3 0
-----
|#####|b2|b1| -BfaTSRoff
-----

7      3      0
-----
| b2 | b1 | -BfaTSRon
-----
```

Sign of Plain Bitfields

For some architectures, the sign of a plain bitfield does not follow standard rules. Normally for:

```
struct _bits {
    int myBits:3;
} bits;
```

the 'myBits' is signed, because plain 'int' is also signed. To implement it as an unsigned bitfield, use the following code:

```
struct _bits {
    unsigned int myBits:3;
} bits;
```

However, some architectures need to overwrite this behavior to be compliant to their EABI (Embedded Application Binary Interface). Under those circumstances, the [option -T](#) (if supported) is used. The option affects the following defines:

```
__PLAIN_BITFIELD_IS_SIGNED__    /* defined if plain bitfield
                                is signed */

__PLAIN_BITFIELD_IS_UNSIGNED__  /* defined if plain bitfield
                                is unsigned */
```

Macros for HC12

[Table 1.37](#) identifies the implementation in the Back End.

Table 1.37 HC12 Compiler—Back End Macros

Name	Defined
__BITFIELD_MSBIT_FIRST__	-BfaBMS
__BITFIELD_LSBIT_FIRST__	-BfaBLS
__BITFIELD_MSBYTE_FIRST__	always
__BITFIELD_LSBYTE_FIRST__	never
__BITFIELD_MSWORD_FIRST__	always
__BITFIELD_LSWORD_FIRST__	never
__BITFIELD_TYPE_SIZE_REDUCTION__	-BfaTSRon
__BITFIELD_NO_TYPE_SIZE_REDUCTION__	-BfaTSRoff
__PLAIN_BITFIELD_IS_SIGNED__	always
__PLAIN_BITFIELD_IS_UNSIGNED__	never

Type Information Defines

The Flexible Type Management sets the defines to identify the type sizes. [Table 1.38](#) lists these defines

Table 1.38 Type Information Defines

Name	Defined
__CHAR_IS_SIGNED__	see option -T or Back End
__CHAR_IS_UNSIGNED__	see option -T or Back End
__CHAR_IS_8BIT__	see option -T or Back End
__CHAR_IS_16BIT__	see option -T or Back End
__CHAR_IS_32BIT__	see option -T or Back End
__CHAR_IS_64BIT__	see option -T or Back End

Table 1.38 Type Information Defines

Name	Defined
__SHORT_IS_8BIT__	see option -T or Back End
__SHORT_IS_16BIT__	see option -T or Back End
__SHORT_IS_32BIT__	see option -T or Back End
__SHORT_IS_64BIT__	see option -T or Back End
__INT_IS_8BIT__	see option -T or Back End
__INT_IS_16BIT__	see option -T or Back End
__INT_IS_32BIT__	see option -T or Back End
__INT_IS_64BIT__	see option -T or Back End
__ENUM_IS_8BIT__	see option -T or Back End
__ENUM_IS_SIGNED__	see option -T or Back End
__ENUM_IS_UNSIGNED__	see option -T or Back End
__ENUM_IS_16BIT__	see option -T or Back End
__ENUM_IS_32BIT__	see option -T or Back End
__ENUM_IS_64BIT__	see option -T or Back End
__LONG_IS_8BIT__	see option -T or Back End
__LONG_IS_16BIT__	see option -T or Back End
__LONG_IS_32BIT__	see option -T or Back End
__LONG_IS_64BIT__	see option -T or Back End
__LONG_LONG_IS_8BIT__	see option -T or Back End
__LONG_LONG_IS_16BIT__	see option -T or Back End
__LONG_LONG_IS_32BIT__	see option -T or Back End
__LONG_LONG_IS_64BIT__	see option -T or Back End
__FLOAT_IS_IEEE32__	see option -T or Back End
__FLOAT_IS_IEEE64__	see option -T or Back End
__FLOAT_IS_DSP__	see option -T or Back End
__DOUBLE_IS_IEEE32__	see option -T or Back End

Table 1.38 Type Information Defines

Name	Defined
__DOUBLE_IS_IEEE64__	see option -I or Back End
__DOUBLE_IS_DSP__	see option -I or Back End
__LONG_DOUBLE_IS_IEEE32__	see option -I or Back End
__LONG_DOUBLE_IS_IEEE64__	see option -I or Back End
__LONG_DOUBLE_IS_DSP__	see option -I or Back End
__LONG_LONG_DOUBLE_IS_IEEE32__	see option -I or Back End
__LONG_LONG_DOUBLE_IS_IEEE64__	see option -I or Back End
__LONG_LONG_DOUBLE_IS_DSP__	see option -I or Back End
__VTAB_DELTA_IS_8BIT__	see option -I
__VTAB_DELTA_IS_16BIT__	see option -I
__VTAB_DELTA_IS_32BIT__	see option -I
__VTAB_DELTA_IS_64BIT__	see option -I
__PLAIN_BITFIELD_IS_SIGNED__	see option -I or Back End
__PLAIN_BITFIELD_IS_UNSIGNED__	see option -I or Back End

Motorola HC12 Specific Defines

[Table 1.39](#) identifies specific implementations in the Back End.

Table 1.39 HC12 Back End Defines

Name	Defined
__HC12__	always
__NO_RECURSION__	never
__PIC__	-Pic
__SMALL__	-Ms
__BANKED__	-Mb
__LARGE__	-Ml
__PTR_SIZE_1__	never

Table 1.39 HC12 Back End Defines

Name	Defined
__PTR_SIZE_2__	always
__PTR_SIZE_3__	never
__PTR_SIZE_4__	never
__PROCESSOR_X4__	-Px4
__DPAGE__	-CpDPAGE
__EPAGE__	-CpEPAGE
__PPAGE__	-CpPPAGE
__NO_DPAGE__	not -CpDPAGE
__NO_EPAGE__	not -CpEPAGE
__NO_PPAGE__	not -CpPPAGE
__OPTIMIZE_REG__	-Or

Compiler Pragmas

A pragma defines how information is passed from the Front End to the Back End, without affecting the parser. In the Compiler, the effect of a pragma on code generation starts at the point of its definition, and ends with the end of the next function. Exceptions to this rule are the pragmas [#pragma ONCE](#) and [#pragma NO STRING CONSTR](#), which are valid for one file.

The pragma syntax is:

```
#pragma pragma_name [optional_arguments]
```

The optional arguments format depends on the pragma's name (some pragmas have no arguments).

NOTE A pragma directive accepts a single pragma with optional arguments. Do not place more than one pragma in a pragma directive as in the following illegal example: `#pragma ONCE NO_STRING_CONSTR`

NOTE This is **illegal**.

All pragmas affecting the Front End are described below. All other pragmas only affect the code generation process and are described in the Back End section.

Pragma Details

The remainder of this section describes each Compiler-available pragma. The pragmas are listed in alphabetical order and are divided into separate tables. [Table 1.40](#) lists and defines the topics that appear in the documentation of each pragma.

Table 1.40 Pragma Documentation Topics

Topic	Description
Scope	Scope of pragma where it is valid. See table below.
Syntax	Specifies the syntax of the pragma in a EBNF format.
Synonym	Lists a synonym for the pragma, none if a synonym does not exist.
Arguments	Describes and lists optional and required arguments for the pragma.
Default	Shows the default setting for the pragma or none.
Description	Provides a detailed description of the pragma and how to use it.

Table 1.40 Pragma Documentation Topics

Topic	Description
Example	Gives an example of usage, and effects of the pragma where possible.
See also	Names related sections.

[Table 1.41](#) gives an overview of the different scopes of pragmas.

Table 1.41 Definition of Items That Can Appear in a Pragma's Scope Topic

Scope	Description
File	The pragma is valid from the current position until the end of the source file. Example: If the pragma is in a header file included from a source file, the pragma is not valid in the source file.
Compilation Unit	The pragma is valid from the current position until the end of the whole compilation unit. Example: If the pragma is in a header file included from a source file, it is valid in the source file too.
Data Definition	The pragma affects only the next data definition. Ensure that you always use a data definition behind this pragma in a header file. If not, the pragma is used for the first data segment in the next header file, or in the main file.
Function Definition	The pragma affects only the next function definition. Ensure that you use this pragma in a header file: The pragma is valid for the first function in each source file where such a header file is included if there is no function definition in the header file.
Next pragma with same name	The pragma is used until the same pragma appears again. If no such pragma follows this one, it is valid until the end of the file.

#pragma CODE_SEG: Code Segment Definition

Scope

Next pragma CODE_SEG

Syntax

```
"#pragma CODE_SEG" (<Modif> <Name> | "DEFAULT")
```

Synonym

CODE_SECTION

Arguments

<Modif>: Some of the following strings may be used:

DIRECT, __DIRECT_SEG,
NEAR, __NEAR_SEG,
CODE, __CODE_SEG,
FAR, __FAR_SEG,
DPAGE, __DPAGE_SEG,
PPAGE, __PPAGE_SEG,
EPAGE, __EPAGE_SEG,
PIC, __PIC_SEG

Each modifier has a synonym in the form of “__<modifier>_SEG”. This reduces clashes with other possible defines in header files, e.g. if NEAR is undefined in another portion of your code.

The meaning of these segment modifiers are backend-dependent. Refer to the backend chapter for information on supported modifiers and their definitions.

<Name>: The name of the segment. This name must be used in the link parameter file on the left side of the assignment in the PLACEMENT part. Refer to the linker manual for details.

Default

DEFAULT

Description

This pragma specifies the function segment it is allocated in. The segment modifiers also specify the function's calling convention. The `CODE_SEG` pragma sets the current code segment. This segment places all new function definitions. Also, all function declarations get the current code segment, when they occur. The segment modifiers of this segment determine the calling convention.

The `CODE_SEG` pragma affects function declarations as well as definitions. Ensure that all function declarations and their definitions are in the same segment.

The synonym `CODE_SECTION` has exactly the same meaning as `CODE_SEG`.

Example

```
/* in a header file */
#pragma CODE_SEG FAR MY_CODE1
extern void f(void);
#pragma CODE_SEG MY_CODE2
extern void h(void);
#pragma CODE_SEG DEFAULT

/* in the corresponding C file : */
#pragma CODE_SEG FAR MY_CODE1
void f(void){ /* f has FAR calling convention */
    h(); /* calls h with default calling convention */
}
#pragma CODE_SEG MY_CODE2
void h(void){ /* f has default calling convention */
    f(); /* calls f with FAR calling convention */
}
#pragma CODE_SEG DEFAULT
```

NOTE Not all back ends do support a FAR calling convention.

NOTE The calling convention can also be specified with a supported keyword. The default calling convention is chosen with the memory model.

Illegal usages of the pragma:

```
#pragma DATA_SEG DATA1
#pragma CODE_SEG DATA1
/* error: segment name has different types! */

#pragma CODE_SEG DATA1
#pragma CODE_SEG FAR DATA1
/* error: segment name has modifiers! */

#pragma CODE_SEG DATA1
void g(void);
#pragma CODE_SEG DEFAULT
void g(void) d) {}
/* error g is declared in different segments */

#pragma CODE_SEG FAR DEFAULT
/* error modifiers for DEFAULT segment no allowed */
```

See also

Compiler Backend

[Segmentation Chapter in the front end](#)

Linker Manual

[#pragma CONST_SEG](#)

[#pragma DATA_SEG](#)

[#pragma STRING_SEG](#)

[Compiler option -Cc](#)

#pragma CONST_SEG: Constant Data Segment Definition

Scope

Next pragma CONST_SEG

Syntax

```
"#pragma CONST_SEG" (<Modif> <Name> | "DEFAULT")
```

Synonym

CONST_SECTION

Arguments

<Modif>: Some of the following strings may be used:

```
SHORT, __SHORT_SEG,  
DIRECT, __DIRECT_SEG,  
NEAR, __NEAR_SEG,  
CODE, __CODE_SEG,  
FAR, __FAR_SEG,  
DPAGE, __DPAGE_SEG,  
PPAGE, __PPAGE_SEG,  
EPAGE, __EPAGE_SEG,  
PIC, __PIC_SEG
```

Each modifier has a synonym in the form of “__<modifier>_SEG”. This reduces clashes with other possible defines in header files, e.g. if NEAR is undefined in another portion of your code.

The segment modifiers are backend-dependent. Refer to the backend chapter to find the supported modifiers and their meaning. The SHORT modifier specifies a segment which is accessed with - bit addresses.

<Name>: The name of the segment. This name must be used in the link parameter file on the left side of the assignment in the PLACEMENT part. Please refer to the linker manual for details.

Default

DEFAULT

Description

This pragma allocates constant variables into a segment. The segment is then located in the link parameter file to specific addresses.

The pragma `CONST_SEG` sets the current const segment. This segment is places all constant variable declarations. The default segment is set with:

```
#pragma CONST_SEG DEFAULT"
```

Constants are allocated in the current data segment that is defined with [#pragma DATA_SEG](#) in the HIWARE object file format when the option `-cc` is not specified, and until the first `#pragma CONST_SEG` occurs in the source. With option `-Cc`, constants are always allocated in constant segments in the ELF object file format, and after the first `#pragma CONST_SEG`.

The `CONST_SEG` pragma also affects constant variable declarations as well as definitions. Ensure that all constant variable declarations and definitions are in the same const segment.

Some compiler optimizations assume that objects having the same segment are placed together. Backends supporting banked data, for example, may set the page register only once for two accesses to two different variables in the same segment. This is also the case for the `DEFAULT` segment. When using a paged access to variables, place one segment on one page in the link parameter file.

When the [#pragma INTO_ROM](#) is active, the current const segment is not used.

The synonym `CONST_SECTION` has exactly the same meaning as `CONST_SEG`.

Example

[Listing 1.4](#) shows code the uses the `CONST_SEG` pragma.

Listing 1.4 Correct Use of the `CONST_SEG` Pragma

```
/* in a header file */
#pragma CONST_SEG SHORT SHORT_CONST_MEMORY
extern const int i_short;
#pragma CONST_SEG CUSTOM_CONST_MEMORY
extern const int j_custom;
#pragma CONST_SEG DEFAULT

/* in some C file, which includes the header file */

void main(void) {
    int k= i; /* may use short access */
```

```
    k= j;
}

/* in the C file defining the constants : */
#pragma CONST_SEG SHORT SHORT_CONST_MEMORY
extern const int i_short=7
#pragma CONST_SEG CUSTOM_CONST_MEMORY
extern const int j_custom=8;
#pragma CONST_SEG DEFAULT
```

[Listing 1.5](#) shows code that uses the CONST_SEG pragma *illegally*.

Listing 1.5 Illegal use of the CONST_SEG Pragma

```
#pragma DATA_SEG CONST1
#pragma CONST_SEG CONST1 /* error: segment name has different types ! */

#pragma CONST_SEG CONST1
#pragma CONST_SEG SHORT CONST1 /* error: segment name has modifiers ! */

#pragma CONST_SEG CONST1
extern int i;
#pragma CONST_SEG DEFAULT
int i; /* error: i is declared in different segments */

#pragma CONST_SEG SHORT DEFAULT /* error: modifiers for DEFAULT segment
not allowed */
```

See also

- Compiler Backend
- [Segmentation Chapter in the front end](#)
- Linker Manual
- [#pragma CODE_SEG](#)
- [#pragma DATA_SEG](#)
- [#pragma STRING_SEG](#)
- [Compiler option -Cc](#)
- [#pragma INTO_ROM](#)

#pragma CREATE_ASM_LISTING: Create an Assembler Include File Listing

Scope

Next pragma CREATE_ASM_LISTING

Syntax

```
"#pragma CREATE_ASM_LISTING" ("ON" | "OFF")
```

Synonym

None

Arguments

ON: All following defines / objects are emitted

OFF: All following defines / objects are not emitted

Default

OFF

Description

This pragma controls if the following defines or objects are printed into the assembler include file.

A new file is only generated when the [Option -La](#) is specified together with a header file containing a "#pragma CREATE_ASM_LISTING ON".

Example

```
#pragma CREATE_ASM_LISTING ON
extern int i; /* i is accessible from asm code*/

#pragma CREATE_ASM_LISTING OFF
extern int j; /* j is only accessible from C code */
```

See also

[Compiler Option -La](#)
[Generating an Assembler Include File](#)

#pragma DATA_SEG: Data Segment Definition

Scope

Next pragma DATA_SEG

Syntax

"#pragma DATA_SEG" (<Modif> <Name> | "DEFAULT").

Synonym

DATA_SECTION.

Arguments

<Modif>: Some of the following strings may be used:

SHORT, __SHORT_SEG,
DIRECT, __DIRECT_SEG,
NEAR, __NEAR_SEG,
CODE, __CODE_SEG,
FAR, __FAR_SEG,
DPAGE, __DPAGE_SEG,
PPAGE, __PPAGE_SEG,
EPAGE, __EPAGE_SEG,
PIC, __PIC_SEG

Each modifier has a synonym in the form of "__<modifier>_SEG". This reduces clashes with other possible defines in header files, e.g. if NEAR is undefined in another portion of your code.

The __SHORT_SEG modifier specifies a segment which is accessed with 8 bit addresses. The meaning of these segment modifiers are backend dependent. Read the backend chapter to find the supported modifiers and their meaning.

<Name>: The name of the segment. This name must be used in the link parameter file on the left side of the assignment in the PLACEMENT part. Please refer to the linker manual for details.

Default

DEFAULT

Description

This pragma allocates variables into a segment. This segment is then located in the link parameter file to specific addresses.

The pragma `DATA_SEG` sets the current data segment. This segment is used to place all variable declarations. The default segment is set with:

```
#pragma DATA_SEG DEFAULT"
```

Constants are also allocated in the current data segment in the HIWARE object file format when the option `-cc` is not specified and no `"#pragma CONST_SEG"` occurred in the source. With option `-Cc` and in the ELF object file format, constants are not allocated in the data segment.

The pragma `DATA_SEG` also affects data declarations, as well as definitions. Ensure that all variable declarations and definitions are in the same segment.

Some compiler optimizations assume that objects having the same segment are together. Backends supporting banked data, for example, may set the page register only once if two accesses two different variables in the same segment are done. This is also the case for the `DEFAULT` segment. When using a paged access to constant variables, put one segment on one page in the link parameter file.

When the [#pragma INTO_ROM](#) is active, the current data segment is not used.

The synonym `DATA_SECTION` has exactly the same meaning as `DATA_SEG`.

Example

[Listing 1.6](#) shows code that uses the `DATA_SEG` pragma.

Listing 1.6 Using the `DATA_SEG` Pragma

```
/* in a header file */
#pragma DATA_SEG __SHORT_SEG SHORT_MEMORY
extern int i_short;
#pragma DATA_SEG CUSTOM_MEMORY
extern int j_custom;
#pragma DATA_SEG DEFAULT

/* in the corresponding C file : */
#pragma DATA_SEG __SHORT_SEG SHORT_MEMORY
int i_short;
#pragma DATA_SEG CUSTOM_MEMORY
int j_custom;
#pragma DATA_SEG DEFAULT
```

```
void main(void) {  
    i = 1; /* may use short access */  
    j = 5;  
}
```

[Listing 1.6](#) shows code that uses the DATA_SEG pragma *illegally*.

Listing 1.7 Illegal use of the DATA_SEG Pragma

```
#pragma DATA_SEG DATA1  
#pragma CONST_SEG DATA1 /* error: segment name has different types ! */  
  
#pragma DATA_SEG DATA1  
#pragma DATA_SEG __SHORT_SEG DATA1  
/* error: segment name has modifiers ! */  
  
#pragma DATA_SEG DATA1  
extern int i;  
#pragma DATA_SEG DEFAULT  
int i; /* error: i is declared in different segments */  
  
#pragma DATA_SEG __SHORT_SEG DEFAULT  
/* error: modifiers for DEFAULT segment no allowed */
```

See also

- [Compiler Backend](#)
- [Segmentation Chapter in the front end](#)
- [Linker Manual](#)
- [#pragma CODE_SEG](#)
- [#pragma CONST_SEG](#)
- [#pragma STRING_SEG](#)
- [Compiler option -Cc](#)
- [#pragma INTO_ROM](#)

#pragma INLINE: Inline Next Function Definition

Scope

Function Definition

Syntax

```
"#pragma INLINE"
```

Synonym

None

Arguments

None

Default

None

Description

This pragma directs the Compiler to inline the next function in the source.

The pragma is the same as using the 'inline' keyword in C++ or using the [-Oi](#) Compiler option.

Example

```
int i;  
#pragma INLINE  
static void foo(void) {  
    i = 12;  
}  
  
void main(void) {  
    foo(); // results into 'i = 12;'  
}
```

See also

[#pragma NO_INLINE](#)
[Compiler Option -Oi](#)
[C++ Front End](#)

#pragma INTO_ROM: Put Next Variable Definition into ROM

Scope

Data Definition

Syntax

```
"#pragma INTO_ROM"
```

Synonym

None

Arguments

None

Default

None

Description

This pragma forces the next variable definition to be const (together with the Compiler option [-Cc](#)).

The pragma is active only for the next single variable definition. A following segment pragma (CONST_SEG, DATA_SEG, CODE_SEG) disables the pragma.

Example

[Listing 1.8](#) shows code that uses the INTO_ROM pragma.

Listing 1.8 Using the INTO_ROM Pragma

```
#pragma INTO_ROM
char *const B[] = {"hello", "world"};

#pragma INTO_ROM
int constVariable; /* put into ROM_VAR, .rodata */

int other; /* put into default segment */
```

```
#pragma INTO_ROM  
#pragma DATA_SEG MySeg /* INTO_ROM overwritten! */  
int other2; /* put into MySeg */
```

See also

[Compiler option -Cc](#)

See also

None

#pragma LINK_INFO: Pass Information to the Linker

Scope

Function

Syntax

```
#pragma LINK_INFO NAME "CONTENT"
```

Synonym

None

Arguments

NAME: Identifier specific to the purpose of this LINK_INFO.
CONTENT: C style string containing only printable ASCII characters.

Default

None

Description

This pragma instructs the compiler to put the passed name content pair into the ELF file. For the compiler, the used name and its content do have no meaning other than one name can only contain one content. However, multiple pragmas with different NAME's are legal.

For the linker or for the debugger however, the NAME might trigger some special functionality with CONTENT as argument.

The linker collects the CONTENT for every NAME in different object files and issues an message if a different CONTENT is given for different object files.

NOTE This pragma only works with the ELF object file format.

Example

Apart from extended functionality implemented in the linker or debugger, this feature can also be used for user defined link time consistency checks:

With the following code in a header file used by all compilation units:

```
#ifdef _DEBUG
#pragma LINK_INFO MY_BUILD_ENV DEBUG
#else
#pragma LINK_INFO MY_BUILD_ENV NO_DEBUG
#endif
```

The linker will issue a message if object files built with `_DEBUG` are linked with object files built without it.

See also

None

#pragma LOOP_UNROLL: Force Loop Unrolling

Scope

Function

Syntax

```
"#pragma LOOP_UNROLL"
```

Synonym

None

Arguments

None

Default

None

Description

If this pragma is present, loop unrolling is performed for the next function. This is the same as if the option `-Cu` is set for the following single function.

Example

```
#pragma LOOP_UNROLL
void F(void) {
    for(i=0; i<5; i++) { // unrolling this loop
        ...
    }
}
```

See also

[#pragma NO_LOOP_UNROLL](#)
[Compiler Option -Cu](#)

#pragma mark: Entry in CodeWarrior IDE Function List

Scope

Line

Syntax

```
"#pragma" "mark" {any text}
```

Synonym

None

Arguments

None

Default

None

Description

This pragma adds an entry into the function list of the CodeWarrior IDE. It also helps to introduce faster code lookups by providing a menu entry which directly jumps to a code position. With the special “#pragma mark -”, a separator line is inserted.

NOTE	The compiler does not actually handle this pragma. The compiler ignores this pragma. The CodeWarrior IDE scans opened source files for this pragma. It is not necessary to recompile a file when this pragma is changed. The IDE updates its menus instantly.
-------------	---

Example

In the example in [Listing 1.9](#), the pragma accesses declarations and definitions.

Listing 1.9 Using the MARK Pragma

```
#pragma mark local function declarations  
static void inc_counter(void);
```

```
static void inc_ref(void);

#pragma mark local variable definitions
static int counter;
static int ref;

#pragma mark -
static void inc_counter(void) {
    counter++;
}
static void inc_ref(void) {
    ref++;
}
```

See also

None

#pragma MESSAGE: Message Setting

Scope

Compilation Unit or until next pragma MESSAGE

Syntax

```
"#pragma" "MESSAGE" {"WARNING" | "ERROR" | "INFORMATION" |  
"DISABLE" | "DEFAULT"} {<CNUM>}}
```

Synonym

None

Arguments

<CNUM>: Number of message to be set in the format C1234

Default

None

Description

Messages are selectively set to an information message, a warning message, a disable message, or an error message.

NOTE This pragma has no effect for messages which are produced during preprocessing. The reason is that the pragma parsing has to be done during normal source parsing, and not during preprocessing.

NOTE This pragma (as other pragmas) has to be specified outside of the function scope. E.g. it is not possible to change a message inside a function or for a part of a function.

Example

In the example shown in [Listing 1.10](#), braces () were left out.

Listing 1.10 Using the MESSAGE Pragma

```
/* treat C1412: Not a function call, */  
/* address of a function, as error */  
#pragma MESSAGE ERROR C1412  
void f(void);  
void main(void) {  
    f; /* () is missing, but still legal in C */  
/* ERROR because of pragma MESSAGE */  
}
```

See also

- [Option -WmsgSi](#)
- [Option -WmsgSw](#)
- [Option -WmsgSd](#)
- [Option -WmsgSe](#)

#pragma NO_ENTRY: No Entry Code

Scope

Function

Syntax

```
"#pragma NO_ENTRY"
```

Synonym

None

Arguments

None

Default

None

Description

This pragma suppresses the generation of the entry code and is useful for inline assembler functions.

The code generated in a function with #pragma NO_ENTRY may not be safe. It is assumed that the user ensures stack use.

NOTE	Not all backends support this pragma. Some still generate entry code even if this pragma is specified.
-------------	--

Example

[Listing 1.11](#) shows how to use the NO_ENTRY pragma (along with others) to avoid any generated code by the compiler. All code is written in inline assembler.

Listing 1.11 Blocking Compiler-generated Function Management Instructions

```
#pragma NO_ENTRY  
#pragma NO_EXIT
```

Using the Compiler

Compiler Pragas

```
#pragma NO_FRAME
#pragma NO_RETURN
void Func0(void) {
    asm { /* no code should be written by the compiler.*/
        ...
    }
}
```

See also

[#pragma NO_EXIT](#)
[#pragma NO_FRAME](#)
[#pragma NO_RETURN](#)

#pragma NO_EXIT: No Exit Code

Scope

Function

Syntax

```
"#pragma NO_EXIT"
```

Synonym

None

Arguments

None

Default

None

Description

This pragma suppresses generation of the exit code and is useful for inline assembler functions.

The code generated in a function with #pragma NO_ENTRY may not be safe. It is assumed that the user ensures stack usage.

NOTE	Not all backends support this pragma. Some still generate exit code even if this pragma is specified.
-------------	---

Example

[Listing 1.12](#) shows how to use the NO_EXIT pragma (along with others) to avoid any generated code by the compiler. All code is written in inline assembler.

Listing 1.12 Blocking Compiler-generated Function Management Instructions

```
#pragma NO_ENTRY  
#pragma NO_EXIT
```

Using the Compiler

Compiler Pragas

```
#pragma NO_FRAME
#pragma NO_RETURN
void Func0(void) {
    asm { /* no code should be written by the compiler.*/
        ...
    }
}
```

See also

[#pragma NO_ENTRY](#)
[#pragma NO_FRAME](#)
[#pragma NO_RETURN](#)

#pragma NO_FRAME: No Frame Code

Scope

Function

Syntax

"#pragma NO_FRAME"

Synonym

None

Arguments

None

Default

None

Description

This pragma suppresses the generation of frame code and is useful for inline assembler functions.

The code generated in a function with #pragma NO_ENTRY may not be safe. It is assumed that the user ensures stack usage.

NOTE	Not all backends support this pragma. Some still generate frame code even if this pragma is specified.
-------------	--

Example

[Listing 1.13](#) shows how to use the NO_FRAME pragma (along with others) to avoid any generated code by the compiler. All code is written in inline assembler.

Listing 1.13 Blocking Compiler-generated Function Management Instructions

```
#pragma NO_ENTRY  
#pragma NO_EXIT
```

Using the Compiler

Compiler Pragas

```
#pragma NO_FRAME
#pragma NO_RETURN
void Func0(void) {
    asm { /* no code should be written by the compiler.*/
        ...
    }
}
```

See also

[#pragma NO_ENTRY](#)
[#pragma NO_EXIT](#)
[#pragma NO_RETURN](#)

#pragma NO_INLINE: Do not Inline next Function Definition

Scope

Function

Syntax

```
"#pragma NO_INLINE"
```

Synonym

None

Arguments

None

Default

None

Description

This pragma prevents the Compiler to inline the next function in the source. The pragma is used to avoid to inline a function which would be otherwise inlined because of the -Oi Compiler option.

Example

(With option -Oi)

```
int i;
#pragma NO_INLINE
static void foo(void) {
    i = 12;
}

void main(void) {
    foo(); // call is not inlined
}
```

See also

[#pragma INLINE](#)

[Compiler Option -Oi](#)

[C++ Front End](#)

#pragma NO_LOOP_UNROLL: Disable Loop Unrolling

Scope

Function

Syntax

```
"#pragma NO_LOOP_UNROLL"
```

Synonym

None

Arguments

None

Default

None

Description

If this pragma is present, no loop unrolling is performed for the next function definition, even if the command line option `-Cu` is given.

Example

```
#pragma NO_LOOP_UNROLL
void F(void) {
    for(i=0; i<5; i++) { // loop is NOT unrolled
        ...
    }
}
```

See also

[#pragma LOOP_UNROLL](#)
[Compiler Option -Cu](#)

#pragma NO_RETURN: No Return Instruction

Scope

Function

Syntax

```
"#pragma NO_RETURN"
```

Synonym

Arguments

Default

Description

This pragma suppresses the generation of the return instruction (return from subroutine, return from interrupt). This may be useful if you care about the return instruction itself, or if the code has to fall through to the first instruction of the next function.

This pragma does not suppress the generation of the exit code at all (e.g. deallocation of local variables, compiler generated local variables). The pragma suppresses the generation of the return instruction.

NOTE

If this feature is used to fall through to the next function, smart linking has to be switched off in the Linker, because the next function may be not referenced from somewhere else. Additionally be careful that both functions are in a linear segment. To be on the safe side allocate both function into a segment, which does only have a linear memory area.

Example

The example in [Listing 1.14](#) places some functions into a special named segment. All functions in this special code segment have to be called from an operating system every 2 seconds after each other. With the pragma, some functions do not return. They fall directly to the next function to be called, saving code size and execution time.

Listing 1.14 Blocking Compiler-generated Function Return Instructions

```
#pragma CODE_SEG CallEvery2Secs
#pragma NO_RETURN
void Func0(void) {
    /* first function, called from OS */
    ...
} /* fall through!!!! */
#pragma NO_RETURN
void Func1(void) {
    ...
} /* fall through */
...
/* last function has to return, no pragma is used! */
void FuncLast(void) {
    ...
}
```

See also

[#pragma NO_ENTRY](#)
[#pragma NO_EXIT](#)
[#pragma NO_FRAME](#)

#pragma NO_STRING_CONSTR: No String Concatenation During Pre-processing

Scope

Compilation Unit

Syntax

```
"#pragma NO_STRING_CONSTR"
```

Synonym

Arguments

Default

Description

This pragma is valid for the rest of the file it appears in. It switches off the special handling of '#' as a string constructor. This is useful if a macro contains inline assembler statements using this character, e.g. for IMMEDIATE values.

Example

The following pseudo assembly code macro shows the use of the pragma. Without the pragma, '#' is handled as string constructor, which is not the desired behavior.

```
#pragma NO_STRING_CONSTR
#define HALT(x)    asm { \
                    LOAD Reg, #3 \
                    HALT x, #255
                    }
```

See also

[Using Immediate Addressing Mode in HLI](#)

#pragma ONCE: Include Once

Scope

File

Syntax

```
"#pragma ONCE"
```

Synonym

None

Arguments

None

Default

None

Description

If this pragma appears in a header file, the file is opened and read only once. This increases compilation speed.

Example

```
#pragma ONCE
```

See also

[Option -Pio](#)

#pragma OPTION: Additional Options

Scope

Compilation Unit or until next pragma OPTION

Syntax

```
"#pragma" "OPTION" ("ADD" [<Handle>] {<Option>} | "DEL" ({ "Handle" } | "ALL")).
```

Synonym

None

Arguments

<Handle>: An identifier - added options can selectively be deleted.

<Option>: A valid option string enclosed in " characters

Default

None

Description

Options are added inside of the source code while compiling a file.

The options given on the command line, or in a configuration file, cannot be changed in any way.

Additional options are added to the current ones with the “ADD” command. A handle may be given optionally.

The “DEL” command either removes all options with a specific handle. It also uses the “ALL” keyword to remove all added options regardless if they have a handle or not. Note that you only can remove options which were added previously with the pragma OPTION ADD.

All keywords, and the handle, are case sensitive.

Restrictions:

- The option `-d` (preprocessor definition) is not allowed. Use a “#define” preprocessor directive instead.

- The option `-odocf` is not allowed. Specify this option on the command line or in a configuration file instead.
- The Message Setting options `-WmsgSi`, `-WmsgSw`, `-WmsgSd` and `-WmsgSe` have no effect. Use the `pragma MESSAGE` instead.
- Only options concerning tasks during code generation are used. Options controlling the preprocessor, for example, have no effect.
- No macros are defined for specific options.
- Only options having function scope may be used.
- The given options must not specify a conflict to any other given option.
- The pragma is not allowed inside of declarations or definitions.

Example

The example in [Listing 1.15](#) shows how to compile only a single function with the additional option `-or`.

Listing 1.15 Using the OPTION Pragma

```
#pragma OPTION ADD function_main_handle "-or"

int sum(int max) { /* compiled with -or */
    int i, sum=0;
    for (i =0; i < max; i++) {
        sum += i;
    }
    return sum;
}

#pragma OPTION DEL function_main_handle
/* now the same options as before the #pragma */
/* OPTION ADD are active again */
```

The examples in [Listing 1.16](#) shows *illegal* uses of the OPTION pragma.

Listing 1.16 Illegal Uses of the OPTION Pragma

```
#pragma OPTION ADD -or /* ERROR, use "-or" */
#pragma OPTION "-or" /* ERROR, use keyword ADD */
#pragma OPTION ADD "-odocf=\"-or\""
/* ERROR, "-odocf" not allowed in this pragma */

void f(void) {
```

Using the Compiler

Compiler Pragas

```
#pragma OPTION ADD "-or"  
/* ERROR, pragma not allowed inside of declarations */  
}  
#pragma OPTION ADD "-cni"  
#ifndef __CNI__  
/* ERROR, macros are not defined for options */  
/* added with the pragma */  
#endif
```

See also

None

#pragma STRING_SEG: String Segment Definition

Scope

Next pragma STRING_SEG

Syntax

```
"#pragma STRING_SEG" (<Modif> <Name> | "DEFAULT")
```

Synonym

STRING_SECTION

Arguments

<Modif>: Some of the following strings may be used:

DIRECT, __DIRECT_SEG,
NEAR, __NEAR_SEG,
CODE, __CODE_SEG,
FAR, __FAR_SEG,
DPAGE, __DPAGE_SEG,
PPAGE, __PPAGE_SEG,
EPAGE, __EPAGE_SEG,
PIC, __PIC_SEG

The __SHORT_SEG modifier specifies a segment that accesses using 8 bit addresses. The definitions of these segment modifiers are backend dependent. Read the backend chapter to find the supported modifiers and their definitions.

<Name>: The name of the segment. This name must be used in the link parameter file on the left side of the assignment in the PLACEMENT part. Please refer to the linker manual for details.

Default

DEFAULT.

Description

This pragma allocates strings into a segment. Strings are allocated in the linker segment STRINGS. This pragma allocates strings in special segments. String

segments also may have modifiers. This instructs the Compiler to access them in a special way when necessary.

Segments defined with the pragma `STRING_SEG` are treated by the linker like constant segments defined with a [#pragma CONST_SEG](#), so they are allocated in ROM areas.

The pragma `STRING_SEG` sets the current string segment. This segment is used to place all newly occurring strings.

NOTE The linker may support a overlapping allocation of strings. E.g. the allocation of “CDE” inside of the string “ABCDE”, so that both strings together need only six bytes. When putting strings into user-defined segments, the linker may no longer do this optimization. Only use a user-defined string segments when necessary.

The synonym `STRING_SECTION` has exactly the same meaning as `STRING_SEG`.

Example

```
#pragma STRING_SEG STRING_MEMORY
char* p="String1";
void f(char*);
void main(void) {
    f("String2");
}
#pragma STRING_SEG DEFAULT
```

See also

Compiler Backend
[Segmentation Chapter in the front end](#)
Linker Manual
[#pragma CODE_SEG](#)
[#pragma CONST_SEG](#)
[#pragma DATA_SEG](#)

#pragma TEST_CODE: Check Generated Code

Scope

Function Definition

Syntax

```
"#pragma TEST_CODE" CompOp <Size> {<HashCode>}.  
CompOp= "==" | "!=" | "<" | ">" | "<=" | ">=".
```

Arguments

<Size>: Size of the function to be used with compare operation

<HashCode>: optional value specifying one specific code pattern.

Default

None

Description

This pragma checks the generated code. If the check fails issues the message [C3601](#).

The following parts are tested:

Size of the function:

The compare operator and the size given as arguments are compared with the size of the function.

This feature checks that the compiler generates less code than a given boundary. Or, to be sure that certain code it can also be checked that the compiler produces more code than specified. To only check the hashcode use a condition which is always TRUE, such as "!= 0".

Hashcode:

The compiler produces a 16-bit hashcode from the produced code of the next function. This hashcode considers:

- The code bytes of the generated functions
- The type, offset and addend of any fixup

To get the hashcode of a certain function, compile the function with an active `#pragma TEST_CODE` which will fail. Then copy the computed hashcode out of the body of the message [C3601](#).

NOTE The code generating by the compiler may change. When the test fails, it is often not sure that the topic chosen to be checked was wrong.

Example:

```
/* check that an empty function is smaller */
/* than 10 bytes */
#pragma TEST_CODE < 10
void main(void) {
}
```

You can also use this pragma to detect when different code is generated:

```
/* if the following pragma fails, check the code. */
/* If the code is OK, add the hashcode to the */
/* list of allowed codes : */
#pragma TEST_CODE != 0 25645 37594
/* check code patterns : */
/* 25645 : shift for *2 */
/* 37594 : mult for *2 */
void main(void) {
    f(2*i);
}
```

See also

[Message C3601](#)

#pragma REALLOC_OBJ: Object Reallocation

Scope

Compilation Unit

Syntax

```
#pragma REALLOC_OBJ "segment" ["objfile"] object qualifier
```

Arguments

qualifier = {"__near", "__far", "__paged", "__rom", "__uni", "__namemangle"}

segment: Name of an already existing segment. This name must have been previously used by a segment pragma (DATA_SEG, CODE_SEG, CONST_SEG, STRING_SEG).

objfile: Name of a object file. If specified, the object is assumed to have static linkage and to be defined in objfile. The name must be specified without alteration by the qualifier "__namemangle".

object: Name of the object to be reallocated. Here the name as known to the linker has to be specified. For C++ linkage, names must be specified according to the C++ name mangling.

qualifier: One of the qualifiers mentioned above. Some of the qualifiers are only allowed to backends not supporting a specified qualifier generating this message. With the special "__namemangle" qualifier, the link name is changed so that the name of the reallocated object does not match the usual name. This feature detects when a pragma REALLOC_OBJ is not applied to all uses of one object.

Default

None

Description

This pragma reallocates an object (e.g. affecting its calling convention). This is used by the linker if the linker has to distribute objects over banks/segments in an automatic way (code distribution). The linker is able to generate an include file containing #pragma RALLOC_OBJ to tell the compiler how to change calling conventions for each object. See the Linker manual for details.

Example

```
#pragma REALLOC_OBJ "DISTRIBUTE1" ("evaluate.o")  
Eval_Plus __near __namemangle
```

See also

[Message C4204](#)
Linker Manual

#pragma TRAP_PROC: Mark Function as Interrupt Function

Scope

Function Definition

Syntax

```
"#pragma TRAP_PROC"
```

Arguments

See Back End

Default

None

Description

This pragma marks a function to be an interrupt function. Because interrupt functions may need some special entry and/or exit code, this pragma has to be used for interrupt functions.

Do not use this pragma for declarations (e.g. in header files), as the pragma is valid for the next definition.

See Back End for details.

NOTE	Using C++, the Compiler will also ‘name mangling’ the name of an interrupt function. The mangled name has to be specified in the linker parameter file (e.g. MyIntFkt_Fv) if the vector number has not been specified with the function definition. To prevent name mangling, declare the function with ‘extern “C”’ <i>Examples:</i> <i>extern “C” interrupt void MyResetFkt(void) {...</i> or <i>#pragma TRAP_PROC</i> <i>extern “C” void MyResetFkt(void) {...</i>
-------------	--

Example:

```
#pragma TRAP_PROC  
void MyInterrupt(void) {  
    ...  
}
```

See also

[interrupt keyword](#)

ANSI-C Front End

The Compiler Front End reads the source file(s), does all the syntactic and semantic checking, and produces intermediate representation of the program which then is passed on to the Back End to generate code.

This section discusses features, restrictions and further properties of the ANSI-C Compiler Front End.

Implementation Features

The Compiler provides a series of pragmas instead of introducing additions to the language to support features such as interrupt procedures. The Compiler implements ANSI-C according to the X3J11 standard. The reference document is “*American National Standard for Programming Language – C*”, ANSI/ISO 9899–1990.

Keywords

auto	break	case	char
const	continue	default	do
double	else	enum	extern
float	for	goto	if
int	long	register	return
short	signed	sizeof	static
struct	switch	typedef	union
unsigned	void	volatile	while

Preprocessor Directives

The Compiler supports the full set of preprocessor directives as required by the ANSI standard:

```
#if, #ifdef, #ifndef, #else, #elif, #endif
#define, #undef
#include
#pragma
#error, #line
```

The preprocessor operators `defined`, `#` and `##` are also supported. There is a special non-ANSI directive `#warning` which is the same as `#error`, but issues only a warning message.

Language Extensions

There is a language extension in the Compiler for ANSI-C. You can use keywords to qualify pointers in order to distinguish them, or to mark interrupt routines.

The Compiler supports the following non-ANSI compliant keywords (see Back End if they are supported and for their semantic):

```
@address
far
near
rom
uni
__alignof__
__va_sizeof__
interrupt
asm
```

NOTE Not all Back Ends may support the above-listed keywords. *See section “Non-ANSI Keywords” in the Back End for more details.*

ANSI-C was not designed with embedded controllers in mind. The listed keywords do not conform to ANSI standards. However, they do enable an easy way to achieve good results from code used for embedded applications.

You can use the `interrupt` keyword to mark functions as interrupt functions, and to link the function to a specified interrupt vector number. `Far`, `near`, `rom` and `uni` may be used to distinguish between different pointer types (e.g. for paging). `Far` and `near` may also be used to specify different calling conventions (e.g. if banking is available).

To allow portable programming between different CPUs (or if the target CPU does not support an additional keyword), you can include the defines listed below in the ‘`hdef.h`’ header file.

```
#define far    /* no far keyword supported */
#define near  /* no near keyword supported */
```

#warning Directive

The #warning directive is used as it is similar to the #error directive.

```
#ifndef MY_MACRO
    #warning "MY_MACRO set to default"
    #define MY_MACRO 1234
#endif
```

Global Variable Address Modifier (@address)

You can assign global variables to specific addresses with the global variable address modifier. These variables are called 'absolute variables'. They are useful for accessing memory mapped I/O ports and have the following syntax:

```
Declaration = <TypeSpec> <Declarator>
                [@ <Address> | @ "<Section>"] [=
<Initializer>];
```

<TypeSpec> is the type specifier, e.g. int, char

<Declarator> is the identifier of your global object, e.g. i, glob

<Address> is the absolute address of the object, e.g. 0xff04, 0x00+8

<Initializer> is the value to which the global variable is initialized.

A segment is created for each global object specified with an absolute address. This address must not be inside any address range in the SECTIONS entries of the link parameter file, otherwise there would be a linker error (overlapping segments). If the specified address has a size greater than that used for addressing the default data page, pointers pointing to this global variable must be "far". An alternate way to assign global variables to specific addresses is:

```
#pragma DATA_SEG [__SHORT_SEG] <segment_name>
```

setting the PLACEMENT section in the linker parameter file. An older method of accomplishing this was:

```
<segment_name> INTO READ_ONLY <Address> ;
```

Examples

```
int glob @0x0500 = 10; // ok, the global variable "glob"
                       // is at 0x0500, initialized with 10

void g() @0x40c0; // error (the object is a function)

void f() {
    int i @0x40cc; // error (the object is a local variable)
}
```

Corresponding link parameter file settings (prm-file):

```
/* the address 0x0500 of "glob" must not be in any address
   range of the SECTIONS entries */
SECTIONS
    MY_RAM    = READ_WRITE 0x0800 TO 0x1BFF;
    MY_ROM    = READ_ONLY  0x2000 TO 0xFEFF;
    MY_STACK  = READ_WRITE 0x1C00 TO 0x1FFF;
    MY_IO_SEG= READ_WRITE 0x0400 TO 0x4ff;
END
PLACEMENT
    IO_SEG      INTO  MY_IO_SEG;
    DEFAULT_ROM INTO  MY_ROM;
    DEFAULT_RAM INTO  MY_RAM;
    SSTACK     INTO  MY_STACK;
END
```

Variable Allocation using @ "SegmentName"

Sometimes it is useful, to have the variable directly allocated in a named segment instead using the #pragma way. Example how to do this:

```
#pragma DATA_SEG SHORT tiny
#pragma DATA_SEG not_tiny
#pragma DATA_SEG SHORT tiny_b
#pragma DATA_SEG DEFAULT
int i@"tiny";
int j@"not_tiny";
int k@"tiny_b";
```

So with some pragmas in a common header file and with another definition for the macro, it is possible to allocate variables depending on a macro.

```
Declaration = <TypeSpec> <Declarator>
              [@" <Section>"] [= <Initializer>];
```

Variables declared and defined with the @"section" syntax behave exactly like variables declared after their respective pragmas.

<TypeSpec> is the type specifier, e.g. int, char

<Declarator> is the identifier of your global object, e.g. i, glob

<Section> is the section name. It should be defined in the link parameter file as well.
E.g. "MyDataSection".

<Initializer> is the value to which the global variable is initialized.

The used section name has to be known at the declaration time by a previous section pragma.

Examples

```
#pragma DATA_SEC __SHORT_SEG MY_SHORT_DATA_SEC
#pragma DATA_SEC MY_DATA_SEC
#pragma CONST_SEC MY_CONST_SEC
#pragma DATA_SEC DEFAULT // not necessary,
                          // but good practice
#pragma CONST_SEC DEFAULT // not necessary,
                          // but good practice
int short_var @"MY_SHORT_DATA_SEC"; // OK, accesses are short
int ext_var @"MY_DATA_SEC" = 10; // OK, goes into
                                // MY_DATA_SECT
int def_var; / OK, goes into DEFAULT_RAM
const int cst_var @"MY_CONST_SEC" = 10; //ok, goes into
                                         // MY_CONST_SECT
```

Corresponding link parameter file settings (prm-file):

```
SECTIONS
    MY_ZRAM = READ_WRITE 0x00F0 TO 0x00FF;
    MY_RAM = READ_WRITE 0x0100 TO 0x01FF;
    MY_ROM = READ_ONLY 0x2000 TO 0xFEFF;
    MY_STACK = READ_WRITE 0x0200 TO 0x03FF;
END
PLACEMENT
    MY_CONST_SEC, DEFAULT_ROM INTO MY_ROM;
    MY_SHORT_DATA_SEC INTO MY_ZRAM;
    MY_DATA_SEC, DEFAULT_RAM INTO MY_RAM;
    SSTACK INTO MY_STACK;
END
```

Absolute Functions

Sometimes it is useful to call an absolute function (e.g. a special function in ROM). Below is a simple example how this could be done using normal ANSI-C.

```
#define erase ((void(*) (void))(0xfc06))

void main(void) {
    erase(); /* call function at address 0xfc06 */
}
```

Absolute Variables and Linking

Special attention is needed if absolute variables are involved in the linker's link process.

If an absolute object is not referenced by your application, the absolute variable is not linked in HIWARE format by default. Instead, it is always linked using the ELF/Dwarf format. To force linking, switch off smart linking in the Linker, or using the ENTRIES command in the linker parameter file.

NOTE: Interrupt vector entries are always linked.

The example in [Listing 1.17](#) shows how the linker handles different absolute variables.

Listing 1.17 Linker Handling of Absolute Variables

```
char i;          /* zero out          */
char j = 1;      /* zero out, copy-down */
const char k = 2; /* download */
char I@0x10;     /* no zero out! */
char J@0x11 = 1; /* copy down */
const char K@0x12 = 2; /* HIWARE: copy down / ELF: download! */
static char L@0x13; /* no zero out! */
static char M@0x14 = 3; /* copy down */
static const char N@0x15 = 4; /* HIWARE: copy down, ELF: download */

void interrupt 2 MyISRfct(void) {} /* download, always linked! */
/* vector number two is downloaded with &MyISRfct */

void foo(char *p) {} /* download */

void main(void) { /* download */
    foo(&i); foo(&j); foo(&k);
    foo(&I); foo(&J); foo(&K);
    foo(&L); foo(&M); foo(&N);
}
```

Zero out means that the default startup code initializes the variables during startup. Copy down means that the variable is initialized during the default startup. To Download means that the memory is initialized while downloading the application.

The Far Keyword

The keyword `__far` is a synonym for `far`, which is allowed when [option -Ansi](#) is present.

NOTE Not all Back Ends may support this keyword. See section “Non-ANSI Keywords” in the Back End.

A far pointer allows access to the whole memory range supported by the processor, not just to the default data page. You can use it to access memory mapped I/O registers that are not on the data page. You can also use it to allocate constant strings in a ROM not on the data page.

The ‘far’ keyword defines the calling convention for a function. Some backends support special calling conventions which also set a page register when a function is called. This enables you to use more code than the address space can usually accommodate. The special allocation of such functions is not done automatically.

Using the far Keyword for Pointers

The keyword `far` is a type qualifier like `const` and is valid only in the context of pointer types and functions. The far keyword (for pointers) always affects the last ‘*’ to its left in a type definition. The declaration of a far pointer to a far pointer to a character is:

```
char *far *far p;
```

The following is a declaration of a normal (short) pointer to a far pointer to a character:

```
char *far * p;
```

NOTE To declare a far pointer, place the `far` keyword *after* the asterisk:

```
char *far p;
```

not

```
char far *p;
```

The second choice is *illegal*.

far and Arrays

The `far` keyword does not appear in the context of the `'*` type constructor in the declaration of an array parameter, as shown:

```
void my_func (char a[37]);
```

Such a declaration specifies a pointer argument. This is equal to:

```
void my_func (char *a);
```

There are two possible uses when declaring such an argument to a far pointer:

```
void my_func (char a[37] far);
```

or alternately

```
void my_func (char *far a);
```

In the context of the `'[]` type constructor in a direct parameter declaration, the `far` keyword always affects the first dimension of the array to its left. In the following declaration, parameter `a` has type “far pointer to array of 5 far pointers to `char`”:

```
void my_func (char *far a[][5] far);
```

far and typedef Names

If the array type has been defined as a `typedef` name as in:

```
typedef int ARRAY[10];
```

then a `far` parameter declaration is:

```
void my_func (ARRAY far a);
```

The parameter is a `far` pointer to the first element of the array. This is equal to:

```
void my_func (int *far a);
```

It is also equal to the following direct declaration:

```
void my_func (int a[10] far);
```

It is *not* the same as specifying a `far` pointer to the array:

```
void my_func (ARRAY *far a);
```

because `a` has type “far pointer to `ARRAY`” instead of “far pointer to `int`”.

far and Global Variables

The ‘far’ keyword can also be used for global variables:

```
int far i;           // ok for global variables
int far *i;         // ok for global variables
int far *far i;    // ok for global variables
```

This forces the Compiler to perform the same addressing mode for this variable as it has been declared in a FAR segment. Note that for the above variable declarations/definitions, the variables are in the DEFAULT_DATA segment if no other data segment is active. Be careful if you mix ‘far’ declarations/definitions within a non-FAR data segment. Assuming that FAR segments have ‘extended’ addressing mode and normal segments have ‘direct’ addressing mode, the following two examples clarify this behavior:

```
// ok, consistent declarations
#pragma DATA_SEG MyDirectSeg // use direct addressing mode
int i;      // direct, segment MyDirectSeg
int j;      // direct, segment MyDirectSeg

#pragma DATA_SEG FAR MyFarSeg // use extended addressing
mode
int k;      // extended, segment MyFarSeg
int l;      // extended, segment MyFarSeg
int far m;  // extended, segment MyFarSeg

// caution: not consistent!!!!
#pragma DATA_SEG MyDirectSeg // use direct addressing mode
int i;      // direct, segment MyDirectSeg
int j;      // direct, segment MyDirectSeg
int far k;  // extended, segment MyDirectSet
int far l;  // extended, segment MyDirectSeg
int far m;  // extended, segment MyDirectSeg
```

far and C++ Classes

If a member function gets the modifier `far`, the “this” pointer is a far pointer. This is useful, if an instance, if the owner class of the function is not allocated on the default data page. See [Listing 1.18](#).

Listing 1.18 far Member Functions

```
class A {
public:
    void f_far(void) far {
        /* far version of member function A::f() */
    }
};
```

```
    }
    void f(void) {
        /* normal version of member function A::f() */
    }
};
#pragma DATA_SEG MyDirectSeg // use direct addressing mode
A a_normal; // normal instance
#pragma DATA_SEG FAR MyFarSeg // use extended addressing mode
A far a_far; // far instance
void main(void) {
    a_normal.f(); // call normal version of A::f() for normal instance
    a_far.f_far(); // call far version of A::f() for far instance
}
```

far and C++ References

The far modifier is applied to references. This is useful if it is a reference to an object outside of the default data page. For example:

```
    int j; // object j allocated outside the default data page
           // (must be specified in the link parameter file)
    void f(void) {
        int &far i = j;
    };
```

Using the far Keyword for Functions

A special calling convention is specified for the far keyword. The far keyword is specified in front of the function identifier:

```
    void far f(void);
```

If the function returns a pointer, the far keyword must be written in front of the first asterisk (“*”).

```
    int far *f(void);
```

It must, however, be after the int and not before it.

For function pointers, many backends assume that the far function pointer is pointing to functions with the far calling convention, even if the calling convention was not specified. Moreover, most backends do not support different function pointer sizes in

one compilation unit. The function pointer size is then dependent only upon the memory model. See the backend chapter for details.

Table 1.42 Interpretation of the far Keyword

Declaration	Allowed	Type Description
int far f();	ok	far function returning an int
far int f();	error	
far f();	ok	far function returning an int
int far *f();	ok	far function returning a pointer to int
int * far f();	ok	function returning a far pointer to int
far int * f();	error	
int far * far f();	ok	far function returning a far pointer to int
int far i;	ok	global far object
int far *i;	ok	pointer to a far object
int * far i;	ok	far pointer to int
int far * far i;	ok	far pointer to a far object
far int *i;	ok	pointer to a far integer
int *far (* far f)(void)	ok	far pointer to function returning a far pointer to int
void * far (* f)(void)	ok	pointer to function returning a far pointer to void
void far * (* f)(void)	ok	pointer to far function returning a pointer to void

near Keyword

NOTE Not all Back Ends may support this keyword. See section “Non-ANSI Keywords” in the Back End.

The `__near` keyword is a synonym for `near`. This is allowed when [option -Ansi](#) is present.

The `near` keyword can be used instead of the `far` keyword. It is used in situations where the `far` modifier is the default and especially short and objects should be specified, or where the `near` calling convention must be explicitly specified.

The far keyword uses two semantic variations. Either it specifies a small size of a function or data pointers, or it specifies the near calling convention.

Table 1.43 Interpretation of the near Keyword

Declaration	Allowed	Type Description
int near f();	ok	near function returning an int
int near far f();	error	
near f();	ok	near function returning an int
int near * far f();	ok	near function returning a far pointer to int
int far *i;	error	
int * near i;	ok	far pointer to int
int * far* near i;	ok	near pointer to far pointer to int
int *far (* near f)(void)	ok	near pointer to function returning a far pointer to int
void * near (* f)(void)	ok	pointer to function returning a near pointer to void
void far *near (*near f)(void)	ok	near pointer to far function returning a far pointer to void

rom Keyword

The `__rom` keyword is a synonym for `rom`, which is allowed when [option -Ansi](#) is present.

NOTE Not all Back Ends support this keyword. *See section “Non-ANSI Keywords” in the Back End for details.*

Some micro controllers support a Harvard Architecture instead the Von Neumann Architecture.

In the Von Neumann Architecture, code (ROM) and data (RAM) are accessible with the same load/store instructions. In the Harvard Architecture, ROM and RAM are separate address spaces using special instructions.

Using a Harvard Architecture, values stored in ROM are accessed only when using special instructions. A `rom` pointer always points to ROM. `Rom` pointers are used to access string constants located in ROM.

Example:

```
const char * rom const ptr; /* points to code; ptr in ROM */
```

uni Keyword

The `__uni` keyword is a synonym for `uni`, which is allowed when [option -Ansi](#) is present.

NOTE Not all Back Ends may support this keyword. See section “Non-ANSI Keywords” in the Back End.

When using a Harvard Architecture, values stored in ROM are accessed only when using the `MOVC` instruction. A pointer must contain the information defining which kind of memory it points to (RAM or ROM).

This information must be present when working with pointers because a pointer is copied at run time. The handling function would not know whether this pointer refers to the code or data memory. Therefore, an additional pointer type has to be introduced: the `uni` (universal) pointer. Such `uni` pointers have an additional byte which signals the kind of memory to be accessed. To handle memory accesses by universal pointers, run time functions may be used.

Example:

```
const char * uni ptr;
/* points to code; ptr in RAM */

char * const ptr;
/* points to data; ptr in ROM */

const char * uni const ptr;
/* points to code; ptr in ROM */
```

The correct pointer type has to be specified for global initialization. For example, it may be dangerous to use `uni` pointers for string pointer allocation if the strings are allocated in a `rom` section, as shown:

```
// wrong, use 'rom'
const char *const uni Bad[] = {"abc", "def"};

// ok, rom pointers
const char *const rom Ok[] = {"abc", "def"};
```

Compatibility

Far pointers and normal pointers are compatible. If necessary, the normal pointer is extended with the default data page to a far pointer (subtraction of two pointers or assignment to a far pointer). In the other case, the far pointer is clipped to a normal pointer (i.e. the page part is discarded).

`__alignof__` Keyword

Some processors align objects according to their type. The unary operator, `__alignof__`, determines the alignment of a specific type. By providing any type, this operator returns its alignment. This operator behaves in the same way as "sizeof(type-name)" operator. See the target backend section to check which alignment corresponds to which fundamental data type (if any is required) or to which aggregate type (structure, array).

This macro may be useful for the `va_arg` macro in `stdarg.h`, e.g. to differentiate the alignment of a structure containing four objects of four bytes from that of a structure containing two objects of eight bytes. In both cases, the size of the structure is 16 bytes but the alignment may differ, as shown:

```
#define va_arg(ap,type)    \
    (((__alignof__(type)>=8) ? \
      ((ap) = (char *)(((int)(ap) \
        + __alignof__(type) - 1) & (~(__alignof__(type) - 1)))) \
      : 0), \
      ((ap) += __va_rounded_size(type)), \
      (((type *) (ap))[-1]))
```

`__va_sizeof__` Keyword

According to the ANSI-C specification, you must promote character arguments in open parameter lists to `int`. The use of "char" in the `va_arg` macro to access this parameter may not work as per the ANSI-C specification.

```
int f(int n, ...) {
    int res;
    va_list l= va_start(n, int);
    res= va_arg(l, char); /* should be va_arg(l, int) */
    va_end(l);
    return res;
}
```

```
void main(void) {
    char c=2;
    int res=f(1,c);
}
```

With the `__va_sizeof__` operator, the `va_arg` macro is written the way that `f` returns 2.

A safe implementation of the `f` function is to use “`va_arg(1, int)`” instead of “`va_arg(1, char)`”.

The `__va_sizeof__` unary operator, which is used exactly as the `sizeof` keyword, returns the size of its argument after promotion as in an open parameter list.

Examples:

```
__va_sizeof__(char) == sizeof (int)
__va_sizeof__(float) == sizeof (double)
struct A { char a; };
__va_sizeof__(struct A) >= 1 (1 if the target needs no
padding bytes)
```

NOTE It is not possible in ANSI-C to distinguish a 1-byte structure without alignment/padding from a character variable in a `va_arg` macro. They need a different space on the open parameter calls stack for some processors.

interrupt Keyword

The `__interrupt` keyword is a synonym for `interrupt`, which is allowed when [option -Ansi](#) is present.

NOTE Not all Back Ends support this keyword. *See the “Non-ANSI Keywords” section in the Back End.*

You can use one of two ways to specify a function to be an interrupt routine:

1. Use the [#pragma TRAP_PROC](#) and adapt the Linker parameter file.
2. Use the nonstandard interrupt keyword.

Use the nonstandard interrupt keyword like any other type qualifier. It specifies a function to be an interrupt routine. It is followed by a number specifying the entry in the interrupt vector that should contain the address of the interrupt routine. If it is not

followed by any number, the interrupt keyword has the same effect as the pragma TRAP_PROC. It specifies a function to be an interrupt routine. Although, the number of the vector entry must be specified in the Linker parameter file with the Linker VECTOR number functionname command.

Example:

```
interrupt void f(); // ok
    // same as #pragma TRAP_PROC,
    // please set the entry number in prm-file

interrupt 3 int g(); // ok
    // third entry in vector points to g()

interrupt int l; // error, not a function
```

Example:

```
interrupt 2 int g();
    // The 2nd entry (number 2) gets the address of func g().
```

asm Keyword

The Compiler supports target processor instructions inside of C functions.

The `__asm` keyword is a synonym for `asm`, which is allowed when [option -Ansi](#) is present.

See the inline assembler section in the backend chapter for details.

Implementation-Defined Behavior

The ANSI standard contains a couple of places where the behavior of a particular Compiler is left undefined. It is possible for different Compilers to implement certain features in different ways, even if they all comply with the ANSI-C standard. Subsequently, we'll discuss those points and the behavior implemented by the Compiler.

Right Shifts

The result of `E1 >> E2` is implementation-defined for a right shift of an object with a signed type having a negative value, if `E1` has a signed type and a negative value.

In this implementation, an arithmetic right shift is performed.

Initialization of Aggregates with Non-Constants

The initialization of aggregates with non-constants is not allowed in the ANSI-C specification. The Compiler allows it if the option [-Ansi](#) is not set.

Example:

```
void main() {
    struct A {
        struct A *n;
    } v={&v}; /* the address of v is not constant */
}
```

Sign of char

The ANSI-C standard leaves it open, whether the data type `char` is signed or unsigned. Check the Back End chapter for data about default settings.

Division and Modulus

The results of the `/` and `%` operators are also not properly defined for signed arithmetic operations unless both operands are positive.

NOTE	The way a Compiler implements <code>/</code> and <code>%</code> for negative operands is determined by the hardware implementation of the target's division instruction(s).
-------------	---

See [Division and Modulus](#) for description and examples.

Translation Limitations

This section describes the internal limitations of the Compiler. Some limitations are stack limitations depending on the operating system used. For example, in some operating systems, limits depend on whether the compiler is a 32-bit compiler running on a 32-bit platform (e.g. Windows NT), or if it is a 16-bit Compiler running on a 16-bit platform (e.g. Windows for Workgroups).

The ANSI column in the table below shows the recommended limitations of the ANSI C (5.2.4.1 in ISO/IEC 9899:1990 (E)) and ANSI C++ standards. These quantities are only guidelines and do not determine compliance. The 'Implementation' column shows the actual implementation value and the possible message number. '-' means

that there is no information available for this topic and 'n/a' denotes that this topic is not available.

Limitation	Implementation	ANSI C	ANSI C++
Nesting levels of compound statements, iteration control structures, and selection control structures	256 (C1808)	15	256
Nesting levels of conditional inclusion	-	8	256
Pointer, array, and function decorators (in any combination) modifying an arithmetic, structure, union, or incomplete type in a declaration	-	12	256
Nesting levels of parenthesized expressions within a full expression	32 (C4006)	32	256
Number of initial characters in an internal identifier or macro name	32767	31	1024
Number of initial characters in an external identifier	32767	6	1024
External identifiers in one translation unit	-	511	65536
Identifiers with block scope declared in one block	-	127	1024
Macro identifiers simultaneously defined in one translation unit	655'360'000 (C4403)	1024	65536
Parameters in one function definition	-	31	256
Arguments in one function call	-	31	256
Parameters in one macro definition	1024 (C4428)	31	256
Arguments in one macro invocation	2048 (C4411)	31	256
Characters in one logical source line	2^31	509	65536
Characters in a character string literal or wide string literal (after concatenation)	8196 (C3301 , C4408 , C4421)	509	65536
Size of an object	32767	32767	262 144
Nesting levels for #include files	256 (C3000)	8	256

Limitation	Implementation	ANSI C	ANSI C++
Case labels for a switch statement (excluding those for any nested switch statements)	1000	257	16384
Data members in a single class, structure, or union	-	127	16384
Enumeration constants in a single enumeration	-	127	4096
Levels of nested class, structure, or union definitions in a single struct declaration list	32	15	256
Functions registered by atexit()	-	n/a	32
Direct and indirect base classes	-	n/a	16384
Direct base classes for a single class	-	n/a	16384
Members declared in a single class	-	n/a	4096
Final overriding virtual functions in a class, accessible or not	-	n/a	16384
Direct and indirect virtual bases of a class	-	n/a	1024
Static members of a class	-	n/a	1024
Friend declarations in a class	-	n/a	4096
Access control declarations in a class	-	n/a	4096
Member initializers in a constructor definition	-	n/a	6144
Scope qualifications of one identifier	-	n/a	256
Nested external specifications	-	n/a	1024
Template arguments in a template declaration	-	n/a	1024
Recursively nested template instantiations	-	n/a	17
Handlers per try block	-	n/a	256
Throw specifications on a single function declaration	-	n/a	256

The table below shows other limitations which are not mentioned in a ANSI standard

Limitation	Description
Type Declarations	Derived types must not contain more than 100 components.
Labels	There may be at most 16 other labels within one procedure.
Macro Expansion	Expansion of recursive macros is limited to 70 (16bit OS) or 2048 (32bit OS) recursive expansions (C4412).
Include Files	The total number of include files is limited to 8196 for a single compilation unit.
Numbers	Maximum of 655'360'000 different number for a single compilation unit (C2700 , C3302).
Goto	M68k only: Maximum of 512 gotos for a single function (C15300).
Parsing Recursion	Maximum of 1024 parsing recursions (C2803).
Lexical Tokens	Limited by memory only (C3200).
Internal ID's	Maximum of 16'777'216 internal ID's for a single compilation unit (C3304). Internal ID's are used for additional local/global variables created by the Compiler (e.g. by using CSE).
Code Size	Code size is limited to 32kB for each single function.
File Names	Maximum length for file names (including path) are 128 characters for 16 bit applications and 256 for Win32 applications. UNIX versions support file names without path of 64 characters length and 256 with path. Paths may be 96 characters on 16 bit PC versions, 192 on UNIX versions and 256 on 32 bit PC versions.

ANSI-C Standard

This section provides a short overview about the implementation (see also ANSI Standard 6.2) of the ANSI-C conversion rules.

Integral Promotions

You may use a char, a short int, or an int bitfield, or their signed or unsigned varieties, or an enum type, in an expression wherever an int or unsigned int is used. If an int represents all values of the original type, the value is converted to an int; otherwise, it is converted to an unsigned int. Integral promotions preserve value including sign.

Signed/Unsigned Integers

Promoting a signed integer type to another signed integer type of greater size requires "sign extension": In two's-complement representation, the bit pattern is unchanged, except for filling the high order bits with copies of the sign bit.

When converting a signed integer type to an unsigned integer type, if the destination has equal or greater size, the first signed extension of the signed integer type is performed. If the destination has a smaller size, the result is the remainder on division by a number, one greater than the largest unsigned number, that is represented in the type with the smaller size.

Arithmetic Conversions

The operands of binary operators do implicit conversions:

- If either operand has type long double, the other operand is converted to long double.
- If either operand has type double, the other operand is converted to double.
- If either operand has type float, the other operand is converted to float.
- The integral promotions are performed on both operands.

Then the following rules are applied:

- If either operand has type unsigned long int, the other operand is converted to unsigned long int.
- If one operand has type long int and the other has type unsigned int, if a long int can represent all values of an unsigned int, the operand of type unsigned int is converted to long int; if a long int cannot represent all the values of an unsigned int, both operands are converted to unsigned long int.
- If either operand has type long int, the other operand is converted to long int.
- If either operand has type unsigned int, the other operand is converted to unsigned int.
- Both operands have type int.

Order of Operand Evaluation

Operators	Associativity
() [] -> .	left to right
! ~ ++ -- + - * & (type) sizeof	right to left
& / %	left to right
+ -	left to right
<< >>	left to right
< <= > >=	left to right
== !=	left to right
&	left to right
^	left to right
	left to right
&&	left to right
	left to right
? :	right to left
= += -= *= /= %= &= ^= = <<= >>=	right to left
,	left to right

Unary +,- and * have higher precedence than the binary forms.

Example:

```
if (a&3 == 2)
```

'==' has higher precedence than '&', thus it is evaluated as

```
if (a & (3==2))
```

which is the same as

```
if (a&1)
```

Hint: use brackets if you are not sure about associativity!

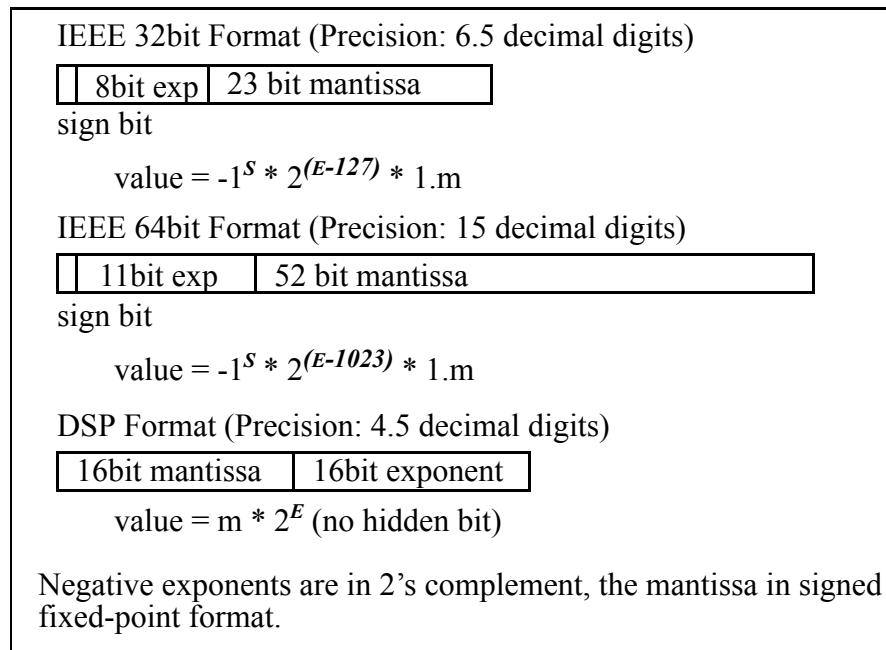
Rules for Standard Type Sizes

```
sizeof(char)  <= sizeof(short)
sizeof(short) <= sizeof(int)
sizeof(int)   <= sizeof(long)
sizeof(long)  <= sizeof(long long)
sizeof(float) <= sizeof(double)
sizeof(double)<= sizeof(long double)
```

In ANSI-C, enumerations have the type of 'int'. In this implementation they have to be smaller or equal than 'int'.

Floating Type Formats

The Compiler supports two IEEE floating point formats: IEEE32 and IEEE64. There may also be a DSP format supported by the processor. The figure below shows these three formats.



Floats are implemented as IEEE32, and doubles as IEEE64. This may vary for a specific Back End, or possibly, both formats may not be supported. Please check the Back End chapter for details, default settings and supported formats.

Floating Point Representation of 500.0 for IEEE

First convert 500.0 from the decimal representation to a representation with base 2:

value = $(-1)^s * m * 2^e$
where sign is 0 or 1,
 $2 > m \geq 1$ for IEEE
and exp is a integral number.

For 500 this gives:

```
sign (500.0) = 1
mant (500.0,IEEE) = 1.953125
exp (500.0,IEEE) = 8
```

NOTE The number 0 (zero) can not be represented this way. So for 0 IEEE defines a special bit pattern consisting of 0 bits only.

Next convert the mantissa into its binary representation.

```
mant (500.0,IEEE) = 1.953125
= 1*2^(0) + 1*2^(-1) + 1*2^(-2) + 1*2^(-3) + 1*2^(-4)
  + 0*2^(-5) + 1*2^(-6) + 0*...
= 1.111101000... (bin).
```

Because this number is computed to be larger or equal to 1 and smaller than 2, there is always a 1 in front of the decimal point. For the remaining steps, this constant 1 is left out to save space.

```
mant (500.0, IEEE, cutted) = .111101000... .
```

The exponent must also be converted to binary format:

```
exp (500.0,IEEE) = 8 == 08 (hex) == 1000 (bin)
```

For the IEEE formats the sign is encoded as separate bit (sign magnitude representation)

Representation of 500.0 in IEEE32 Format

The exponent in IEEE32 has a fixed offset of 127 to always have positive values:

```
exp (500.0,IEEE32) = 8+127 == 87 (hex) == 10000111 (bin)
```

The fields must be put together according to the graphic:

```
500.0 (dec)
= 0 (sign) 10000111 (exponent)
  111101000000000000000000 (mantissa) (IEEE32 as bin)
```


Representation of 500.0 in DSP Format

Convert 500.0 from the decimal representation to a representation with base 2. In contradiction to IEEE, DSP normalizes the mantissa between 0 and 1 and not between 1 and 2. This makes it possible to also represent 0, which must have a special pattern in IEEE. Also, the exponent is different from IEEE.

$value = (-1)^s * m * 2^e$
where sign is 1 or -1,
 $1 > m \geq 0$
and exp is a integral number.

For 500 this gives:

```
sign (500.0) = 1
mant (500.0,DSP) = 0.9765625
exp (500.0,DSP) = 9
```

Next convert the mantissa into its binary representation.

```
mant (500.0, DSP) = 0.9765625 (dec)
= 0*2^(0) + 1*2^(-1) + 1*2^(-2) + 1*2^(-3) + 1*2^(-4) +
1*2^(-5)
  + 0*2^(-6) + 1*2^(-7) + 0*...
= 0.1111101000... (bin).
```

Because this number is computed to be always larger or equal to 0 and smaller than 1, there is always a 0 in front of the decimal point. For the remaining steps this constant is left out to save space. There is always a 1 after the decimal point, except for 0 and intermediate results. This bit is encoded, so the DSP loses one additional bit of precision compared with IEEE.

```
mant (500.0, DSP, cutted) = .1111101000... .
```

The exponent must also be converted to binary format:

```
exp (500.0,DSP) = 9 == 09 (hex) == 1001 (bin)
```

Negative exponents are encoded by the 2's representation of the positive value.

The sign is encoded into the mantissa by taking the 2's complement for negative numbers and adding a 1 bit in the front. For DSP and positive numbers a 0 bit is added at the front.

```
mant(500.0, DSP) = 0111110100000000 (bin)
```

The twos complement is taken for negative numbers:

```
mant(-500.0, DSP) = 1000001100000000 (bin)
```


Finally the mantissa and the exponent must be joined according to the graphic above:

```

500.0 (dec)
= 7D 00 (mantissa) 00 09 (exponent) (DSP as hex)
= 7D 00 00 09 (DSP as hex)
= 0111 1101 0000 0000 0000 0000 0000 1001 (DSP as bin)

-500.0 (dec)
= 83 00 (mantissa) 00 09 (exponent) (DSP as hex)
= 83 00 00 09 (DSP as hex)
= 1000 0011 0000 0000 0000 0000 0000 1001 (DSP as bin)

```

NOTE The order of the byte representation of a floating point value depends on the byte ordering of the backend. The first byte in the previous diagrams must be considered as the most significant byte.

Volatile Objects, Absolute Variables

The Compiler does not do register- and constant tracing on volatile/absolute global objects. Accesses to volatile/absolute global objects are not eliminated.

Example:

```

volatile int x;

void main(void) {
    x = 0;
    ...
    if(x == 0) { // without volatile attribute, the
                // comparison may be optimized away!
        Error(); // Error() is called without compare!
    }
}

```

Bit Fields

There is no standard way to allocate bit fields. Bit-field allocation varies from Compiler to Compiler even for the same target. Using bit fields for access to I/O registers is non-portable and inefficient for the masking involved in unpacking individual fields. It is recommended that you use regular bit-and (&) and bit-or (|) operations for I/O port access.

The maximum width of bit fields is Back End dependent (see Back End for details), in that plain `int` bit fields are signed. A bit field never crosses a word (2 bytes)

boundary. As stated in Kernighan and Ritchie's *"The C Programming Language"*, 2ND ed., the use of bit fields is equivalent to using bit masks to which the operators `&`, `|`, `~`, `|=` or `&=` are applied. In fact, the Compiler translates bit field operations to bit mask operations.

Signed Bit Fields

A common mistake is to use signed bit fields, but testing them as if they were unsigned. Signed bit fields have a value of -1 or 0. Consider the following example:

```
typedef struct _B {
    signed int b0: 1;
} B;

B b;

if (b.b0 == 1) ...
```

The Compiler issues a warning and replaces the 1 with -1 because the condition `(b.b0 == 1)` does not make sense, i.e. it is always false. The test `(b.b0 == -1)` is performed as expected. This substitution is not ANSI compatible and will not be performed when the [-Ansi](#) Compiler option is active.

The correct way to specify this is with an unsigned bit field. Unsigned bit fields have the values 0 or 1.

```
typedef struct _B {
    unsigned b0: 1;
} B;

B b;

if (b.b0 == 1) ...
```

Because `b0` is an unsigned bit field having the values 0 or 1, the test `(b.b0 == 1)` is correct.

Recommendations

In order to save memory, it is recommended to implement globally accessible boolean flags as unsigned bit fields of width 1. However, it is not recommended using bit fields for other purposes because:

- Using bit fields to describe a bit pattern in memory is not portable between Compilers, even on the same target, as different Compilers may allocate bit fields differently.

For information about how the Compiler allocates bit fields, see the *Back End, Data Types* section.

Segmentation

The Linker supports the concept of segments in that the memory space may be partitioned into several segments. The Compiler allows attributing a certain segment name to certain global variables or functions which then will be allocated into that segment by the Linker. Where that segment actually lies is determined by an entry in the Linker parameter file.

The syntax of the segment specification pragma:

```
SegDef= "#pragma" SegmentType ( {SegmentMod} SegmentName |
                                         "DEFAULT" ) .

SegmentType= "CODE_SEG" | "CODE_SECTION" |
             "DATA_SEG" | "DATA_SECTION" |
             "CONST_SEG" | "CONST_SECTION" |
             "STRING_SEG" | "STRING_SECTION" .

SegmentMod= "DIRECT" | "NEAR" | "CODE" | "FAR" | "BIT" |
            "Y_BASED" | "Z_BASED" | "DPAGE" | "PPAGE" |
            "EPAGE" | "PIC" .
```

Since there are two basic types of segments, code and data segments, there are also two pragmas to specify segments:

```
#pragma CODE_SEG <segment_name>
#pragma DATA_SEG <segment_name>
```

In addition there are pragmas for constant data and for strings:

```
#pragma CONST_SEG <segment_name>
#pragma STRING_SEG <segment_name>
```

All four pragmas are valid until the next pragma of the same kind is encountered.

In the HIWARE object file format, constants are put into the DATA_SEG if no CONST_SEG was specified. In the ELF Object file format, constants are always put into a constant segment.

Strings are put into the segment STRINGS until a pragma STRING_SEG is specified. After this pragma, all strings are allocated into this constant segment. The linker then treats this segment like any other constant segment.

If no segment is specified, the Compiler assumes two default segments named DEFAULT_ROM (the default code segment) and DEFAULT_RAM (the default data

segment). Use the segment name `DEFAULT` to explicitly make these default segments the current segments :

```
#pragma CODE_SEG DEFAULT
#pragma DATA_SEG DEFAULT
#pragma CONST_SEG DEFAULT
#pragma STRING_SEG DEFAULT
```

Segments may also be declared as `__SHORT_SEG` by inserting the keyword `__SHORT_SEG` just before the segment name (with the exception of the predefined segment `DEFAULT` – this segment cannot be `SHORT`). This makes the Compiler use short (i.e. 8 bits or 16 bits, depending on the Back End) absolute addresses to access global objects, or to call functions. It is the programmer's responsibility to allocate `SHORT` segments in the proper memory area.

NOTE The default code and data segments may not be declared `SHORT`.

The meaning of the other segment modifiers, such as `NEAR` and `FAR`, are backend specific. Modifiers that are not supported by the back end are ignored. Please refer to the backend chapter for data about which modifiers are supported.

The segment pragmas also have an effect on static local variables. Static local variables are local variables with the 'static' flag set. They are in fact normal global variables but with scope only to the function in which they are defined:

```
#pragma DATA_SEG MySeg
static char foo(void) {
    static char i = 0; /* place this variable into MySeg */
    return i++;
}
#pragma DATA_SEG DEFAULT
```

NOTE Using the ELF/DWARF object file format (option `-F1` or `-F2`), all constants are placed into the section `.rodata` by default unless a `#pragma CONST_SEG` is used.

NOTE There are aliases to satisfy the ELF naming convention for all segment names. Use `CODE_SECTION` instead of `CODE_SEG`. Use `DATA_SECTION` instead of `DATA_SEG`. Use `CONST_SECTION` instead of `CONST_SEG`. Use `STRING_SECTION` instead of

STRING_SEG. These aliases behave exactly are the XXX_SEG name versions.

Example of Segmentation Without Compiler -Cc Option

```

static int a;                /* Placed into Segment: */
static const int c0 = 10;    /* DEFAULT_RAM(-1) */
                             /* DEFAULT_RAM(-1) */

#pragma DATA_SEG MyVarSeg
static int b;                /* MyVarSeg(0) */
static const int c1 = 11;    /* MyVarSeg(0) */

#pragma DATA_SEG DEFAULT
static int c;                /* DEFAULT_RAM(-1) */
static const int c2 = 12;    /* DEFAULT_RAM(-1) */

#pragma DATA_SEG MyVarSeg
#pragma CONST_SEG MyConstSeg
static int d;                /* MyVarSeg(0) */
static const int c3 = 13;    /* MyConstSeg(1) */

#pragma DATA_SEG DEFAULT
static int e;                /* DEFAULT_RAM(-1) */
static const int c4 = 14;    /* MyConstSeg(1) */

#pragma CONST_SEG DEFAULT
static int f;                /* DEFAULT_RAM(-1) */
static const int c5 = 15;    /* DEFAULT_RAM(-1) */

```

Example for Segmentation With Compiler -Cc Option

```

static int a;                Placed into Segment:
static const int c0 = 10;    /* DEFAULT_RAM(-1) */
                             /* ROM_VAR(-2) */

#pragma DATA_SEG MyVarSeg
static int b;                /* MyVarSeg(0) */
static const int c1 = 11;    /* MyVarSeg(0) */

#pragma DATA_SEG DEFAULT
static int c;                /* DEFAULT_RAM(-1) */

```

```
static const int c2 = 12;          /* ROM_VAR(-2)    */

#pragma DATA_SEG MyVarSeg
#pragma CONST_SEG MyConstSeg
static int d;                     /* MyVarSeg(0)    */
static const int c3 = 13;        /* MyConstSeg(1) */

#pragma DATA_SEG DEFAULT
static int e;                     /* DEFAULT_RAM(-1) */
static const int c4 = 14;        /* MyConstSeg(1)  */

#pragma CONST_SEG DEFAULT
static int f;                     /* DEFAULT_RAM(-1) */
static const int c5 = 15;        /* ROM_VAR(-2)    */
```

Optimizations

The Compiler applies a variety of code improving techniques under the term "optimization". This section provides a short overview about the most important optimizations.

Peephole Optimizer

A peephole optimizer is a simple optimizer in a Compiler. A peephole optimizer tries to optimize specific code patterns on speed or code size. After recognizing these specific patterns, they will be replaced by other optimized patterns.

After code is generated by the back end of an optimizing Compiler, it is still possible that code patterns may result that are still capable of being optimized. The optimizations of the peephole optimizer are highly back end dependent because the peephole optimizer was implemented with characteristic code patterns of the back end in mind.

Certain peephole optimizations only make sense in conjunction with other optimizations, or together with some code patterns. These patterns may have been generated by doing other optimizations. There are optimizations (e.g removing of a branch to the next instructions) that are removed by the peephole optimizer, though they could have been removed by the branch optimizer as well. Such simple branch optimizations are performed in the peephole optimizer to reach new optimizable states.

Strength Reduction

Strength reduction is an optimization that strives to replace expensive operations by cheaper ones, where the cost factor is either execution time or code size. Examples are the replacement of multiplication and division by constant powers of two with left or right shifts.

NOTE The compiler can only replace a division by two using a shift operation if either the target division is implemented the way that $-1/2 == -1$, or if the value to be divided is unsigned. The result is different for negative values. To give the compiler the possibility to use a shift, the C source code should already contain a shift, or the value to be shifted should be unsigned.

Shift Optimizations

Shifting a byte variable by a constant number of bits is intensively analyzed. The Compiler always tries to implement such shifts in the most efficient way.

Branch Optimizations

This optimization tries to minimize the span of branch instructions. The Compiler will never generate a long branch where a short branch would have sufficed. Also, branches to branches may be resolved into two branches to the same target. Redundant branches (e.g. a branch to the instruction immediately following it) may be removed.

Dead Code Elimination

The Compiler removes dead assignments while generating code. In some programs it may find additional cases of expressions that are not used.

Constant Variable Optimization

If a constant non-volatile variable is used in any expression, the Compiler replaces it by the constant value it holds. This needs less code than taking the object itself.

The constant non-volatile object itself is removed if there is no expression taking the address of it. This results in using less memory space.

Example:

```
void f(void) {
    const int ci = 100; // ci removed (no address taken)
    const int ci2 = 200; // ci2 not removed
                        // (address taken below)
    const volatile int ci3 = 300; //ci3 not removed (volatile)
    int i;
    int *p;
    i = ci; // replaced by i=100;
    i = ci2; // no replacement
    p = &ci2; // address taken
}
```

Global constant non-volatile variables are not removed. Their use in expressions are replaced by the constant value they hold.

Constant non-volatile arrays are also optimized.

Example:

```
void g(void) {
    const int array[] = {1,2,3,4};
    int i;
    i = array[2]; // replaced by i=3;
}
```

Tree Rewriting

The structure of the intermediate code between Front End and Back End allows the Compiler to perform some optimizations on a higher level. Examples are shown in the following sections.

Switch Statements

Efficient translation of switch statements is mandatory for any C Compiler. The Compiler applies different strategies, i.e. branch trees, jump tables, and a mixed strategy, depending on the case label values and their numbers.

Method	Description
Branch Sequence	For small switches with scattered case label values, the Compiler generates an if ... elsif ... elsif ... else ... sequence if the Compiler switch <code>-Os</code> is active.
Branch Tree	For small switches with scattered case label values, the Compiler generates a branch tree. This is the equivalent to unrolling a binary search loop of a sorted jump table and therefore is very fast. However, there is a point at which this method is not feasible simply because it uses too much memory.
Jump Table	In such cases, the Compiler creates a table plus a call of a switch processor. There are two different switch processors. If there are a lot of labels with more or less consecutive values, a direct jump table is used. If the label values are scattered, a binary search table is used.
Mixed Strategy	Finally, there may be switches having "clusters" of label values separated by other labels with scattered values. In this case, a mixed strategy is applied, generating branch trees or search tables for the scattered labels and direct jump tables for the clusters.

Absolute Values

Another example for optimization on a higher level is the calculation of absolute values. In C, the programmer has to write something on the order of:

```
float x, y;  
x = (y < 0.0) ? -y : y;
```

This results in lengthy and inefficient code. The Compiler recognizes cases like this and treats them specially in order to generate the most efficient code. Only the most significant bit has to be cleared.

Combined Assignments

The Compiler can also recognize the equivalence between the three following statements:

```
x = x + 1;  
x += 1;  
x++;
```

and between:

```
x = x / y;
x /= y;
```

Therefore, the Compiler generates equally efficient code for either case.

Using Qualifiers for Pointers

The use of qualifiers (const, volatile, ...) for pointers is confusing. This section provides some examples for the use of const/volatile as const and volatile are very common for Embedded Programming.

Consider the following example:

```
int i;
const int ci;
```

The above definitions are: a 'normal' variable 'i' and a constant variable 'ci'. Each are placed into ROM. Note that for C++, the constant 'ci' must be initialized.

```
int *ip;
const int *cip;
```

'ip' is a pointer to an 'int', where 'cip' is a pointer to a 'const int'.

```
int *const icp;
const int *const cicp;
```

'icp' is a 'const pointer' to an 'int', where 'cicp' is a 'const pointer' to a 'const int'.

It helps if you know that the qualifier for such pointers is always on the right side of the '*'. Another way is to read the source from right to left.

You can express this rule in the same way to volatile. Consider the following example of an 'array of five constant pointers to volatile integers':

```
volatile int *const arr[5];
```

'arr' is an array of five constant pointers pointing to volatile integers. Because the array itself is constant, it is put into ROM. It does not matter if the array is constant or not regarding where the pointers point to. Consider the next example?

```
const char *const *buf[] = {&a, &b};
```

Because the array of pointers is initialized, the array is not constant. 'buf' is a (non-constant) array of two pointers to constant pointers which points to constant characters. Thus 'buf' cannot be placed into ROM by the Compiler/Linker.

Consider a constant array of five ordinary function pointers. Assuming that:

```
void (*fp)(void);
```

is a function pointer 'fp' returning void and having void as parameter, you can define it with:

```
void (*fparr[5])(void);
```

It is also possible to use a typedef to separate the function pointer type and the array:

```
typedef void (*Func)(void);  
Func fp;  
Func fparr[5];
```

You can write a constant function pointer as:

```
void (*const cfp) (void);
```

Consider a constant function pointer having a constant int pointer as a parameter returning void:

```
void (*const cfp2) (int *const);
```

Or a const function pointer returning a pointer to a volatile double having two constant integers as parameter:

```
volatile double *(*const fp3) (const int, const int);
```

And an additional one:

```
void (*const fp[3])(void);
```

This is an array of three constant function pointers, having void as parameter and returning void. 'fp' is allocated in ROM because the 'fp' array is constant.

Consider an example using function pointers:

```
int (* (** func0(int (*f) (void))) (int (*) (void))) (int  
  (*) (void)) {  
    return 0;  
}
```

It is actually a function called func. This func has one function pointer argument called f. The return value is more complicated in this example. It is actually a function pointer of a complex type. Here we do not explain where to put a const so that the

destination of the returned pointer cannot be modified. Alternately, the same function is written more simply using typedefs:

```
typedef int (*funcType1) (void);
typedef int (* funcType2) (funcType1);
typedef funcType2 (* funcType3) (funcType1);

funcType3* func0(funcType1 f) {
    return 0;
}
```

Now, the places of the const becomes obvious. Just behind the * in funcType3:

```
typedef funcType2 (* const constFuncType3) (funcType1);

constFuncType3* func1(funcType1 f) {
    return 0;
}
```

By the way, also in the first version here is the place where to put the const:

```
int (* (*const * func1(int (*f) (void))) (int (*) (void)))
    (int (*) (void)) {
    return 0;
}
```

Defining C Macros Containing HLI Assembler Code

You can define some ANSI C macros that contain HLI assembler statements when you are working with the HLI assembler. Because HLI assembler is heavily Back End dependent, the following example uses a pseudo Assembler Language:

```
CLR Reg0      ; Clear Register zero
CLR Reg1      ; Clear Register one
CLR var       ; Clear variable 'var' in memory
LOAD var,Reg0 ; Load the variable 'var' into Register 0
LOAD #0, Reg0 ; Load immediate value zero into Register 0
LOAD @var,Reg1 ; Load address of variable 'var' into Reg1
STORE Reg0,var ; Store Register 0 into variable 'var'
```

The HLI instructions are only used as a possible example. For real applications, you must replace the above pseudo HLI instructions with the HLI instructions for your target.

Defining a Macro

An HLI assembler macro is defined using the preprocessor directive ‘define’.

Example:

```
/* Following macro clears the register zero. */
#define ClearReg0 {asm CLR Reg0;}
```

The macro is invoked in the following way in the source code:

```
ClearReg0;
```

The preprocessor expands the macro:

```
{asm CLR Reg0;};
```

An HLI assembler macro can contain one or several HLI assembler instructions. As the ANSI C preprocessor expands a macro on a single line, you cannot define an HLI assembler block in a macro. You can, however, define a list of HLI assembler instructions.

Example:

```
/* Following macro clears the registers 0 and 1. */
#define ClearReg0And1 {asm CLR Reg0; asm CLR Reg1}
```

The macro is invoked in the following way in the source code:

```
ClearReg0And1;
```

The preprocessor expands the macro:

```
{asm CLR Reg0; asm CLR Reg1;};
```

You can define an HLI assembler macro on several lines using the line separator ‘\’.

NOTE This may enhance the readability of your source file. However, the ANSI C preprocessor still expands the macro on a single line.

Example:

```
/* Following macro clears the registers 0 and 1. */
#define ClearR0andR1 {asm CLR Reg0; \
                    asm CLR Reg1}
```

The macro is invoked in the following way in the source code:

```
ClearR0andR1;
```

The preprocessor expands the macro:

```
{asm CLR Reg0; asm CLR Reg1;};
```

Using Macro Parameters

An HLI assembler macro may have some parameters which are referenced in the macro code.

Example:

```
/* This macro initializes the specified variable to 0.*/  
#define Clear(var) {asm CLR var}
```

The macro is invoked in the following way in the source code:

```
Clear(var1);
```

The preprocessor expands the macro:

```
{asm CLR var1 ; };
```

Using Immediate Addressing Mode in HLI Assembler Macros

There may be one ambiguity if you are using the immediate addressing mode inside of a macro.

For the ANSI C preprocessor, the symbol # inside of a macro has a specific meaning (string constructor).

Using the [#pragma NO_STRING_CONSTR](#), you can tell the Compiler that in all the macros defined afterward, instructions should remain unchanged where ever the symbol # is specified. This macro is valid for the rest of the file it is specified in.

Example:

```
/* This macro initializes the specified variable to 0.*/  
#pragma NO_STRING_CONSTR  
#define Clear(var) {asm LOAD #0,Reg0; asm STORE Reg0,var}
```

The macro is invoked in the following way in the source code:

```
Clear(var1);
```

The preprocessor expands the macro:

```
{ asm LOAD #0,Reg0; asm STORE Reg0,var1 };
```

Generating unique Labels in HLI Assembler Macros

When some labels are defined in HLI Assembler Macros, if you invoke the same macro twice in the same function, the ANSI C preprocessor generates the same label

twice (once in each macro expansion). Use the special string concatenation operator of the ANSI C preprocessor ('##') in order to generate unique labels. See [Listing 1.19](#).

Listing 1.19 Using the ANSI C Preprocessor String Concatenation Operator

```
/* The following macro copies the string pointed to by 'src'
   into the string pointed to by 'dest'.
   'src' and 'dest' must be valid array of characters.
   'inst' is the instance number of the macro call. This
   parameter must differ for each invocation of the
   macro to allow the generation of unique labels. */
#pragma NO_STRING_CONSTR
#define copyMacro2(src, dest, inst) { \
asm          LOAD @src,Reg0; /* load src addr */ \
asm          LOAD @dest,Reg1; /* load dst addr */ \
asm          CLR Reg2; /* clear index reg */ \
asm lp##inst: LOADB (Reg2, Reg0); /* load byte reg indir */ \
asm          STOREB (Reg2, Reg1); /* store byte reg indir */ \
asm          ADD #1,Reg2; /* increment index register */ \
asm          TST Reg2; /* test if not zero */ \
asm          BNE lp##inst; }
```

The `copyMacro2` macro is invoked in the following way in the source code:

```
copyMacro2(source2, destination2, 1);
copyMacro2(source2, destination3, 2);
```

During expansion of the first macro, the preprocessor generates an 'lp1' label. During expansion of the second macro, an 'lp2' label is created.

Generating Assembler Include Files (Option [-La](#))

In many projects it often make sense to use both a C compiler and an assembler. Both have different advantages. The compiler uses portable and readable code while the assembler provides full control for time-critical applications, or for direct accessing of the hardware.

The compiler can not read include files of the assembler as the assembler can not read the header files of the compiler.

The assembler include file output of the compiler lets both tools using one single source to share constants, variable/labels, and even structure fields.

The compiler writes an output file in the format of the assembler which contains all needed information of a C header file.

The current implementation supports the following mappings:

- **Macros**
C defines are translated to assembler EQU directives.
- **enum values**
C enum values are translated to EQU directives.
- **C types**
The size of any type and the offset of structure fields is emitted for all typedefs. For bitfield structure fields, the bit offset and the bit size are also emitted.
- **Functions**
For each function a XREF entry is emitted.
- **Variables**
C Variables are emitted with a XREF. For structures or unions additionally all fields are defined with a EQU directive.
- **Comments**
C style comments (`/* ... */`) are included as assembler comments (`;`....).

General

A header file must be specially prepared to emit the assembler include file.

The assembler output is enabled with a pragma anywhere in the header file:

```
#pragma CREATE_ASM_LISTING ON
```

Only macro definitions and declarations behind this pragma are emitted. The compiler stops emitting future elements when the pragma [CREATE_ASM_LISTING](#) occurs with an OFF parameter.

```
#pragma CREATE_ASM_LISTING OFF
```

Not all entries generate legal assembler constructs. Care must be taken for macros. The compiler does not check for legal assembler syntax when translating macros. Macros containing elements not supported by the assembler, should be in a section controlled by a `#pragma CREATE_ASM_LISTING OFF`.

The compiler only creates an output file when the `-la` option is specified, and the compiled sources contain a `#pragma CREATE_ASM_LISTING ON`.

Example:

Header file: a.h

```
#pragma CREATE_ASM_LISTING ON

typedef struct {
    short i;
    short j;
} Struct;

Struct Var;

void f(void);

#pragma CREATE_ASM_LISTING OFF
```

When the compiler reads this header file with the option `-La=a.inc a.h`, it generates the following a.inc file:

```
Struct_SIZE      EQU $4
Struct_i         EQU $0
Struct_j         EQU $2
                 XREF Var
Var_i            EQU Var + $0
Var_j            EQU Var + $2
                 XREF f
```

You can now use the assembler INCLUDE directive to include this file into any assembler file. The content of the C variable, Var_i, can also be accessed from the assembler without any uncertain assumptions about the alignment used by the compiler. Also, whenever a field is added to the structure Struct, the assembler code must not be altered. You must, however, regenerate the a.inc file with a make tool.

Usually the assembler include file is not created every time the compiler reads the header file. IT is created only a separate pass when the header file has changed significantly. The `-la` option is only specified when the compiler must generate a.inc. If `-la` is always present, a.inc is always generated. A make tool will always restart the assembler as the assembler files depend on a.inc. Such a makefile might be similar to:

```
a.inc : a.h
    $(CC) -la=a.inc a.h

a_c.o : a_c.c a.h
    $(CC) a_c.c

a_asm.o : a_asm.asm a.inc
    $(ASM) a_asm.asm
```

The order of elements in the header file is the same as the order of the elements in the created file, except that comments may be inside of elements in the C file. In this case, the comments may be before or after the whole element.

The order of defines does not matter for the compiler. The order of EQU directives does matter for the assembler. If the assembler has problems with the EQU directives order in a generated file, the corresponding header file must be changed accordingly.

Macros

The translation of defines is done lexically and not semantically. So the compiler does not check the accuracy of the define.

The following example shows some legal uses of this feature:

```
#pragma CREATE_ASM_LISTING ON
int i;
#define UseI i
#define Constant 1
#define Sum Constant+0X1000+01234
```

Creates:

```
UseI           XREF i
               EQU   i
Constant       EQU   1
Sum            EQU   Constant + $1000 + @234
```

The hexadecimal C constant 0x1000 was translated to \$1000 while the octal 01234 was translated to @1234. Additionally, the compiler has inserted one space between every two tokens. These are the only changes the compiler make in the assembler listing for defines.

Macros with parameters, predefined macros, and macros with no defined value are not emitted.

The following defines do not work or are not emitted:

```
#pragma CREATE_ASM_LISTING ON
int i;
#define AddressOfI &i
#define ConstantInt ((int)1)
#define Mul7(a) a*7
#define Nothing
#define useUndef UndefFkt*6
#define Anything § § / % & % / & + * % ç 65467568756 86
```

Creates:

```

                                XREF i
AddressOfI                       EQU & i
ConstantInt                       EQU ( ( int ) 1 )
useUndef                          EQU UndefFkt * 6
Anything                          EQU § § / % & % / & + * % ç
65467568756 86

```

The AddressOfI macro does not assemble because the assembler does not know the C address operator &. Also, other C-specific operators such as dereferenciation (*ptr) must not be used. The compiler emits them into the assembler listing file without any translation.

The ConstantInt macro does not work because the assembler does not know the cast syntax and the types.

Macros with parameters are not written to the listing,. Therefore, Mul7 does not occur in the listing. Also, macros just defined with no actual value as Nothing are not emitted.

The C preprocessor does not care about the syntactical content of the macro, though the assembler EQU directive does. Therefore, the compiler has no problems with the useUndef macro using the undefined object UndefFkt. The assembler EQU directive requires that all used objects are defined.

The Anything macro shows that the compiler does not care about the content of a macro. The assembler, of course, cannot treat these random characters.

These types of macros are in a header file used to generate the assembler include file. They must only be in a region started with a "#pragma [CREATE_ASM_LISTING OFF](#)" so that the compiler will not emit anything for them.

Enums

Enums in C have a unique name and a defined value. They are simply emitted by the compiler as an EQU directive.

```

#pragma CREATE_ASM_LISTING ON
enum {
    E1=4,
    E2=47,
    E3=-1*7
};

```

Creates:

```
E1          EQU $4
E2          EQU $2F
E3          EQU $FFFFFFF9
```

NOTE Negative values are emitted as 32-bit hex numbers.

Types

As it does not make sense to emit the size of any occurring type, only typedefs are considered.

The size of the newly defined type is specified for all typedefs. As name, the typedef name with an additional end "_SIZE" is used. For structures, the offset of all structure fields relative to the structure start is emitted. The name of the structure offsets is built by using the typedef name, and then the structure fields name after an underline ("_").

```
#pragma CREATE_ASM_LISTING ON

typedef long LONG;
struct tagA {
    char a;
    short b;
};

typedef struct {
    long d;
    struct tagA e;
    int f:2;
    int g:1;
} str;
```

Creates:

```
LONG_SIZE          EQU $4
str_SIZE           EQU $8
str_d              EQU $0
str_e              EQU $4
str_e_a            EQU $4
str_e_b            EQU $5
str_f              EQU $7
str_f_BIT_WIDTH    EQU $2
str_f_BIT_OFFSET   EQU $0
str_g              EQU $7
str_g_BIT_WIDTH    EQU $1
str_g_BIT_OFFSET   EQU $2
```

All structure fields inside of structures are contained. The generated name contains all names of all files listed in the path. If any element of the path does not have a name (e.g. an anonymous union), this element is not emitted.

The width and the offset are additionally emitted for all bitfield members. The offset 0 specifies the least significant bit, which is accessed with mask 0x1. The offset 2 the most significant bit, which is accessed with mask 0x4. The width specifies the number of bits.

The offsets, bit widths and bit offsets, given here are examples. Different compilers may emit different values. In C, the structure alignment and the bitfield allocation is determined by the compiler which specifies the correct values.

Functions

Declared functions are emitted by the XREF directive. This enables them to be used with the assembler. The function to be called from C, but defined in assembler, should not be emitted into the output file as the assembler does not allow the redefinition of labels declared with XREF. Such function prototypes are placed in an area started with a "#pragma [CREATE_ASM_LISTING OFF](#)", as shown below.

```
#pragma CREATE_ASM_LISTING ON
void main(void);
void f_C(int i, long l);

#pragma CREATE_ASM_LISTING OFF
void f_asm(void);
```

Creates:

```
XREF main
XREF f_C
```

Variables

Variables are declared with XREF. Additionally for structures, every field is defined with an EQU directive. For bitfields, the bit offset and bit size are also defined.

Variables in the SHORT segment are defined with XREF.B to inform the assembler about the direct access. Fields in structures in SHORT segments, are defined with a EQU.B directive.

```
#pragma CREATE_ASM_LISTING ON
struct A {
    char a;
    int i:2;
};
```

```
struct A VarA;
#pragma DATA_SEG __SHORT_SEG ShortSeg
int VarInt;
```

Creates:

```
VarA_a           XREF VarA
                 EQU VarA + $0
VarA_i           EQU VarA + $1
VarA_i_BIT_WIDTH EQU $2
VarA_i_BIT_OFFSET EQU $0
                 XREF.B VarInt
```

The variable size is not explicitly written. To emit the variable size, use a typedef with the variable type.

The offsets, bit widths and bit offsets, given here are examples. Different compilers may emit different values. In C, the structure alignment and the bitfield allocation is determined by the compiler which specifies the correct values.

Comments

Comments inside a region emitted with "`#pragma CREATE_ASM_LISTING ON`" are also written on a single line in the assembler include file.

Comments inside of a typedef, a structure, or a variable declaration, are placed either before or after the declaration. They are never placed inside the declaration, even if the declaration contains multiple lines. Therefore, a comment after a structure field in a typedef, is written before or after the whole typedef, not just after the type field. Every comment is on a single line. An empty comment (`/* */`) inserts an empty line into the created file.

Example:

```
#pragma CREATE_ASM_LISTING ON
/*
  The function main is called by the startup code.
  The function is written in C. It is responsible
  to initialize the application. */
void main(void);
/*
  The SIZEOF_INT macro specified the size of an integer type
  in the compiler. */
typedef int SIZEOF_INT;
#pragma CREATE_ASM_LISTING OFF
```

Creates:

```

;
; The function main is called by the startup code.
; The function is written in C. It is responsible
; to initialize the application.
;                                     XREF main
;
; The SIZEOF_INT macro specified the size of an integer
type
; in the compiler.
SIZEOF_INT_SIZE          EQU $2

```

Guidelines

The `-La` option translates specified parts of header files into an include file to import labels and defines into an assembler source. Because the `-La` option is a very powerful option, incorrect use must be avoided using the following guidelines implemented in a real project. This section describes how the programmer uses this option to combine C and assembler sources, both using common header files.

The following recommendations help to avoid problems when writing software using the common header file technique.

General Implementation Guide Lines

- All interface memory reservations/definitions must be made in C source files. Memory areas, only accessed from assembler files, can still be defined in the common assembler way.
- Compile only C header files (and not the C source files) with the `-La` option to avoid multiple defines and other problems. The project-related makefile must contain an inference rules section that defines the C header file(s)-dependent include files to be created.
- Use `#pragma CREATE_ASM_LISTING ON/OFF` only in C header files. This `#pragma` selects the objects which should be translated to the assembler include file. The created assembler include file then holds the corresponding assembler directives.
- The `-La` option should not be part of the command line options used for all compilations. Use this option in combination with the option `-Cx` (no Code Generation). Without this option, the compiler creates an object file which could accidentally overwrite a C source object file.

- Remember to extend the list of dependencies for assembler sources in your make file.
- Check if the compiler-created assembler include file is included into your assembler source.

Notes

- In case of a zero page declared object (if this is supported by the target), the compiler translates it into an XREF.B directive for the base address of a variable/constant. The compiler translates structure fields in the zero page into a EQU.B directive in order to access them. Explicit zero page addressing syntax may be necessary as some assemblers use extended addresses to EQU.B defined labels.
- Project-defined data types must be declared in the C header file by including a global project header (e.g. global.h). This is necessary as the header file is compiled in a stand-alone fashion.

C++ Front End

C++

Overview

This chapter provides an overview of the implementation of the C++ language used in this Compiler. It explains the main features of the language together with information about their implementation, taking into account the differences between various Compiler vendors.

The impacts of C++ for embedded applications are also discussed.

Implementation

The C++ Compiler described in this section is based on the book "Ellis/Stroustrup: The Annotated C++ Reference Manual".

Programmers not familiar with C++ should read the following additional documentation:

- "Ellis/Stroustrup: The Annotated C++ Reference Manual", ANSI Base Document, 1995, Addison-Wesley, ISBN 0-201-51459-1
- "Bjarne Stroustrup: The C++ Programming Language", 1987, Addison-Wesley, ISBN 0-201-12078-X
- "Bjarne Stroustrup: The Design and Evolution of C++", 1994, ISBN 0-201-54330-3
- "P.J. Plauger: The Draft Standard C++ Library", 1995, Prentice Hall, ISBN 0-13-117003-1

Features

The following C++ features are supported by the cC++ Compiler:

- Stronger type checking
- C++ standard name encoding
- Overloading of functions and operators
- Classes with (multiple) inheritance
- Access control to class members (private, protected, public, friend)
- Constructors and Destructors for Classes
- Ambiguity resolution

- Static class member variables and static class member functions
- Constant class member variables and constant class member functions
- Declarations of variables are anywhere within a block of statements
- C++ comments
- References
- Inlining
- C linkage (extern "C")
- Standard predefined macro "__cplusplus"
- Explicit Constructor calls are creating temporary class objects
- Virtual functions and virtual base classes
- Pure virtual functions and abstract classes
- Templates
- Pointer to members
- Default Arguments
- Operators "new" and "delete"
- C++ libraries (streams, new/delete, strings, complex, bitset, STL)
- Special segments for virtual tables and compiler generated functions

The following C++ features are not supported:

- Static local class objects
- Non-constant initialization of global non-class objects
- Anonymous unions
- Goto-statement checks for initialization and Destructor calls
- Exception handling
- Namespaces
- Runtime Type Information (RTTI)
- Keywords bool, explicit, mutable, using, typeid
- Overloading with non-exact match
- Explicit operator calls
- Alternative C++ cast syntax
- Base class member access modification
- "namespace", "using", "bool", "mutable" keywords

- "const_cast", "static_cast", "reinterpret_cast"
- C++ libraries "exception" and "valarray"

Additional Keywords in C++

The following keywords are available in C++ programs:

```
class      operator   this
delete    private    throw
friend    protected   try
inline    public       catch
new       template     virtual
```

C Linkage

You can mix C and C++ sources using the guidelines defined in this section.

To call a C function from a C++ program, the function prototype must be declared with extern "C". This lets the C++ Compiler know that the function is encoded in the "normal" C name encoding format.

Example:

```
extern "C" void f(void);

void main(void) {
    f(); /* call the C function f() */
}
```

Linkage specifications are used for linking functions written in different languages. The linkage specifications currently supported by this compiler are "C" and "C++".

Example:

```
extern "C" {
    void g(); // "C" linkage
    extern "C++" {
        int f(); // "C++" linkage
    }
}
```

The Standard Predefined Macro `__cplusplus`

The macro, '`__cplusplus`', is automatically defined if the Compiler translates a C++ source. This macro distinguishes, on source level, between ANSI-C and C++ Compilers, and makes sources compatible for both for ANSI-C and C++ Compilers.

Example:

The source code inside this Compiler directive is compiled only if the source is compiled as a C++ program. Otherwise, it is ignored.

```
struct A {
    int j;
    #ifdef __cplusplus
        void f(int i); /* only legal for C++ */
    #endif
} a;
```

Example:

The following example shows the use of the macro in ANSI-C header files to make them compatible for both ANSI-C and C++.

```
#ifdef __cplusplus
    extern "C" { /* C++: use C calling convention */
#endif

void foo(int, double);
/* ... */

#ifdef __cplusplus
}
#endif
```

Special Segment Support for C++

Programming in C++ requires special attention to program segmentation. Normally, you have control over data and code allocation, using pragmas, as in normal C programs. However, there are special segments used for C++.

VIRTUAL_TABLE_SEGMENT

The compiler generates virtual function tables if virtual functions are used. Because classes often are declared in header files, each implementation file including such

header files with classes containing virtual member functions, may generate virtual function tables. These tables are constant by default and may be allocated in ROM.

To simplify this, the compiler places all virtual tables into a special segment named `VIRTUAL_TABLE_SEGMENT`. You can use this in the linker parameter file to allocate the virtual tables into ROM:

```
DEFAULT_ROM, ROM_VAR, VIRTUAL_TABLE_SEGMENT INTO MY_ROM
```

Additionally, the linker uses this segment name to avoid duplicate definitions of virtual function tables in your linked application.

GEN_FUNCS_SEGMENT

The compiler generates some compiler-generated functions: copy constructors, default constructors and destructors.

All compiler-generated functions are placed into a special segment named `GEN_FUNCS_SEGMENT`. This segment may be used in the linker parameter file:

```
DEFAULT_ROM, GEN_FUNCS_SEGMENT INTO MY_ROM
```

Additionally, the linker uses this segment name to avoid duplicate definitions of compiler generated functions in your linked application.

Differences between ANSI-C and C++

Empty Parameter Declarations

A function such as `f()` has no parameters in C++. Although in C, it can contain any number of functions:

```
void foo();  
/* C++ : same as 'void foo(void)' */  
/* ANSI-C: undefined number of parameters */
```

Return Values

Functions returning a value must have a correct C++ return statement.

Example:

```
int f(void) {  
    int i;  
    i=3;  
} /* C legal, C++ error: return required. */
```

Implicit Parameter Declaration

Declare all functions before using them in C++.

Example:

```
void f(void) {
    g(); /* ANSI-C legal, C++ error: missing prototype */
}
```

See also Option [-Wpd](#)

Constant Variables

Initialize all constant variables in C++.

```
#ifdef __cplusplus
    const int i = 3; /* C++ requires initialisation */
#else
    const int i; /* legal for ANSI-C */
#endif
```

Additionally, constant objects without ‘extern’, have static linkage. Objects with static linkage cannot be used in other modules. You must declare C++ constant objects with ‘extern’ to implement external linkage for these objects. See also [Ellis, page 108] for details.

```
#ifdef __cplusplus
    const int i = 3; // definition and static linkage
    extern const int j; // declaration
    const int j = 4; // definition and external linkage
    static const int k = 3; // definition and static linkage
#else
    const int i = 3; /* definition and external linkage */
    extern const int j; /* declaration */
    const int j = 4; /* definition and external linkage */
    static const int k = 3; // definition and static linkage
#endif
```

Name Spaces

The name space of structure tags and typedefs differ between C and C++.

Empty Classes

The size of an empty struct/class is always one. The Linker cannot allocate an object with size zero. Non-empty classes derived from empty classes do not contain a dummy byte.

Example:

```
class EmptyClass {} ; // sizeof(EmptyClass) returns 1!
class DerivedFromEmpty : EmptyClass {
    int a;
};

int i, j;

void main(void) {
    i = sizeof(EmptyClass);          /* == 1 */
    j = sizeof(DerivedFromEmpty); /* == sizeof(int) */
}
```

More Details about C++

For more details please refer to "Ellis/Stroustrup: The Annotated C++ Reference Manual".

C++ and Embedded Systems

C++ Compilers are known to produce inefficient code. However, it is possible to achieve small more efficient code. This chapter provides you with tips on how to write efficient C++ programs suitable to embedded systems development.

Depending on your need for efficient code, you can choose between the languages Full ANSI Draft C++, Embedded C++ (EC++), and compactC++ (cC++) using the [-C++](#) option.

- Full ANSI Draft C++ supports the whole C++ language.
- Embedded C++ (EC++) supports a constant subset of the C++ language. EC++ does not support templates, multiple inheritance, virtual base classes and exception handling.
- compactC++ (cC++) supports a configurable subset of the C++ language. You can configure this subset with the [-Cn](#) option. This enables you to select which features to switch off or on, depending on your needs.

About Compiler Generated Functions

The Compiler generates special member functions for classes where necessary. This increases the code size of a module. However, those generated functions are often not called in the application. The Linker discards functions that are not called in the application.

Alternately, you can avoid the Compiler generating those functions by using the `-Cn=Ctr` option. Use the compiler `-Cn=Ctr` option to not create compiler-defined functions in C++. You may also do this manually:

```
class A {}

A::A(){} // default constructor
A::A(const A&){} // copy constructor
A& A::operator(const A&) // assignment operator
A::~~A(){} // destructor
```

Use inlining or class templates (described in the following two sections) if the 'Default Copy Constructor' does not generate automatically:

Use Inlining

Declare all member functions with the inline specifier or write the function body inside the class declaration.

Example:

```
struct A {
    inline void f(void) /* inlined function */
    void g(void) { /* ... */ } /* inlined function */
};

void A::f(void) {
}
```

NOTE Inline functions do have implicit static linkage.

Another way is to use the option `-Oi`.

Use Class Templates

You can parameterize classes with templates. This enables you to avoid class Constructors that perform unnecessary tasks at runtime. See [Listing 1.20](#).

Listing 1.20 Using Templates

```
/* ***** */
/* bad: */
/* ***** */
class A {
    int *array;
    A(int i) { // needs a lot of run time!!!
        array = malloc(i);
    }
};

A a1(4); // class A with array of 4 elements
A a2(7); // class A with array of 7 elements

/* ***** */
/* good: */
/* ***** */
template<int i> class A {
    int array[i];
    A();
};

A<4> a1; // class A with array of 4 elements
A<7> a2; // class A with array of 7 elements
```

Avoid Function Templates

Function templates produce a good deal of code. Each instantiation of a template function generates code for the whole function, along with specific template arguments.

Example:

```
template<class T> void f(T t) { /* ... */ }

void g(void) {
    char *chp;
    f(4); // generate void f(int) { /* ... */ }
    f(chp); // generate void f(char *) { /* ... */ }
}
```

Reduce the Type for Virtual Function Table Delta

Virtual function tables are generated using virtual member functions. These tables contain a function pointer and an associated delta value that accesses the base class. The delta values have a (signed) 16-bit type, allowing class objects with a size of 32 kBytes each. You can change the delta value type, using the `-Tvtd` option, to save ROM usage for function tables. For example, if all class objects are smaller or equal 127 bytes, change the virtual table delta type to a signed 1 byte type using `-Tvtd`. If there is a class object not fitting into this type, an error message ([C1393](#)) is generated.

Avoid Pointer to Member Parameters and Pointer to Member Returns

The compiler handles a data structure as the pointer to member type is not a pointer (see “The annotated C++ reference manual” from ELLIS-STROUSTRUP). Refer to [Listing 1.21](#).

Listing 1.21 Avoid Pointer Member Parameters and Pointer Member Returns

```
class A{
public:
    void fct(void){ /*.....*/ }
};
void f(void (A::*pm)(void)){
    A a;
    (a.*pm)();
}
void main(void){
    f(&A::fct);
}

// Produces the following behavior:
typedef ptrmbrType{
    int offset;
    int index;
    void *fctMbr;
};
class A{
public:
    void fct(void){ /*.....*/ }
};
```

```
void f(ptrmbrType pm){
    A a;
    if (!(pm.offset==0 && pm.index==0 && pm.fctMbr==NULL)){
        if (pm.index==-1){
            (a.*pm)(); // call function in a normal way
        } else {
            (a.*pm)(); // call function in a virtual way
        }
    }
}
}
void main(void){
    ptrmbrType dummy;
    dummy.offset = 0;
    dummy.index = -1;
    dummy.fctMbr = &A::fct;
    f(dummy); // call f function in a normal way
}
```

The same kind of behavior is generated when returning pointer to member. No information is available at the function call statement in the event of a pointer-to-member as a parameter, or as a return. Handling these tests at runtime addresses this issue.

Avoid Class Parameters and Class Returns

Every class parameter passing and class return requires a call to the copy constructor of the class if the class needs to call a constructor. These types of copy constructor calls are not efficient. It is more efficient to use pass references. See [Listing 1.22](#).

Listing 1.22 Avoid Class Parameters and Class Returns

```
/* ***** */
/* bad: */
/* ***** */
class A {
    A(void);
    A(A &);
};

A f(A a) {
    A ret;
    return ret; // call copy constructor for return b
}
```

```
void g(void) {
    A a, b;
    b=f(a); // call copy constructor for argument a
}

/*****
/* good:                                     */
/*****/
class A {
    A(void);
    A(A &);
};

void f(A &a, A &b) {
    A ret;
    b=ret;
}

void g(void) {
    A a, b;
    f(a, b); // pass the address of a and b
}
```

Avoid Virtual Functions

Virtual functions are the key feature of object oriented programming. Though they are very inefficient in use. It is recommended to avoid them.

Avoid Virtual Base Classes

Virtual base classes are not efficient. It is recommended to avoid them. See also [‘Short C++ tutorial’](#)

Avoid NULL-Check of Class Pointers

Operations with pointers to related classes always require separate NULL-checks before adding offsets from base classes to inherited classes. Avoid operations of pointers to different, but related classes.

Example:

```
class A {
    int i;
};

class AA {
    int j;
};

class B : A {
};

void f(void) {
    A *ap; // pointer to base class
    B *bp; // pointer to inheriting class
    ap=bp; // generates following code:
           // ap=(bp==0)?0:(A *)((char *)bp+delta(A));
}
```

Declare Near First Use

An object is initialized (constructed) the moment it is declared. If you don't have enough information to initialize an object until you are half way down the function, create it half way down the function where the system can correctly initialize it. Don't initialize it to an "empty" value at the top then "assign" it later as this affects runtime performance.

Examples:

```
//bad:
void f() {
    int i=0;
    /* ... */
    i=5;
    /* using i */
}

//good:
void f() {
    /* ... */
    int i=5;
    /* using i */
}
```

About Code Size

Object files are quite large, especially if the source code is trivial. A simple "hello world" program generates an executable that is larger than most people expect. The reason is: the `<iostream.h>` library is quite large and consists of numerous classes and virtual functions. Using any part of it might pull in nearly all of the `<iostream.h>` code as a result of the interdependencies. However, the linker discards functions and objects which are not used. The size of the executable decreases in comparison to the object file.

C++ Overhead

[Table 1.44](#) gives an overview about the possible overhead (ROM/RAM) using a C++ feature compared with standard ANSI-C.

Table 1.44 Overhead of C++ Features

C++ Feature	Overhead
C++ comments (e.g. <code>/**</code>)	None
Default arguments (e.g. <code>foo(int, int b=3)</code>)	None, except that for calling <code>foo</code> with <code>foo(5)</code> will result in a call with an additional parameter <code>foo(5,3)</code> .
classes	None, if no inheritance or virtual functions are used. An empty struct/class occupies one byte of memory (RAM) (not possible in ANSI-C), but a derived class from an empty class does not contain this dummy byte.
access control (public, private, protected)	None
virtual functions (virtual keyword)	Large as additional pointers in the class object (virtual base pointers) are used (RAM) and the virtual function tables has to be allocated (ROM). Additionally, most of the virtual function calls have to reference this virtual function tables (dereferenciation) which results in additional code (ROM) compared with normal function calls.
stronger type checking (name encoding)	None
templates	Large only for function templates, because each instantiation generates additional code (ROM).
C linkage (e.g. <code>extern "C"</code>)	None

Short C++ Tutorial

1. [Classes](#)
2. [Member Access Control](#)
3. [Special Member Functions](#)
4. [Virtual Functions](#)
5. [Virtual Base Classes](#)
6. [Templates](#)
7. [Exception Handling](#)
8. [Pure Virtual Functions / Abstract Classes](#)
9. [Overloading](#)
10. [Pointer to Members](#)
11. [Temporary Objects](#)

1. Classes

The C++ class concept is a generalization of the C notion of a structure. Said another way, the C concept of a structure is a simple variant of the C++ class concept. The C structures do not support member functions of any kind.

The difference between using the keywords "class" and "struct" lies only in the default access control of the members. The structure members and base classes are public by default. Class members are private by default.

Example:

```
struct A {
    int i;      // i is a public member of A
    protected:
    void f(); // is a protected member function of A
};

class B {
    int i;      // is a private member of B
    protected:
    void f(); // is a protected member function of B
};
```

A class is derived from another class which is then called a base class of the derived class. The derived class inherits the properties of its base classes, including its data

members and member functions. In addition, the derived class overrides virtual functions of its bases and declare additional data members, functions, and so on. Access to class members is checked for ambiguity.

Sharing about the base classes that make up a class is expressed using virtual base classes.

Classes are declared abstract to ensure they are used only as base classes.

Example:

```
struct A {
    int i;
}; // A contains member i.

struct B : A {
    int j;
}; // B contains members i (inherited from A) and j.

void main(void) {
    A a;
    B b;
    a.i=5;
    b.i=10;
    b.j=15;
}
```

Static Members

A data or function member of a class is declared “static” in the class declaration. There is only one copy of a static data member. This copy is shared by all objects of the class in a program.

Example:

```
class A {
public:
    static int s;
    int i;
};

int A::s; // instantiation of the static member
void f(void) {
    A a;
    a.i=5; // ok
    a.s=10; // ok
    A::i=15; // error
    A::s=20; // ok
}
```

Member Functions

In a non-static member function, the keyword “this” is a pointer to the object for which the function is called.

Example:

```
class A {
    int i;
    void f(int j) {
        this->i=j;
    }
};
```

Implicit Casting of Classes

Class objects are assigned to base class objects. The base class part of the derived class object is copied to the base class object.

Pointers to class objects are assigned to pointers that point to base class objects. The pointer points to the base class part of the derived class.

Example:

```
class A {
    int i;
};

class B : public A {
    int j;
};

void main(void) {
    A a;
    A *ap=&a;
    B b;
    B *bp=&b;
    a=b;        // same as a.j=b.j
    ap=bp;     // same as ap=(A *)bp;
    b=a;       // error
    bp=ap;     // error
}
```

2. Member Access Control

Private

A member of a class is private; its name used only by member functions, member initializers, and friends of the class in which it is declared.

Protected

Its name is used only by member functions, member initializers, and friends of the class in which it is declared; and by member functions and friends of classes derived from this class.

Public

Its name is used by any function or initializer.

The code in [Listing 1.23](#) demonstrates how the access control specifiers affect access to class methods and data members.

Listing 1.23 Example Code—Class Member Access Control

```
class A {
    private:
        int i;
    protected:
        int j;
    public:
        int k;
        void f(void);
};

class B : A {
    void f(void);
};

void A::f(void) {
    this->i=5; // ok, private member accessed by
              // member function of same class
    this->j=5; // ok, protected member accessed by
              // member function of same class
    this->k=5; // ok, public member
}
```

```
void B::f(void) {
    this->i=10; // error, private member accessed by
               // member function of different class
    this->j=10; // ok, protected member accessed by
               // member function of class derived
    this->k=10; // ok, public member
}

void main(void) {
    A a;
    a.i=15; // error, private member accessed outside
    a.j=15; // error, protected member accessed outside
    a.k=15; // ok, public member
}
```

Private Base Class

Access specifiers can also be applied to base classes. If the base class is private and the public and protected members of the base class are private in the derived class, the private members cannot be accessed in the derived class.

Protected Base Class

The public and protected members of the base class are protected in the derived class. The private members cannot be accessed in the derived class.

Public Base Class

The public members of the base class are public in the derived class. The protected members of the base class are protected in the derived class. The private members cannot be accessed in the derived class.

The code in [Listing 1.24](#) illustrates the effect of public, protected, and private class inheritance.

Listing 1.24 Example Code—Public, Private, and Protected Inheritance

```
class A {
    public:
        int i;
};

class B {
    public:
```

```
    int j;
};

class C : public A, private B {
    int k;
};

void main(void) {
    C c;
    c.i=5;    // ok
    c.j=10;   // error
}
```

Friends

A friend of a class is a function that is not a member of the class but permitted to use the private and protected member names from the class. [Listing 1.25](#) shows an example.

Listing 1.25 Example Code—Using friend Functions

```
class A {
    int i;
    friend void f(void); // f() is a friend of A
    friend class X;     // all member functions of X are friends of A
};

class X {
    void f(void) {
        A a;
        a.i=10; // ok
    }
};

void f(void) {
    A a;
    a.i=5; // ok
}
```

3. Special Member Functions

Constructors, destructors and conversions are special member functions.

Constructors

The constructor of a class is called whenever an object of that class is created. The following tasks are performed:

- Assign vptr (pointer to virtual base class)
- Call constructors of base classes and member class objects (in declaration order)
- Assign vptr (pointer to virtual function table)
- Execute function body of constructor

The code in [Listing 1.26](#) shows this process.

Notes:

- Constructors are overloaded (“default constructors” contain no parameters).
- Global class objects call their constructors when all global objects get initialized.

Listing 1.26 Example Code—Constructors

```
struct A {
    A(void) { /* function body */ } // Default constructor
    A(int i) { /* function body */ }
    A(A &a) { /* function body */ } // Copy constructor
};

struct B : A {
    B(void) : A(5) { /* function body */ } // Default constructor
};

void f(void) {
    A a; // calls A::A(void)
    A a2(5); // calls A::A(int i)
    B b; // calls B::B(void), that calls A::A(int i)
}
```

Destructors

The class destructor is called before an object of that class is destroyed.

The following tasks are performed:

- Execute function body of destructor
- Call destructors of base classes and member class objects (in reverse declaration order)

The code in [Listing 1.27](#) shows the order in which an object's destructors are called.

Notes:

- Destructors cannot be overloaded.
- Global class objects call their destructors at the end of the program (after the main routine finished)

Listing 1.27 Example Code—Destructors

```
struct A {
    ~A(void) { /* function body */ }
};
struct B : A {
    ~B(void) { /* function body */ }
};

void f(void) {
    A a;
    B b;
} // a object calls A::~~A(void)
   // b object calls B::~~B(void), that calls A::~~A(void)
```

Conversion by Constructor

A constructor accepting a single argument specifies a conversion from its argument type to the type of its class.

Example:

```
class A {
public:
    A(int);
};
```

```
void main(void) {  
    A a = 1;    // a = A(1)  
}
```

Conversion Functions

Conversion operators specify conversions from the owner class type to the type specified.

Example:

```
class A {  
    operator char*(); // defines a conversion from A to char*  
};
```

Compiler Generated Functions

- Default constructor

The default constructor is generated if no constructor is declared by the programmer. It is also generated if there is a base or member class having a constructor or, there are virtual base classes or virtual member functions.

- Copy constructor

The copy constructor is generated if no copy constructor is declared by the programmer.

- Destructor

The default destructor is generated if no destructor is declared by the programmer, and if there is a base or member class having a destructor.

- Assignment operator

The assignment operator is generated if no assignment operator is declared by the programmer.

Sometimes special member functions are generated by the compiler in several compilation units (e.g if there is a class declaration in a header file included in several compilation units). A normal linker treats them as different static linkage functions. This is not efficient as the code of the same function exists more than once in the executable. The Smart Linker merges the same compiler generated function from several compilation units into one function.

4. Virtual Functions

A virtual function is a member function that is redefined in derived classes. You can call a virtual function for that object and execute the derived class's version of the function when you refer to a derived class object using a pointer or a reference to the base class. See [Listing 1.28](#).

Listing 1.28 Example Code—Calling Different Versions of a Virtual Function

```
class A{
    public:
        virtual void f(void);
};

class B : public A{
    public:
        void f(void);
};

A a;
B b;
A pta;

void main(void) {
    pta = &a;
    pta->f(); // calls A::f
    pta = &b;
    pta->f(); // calls B::f
}
```

The **virtual** keyword is needed only in the base class's declaration of the function; any subsequent declarations in derived classes are virtual by default.

A derived class's version of a virtual function must have the same parameter list and return type as those of the base class. If these are different, the function is not considered a redefinition of the virtual function.

“Virtual functions” are functions that ensure the correct function is called for an object, regardless of the expression used to make the function call.

Suppose a base class contains a function declared virtual and a derived class defines the same function. The function from the derived class is invoked for objects of the derived class, even if it is called using a pointer or reference to the base class.

Functions in derived classes override virtual functions in base classes only if their type is the same. A function in a derived class cannot differ from a virtual function in a base class in its return type only; the argument list must differ as well.

When calling a function using pointers or references, the following rules apply:

- A call to a virtual function is resolved according to the underlying type of object for which it is called.
- A call to a non-virtual function is resolved according to the type of the pointer or reference.

Because virtual functions are called only for objects of class types, you cannot declare global or static functions as **virtual**.

The **virtual** keyword is used when declaring overriding functions in a derived class, but it is unnecessary; overrides of virtual functions are always virtual.

Virtual functions in a base class must be defined unless they are declared using the *pure-specifier*.

The virtual function call mechanism is suppressed by explicitly qualifying the function name using the scope-resolution operator ‘::’. See [Listing 1.29](#).

Listing 1.29 Example Code—Suppressing the Virtual Function Call Mechanism

```
class A{
public:
    A(void);           //constructor
    virtual void f(void); //virtual function member
    virtual void g(void); //virtual function member
};
void A::A(void){...} /*implementation of constructor for A.*/
void A::f(void){...} //implementation of f for A.
void A::g(void){...} //implementation of g for A.
class B : public A{
private:
    void g(void);
};
void B::g(void){...} //implementation of g for B.

void main(void) {
    B *ptb = new B();
    ptb->A::g(); /*explicit qualification call A::g.*/
    A *pta = ptb;
    pta->A::g(); /*explicit qualification call A::g.*/
}
```

Both calls to `g()` in the preceding example suppress the virtual function-call mechanism.

Access to Virtual Functions

The access control applied to virtual functions is determined by the type used to make the function call. Overriding declarations of the function does not affect the access control for a given type. See [Listing 1.30](#).

Listing 1.30 Example Code—Access Control and Virtual Functions

```
class A{
    public:
        virtual void f(void);
};

class B : public A{
    private:
        void f(void);
};

void main(void) {
    B b;
    A *pta = &b;
    B *ptb = &b;
    pta->f(); // f is public.
    ptb->f(); // f is private, ERROR
}
```

NOTE The virtual function `f` is called using a pointer to the base class `A`. This does not mean that the function called is the base-class version of that function.

Function Specifiers

Virtual Specifier

The **virtual** keyword is applied only to non-static class member functions. It signifies that binding of calls to the function is deferred until run time.

- Advantage

Derived classes and virtual functions are the key to the design of many C++ programs.

The use of derived classes and virtual functions is often called object-oriented programming. Furthermore, the ability to call a variety of functions using exactly the same interface, as is provided by virtual functions, is sometimes called polymorphism.

- Disadvantage

Such characteristics require more memory (many additional objects), more compilation time (many additional objects to manage) and generate more code (many additional objects to handle).

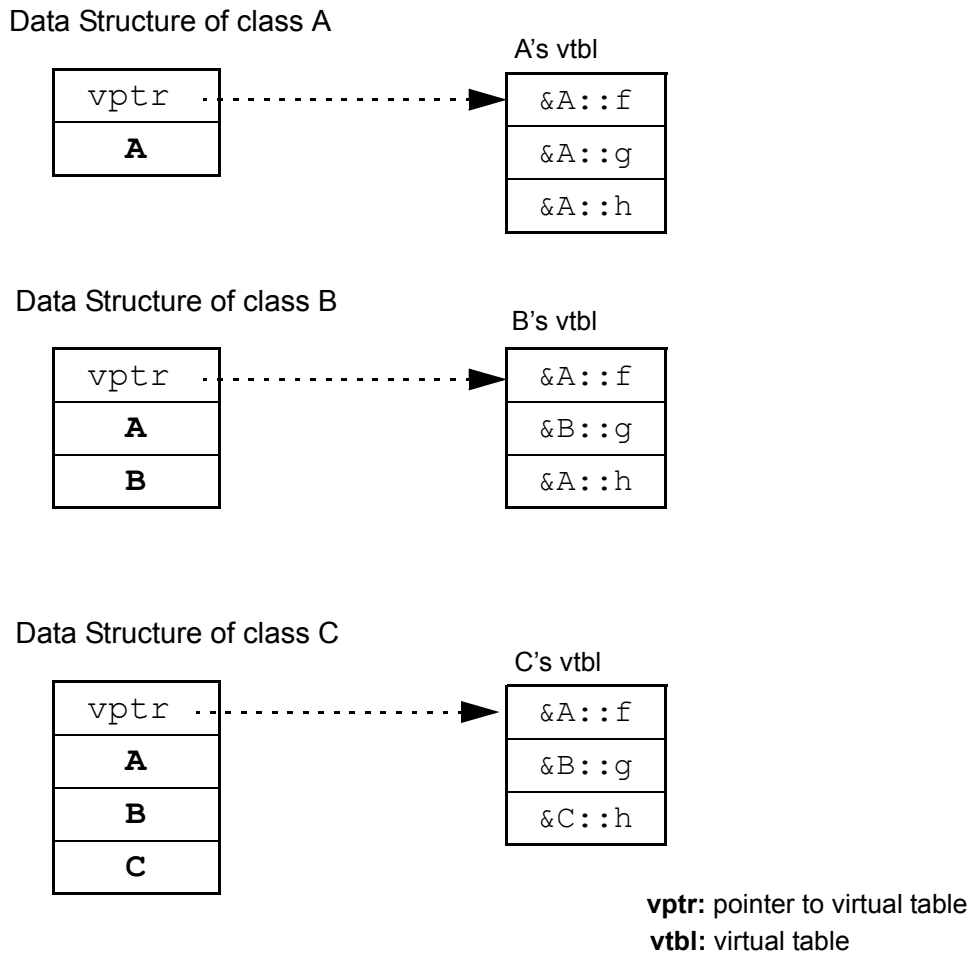
- Implementation

The implementation of the virtual-functions mechanism is based on the following concept. Virtual functions are implemented with a table of pointers to virtual functions, the `vtbl`. A pointer object is introduced in the class scope, the `vptr`. It points to the `vtbl`.

Single Inheritance and Virtual Functions

[Figure 1.2](#) shows the virtual tables and other data structures produced by the code shown in [Listing 1.31](#).

Figure 1.1 Single Inheritance—vtbl Layout Produced by Example Code



Listing 1.31 Example Code—Single Inheritance and Virtual Functions

```
class A{
public:
    virtual void f(int);
    virtual void g(int);
    virtual void h(int);
};

class B : public A{
public:
    void g(int);
};
```

```
class C : public B{
public:
    void h(int);
};
```

A call to a virtual function is transformed by the Compiler into an indirect call. For example:

```
C *pc = new C;
pc->g(2);
```

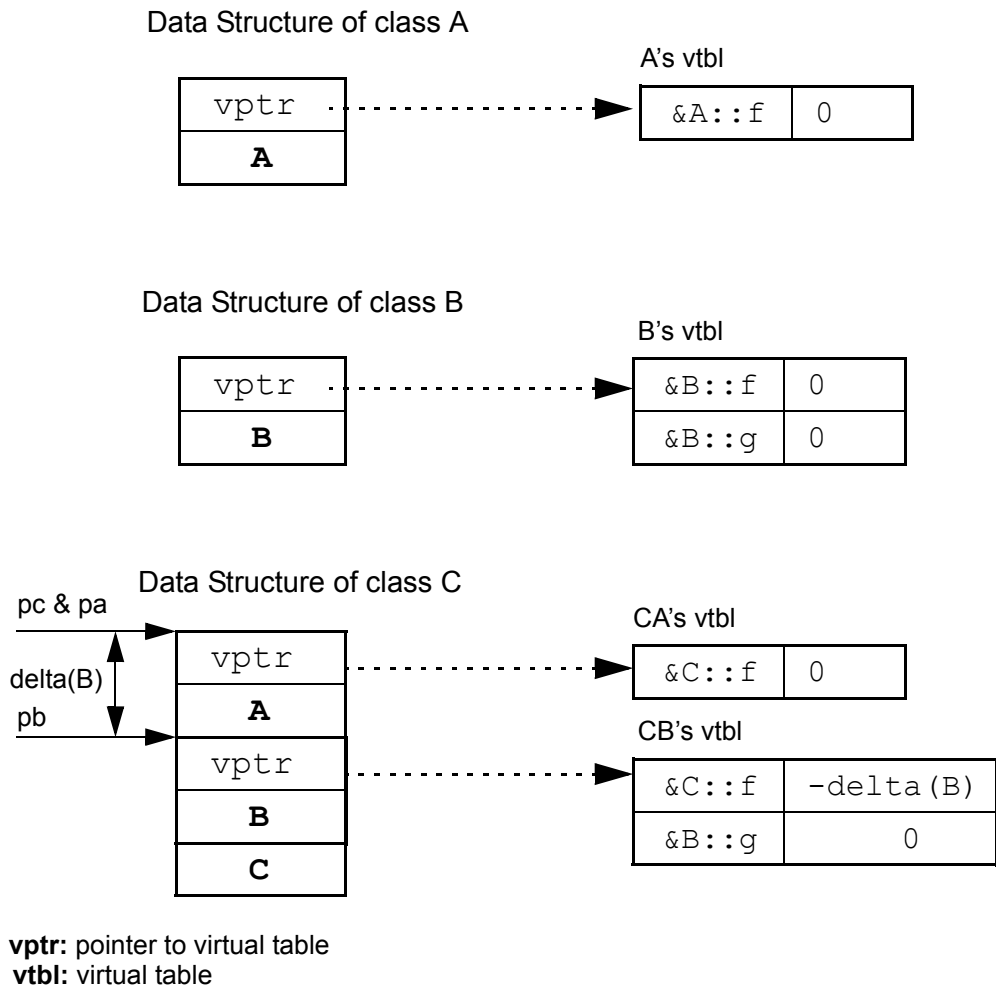
becomes something like:

```
(* (pc->vptr[1]))(pc,2);
```

Multiple Inheritance and Virtual Functions

[Figure 1.2](#) shows the virtual tables and other data structures produced by the code shown in [Listing 1.32](#).

Figure 1.2 Multiple Inheritance—vtbl Layout Produced by Example Code



Listing 1.32 Example Code—Multiple Inheritance and Virtual Functions

```
class A{
public:
    virtual void f(int);
};

class B{
public:
    virtual void f(int);
    virtual void g(int);
};
```

```
class C : public A, public B{
public:
    void f(int);
};

C *pc = new C;
A *pa = pc;
B *pb = pc;
```

Because class C derived from class A and from class B, the following calls will all invoke C::f():

```
pa->f();
pb->f();
pc->f();
```

On entry to C::f(), the this pointer must point to the beginning of the C object, and not to the B part. It cannot always be known at compile time, however, that the B pointed by pb is part of the C, so the offset of a B object within a C object, delta(B), is not a constant at compile time. Consequently delta(B) must be stored where it is found at run time. Because the offset is used only for calling a virtual function, the logical place to store it is in the virtual function table.

The call

```
pb->f();
```

in the example above invokes C::f(), having been transformed by the Compiler to something like this:

```
register vtbl_entry *vt =
&pb->vtbl[index(f)];
(*vt->fct)((B *)((char *)pb+vt->delta));
```

Virtual Tables Naming Convention

In some C++ implementation, the code for a virtual function table is duplicated in the object file produced for each C++ source file that declares or includes declarations of the class containing the virtual functions.

Now suppose that these declarations are included in multiple C++ source files. Each time a Compiler processes these declarations, even if it knows the declarations came from a header file, it will not know whether the virtual function tables have already been generated in a separate compilation. Therefore, it must generate the tables. Because most Linkers will report an error if an identifier is defined more than once, virtual function tables must have unique names. Unique names are created by including the name of the source file in the name of the table. With the declarations

above, when included in the files `windows.c` and `interface.c`, might yield tables named as follows:

```
___vtbl__A__windows_c
___vtbl__B__windows_c
___vtbl__CA__windows_c
___vtbl__CB__windows_c
___vtbl__A__interface_c
___vtbl__B__interface_c
___vtbl__CA__interface_c
___vtbl__CB__interface_c
```

The Linker supports merging virtual tables with the same name in different files. So the filename does not have to be encoded into the virtual table name. This results in having only one virtual table in memory for each class, even if the class is used in different compilation units.

5. Virtual Base Classes

Multiple Base Classes

A class is derived from any number of base classes. The use of more than one direct base class is called multiple inheritance.

The order of derivation is not significant except as specified by the semantics of initialization by constructor, cleanup, and storage layout.

A class shall not be specified as a direct base class of a derived class more than once. But you can assign it as an indirect base class more than once. See [Listing 1.33](#).

Listing 1.33 Example Code—Multiple Inheritance

```
class A{
public:
    // member list
};
class B : public A, public A{ //Ill-formed
public:
    // member list
};
```

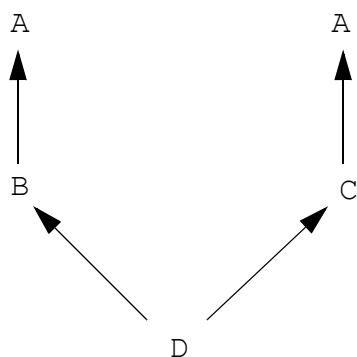


```
class A{
public:
    int next;
    // member list
};
class B : public A {
public:
    // member list
};
class C : public A {
public:
    // member list
};
class D : public B, public C { //Well-formed
public:
    void f(){}
    // member list
};
```

A base class specifier that does not contain the keyword **virtual**, specifies a *non-virtual* base class. A base class specifier that contains the keyword **virtual**, specifies a *virtual* base class. For each distinct occurrence of a *non-virtual* base class in the class lattice of the most derived class, the complete object shall contain a corresponding distinct base class sub-object of that type. For each distinct base class that is specified virtual, the complete object shall contain a single base class sub-object of that type.

Example:

For an object of class type C, each distinct occurrence of a (non-virtual) base class A in the class lattice of C corresponds one to one with a distinct A sub-object within the object of the type C. Given the class D defined above, an object of class D will have two sub-objects of class A as shown below.



In such lattices, explicit qualification is used to specify which sub-object is meant. The body of the function

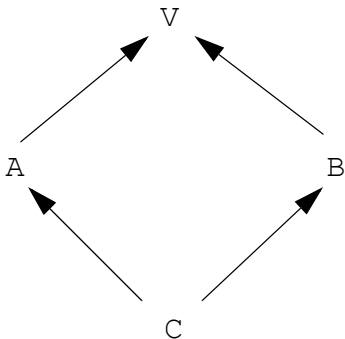
```
C::f() { A::next = B::next; } // Well-formed
```

Without the A:: or B:: qualifiers, the definition of C::f above would be ill-formed because of ambiguity.

For another example:

```
class V{  
public:  
    // member list  
};  
  
class A : public virtual V {  
public:  
    // member list  
};  
  
class B : public virtual V {  
public:  
    // member list  
};  
  
class C : public A, public B {  
public:  
    // member list  
};
```

For an object *c* of class type C, a single sub-object of type V is shared by every base sub-object of *c* that is declared to have a *virtual* base class of type V. Given the class C defined above, an object of class C will have one sub-object of class V, as shown below.



For another example:

A class can have both virtual and non-virtual base classes of a given type.

```
class A{
public:
    // member list
};

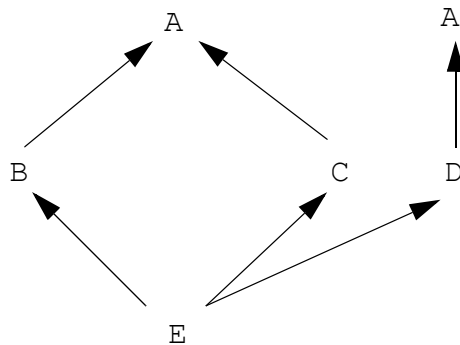
class B : public virtual A {
public:
    // member list
};

class C : public virtual A {
public:
    // member list
};

class D : public A {
public:
    // member list
};

class E : public B, public C, public D {
public:
    // member list
};
```

For an object of class type E, all *virtual* occurrences of base class A in the lattice of E correspond to a single A sub-object within the object of type E, and every other occurrence of a (non-virtual) base class A in the lattice of E correspond one to one with a distinct A sub-object within the object of type E. Given the class E defined above, class E has two sub-objects of class A: D's A and the virtual A shared by B and C, as shown below.



Implementation

Suppose we have the following inheritance hierarchy.

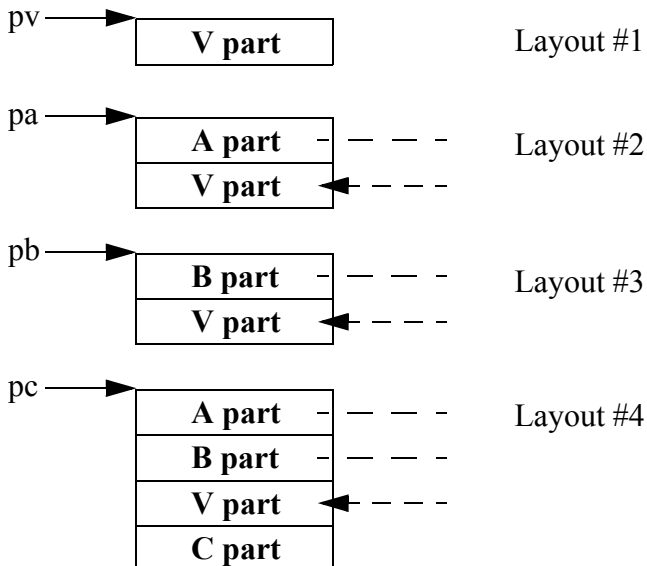
```
class V{
public:
    // member list
};

class A : public virtual V {
public:
    // member list
};

class B : public virtual V {
public:
    // member list
};

class C : public A, public B {
public:
    // member list
};
```

Each A object or B object will contain an V, but only one object of class V will exist in a C object. Clearly the object representing the virtual base class V cannot be in the same position relative to both A and B in all objects. Therefore a pointer to V must be stored in all objects of classes that have V as a virtual base. An implementation of A, B and C objects will look something like the figure below.



The virtualness of V in A, B and C is a property of the derivation, and not a property of the V itself.

To obtain such a memory layout (see above #4), the Compiler has to know that constructors of A and B classes have not to call V class constructor, whereas they have to call V class constructor to obtain layouts #2 and #3. To give the Compiler this information, an hidden global variable called “StandAlone” is used, it is defined as one byte type in memory. StandAlone is set to 1 if A or B classes are not base classes, then constructor of virtual base class V will be called. StandAlone is set to 0 if A or B classes are base classes (here of class C), then constructor of virtual base class V won't be called. The Compiler is implemented this way:

```
oneByteType StandAlone
set StandAlone to 1
...
if current class contains base class(es) and not a VBPTR
  for each base class
    if current base class contains a VBPTR
      set StandAlone to 0
...
for each constructor
  if constructor of class containing a VBPTR
    for each base class
      if virtual base class and StandAlone is set to 1
        call constructor
      else if not virtual base class
        call constructor
  else
    call constructor
```

Except that it results in a unique object in its derived classes, a virtual base class behaves the same way a non-virtual base class does. Every virtual base of a given class type in an inheritance structure. Given the declarations in [Listing 1.34](#) ...

Listing 1.34 Example Code—Virtual Base Classes

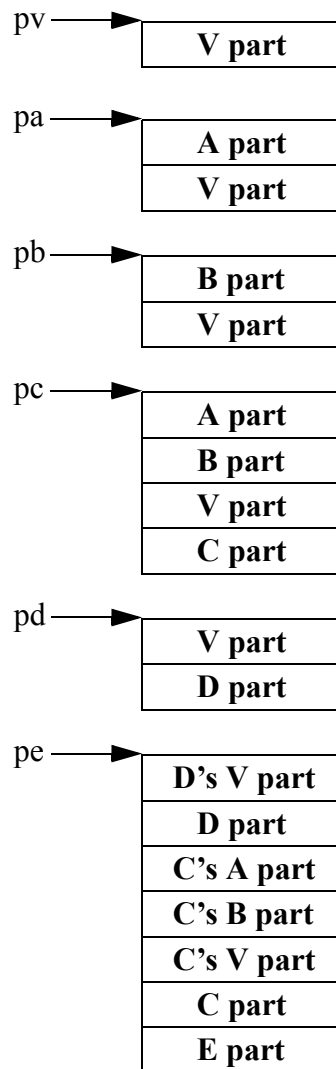
```
class V{
public:
  // member list
};

class A : public virtual V {
public:
  // member list
};
```

```
class B : public virtual V {
public:
    // member list
};
class C : public A, public B {
public:
    // member list
};
class D : public V {
public:
    // member list
};
class E : public D, public C {
public:
    // member list
};
```

an E object will contain two V objects, one virtual and one non-virtual. An implementation of an E object will look something the illustration in [Figure 1.3](#).

Figure 1.3 Layout of an Object of Class E



Virtual Base Classes and Casting

One can cast from a derived class to a virtual base class. The generated code will use the pointer to the virtual base class stored in the derived class.

Casting from a virtual base class to a derived class is disallowed to avoid requiring an implementation to maintain pointers to enclosing objects.

Multiple Access

In multiple-inheritance lattices involving virtual base classes, a given name is reached through more than one path. Because different access control is applied along these different paths, the Compiler chooses the path that gives the most access.

```
class V{
public:
    // member list
};

class A : private virtual V {
public:
    // member list
};

class B : public virtual V {
public:
    // member list
};

class C : public A, public B {
public:
    // member list
};
```

In the figure above, a name declared in class V is always reached through class B. The right path is more accessible because B declares V as a public base class, whereas A declares V as private.

6. Templates

A template defines a family of types or functions.

Class Templates

A class template specifies how individual classes are constructed.

Example: Several lists with elements of different types should be constructed.

```
template <class T> class List {
    T    data;
    List *next;
};

List<int> li;    // generate list class
                // where T stands for int
List<char *> lcp; // generate list class
                // where T stands for pointer to char
```

Function Templates

A function template defines an unbounded set of related functions. You must use every template argument in the argument types of a function template.

Example: Several sorting functions for different types are constructed.

```
template <class T> void sort(T elem) {
    /* ... */
}

void main() {
    Type1 t1;
    Type2 t2;

    sort(t1); // generate sort function
              // where T stands for Type1
    sort(t2); // generate sort function
              // where T stands for Type2
}
```

Member Function Templates

A member function of a template class is implicitly a template function with the template arguments of its class as its template arguments.

Example:

```
template <class T> class A {
    T f(void);
};

template <class T> T A<T>::f(void) {
    /* ... */
}
```

Template Arguments

There are two kinds of template arguments: type specification and expression specification. See [Listing 1.35](#).

Listing 1.35 Templates—Type Specification and Expression Specification

```
template <class T> /* type specification */
class A {
    T member;
};
```

```
A<int> ai;    // generate A with a member of type int
A<int *> ai; // generate A with a member of type pointer to int

template <int i> /* expression specification */
class B {
    int array[i];
};

B<5> b5;      // generate B with an array of 5 elements
B<4*20> b80;  // generate B with an array of 80 elements
```

Static Members and Variables

Each template class or function generated from a template has its own copies of any static variables or members. See [Listing 1.36](#).

Listing 1.36 Templates—Static Members and Variables

```
template <class T> class X {
    static T s;
};

X<int> aa;    // generate X with static member of type int
X<char *> bb; // generate X with static member of type char*

template <class T> f(T p) {
    static T s;
    /* ... */
}

void g(int a, char *b) {
    f(a); // generate f() with local static of type int
    f(b); // generate f() with local static of type char*
}
```

Declarations and Definitions

There must be exactly one definition (provided by the programmer) for each template of a given name in a compilation unit (for classes and static linkage functions), or in a program (for external linkage functions). T

here are many declarations. The definition generates specific template classes and template functions to match the uses of the template. Using a template class name constitutes a declaration of template class.

Template classes must be defined before being used. Template functions do not have to be defined before using. If a specific function could not be generated from a template function definition, the linker will tell, which definition is needed. See [Listing 1.37](#).

Listing 1.37 Example Code—Link source1.cpp with source2.cpp

```
/* source1.cpp */
template <class A> void f(A i); // declaration, not definition

void main() {
    f(3); // Compiler does not generate f(), but no error !
}

/* source2.cpp */
template <class A> void f(A i) { // definition
    /* ... */
}

static void dummy() {
    /* dummy function for generating function from the template */
    f(3); // without this, the linker would complain !
}
```

7. Exception Handling

Exception handling is not implemented yet.

8. Pure Virtual Functions / Abstract Classes

Pure Virtual Functions

A virtual function is specified pure by using a pure-specifier (“=0”) in the function declaration and in the class declaration.

```
class A{
public:
    virtual void f(void) = 0; // pure virtual function.
};
```

A definition for a pure virtual function is not needed unless explicitly called with the qualified-id syntax (nested-name-specifier templateopt unqualified-id).

```
class A{
public:
    virtual void f(void) = 0;
};

class B : public A{
public:
    void f(void){ int local=0; }
};

void main(void){
    B b;
    b.A::f();//causes link error because no object is defined.
    b.f();    //call the function defined in B class.
}
```

Pure virtual functions make up the class containing an abstract class. Abstract class mechanisms support the notion of a general concept, of which only more concrete variants can actually be used. An abstract class also defines an interface for which derived classes provide a variety of implementations.

Pure virtual functions are the base of the abstract class concept.

Abstract Classes

The abstract class mechanism defines a general concept, such as a shape, through which more concrete variants, such as circle and square, are defined. An abstract class can also define an interface for which derived classes provide a variety of implementations.

An abstract class is a class that is used only as a base class of some other class. No objects of an abstract class may be created except as objects representing a base class of a class derived from it. A class is abstract if it has at least one pure virtual function.

A virtual function is specified pure by using a pure-specifier (= 0) in the function declaration and in the class declaration. You must define a pure virtual function explicitly, calling it with the qualified-name syntax (ClassName::Member).

Example:

```
class A{
public:
    virtual void f(void) = 0;
```

```
    //...
};

class B : public A{
public:
    void f(void){}
};
```

An abstract class may not be used as an argument type, as a function return type, or as the type of an explicit conversion. Pointers and references to an abstract class may be declared.

Example:

```
A a;           // ERROR
A fct(void);   // ERROR
void fct(A);   // ERROR
B b;
A *pa = &(A)b; // ERROR
A *pa;         // OK
A *fct(void);  // OK
void fct(A *); // OK
A *pa = (A *)b; // OK
```

Pure virtual functions are inherited as pure virtual functions.

Example:

```
class A{
public:
    virtual void f(void) = 0;
    virtual void g(void) = 0;
    //...
};

class B : public A{
public:
    void f(void){}
    // void B::g(void) is a pure virtual function
};
```

Since A::g() is a pure virtual function B::g() is a pure virtual by default. The alternative declaration is:

```
class B : public A{
public:
    void f(void){}
    void g(void); // must be define somewhere
};
```

This would make class B non-abstract. A definition of B::g() must be provided somewhere in your code.

Member functions are called from a constructor of an abstract class. An error is generated if a pure virtual function is called directly or indirectly for the object being created from such a constructor.

```
class A {
public:
    virtual void f(void) = 0;
    A(){
        f(); // ERROR
    }
};
```

You can define that as a pure virtual. The virtual is called using explicit qualification only, as follows:

```
class A {
public:
    virtual void f(void) = 0;
    A(){
        f(); // ERROR
    }
};

void A::f(void){
    //...
};
```

Abstract classes with virtual base classes.

See [Listing 1.38](#), [Listing 1.39](#), [Listing 1.40](#), and [Listing 1.41](#).

Listing 1.38 Example 1: Abstract Classes with Virtual Base Classes

```
class A {
public:
    virtual void f(void) = 0;
    virtual void g(void) = 0;
    virtual void h(void) = 0;
    //...
};

class B : virtual public A{
public:
    void g(void){}
```

```
};

class C : virtual public A{
    public:
        void g(void){}
};

class D : public A, public B{
    public:
        void h(void){}
};
```

A class is abstract: contains 3 pure virtual functions (f, g, h)

B class is abstract: contains 2 pure virtual functions (f, h)

C class is abstract: contains 2 pure virtual functions (f, h)

D class is abstract: contains 1 pure virtual function (f)

Listing 1.39 Example 2: Abstract Classes with Virtual Base Classes

```
class A{
    public:
        virtual void f(void) = 0;
        virtual void g(void) = 0;
        virtual void h(void) = 0;
        //...
};

class B : virtual public A{
    public:
        void f(void){}
};

class C : virtual public A{
    public:
        void g(void){}
};

class D : public A, public B{
    public:
        void h(void){}
};
```

A class is abstract: contains 3 pure virtual functions (f, g, h)

B class is abstract: contains 2 pure virtual functions (g, h)

C class is abstract: contains 2 pure virtual functions (f, h)

D class is not abstract

Listing 1.40 Example 3: Abstract Classes with Virtual Base Classes

```
class A{
    public:
        virtual void f(void) = 0;
        virtual void g(void) = 0;
        virtual void h(void) = 0;
    //...
};

class B : public A{
    public:
        void g(void){}
};

class C : public A{
    public:
        void g(void){}
};

class D : public A, public B{
    public:
        void h(void){}
};
```

A class is abstract: contains 3 pure virtual functions (f, g, h)

B class is abstract: contains 2 pure virtual functions (f, h)

C class is abstract: contains 2 pure virtual functions (f, h)

D class is abstract: contains 2 pure virtual functions (B::f, C::f)

Listing 1.41 Example 4: Abstract Classes with Virtual Base Classes

```
class A{
    public:
        virtual void f(void) = 0;
        virtual void g(void) = 0;
```

```
    virtual void h(void) = 0;
    //...
};

class B : public A{
public:
    void f(void){}
};

class C : public A{
public:
    void g(void){}
};

class D : public A, public B{
public:
    void h(void){}
};
```

A class is abstract: contains 3 pure virtual functions (f, g, h)

B class is abstract: contains 2 pure virtual functions (g, h)

C class is abstract: contains 2 pure virtual functions (f, h)

D class is abstract: contains 2 pure virtual functions (B::g, C::f)

9. Overloading

Function Overloading

Overloading allows multiple functions with the same name to be defined provided their argument lists differ sufficiently for calls to be resolved.

Example:

```
void f(int i);
void f(void);
void g(void) {
    f(5);    // call f(int i)
    f();    // call f(void)
}
```

Operator Overloading

By overloading operators, you can redefine the meaning of most C++ operators when at least one operand is a class object.

Example:

```
class X {
    X operator + (int);
};

void g(X x) {
    X a;
    a=x+10; // call X::operator + (int)
}
```

Default Arguments

If an expression is specified in an argument declaration this expression is used as a default argument. All subsequent arguments must have default arguments supplied in this or previous declarations of this function.

Default arguments are used in calls where trailing arguments are missing. A default argument cannot be redefined by a later declaration (not even to the same value).

Example:

The declaration

```
point(int = 3, int = 4);
```

declares a function, that is called in any of these ways:

```
point(1,2);
point(1); // equivalent to point(1,4);
point(); // equivalent to point(3,4);
```

Operator new and delete

The "new" operator attempts to create an object of the type specified.

If the type is a class having a constructor, the object is created only if suitable arguments are provided, or if the class has a default constructor. First, the "new" operator is called. Then the constructor is called if necessary. If the type is a class array, the default constructor of each element is called. The compiler generates a loop going through all array elements.

[Listing 1.42](#) shows code that uses the global new operator.

Listing 1.42 Using the Global new Operator

```
class A {
    /* ... */
    A();
    A(int, int);
};

void f() {
    char *cp = new char; // create a "char" object
    int *ip = new int[3]; // create an "array of int" object
    A *ap = new A(4,3); // create a "A" object with Constructor
                        // call to A::A(int,int)
    A *aap = new A[3]; // create an "array of A" object with
                      // default Constructor call for each element
}
```

The "new" operator is defined globally or within a class. The global declaration is done internal to the compiler. The member operator "new" is a static member.

[Listing 1.43](#) shows code that defines two versions of new operator within a class and then uses each definition of this operator.

Listing 1.43 Implementing the new Operator Within a Class

```
void *operator new(size_t size) {
}

class A {
    void *operator new(size_t size) {
    }
    void *operator new(size_t size, int flag) {
    }
};

void f(void) {
    A *a = new(10) A; // calls A::operator new(size_t, int)
                    // with parameter "flag"=10
    A *a2 = new A; // calls A::operator new(size_t)
}


```

The "delete" operator destroys an object created by the new operator.

If the type of the object is a class having a destructor, the destructor has to be called before the call of the "delete" operator. If the type is a class array having a destructor,

the destructor of each element must be called. Therefore the compiler generates a loop going through all array elements. The "delete" operator is defined globally or within a class.

[Listing 1.44](#) shows code that uses the global delete operator.

Listing 1.44 Using the Global delete Operator

```
class A {
    /* ... */
    ~A();
};

void f(char *cp, int *ip, A *ap, A *aap) {
    delete cp;          // ok
    delete[] cp;       // ok
    delete[3] cp;      // ok, ignoring number of elements

    delete ip;         // ok
    delete[] ip;       // ok
    delete[3] ip;      // ok, ignoring number of elements

    delete ap;         // ok, calls once the destructor
    delete[] ap;       // error, don't know, how many destructor calls
    delete[3] ap;      // ok, calls 3 times the destructor
}
```

The "delete" operator is defined globally or within a class. The global declaration is already done internally in the compiler. The member operator "delete" is a static member.

[Listing 1.45](#) shows code that defines a delete operator within a class and then uses this definition.

Listing 1.45 Implementing the delete Operator Inside a Class

```
void operator delete(void *p) {
}

class A {
public:
    void operator delete(void *p) {
    }
};
```

```
class B {
public:
    void operator delete(void *p, size_t size) {
    }
};

void f() {
    B *b;
    delete b; // calls B::operator delete(void *, size_t)
              // with "size"=sizeof(B)
}
```

The global "new" and "delete" operators are implemented in the C++ library. A program calling new and delete needs to be linked with the appropriate library. Otherwise, those operators must be implemented by the programmer.

It does not matter to the Compiler if you do not provide any implementation of "new" and "delete" to your program as the global operators are internally declare (internal to the compiler). But the linker may not operate correctly if it does not find any implementation of "new" and "delete".

10. Pointer to Members

The C++ language provides no way of expressing the concept of a pointer to a member of a class. When a pointer to a member function is needed in an error handling function (for example), you had to subvert the language's type checking.

The type of a nonmember function:

```
int fct(char *),
```

An example is:

```
int (char *),
```

A pointer to such a function is of type:

```
int (*) (char *).
```

Pointers to nonmember functions are declared and used as:

```
void fct(char *); //declare function
fct("Hello"); //call

void (*pfct)(char *); //declare pointer to function
(*pfct) ("Goodbye"); //call through pointer
```

Consider a trivial class for which the member functions, `fctMbr` and object `mbr`, are and an object (`obj`) of that class are declared as follows:

```
class A{
    int fctMbr(char *);
    int mbr;
};

int A::fctMbr(char *){
    /*...*/
}

A obj;
```

One can take the address of the member `mbr` in the object `obj`, as follows:

```
int *pMbr = &obj.mbr; // pMbr points to A's member mbr
```

The notation for the pointer to member of class `A` is `A::*`. The notation for taking the address of a member of a class `A` is `&A::`. You can take the address of a member `mbr` in class `A` as follows:

```
int A::* spMbr = &A::mbr; // spMbr gets offset
                        // of 'mbr' in an A
```

Note that `&obj.mbr` yields the address of `mbr` in the specific object `obj`. Whereas `&A::mbr` yields a representation of `mbr`'s relative position in all objects of class `A`.

It is not legal to take the address of a member that does not have a name. For example:

```
class X {
public:
    int a[2];
};

int X::*ai = &X::a[1]; // error: can't take address
                    // of unnamed member.
```

In a definition, the member function `fctMbr` of class `A` declared above appears as:

```
int A::fctMbr(char *){
    /*...*/
}
```

The type of `A::fctMbr` is now expressed as `int A::(char *)`. That is, “member of A that is a function taking a `char *` argument and returning an `int`”. A pointer to such a function is of type `int (A::*)(char *)`. You can write this as:

```
// declare and initialize pointer to member function
int (A::*pmf)(char *) = &A::f;

// create an instance of A
A obj;

// call function through pointer for the object obj
int j = (obj.*pmf)("hello");
```

The above syntax is consistent with the C declarator syntax.

A pointer to member function is called through a pointer to an object as follows:

```
A *pObj;

// call function through pointer for the object *pObj
int k = (pObj->*pmf)("Goodbye!");
```

A virtual function is called through a pointer to an object. See [Listing 1.46](#).

Listing 1.46 Calling a Virtual Function Through a Pointer to an Object

```
class B{
    virtual vf();
};

class C : B{
    vf();
};

int f2(B *pb, int (B::*pbf)()){
    //call virtual function pointed to
    //by pbf for object that pb points to
    return (pb->*pbf)();
}

void f1(){
    C c;
    //call f2 and pass pointer to derived object
    //and pointer to virtual function in base class
    int i = f2(&c, &B::vf);
}
```

In f2, as called by f1 shown here, C::vf() is invoked. The implementation looks in the C table of virtual functions exactly as it would search for a call to a virtual function identified by name rather than by pointer.

Pointers to Static Members

Pointers to static members are ordinary pointers. The pointer to member syntax is not used with the static members. The address of a static member is taken with the pointer syntax for non-member objects. Similarly, a pointer that points to a static member is dereferenced as an ordinary pointer.

11. Temporary objects

In some circumstances, it may be necessary or convenient for the compiler to generate a temporary object. Such introduction of temporaries is implementation-dependent. When a compiler introduces a temporary object of a class that has a constructor, it must ensure that a constructor is called for the temporary object. Similarly, the destructor must be called for a temporary object of a class where a destructor is declared.

- Assigning constants to references:

```
void f(void) {
    int const & ri = 42;
    // ri points to a temporary holding the value 42
}
```

- Explicit constructor calls:

```
class A {
public:
    A();
    ~A();
};

void f(void) {
    A(); // a temporary is created.
        // Its address is passed to A::A()
} // dtor of the temporary is called here at the latest
```

- Functions returning a class type:

```
class A {
    A();
    ~A();
};
```

```
A f(void);

void g(void) {
    A a;
    a=f(); // return value of f() is copied to a temporary
           // with the copy constructor,
           // then the temporary is assigned to "a"
} // at the latest here the destructors of "a"
   // and of the created temporary are called

void h(void) {
    A &a=f(); // return value of f() copied to a temporary
             // with the copy constructor,
             // then the address of the temporary is assigned to the
             // reference
} // at the latest here the destructor
   // of the created temporary is called
```

C++ Name Encoding, Type-safe Linkage

One of the advantages of using C++ is having safer type linkage than in ANSI-C. In ANSI-C, linkage is done by name. The Linker has no chance to detect a type mismatch (see also [“Implicit Parameter Declarations”](#)).

In C++ the parameter types (NOT the return type) of each function are encoded into the function name. The C++ Compiler does not encode function names if the name of the function is ‘main’, or if the function is defined or declared with a C linkage (extern “C”):

```
int foo2(void) {
    /* name in object file is 'foo2__F'
}

extern "C" int foo(int a, double d) {
    /* name in object file is 'foo'
}

void main(void) {
    /* name in object file is 'main' */
}
```

The C++ object files have different object name encoding than the ANSI-C object files. If you link C++ object files with ANSI-C object files, the imported functions

must contain the linkage of the language from where they are exported. See the following example:

```
/* a.c (ANSI-C) */
void f(void) {
    /* ... */
}

/* b.cpp (C++) */
extern "C" void f(void);
/* f() has "C" linkage, because exported from a ANSI-C
source */

void main(void) {
    f();
}
```

Type	Encoding
void	v
char	c
wide char	w
short	s
int	i
long	l
long long int	x
float	f
double	d
long double	r
long long double	r
generic 1 byte type	b1
generic 2 byte type	b2
generic 3 byte type	b3
generic 4 byte type	b4
generic 5 byte type	b5
generic 6 byte type	b6
generic 7 byte type	b7

Type	Encoding
generic 8 byte type	b8
...	e

Modifier	Encoding
unsigned	U
const	C
volatile	V
signed (only for characters!)	S

Types	Notation	Encoding
simple	Complex	7Complex
qualified	X::YY	Q21X2YY
pointer	*	P
far pointer	*far	PKF
near pointer	*near	PKN
rom pointer	*rom	PKR
uni pointer	*uni	PKU
paged pointer	*paged	PKP
reference	&	R
array	[10]	A10_
function	()	F
global operator	op ()	FG
pointer to member	S::*	M1S

Structs, classes and enumerations are encoded using the ‘simple’ notation:

```
void foo(struct MyStruct, class MyClass, enum MyEnum);
```

is encoded as:

```
foo__F8MyStruct7MyClass6MyEnum
```

Operator	Encoding
*	__ml
/	__dv
%	__md
+	__pl
-	__mi
>>	__rs
<<	__ls
==	__eq
!=	__ne
<	__lt
>	__gt
<=	__le
>=	__ge
&	__ad
	__or
^	__er
&&	__aa
	__oo
!	__nt
~	__co
++	__pp
--	__mm
=	__as
->	__rf
+=	__apl
-=	__ami
*=	__aml
/=	__adv

Operator	Encoding
%=	__amd
<<=	__als
>>=	__ars
&=	__aad
=	__aor
^=	__aer
,	__cm
->*	__rm
'?'? (not supported yet)	__mn
!'? (not supported yet)	__mx
?: (not supported yet)	__cn
() (function call)	__cl
[] (subscripting)	__vc
constructor	__ct
destructor	__dt
operator new()	__nw
operator delete()	__dl
operator T()	__op<signature of T>

Generating Compact Code

The Compiler tries whenever possible to generate compact and efficient code. But not everything is handled directly by the Compiler. With a little help from the programmer, it is possible to reach denser code. Some Compiler options, or using SHORT segments (if available), help you to generate compact code.

Compiler Options

Using the following compiler options helps you to reduce the size of the code generated. Note that not all options may be available for your target.

-Or: Register Optimization

When accessing pointer fields, this option prevents the compiler from reloading the address of the pointer for each access. An index register holds the pointer value over statements where possible.

NOTE This option may not be available for all targets.

-Oi: Inline Functions

Use the inline keyword or the command line option -Oi for C++ functions. Defining a function before it is used helps the Compiler to inline it:

```
/* ok */                /* better! */
void foo(void);         void foo(void) {
void main(void) {      // ...
    foo();              }
}                       void main(void) {
void foo(void) {       foo();
    // ...              }
}                       }
```

This also helps the compiler to use a relative branch instruction instead an absolute.

-Oc: Common Subexpression Elimination

The compiler tries to perform CSE. Instead of evaluating the same expression several times, the Compiler evaluates it once and stores it on the stack for later retrieval.

NOTE This option may not be available for all targets.

SHORT Segments

Variables allocated on the direct page (between 0 and 0xFF) are accessed using the direct addressing mode. You can instruct the Compiler that some variables are allocated on the direct page if you define them in a **SHORT** segment (not available for all targets).

Example:

```
#pragma DATA_SEG __SHORT_SEG myShortSegment
unsigned int myVar1, myVar2;
#pragma DATA_SEG DEFAULT
unsigned int myvar3, myVar4.
```

In the previous example, 'myVar1' and 'myVar2' are both accessed using the direct addressing mode. Variables 'myVar3' and 'myVar4' are accessed using the extended addressing mode.

When some exported variables are defined in a **SHORT** segment, the external declaration for these variables must also specify that they are allocated in a **SHORT** segment. The External definition of the variable defined above looks like:

```
#pragma DATA_SEG __SHORT_SEG myShortSegment
extern unsigned int myVar1, myVar2;
#pragma DATA_SEG DEFAULT
extern unsigned int myvar3, myVar4.
```

The segment must be placed on the direct page in the PRM file.

Example:

```
LINK test.abs
NAMES test.o startup.o ansi.lib END
SECTIONS
    Z_RAM = READ_WRITE 0x0080 TO 0x00FF;
    MY_RAM = READ_WRITE 0x0100 TO 0x01FF;
    MY_ROM = READ_ONLY 0xF000 TO 0xFEFF;
PLACEMENT
    DEFAULT_ROM INTO MY_ROM;
    DEFAULT_RAM INTO MY_RAM;
    _ZEROPAGE, myShortSegment INTO Z_RAM;
END
STACKSIZE 0x60
VECTOR 0 _Startup /* set reset vector on _Startup */
```

NOTE The linker is case sensitive. The segment name must be identical in the C and PRM file.

Defining IO Registers

The I/O Registers are usually based at address 0. In order to tell the compiler it must use direct addressing mode to access the IO registers, these registers are defined in a SHORT section (if available) based at the specified address.

The IO register is defined in the C source file as follows:

Example:

```
typedef struct {
    unsigned char SCC1;
    unsigned char SCC2;
    unsigned char SCC3;
    unsigned char SCS1;
    unsigned char SCS2;
    unsigned char SCD;
    unsigned char SCBR;
} SCIstruct;
#pragma DATA_SEG __SHORT_SEG SCIRegs
SCIstruct  SCI;
#pragma DATA_SEG DEFAULT
```

Then the segment must be placed at the appropriate address in the PRM file.

Example:

```
LINK test.abs
NAMES test.o startup.o ansi.lib END
SECTIONS
    SCI_RG = READ_WRITE 0x0013 TO 0x0019;
    Z_RAM  = READ_WRITE 0x0080 TO 0x00FF;
    MY_RAM = READ_WRITE 0x0100 TO 0x01FF;
    MY_ROM = READ_ONLY  0xF000 TO 0xFEFF;
PLACEMENT
    DEFAULT_ROM          INTO MY_ROM;
    DEFAULT_RAM          INTO MY_RAM;
    _ZEROPAGE            INTO Z_RAM;
    SCIRegs              INTO SCI_RG;
END
STACKSIZE 0x60
VECTOR 0 _Startup /* set reset vector on _Startup */
```

NOTE The linker is case sensitive. The segment name must be identical in the C and PRM file.

Programming Guidelines

Following a few programming guidelines helps you reduce code size. Many things are optimized by the Compiler. However, if the programming style is very complex or if it forces the Compiler to perform special code sequences, code efficiency is not what you would expect from a typical optimization.

Constant Function at a Specific Address

Sometimes functions are placed at a specific address, but you do not have the sources or information regarding them. You just know that the function starts at address 0x1234 and you want to call it. Without having the definition of the function, you run into a linker error because you do not have the target function code. The solution is to use a constant function pointer:

```
void (*const fktPtr)(void) = (void(*) (void))0x1234;
void main(void) {
    fktPtr();
}
```

This gives you efficient code and no linker errors. But you must ensure that the function at 0x1234 really exists.

Even a better way (without the need for a function pointer):

```
#define erase ((void(*) (void))(0xfc06))
void main(void) {
    erase(); /* call function at address 0xfc06 */
}
```

HLI Assembly

Do not mix High Level Inline (HLI) Assembly. Using HLI assembly may affect the register trace of the compiler. The Compiler cannot touch HLI Assembly and thus it is out of range for any optimizations (except branch optimization, of course).

The Compiler in the worst case has to assume that everything has changed. It cannot hold variables into registers over HLI statements. Normally it is better to place special HLI code sequences into separate functions. However, there is the drawback of an

additional call/return. Placing HLI instructions into separate functions (and module) simplify porting the software to another target.

Example (not recommended):

```
void foo(void) {
    /* some local variable declarations */
    /* some C/C++ statements */
    asm {
        /* some HLI statements */
    }
    /* maybe other C/C++ statements */
}
```

Example (recommended):

```
/* hardware.c */
void special_hli(void) {
    asm {
        /* some HLI statements */
    }
}

/* foo.c */
void foo(void) {
    /* some local variable declarations */
    /* some C/C++ statements */
    special_hli();
    /* maybe other C/C++ statements */
}
```

Post/Pre Operators in Complex Expressions

Writing a complex program results in complex code. In general it is the job of the compiler to optimize complex functions. Some rules may help the compiler to generate efficient code.

If your target does not support powerful postincrement/postdecrement and preincrement/predecrement instructions, it is not recommended to use the ‘++’ and ‘--’ operator in complex expressions. Especially postincrement/postdecrement may result in additional code:

```
a[i++] = b[--j];
```

Write above statement as:

```
i--; a[i] = b[j]; j--;
```

Using it in simple expressions as:

```
i++;
```

Avoid assignments in parameter passing or side effects (as ‘++’ and ‘--’). The evaluation order of parameters is undefined (ANSI C standard 6.3.2.2) and may vary from Compiler to Compiler, and even from one release to another:

Example:

```
i = 3;  
foo(i++, --i);
```

In the above example, foo() is called either with ‘foo(3,3)’ or with ‘foo(2,2)’.

Boolean Types

In C, the boolean type of an expression is an ‘int’. A variable or expression evaluating to ‘0’ (zero) is FALSE and everything else (!= 0) is TRUE. Instead of using an ‘int’ (usually 16 or 32 bit), it may be better to use an 8-bit type to hold a boolean result. For ANSI-C compliance, the basic boolean types are declared in ‘stdtypes.h’:

```
typedef int Bool;  
#define TRUE 1  
#define FALSE 0
```

Using

```
typedef Byte Bool_8;
```

from ‘stdtypes.h’ (‘Byte’ is an unsigned 8bit data type also declared in ‘stdtypes.h’) reduces memory usage and improves code density.

Printf/Scanf

You can reduce the printf/scanf in the ANSI library if no floating point support (%f) is used. Refer to the ANSI library reference and the printf.c/scanf.c in your library for details on how to save code (not using float/doubles in printf may result in half the code).

Bitfields

Using bitfields to save memory may be a bad idea as bitfields produce a lot of additional code. For ANSI-C compliance, bitfields have a type of ‘signed int’, thus a

bitfield of size 1 is either '-1' or '0'. This could force the compiler to 'sign extend' operations:

```
struct {
    int b:0; /* -1 or 0 */
} B;

int i = B.b; /* load the bit, sign extend it to -1 or 0 */
```

Sign extensions are normally time and code inefficient operations.

Struct Returns

ANSI-C/C++ allows functions that return a struct, unless the struct is returned in a single register. Returning a struct can force the Compiler to produce a lengthy code:

```
struct S foo(void) {
    /* ... */
    return s; // (4)
}

void main(void) {
    struct S s;
    /* ... */
    s = foo(); // (1), (2), (3)
    /* ... */
}
```

Normally the compiler has first to allocate space on the stack for the return value (1) and then to call the function (2). In the callee 'foo' during the return sequence, the Compiler has to copy the return value (4, struct copy).

Depending on the size of the struct, this may be done inline or with a special memory copy routine (strcpy). After return, the caller 'main' has to copy the result back into 's'. Depending on the Compiler/Target, it is possible to optimize some sequences (avoiding some copy operations). However, returning a struct by value may use a lot of execution time and means a lot of code and stack usage.

A better way is pass only a pointer to the callee for the return value:

```
void foo(struct S *sp) {
    /* ... */
    *sp = s; // (4)
}

void main(void) {
    S s;
    /* ... */
    foo(&s); // (2)
```

```
    /* ... */  
}
```

With the above example, the Compiler just has to pass the destination address and to call ‘foo’ (2). On the callee side, the callee copies the result indirectly into the destination (4). This approach reduces stack usage, avoids copying structs, and results in denser code. Note that the Compiler may also inline the above sequence (if supported). But for rare cases the above sequence may not be exactly the same as returning the struct by value (e.g. if the destination struct is modified in the callee).

Local Variables

Using local variables instead of global variable results in better manageability of the application as side effects are reduced or totally avoided. Using local variables/parameters reduces global memory usage but increases stack usage.

Stack access capabilities of the target influences the code quality. Depending on the target capabilities, access to local variables may be very inefficient. The reason being that no dedicated stack pointer (another address register has to be used instead, thus it might not be used for other values) or access to local variables is inefficient due the target architecture (limited offsets, only few addressing modes).

Allocating a huge amount of local variables may be inefficient because the Compiler has to generate a complex sequence to allocate the stack frame in the beginning of the function and to deallocate them in the exit part:

```
void foo(void) {  
    /* huge amount of local variables: allocate space! */  
    /* ... */  
    /* deallocate huge amount of local variables */  
}
```

If the target provides special entry/exit instructions for such cases, allocation of many local variables is not a problem. A solution is to use global or static local variables. This deteriorates maintainability and also may waste global address space.

The Compiler may offer an option to overlap parameter/local variables using a technique called ‘overlapping’. Local variables/parameters are allocated as global ones. The linker overlaps them depending on their use. For targets with limited stack (e.g. no stack addressing capabilities), this often is the only solution. However this solution makes your code non-reentrant (no recursion is allowed).

Parameter Passing

Avoid parameters which exceed the data passed through registers (see Back End).

Unsigned Data Types

Using unsigned data types is acceptable as signed operations are much more complex than unsigned ones (e.g. shifts, divisions and bitfield operations). But it is a bad idea to use unsigned types just because a value is always larger or equal to zero, and because the type can hold a larger positive number.

Inlining/Macros

abs() and absl()

Use the corresponding macro `M_ABS` defined in `stdlib.h` instead of calling `abs()` and `absl()` in the `stdlib`:

```
/* extract
/* macro definitions of abs() and labs() */
#define M_ABS(j)  (((j) >= 0) ? (j) : -(j))
extern int      abs  (int j);
extern long int labs (long int j);
```

But be careful as `M_ABS()` is a macro,

```
i = M_ABS(j++);
```

and is not the same as:

```
i = abs(j++);
```

memcpy() and memcpy2()

ANSI-C requires that the `memcpy()` library function in ‘`strings.h`’ returns a pointer of the destination and handles, and is able to also handle a count of zero:

```
/* extract of string.h */
extern void*
memcpy(void *dest, const void *source, size_t count);

extern void
memcpy2(void *dest, const void* source, size_t count);
/* this function doesn't return dest and assumes count>0 */

/* extract of string.c */
void*
memcpy(void *dest, const void *source, size_t count) {
    uchar *sd = dest;
    uchar *ss = source;
```

```
while (count--)  
    *sd++ = *ss++;  
  
return (dest);  
}
```

If the function does not have to return the destination and it does have to handle a count of zero, the memcopy below is much more simpler and faster:

```
/* extract of string.c */  
void  
memcpy2(void *dest, const void* source, size_t count) {  
    /* this func does not return dest and assumes count > 0 */  
    do {  
        *((uchar *)dest)++ = *((uchar*)source)++;  
    } while(count--);  
}
```

Replacing calls to memcpy() with calls to memcpy2() saves runtime and code size.

Data Types

Do not use larger data types than necessary. Use IEEE32 floating point format both for float and doubles if possible. Set the enum type to a smaller type than 'int' using the -T option. Avoid data types larger than registers.

Short Segments

Whenever possible and available (not all targets support it), place frequently used global variables into a DIRECT or SHORT segment using

```
#pragma DATA_SEG __SHORT_SEG MySeg
```

Qualifiers

Use the 'const' qualifier to help the compiler. The 'const' objects are placed into ROM for the HIWARE object file format if the command line option -Cc is given.

Motorola HC12 Back End

The Back End is the target-dependent part of a Compiler, containing the code generator. This section discusses the technical details of the Back End for the M68HC12 family.

Memory Models

SMALL Memory Model

The Compiler for the MC68HC12 supports three different memory models. The default is the *SMALL* memory model, which corresponds to the normal setup, i.e. a 64kB code-address space. If you use a code memory expansion scheme, you may use the *BANKED* memory model. The *LARGE* memory model supports both data and code expansion. The different memory models change the default behavior of the compiler.

BANKED Memory Model

Some micro controllers of the M68HC12 family have the ability to extend the address range of the CPU beyond the 64kB limit given by the 16 CPU address lines. This feature is provided by a paging scheme using expansion address lines. The exact method to extend the address space is hardware-dependent.

There are several expansion memory banks. Which bank is active is determined by the value of a dedicated I/O register in memory (page register). Part of the memory is non-banked, accessible from all expansion memory banks.

The *BANKED* memory model is identical to the *SMALL* memory model in terms of variable allocation. Part of your code may be allocated to extended memory, thus breaking the 64kB limit.

If a function is in extended memory, it has to be called differently than a function in non-banked memory. In particular, a bank switch has to be done, i.e.

- The current bank number has to be saved
- The called function's bank number has to be written to the bank register (bank switch)
- The function has to be called.

far and near for Functions

In order to minimize overhead, functions are separated into two classes: *far* functions are always called with a `CALL`, while *near* functions are simply called with a `JSR/BSR`. If a *near* function is called, the callee must be either in non-banked memory, or in the same memory bank as the caller.

When compiling in the *BANKED* or the *LARGE* memory model, all functions, by default, are *far*. To override this default, explicitly declare a function as *near* or *far*, e.g.

```
static int far my_func (int *p);
```

In the *BANKED* or in the *LARGE* memory model, function pointers are always 24 bits wide. The page is allocated differently for 24-bit function pointer and for 24-bit *far* data pointer. For 24-bit function pointer, the page is allocated at offset 2. This difference is because of hardware requirements.

The following table shows the allocation for a banked function pointer:

Byte 0	Byte 1	Byte 2
offset highbyte	offset lowbyte	page

The next table shows the allocation for a far data pointer allocation:

Byte 0	Byte 1	Byte 2
page	offset highbyte	offset lowbyte

The compiler does not exchange the byte order when assigning a far function pointer to far data pointer or a far data pointer to far function pointer. The special byte ordering is also not automatically adapted when using absolute addresses for far function pointers.

The following two macros can be used to manually assign and adapt one far data pointer to a far function pointer (or vice versa):

```
#define CONV_FAR_FUN_TO_DATA_PTR(to, from)\
    *(int*)((char*)&to+1) = *(int*)&from; \
    *(char*)&to = *((char*)&from+2);

#define CONV_FAR_DATA_TO_FUN_PTR(to, from)\
    *(int*)&to = *(int*)((char*)&from+1);\
    *((char*)&to+2) = *(char*)&from;
```

**Listing 1.47 Using the CONV_FAR_FUN_TO_DATA_PTR and
CONV_FAR_DATA_TO_FUN_PTR Macros**

```
#pragma CODE_SEG PIC NEAR_SEG PIC_CODE
void __far Function(void) {
}
void __far NextFun(void) {}
#pragma CODE_SEG DEFAULT
char RamBuf[100];
void Test(void) {
    void (*__far startFunPtr)(void)= Function;
    void (*__far endFunPtr)(void)= NextFun;
    void (*__far bufferFunPtr)(void);
    char *__far startDataPtr;
    char *__far endDataPtr;
    char *__far bufferDataPtr= RamBuf;
    int i=0;
    CONV_FAR_FUN_TO_DATA_PTR(startDataPtr, startFunPtr);
    CONV_FAR_FUN_TO_DATA_PTR(endDataPtr, endFunPtr);
    CONV_FAR_DATA_TO_FUN_PTR(bufferFunPtr, bufferDataPtr);
    while (startDataPtr != endDataPtr) {
        RamBuf[i++]= *(startDataPtr++);
    }
    bufferFunPtr();
}
```

NOTE In the previous example, code is executed at a different place than it was linked. Therefore, this code must be compiled position independent. However, pic code is not supported for the bank part of the address.

NOTE The different byte ordering does only cause problems with far function pointer. With the near calling convention, straight forward code can be used. Also as PIC is only supported inside of one bank, PIC code is usually using the near calling convention.

See also the chapter [Position Independent Code \(PIC\)](#) and the [option -Pic](#).

Non-Banked Memory

Some parts of an application must always be in non-banked memory, in particular:

- The prestart code (segment `_PRESTART`)
- The startup code (segment `NON_BANKED`) and the startup descriptor(s) (segment `STARTUP`)
- All runtime support routines (segment `NON_BANKED`)
- All interrupt handlers, because trap vectors are only 16 bits wide.

For more information on these segments, see the Linker manual.

Usually, some initial settings are necessary to enable the memory expansion scheme. You might want to include this initialization code in the startup function.

Using the Banked Memory Model

When the banking memory model is used, some constraints apply to the application linker parameter files.

Definition of the Application Memory Map

The `SECTIONS` block in the PRM file contains the memory area definitions that are used by the application. A typical `SECTIONS` block for a banked application contains at least one definition for following memory blocks:

- One or several sections for the RAM area
- One section for the non banked ROM area
- One section for each bank used by the application.

Banking is performed through a window. The size and start address depends on the hardware. The address space define for each bank is defined in the following way in the linker PRM file:

```
0x<bnr><startAddr> TO <bnr><endAddr>
```

Where:

`bnr`: is the bank number. The value of this number depends on the hardware and is the bit pattern to be written into the bank register to access this bank. Valid values depend on the hardware configuration.

`startAddr`: is the start address of the bank window. This has to be 4 hex digits.

`endAddr`: is the end address of the bank window (inclusive; 4 hex digits).

Example:

In the following example, it is assumed that the bank window is defined between address 0x8000 and 0xBFFF:

```

SECTIONS
    DIRECT_RAM      = READ_WRITE    0x00000 TO 0x000FF;
    RAM_AREA        = READ_WRITE    0x00800 TO 0x00BFF;
    BANK_0          = READ_ONLY     0x08000 TO 0x0BFFF;
    BANK_1          = READ_ONLY     0x18000 TO 0x1BFFF;
    BANK_2          = READ_ONLY     0x28000 TO 0x2BFFF;
    BANK_3          = READ_ONLY     0x38000 TO 0x3BFFF;
    NON_BANKED_ROM = READ_ONLY     0x0C000 TO 0x0FFFF;

```

Segment Allocation

Some redefined sections must be allocated in the NON_BANKED memory area otherwise the application will not be able to run correctly. The following redefined sections must always be located in the non-banked ROM memory area:

- `_PRESTART`: Contains the application prestart code.
- `STARTUP`: Contains the application startup structure
- `ROM_VAR`: Contains the application constant variables
- `STRINGS`: Contains the application string constants
- `COPY`: Contains the initialization values for the application variables.
- `NON_BANKED`: Contains the run time library functions.

Additionally, as banked memory is only available for code sections (sections containing functions), all user-defined data or constant segments must be located on the non-banked memory area.

As the entry in the vector table is only two bytes wide, all the interrupt functions must also be allocated in the non-banked memory area.

In the following example, it is assumed that the bank window is defined between address 0x8000 and 0xBFFF:

```

LINK test.abs

NAMES test.o ansib.lib start12b.o END
SECTIONS
    DIRECT_RAM      = READ_WRITE    0x00000 TO 0x000FF;
    RAM_AREA        = READ_WRITE    0x00800 TO 0x00BFF;
    BANK_0          = READ_ONLY     0x08000 TO 0x0BFFF;
    BANK_1          = READ_ONLY     0x18000 TO 0x1BFFF;
    BANK_2          = READ_ONLY     0x28000 TO 0x2BFFF;

```

```
BANK_3          = READ_ONLY    0x38000 TO 0x3BFFF;
NON_BANKED_ROM = READ_ONLY    0x0C000 TO 0x0FFFF;
PLACEMENT
  _PRESTART, STARTUP,ROM_VAR,
  STRINGS, NON_BANKED,
  Int_Function,
  COPY                      INTO NON_BANKED_ROM;
  DEFAULT_RAM                INTO RAM_AREA;
  UserSeg1, UserSeg2,
  UserSeg3, DEFAULT_ROM     INTO BANK_0, BANK_1, BANK_2,
BANK_3;
END
STACKSIZE 0x50
```

According to the previous PRM file,

- The section `NON_BANKED_ROM` contains the predefined sections enumerated above and the user-defined code segment, 'Int_Function', is where all the interrupt functions are allocated.
- The section `RAM_AREA` contains all the linker predefined and user-defined data segments, as well as the stack.
- The sections `BANK_0`, `BANK_1`, `BANK_2` and `BANK_3` contain the `DEFAULT_ROM` segment, as well as the user-defined code segments 'UserSeg1', 'UserSeg2' and 'UserSeg3'.
- The linker allocated first all functions implemented in the segment 'UserSeg1', then the functions from 'UserSeg2', then the functions from 'UserSeg3', and finally the functions defined in the other segments.
- For the allocation of the functions, the linker first uses the section `BANK_0`. As soon as this section is full, allocation continues in section `BANK_1`, then in `BANK_2` and so on until all functions are allocated. During the allocation, a specific function is always allocated on a single bank.

Simple Example for HC12DG128

A simple example for the HC12DG128 is shown below. The application uses three code banks:

- Bank 1 contains the code (read only)
- Bank 2 contains constant initialized data (read only, MyConstSegPage2)
- Bank 3 contains constant initialized data (read only, MyConstSegPage3)

The source for this is:

```
/* bankcnst.c */

#pragma CONST_SEG PPAGE MyConstSegPage2
volatile const int aa = 3;

#pragma CONST_SEG PPAGE MyConstSegPage3
volatile const int xx = 2;

#pragma CONST_SEG DEFAULT

void main(void) {
    volatile int cc = xx+aa;
}
```

All variables are declared as volatile to avoid the compiler optimizing many accesses. The above source is compiled with following compiler command line:

```
bankcnst.c -F2 -CpPpage=RUNTIME -Mb
```

- The ELF/Dwarf Object File Format is chosen with -F2
- -CpPpage=RUNTIME is used because we are accessing other PPAGE constant data (MyConstSegPage2, MyConstSegPage3) from the code page (page 1). We use a runtime routine to switch the (code) pages. This runtime routine has to be placed in a non banked area.
- -Mb tells the compiler to use the banked memory model.

The startup module and the data page module must be recompiled because they are not delivered by default with the above-listed configuration/option settings:

```
datapage.c start12.c -F2 -CpPpage=RUNTIME -Mb -DDG128
```

- The reasons for -F2, -CpPpage and -Mb are listed above
- The option -DDG128 is not for the startup code, it is for datapage.c. Because of this define, datapage.c knows that the page register is at 0xff. And datapage.c also uses a more efficient version which only considers one page register.
- Recompiling datapage.c is necessary because the page register is for the DG128 at a different location.
- The start12.c startup code is recompiled even if it is not really necessary here. Recompiling start12.c is necessary only because the startup code does not initialize variables in pages by default in the small and banked memory model. In the example, the initialized variables are constant and thus initialized during downloading.
- Note that some segments in the prm file must not be in a paged area (e.g. NON_BANKED).

Now application is linked. In the linker parameter file below, all our three pages are declared. The Bank Window for PPAGE is in the range of 0x8000 to 0xBFFF:

```
LINK bankcnst.abs

NAMES bankcnst.o datapage.o start12.o ansib.lib END

SECTIONS
    MY_RAM = READ_WRITE 0x800 TO 0x80F;
    MY_ROM = READ_ONLY 0x810 TO 0xAFF;
    MY_PAGE1 = READ_ONLY 0x18000 TO 0x1BFFF;
    MY_PAGE2 = READ_ONLY 0x28000 TO 0x2BFFF;
    MY_PAGE3 = READ_ONLY 0x38000 TO 0x3BFFF;
    MY_STK = READ_WRITE 0xB00 TO 0xBFF;
END

PLACEMENT
    DEFAULT_ROM      INTO MY_PAGE1;
    MyConstSegPage2  INTO MY_PAGE2;
    MyConstSegPage3  INTO MY_PAGE3;
    _PRESTART, STARTUP,
    ROM_VAR, STRINGS,
    NON_BANKED, COPY INTO MY_ROM;
    DEFAULT_RAM      INTO MY_RAM;
    SSTACK           INTO MY_STK;
END

VECTOR 0 _Startup
```

Finally, load the application into the simulator to simulate it, or download it onto the HC12DG128.

LARGE Memory Model

The large memory model supports both extended data and code by default. See the [BANKED Memory Model](#) chapter for code banking constraints. See the [Paged Variables](#) chapter for data paging support.

Because Paged Variables are not directly supported by the HC12 instruction set, the LARGE Memory Model has significant overhead compared with the SMALL or BANKED Memory Model.

Note that far functions and paged variables are possible in all memory models. If they are not defaulted to by the memory model, the code is adapted to use these features. If only a small part of the application actually needs paged variables, for example, then

using a smaller memory model and adapting the small generates smaller and faster code.

Implicit near pointer conversions

In the large memory model, the stackpointer is 16 bits. All objects allocated on the stack are near by default.

```
int i_global;
void main(void) {
    int i_local;
}
```

In the above example, `i_global` is accessed with a far access, while `i_local` is accessed directly.

The HC12 does casts near pointers to standard pointers for all implicit parameter declarations, and for open parameter arguments. Only with this extension, the following code will work:

```
void main(void) {
    int i;
    sscanf("3", "%d", &i);
}
```

NOTE The size of a near pointer only differs in the LARGE Memory Model from the size of the standard pointer type. Therefore, applications using the SMALL or BANKED Memory Model are not influenced.

Non-ANSI Keywords

The following table gives an overview about the supported non-ANSI keywords:

Keyword	Data Pointer	Supported for Function Pointer	Function
far	yes	supported for ELF or BANKED/LARGE Memory Model	yes
near	yes	supported for ELF or SMALL Memory Model	yes
rom	no	no	no

Keyword	Data Pointer	Supported for Function Pointer	Function
uni	no	no	no
interrup	no	no	yes

Data Types

This section describes how the basic types of ANSI-C are implemented by the MC68HC12 Back End.

Scalar Types

All basic types may be changed with the `-T` option. Note that all scalar types (except char) have no signed/unsigned qualifier, and are considered signed by default, e.g. 'int' is the same as 'signed int'.

The sizes of the simple types are given by the table below together with the possible formats using the `-T` option:

Type	Default Format	Default Value Range		Formats Available With Option -T
		Min	Max	
char (signed)	8bit	-12	127	8bit, 16bit, 32bit
signed char	8bit	-128	127	8bit, 16bit, 32bit
unsigned char	8bit	0	255	8bit, 16bit, 32bit
signed short	16bit	-32768	32767	8bit, 16bit, 32bit
unsigned short	16bit	0	65535	8bit, 16bit, 32bit
enum (signed)	16bit	-32768	32767	8bit, 16bit, 32bit
signed int	16bit	-32768	32767	8bit, 16bit, 32bit
unsigned int	16bit	0	65535	8bit, 16bit, 32bit
signed long	32bit	-2147483648	2147483647	8bit, 16bit, 32bit
unsigned long	32bit	0	4294967295	8bit, 16bit, 32bit
signed long long	32bit	-2147483648	2147483647	8bit, 16bit, 32bit
unsigned long long	32bit	0	4294967295	8bit, 16bit, 32bit

NOTE Plain type char is signed. This default is changed with the `-T` option.

Floating Point Types

The Compiler supports the two IEEE standard formats (32 and 64 bits wide) for floating point types. By default, the Compiler uses the IEEE32 format both for `float` and `double`.

The option `-T` may be used to change the default format of float/double.

Type	Default Format	Default Value Range		Formats Available With Option -T
		Min	Max	
float	IEEE32	-1.17549435E-38F	3.402823466E+38F	IEEE32, IEEE64
double	IEEE32	1.17549435E-38F	3.402823466E+38F	IEEE32, IEEE64
long double	IEEE32	1.17549435E-38F	3.402823466E+38F	IEEE32, IEEE64
long long double	IEEE32	1.17549435E-38F	3.402823466E+38F	IEEE32, IEEE64

WJW

Pointer Types and Function Pointers

The size of pointer types depends on the memory model selected. The following table gives an overview.

Type	Example	Size		
		SMALL	BANKED	LARGE
default data pointer	char*	2 bytes	2 bytes	3 bytes
near data pointer	char* __near	2 bytes	2 bytes	2 bytes
far data pointer	char* __far	3 bytes	3 bytes	3 bytes
default function pointer	void (*)(void)	2 bytes	3 bytes	3 bytes

Type	Example	Size		
		SMALL	BANKED	LARGE
near function pointer	void (*__near)(void)	2 bytes	2 bytes ⁽¹⁾	2 bytes ⁽¹⁾
far function pointer	void (*__far)(void)	3 bytes ⁽¹⁾	3 bytes	3 bytes

⁽¹⁾: Only supported in the ELF Object File Format.

Structured Types, Alignment

Local variables are allocated on the stack (which grows downwards). The order of allocation of local variables is the same as the order of their declaration. The most significant part of a simple variable always is stored at the low memory address.

Bit Fields

The maximum width of bit fields is 32 bits. The allocation unit is one byte. The Compiler uses words only if a bit field is wider than eight bits, or using bytes would cause more than two bits to be left unused. Allocation order is from the least significant bit up to the most significant bit in the order of declaration. The figure below illustrates this allocation scheme.

Paged Variables

The HC12 has several page registers that control different areas of the 64K address space. The following table gives an overview about the page register names, their memory addressing capabilities and their default location:

Page Register	Start Address	End Address	Default Port Address
DPAGE	0x7000	0x7FFF	0x34
EPAGE	0x0400 or 0x0000	0x07FF or 0x03FF	0x36
PPAGE	0x8000	0xBFFF	0x35

The Compiler supports variable accesses with the DPAGE, the EPAGE, and with the PPAGE page registers. Variables in paged memory areas must be defined after one of the following pragmas:

```
#pragma DATA_SEG DPAGE segment_name
#pragma DATA_SEG EPAGE segment_name
#pragma DATA_SEG PPAGE segment_name
```

Segment_name must be allocated with the Linker at a memory area which is controlled by the corresponding page register.

The Compiler supports the `far` data pointer, which may point to all variables independent of their page register. The `far` keyword is written immediately after the “*”.

Example:

```
#pragma DATA_SEG DPAGE my_DPAGE
int a; /* variable in memory controlled by DPAGE reg.*/
int *far p = &a; /* far pointer to access any variable */
```

For the following topics, the Compiler must know which page register is used for data paging:

- interrupt routines:
An interrupt routine saves, by default, those page registers given by the command line option “-Cp”.
- `far` data pointer accesses
If only one page register is used, then the `far` data pointer accesses is inlined because the page register is obvious. If several page registers are possible, a runtime routine determines the correct page register. The page register is determined from the offset portion of the address.

There are two ways to access a variable in paged memory:

- Store the page into the page register and then perform the usual assembler instructions.
- Use a runtime routine

The first method is faster and denser than the second. If code and paged variables are in memory areas that are controlled by the same page register, the page register must not be modified. In this case a runtime routine for memory accesses must be used. Runtime routines must be in a non paged memory area. By default, the first method is used except for PPAGE accesses in the *BANKED* memory model where a runtime routine is used.

```
-CpDPAGE [ "=" (address | "RUNTIME" ) ]
-CpEPAGE [ "=" (address | "RUNTIME" ) ]
-CpPPAGE [ "=" (address | "RUNTIME" ) ]
```

Example:

```
-CpDPAGE=0x34
```

Variable accesses to DPAGE segments are inlined. The address 0x34 is also a built-in default, so "-CpDPAGE" is equivalent to this argument.

NOTE With the form -CpDPAGE=0x34 is implied that code could be inlined. If a runtime routine must be taken, then the address is not necessary.

To use a different page address than the default, the library file `datapage.c` must be adapted. It contains a define for the specific page register address. To use a modified `datapage.c`, compile it with the correct options set and then specify the generated object file in front of the ANSI library in the link parameter file NAMES section.

Example:

```
-CpEPAGE=RUNTIME
```

Variable accesses to the EPAGE segments are done with a runtime routine.

NOTE The runtime routine is adapted to special requirements. The runtime routines are written for the most general case. If only one PAGE register is used, the runtime routines could be made faster and shorter. The runtime routines for paged data memory access are in the file "`datapage.c`". Take care to implement the same interface, i.e. to save all registers as stated in the source code. Especially when using a RUNTIME access, which is the default in the large memory model. Adapting the `datapage.c` can result in a time improvement of factor 2 or more.

Example:

```
-CpPPAGE
```

In the *SMALL* memory model, variable accesses to PPAGE segments are inlined. No code of this compilation unit must be linked between 0x8000 and 0xbfff. In the *BANKED* memory model variable accesses are done with a runtime routine. Therefore there are no restrictions in linking the code between 0x8000 and 0xbfff.

NOTE The Compiler defined the macros "`__DPAGE__`", "`__EPAGE__`" and "`__PPAGE__`" if the corresponding Compiler option are used.

Example, consider the following situation:

- The page registers are mapped to 0x2000 to be able to use the zero page.
- Variables are placed from 0x7000 up to 0x9FFF in different pages using the DPAGE and the PPAGE register.
- The code is placed from 0x2000 up to 0x7000 and from 0x9fff up to 0bfff.

The area controlled by the PPAGE register is used for functions and for variables. The following Compiler options should be used:

```
-CpDPAGE=0x2034 -CpPPAGE=RUNTIME
```

Variable accesses to the DPAGE are also done with the runtime routine, but the code is larger. Variable accesses to the PPAGE must be done with a runtime routine.

NOTE Several page registers could be used for data paging in the same compilation unit.

NOTE The RUNTIME option must be given in the SMALL memory model. In the BANKED and in the Large memory model it is the default and could be avoided. Nevertheless it is good practise to specify it.

Another point to consider about banked variables is the initialization. For the large memory model, paged variables are initialized correctly by default. In the small and banked memory models, the startup code and the Linker must be explicitly set up to use 24-bit addresses instead of 16-bit addresses. To produce startup code which handles 24-bit addresses, the startup code must be compiled with one of the Compiler options "-Cp..." as explained above.

For the HIWARE object file format, the Linker must be told to produce 24-bit addresses with the command "HAS_BANKED_DATA" in the link parameter file. For the ELF object file format, the Linker reads the size of the pointers for the startup structure by analyzing the debug info of the startup code. Only the startup code must be recompiled with the correct Compiler options for the ELF object file format.

The reason that the initialization for banked variables must be specified explicitly is that no overhead of banked data should occur as long as banked variables are not used.

By default the compiler assumes that objects in the default segment are distributed into different pages. However, objects in user-defined segments are on only one page. This behavior is changed with the [option -PSeg](#).

Position Independent Code (PIC)

The HC12 compiler supports position independent code. PIC functions are larger and slower than non-pic functions, therefore PIC code should only be generated when necessary.

To compile one function as PIC, use the [#pragma CODE_SEG](#) with the modifier PIC. To compile one compilation unit as PIC, use the option [-Pic](#). The pragma has the advantage that it allows pic and non-pic functions and function calls in the same compilation unit. With this option, all functions and all calls (except runtime routine calls) are position-independent.

Listing 1.48 Compiling a Function or Compilation Unit as PIC

```
#pragma CODE_SEG PIC PIC_CODE
void f_PIC(void); /* declare f_PIC to be in specific PIC segment */

#pragma CODE_SEG DEFAULT
void f_NonPic(void) {
    f_PIC(); /* NON pic call, calls PIC function at link address only */
}

#pragma CODE_SEG PIC PIC_CODE
void g_PIC(void) {}
int i;
void f_PIC(void) {
    if (i) { /* global variables are accessed absolute */
        g_PIC(); /* calls g_PIC relative to current location */
        f_NonPic(); /* calls function at link time address */
    }
}
```

Listing 1.49 Machine Code Generated by the Source Code Listed Above

```
f_NonPic:
    0000 060000      JMP    f_PIC

g_PIC:
    0000 3d          RTS

f_PIC:
    0000 fc0000      LDD    i
    0003 2707        BEQ    *+9 ;abs = 000c
    0005 15fa0000    JSR    g_PIC,PCR
```

```
0009 160000      JSR   f_NonPic
000c 3d          RTS
```

Note that the call from the PIC function `f_PIC` to the PIC function `g_PIC` is done with a PC relative JSR instead of an shorter extended JSR. The calls from the non PIC function to `f_PIC` and back are encoded with absolute calls.

Taking the address of a function returns the link time address of this function. The next example shows a small application that copies a part of itself into RAM. Then the RAM copy is started and executed until a HALT occurs (which is implemented with a HC12 SWI instruction).

Listing 1.50 Taking the Address of a Function

```
#include <hidef.h> /* for HALT */
#include <string.h> /* for memmove */

#pragma CODE_SEG PIC NEAR PIC_CODE
/* declarations of PIC functions */
void f0(void);
void f1(void);
void f2(void);
/* implementation of PIC functions */
void f0(void) {
    /* here we calculate the address of the RAM copy of f1 */
    /* by using inline assembler */
    void (*pf1) (void);
    __asm LEAX f1,pcr;
    __asm STX pf1;
    pf1();
}
void f1(void) { /* just call f2 */
    f2();
}
void f2(void) {
    HALT; /* finished, call the user/debugger */
}
void end(void){} /* dummy function to calculate the end of */
                /* the PIC_CODE segment */

/* implementation of main module. Copies and starts the PIC code */
#pragma CODE_SEG DEFAULT
char buf[100]; /* ram area to copy the PIC functions into */
```

```
void main(void) {
    /* copy pic functions */
    memmove(buf, (char*)f0, (char*)end - (char*)f0);
    /* start f0 */
    ((void(*) (void))buf) (); /* cast buf to fct pointer and call it */
}
```

Listing 1.51 Machine Code Generated by the Source Code Listed Above

```
f0:
    0000 3b          PSHD
    0001 1afa0000    LEAX  f1,PCR
    0005 6e80        STX   0,SP
    0007 15f30000    JSR   [0,SP]
    000b 3a          PULD
    000c 3d          RTS

f1:
    0000 05fa0000    JMP   f2,PCR

f2:
    0000 c7          CLR B
    0001 3f          SWI
    0002 3d          RTS

end:
    0000 3d          RTS

main:
    0000 cc0000    LDD   #buf
    0003 3b          PSHD
    0004 ce0000    LDX   #f0
    0007 34          PSHX
    0008 cc0000    LDD   #end
    000b 830000    SUBD  #f0
    000e 160000    JSR   memmove
    0011 1b84        LEAS  4,SP
    0013 060000    JMP   buf
```

With the option [-Pic](#), runtime functions are still called absolutely. In order to generate PIC runtime calls, use the additional option [-PicRts](#).

The delivered libraries are not built position-independent. In order to move them together with your code, rebuild your code with the option "[-Pic -PicRts](#)". There is a make file to build the library. Please check the maker manual for details.

PIC Impacts on Generated Code

- Absolute calls are encoded PC relative. Calls via function pointers are not affected.
- Long branches are done with the LBRA instruction instead of an extended JMP.
- Indexed 16 Bit Constant Indirect ([IDX2]) using the PC register is not used by the compiler to access via absolute pointers.
- Switches are encoded by binary search trees instead of tables (which contain absolute addresses).

Restrictions

The compiler does not support position-independent data. To use position-independent data, a local variable or parameter pointing to a moveable structure containing all global data must be used. If the whole application, including constants, should be position independent, this restriction has the following implications:

- The startup code accesses the global data structure `_startupData` absolutely. In order to build a completely PIC application, do not use this startup code. Without the startup code, global variables won't be initialized.
- Strings as in `'PutString("Hello World");'` are considered as global data and can therefore not be moved together with the code. Use a pointer pointing to the actual string instead. E.g. `"PutString(dataPtr->hello_world);"` with `dataPtr` set the actual position before.
- The debug info is only generated for the link time version of the functions. Without any debugger extension, copied PIC functions will not have debug info.
- Only near (16-bit address space) functions are fully supported for PIC code. For calls to far (24-bit) functions, only the 16-bit offset of the address is position independent. The page is hard encoded into the call instructions. Therefore far functions can be moved in the same page and to a non-paged area. They cannot be moved into a different page.
- Runtime routine calls have are always near. They are absolute, unless the option [-PicRts](#) is specified too. Note that the message C3605 is issued whenever a runtime routine is called. By setting this message to an error, you can check if your code uses runtime routines.
- Some ANSI routines are using global data, like the error variable `"errno"`. The memory allocation functions do access the global memory and the ANSI function

strtok does also have a global state. These functions require to have fix placed data.

See also:

- Option -Pic
- Option -PicRTS
- Pragma CODE_SEG

Register Usage

The Compiler uses all registers of the MC68HC12 except the TMP2 and the TMP3 registers. These registers are never accessed from C code.

Call Protocol and Calling Conventions

Argument Passing

The Pascal calling convention is used for functions with a fixed number of parameters: The caller pushes the arguments from left to right. After the call, the caller removes the parameters from the stack.

The C calling convention is used for functions with a variable number of parameters. In this case, the caller pushes the arguments from right to left. If the last parameter of a function with a fixed number of arguments has a simple type, it is not pushed but passed in a register.

This results in shorter code because pushing the last parameter is saved. The following table gives an overview of the registers used for argument passing.

Size of Last Parameter	Type Example	Register
1 byte	char	B
2 bytes	int, array	D
3 bytes	far data pointer	X(L), B(H)
4 bytes	long	D(L), X(H)

Parameters having a type not listed are passed on the stack (i.e. all those having a size greater than four bytes).

Return Values

Function results are returned in registers, except if the function returns a result larger than one word (see below). Depending on the return type, different registers are used.

Size of Return Value	Type Example	Register
1 byte	char	B
2 bytes	int	D
3 bytes	far data pointer	X(L), B(H)
4 bytes	long	D(L), X(H)

Returning Large Results

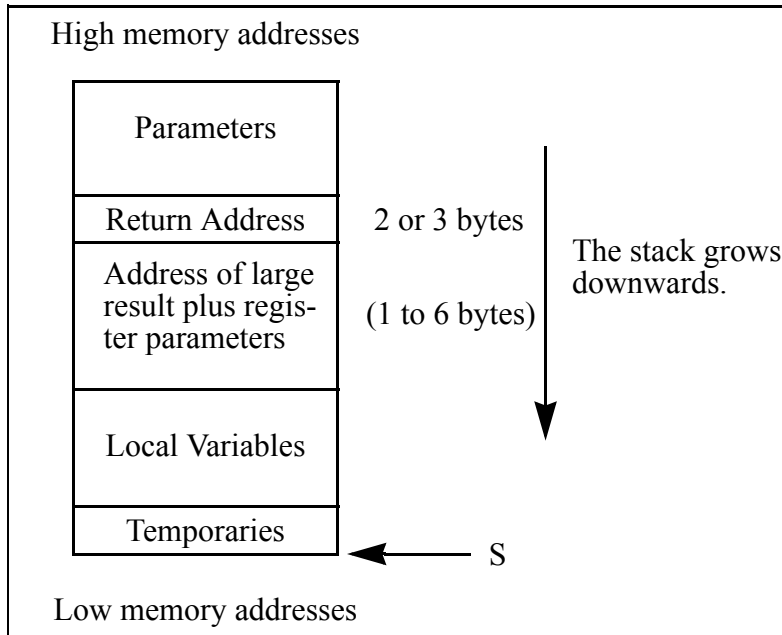
Functions returning a result larger than two words are called with an additional parameter. This parameter is the address where the result should get copied to.

Stack Frames

Functions have a stack frame containing all their local data. The Compiler uses the stack pointer as the base address for accessing local data.

If one of the pragmas `NO_ENTRY`, `NO_EXIT` or `NO_FRAME` is active, the Compiler does not generate code to set up a stack frame for this function. In this case the function must have neither local variables nor parameters.

The figure below shows the stack frame of a normal function, i.e. compiled with above pragmas inactive.



Entry Code

Normal *entry code* is a sequence of instructions reserving space for local variables and writing eventually the register parameter to the stack:

for 1 byte register parameter:

```
PSHB
```

for 2 byte register parameter:

```
PSHD
```

for 3 byte register parameter:

```
PSHX  
PSHB
```

for 4 byte register parameter:

```
PSHD  
PSHX
```

Additionally, the entry code also allocates space for local variables. This may be done before and after the push for the register parameter. If it is done before the push of the register parameter, the push and the allocation may be optimized into a single store instruction with auto decrement. Also, space for one or two bytes may be allocated by a push instruction instead of a LEAS to save space.

Exit Code

Exit code removes local variables from the stack before returning to the caller. The exit code is optimized depending on the Compiler command line switches `-Os` (optimize for size, default) or `-Ot` (optimize for time):

	<code>-Os</code>	<code>-Ot</code>
1 byte to release:	<code>PULA or PULB</code>	<code>LEAS #1, SP</code>
2 bytes to release:	<code>PULX, PULY or PULD</code>	<code>LEAS #2, SP</code>
3 bytes or more to release:	<code>LEAS #size, SP</code>	<code>LEAS #size, SP</code>

If the pragma `TRAP_PROC` is active, the `RTC/RTS` is replaced by an `RTI` instruction.

Calling a far Function

Calling a normal far function is done with `CALL/RTC`. The return address for far function is three bytes large. The offset of parameters not passed in a register is one larger than for near functions.

Far and near

The keywords `near` and `far` enable you to control the calling convention.

Example:

```
void far f(void);
void near g(void);

#pragma DATA_SEG NEAR my_near_seg

void h(void) {
    f();
    g();
}
```

The function `h` is compiled with the `near` calling convention, i.e. it ends with an `RTS` instruction. The call to `f` is done with the `far` calling convention, i.e. with a `CALL` instruction. The call to `g` is done with the `near` calling convention, i.e. with either a `BSR` or a `JSR` instruction. The difference between using the `near` and the `far`

keywords to using the pragma is that the pragma also specifies a segment. With the far keyword it is up to you to place a near function at a reachable address.

The default calling convention depends on the memory model. It is near for the SMALL memory model and far for the BANKED memory model.

The far keyword can also be used to specify a far data pointer. The keyword far is placed immediately after the "*" like the type qualifier const. If no keyword far is used, a data pointer will be 16 bits wide.

Pragmas

The Compiler provides a couple of pragmas that control the allocation of stack frames and the generation of entry and exit code.

TRAP_PROC

The procedure terminates with an RTI instruction instead of an RTS.

NO_ENTRY

Omits generation of procedure entry code.

NO_EXIT

Does not generate procedure exit code. It's the programmer's responsibility that the function does return somehow!

NO_FRAME

No stack frame is set up, but the Compiler generates an RTS/RTC (or RTI, if pragma TRAP_PROC is active).

Interrupt Functions

For interrupt procedures the compiler must handle two topics differently. First the function returns with a RTI. Second all modified registers must be saved. The processor registers D,X,Y are saved by the hardware. The Compiler must additionally save the page registers if they are to be modified inside of the function.

#pragma TRAP_PROC

Which page registers are saved is determined by `pragma TRAP_PROC`. The syntax of this pragma is

```
#pragma TRAP_PROC [SAVE_ALL_REGS | SAVE_NO_REGS]
```

If `TRAP_PROC SAVE_ALL_REGS` is used, all page registers are saved, whether they're used in the interrupt procedure or not. If `TRAP_PROC SAVE_NO_REGS` is given, no page registers are saved. If only `TRAP_PROC` is given, all page registers specified with the option `-Cp` are saved. It is up to you to ensure that no other page registers are modified.

NOTE The page registers are changed by paged data accesses. For details, see chapter "Paged Variables".

Interrupt Vector Table Allocation

The Compiler provides a non-ANSI compliant way to specify directly the interrupt vector number in the source:

```
void interrupt 0 ResetFunction(void) {
    /* reset handler */
}
```

The Compiler uses the following translation from interrupt vector number to interrupt vector address.

Vector Number	Vector Address	Vector Address Size
0	0xFFFFE, 0xFFFFF	2
1	0xFFFFC, 0xFFFFD	2
2	0xFFFFA, 0xFFFFB	2
...
n	0xFFFFF - (n*2)	2

Debug Information

The following debug information must be considered for the HC12 Compiler.

- There is no debug information for variables held in a register. This may happen if either register variables are enabled (option `-Or` to switch on), or variables are

allocated by the induction variable optimization (option -OI0 to switch it off, it is enabled by default). Additionally, the option -ou removes stores to local variables when possible. The last parameter of a function is passed in a register if its size is smaller or equal to four bytes. When this parameter is accessed while it is still in the register at function beginning, it is never stored to the stack. When a variable is never stored to the stack, no space is allocated for it and the debug information says that this variable is not allocated.

- The common code optimization does not generate any source positions inside common code. Some linear sequences may not contain any marker at all. Previous compiler versions did generate source position inside of common code. Then single stepping inside of such code did move the whole function. Seeing the source code, it is often not obvious which code is common code. The common code optimization is switched off with -Onf.
- The peephole BRA to RET optimization (-OnP=r) and the JSR RTS optimization causes the final RTS instruction at the end of a function to not always be executed. Setting a breakpoint at the last RTS will not always stop the application.
- The peephole JSR RTS optimization does remove the stack frame of a function from the stack before it is logically finished. Such functions disappear from the call chain. A step out from the last called function steps out two functions wide.
- The debugger does not know about constants in the code. Those constants may come from DC instructions (Assembler/HLI Assembler) or from tables used for switch processing. The disassembly module of the debugger tries to decode those constants as normal processor instructions.
- The debugger does not know about switch runtime routines. A step over a call of a switch runtime routine does not stop at the next statement. But source stepping does work. When the runtime routine is found, the debugger will step in. When the runtime routine is finished, the debugger will continue at the right place. It is recommended to not use step over at the switch selector.
- The long branch optimization replaces a long branch with a short one to a place which also branches to the same target. When debugging the intermediate branch instruction this does also occur, although there seems to be no relation to the code actually executed. Use -OnB=l to switch this optimization off.
- The short branch optimization replaces a branch always over two bytes or one byte with the opcodes "BNE" or "CPS #". In the second and third byte of this instruction, other assembler instructions are encoded. This situation is not known by the decoder or the assembly window of the simulator/debugger. It seems that some branches are targeting inside of BNE and CPS instructions. Please see the manual for details about this optimization. Use -OnB=a to switch this optimization off.
- The HIWARE object file format and ELF/DWARF 1.1 do not support multiple C source files. When several source files in one compilation unit contain code, the

debug information is correct only for the main file (the one noted on the command line). This problem arises from the fact that debug information formats do not support multiple source files. This is no limitation of the compiler/simulator/debugger. ELF/DWARF 2.0 fully supports this situation, where correct debugging is also possible. Please note that source code in header files is the usual case for C++ inline functions.

- ELF/Dwarf object files do not handle smart linking for data objects yet. Objects not linked by a smart linker just have address zero as debug information. In embedded applications, an object is placed at address zero so the debugger can not detect that such an object has been removed. Therefore, it lists such an object as a normal object.

C++ specific:

- Inline functions do not generate special debug information.
- Global object initialization / finalization functions generate special debug information. The functions generated to do this, have source positions over the whole module. But this debug information is not covered by all simulators/debuggers.
- The HIWARE object file format does not support special names for functions. Therefore the simulator shows the mangled names (types are encoded into the name) when using HIWARE object file format together with C++. When using ELF/DWARF 1.1 or ELF/DWARF 2.0 the correct names are displayed.
- The compiler-generated functions have no source. The source position emitted by the compiler is the position of the class.

Segmentation

The Linker memory space may be partitioned into several segments. The Compiler allows attributing a certain segment name to certain global variables or functions which then are allocated into that segment by the Linker. Where that segment actually lies is determined by an entry in the Linker parameter file.

There are two basic types of segments, code and data segments, each with a matching pragma:

```
#pragma CODE_SEG [ __NEAR_SEG | __FAR_SEG | __SHORT_SEG ] <name>
#pragma DATA_SEG
[ __DPAGE_SEG | __PPAGE_SEG | __EPAGE_SEG | __SHORT_SEG ] <n>
```

Both are valid until the next pragma of the same kind is encountered. If no segment is specified, the Compiler assumes two default segments named `DEFAULT_ROM` (the

default code segment) and `DEFAULT_RAM` (the default data segment). To explicitly make these default segments the current ones, use the segment name `DEFAULT`:

```
#pragma CODE_SEG DEFAULT
#pragma DATA_SEG DEFAULT
```

The additional keyword `__SHORT_SEG` informs the Compiler that a data segment is allocated in the zero page (address range from `0x0000` to `0x00FF`):

```
#pragma DATA_SEG __SHORT_SEG <segment_name>
```

or

```
#pragma DATA_SEG __SHORT_SEG DEFAULT
```

Using the zero page enables the Compiler to generate much denser code because *DIRECT* addressing mode is used instead of *EXTENDED*.

NOTE It's the programmer's responsibility to actually allocate `__SHORT_SEG` segments in the zero page in the Linker parameter file. For more information, see Linker.

The keywords `far` and `near` specify the calling convention for functions. `far` function calls are setting the `PPAGE`. `near` function calls must stay in the same page. In the *BANKED* memory model functions are `far` by default. In the *SMALL* memory model, functions are `near` by default.

The keywords `DPAGE`, `EPAGE` and `PPAGE` are used to specify the page register for paged variables. For details see "Paged Variables".

Optimizations

The Compiler applies a variety of code improving techniques commonly defined as "optimization". This section gives a short overview about the most important optimizations.

Lazy Instruction Selection

Lazy instruction selection is a very simple optimization that replaces certain instructions by shorter and/or faster equivalents. Examples are the use of `TSTA` instead of `CMPA #0` or using `COMB` instead of `EORB #0xFF`.

Peephole Optimizations

The peephole optimizer replaces longer code patterns with shorter ones. All peephole optimizations are switched off together with `-OnP` or each peephole optimization is switched off separately with the command line option `-OnP={<char>}`. Peephole optimization are not done for inline assembler code.

LEAS to PUSH/POP Optimization (-OnP=a to disable it)

```
LEAS -2,SP
```

is optimized to:

```
PSHD
```

This optimizations uses a PULL or a POP for a small SP changes instead of using a LEAS. This optimization is switched off by the command line option `-Ot`, optimize for time

POP PULL Optimization (-OnP=b to disable it)

```
PSHA  
PULA
```

A value is pushed and immediately afterwards popped again, so both instructions are removed.

Compare 0 Optimization (-OnP=c to disable it)

```
L2: LDD a  
    CPD #0  
    BNE L2
```

is optimized to:

```
L2: LDD a  
    BNE L2
```

This optimization avoids compares to 0 if the flags are already set by another instruction.

Load/Store Optimization (-OnP=d to disable it)

```
STD a  
LDD a
```

is optimized to:

```
STD a
```

This optimization removes redundant loads and stores. The load/store optimization traces the used registers and the memory. The optimization is only done if neither the registers are modified nor the memory is accessed.

LEA/LEA Optimization (-OnP=e to disable it)

This optimization doesn't work if there are instructions between the two LEA's (for that case use optimization above).

```
LEAX 2, X
LEAX 2, X
```

is optimized to:

```
LEAX 4, X
```

Load/Store to POP/PUSH Optimization (-OnP=f to disable it)

```
STD 2, -SP
```

is optimized to:

```
PSHD
```

Instead of creating PULL and POP instruction, the Compiler generates normal load and stores to the stack with explicit stackpointer changes. Such instructions can sometimes be combined with explicit stackpointer changes. Otherwise, the load and store operations are converted by peephole optimization into PULL and POP instructions.

Load Arithm Store Optimization (-OnP=g to disable it)

```
LDAA c
INCA
STAA c
```

is optimized to:

```
INC c
```

and

```
LDAA 0, Y
ANDA #0x0f
STAA 0, Y
```

is optimized to:

```
BCLR 0, Y, #240
LDAA 0, Y
```

JSR/RTS Optimization (-OnP=h to disable it)

```
JSR function  
RTS
```

is optimized to:

```
JMP function
```

NOTE This optimization removes stack frames before calling other functions. While debugging, this optimization removes functions from the call chain when the last function is called, and not when this function is actually finished. For better debug information, this optimization can selectively be switched off by using the option “-OnP=h”.

INC/DEC Compare Optimization (-OnP=i to disable it)

```
L3: ADDD #1  
    BNE L3
```

is optimized to:

```
L3: IBNE D,L3
```

Store Optimization (-OnP=j to disable it)

```
STD b  
INCA  
STD b
```

is optimized to:

```
INCA  
STD b
```

The store/store optimization traces only the memory accesses. The optimization is done only if no memory access occurs between the two stores.

LEA 0 Optimization (-OnP=k to disable it)

```
LEAS 0,SP
```

is optimized to:

```
/* no instruction */
```

LEA into Addressing Mode Optimization(-OnP=l to disable it)

```
LEAS 2,SP  
STD 0,SP
```

is optimized to:

```
STD 2,+SP
```

and

```
LEAS 2,SP  
STD 2,+SP
```

is optimized to:

```
STD 4,+SP
```

The compiler tries to move LEAX, LEAY and LEAS instruction into register indirect memory accesses. The LEA into addressing mode optimization includes also a LEA/LEA optimization. The other LEA/LEA optimization does not handle instructions between the two LEAs.

```
LEAX 2,X  
NOP  
LEAX 2,X
```

is optimized to:

```
NOP  
LEAX 4,X
```

RTS/RTS Optimization (-OnP=m to disable it)

```
RTS  
RTS
```

is optimized to:

```
RTS
```

BCLR, BCLR Optimization (-OnP=n to disable it)

```
BCLR 0,Y, 0x01  
BCLR 0,Y, 0x02
```

is optimized to:

```
BCLR 0,Y,#3
```


PULL POP Optimization (-OnP=p to disable it)

```
PULA  
PSHA  
CLRA
```

is optimized to:

```
CLRA
```

BRA to RTS Optimization (-OnP=r to disable it)

```
    BRA lrts  
    ...  
lrts: RTS
```

is optimized to:

```
    RTS  
    ...  
lrts: RTS
```

Unconditional branches to an RTS are directly replaced with an RTS.

NOTE	When debugging, it may happen that a function finishes although there is a breakpoint at the last instruction. This is avoided with this option.
-------------	--

TFR/TFR Optimization (-OnP=t to disable it)

```
TFR D,X  
TFR D,X
```

is optimized to:

```
TFR D,X
```

Unused Optimization (-OnP=u to disable it)

```
INCA  
CLRA  
STAA a
```

is optimized to:

```
CLRA  
STAA a
```

PSHC PULC optimization (-OnP=q to disable it)

With the options [-Or](#) or [-Ol](#), the compiler sometimes generates unnecessary PSHC and PULC instructions during code generation. When some stores, loads and transfers are done before the instruction sets some flags, the PSHC and PULC are not necessary. The compiler does this in order for the peephole optimizer to remove them, wherever possible. This optimization actually improves intentionally generated code patterns. This optimization moves the loads, stores and transfers and removes the PSHC and PULC, if possible.

```
LDAA 0,SP
PSHC
LDX 2,SP
PULC
```

is optimized to:

```
LDX 1,SP
LDAA 0,SP
```

Removing unnecessary compare instruction (-OnP=v to disable it)

This optimization removes unnecessary compare instructions in following case:

With -OnP=v:

```
CPX <opr>
BLE L1
CPX <opr>           ; This is the unnecessary compare instruction
BNE L2
...
```

Without -OnP=v:

```
CPX <opr>
BLE L1
BNE L2
...
```

The remove may also be disabled by setting the 'volatile' attribute for <opr>.

Branch Optimizations

The Compiler uses branch instructions with 1-byte offsets whenever possible. Additionally, other optimizations for branches are also available.

Short BRA Optimization (-OnB=a to disable it)

A branch over one byte is replaced with the opcode of "BRN". A branch over two bytes is replaced with the opcode of "CPS #".

Example:

```
int q(void) {
    if (f()) {
        return 1;
    } else {
        return 0;
    }
}
```

The code produced with this optimization:

```
0000 160000 JSR    f
0003 044403 TBEQ   D,3    ;abs = 0009
0006 C601   LDAB   #1
0008 21C7   BRN    -57   ;abs = FFD1
000A 87     CLRA
000B 3D     RTS
```

With the Option -OnB=a (disable short BRA optimization) the Compiler produces one byte more:

```
0000 160000 JSR    f
0003 044404 TBEQ   D,4    ;abs = 000A
0006 C601   LDAB   #1
0008 2001   BRA    1    ;abs = 000B
000A C7     CLR   B
000B 87     CLRA
000C 3D     RTS
```

The branch optimizer replaces the "BRA 1" in the second example with the opcode of "BRN", 0x21. Then the Decoder joins the BRN with the CLR B to one BRN. Actually the Decoder writes something like the following:

```
0008 21     "BRA 1"
000A C7     CLR   B
```

The CLR B out of the second code disappears in the first listing into the offset of the BRN instruction. The same type of optimization is also done with a "BRA 2". Then the opcode of a "CPS #" is taken.

NOTE BRN and CPS in a Decoder listing are often the result of this optimization. If so, one or two additional machine instructions are

hidden after the opcode. The compiler will write this as SKIP1 or SKIP2 pseudo opcode to the listing file.

Branch JSR to BSR Optimization (-OnB=b to disable it)

This optimization uses a BSR instead of a JSR, if the offset is small enough and known.

Long Branch Optimization (-OnB=l to disable it)

This optimization tries to replace a long branch with a short branch to another branch, which branches to the same target.

Example:

```
    ...
    LBNE 10
    ...
    LBNE 10
    // more than 0x80 bytes of code
10:  ...
```

This situation is recognized and replaced with the following:

```
    ...
    BNE 11
    ...
11:  LBNE 10
    // more than 0x80 bytes of code
10:  ...
```

Branch Tail Optimization (-OnB=t to disable it)

Branch tail merging removes common code if the common code patterns branch to the same place.

Constant Folding

Constant folding options only affect constant folding over statements. The constant folding inside of expressions is always done.

Volatile Objects

The Compiler does not do register tracing on volatile objects. Accesses to volatile objects are not eliminated. It also doesn't change word operations to byte operations on volatile objects as it does for other memory accesses.

Programming Hints

The MC68HC12 is an 8/16-bit processor not designed with high-level languages in mind. You must observe certain points in order to allow the Compiler to generate reasonably efficient code. The following list provides an idea of what is "good" programming from the processor's point of view.

- Allocate frequently used static variables in the zero page using `__SHORT_SEG` segments.
- Use variables of type `char` if the value range is large enough for your purpose (0 - 255 for unsigned `char`; -128 - 127 for signed `char`).

Consider however that expressions containing both `char` and `int` variables usually are worse than equivalent expressions containing only `int` variables because the `char` variables have to be extended first. The same also holds for certain expressions on characters like

```
char a, b, c, d;  
a = (b + c) / d;
```

or

```
if (a+1 < b) ...
```

because they must be evaluated to 16 bits to comply to the semantics of ANSI-C.

Using unsigned types instead of signed types is better in the following cases:

- Implicit or explicit extensions from `char` to `int` or from `int` to `long`.
- Use types `long`, `float` or `double` only when absolutely necessary. They produce a lot of code!
- Avoid stack frames larger than 256 bytes. The stack frame includes the parameters, local variables and usually some additional bytes for temporary values.
- Avoid `structs` larger than 256 bytes if the fields are accessed via pointers.

High Level Inline Assembler for Motorola HC12

The HLI (High Level Inline) Assembler provides a means to make full use of the properties of the target processor right within a C program. There is no need to write a separate assembly file, assemble it and later bind it with the rest of the application written in ANSI-C/C++ with the inline assembler. The Compiler does all that work for you. For further information, please refer to the HC12 Reference Manual.

Syntax

Inline assembly statements can appear anywhere a C statement can appear (an `asm` statement must be inside a C function). Inline assembly statements take one of two forms, shown in various configurations:

```
"asm" <Assembly Instruction> ";" ["/*" Comment "*/"]  
"asm" <Assembly Instruction> ";" ["//" Comment]
```

or

```
"asm" "{ "  
  { <Assembly Instruction> [";" Comment] "\n" }  
  }"
```

or

```
"asm" " (" <Assembly Instruction> ";" ["/*" Comment "*/"]  
)" " ";"
```

or

```
"asm" [" (" ] <string Assembly instruction > [")"] [";"]  
with   <string Assembly instruction >  
=     <Assembly Instruction> [";" <Assembly instruction>]
```

or

```
"#asm"  
<Assembly Instruction> [";" Comment] "\n"  
"#endasm"
```

If you use the first form, multiple `asm` statements are contained on one line and comments are delimited like regular C or C++ comments. If you use the second form, one to several assembly instructions are contained within the `asm` block, but only one assembly instruction per line is possible and the semicolon starts an assembly comment.

Mixing HLI Assembly and HLL

Mixing High Level Inline (HLI) Assembly with a High Level Language (HLL, e.g. C or C++) requires special attention. The Compiler does not care about used/modified registers in HLI Assembly, thus you have save/restore registers which are used in HLI. This is not a problem if a function contains HLI Assembly only. It is recommended to place complex HLI Assembly code, or HLI Assembly code modifying any registers, into separate functions.

Example:

```
void foo(void) {
    /* some C statements */
    p->v = 1;
    asm {
        /* some HLI statements destroying registers */
    }
    /* some C statements */
    p->v = 2;
}
```

In the above sequence, the Compiler holds the value of p in a register. If the register is modified in the HLI block, this may crash your code.

Example

A simple example illustrates the use of the HLI-Assembler. Assume the following:

- from points to some memory area
- to points to some other, non-overlapping memory area.

Then we can write a simple string copying function in assembly language as follows (we assume the *SMALL* memory model):

```
#pragma NO_ENTRY
void strcpy (char *from, char *to)
    /* 'to' is passed in D
       'from' is passed on the stack SP:2 */
{
    asm {
        TFR    D,X
        LDY    2,SP
    loop:
        LDAA  1,Y+
        STAA  1,X+
        BNE   loop
    }
```



```
}  
}
```

NOTE If `#pragma NO_ENTRY` is not set, the Compiler takes care of entry and exit code. You do not have to worry about setting up a stack frame.

C Macros

The C macros are expanded inside of inline assembler code as they are expanded in C. One special point to note is the syntax of `asm` directive generated by macros. As macros always expand to one single line, only the first form of the `asm` keyword is used in macros:

```
asm NOP;
```

E.g.

```
#define SPACE_OK { asm NOP; asm NOP; }
```

Using the second form is illegal:

```
#define NOT_OK { asm { \  
                    NOP; \  
                    NOP; \  
                } }
```

The macro, `NOT_OK`, is expanded by the preprocessor to one single line, which is then incorrectly translated because every assembly instruction must be explicitly terminated by a newline. Use the [pragma NO_STRING_CONSTR to build immediates by using #](#) inside macros.

Special Features

Caller/Callee Saved Registers

Because the compiler does not save any registers on the caller/callee side, you do not have to save or restore any registers in the HLI over function calls.

Reserved Words

The inline assembler knows a couple of reserved words, which must not collide with user defined identifiers such as variable names. These reserved words are:

- All opcodes (LDAA, STX, ...)
- All register names (A, B, D, X, Y, CCR, SP)
- The identifier PAGE

For these reserved words, the inline assembler is *not* case sensitive, i.e. LDAB is the same as ldab or even LdAb. For all other identifiers (labels, variable names and so on) the inline assembler is case sensitive.

Pseudo-Opcodes

The inline assembler provides some pseudo opcodes to put constant bytes into the instruction stream. These are:

```
DC.B 1      ; Byte constant 1
DC.B 0      ; Byte constant 0
DC.W 12     ; Word constant 12
DC.L 20,23  ; Longword constants
```

Accessing Variables

The inline assembler allows accessing local and global variables declared in C by using their name in the instruction. Global variable names are translated into *EXTENDED* or *DIRECT* addressing mode, depending on the segment the variable is in.

Constant Expressions

Constant expressions may be used anywhere an *IMMEDIATE* value is expected. They may contain the binary operators for addition ("+"), subtraction ("-"), multiplication ("*"), and division ("/"). Also, the unary operator "-" is allowed. Round brackets may be used to force an evaluation order other than the normal one. The syntax of numbers is the same as in ANSI-C.

Addresses of Variables

A constant expression may also be the address of a global variable or the offset of a local variable.

```
AddrOfVar = "@" Variable.
```

Examples:

```
LDX @g ; Load X with address of global variable
LDY @l ; Load Y with frame offset of local variable or param
```

It is also possible to access the fields of a struct or a union by using the normal ANSI-C notation.

```
LDD r.f ; Load D with content of field f.
```

The inline assembler enables you to specify an offset from the address of a variable in order to access the low word of a long or a float variable:

```
Offset          = ":" ConstExpr.
Variable        = Ident {"." Ident}.
```

Some examples (assume all variables are long):

```
LDY @g:2 ; Load Y with ((address of g) + 2)
LDX g:2 ; Load X with the value stored there
LDD r.f:2 ; Load D with low word of field f.
```

This feature may also be used to access array elements with a constant index:

```
int a[20];
LDD a:24 ; Load a[12] into D
```

In the *BANKED* memory model, it is sometimes necessary to specify the bank number of the memory bank a particular function is allocated in.

Using the Compiler

High Level Inline Assembler for Motorola HC12

Messages

This chapter describes the messages produced by the application. Because of the large amount of different messages, not all of them may be in this document as of this release.

Message Kinds

The Compiler generates five kinds of messages:

- INFORMATION

A message is printed and the compilation continues. Information messages indicate actions taken by the application.

- WARNING

A message is printed and processing continues. Warning messages indicate possible programming errors.

- ERROR

A message is printed and processing is stopped. Error messages indicate illegal use of the language.

- FATAL

A message is printed and processing is aborted. A fatal message indicates a severe error which will stop processing.

- DISABLE

The message has been disabled. No message is issued and processing continues as if there was no such message. The application ignores this kind of message.

Message Details

If the application prints out a message, the message contains a message code and a four to five digit number. This number may be used to search for the indicated message.

The following message codes are supported:

- “A” for Assemblers
- “B” for Burner
- “C” for Compilers
- “D” for Decoder
- “L” for Linker
- “LM” for Libmaker
- “M” for Maker

All messages generated by the application are documented in increasing numerical order for easy and fast retrieval. Each message also has a description and if available, a short example with a possible solution or tips to fix a problem.

For each message the type of the message is also noted, e.g. [ERROR] indicates that the message is an error message.

[DISABLE, INFORMATION, WARNING, ERROR]

This indicates that the message is a warning message by default. You can change the message either to DISABLE, INFORMATION or ERROR.

After the message kind, there may be an additional entry telling for which language the message is generated:

- C++: Message is generated for C++
- M2: Message is generated for Modula-2

Message List

The following pages describe all messages.

All message numbers below 10000 are common to all compilers. Not every compiler emits all of them. For example, many compilers support any type of struct return. Such compilers will never emit the message “C2500: Expected: No support of class/struct return type”.

C1: Unknown message occurred

[FATAL]

Description

The application tried to emit a message which was not defined. This is an internal error which should not occur. Please report any occurrences to your distributor.

Tips

Try to find out the and avoid the reason for the unknown message.

C2: Message overflow, skipping <kind> messages

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The application did show the number of messages of the specific kind as controlled with the options [-WmsgNi](#), [-WmsgNw](#) and [-WmsgNe](#). Further options of this kind are not displayed.

Tips

Use the options [-WmsgNi](#), [-WmsgNw](#) and [-WmsgNe](#) to change the number of messages.

C50: Input file '<file>' not found

[FATAL]

Description

The Application was not able to find a file needed for processing.

Tips

Check if the file really exists. Check if you are using a file name containing spaces (in this case you have to quote it).

C51: Cannot open statistic log file <file>

[DISABLE, INFORMATION, WARNING, ERROR]

Description

It was not possible to open a statistic output file, therefore no statistics are generated.

Note: Not all tools support statistic log files. Even if a tool does not support it, the message still exists, but is never issued in this case.

C52: Error in command line <cmd>

[FATAL]

Description

In case there is an error while processing the command line, this message is issued.

C64: Line Continuation occurred in <FileName>

[DISABLE, INFORMATION, WARNING, ERROR]

Description

In any environment file, the character '\' at the end of a line is taken as line continuation. This line and the next one are handles as one line only. Because the path separation character of MS-DOS is also '\', paths are often incorrectly

written ending with '\'. Instead use a '.' after the last '\' to not finish a line with '\' unless you really want a line continuation.

Example

Current Default.env:

```
...
LIBPATH=c:\metrowerks\lib\
OBJPATH=c:\metrowerks\work
...
Is taken identical as
...
LIBPATH=c:\metrowerks\libOBJPATH=c:\metrowerks\work
...
```

Tips

To fix it, append a '.' behind the '\'.

```
...
LIBPATH=c:\metrowerks\lib\
OBJPATH=c:\metrowerks\work
...
```

Note

Because this information occurs during the initialization phase of the application, the message prefix might not occur in the error message. So it might occur as "64: Line Continuation occurred in <FileName>".

C65: Environment macro expansion message '<description>' for <variable name>

[DISABLE, INFORMATION, WARNING, ERROR]

Description

During a environment variable macro substitution an problem did occur. Possible causes are that the named macro did not exist or some length limitation was reached. Also recursive macros may cause this message.

Example

Current variables:

```
...  
LIBPATH=${LIBPATH}  
...
```

Tips

Check the definition of the environment variable.

C66: Search path <Name> does not exist

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The tool did look for a file which was not found. During the failed search for the file, a non existing path was encountered.

Tips

Check the spelling of your paths. Update the paths when moving a project. Use relative paths.

C1000: Illegal identifier list in declaration

[ERROR]

Description

A function prototype declaration had formal parameter names, but no types were provided for the parameters.

Example

```
int f(i);
```

Tips

Declare the types for the parameters.

C1001: Multiple const declaration makes no sense

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The "constant" qualifier was used more than once for the same variable.

Example

```
const const int i;
```

Tips

Constant variables need only one "constant" qualifier.

See also

Qualifiers

C1002: Multiple volatile declaration makes no sense

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The "volatile" qualifier was used more than once for the same variable.

Example

```
volatile volatile int i;
```

Tips

Volatile variables need only one "volatile" qualifier.

C1003: Illegal combination of qualifiers

[ERROR]

Description

The combination of qualifiers used in this declaration is illegal.

Example

```
int *far near p;
```

Tips

Remove the illegal qualifiers.

C1004: Redefinition of storage class

[ERROR]

Description

A declaration contains more than one storage class.

Example

```
static static int i;
```

Tips

Declare only one storage class per item.

C1005: Illegal storage class

[ERROR]

Description

A declaration contains an illegal storage class.

Example

```
auto int i; // 'auto' illegal for globals
```

Tips

Apply a correct combination of storage classes.

See also

Storage Classes

C1006: Illegal storage class

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A declaration contains an illegal storage class. This message is used for storage classes which makes no sense and are ignored (e.g. using 'register' for a global variable).

Example

```
register int i; //'register' for globals
```

Tips

Apply a correct combination of storage classes.

C1007: Type specifier mismatch

[ERROR]

Description

The type declaration is wrong.

Example

```
int float i;
```

Tips

Do not use an illegal type chain.

C1008: Typedef name expected

[ERROR]

Description

A variable or a structure field has to be either one of the standard types (char, int, short, float, ...) or a type declared with a typedef directive.

Example

```
struct A {  
    type j; /* type is not known */  
} A;
```

Tips

Use a typedef-name for the object declaration.

C1009: Invalid redeclaration

[ERROR]

Description

Classes, structures and unions may be declared only once. Function redeclarations must have the same parameters and return values as the original declaration. In C++, data objects cannot be redeclared (except with the "extern" specifier).

Example

```
struct A {  
    int i;  
};  
  
struct A { // error  
    int i;  
};
```

Tips

Avoid redeclaration, e.g. guarding include files with '#ifndef'.

C1010: Illegal enum redeclaration

[ERROR]

Description

An enumeration has been declared twice.

Example

```
enum A {  
    B  
};  
  
enum A { //error  
    B  
};
```

Tips

Enums have to be declared only once.

C1012: Illegal local function definition

[ERROR], C++

Description

Non-standard error!

Example

```
void main() {
    struct A {
        void f() {}
    };
}
```

Tips

The function definitions must always be in the global scope.

```
void main(void) {
    struct A {
        void f();
    };
}

void A::f(void) {
    // function definition in global scope
}
```

C1013: Old style declaration

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The compiler has detected an old style declaration. Old style declarations are common in old non-ANSI sources, however they are accepted. With old style declarations, only the names are in the parameter list and the names and types are declared afterwards.

Example

```
foo(a, b)
    int a, long b;
{
    ...
}
```


Tips

Remove such old style declarations from your application:

```
void foo(int a, long b) {  
    ...  
}
```

C1014: Integral type expected or enum value out of range

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A non-integral value was assigned to a member of an enum or the enumeration value does not fit into the size specified for the enum (in ANSI-C the enumeration type is int).

Example

```
enum E {  
    F="Hello"  
};
```

Tips

Enum-members may only get int-values.

C1015: Type is being defined

[ERROR]

Description

The given class or structure was declared as a member of itself. Recursive definition of classes and structures are not allowed.

Example

```
struct A {  
    A a;  
};
```

Tips

Use a pointer to the class being defined instead of the class itself.

C1016: Parameter redeclaration not permitted

[ERROR]

Description

A parameter object was declared with the same name as another parameter object of the same function.

Example

```
void f(int i, int i);
```

Tips

Choose another name for the parameter object with the already used name.

C1017: Empty declaration

[ERROR]

Description

A declaration cannot be empty.

Example

```
int;
```

Tips

There must be a name for an object.

C1018: Illegal type composition

[ERROR]

Description

The type was composed with an illegal combination.

A typical example is

```
extern struct A dummy[];
```

An array type describes a contiguously allocated nonempty set of objects with a particular member object type, called the element type. Since object types do not include incomplete types, an array of incomplete type cannot be constructed.

Example

```
void v[2];
```

Tips

Type compositions must not contain illegal combinations.

C1019: Incompatible type to previous declaration

[ERROR]

Description

The specified identifier was already declared

Example

```
int i;  
int i();
```

Tips

Choose another name for the identifier of the second object.

C1020: Incompatible type to previous declaration

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The specified identifier was already declared with different type modifiers. If the option [-Ansi](#) is enabled, this warning becomes an error.

Example

```
int i;  
int i();
```

Tips

Use the same type modifiers for the first declaration and the redeclaration.

C1021: Bit field type is not 'int'

[ERROR]

Description

Another type than 'int' was used for the bitfield declaration. Some Back Ends may support non-int bitfields, but only if the Compiler switch [-Ansi](#) is not given.

Example

```
struct {  
    char b:1;  
} S;
```

Tips

Use 'int' type for bitfields or remove the [-Ansi](#) from the Compiler options.

See also

Message C1106

C1022: 'far' used in illegal context

[ERROR]

Description

'far', 'rom' or 'uni' has been specified for an array parameter where it is not legal to use it. In ANSI C, passing an array to a function always means passing a pointer to the array, because it is not possible to pass an array by value. To indicate that the pointer is a non-standard pointer, non-standard keywords as 'near' or 'far' may be specified if supported.

Example

```
void foo(int far a) {}; /* error */  
void foo(ARRAY far ap) {} /* ok: passing a far pointer */
```

Tips

Remove the illegal modifier.

C1023: 'near' used in illegal context

[ERROR]

Description

'far', 'rom' or 'uni' has been specified for an array parameter where it is not legal to use it. In ANSI C, passing an array to a function always means passing a pointer to the array, because it is not possible to pass an array by value. To indicate that the pointer is a non-standard pointer, non-standard keywords as 'near' or 'far' may be specified if supported.

Example

```
void foo(int near a) {}; /* error */  
void foo(ARRAY near ap) {} /* ok: passing a near pointer */
```

Tips

Remove the illegal modifier.

C1024: Illegal bit field width

[ERROR]

Description

The type of the bit field is too small for the number of bits specified.

Example

```
struct {  
    int b:1234;  
} S;
```

Tips

Choose a smaller number of bits, or choose a larger type of the bitfield (if the backend allows such a non-standard extension).

C1025: ';' expected before '...'

[ERROR]

Description

An open parameter list was declared without a ',' before the '...'.

Example

```
void foo(int a ...);
```

Tips

Insert a ',' before the '...'.

C1026: Constant must be initialized

[ERROR], C++

Description

The specified identifier was declared as const but was not initialized.

Example

```
const int i;           // error
extern const int i;    // ok
```

Tips

Initialize the constant object, or remove the 'const' specifier from the declaration.

C1027: Reference must be initialized

[ERROR], C++

Description

A reference was not initialized when it was declared.

Example

```
int j;
int& i /* = j; missing */
```

Tips

Initialize the reference with an object of the same type as the reference points to.

C1028: Member functions cannot be initialized

[ERROR], C++

Description

A member function of the specified class was initialized.

Tips

Do not initialize member functions in the initialization list for a class or structure.

C1029: Undefined class

[ERROR], C++

Description

A class is used which is not defined/declared.

Example

```
class A;  
class B {  
    A::I i; // error  
};
```

Tips

Define/declare a class before using it.

C1030: Pointer to reference illegal

[ERROR], C++

Description

A pointer to a reference was declared.

Example

```
void f(int & * p);
```

Tips

The variable must be dereferenced before a pointer to it can be declared.

C1031: Reference to reference illegal

[ERROR], C++

Description

A reference to a reference was declared.

Tips

This error can be avoided by using pointer syntax and declaring a reference to a pointer.

C1032: Invalid argument expression

[ERROR], C++

Description

The argument expression of a function call in a Ctor-Init list was illegal.

Example

```
struct A {
    A(int i);
};

struct B : A {
    B();
};

B::B() : A(3) { // error
}
```

Tips

In the argument expression of a Ctor-Init function call, there must be the same number of "(" as ")".

C1033: Ident should be base class or data member

[ERROR], C++

Description

An object in an initialization list was not a base class or member.

Example

```
class A {
    int i;
    A(int j) : B(j) {} // error
};
```

Tips

Only a member or base class can be in the initialization list for a class or structure.

C1034: Unknown kind of linkage

[ERROR], C++

Description

The indicated linkage specifier was not legal. This error is caused by using a linkage specifier that is not supported.

Example

```
extern "MODULA-2" void foo(void);
```

Tips

Only the "C" linkage specifier is supported.

C1035: Friend must be declared in class declaration

[ERROR], C++

Description

The specified function was declared with the friend specifier outside of a class, structure or union.

Example

```
friend void foo(void);
```

Tips

Do not use the friend specifier outside of class, structure or union declarations.

C1036: Static member functions cannot be virtual

[ERROR], C++

Description

A static member function was declared as virtual.

Example

```
class A {  
    static virtual f(void); // error  
};
```

Tips

Do not declare a static member function as virtual.

C1037: Illegal initialization for extern variable in block scope

[ERROR]

Description

A variable with extern storage class cannot be initialized in a function.

Example

```
void f(void) {  
    extern int i= 1;  
}
```

Tips

Initialize the variable, where it is defined.

C1038: Cannot be friend of myself

[DISABLE, INFORMATION, WARNING, ERROR], C++

Description

The friend specifier was applied to a function/class inside the scope resolution of the same class.

Example

```
class A {  
    friend A::f(); //treated by the  
};           // compiler as "friend f();"
```

Tips

Do not write a scope resolution to the same class for a friend of a class.

C1039: Typedef-name or ClassName expected

[ERROR]

Description

In the current context either a typedef name or a class name was expected.

Example

```
struct A {  
    int i;  
};  
  
void main() {  
    A *a;  
    a=new a; // error  
}
```

Tips

Write the ident of a type or class/struct tag.

C1040: No valid :: classname specified

[ERROR], C++

Description

The specified identifier after a scope resolution was not a class, structure, or union.

Example

```
class B {  
    class A {  
    };  
};  
  
class C : B::AA { // AA is not valid  
};
```

Tips

Use an identifier of an already declared class, structure, or union.

C1041: Multiple access specifiers illegal

[ERROR], C++

Description

The specified base class had more than one access modifier.

Tips

Use only one access modifier (public, private or protected).

C1042: Multiple virtual declaration makes no sense

[DISABLE, INFORMATION, WARNING, ERROR], C++

Description

The specified class or structure was declared as virtual more than once.

Tips

Use only one virtual modifier for each base class.

C1043: Base class already declared in base list

[ERROR], C++

Description

The specified class (or structure) appeared more than once in a list of base classes for a derived class.

Example

```
class A {};  
class B: A, A {  
};
```

Tips

Specify a direct base class only once.

C1044: User defined Constructor is required

[ERROR], C++

Description

A user-defined constructor should be defined. This error occurs when a constructor should exist, but cannot be generated by the Compiler for the class.

Example

```
class A {  
    const int i;  
};
```

The compiler can not generate a constructor because he does not know the value for i.

Tips

Define a constructor for the class.

C1045: <Special member function> not generated

[DISABLE, INFORMATION, WARNING, ERROR], C++

Description

The Compiler option [-Cn=Ctr](#) disabled the creation of Compiler generated special member functions (Copy Constructor, Default Constructor, Destructor, Assignment operator).

Tips

If you want the special member functions to be generated by the Compiler, disable the Compiler option [-Cn=Ctr](#).

C1046: Cannot create compiler generated <Special member function> for nameless class

[ERROR], C++

Description

The Compiler could not generate a special member function (Copy Constructor, Default Constructor, Destructor, Assignment operator) for the nameless class.

Example

```
class B {
public:
    B();
};

class {
    B b;
} A;
```

Tips

Give a name to nameless class.

C1047: Local compiler generated <Special member function> not supported

[DISABLE, INFORMATION, WARNING, ERROR], C++

Description

Local class declarations would force the compiler to generate local special member functions (Copy Constructor, Default Constructor, Destructor, Assignment operator). But local functions are not supported.

Example

```
;
```

Tips

If you really want the compiler generated special member functions to be created, then declare the class (or struct) in the global scope.

C1048: Generate compiler defined <Special member function>

[DISABLE, INFORMATION, WARNING, ERROR], C++

Description

A special member function (Copy Constructor, Default Constructor, Destructor, Assignment operator) was created by the compiler.

When a class member or a base class contains a Constructor or a Destructor, then the new class must also have this special function so that the base class Constructor or Destructor is called in every case. If the user does not define one, then the compiler automatically generates one.

Example

```
struct A {  
    A(void);  
    A(const A&);  
    A& operator =(const A& );  
};
```

```
    ~A();  
};  
struct B : A {  
};
```

Tips

If you do not want the compiler to generate the special member functions, then enable the option [-Cn=Ctr](#).

The compiler only calls a compiler generated function if it is really necessary. Often a compiler generated function is created, but then never called. Then the smart linker does not waste code space for such functions.

C1049: Members cannot be extern

[ERROR], C++

Description

Class member cannot have the storage class "extern".

Example

```
class A {  
    extern int f();  
};
```

Tips

Remove the "extern" specifier.

C1050: Friend must be a class or a function

[ERROR], C++

Description

The "friend"-specifier can only be used for classes (or structures or unions) and functions.

Example

```
typedef int I;  
struct A {  
    friend I; // illegal  
};
```

Tips

Use the "friend" specifier only for classes (or structures or unions) and functions.

C1051: Invalid function body

[ERROR]

Description

The function body of a member function inside a class declaration is invalid.

Example

```
struct A {  
    void f() { {{int i; }  
};
```

Tips

The function body of a member function inside a class declaration must have the same number of "{" as "}".

C1052: Unions cannot have class/struct object members containing Con/Destructor/Assign-Operator

[ERROR], C++

Description

The specified union member was declared with a special member (Con/Destructor/Assign-Operator).

Example

```
class A {  
    A(void);  
};  
  
union B {  
    A a;  
};
```

Tips

The union member may contain only compiler generated special members. So try to compile with the option [-Cn=Ctr](#) enabled.

C1053: Nameless class cannot have member functions

[ERROR], C++

Description

A function was declared in a nameless class.

Example

```
class {  
    void f(void);  
};
```

Tips

Name the nameless class, or remove all member functions of the nameless class.

C1054: Incomplete type or function in class/struct/union

[ERROR], C++

Description

A used type in a function, class, struct or union was not completely defined.

Example

Tips

Define types before using them.

C1055: External linkage for class members not possible

[ERROR], C++

Description

Member redeclarations cannot have external linkage.

Example

```
struct A {  
    f();  
}a;  
  
extern "C" A::f() {return 3;}
```

Tips

Do not declare members as extern.

C1056: Friend specifier is illegal for data declarations

[ERROR], C++

Description

The friend specifier cannot be used for data declarations.

Example

```
class A {  
    friend int a;  
};
```

Tips

Remove the friend specifier from the data declaration.

C1057: Wrong return type for <FunctionKind>

[ERROR], C++

Description

The declaration of a function of *FunctionKind* contained an illegal return type.

Tips

Depending on FunctionKind:

- operator -> must return a pointer or a reference or an instance of a class, structure or union
 - operator delete must return "void"
 - operator new must return "void *"
-

C1058: Return type for FunctionKind must be <ReturnType>

[ERROR], C++

Description

Some special functions must have certain return types. An occurred function did have an illegal return type.

Tips

Depending on FunctionKind:

- operator -> must return a pointer or a reference or an instance of a class, structure or union
 - operator delete must return "void"
 - operator new must return "void *"
-

C1059: Parameter type for <FunctionKind> parameter <No> must be <Type>

[ERROR], C++

Description

The declaration of a function of FunctionKind has a parameter of a wrong type.

Tips

Depending on FunctionKind:

- operator new parameter 1 must be “unsigned int”
- operator delete parameter 1 must be “void *”
- operator delete parameter 2 must be “unsigned int”

C1060: <FunctionKind> wrong number of parameters

[ERROR], C++

Description

The declaration of a function of FunctionKind has a wrong number of parameters

Tips

Depending on FunctionKind:

- member operator delete must have one or two parameters

C1061: Conversion operator must not have return type specified before operator keyword

[ERROR], C++

Description

A user-defined conversion cannot specify a return type.

Example

```
class A {  
    public:  
        int operator int() {return value;} //error  
        operator int() {return value;}    // ok  
    private:  
        int value;  
}
```

Tips

Do not specify a return type before the operator keyword.

C1062: Delete can only be global, if parameter is (void *)

[ERROR], C++

Description

Global declarations/definitions of operator delete are allowed to have only one parameter.

Tips

Declare only one parameter for the global delete operator.

Or declare the delete operator as a class member, where it can have 2 parameters.

C1063: Global or static-member operators must have a class as first parameter

[ERROR], C++

Description

The specified overloaded operator was declared without a class parameter.

Example

```
int operator+ (int, int); // error;
```

Tips

The first parameter must be of class type.

C1064: Constructor must not have return type

[ERROR], C++

Description

The specified constructor returned a value, or the class name is used for a member.

Example

```
struct C {  
    int C(); // error  
    C();    // ok  
};
```

Tips

Do not declare a return type for constructors.

C1065: 'inline' is the only legal storage class for Constructors

[ERROR], C++

Description

The specified constructor has an illegal storage class (auto, register, static, extern, virtual).

Tips

The only possible storage class for constructors is "inline".

C1066: Destructor must not have return type

[ERROR], C++

Description

The specified destructor returned a value.

Example

Tips

Do not declare a return type for destructors.

C1067: Object is missing decl specifiers

[ERROR]

Description

An object was declared without decl-specifiers (type, modifiers, ...). There is no error, if compiling C-source without the [-ANSI](#) option.

Example

```
i
```

Tips

Apply decl-specifiers for the object, or compile without the options [-ANSI](#) and [-C++](#).

C1068: Illegal storage class for Destructor

[ERROR], C++

Description

The specified destructor has an illegal storage class (static, extern).

Tips

Do not use the storage classes "static" and "extern" for destructors.

C1069: Wrong use of far/near/rom/uni/paged in local scope

[DISABLE, INFORMATION, WARNING, ERROR], C++

Description

The far/near/rom/uni/paged keyword has no effect in the local declaration of the given identifier. 'far' may be used to indicate a special addressing mode for a global variable only. Note that such additional keywords are not ANSI compliant and not supported on all targets.

Example

```
far int i; // legal on some targets
void foo(void) {
    far int j; // error message C1069
}
```

Tips

Remove the far/near/rom/uni/paged qualifier, or declare the object in the global scope.

C1070: Object of incomplete type

[ERROR]

Description

An Object with an undefined or not completely defined type was used.

Example

```
void f(struct A a) {  
}
```

Tips

Check the spelling of the usage and the definition of this type. It is legal in C to pass a pointer to a undefined structure, so examine if is possible to pass a pointer to this type rather than the value itself.

C1071: Redefined extern to static

[ERROR]

Description

An extern identifier was redefined as static.

Example

```
extern int i;  
static int i; // error
```

Tips

Remove either the 'extern' specifier of the first declaration, or the 'static' specifier of the second occurrence of the identifier.

C1072: Redefined extern to static

[DISABLE, INFORMATION, WARNING, ERROR]

Description

If the option [-ANSI](#) is disabled, the nonstandard extension issues only a warning, not an error.

Example

```
extern int i;  
static int i; // warning
```

Tips

Remove either the 'extern' specifier of the first declaration, or the 'static' specifier of the second occurrence of the identifier.

C1073: Linkage specification contradicts earlier specification

[ERROR], C++

Description

The specified function was already declared with a different linkage specifier. This error can be caused by different linkage specifiers found in include files.

Example

```
int f(int i);  
extern "C" int f(int i);
```

Tips

Use the same linkage specification for the same function/variable.

C1074: Wrong member function definition

[ERROR], C++

Description

The specified member function was not declared in the class/structure for the given parameters.

Example

```
class A {  
    void f(int i);  
};  
  
void A::f(int i, int i) { // error  
}
```

Tips

Check the parameter lists of the member function declarations in the class declaration and the member function declarations/definitions outside the class declaration.

C1075: Typedef object id already used as tag

[ERROR], C++

Description

The identifier was already used as tag. In C++, tags have the same namespace than objects. So there would be no name conflict compiling in C.

Example

```
typedef const struct A A; // error in C++, ANSI-C ok
```

Tips

Compile without the option [-C++](#), or choose another name for the typedef object id.

C1076: Illegal scope resolution in member declaration

[ERROR], C++

Description

An access declaration was made for the specified identifier, but it is not a member of a base class.

Example

```
struct A {  
    int i;  
};  
  
struct B {  
    int j;  
};  
  
struct C : A {  
    A::i; // ok  
    B::j; // error  
};
```

Tips

Put the owner class of the specified member into the base class list, or do without the access declaration.

C1077: <FunctionKind> must not have parameters

[ERROR], C++

Description

Parameters were declared where it is illegal.

Tips

Do not declare parameters for Destructors and Conversions.

C1078: <FunctionKind> must be a function

[ERROR], C++

Description

A constructor, destructor, operator or conversion operator was declared as a variable.

Example

```
struct A {  
    int A;  
};
```

Tips

Constructors, destructors, operators and conversion operators must be declared as functions.

C1080: Constructor/destructor: Parenthesis missing

[ERROR], C++

Description

A redeclaration of a constructor/destructor is done without parenthesis.

Example

```
struct A {  
    ~A();  
};  
  
A::~~A;    // error  
A::~~A(); // ok
```

Tips

Add parenthesis to the redeclaration of the constructor/destructor.

C1081: Not a static member

[ERROR], C++

Description

The specified identifier was not a static member of a class or structure.

Example

```
struct A {
    int i;
};

void main() {
    A::i=4;    // error
}
```

Tips

Use a member access operator (. or ->) with a class or structure object; or declare the member as static.

C1082: <FunctionKind> must be non-static member of a class/struct

[ERROR], C++

Description

The specified overloaded operator was not a member of a class, structure or union, and/or was declared as static. FunctionKind can be a conversion or an operator =, -> or ().

Tips

Declare the function inside a class declaration without the "static" storage class.

C1084: Not a member

[ERROR], C++

Description

An ident has been used which is not a member of a class or a struct field.

Tips

Check the struct/class declaration.

C1085: <ident> is not a member

[ERROR], C++

Description

A nonmember of a structure or union was incorrectly used.

Example

```
struct A {
    int i;
};

void main() {
    A a;
    a.r=3; // error
}
```

Tips

Using . or ->, specify a declared member.

C1086: Global unary operator must have one parameter

[ERROR], C++

Description

The specified overloaded operator was incorrectly declared with the wrong number of parameters.

Tips

Global member unary operator must have exactly one parameter.

C1087: Static unary operator must have one parameter

[ERROR], C++

Description

The specified overloaded operator was incorrectly declared with the wrong number of parameters.

Tips

Static member unary operator must have exactly one parameter.

C1088: Unary operator must have no parameter

[ERROR], C++

Description

The specified overloaded operator was incorrectly declared with the wrong number of parameters.

Tips

Member unary operator must have no parameters.

C1089: Global binary operator must have two parameters

[ERROR], C++

Description

The specified overloaded operator was incorrectly declared with the wrong number of parameters.

Tips

Global binary operator must have two parameters.

C1090: Static binary operator must have two parameters

[ERROR], C++

Description

The specified overloaded operator was incorrectly declared with the wrong number of parameters.

Tips

Static binary operator must have two parameters.

C1091: Binary operator must have one parameter

[ERROR], C++

Description

The specified overloaded operator was incorrectly declared with the wrong number of parameters.

Tips

Binary operator must have one parameter.

C1092: Global unary/binary operator must have one or two parameters

[ERROR], C++

Description

The specified overloaded operator was incorrectly declared with the wrong number of parameters.

Tips

Global unary/binary operator must have one or two parameters.

C1093: Static unary/binary operator must have one or two parameters

[ERROR], C++

Description

The specified overloaded operator was incorrectly declared with the wrong number of parameters.

Tips

Static unary/binary operator must have one or two parameters.

C1094: Unary/binary operator must have no or one parameter

[ERROR], C++

Description

The specified overloaded operator was incorrectly declared with the wrong number of parameters.

Tips

Unary/binary operator must have no or one parameter.

C1095: Postfix ++/-- operator must have integer parameter

[ERROR], C++

Description

The specified overloaded operator was incorrectly declared with the wrong type of parameters.

Tips

Postfix ++/-- operator must have integer parameter.

C1096: Illegal index value

[ERROR]

Description

The index value of an array declaration was equal or less than 0.

Example

```
int i[0]; // error;
// for 16bit int this is 0x8CA0 or -29536 !
static char dct_data[400*90];
```

Tips

The index value must be greater than 0. If the index value is a calculated one, use a 'u' to make the calculation unsigned (e.g. 400*90u).

C1097: Array bounds missing

[ERROR]

Description

The non-first dimension of an array has no subscript value.

Example

```
int i[3][]; // error
int j[][4]; // ok
```

Tips

Specify a subscript value for the non-first dimensions of an array.

C1098: Modifiers for non-member or static member functions illegal

[ERROR], C++

Description

The specified non-member function was declared with a modifier.

Example

```
void f() const; // error;
```

Tips

Do not use modifiers on non-member or static member functions.

C1099: Not a parameter type

[ERROR]

Description

An illegal type specification was parsed.

Example

```
struct A {  
    int i;  
};  
  
void f(A::i); // error
```

Tips

Specify a correct type for the parameter.

C1100: Reference to void illegal

[ERROR], C++

Description

The specified identifier was declared as a reference to void.

Example

```
void &vr; // error;
```

Tips

Don not declare references to a void type.

C1101: Reference to bitfield illegal

[ERROR], C++

Description

A reference to the specified bit field was declared.

Example

```
struct A {  
    int &i : 3; // error  
};
```


Tips

Do not declare references to bitfields.

C1102: Array of reference illegal

[ERROR], C++

Description

A reference the specified array was declared.

Example

```
extern int &j[20];
```

Tips

Do not declare references to arrays.

C1103: Second C linkage of overloaded function not allowed

[ERROR], C++

Description

More than one overloaded function was declared with C linkage.

Example

```
extern "C" void f(int);  
extern "C" void f(long);
```

Tips

When using C linkage, only one form of a given function can be made external.

C1104: Bit field type is neither integral nor enum type

[ERROR]

Description

Bit fields must have an integral type (or enum type for C).

Example

```
struct A {  
    double d:1;  
};
```

Tips

Specify an integral type (int, long, short, ...) instead of the non-integral type.

C1105: Backend does not support non-int bitfields

[ERROR]

Description

Bit fields must be of integer type. Any other integral or non-integral type is illegal.

Some backends support non int bitfields, others do not. See the chapter backend for details.

Example

```
struct A {  
    char i:2;  
}
```

When the actual backend supports non-int bitfields, this message does not occur.

Tips

Specify an integer-type (int, signed int or unsigned int) for the bitfield.

C1106: Non-standard bitfield type

[DISABLE, INFORMATION, WARNING, ERROR]

Description

Some of the Back Ends allow bitfield structure members of any integral type.

Example

```
struct bitfields {  
    unsigned short j:4; // warning  
};
```

Tips

If you want portable code, use an integer-type for bitfields.

C1107: Long long bit fields not supported yet

[ERROR]

Description

Long long bit fields are not yet supported.

Example

```
struct A {  
    long long l:64;  
};
```

Tips

Do not use long long bit fields.

C1108: Constructor cannot have own class/struct type as first and only

parameter

[ERROR], C++

Description

A constructor was declared with one parameter, and the parameter has the type of the class itself.

Example

```
struct B {
    B(B b); // error
};
```

Tips

Use a reference of the class instead of the class itself.

C1109: Generate call to Copy Constructor

[DISABLE, INFORMATION, WARNING, ERROR], C++

Description

An instance of a class was passed as argument of a function, needing to be copied onto the stack with the Copy Constructor.

Or an instance of a class was used as initializer of another instance of the same class, needing to be copied to the new class instance with the Copy Constructor

Example

```
struct A {
    A(A &);
    A();
};

void f(A a);

void main(void) {
    A a;
    f(a); // generate call to copy ctor
}
```

Tips

If conventional structure copying is desired, try to compile with the option `-Cn=Ctr` and do not declare copy constructors manually.

C1110: Inline specifier is illegal for data declarations

[ERROR], C++

Description

The "inline" specifier was used for a data declaration.

Example

```
inline int i;
```

Tips

Do not use "inline" specifiers for data declarations.

C1111: Bitfield cannot have indirection

[ERROR]

Description

A bitfield declaration must not contain a "*". There are no pointer to bits in C. Use instead a pointer to the structure containing the bitfield.

Example

```
struct bitfield {  
    int *i : 2; // error  
};
```

Tips

Do not use pointers in bitfield declarations.

C1112: Interrupt specifier is illegal for data declaration

[ERROR]

Description

The interrupt specifier was applied to a data declaration.

Example

```
interrupt int i; // error
```

Tips

Apply the interrupt specifier for functions only

C1113: Interrupt specifier used twice for same function

[ERROR]

Description

The interrupt specifier was used twice for the same function.

Example

```
interrupt 4 void interrupt 2 f(); // error
```

Tips

C1114: Illegal interrupt number

[ERROR]

Description

The specified vector entry number for the interrupt was illegal.

Example

```
interrupt 1000 void f(); // error
```

Tips

Check the backend for the range of legal interrupt numbers!

The interrupt number is not the same as the address of the interrupt vector table entry.

The mapping from the interrupt number to the vector address is backend specific.

C1115: Template declaration must be class or function

[ERROR], C++

Description

A non-class/non-function was specified in a template declaration.

Example

```
template<class A> int i; // error
```

Tips

Template declarations must be class or function

C1116: Template class needs a tag

[ERROR], C++

Description

A template class was specified without a tag.

Example

```
template<class A> struct { // error
    A a;
};
```

Tips

Use tags for template classes.

C1117: Illegal template/non-template redeclaration

[ERROR], C++

Description

An illegal template/non-template redeclaration was found.

Example

```
template<class A> struct B {
    A a;
};

struct B { // error
    A a;
};
```

Tips

Correct the source. Protect header files with from multiple inclusion.

C1118: Only bases and class member functions can be virtual

[ERROR], C++

Description

Because virtual functions are called only for objects of class types, you cannot declare global functions or union member functions as 'virtual'.

Example

```
virtual void f(void); // ERROR: definition of a global
                        // virtual function.
union U {
    virtual void f(void); // ERROR: virtual union member
                        // function
};
```

Tips

Do not declare a global function or a union member function as virtual.

C1119: Pure virtual function qualifier should be (=0)

[ERROR], C++

Description

The '=0' qualifier is used to declare a pure virtual function. Following example shows an ill-formed declaration.

Example

```
class A{           // class
public:
    virtual void f(void)=2; // ill-formed pure virtual
                        // function declaration.
};
```

Tips

Correct the source.

C1120: Only virtual functions can be pure

[ERROR], C++

Description

Only a virtual function can be declared as pure. Following example shows an ill-formed declaration.

Example

```
class A{                // class
public:
    void f(void)=0;    // ill-formed declaration.
};
```

Tips

Make the function virtual. For overloaded functions check if the parameters are identical to the base virtual function.

C1121: Definition needed if called with explicit scope resolution

[DISABLE, INFORMATION, WARNING, ERROR], C++

Description

A definition for a pure virtual function is not needed unless explicitly called with the qualified-id syntax (nested-name-specifier [template] unqualified-id).

Example

```
class A{
public:
    virtual void f(void) = 0; // pure virtual function.
};

class B : public A{
public:
    void f(void){ int local=0; }
};

void main(void){
    B b;
    b.A::f();                // generate a linking error
    cause                    // no object is defined.
}
```

```
        b.f();                // call the function defined in
    }                        // B class.
```

Tips

Correct the source.

C1122: Cannot instantiate abstract class object

[ERROR], C++

Description

An abstract class is a class that can be used only as a base class of some other class; no objects of an abstract class may be created except as objects representing a base class of a class derived from it.

Example

```
class A{
public:
    virtual void f(void) = 0; //pure virtual function ==> A
                               //is an abstract class
};

void main(void){
    A a;
}
```

Tips

- Use a pointer/reference to the object:

```
void main(void){
    A *pa;
}
```

- Use a derived class from abstract class:

```
class B : public A{
public:
```

```
    void f(void){}
};
void main(void){
    B b;
}
```

C1123: Cannot instantiate abstract class as argument type

[ERROR], C++

Description

An abstract class may not be used as argument type

Example

```
class A{
public:
    virtual void f(void) = 0; // pure virtual function
                               // ==> A is an abstract class
};
void main(void){
    void fct(A);
}
```

Tips

- Use a pointer/reference to the object:

```
void main(void){
    void fct(A *);
}
```

- Use a derived class from abstract class

```
class B : public A{
public:
    void f(void){}
};
void main(void){
    void fct(B);
}
```

C1124: Cannot instantiate abstract class as return type

[ERROR], C++

Description

An abstract class may not be used as a function return type.

Example

```
class A{
public:
    virtual void f(void) = 0; //pure virtual function ==> A
                               //is an abstract class
};

void main(void){
    A fct(void);
}
```

Tips

- Use a pointer/reference to the object

```
void main(void){
    A *fct(void);
}
```

- Use a derived class from abstract class

```
class B : public A{
public:
    void f(void){}
};

void main(void){
    B fct(void);
}
```

C1125: Cannot instantiate abstract class as a type of explicit conversion

[ERROR], C++

Description

An abstract class may not be used as a type of an explicit conversion.

Example

```
class A{
public:
    virtual void f(void) = 0; //pure virtual function ==> A
    is an abstract class
};

class B : public A{
public:
    void f(void){}
};

void main(void){
    A *pa;
    B b;

    pa = &(A)b;
}
```

Tips

Use a pointer/reference to the object

```
void main(void){
    A *pa;
    B b;

    pa = (A *)b;
}
```

C1126: Abstract class cause inheriting pure virtual without overriding function(s)

[DISABLE, INFORMATION, WARNING, ERROR], C++

Description

Pure virtual functions are inherited as pure virtual functions.

Example

```
class A{
public:
    virtual void f(void) = 0;
    virtual void g(void) = 0;
};

class B : public A{
public:
    void f(void){}
    // void B::g(void) is inherited pure virtual
    // ==> B is an implicit abstract class
};
```

C1127: Constant void type probably makes no sense

[DISABLE, INFORMATION, WARNING, ERROR],C++

Description

A pointer/reference to a constant void type was declared

Example

```
const void *cvp;    // warning (pointer to constant void)
void *const vpc;   // no warning (constant pointer)
```

Tips

A pointer to a constant type is a different thing than a constant pointer.

C1128: Class contains private members only

[DISABLE, INFORMATION, WARNING, ERROR],C++

Description

A class was declared with only private members.

Example

```
class A {  
    private:  
        int i;  
};
```

Tips

You can never access any member of a class containing only private members!

C1129: Parameter list missing in pointer to member function type

[ERROR], C++

Description

The current declaration is neither the one of pointer to member nor the one of pointer to member function. But something looking like melting of both.

Example

```
class A{  
    public:  
        int a;  
};  
  
typedef int (A::*pm);
```

Tips

Use the standard declaration: for a pointer to member 'type class::*ident' and for a pointer to member function 'type (class::*ident)(param list)'

```
class A{  
    public:  
        int a;  
        void fct(void);  
};  
  
typedef int A::*pmi;  
typedef void (A::*pmf)(void);
```

C1130: This C++ feature is disabled in your current cC++/EC++ configuration

[ERROR], C++

Description

Either the Embedded C++ language (EC++) is enabled ([option -C++e](#)), or the compactC++ language (cC++) is enabled ([option -C++c](#)) plus the appropriate feature is disabled ([option -Cn](#)).

Following features could be disabled:

- virtual functions
- templates
- pointer to member
- multiple inheritance and virtual base classes
- class parameters and class returns

Tips

If you really don't want to use this C++ feature, you have to find a workaround to the problem. Otherwise change the C++ language configuration with the options [-C++](#) and [-Cn](#), or use the advanced option dialog

C1131: Illegal use of global variable address modifier

[ERROR]

Description

The global variable address modifier was used for another object than a global variable.

Example

```
int glob @0xf90b; // ok, the global variable "glob" is
at 0xf90b

int *globp @0xf80b = &glob; // ok, the global variable
// "globp" is at 0xf80b and
// points to "glob"

void g() @0x40c0; // error (the object is a function)

void f() {
    int i @0x40cc; // error (the object is a local
variable)
}
```

Tips

Global variable address modifiers can only be used for global variables. They cannot be used for functions or local variables. Global variable address modifiers are not ANSI standard. So the option [-Ansi](#) has to be disabled.

To Put a function at a fixed address, use a pragma `CODE_SEG` to specify a segment for a function. Then map the function in the `prm` file with the linker.

To call a function at a absolute address use a cast:

```
#define f ((void (*)(void)) 0x100)

void main(void) {
    f();
}
```

C1132: Cannot define an anonymous type inside parentheses

[ERROR], C++

Description

An anonymous type was defined inside parentheses. This is illegal in C++.

Example

```
void f(enum {BB,AA} a) { // C ok, C++ error
}
```

Tips

Define the type in the global scope.

C1133: Such an initialization requires **STATIC CONST INTEGRAL** member

[FATAL, ERROR, WARNING, INFORMATION], C++

Description

A static CONST member of integral type may be initialized by a constant expression in its member declaration within the class declaration.

Example

```
int e = 0;

class A{
public:
    static int a = 1; // ERROR: non-const initialized
    const int b = 2; // ERROR: non-static initialized
    static const float c = 3.0; // ERROR: non-integral
                                // initializer
    static const int d = e; // ERROR: non-const initializer
    // ...
};
```

Tips

```
class A{
public:
    static const int a = 5; // Initialization
    // ...
};

const int A::a; // Definition
```

or the other way round:

```
class A{
public:
    static const int a; // Definition
```

```
    // ...  
};  
const int A::a = 5;           // Initialization
```

C1134: Static data members are not allowed in local classes

[ERROR], C++

Description

Static members of a local class have no linkage and cannot be defined outside the class declaration. It follows that a local class cannot have static data members.

Example

```
void foo(void){  
    class A{  
    public:  
        static int a; // ERROR because static data member  
        static void myFct(void); // OK because static method  
    };  
}
```

Tips

Remove the static specifier from the data member declarations of any local class.

```
void foo(void){  
    class A{  
    public:  
        int a; // OK because data member.  
        static void myFct(void); // OK because static method  
    };  
}
```

C1135: Ignore Storage Class Specifier cause it only applies on objects

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The specified Storage Class Specifier is not taken in account by the compiler, because it does not apply to an object.

Example

```
static class A{
    public:
    int a;
};
```

Tips

Remove the Storage Class Specifier from the class definition and apply it to the instances.

```
class A{
    public:
    int a;
};

static A myClassA;
```

C1136: Class <Ident> is not a correct nested class of class <Ident>

[ERROR], C++

Description

Error detected while parsing the scope resolution of a nested class.

Example

```
class A{
    class B;
}

class A::C{};
```

Tips

Check that the scope resolution matches the nested class.

```
class A{
    class B;
}
class A::B{};
```

C1137: Unknown or illegal segment name

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A segment name used in a segment specifier was not defined with a segment pragma before.

Example

```
#pragma DATA_SEG AA
#pragma DATA_SEG DEFAULT
int i @ "AA"; // OK
int i @ "BB"; // Error C1137, segment name BB not known
```

Tips

All segment names must be known before they are used to avoid tipping mistakes and to specify a place to put segment modifiers.

See also

[#pragma DATA_SEG](#)
[#pragma CONST_SEG](#)
[#pragma CODE_SEG](#)

C1138: Illegal segment type

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A segment name with an illegal type was specified. Functions can only be placed into segments of type CODE_SEG, variable/constants can only be placed into segments of type DATA_SEG or CONST_SEG.

Example

```
#pragma DATA_SEG AA
#pragma CODE_SEG BB
int i @ "AA"; // OK
int i @ "BB"; // Error C1138,
               // data cannot be placed in codeseg
```

Tips

Use different segment names for data and code. To place constants into rom, use segments of type CONST_SEG.

See also

[#pragma DATA_SEG](#)
[#pragma CONST_SEG](#)
[#pragma CODE_SEG](#)

C1139: Interrupt routine should not have any return value nor any parameter

[DISABLE, INFORMATION, WARNING, ERROR]

Description

Interrupt routines should not have any return value nor any parameter. In C++, member functions cannot be interrupt routines due to hidden THIS parameter. Another problem may be that a [#pragma TRAP_PROC](#) is active where it should not be.

Example

```
int interrupt myFct1(void){
    return 4;
}

#pragma TRAP_PROC

void myFct2(int param){ }

class A{
public:
    void myFctMbr(void);
};

void interrupt A::myFctMbr(void){}
```

Tips

Remove all return value and all parameter (even hidden, e.g. 'this' pointer for C++):

```
void interrupt myFct1(void){ }

#pragma TRAP_PROC

void myFct2(void){
}

class A{
public:
    void myFctMbr(void);
};

void A::myFctMbr(void){ }

void interrupt myInterFct(void){ }
```

C1140: This function is already declared and has a different prototype

[DISABLE, INFORMATION, WARNING, ERROR]

Description

There are several different prototypes for the same function in a C module.

Example

```
int Foo (char,float,int,int* );  
int Foo (char,float,int,int**);  
int Foo (char,char,int,int**);
```

Tips

Check which one is correct and remove the other(s).

C1141: Ident <ident> cannot be allocated in global register

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The global variable <ident> cannot be allocated in the specified register. There are two possible reasons:

- The type of the variable is not supported to be accessed in a register.
- or
- The specified register number is not possible (e.g. used for parameter passing).

Example

```
extern int glob_var @__REG 4; //r4 is used for parameters
```

Tips

Consider the ABI of the target processor.

C1390: Implicit virtual function

[DISABLE, INFORMATION, WARNING, ERROR],C++

Description

The 'virtual' keyword is needed only in the base class's declaration of the function; any subsequent declarations in derived classes are virtual by default.

Example

Example 1:

```
class A{ //base class
public:
    virtual void f(void){ glob=2; } //definition of a
                                   //virtual function
};

class B : public A{ //derived class
public:
    void f(void){ glob=3; } //overriding function
                           //IMPLICIT VIRTUAL FUNCTION
};
```

Example 2:

```
class A{ // base class
public:
    virtual void f(void){ glob=2; } //definition of a
                                   //virtual function.
};

class B : public A{ //derived class
public:
    virtual void f(void){ glob=3; } //overriding function:
                                   //'virtual' is not
                                   // necessary here
};
```

Example 3:

```
class A{ //base class
public:
    virtual void f(void){ glob=2; } //definition of a
                                   //virtual function.
};

class B : public A { //derived class
public:
    void f(int a){ glob=3+a; } // not overriding function
};
```

Tips

A derived class's version of a virtual function must have the same parameter list and return type as those of the base class. If these are different, the function is not considered a redefinition of the virtual function. A redefined virtual function cannot differ from the original only by the return type.

C1391: Pseudo Base Class is added to this class

[DISABLE, INFORMATION, WARNING, ERROR], C++

Description

The 'virtual' keyword ensures that only one copy of the subobject is included in the memory scope of the object. This single copy is the PSEUDO BASE CLASS.

Example

```
class A{ //base class
    // member list
};

class B : public virtual A { //derived class
public:
    // member list
};

class C : public virtual A { //derived class
public:
    // member list
};

class D : public B, public C { //derived class
public:
    // member list
};
```

Tips

According to this definition, an object 'd' would have the following memory layout:

```
A part
B part
```

```
-----  
A part  
C part  
-----  
D part
```

But the 'virtual' keyword makes the compiler to generate the following memory layout.

```
B part  
-----  
C part  
-----  
A part      // This is the PSEUDO BASE CLASS of class D  
-----  
D part
```

In addition, a pointer to the PSEUDO BASE CLASS is included in each base class that previously derived from virtual base class (here B and C classes).

C1392: Pointer to virtual methods table not qualified for code address space (use `-Qvtprom` or `-Qvtpuni`)

[ERROR], C++

Description

If a virtual methods table of a class is forced to be allocated in code address space (only possible with Harvard architecture), the pointers to the virtual methods table must be qualified with a 'rom' attribute (i.e. rom pointer). This message currently appears only if you specify the compiler option `-Cc` (allocate 'const' objects in rom). For Harvard targets all virtual methods tables are put into code address space because the virtual methods tables are always constant. In this case the compiler generated pointers to the virtual methods table must be qualified with the 'rom'- or 'uni' attribute (see under Tips).

Tips

Qualify virtual table pointers with 'rom' by setting the compiler option `-Qvtprom`.

See also

Option [-Qvtp](#)

C1393: Delta value does not fit into range (option [-Tvtd](#))

[ERROR], C++

Description

An option '-Tvtd' is provided by the compiler to let the user specify the delta value size. The delta value is used in virtual functions management in order to set up the value of the THIS pointer. Delta value is stored in virtual tables. Letting the user specify the size of the delta value can save memory space. But one can imagine that the specified size can be too short, that is the aim of this error message.

Example

```
class A{
public:
    long a[33]
};

class B{
public:
    void virtual fct2 (void){}
};

class C : public A, public B{
public:
};

void main (void){
    C c;
    c.fct2();
}
```

If the previous example is compiled using the option '-Tvtd1' then the minimal value allowed for delta is (-128) and a real value of delta is $-(4*33)=-132$.

Tips

Specify a larger size for the delta value: '-Tvtd2'.

See also option [-T](#), [C++ Front End](#)

C1395: Classes should be the same or derive one from another

[ERROR], C++

Description

Pointer to member is defined to point on a class member, then classes (the one which member belongs to and the one where the pointer to member points) have to be identical. If the member is inherited from a base class then classes can be different.

Example

```
class A{
public:
    int a;
    void fct1(void){}
};

class B{
public:
    int b;
    void fct2(void){}
};

void main(void){
    int B::*pmi = &A::a;
    void (B::*pmf)() = &A::fct1;
}
```

Tips

Use the same classes

```
class A{
public:
    int a;
    void fct1(void){}
};

class B{
public:
    int b;
```

```
    void fct2(void){}
};
void main(void){
    int A::*pmi = &A::a;
    void (A::*pmf)() = &A::fct1;
}
```

Use classes which derive one from an other

```
class A{
public:
    int a;
    void fct1(void){}
};
class B : public A{
public:
    int b;
    void fct2(void){}
};
void main(void){
    int B::*pmi = &A::a;
    void (B::*pmf)() = &A::fct1;
}
```

C1396: No pointer to STATIC member: use classic pointer

[ERROR], C++

Description

Syntax of pointer to member cannot be used to point to a static member. Static member have to be pointed in the classic way.

Example

```
int glob;
class A{
public:
    static int a;
```

```
    static void fct(void){}
};

void main(void){
    int A::*pmi = &A::a;
    void (A::*pmf)() = &A::fct;
}
```

Tips

Use the classic pointer to point static members

```
class A{
public:
    static int a;
    static void fct(void){}
};

void main(void){
    A aClass;
    int *pmi = &aClass.a;
    void (*pmf)() = &aClass.fct;
}
```

C1397: Kind of member and kind of pointer to member are not compatible

[ERROR], C++

Description

A pointer to member can not point to a function member and a pointer to function member can not point a member.

Example

```
class A{
public:
    int b;
    int c;
    void fct(){}
}
```



```
    void fct2(){}  
};  
  
void main(void){  
    int A::*pmi = &A::b;  
    void (A::* pmf)() = &A::fct;  
    pmi=&A::fct2;  
    pmf=&A::c;  
}
```

Tips

```
class A{  
public:  
    int b;  
    int c;  
    void fct(){}  
    void fct2(){}  
};  
  
void main(void){  
    int A::*pmi = &A::b;  
    void (A::* pmf)() = &A::fct;  
    pmf=&A::fct2;  
    pmi=&A::c;  
}
```

C1398: Pointer to member offset does not fit into range of given type (option -Tpmo)

[ERROR], C++

Description

An option -Tpmo is provided by the compiler to let the user specify the pointer to member offset value size. Letting the user specify the size of the offset value can save memory space. But one can imagine that the specified size is too short, that is the aim of this message.

Example

```
class A{  
public:
```

```
    long a[33];
    int b;
};

void main (void){
    A myA;
    int A::*pmi;

    pmi = &A::b;
    myA.*pmi = 5;
}
```

If the previous example is compiled using the option `-Tpmo1` then the maximal value allowed for offset is (127) and a real value of offset is $(4*33)=132$.

Tips

Specify a larger size for the offset value: `-Tpmo2`. See also option [-T, C++ Front End](#).

C1400: Missing parameter name in function head

[DISABLE, INFORMATION, WARNING, ERROR]

Description

There was no identifier for a name of the parameter. Only the type was specified. In function declarations, this is legal. But in function definitions, it's illegal.

Example

```
void f(int) {} // error
void f(int);  // ok
```

Tips

Declare a name for the parameter.

In C++ parameter names must not be specified.

C1401: This C++ feature has not been implemented yet

[ERROR], C++

Description

The C++ compiler does not support all C++ features yet. See also the C++ section about features that are not implemented yet.

Tips

Try to find a workaround of the problem or ask about the latest version of the compiler.

C1402: This C++ feature (<Feature>) is not implemented yet

[ERROR], C++

Description

The C++ compiler does not support all C++ features yet.

Here is the list of features causing the error:

- Compiler generated functions of nested nameless classes
- calling destructors with goto
- explicit operator call
- Create Default Ctor of unnamed class
- Base class member access modification
- local static class obj
- global init with non-const

Tips

Try to avoid to use such a feature, e.g. using global static objects instead local ones.

C1403: Out of memory

[FATAL]

Description

The compiler wanted to allocate memory on the heap, but there was no space left.

Tips

Modify the memory management on your system.

C1404: Return expected

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A function with a return type has no return statement. In C it's a warning, in C++ an error.

Example

```
int f() {} // warning
```

Tips

Insert a return statement, if you want to return something, otherwise declare the function as returning 'void' type.

C1405: Goto <undeclared Label> in this function

[ERROR]

Description

A goto label was found, but the specified label did not exist in the same function.

Example

```
void main(void) {  
    goto label;  
}
```

Tips

Insert a label in the function with the same name as specified in the goto statement.

C1406: Illegal use of identifierList

[ERROR]

Description

A function prototype declaration had formal parameter names, but no types were provided for the parameters.

Example

```
int f(i); // error
```

Tips

Declare the types for the parameters.

C1407: Illegal function-redefinition

[ERROR]

Description

The function has already a function body, it has already been defined.

Example

```
void main(void) {}  
void main(void) {}
```

Tips

Define a function only once.

C1408: Incorrect function-definition

[ERROR]

Description

The function definition is not correct or ill formed.

Tips

Correct the source.

C1409: Illegal combination of parameterlist and identlist

[ERROR]

Description

The parameter declaration for a function does not match with the declaration.

Tips

Correct the source. Maybe a wrong header file has been included.

C1410: Parameter-declaration - identifier-list mismatch

[ERROR]

Description

The parameter declaration for a function does not match with the declaration.

Tips

Correct the source. Maybe a wrong header file has been included.

C1411: Function-definition incompatible to previous declaration

[DISABLE, INFORMATION, WARNING, ERROR]

Description

An old-style function parameter declaration was not compatible to a previous declaration.

Example

```
void f(int i);  
void f(i,j) int i; int j; {} // error
```

Tip

Declare the same parameters as in the previous declaration.

C1412: Not a function call, address of a function

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A function call was probably desired, but the expression denotes an address of the function.

Example

```
void f(int i);  
void main() {  
    f; // warning  
}
```

Tips

Write parenthesis "(" , ")" with the arguments after the name of the function to be called.

C1413: Illegal label-redeclaration

[ERROR]

Description

The label was defined more than once.

Example

```
Label:
...
Label: // label redefined
```

Tips

Choose another name for the label.

C1414: Casting to pointer of non base class

[DISABLE, INFORMATION, WARNING, ERROR], C++

Description

A cast was done from a pointer of a class/struct to a pointer to another class/struct, but the second class/struct is not a base of the first one.

Example

```
class A{} a;
class B{};
void main(void) {
    B* b= (B*)&a;
}
```


Tips

Check if your code really does what you want it to.

C1415: Type expected

[ERROR]

Description

The compiler cannot resolve the type specified or no type was specified. This message may also occur if no type is specified for a new operator.

Tips

Correct the source, add a type for the new operator.

C1416: No initializer can be specified for arrays

[ERROR]

Description

An initializer was given for the specified array created with the new operator.

Tips

Initialize the elements of the array after the statement containing the "new" operator.

C1417: Const/volatile not allowed for type of new operator

[ERROR]

Description

The new operator can only create non const and non volatile objects.

Example

```
void main() {  
    int *a;  
    typedef const int I;  
    a=new I; // error  
}
```

Tips

Do not use const/volatile qualifiers for the type given to the new operator.

C1418:] expected for array delete operator

[ERROR]

Description

There was no "]" found after the "[" of a delete operator.

Example

```
delete [] MyArray; // ok  
delete [3] MyArray; // error
```

Tips

Add a "]" after the "[".

C1419: Non-constant pointer expected for delete operator

[ERROR]

Description

A pointer to a constant object was illegally deleted using the delete operator.

Example

```
void main() {
    const int *a;
    a=new int;
    delete a; // error
}
```

Tips

The pointer to be deleted has to be non-constant.

C1420: Result of function-call is ignored

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A function call was done without saving the result.

Example

```
int f(void);
void main(void) {
    f(); /* ignore result */
}
```

Tips

Assign the function call to a variable, if you need the result afterwards.

Otherwise cast the result to void. E.g.:

```
int f(void);
void main(void) {
    (void)f(); /* explicitly ignore result */
}
```

C1421: Undefined class/struct/union

[ERROR]

Description

An undefined class, structure or union was used.

Example

```
void f(void) {  
    struct S *p, *p1;  
    *p=*p1;  
}
```

Tips

Define the class/struct/union.

C1422: No default Ctor available

[ERROR], C++

Description

No default constructor was available for the specified class/struct. The compiler will supply a default constructor only if user-defined constructors are not provided in the same class/struct and there are default constructors provided in all base/member classes/structs.

Example

```
class A {  
    public:  
        A(int i); // constructor with non-void parameter  
        A();      // default constructor  
};
```

Tips

If you provide a constructor that takes a non-void parameter, then you must also provide a default constructor.

Otherwise, if you do not provide a default constructor, you must call the constructor with parameters.

Example

```
class A {
    public:
    A(int i);
};

A a(3); // constructor call with parameters
```

C1423: Constant member must be in initializer list

[ERROR], C++

Description

There are constant members in the class/struct, that are not initialized with an initializer list in the object constructor.

Example

```
struct A {
    A();
    const int i;
};

A::A() : i(4) { // initialize i with 4
}
```

Tips

If a const or reference member variable is not given a value when it is initialized, it must be given a value in the object constructor.

C1424: Cannot specify explicit initializer for arrays

[ERROR], C++

Description

The specified member of the class/struct could not be initialized, because it is an array.

Tips

Initialize the member inside the function body of the constructor.

C1425: No Destructor available to call

[DISABLE, INFORMATION, WARNING, ERROR], C++

Description

No destructor is available, but one must be called.

C1426: Explicit Destructor call not allowed here

[ERROR], C++

Description

Explicit Destructor calls inside member functions without using "this" are illegal.

Example

```
struct A {  
    void f();  
};
```

```
    ~A();  
};  
  
void A::f() {  
    ~A(); // illegal  
    this->~A(); // ok  
}
```

Tips

Use the this pointer.

C1427: 'this' allowed in member functions only

[ERROR], C++

Description

The specified global function did not have a this pointer to access.

Tips

Do not use "this" in global functions.

C1428: No wide characters supported

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The Compiler does not support wide characters. They are treated as conventional characters.

Example

```
char c= L'a'; // warning
```

Tips

Do not specify the "L" before the character/string constant.

C1429: Not a destructor id

[ERROR], C++

Description

Another name than the name of the class was used to declare a destructor.

Tips

Use the same name for the destructor as the class name.

C1430: No destructor in class/struct declaration

[ERROR], C++

Description

There was no destructor declared in the class/struct.

Example

```
struct A {  
};  
A::~~A() {} // error  
void main() {  
    A a;  
    a.~A(); // legal  
}
```

Tips

Declare a destructor in the class/struct.

C1431: Wrong destructor call

[ERROR], C++

Description

This call to the destructor would require the destructor to be static. But destructors are never static.

Example

```
class A {
public:
    ~A();
    A();
};

void main() {
    A::~~A(); // error
    A::A();  // ok, generating temporary object
}
```

Tips

Do not make calls to static destructors, because there are no static destructors.

C1432: No valid classname specified

[ERROR], C++

Description

The specified identifier was not a class/structure or union.

Example

```
int i;

void main() {
    i::f(); // error
}
```

Tips

Use a name of a class/struct/union.

C1433: Explicit Constructor call not allowed here

[ERROR], C++

Description

An explicit constructor call was done for a specific object.

Example

```
struct A {
    A();
    void f();
};

void A::f() {
    this->A(); // error
    A();      // ok, generating temporary object
}

void main() {
    A a;
    a.A();   // error
    A();     // ok, generating temporary object
}
```

Tips

Explicit constructor calls are only legal, if no object is specified, that means, a temporary object is generated.

C1434: This C++ feature is not yet implemented

[DISABLE, INFORMATION, WARNING, ERROR], C++

Description

The C++ compiler does not yet support all C++ features.

Here is a list of not yet implemented features causing a warning:

- Check for NULL ptr for this complex expression

- Class parameters (for some processors this is already implemented!)
- Class returns (for some processors this is already implemented!)

Tips

The C++ compiler ignores this C++ feature and behaves like a C-Compiler.

C1435: Return expected

[ERROR], C++

Description

The specified function was declared as returning a value, but the function definition did not contain a return statement.

Example

```
int foo(void) {}
```

Tips

Write a return statement in this function or declare the function with a void return type.

C1436: delete needs number of elements of array

[DISABLE, INFORMATION, WARNING, ERROR], C++

Description

A call to the delete[] operator was made without specifying the number of elements of the array, which is necessary for deleting a pointer to a class needing to call a destructor.

Example

```
class A {  
    /* ... */
```

```
    ~A();  
};  
class B {  
    /* ... */  
};  
void f(A *ap, B *bp) {  
    delete ap;      // ok  
    delete[] ap;   // error  
    delete[4] ap;  // ok  
    delete bp;     // ok  
    delete[] bp;   // ok  
    delete[4] bp;  // ok  
}
```

Tips

Specify the number of elements at calling delete[].

C1437: Member address expected

[ERROR], C++

Description

A member address is expected to initialize the pointer to member. 0 value can also be provide to set the pointer to member to NULL.

Example

```
class A{  
public:  
    int a;  
    void fct(void){}  
};  
void main(void){  
    int A::*pmi = NULL;  
    ...  
}
```

Tips

Use a member address

```
class A{
public:
    int a;
    void fct(void){}
};

void main(void){
    int A::*pmi = &A::a;
    void (A::*pmf)() = &A::fct;
    ...
}
```

Use 0 value to set the pointer to member to NULL

```
class A{
public:
    int a;
    void fct(void){}
};

void main(void){
    int A::*pmi = 0;
    void (A::*pmf)() = 0;
    ...
}
```

C1438: ... is not a pointer to member ident

[ERROR], C++

Description

Parsing ident is not a pointer to member as expected.

Example

```
int glob;

class A{
public:
    int a;
```

```
    void fct(void){}
};

void main(void){
    int A::*pmi = &A::a;
    void (A::*pmf)() = &A::fct;
    A aClass;
    ...
    aClass.*glob = 4;
    (aclass.*glob)();
}
```

Tips

Use the pointer to member ident

```
class A{
public:
    int a;
    void fct(void){}
};

void main(void){
    int A::*pmi = &A::a;
    void (A::*pmf)() = &A::fct;
    A aClass;
    ...
    aClass.*pmi = 4;
    (aclass.*pmf)();
}
```

C1439: Illegal pragma `__OPTION_ACTIVE__`, <Reason>

[DISABLE, INFORMATION, WARNING, ERROR]

Description

An ill formed `__OPTION_ACTIVE__` expression was detected. The reason argument gives a more concrete hint what actually is wrong.

Example

```
#if __OPTION_ACTIVE__( "-dABS" )
#endif
```

The `__OPTION_ACTIVE__` expression only allows the option to be tested (here “-d” and not the content of the option here “ABS”).

Tips

Only use the option. To check if a macro is defined as in the example above, use “`#if defined(ABS)`”. Only options known to the compiler can be tested. This option can be moved to an warning or less.

See also

`__OPTION_ACTIVE__`

C1440: This is causing previous message <MsgNumber>

[DISABLE, INFORMATION, WARNING, ERROR]

Description

This message informs about the problem causing the previous message with the number <MsgNumber>. Because the reason for the previous message may be in another file (e.g. header file), this message helps to find out the problem.

Example

```
void foo(void);  
int foo(void) {}
```

produces following messages:

```
int foo(void) {}  
^ERROR C1019: Incompatible type to previous declaration  
      (found 'int (*) ()', expected 'void (*) ()')  
void foo(void);  
^ INFORMATION C1440: This is causing previous message  
1019
```

Tips

The problem location is either the one indicated by the previous message or the location indicated by this message.

C1441: Constant expression shall be integral constant expression

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A constant expression which has to be an integral expression is not integral. A non-integral expression is e.g. a floating constant expression.

Example

```
#if 1.    /* << has to be integral! */  
;  
#endif
```

Tips

Use a integral constant expression. Note: if you move this message (to disable/information/warning), the non-integral constant expression is transformed into an integral expression (e.g. 2.3 => 2).

C1442: Typedef cannot be used for function definition

[ERROR]

Description

A typedef name was used for a function definition.

Example

```
typedef int INTFN();  
INTFN f { return (0); } /* << error */
```

Tips

Do not use a typedef name for a function definition.

C1443: Illegal wide character

[ERROR]

Description

There is a illegal wide character after a wide character designator (“L”).

Example

```
int i = sizeof(L 3.5);
```

Tips

After “L” there has to be a character constant (e.g. L’a’) or a string (e.g. L”abc”).

C1444: Initialization of <Variable> is skipped by 'case' label

[DISABLE, INFORMATION, WARNING, ERROR] C++

Description

Initialization of a local variable is skipped by a 'case' label.

Example

```
void main(void){
    int i;

    switch(i){
        int myVar = 5;
        case 0:           // C1444 init skipped
            //...
            break;
        case 1:           // C1444 init skipped
            //...
            break;
    }
}
```

Tips

Declare the local variable in the block where it is used.

```
void main(void){
    int i;

    switch(i){
        case 0:
            //...
            break;
        case 1:
            int myVar = 5;
            //...
            break;
    }
}
```

C1445: Initialization of <Variable> is skipped by 'default' label

[DISABLE, INFORMATION, WARNING, ERROR] C++

Description

Initialization of a local variable is skipped by a 'default' label.

Example

```
void main(void){
    int i;

    switch(i){
        case 0:
            //...
            break;
        int myVar = 5;
        default:           // C1445 init skipped
            //...
            break;
    }
}
```

Tips

Declare the local variable in the block where it is used.

```
void main(void){
    int i;

    switch(i){
        case 0:
            //...
            break;
        default:
            int myVar = 5;
            //...
            break;
    }
}
```

C1800: Implicit parameter-declaration (missing prototype)

[ERROR]

Description

A function was called without its prototype being declared before.

Example

```
void f(void) {
    g();
}
```

This message is only used for C++ or for C if option [-Wpd](#), but not Option [-Ansi](#) is given

Tips

Prototype the function before calling it.

Use void to define a function with no parameters.

```
void f();
void g(void);
```

The C the declaration `f` does not define anything about the parameters of `f`. The first time `f` is used, the parameters get defined implicitly. The function `g` is defined to have no parameters.

C1801: Implicit parameter-declaration

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A function was called without its prototype being declared before.

Example

```
void f(void) {
    g();
}
```

Tips

Prototype the function before calling it.

C1802: Must be static member

[ERROR]

Description

A non-static member has been accessed inside a static member function.

Example

```
struct A {
    static void f();
    int i;
};

void A::f() {
    i=3; // error
}
```

Tips

Remove the "static" specifier from the member function, or declare the member to be accessed as "static".

C1803: Illegal use of address of function compiled under the pragma REG_PROTOTYPE

[ERROR]

Description

A function compiler with the pragma REG_PROTOTYPE was used in a unsafe way.

C1804: Ident expected

[ERROR]

Description

An identifier was expected.

Example

```
int ;
```

C1805: Non standard conversion used

[DISABLE, INFORMATION, WARNING, ERROR]

Description

In ANSI-C it is normally not allowed to cast an object pointer to a function pointer or a function pointer to an object pointer. Note that the layout of a function pointer may not be the same than the layout of a object pointer.

Example

```
typedef unsigned char (*CmdPtrType)
    (unsigned char, unsigned char);
typedef struct STR {int a;} baseSTR;
baseSTR strDescriptor;
CmdPtrType myPtr;
/* next line does not strictly correspond to ANSI C
   but we make sure that the correct cast is being used */
void foo(void) {
    myPtr=(CmdPtrType)(void*)&strDescriptor; // message
C1805
}
```

C1806: Illegal cast-operation

[ERROR]

Description

There is no conversion for doing the desired cast.

Tips

The cast operator must specify a type, that can be converted to the type, which the expression containing the cast operator would be converted to.

C1807: No conversion to non-base class

[ERROR]

Description

There is no conversion from a class to another class that is not a base class of the first class.

Example

```
struct A {
    int i;
};

struct B : A {
    int j;
};

void main() {
    A a;
    B b;
    b=a; // error: B is not a base class of A
}
```

Tips

Remove this statement, or modify the class hierarchy.

C1808: Too many nested switch-statements

[ERROR]

Description

The number of nested switches was too high.

Example

```
switch(i0) {
    switch(i1) {
        switch(i2) {
            ...
        }
    }
}
```

Tips

Use "if-else if" statements instead or reduce nesting level.

See also

Limitations

C1809: Integer value for switch-expression expected

[ERROR]

Description

The specified switch expression evaluated to an illegal type.

Example

```
float f;
void main(void) {
    switch(f) {
        case 1:
            f=2.1f;
            break;
        case 2:
            f=2.1f;
            break;
    }
}
```

Tips

A switch expression must evaluate to an integral type, or a class type that has an unambiguous conversion to an integral type.

C1810: Label outside of switch-statement

[ERROR]

Description

The keyword case was used outside a switch.

Tips

The keyword case can appear only within a switch statement.

C1811: Default-label twice defined

[ERROR]

Description

A switch statement must have no or one default label. Two default labels are indicated by this error.

Example

```
switch (i) {
    default: break;
    case 1: f(1); break;
    case 2: f(2); break;
    default: f(0); break;
}
```

Tips

Define the default label only once per switch-statement.

C1812: Case-label-value already present

[ERROR]

Description

A case label value is already present.

Tips

Define a case-label-value only once for each value. Use different values for different labels.

C1813: Division by zero

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A constant expression was evaluated and found to have a zero denominator.

Example

```
int i = 1/0;
```

Tips

mod or divide should never be by zero.

Note that this error can be changed to a warning or less. This way code like the following can be compiled:

```
int i = (sizeof(int) == sizeof(long)) ? 0 : sizeof(long)
/ (sizeof(long)-sizeof(int))
```

C1814: Arithmetic or pointer-expression expected

[ERROR]

Description

The expression had an illegal type!.

Tips

Expressions after a “!” operator and expressions in conditions must be of arithmetic or pointer type.

C1815: <Name> not declared (or typename)

[ERROR]

Description

The specified identifier was not declared.

Example

```
void main(void) {  
    i=2;  
}
```

Tips

A variable's type must be specified in a declaration before it can be used. The parameters that a function uses must be specified in a declaration before the function can be used.

This error can be caused, if an include file containing the required declaration was omitted.

C1816: Unknown struct- or union-member

[ERROR]

Description

A nonmember of a structure or union was incorrectly used.

Example

```
struct A {  
    int i;  
} a;  
  
void main(void) {  
    a.I=2;  
}
```

Tips

On the right side of the “->” or “.” operator, there must be a member of the structure/union specified on the left side.

C is case sensitive.

C1817: Parameter cannot be converted to non-constant reference

[ERROR], C++

Description

A constant argument was specified for calling a function with a reference parameter to a non-constant.

Example

```
void f(const int &); // ok
void f(int &); // causes error, when calling
               // with constant argument

void main() {
    f(3); // error for second function declaration
}
```

Tips

The parameter must be a reference to a constant, or pass a non-constant variable as argument.

C1819: Constructor call with wrong number of arguments

[ERROR], C++

Description

The number of arguments for the constructor call at a class object initialization was wrong.

Example

```
struct A {
    A();
};

void main() {
    A a(3); // error
}
```

Tips

Specify the correct number of arguments for calling the constructor.

Try to disable the option `-Cn=Ctr`, so the compiler generates a copy constructor, which may be required in your code.

C1820: Destructor call must have 'void' formal parameter list

[ERROR], C++

Description

A destructor call was specified with arguments.

Example

```
struct A {
    ~A();
};

void main() {
    A a;
    a.~A(3);    // error
}
```

Tips

Destructor calls have no arguments!

C1821: Wrong number of arguments

[ERROR]

Description

A function call was specified with the wrong number of formal parameters.

Example

```
struct A {  
    void f();  
};  
  
void main() {  
    A a;  
    a.f(3);    // error  
}
```

Tips

Specify the correct number of arguments.

C1822: Type mismatch

[ERROR]

Description

There is no conversion between the two specified types.

Example

```
void main() {  
    int *p;  
    int j;  
    p=j;    // error  
}
```

Tips

Use types that can be converted.

C1823: Undefined an implicit parameter-declaration

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A implicit parameter declaration was removed because of a assignment.

Example

```
void (*f)();  
void g(long );  
void main(void) {  
    f(1);  
    f=g;  
    f(2);  
}
```

Tips

Avoid implicit parameter declarations whenever possible.

C1824: Indirection to different types

[ERROR]

Description

There are two pointers in the statement pointing to non-equal types.

Example

```
void main() {  
    int *i;  
    const int *ci;  
    char *c;  
    i=ci;    // C: warning, C++ error, C++ -ec warning  
    i=c;    // C: warning, C++: error  
}
```

Tips

Both pointers must point to equal types. If the types only differ in the qualifiers (const, volatile) try to compile with the option [-ec](#).

C1825: Indirection to different types

[DISABLE, INFORMATION, WARNING, ERROR]

Description

There are two pointers in the statement pointing to non-equal types.

Example

```
void main() {  
    int *i;  
    char *c;  
    i=c; // C: warning, C++: error  
}
```

Tips

Both pointers should point to equal types.

C1826: Integer-expression expected

[ERROR]

Description

The expression was not of integral type.

Example

```
void main() {  
    int *p;  
    p<<3;// error  
}
```

Tips

The expression must be an integral type.

C1827: Arithmetic types expected

[ERROR]

Description

After certain operators as * or /, arithmetic types must follow.

Example

```
void main() {  
    int * p;  
    p*3;    // error  
}
```

Tips

“*” and “/” must have operands with arithmetic types.

C1828: Illegal pointer-subtraction

[ERROR]

Description

A pointer was subtracted from an integral type.

Example

```
void main() {  
    int *p;  
    int i;  
    i-p;    // error  
}
```

Tips

Insert a cast operator from the pointer to the integral type.

C1829: + - incompatible Types

[ERROR]

Description

For + and - only compatible types on both sides can be used. In C++ own implementation can be used with overloading.

Example

```
struct A {
    int i;
};

void main() {
    int i;
    A a;
    i=i+a;    // error
}
```

Tips

Use compatible types on the left and on the right side of the +/- operator. Or use the operator-overloading and define an own "+" or "-" operator!

C1830: Modifiable lvalue expected

[ERROR]

Description

An attempt was made to modify an item declared with const type.

Example

```
const i;

void main(void) {
    i=2;
}
```

Tips

Do not modify this item, or declare the item without the const qualifier.

C1831: Wrong type or not an lvalue

[ERROR]

Description

An unary operator has an operand of wrong or/and constant type.

Tips

The operand of the unary operator must be a non-const integral type or a non-const pointer to a non-void type. Or use operator overloading!.

C1832: Const object cannot get incremented

[ERROR]

Description

Constant objects can not be changed.

Example

```
int* const pi;  
void main(void) {  
    *pi++;  
}
```

Tips

Either do not declare the object as constant or use a different constant for the new value.

In the case above, use parenthesis to increment the value pi points to and to not increment pi itself.

```
int* const pi;
void main(void) {
    (*pi)++;
}
```

C1833: Cannot take address of this object

[ERROR]

Description

An attempt to take the address of an object without an address was made.

Example

```
void main() {
    register i;
    int *p=&i;    // error
}
```

Tips

Specify the object you want to dereference in a manner that it has an address.

C1834: Indirection applied to non-pointer

[ERROR]

Description

The indirection operator (*) was applied to a nonpointer value.

Example

```
void main(void) {
    int i;
```

```
    *i=2;  
}
```

Tips

Apply the indirection operator only on pointer values.

C1835: Arithmetic operand expected

[ERROR]

Description

The unary (-) operator was used with an illegal operand type.

Example

```
const char* p= -"abc";
```

Tips

There must be an arithmetic operand for the unary (-) operator.

C1836: Integer-operand expected

[ERROR]

Description

The unary (~) operator was used with an illegal operand type.

Example

```
float f= ~1.45;
```

Tips

There must be an operand of integer type for the unary (~) operator.

C1837: Arithmetic type or pointer expected

[ERROR]

Description

The conditional expression evaluated to an illegal type.

Tips

Conditional expressions must be of arithmetic type or pointer.

C1838: Unknown object-size: sizeof (incomplete type)

[ERROR]

Description

The type of the expression in the sizeof operand is incomplete.

Example

```
int i = sizeof(struct A);
```

Tips

The type of the expression in the sizeof operand must be defined complete.

C1839: Variable of type struct or union expected

[ERROR]

Description

A variable of structure or union type was expected.

C1840: Pointer to struct or union expected

[ERROR]

Description

A pointer to a structure or union was expected.

C1842: [incompatible types

[ERROR]

Description

Binary operator “[“: There was no global operator defined, which takes the type used.

Example

```
struct A {
    int j;
    int operator [] (A a);
};

void main() {
    A a;
    int i;
    int b[3];
    i=a[a]; // ok
    i=b[a]; // error
}
```

Tips

Use a type compatible to “[“. If there is no global operator for “[“, take an integer type.

C1843: Switch-expression: integer required

[ERROR]

Description

Another type than an integer type was used in the switch expression.

Tips

Use an integer type in the switch expression.

C1844: Call-operator applied to non-function

[ERROR]

Description

A call was made to a function through an expression that did not evaluate to a function pointer.

Example

```
int i;  
void main(void) {  
    i();  
}
```

Tips

The error is probably caused by attempting to call a nonfunction.

In C++ classes can overload the call operator, but basic types as pointers cannot.

C1845: Constant integer-value expected

[ERROR]

Description

The case expression was not an integral constant.

Example

```
int i;
void main(void) {
    switch (i) {
        case i+1:
            i=1;
        }
}
```

Tips

Case expressions must be integral constants.

C1846: Continue outside of iteration-statement

[ERROR]

Description

A “continue” was made outside of an iteration-statement.

Tips

The “continue” must be done inside an iteration-statement.

C1847: Break outside of switch or iteration-statement

[ERROR]

Description

A “break” was made outside of an iteration-statement.

Example

```
int i;

void f(void) {
    int res;
    for (i=0; i < 10; i++ )
        res=f(-1);
        if (res == -1)
            break;
    printf("%d\n", res);
}
```

Tips

The “break” must be done inside an iteration-statement.

Check for the correct number of open braces.

C1848: Return <expression> expected

[ERROR]

Description

A return was made without an expression to be returned in a function with a non-void return type.

Tips

The return statement must return an expression of the return-type of the function.

C1849: Result returned in void-result-function

[ERROR]

Description

A return was made with an expression, though the function has void return type.

Example

```
void f(void) {  
    return 1;  
}
```

Tips

Do not return an expression in a function with void return type. Just write “return”, or write nothing.

C1850: Incompatible pointer operands

[ERROR]

Description

Pointer operands were incompatible.

Tips

Either change the source or explicitly cast the pointers.

C1851: Incompatible types

[ERROR]

Description

Two operands of a binary operator did not have compatible types (there was no conversion, or the overloaded version of the operand does not take the same types as the formal parameters).

Tips

Both operands of the binary operator must have compatible types.

C1852: Illegal sizeof operand

[ERROR]

Description

The sizeof operand was a bitfield.

Tips

Do not use bitfields as sizeof operands.

C1853: Unary minus operator applied to unsigned type

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The unary minus operator was applied to an unsigned type.

Example

```
void main(void) {
    unsigned char c;
    unsigned char d= -c;
}
```

Tips

An unsigned type never can become a negative value. So using the unary minus operator may cause an unwanted behavior!

Note that ANSI C treats -1 as negated value of 1. Therefore 2147483648 is an unsigned int, if int is 32 bits large or an unsigned long if not.

The negation is a unary function as any other, so the result type is the argument type propagated to int, if smaller.

Note that the value -2147483648 is the negation of 2147483648 and therefore also of a unsigned type, even if the signed representation contains this value.

C1854: Returning address of local variable

[DISABLE, INFORMATION, WARNING, ERROR]

Description

An address of a local variable is returned.

Example

```
int &f(void) {
    int i;
    return i;    // warning
}
```

Tips

Either change the return type of the function to the type of the local variable returned, or declare the variable to be returned as global (returning the reference of this global variable)!

C1855: Recursive function call

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A recursive function call was detected. There is a danger of endless recursion, which leads to a stack overflow.

Example

```
void f(void) {
    f(); // warning; this code leads to an endless
    recursion
}

void g(int i) {
    if(i>0) {
        g(--i); // warning; this code has no endless
    }
    recursion
}
```

```
    }  
}
```

Tips

Be sure there is no endless recursion. This would lead to a stack overflow.

C1856: Return <expression> expected

[DISABLE, ERROR, WARNING, INFORMATION], C

Description

A return statement without expression is executed while the function expects a return value. In ANSI-C, this is correct but not clean. In such a case, the program runs back to the caller. If the caller uses the value of the function call then the behavior is undefined.

Example

```
int foo(void){  
    return;  
}  
  
void main(void){  
    int a;  
  
    ...  
    a = foo();  
    ...          /* behaviour undefined */  
}
```

Tips

```
#define ERROR_CASE_VALUE 0  
  
int foo(void){  
    return ERROR_CASE_VALUE; /* return something... */  
}  
  
void main(void){  
    int a;  
  
    ...  
    a = foo();
```

```
    if (a==ERROR_CASE_VALUE){ /* ... and treat this case
*/
    ...
    } else {
    ...
    }
    ...
}
```

C1857: Access out of range

[DISABLE, ERROR, WARNING, INFORMATION], C

Description

The compiler has detected that there is an array access outside of the array bounds. This is legal in ANSI-C/C++, but normally it is a programming error. Check carefully such accesses that are out of range. This warning does not check the access, but also taking the address out of an array. However, it is legal in C to take the address of one element outside the array range, so there is no warning for this. Because array accesses are treated internally like address-access operations, there is no message for accessing on element outside of the array bounds.

Example

```
char buf[3], *p;
p = &buf[3]; // no message!
buf[4] = 0; // message
```

C1858: Partial implicit parameter-declaration

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A function was called without its prototype being totally declared before.

Example

```
void foo(); // not complete prototype, arguments not
known

void main(void) {
    foo();
}
```

Tips

Prototype all arguments of the function before calling it.

C1859: Indirection operator is illegal on Pointer To Member operands

[DISABLE, INFORMATION, WARNING, ERROR], C++

Description

It is illegal to apply indirection '*' operator to Pointer To Member operands.

Example

```
class A {
public:
    void f(void) {}
};

typedef void (A::*ptrMbrFctType)(void);

void fct0(void){
    ptrMbrFctType pmf;
    *pmf=A::f; // ERROR
}

void fct1(void){
    void (* A::*pmf)(void)=A::f; // ERROR
}
```

Tips

Remove the indirection operator.

```
class A {
public:
```



```
    void f(void) {}  
};  
typedef void (A::*ptrMbrFctType)(void);  
void fct0(void){  
    ptrMbrFctType pmf;  
    pmf=&A::f;  
}  
void fct1(void){  
    void (A::*pmf)(void)=&A::f;  
}
```

C1860: Pointer conversion: possible loss of data

[DISABLE, INFORMATION, WARNING, ERROR]

Description

Whenever there is a pointer conversion which may produce loss of data, this message is produced. Loss of data can happen if a 'far' (e.g. 3 byte pointer) is assigned to a pointer of smaller type (e.g. a 'near' 1 byte pointer).

Example

```
char *near nP;  
char *far fP;  
void foo(void) {  
    nP = fP; // warning here  
}
```

Tips

Check if this loss of data is intended.

C1861: Illegal use of type 'void'

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The compiler has detected an illegal usage of the 'void' type. The compiler accepts this because of historical reasons. Some other vendor compilers may not accept this at all, so this may cause portability problems.

Example

```
int foo(void buf[256]) { // warning here
    ...
}
```

Tips

Correct your code. E.g. replace in the above example the argument with 'void *buf'.

C2000: No constructor available

[ERROR], C++

Description

A constructor must be called, but none is available.

Tips

Define a constructor. No compiler defined default constructor is defined in some situations, for example when the class has constant members.

C2001: Illegal type assigned to reference.

[ERROR], C++

Description

There is no conversion from type assigned to the type of the reference.

Example

```
int *i;
int &r=i; // error
```

Tips

The type of the reference must be equal to the type assigned.

C2004: Non-volatile reference initialization with volatile illegal

[ERROR], C++

Description

The reference type is not volatile, the assigned type is.

Example

```
volatile i;
const int &r=i; // illegal
```

Tips

Either both are volatile or both are not volatile.

C2005: Non-constant reference initialization with constant illegal

[ERROR], C++

Description

The reference type is not constant, the assigned type is.

Example

```
void main(void) {
    const int i=1;
    int &p=i;
}
```

Tips

Either both are const or both are not const.

C2006: (un)signed char reference must be const for init with char

[ERROR], C++

Description

The initializer for a reference to a signed or unsigned char must be const for initialization with a plain char.

Example

```
char i;  
signed char &r=i;    // error
```

Tips

Either declare the reference type as const, or the type of the initializer must not be plain.

C2007: Cannot create temporary for reference in class/struct

[ERROR], C++

Description

A member initializer for a reference was constant, though the member was non-constant

Example

```
struct A {  
    int &i;
```

```
        A();  
    };  
A::A() : i(3) { // error  
}
```

Tips

Initialize the reference with a non-constant variable.

C2008: Too many arguments for member initialization

[ERROR], C++

Description

The member-initializer contains too many arguments.

Example

```
struct A {  
    const int i;  
    A();  
};  
A::A() : i(3,5) { // error  
}
```

Tips

Supply the correct number of arguments in the initializer list of a constructor.

C2009: No call target found!

[ERROR]

Description

The ambiguity resolution mechanism did not find a function in the scope, where it expected one.

Tips

Check, if the function called is declared in the correct scope.

C2010: <Name> is ambiguous

[ERROR], C++

Description

The ambiguity resolution mechanism found an ambiguity. That means, more than one object could be taken for the identifier Name. So the compiler does not know which one is desired.

Example

```
struct A {
    int i;
};

struct B : A {
};

struct C : A {
};

struct D : B, C {
};

void main() {
    D d;
    d.i=3;    // error, could take i from B::A or C::A
    d.B::i=4; // ok
    d.C::i=5; // ok
}
```

Tips

Specify a path, how to get to the desired object. Or use virtual base classes in multiple inheritance.

The compiler can handle a most 10'000 different numbers for a compilation unit. Internally for each number a descriptor exists. If an internal number descriptor already exists for a given number value with a given type, the existing one is

used. But if e.g. more than 10'000 different numbers are used, this message will appear.

C2011: <Name> can not be accessed

[ERROR], C++

Description

There is no access to the object specified by the identifier.

Example

```
struct A {
private:
    int i;
protected:
    int j;
public:
    int k;
    void g();
};

struct B : public A {
    void h();
};

void A::g() {
    this->i=3; // ok
    this->j=4; // ok
    this->k=5; // ok
}

void B::h() {
    this->i=3; // error
    this->j=4; // ok
    this->k=5; // ok
}

void f() {
    A a;
    a.i=3; // error
    a.j=4; // error
    a.k=5; // ok
}
```

Tips

Change the access specifiers in the class declaration, if you really need access to the object.

Or use the friend-mechanism.

See also

Limitations

C2012: Only exact match allowed yet or ambiguous!

[ERROR], C++

Description

An overloaded function was called with non-exact matching arguments.

Tips

Supply exact matching parameters.

In later compiler versions this error will disappear!

See also

Limitations

C2013: No access to special member of base class

[DISABLE, INFORMATION, WARNING, ERROR], C++

Description

The special member (Constructor, destructor or assignment operator) could not be accessed.

Example

```
struct A {
    private:
        A();
};

struct B : A {
};

void main() {
    B b;    // error
}
```

Tips

Change the access specifier for the special member.

See also

Limitations

C2014: No access to special member of member class

[`DISABLE`, `INFORMATION`, `WARNING`, `ERROR`], C++

Description

The special member (Constructor, destructor or assignment operator) could not be accessed.

Example

```
struct A {
    private:
        A();
};

struct B {
    A a;
};

void main() {
    B b;    // error
}
```

Tips

Change the access specifier for the special member.

See also

Limitations

C2015: Template is used with the wrong number of arguments

[ERROR], C++

Description

A template was instantiated with the wrong number of template arguments.

Example

```
template<class S> struct A {
    S s;
};
A<int, int> a; // error
```

Tips

The instantiation of a template type must have the same number of parameters as the template specification.

C2016: Wrong type of template argument

[ERROR], C++

Description

A template was instantiated with the wrong type template arguments.

Example

```
template<class S> struct A {  
    S s;  
};  
A<4> a; // error
```

Tips

The instantiation of a template type must have the same argument type as the ones template specification.

C2017: Use of incomplete template class

[ERROR], C++

Description

A template was instantiated from an incomplete class.

Example

```
template<class S> struct A;  
A<int, int> a; // error
```

Tips

The template to be instantiated must be of a defined class.

C2018: Generate class/struct from template

[DISABLE, INFORMATION, WARNING, ERROR], C++

Description

A class was instantiated from a template.

Example

```
template<class S> struct A {
    S s;
};

A<int> a; // information
```

C2019: Generate function from template

[DISABLE, INFORMATION, WARNING, ERROR], C++

Description

A function was instantiated from a template.

Example

```
template<class S> void f(S s) {
    /* ... */
};

void main(void) {
    int i;
    char ch;
    f(4); // generate
    f(i); // not generating, already generated
    f(ch); // generate
}
```

Tips

The fewer functions are instantiated from a template, the less code is produced. So try to use already generated template functions instead of letting the compiler generate new ones.

C2020: Template parameter not used in function parameter list

[ERROR], C++

Description

A template parameter didn't occur in the parameter list of the template function.

Example

```
template<class S> void f(int i) { // error
    /* ... */
};
```

Tips

The parameter list of the template function must contain the template parameters.

C2021: Generate NULL-check for class pointer

[DISABLE, INFORMATION, WARNING, ERROR], C++

Description

Operations with pointers to related classes always need separate NULL-checks before adding offsets from base classes to inherited classes.

Example

```
class A {
};

class B : public A{
};

void main() {
    A *ap;
    B *bp;
    ap=bp; // warning
}
```

Tips

Try to avoid operations with pointers to different, but related classes.

C2022: Pure virtual can be called only using explicit scope resolution

[ERROR], C++

Description

Pure virtual functions can be called from a constructor of an abstract class; the effect

of calling a pure virtual function directly or indirectly for the object being created

from such a constructor is an error.

Example

```
class A{
public:
    virtual void f(void) = 0;
    A(){
        f();
    }
};
```

Tips

A pure virtual can be defined. It can be called using explicit qualification only.

```
class A{
public:
    virtual void f(void) = 0;
    A(){
        A::f();
    }
};

void A::f(void){ // defined somewhere
    //...
}
```

C2023: Missing default parameter

[ERROR], C++

Description

A subsequent parameter of a default parameter is not a default parameter.

Example

```
void f(int i=0, int j);    // error
void f(int i=0, int j=0); // ok
```

Tips

All subsequent parameters of a default parameter must be default, too.

See also

Overloading.

C2024: Overloaded operators cannot have default arguments

[ERROR], C++

Description

An overloaded operator was specified with default arguments.

Example

```
struct A{ /* ... */ };
operator + (A a, int i=0); // error
```

Tips

Overloaded operators cannot have default arguments. Declare several versions of the operator with different numbers of arguments.

See also

Overloading.

C2025: Default argument expression can only contain static or global objects or constants

[ERROR], C++

Description

A local object or non-static class member was used in the expression for a default argument.

Example

```
struct A {
    int t;
    void f(int i=t); // error
};
void g(int i, int j=i); // error
```

Tips

Only use static or global objects or constants in expressions for default arguments.

C2200: Reference object type must be const

[ERROR], C++

Description

If a reference is initialized by a constant, the reference has to be constant as well

Example

```
int &ref = 4; // err
```


Tips

Declare the reference as constant.

See also

Limitations

C2201: Initializers have too many dimensions

[ERROR], C++

Description

An initialization of an array of class objects with constructor call arguments was having more opening braces than dimensions of the array.

Example

```
struct A {
    A(int);
};

void main() {
    A a[3]={{3,4},4}; // errors
    A a[3]={3,4,4};   // ok
}
```

Tips

Provide the same number of opening braces in an initialization of an array of class objects.

See also

Limitations

C2202: Too many initializers for global Ctor arguments

[ERROR], C++

Description

An initialization of a global array of class objects with constructor call arguments was having more arguments than elements in the array.

Example

```
struct A {
    A(int);
};

A a[3]={3,4,5,6}; // errors
A a[3]={3,4,5};   // ok
```

Tips

Provide the same number of arguments than number of elements in the global array of class objects.

If you want to make calls to constructors with more than one argument, use explicit calls of constructors.

See also

Limitations

C2203: Too many initializers for Ctor arguments

[ERROR], C++

Description

An initialization of an array of class objects with constructor call arguments was having more arguments than elements in the array.

Example

```
struct A {
    A(int);
};

void main() {
    A a[3]={3,4,5,6}; // errors
    A a[3]={3,4,5};   // ok
}
```

Tips

Provide the same number of arguments than number of elements in the array of class objects.

If you want to make calls to constructors with more than one argument, use explicit calls of constructors.

Example

```
struct A {
    A(int);
    A();
    A(int,int);
};

void main() {
    A a[3]={A(3,4),5,A()};
    // first element calls A::A(int,int)
    // second element calls A::A(int)
    // third element calls A::A()
}
```

See also

Limitations

C2204: Illegal reinitialization

[ERROR]

Description

The variable was initialized more than once.

Example

```
extern int i=2;
int i=3;    // error
```

Tips

A variable must be initialized at most once.

See also

Limitations

C2205: Incomplete struct/union, object can not be initialized

[ERROR]

Description

Incomplete struct/union, object can not be initialized

Example

```
struct A;  
extern A a={3}; // error
```

Tips

Do not initialize incomplete struct/union. Declare first the struct/union, then initialize it.

See also

Limitations

C2206: Illegal initialization of aggregate type

[ERROR]

Description

An aggregate type (array or structure/class) was initialized the wrong way.

Tips

Use the braces correctly.

See also

Limitations

C2207: Initializer must be constant

[ERROR]

Description

A global variable was initialized with a non-constant.

Example

```
int i;  
int j=i; // error
```

or

```
void function(void){  
    int local;  
    static int *ptr = &local;  
    // error: address of local can be different  
    // in each function call.  
    // At second call of this function *ptr is not the  
    same!  
}
```

Tips

In C, global variables can only be initialized by constants. If you need non-constant initialization values for your global variables, create an “InitModule()” function in your compilation unit, where you can assign any expression to your globals. This function should be called at the beginning of the execution of your program.

If you compile your code with C++, this error won’t occur anymore!

In C, initialization of a static variables is done only once. Initializer is not required to be constant by ANSI-C, but this behavior will avoid troubles hard to debug.

See also

Limitations

C2209: Illegal reference initialization

[ERROR], C++

Description

A reference was initialized with a braced “{”, “}” initializer.

Example

```
struct A {
    int i;
};

A &ref = {4}; // error
A a = {4};    // ok
A &ref2 = a;  // ok
```

Tips

References must be initialized with non-braced expressions.

See also

Limitations

C2210: Illegal initialization of non-aggregate type

[ERROR]

Description

A class without a constructor and with non-public members was initialized.

Tips

Classes with non-public members can only be initialized by constructors.

See also

Limitations

C2211: Initialization of a function

[ERROR]

Description

A function was initialized.

Example

```
void f()=3;
```

Tips

Functions cannot be initialized. But function pointers can.

See also

Limitations

C2401: Pragma <ident> expected

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A single #pragma was found.

Example

```
#pragma
```

Tips

Probably this is a bug. Correct it.

C2402: Variable <Ident> <State>

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A variable was allocated differently because of a pragma INTO_ROM or a pragma FAR.

Example

```
#pragma INTO_ROM
const int i;
```

Tips

Be careful with the pragmas INTO_ROM and pragma FAR. They are only valid for one single variable. In the following code the pragma INTO_ROM puts var_rom into the rom, but var_ram not.

```
#pragma INTO_ROM
const int var_rom, var_ram;
```

Note that pragma INTO_ROM is only for the HIWARE Object file format.

C2450: Expected: <list of expected keywords and tokens>

[ERROR]

Description

An unexpected token was found.

Example

```
void f(void);  
void main(void) {  
    int i=f(void); // error: "void" is an unexpected  
keyword!  
}
```

Tips

Use a token listed in the error message. Check if you are using the right compiler language option. E.g. you may compile a file with C++ keywords, but are not compiling the file with C++ option set.

Too many nested scopes

C2550: Too many nested scopes

[FATAL]

Description

Too many scopes are open at the same time.

For the actual limitation number, please see chapter [Limitations](#)

Example

```
void main(void) {  
    {  
        {  
            {  
                ....  
            }  
        }  
    }  
}
```

Tips

Use less scopes.

See also

[Limitations](#)

C2700: Too many numbers

[FATAL]

Description

Too many different numbers were used in one compilation unit.

For the actual limitation number, please see chapter [Limitations](#)

Example

```
int main(void) {  
    return 1+2+3+4+5+6+.....  
}
```

Tips

Split up very large compilation units.

See also

Limitations

C2701: Illegal floating-point number

[DISABLE, INFORMATION, WARNING, ERROR]

Description

An illegal floating point number has been specified or the exponent specified is too large for floating number.

Example

```
float f = 3.e345689;
```

Tips

Correct the floating point number.

See also

Number Formats
header file “float.h”

C2702: Number too large for float

[ERROR]

Description

A float number larger than the maximum value for a float has been specified.

Example

```
float f = 3.402823466E+300F;
```

Tips

Correct the number.

See also

Number Formats
header file “float.h”

C2703: Illegal character in float number

[ERROR]

Description

The floating number contains an illegal character. Legal characters in floating numbers are the postfixes ‘f’ and ‘F’ (for float) or ‘l’ and ‘L’ (for long double). Valid characters for exponential numbers are ‘e’ and ‘E’.

Example

```
float f = 3.x4;
```

Tips

Correct the number.

See also

Number Formats

C2704: Illegal number

[ERROR]

Description

An illegal immediate number has been specified.

Example

```
int i = 4x; /* error */  
float f= 12345678901234567890;//error too large for a  
long!  
float f= 12345678901234567890.;//OK, doubles can be as  
large
```

Tips

Correct the number.

For floating point numbers, specify a dot.

See also

Number Formats

C2705: Possible loss of data

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The compiler generates this message if a constant is used which exceeds the value for a type.

Another reason for this message is if a object (e.g. long) is assigned to an object with smaller size (e.g. char).

Another example is to pass an actual argument too large for a given formal argument, e.g. passing a 32bit value to a function which expects a 8bit value.

Example

```
signed char ch = 128; /* char holds only -128..127 */
char c;
long L;

void foo(short);

void main(void) {
    c = L; // possible lost of data
    foo(L); // possible lost of data
}
```

Tips

Usually this is a programming error.

See also

Header file "limits.h"

C2706: Octal Number

[DISABLE, INFORMATION, WARNING, ERROR]

Description

An octal number was parsed.

Example

```
int f(void) {
    return 0100; // warning
}
```

Tips

If you want to have a decimal number, don't write a '0' at the beginning.

C2707: Number too large

[ERROR], M2

Description

While reading a numerical constant, the compiler has detected the number is too large for a data type.

Example

```
x: REAL;  
x := 300e51234;
```

Tips

Reduce the numerical constant value, or choose another data type.

C2708: Illegal digit

[ERROR], M2

Description

While reading a numerical constant, an illegal digit has been found.

Example

```
x: REAL;  
x := 123e4a;
```

Tips

Check your numerical constant for correctness.

C2709: Illegal floating-point exponent ('-', '+' or digit expected)

[ERROR]

Description

While reading a numerical constant, an illegal exponent has been found.

Example

```
x = 123e;
```

Tips

Check your numerical constant for correctness. After the exponent, there has to be an optional '+' or '-' sign followed by a sequence of digits.

C2800: Illegal operator

[ERROR]

Description

An illegal operator has been found. This could be caused by an illegal usage of saturation operators, e.g. the using saturation operators without enabling them with a compiler switch if available.

Note that not all compiler backends support saturation operators.

Example

```
i = j +? 3; /* illegal usage of saturation operator */
```

Tips

Enable the usage of Saturation operators if available.

See also

Saturation Operator

Compiler Backend Chapter

C2801: <Symbol> missing"

[ERROR]

Description

There is a missing symbol for the Compiler to complete a parsing rule. Normally this is just a closing parenthesis or a missing semicolon.

Example

```
void main(void) {  
  
    // '}' missing
```

other Example

```
void f() {  
    int i  
}
```

Tips

Usually this is a programming error. Correct your source code!

C2802: Illegal character found: <Character>

[DISABLE, INFORMATION, WARNING, ERROR]

Description

In the source there is a character which does not match with the name rules for C/C++. As an example it is not legal to have '\$' in identifiers.

Note: The [pragma MESSAGE](#) does not apply to this message because it is issued in the preprocessing phase.

Example

```
int $j;
```


Tips

Usually this is a programming error. Replace the illegal character with a legal one. Some E-MAIL programs set the most significant bit of two immediately following spaces. In a hex editor, such files then contain “a0 a0 a0 20” for four spaces instead of “20 20 20 20”. When this occurs in your E-Mail configuration, send sources as attachment.

C2803: Limitation: Parser was going out of sync!

[ERROR]

Description

The parser was going out of synchronization.

This is caused by complex code with many blocks, gotos and labels.

Example

It would take too much space to write an example here!

Tips

Try to simplify your code!

See also

Limitations

C2900: Constant condition found, removing loop

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A constant loop condition has been found and the loop is never executed. No code is produced for such a loop. Normally, such a constant loop condition may be a programming error.

Example of a constant loop condition:

```
for(i=10; i<9; i--)
```

Because the loop condition 'i<9' never becomes true, the loop is removed by the compiler and only the code for the initialization 'i=10' is generated.

Tips

If it is a programming error, correct the loop condition.

See also

Loop Unrolling

C2901: Unrolling loop

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A loop has been detected for unrolling. Either the loop has only one round, e.g.

```
for(i=1; i<2; i++)
```

or loop unrolling was explicitly requested (Compiler Option [-Cu](#) or pragma LOOP_UNROLL) or the loop has been detected as empty as

```
for(i=1; i<200; i++);
```

Tips

If it is a programming error, correct the loop condition.

See also

Loop Unrolling

C3000: File-stack-overflow (recursive include?)

[FATAL]

Description

There are more than 256 file includes in one chain or a possible recursion during an include sequence. Maybe the included header files are not guarded with `#ifndef`

Example

```
/* foo.c */
#include "foo.c"
```

Tips

Use `#ifndef` to break a possible recursion during include:

```
/* foo.h */
#ifndef FOO_H
#define FOO_H

/* additional includes, declarations, ... */

#endif
```

Simplify the include complexity to less than 256 include files in one include chain.

See also

Limitations

C3100: Flag stack overflow -- flag ignored

[DISABLE, INFORMATION, WARNING, ERROR], MODULA-2

Description

There were too many flags used at the same time. This message occurs for Modula 2 versions of the compiler only. It occurs for C/C++ compilers.

C3200: Source file too big

[FATAL]

Description

The compiler can handle about 400'000 lexical source tokens. A source token is either a number or an ident, e.g. 'int a[2] = {0,1};' contains the 12 tokens 'int', 'a', '[', '2', ']', '=', '{', '0', '1', '}' and ';'.

Example

A source file with more than 400'000 lexical tokens.

Tips

Split up the source file into parts with less then 400'000 lexical tokens.

See also

Limitations

C3201: Carriage-Return without a Line-Feed was detected

[DISABLE, INFORMATION, WARNING, ERROR]

Description

On a PC, the usual 'newline' sequence is a carriage return (CR) followed by a line feed (LF). With this message the compiler warns that there is a CR without a LF. The reason could be a not correctly transformed UNIX source file. However, the compiler can handle correct UNIX source files (LF only).

Note: The [pragma MESSAGE](#) does not apply to this message because it is issued in the preprocessing phase.

Tips

Maybe the source file is corrupted or the source file is not properly converted from a UNIX source file. Try to load the source file into an editor and to save the source file, because most of the editors will correct this.

C3202: Ident too long

[FATAL]

Description

An identifier was longer than allowed. The compiler supports identifiers with up to 16000 characters. Note that the limits of the linker/debugger may be smaller.

The 16000 characters are in respect of the length of the identifier in the source. A name mangled C++ identifier is only limited by available memory.

Tips

Do not use such extremely large names!

C3300: String buffer overflow

[FATAL]

Description

The compiler can handle a maximum of about 10'000 strings in a compilation unit. If the compilation unit contains too many strings, this message will appear.

Example

A source file with more than 10'000 strings, e.g.

```
char *chPtr[] = {"string0", "string1",  
                "string2", ... "string1000"};
```

Tips

Split up the source file into parts with less than 10'000 strings.

See also

Limitations

C3301: Catenated string too long

[FATAL]

Description

The compiler cannot handle an implicit string concatenation with a total of more than 8192 characters.

Example

Implicit string concatenation of two strings with each more than 4096 characters:

```
char *str = "MoreThan4096...."  
"OtherWithMoreThan4096...."
```

Tips

Do not use implicit string concatenation, write the string in one piece:

```
char *str = "MoreThan4096....OtherWithMoreThan4096...."
```

See also

Limitations

Message C3303

C3302: Praise_number-buffer overflow

[FATAL]

Description

This message may occur during preprocessing if there are too many numbers to handle for the compiler in a compilation unit.

The compiler can handle a most 10'000 different numbers for a compilation unit. Internally for each number a descriptor exists. If an internal number descriptor already exists for a given number value with a given type, the existing one is used. But if e.g. more than 10'000 different numbers are used, this message will appear.

Example

An array initialized with the full range of numbers from 0 to 10'000:

```
const int array[] = {0, 1, 2, ... 10000};
```

Tips

Splitting up the source file into smaller parts until this message disappears.

See also

Limitations

C3303: Implicit concatenation of strings

[DISABLE, INFORMATION, WARNING, ERROR]

Description

ANSI-C allows the implicit concatenation of strings: Two strings are merged by the preprocessor if there is no other preprocessor token between them. This is a useful feature if two long strings should be one entity and you do want to write a very long line:

```
char *message = "This is my very long message string  
which "  
                "which has been splitted into two parts!"
```

This feature may be dangerous if there is just a missing comma (see example below!). If intention was to allocate a array of char pointers with two elements, the compiler only will allocate one pointer to the string "abcdef" instead two pointers if there is a comma between the two strings.

Note: The [pragma MESSAGE](#) does not apply to this message because it is issued in the preprocessing phase.

Example

```
char *str[] = {"abc" "def"}; /* same as "abcdef" */
```

Tips

If it is a programming error, correct it.

C3304: Too many internal ids, split up compilation unit

[FATAL]

Description

The compiler internally maintains some internal id's for artificial local variables. The number of such internal id's is limited to 256 for a single compilation unit.

Tips

Split up the compilation unit.

See also

Limitations

C3400: Cannot initialize object (dest too small)

[DISABLE, INFORMATION, WARNING, ERROR]

Description

An object cannot be initialized, because the destination is too small, e.g. because the pointer is too small to hold the address. The message typically occurs if the programmer tries to initialize a 'near' pointer (e.g. 16bit) with a 'far' pointer (e.g. 24bit).

Example

```
#pragma DATA_SEG FAR MyFarSegment
char Array[10];

#pragma DATA_SEG DEFAULT
char *p = Array;
```

Tips

Increase the type size for the destination (e.g. with using the 'far' keyword if supported)

```
char *far p = Array;
```

Be careful when disabling this message.

See also

Limitations

C3401: Resulting string is not zero terminated

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The compiler issues this message if a the resulting string is not terminated with a zero byte. Thus if such a string is used for printf or strcpy, the operation may fail. In C it is legal to initialize an array with a string if the string fits without the zero byte.

Example

```
void main(void) {
    char buf[3] = "abc";
}
```

Tips

For array initialization it is always better to use [] instead to specify the size:

```
char buf[] = "abc";
```

C3500: Not supported fixup-type for ELF-Output occurred

[FATAL]

Description

A fixup type not supported by the ELF Object file writer occurred. This message indicates an internal compiler error because all necessary fixup types must be supported. This message also can occur if in HLI (High Level Inline) Assembler an unsupported relocation/fixup type is used.

Tips

Report this error to your distributor.

C3501: ELF Error <Description>

[FATAL]

Description

The ELF generation module reports an error. Possible causes are when the object file to be generated is locked by another application or the disk is full.

Tips

Check if the output file exists and is locked. Close all applications which might lock it.

C3600: Function has no code: remove it!

[ERROR]

Description

It is an error when a function is really empty because such a function can not be represented in the memory and it does not have an address.

Because all C functions have at least a return instruction, this error can only occur with the pragma NO_EXIT. Remark that not all targets support NO_EXIT.

Example

```
#pragma NO_EXIT
void main(void) {}
```

Tips

Remove the function. It is not possible to use an empty function.

C3601: Pragma TEST_CODE: mode <Mode>, size given <Size> expected <Size>, hashcode given <HashCode>, expected <HashCode>

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The condition tested with a pragma TEST_CODE was false.

Example

```
#pragma TEST_CODE == 0
void main(void) {}
```

Tips

There are many reasons why the generated code may have been changed. Check why the pragma was added and which code is now generated. If the code is correct, adapt the pragma. Otherwise change the code.

See also

#pragma TEST_CODE description

C3602: Global objects: <Number>, Data Size (RAM): <Size>, Const Data Size (ROM): <Size>

[DISABLE, INFORMATION, WARNING, ERROR]

Description

This message is used to give some additional information about the last compilation unit compiled.

Example

Compile any C file.

Tips

Smart Linking may not link all variables or constants, so the real application may be smaller than this value.

No alignment bytes are counted.

C3603: Static '<Function>' was not defined

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A static function was used, but not defined.

As static functions can only be defined in this compilation unit, the function using the undefined static cannot successfully link.

Example

```
static void f(void);  
void main(void) {  
    f();  
}
```

Tips

Define the static function, remove its usage or declare it as external.

C3604: Static '<Object>' was not referenced

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A static object was defined but not referenced.

When using smart linking, this object will not be used.

Example

```
static int i;
```

Tips

Remove the static object, comment it out or do not compile it with conditional compilation. Not referenced static functions often exist because they were used sometime ago but no longer or because the usage is present but not compiled because of conditional compilation.

C3605: Runtime object '<Object>' is used at PC <PC>

[DISABLE, INFORMATION, WARNING, ERROR]

Description

By default this message is disabled. This message may be enabled to report every runtime object used. Runtime objects (or calls) are used if the target CPU itself does not support a specific operation, e.g. a 32bit division or if the usage of such a runtime function is better than directly to inline it.

The message is issued at the end of a function and reports the name and the PC where the object is used.

Example

```
double d1, d2;
void foo(void) {
    d1 = d2 * 4.5; // compiler calls _DMUL for
                  // IEEE64 multiplication
}
```

Tips

Set this message to an error if you have to ensure that no runtime calls are made.

C3606: Initializing object '<Object>'

[DISABLE, INFORMATION, WARNING, ERROR]

Description

If global variables are initialized, such initialized objects have to be initialized during startup of the application. This message (which is disabled by default) reports every single global or static local initialization.

Example

```
int i = 3;           // message C3606
char *p = "abc";    // message C3606
void foo(void) {
    int k = 3;       // no message!
    static int j = 3; // message C3606
}
```

Tips

Set this message to an error if you have to ensure that no additional global initialization is necessary for a copy down during startup of the application.

C3700: Special opcode too large

[FATAL]

Description

An internal buffer overflow in the ELF/DWARF 2 debug information output. This error indicates an internal error. It should not be possible to generate this error with legal input.

C3701: Too many attributes for DWARF2.0 Output

[FATAL]

Description

The ELF/DWARF 2 debug information output supports 128*128-128 different DWARF tags. This error indicates an internal error. It should not be possible to

generate this error with legal input because similar objects use the same tag and there much less possible combinations.

C3800: Segment name already used

[ERROR]

Description

The same segment name was used for different segment type.

Example

```
#pragma DATA_SEG Test
#pragma CODE_SEG Test
```

Tips

Use different names for different types. If the two segments must be linked to the same area, this could be done in the link parameter file.

C3801: Segment already used with different attributes

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A segment was used several times with different attributes.

Example

```
#pragma DATA_SEG FAR AA
..
#pragma DATA_SEG NEAR BB
..
```

Tips

Use the same attributes with one segment. Keep variables of the same segment together to avoid inconsistencies.

C3802: Segment pragma incorrect

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A section pragma was used with incorrect attributes or an incorrect name.

Example

```
#pragma DATA_SEG FAR FAR
```

Tips

Take care about not using keywords as names segment names. Note that you can use e.g. the `__FAR_SEG` instead `FAR`.

Example

```
#pragma DATA_SEG __FAR_SEG MyFarSeg
```

C3803: Illegal Segment Attribute

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A Segment attribute was recognized, but this attribute is not applicable to this segment.

Code segments may only be `FAR`, `NEAR` and `SHORT`. The `DIRECT` attribute is allowed for data segments only.

The actual available segment attributes and their semantic depends on the target processor.

Example

```
#pragma CODE_SEG DIRECT MyFarSegment
```

Tips

Correct the attribute. Do not use segment attribute specifiers as segment names. Note that you can use the 'safe' qualifiers as well, e.g. `__FAR_SEG`.

C3804: Predefined segment '<segmentName>' used

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A Segment name was recognized which is a predefined one. Predefined segment names are FUNCS, STRINGS, ROM_VAR, COPY, STARTUP, _PRESTART, SSTACK, DEFAULT_RAM, DEFAULT_ROM and _OVERLAP.

If you use such segment names, this may raise conflicts during linking.

Example

```
#pragma CODE_SEG FUNCS // WARNING here
```

Tips

Use another name. Do not use predefined segment names.

C3900: Return value too large

[ERROR]

Description

The return type of the function is too large for this compiler.

Example

```
typedef struct A {
    int i,j,k,l,m,n,o,p;
}A;
A f();
```

Tips

In C++, instead of a class/struct type, return a reference to it! In C, allocate the structure at the caller and pass a pointer/reference as additional parameter.

See also

Compiler Backend

C4000: Condition always is TRUE

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The compiler has detected a condition to be always true. This may also happen if the compiler uses high level optimizations, but could also be a hint for a possible programming error.

Example

```
unsigned int i;
if (i >= 0) i = 1;
```

Tips

If it is a programming error, correct the statement

C4001: Condition always is FALSE

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The compiler has detected a condition to be always false. This may also happen if the compiler uses high level optimizations, but could also be a hint for a possible programming error.

Example

```
unsigned int i;  
if (-i < 0) i = -i;
```

Tips

If it is a programming error, correct the statement

C4002: Result not used

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The result of an expression outside a condition is not used. In ANSI-C it is legal to write code as in the example below. Some programmers are using such a statement to enforce only a read access to a variable without write access, but in most cases the compiler will optimize such statements away.

Example

```
int i;  
i+1; /* should be 'i=1;', but programming error */
```

Tips

If it is a programming error, correct the statement.

C4003: Shift count converted to unsigned char

[DISABLE, INFORMATION, WARNING, ERROR]

Description

In ANSI-C, if a shift count exceeds the number of bits of the value to be shifted, the result is undefined. Because there is no integral data type available with more than 256 bits yet, the compiler implicitly converts a shift count larger than 8 bits (char) to an unsigned char, avoiding loading a shift count too large for shifting, which does not affect the result.

This ensures that the code is as compact as possible.

Example

```
int j, i;
i <<= j; /* same as 'i <<= (unsigned char)j;' */
```

In the above example, both 'i' and 'j' have type 'int', but the compiler can safely replace the 'int' shift count 'j' with a 'unsigned char' type.

Tips

None, because it is a hint of compiler optimizations.

C4004: BitSet/BitClr bit number converted to unsigned char

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The compiler has detected a shift count larger than 8bit used for a bitset/bitclear operation. Because it makes no sense to use a shift count larger than 256, the compiler optimizes the shift count to a character type. Reducing the shift count may reduce the code size and improve the code speed (e.g. a 32bit shift compared with a 8bit shift).

Example

```
int j; long L;
j |= (1<<L); // the compiler converts 'L'
             // to a unsigned character type
```

Tips

None, because it is a hint of compiler optimizations.

C4005: Expression with a cast is not a lvalue

[DISABLE, INFORMATION, WARNING, ERROR]

Description

In ANSI-C, an expression which modifies a value has to be a modifiable lvalue. If the expression has a cast as root, the expression itself is not a lvalue.

Example

```
int i;  
(int)i++;
```

Tips

Remove the cast if it is useless.

C4006: Expression too complex

[FATAL]

Description

The compiler cannot handle an expression which has more than 32 recursion levels.

Example

```
typedef struct S {  
    struct S *n;  
} S;  
  
S *s;  
  
void foo(void) {  
    s->n->n->n->n->n-> ... n->n->n->n->n->n->n->n->n = 0;  
}
```

Tips

Try to simplify the expression, e.g. use temporary variables to hold expression results.

See also

Limitations

C4100: Converted bit field signed -1 to 1 in comparison

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A signed bitfield entry of size 1 can only have the values 0 and -1. The compiler did find a comparison of such a value with 1. The compiler did use -1 instead to generate the expected code.

Example

```
struct A {
    int i:1;
} a;

void f(void);

void main(void) {
    if (a.i == 1) {
        f();
    }
}
```

Tips

Correct the source code. Either use an unsigned bitfield entry or compare the value to -1.

C4101: Address of bitfield is illegal

[ERROR]

Description

The address of a bitfield was taken.

Example

```
typedef struct A {
    int bf1:1;
} A;

void f() {
    A a;
    if(&a.bf1);
}
```

Tips

Use a "normal" integral member type, if you really need to have the address.

C4200: Other segment than in previous declaration

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A object (variable or function) was declared with inconsistent segments.

Example

```
#pragma DATA_SEG A
extern int i;

#pragma DATA_SEG B
int i;
```

Tips

Change the segment pragmas so, that all declarations and the definition of one object are in the same segment. Otherwise wrong optimizations could happen.

C4201: pragma <name> was not handled

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A pragma was not used by the compiler. This may have different reasons:

- the pragma is intended for a different compiler
- by a typing mistake, the compiler did not recognize a pragma. Note that pragma names are case sensitive.
- there was no context, a specific pragma could take some action
- The segment pragmas DATA_SEG, CODE_SEG, CONST_SEG and their aliases never issue this warning, even if they are not used.

Example

```
#pragma TRAP_PROG
// typing mistake: the interrupt pragma is called
TRAP_PROC

void Inter(void) {
    ...
}
```

Tips

Investigate this warning carefully.

This warning can be mapped to an error if only pragmas are used which are known.

C4202: Invalid pragma OPTION, <description>

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A ill formed pragma OPTION was found or the given options were not valid. The description says more precisely what is the problem with a specific [pragma OPTION](#).

Example

```
#pragma OPTION add "-or"
```

The pragma OPTION keyword ADD is case sensitive!

Write instead:

```
#pragma OPTION ADD "-or"
```

Tips

When the format was illegal, correct it. You can add comments, but they must follow the usual C rules.

Be careful which options are given by the command line when adding options.

It is not possible to add options which contradicts to command line options.

Notice the limitations of the [pragma OPTION](#).

See also

[pragma OPTION](#)

C4203: Invalid pragma MESSAGE, <description>

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A ill formed pragma MESSAGE was found or the given message number cannot be moved. The description says more precisely what is the problem with a specific [pragma MESSAGE](#).

Example

```
#pragma MESSAGE warning C4203
```

The pragma OPTION keyword warning is case sensitive!

Write instead:

```
#pragma MESSAGE WARNING C4203
```

Tips

When the format was illegal, correct it. You can add comments, but they must follow the usual C rules.

The same message can be moved at different code positions to a different state.

Be careful not to specify the same message with a option or with graphical user interface and with this pragma. If this is done, it is not defined which definition is actually taken.

See also

[pragma MESSAGE](#)

C4204: Invalid pragma REALLOC_OBJ, <description>

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The pragma REALLOC_OBJ was used in a ill formed way. The correct syntax this pragma is can be found here: [#pragma REALLOC OBJ](#)

See also

[#pragma REALLOC OBJ](#)

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C4205: Invalid pragma LINK_INFO, <description>

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The pragma LINK_INFO was used in a ill formed way. The correct syntax this pragma is can be found here: [#pragma LINK INFO](#)

See also

[#pragma LINK_INFO](#)

C4300: Call of an empty function removed

[DISABLE, [INFORMATION](#), WARNING, ERROR]

Description

If the option [-Oi](#) is enabled, calls of empty functions are removed.

Example

```
void f() {  
}  
  
void main() {  
    f();           // this call is removed !  
}
```

Tips

If for any reason you need a call of an empty function, disable the option [-Oi](#).

See also

[Option -Oi](#)

C4301: Inline expansion done for function call

[DISABLE, [INFORMATION](#), WARNING, ERROR]

Description

The compiler was replacing the function call with the code of the function to be called.

Example

```
inline int f(int i) {
    return i+1;
}

void main() {
    int i=f(3); // gets replaced by i=3+1;
}
```

Tips

To force the compiler to inline function calls use the keyword "inline".

See also

[Option -Oi](#)

C4302: Could not generate inline expansion for this function call

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The compiler could not replace the function call with the code of the function to be called. The expression containing the function call may be too complex, the function to be called may be recursive or too complex.

Example

```
inline int f(int i) {
    if(i>10) return 0;
    return f(i+1);
}

void main() {
    int i=f(3); // Cannot inline,
               // because f() contains a recursive call
}
```

Tips

To have the same effect as inlining the function, replace the call with the code of the function manually.

C4303: Illegal pragma <name>

[DISABLE, INFORMATION, WARNING, ERROR]

Description

An parsing error was found inside of the given pragma.

Example

```
#pragma INLINE Inline it!  
/* pragma INLINE does not expect any arguments */  
void foo(void) {  
}
```

Tips

Check the exact definition of this pragma.

Use comments to add text behind a pragma.

C4400: Comment not closed

[FATAL]

Description

The preprocessor has found a comment which has not been closed.

Example

```
/*
```

Tips

Close the comment.

C4401: Recursive comments not allowed

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A recursive comment has been found (a comment with inside a comment).

Example

```
/* /* nested comment */
```

Tips

Either correct the comment, use ‘#if 0’ - ‘#endif’ or the C++ like comment ‘\|’:

```
#if 0
    /* nested comment */
#endif
// /* /* nested comment */
```

C4402: Redefinition of existing macro ‘<MacroName>’

[FATAL]

Description

It is not allowed to redefine a macro.

Example

```
#define ABC 10
#define ABC 20
```

Tips

Correct the macro (e.g. using another name).

C4403: Macro-buffer overflow

[FATAL]

Description

There are more than 10'000 macros in a single compilation unit.

Example

```
#define macro0  
#define macro1  
...  
#define macro10000
```

Tips

Simplify the compilation unit to reduce the amount of macro definitions.

See also

Limitations

C4404: Macro parents not closed

[FATAL]

Description

In a usage of a macro with parameters, the closing parenthesis is not present.

Example

```
#define cat(a,b) (a##b)  
int i = cat(12,34;
```

Tips

Add a closing ')’.

C4405: Include-directive followed by illegal symbol

[FATAL]

Description

After an #include directive, there is an illegal symbol (not a file name in double quotes or within '<' and '>').

Example

```
#include <string.h> <<< message C4405 here
```

Tips

Correct the #include directive.

C4406: Closing '>' missing

[FATAL]

Description

There is a missing closing '>' for the include directive.

Example

```
#include <string.h
```

Tips

Correct the #include directive.

C4407: Illegal character in string or closing '>' missing

[FATAL]

Description

Either there is a non-printable character (as control characters) inside the file name for the `#include` directive or the file name is not enclosed with '`<`' and '`>`'.

Example

```
#include <abc.h[control character]
```

Tips

If there are non-printable characters inside the file name, remove them.

If there is a missing '`>`', add a '`>`' to the end of the file name.

C4408: Filename too long

[FATAL]

Description

A include file name longer than 2048 characters has been specified.

Example

```
#include <VeryLongFilename.....>
```

Tips

Shorten the file name, e.g. using a relative path or setting up the include file path in the `default.env` environment file.

See also

Limitations

C4409: a ## b: the concatenation of a and b is not a legal symbol

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The concatenation operator `##` is used to concatenate symbols. If the resulting symbol is not a legal one, this message is issued.

Note: The [pragma MESSAGE](#) does not apply to this message because it is issued in the preprocessing phase.

Example

```
#define concat(a,b) a ## b
void foo(int a) {
    a concat(=,@) 5; // message: =@ is not a legal symbol
}
```

Tips

Check your macro definition. Generate a preprocessor output (option [-Lp](#)) to find the problem.

C4410: Unbalanced Parentheses

[FATAL]

Description

The number of opening parentheses ‘(’ and the number of closing parentheses ‘)’ does not match.

Tips

Check your macro definition. Generate a preprocessor output (option [-Lp](#)) to find the problem.

C4411: Maximum number of arguments for macro expansion reached

[FATAL]

Description

The compiler has reached the limit for the number of macro arguments for a macro invocation.

Example

```
#define A0(p1,p2,...,p1024) (p1+p2+...+p1024)
#define A1(p1,p2,...,p1024) A0(p1+p2+...+p1024)

void foo(void) {
    A1(1,2,...,1024); // message C4411 here
}
```

Tips

Try to avoid such a huge number of macro parameters, use simpler macros instead.

See also

Limitations

C4412: Maximum macro expansion level reached

[FATAL]

Description

The compiler has reached the limit for recursive macro expansion. A recursive macro is if a macro depends on another macro. The compiler also stops macro expansion with this message if it seems to be an endless macro expansion.

Example

```
#define A0 0
#define A1 A0
#define A2 A1
...
```

Tips

Try to reduce huge dependency list of macros.

See also

Limitations

C4413: Assertion: pos failed

[FATAL]

Description

This is a compiler internal error message only. It happens if during macro expansion the macro definition position is not the same as during the initial macro scanning.

Tips

If you encounter this message, please send us a preprocessor output (option [-Lp](#)).

C4414: Argument of macro expected

[FATAL]

Description

The preprocessor tries to resolve a macro expansion. However, there is no macro argument given after the comma separating the different macro arguments.

Example

```
#define Macro(a,b)
void foo(void) {
    Macro(,);
}
```

Tips

Check your macro definition or usage. Generate a preprocessor output (option [-Lp](#)) to find the problem.

C4415: ')' expected

[FATAL]

Description

The preprocessor expects a closing parenthesis. This may happen if a preprocessor macro has been called more argument than previously declared.

Example

```
#define A(a,b) (a+b)
void main(void) {
    int i = A(3,4,5); // message C4415 here
}
```

Tips

Use the same number of arguments as declared in the macro.

C4416: Comma expected

[FATAL]

Description

The preprocessor expects a comma at the given position.

Tips

Check your macro definition or usage.

C4417: Mismatch number of formal, number of actual parameters

[FATAL]

Description

A preprocessor macro has been called with a different number of argument than previously declared.

Example

```
#define A(a,b) (a+b)

void main(void) {
    int i = A(3,5,7); // message C4417 here
}
```

Tips

Use the same number of arguments as declared in the macro.

C4418: Illegal escape sequence

[DISABLE, INFORMATION, WARNING, ERROR]

Description

An illegal escape sequence occurred. A set of escape sequences is well defined in ANSI C. Additionally there are two forms of numerical escape sequences. The compiler has detected an escape sequence which is not covered by ANSI.

Note: The [pragma MESSAGE](#) does not apply to this message because it is issued in the preprocessing phase.

Example

```
char c= '\p';
```

Tips

Remove the escape character if you just want the character.

When this message is ignored, the compiler issued just the character without considering the escape character. So '\p' gives just a 'p' when this message is ignored.

To specify an additional character use either the octal or hexadecimal form of numerical escape sequences.

```
char c_space1= ' '; /* conventional space */
char c_space2= '\x20'; /* space with hex notation */
char c_space3= '\040'; /* space with octal notation */
```

Only 3 digits are read for octal numbers, so when you specify 3 digits, then, there is no danger of combining the numerical escape sequence with the next character in sequence. Hexadecimal escape sequences should be terminate explicitly.

```
const char string1[]= " 0";// gives " 0"
const char string2[]= "\400";// error because 0400> 255
const char string3[]= "\x200";// error because 0x200 >
255
const char string4[]= "\0400";// gives " 0"
const char string5[]= "\x20" "0";// gives " 0"
```

See also

List of Escape Sequences

C4419: Closing “ missing

[FATAL]

Description

There is a string which is not terminated by a double quote. This message is also issued if the not closed string is at the end of the compilation unit file.

C4420: Illegal character in string or closing " missing

[FATAL]

Description

A string contains either an illegal character or is not terminated by a closing double quote.

Example

```
#define String "abc
```

Tips

Check your strings for illegal characters or if they are terminated by a double quote.

C4421: String too long

[FATAL]

Description

Strings in the preprocessor are actually limited to 8192 characters.

Tips

Use a smaller string or try to split it up.

See also

Limitations

C4422: ' missing

[FATAL]

Description

To define a character, it has to be surrounded by single quotes (').

Example

```
#define CHAR 'a
```

Tips

Add a single quote at the end of the character constant.

C4423: Number too long

[FATAL]

Description

During preprocessing, the maximum length for a number has been reached. Actually this length is limited to 8192 characters.

Example

```
#define MyNum 12345.....8193 // 8193 characters
```

Tips

Probably there is a typing error or the number is just too big.

See also

Limitations

C4424: # in substitution list must be followed by name of formal parameter

[FATAL]

Description

There is a problem with the '#' operator during preprocessing, because there is no legal name as formal parameter specified.

Example

```
#define cat(a,b) a #  
void foo(void) {  
    i = cat(3,3);  
}
```

Tips

Check your macro definition or usage. Generate a preprocessor output (option [-Lp](#)) to find the problem.

C4425: ## in substitution list must be preceded and followed by a symbol

[FATAL]

Description

There is a problem with the string concatenation '##' operator during preprocessing, because there is no legal name as formal parameter specified.

Example

```
#define cat(a,b) a ##  
void foo(void) {  
    i = cat(3,3);  
}
```

Tips

Check your macro definition or usage. Generate a preprocessor output (option [-Lp](#)) to find the problem.

C4426: Macro must be a name

[FATAL]

Description

There has to be a legal C/C++ ident to be used as a macro name. An ident has to be start with a normal letter (e.g. 'a'..'Z') or any legal ident symbol.

Example

```
#define "abc"
```

Tips

Use a legal macro name, e.g. not a string or a digit.

C4427: Parameter name expected

[FATAL]

Description

The preprocessor expects a name for preprocessor macros with parameters.

Example

```
#define A(3) (B)
```

Tips

Do not use numbers or anything else than a name as macro parameter names.

C4428: Maximum macro arguments for declaration reached

[FATAL]

Description

The preprocessor has reached the maximum number of arguments allowed for a macro declaration.

Example

```
#define A(p0, p1, ..., p1023, p1024) (p0+p1+...p1024)
```

Tips

Try to split your macro into two smaller ones.

See also

Limitations

C4429: Macro name expected

[FATAL]

Description

The preprocessor expects macro name for the `#undef` directive.

Example

```
#undef #xyz
```

Tips

Use only a legal macro name for the `#undef` directive.

C4430: Include macro does not expand to string

[FATAL]

Description

The file name specified is not a legal string. A legal file name has to be surrounded with double quotes `""`.

Example

```
#define file 3  
  
#include file
```

Tips

Specify a legal file name.

C4431: Include "filename" expected

[FATAL]

Description

There is no legal file name for a include directive specified. A file name has to be non-empty and surrounded either by '<' and '>' or by double quotes "".

Example

```
#include <>
```

Tips

Specify a legal file name.

C4432: Macro expects '('

[FATAL]

Description

While expanding macros, the preprocessor expects here an opening parenthesis to continue with macro expansion.

Tips

Check your macro definition or usage. Generate a preprocessor output (option [-Lp](#)) to find the problem.

C4433: Defined <name> expected

[FATAL]

Description

Using 'defined', it can be checked if a macro is defined or not. However, there has to be a name used as argument for defined.

Example

```
#if defined()  
#endif
```

Tips

Specify a name for the defined directive, e.g. #if defined(abc).

C4434: Closing ')' missing

[FATAL]

Description

During macro expansion, the preprocessor expects a closing parenthesis to continue.

Tips

Check your macro definition or usage. Generate a preprocessor output (option [-Lp](#)) to find the problem.

C4435: Illegal expression in conditional expression

[FATAL]

Description

There is an illegal conditional expression used in a `#if` or `#elif` directive.

Example

```
#if (3*)  
#endif
```

Tips

Check the conditional expression.

C4436: Name expected

[FATAL]

Description

The preprocessor expects a name for the `#ifdef` and `#ifndef` directive.

Example

```
#ifndef 3333_H // << C4436 here */  
#define 3333_H  
#endif
```

Tips

Check if a legal name is used, e.g. it is not legal to start a name with a digit.

C4437: Error-directive found: <message>

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The preprocessor stops with this message if he encounters an `#error` directive.

Note: The [pragma MESSAGE](#) does not apply to this message because it is issued in the preprocessing phase.

Example

```
#error "error directive"
```

Tips

Check why the preprocessor evaluates to this error directive. Maybe you have forgotten to define a macro which has caused this error directive.

C4438: Endif-directive missing

[FATAL]

Description

All `#if` or `#ifdef` directives need a `#endif` at the end. If the compiler does not find one, this message is issued.

Example

```
#if 1
```

Tips

Check where the `#endif` is missing. Generate a preprocessor output (option [-Lp](#)) to find the problem.

C4439: Source file <file> not found

[FATAL]

Description

The compiler did not find the source file to be used for preprocessing.

Tips

Check why the compiler was not able to open the indicated file. Maybe the file is not accessible any more or locked by another application.

C4440: Unknown directive: <directive>

[FATAL]

Description

The preprocessor has detected a directive which is unknown and which cannot be handled.

Example

```
#notadirective
```

Tips

Check the directive. Maybe it is a non-ANSI directive supported by another compiler.

C4441: Preprocessor output file <file> could not be opened

[FATAL]

Description

The compiler was not able to open the preprocessor output file. The preprocessor file is generated if the option [-Lp](#) is specified.

Tips

Check your macro definition or usage. Check the option [-Lp](#): the format specified may be illegal.

C4442: Endif-directive missing

[FATAL]

Description

The `#asm` directive needs a `#endasm` at the end. If the compiler does not find one, this message is issued.

Example

```
#asm
```

Tips

Check where the `#endasm` is missing. Generate a preprocessor output (option [-Lp](#)) to find the problem.

C4443: Undefined Macro 'MacroName' is taken as 0

[DISABLE, INFORMATION, WARNING, ERROR]

Description

Whenever the preprocessor evaluates a condition and finds a identifier which was not defined before, he implicitly takes its value to be the integral value 0. This C style behavior may arise in hard to find bug. So when the header file, which actually defines the value is not included or when the macro name was entered incorrectly, for example with a different case, then the preprocessor `"#if"` and `"#elif"` instructions wont behave as expected.

Note: The [pragma MESSAGE](#) does not apply to this message because it is issued in the preprocessing phase.

Example

```
#define _Debug_Me 1
...
void main(int i) {
    #if Debug_Me /* missing _ in front of _Debug_Me. */
        assert(i!=0);
    #endif
}
```

```
#endif
}
```

The assert will never be encoded.

Tips

This warning is a good candidate to be mapped to an error. To save test macros defined in some header files, also test if the macros are defined:

```
#define _Debug_Me
...
void main(int i) {
#ifdef Debug_Me
#error /* macro must be defined above */
#endif
#ifdef Debug_Me /* missing _ in front of _Debug_Me. */
    assert(i!=0);
#endif
}
```

The checking of macros with "#ifdef" and "#ifndef" cannot detect if the header file, a macro should define is really included or not. Note that using a undefined macro in C source will treat the macro as C identifier and so usually be remarked by the compiler. Also note a undefined macro has the value 0 inside of preprocessor conditions, while a defined macro with nothing as second argument of a "#define" replaces to nothing. E.g.

```
#define DEFINED_MACRO

#ifdef UNDEFINED_MACRO // evaluates to 0, giving this
warning
#endif

#ifdef DEFINED_MACRO // error FATAL: C4435: Illegal
// expression in conditional expression
#endif
```

C4444: Line number for #line directive must be > 0 and <= 32767

[DISABLE, INFORMATION, WARNING, ERROR]

Description

ANSI requires that the line number for the line directive is greater zero or smaller-equal than 32767. If this message occurs and it is currently not mapped to an error, the compiler sets the line number to 1.

Example

```
#line 0  
  
#line 32768 "myFile.c"
```

Tips

Specify a line number greater zero and smaller 32768.

For automatically generated code, which has such illegal line directives, you can move this error to a warning.

C4445: Line number for #line directive expected

[DISABLE, INFORMATION, WARNING, ERROR]

Description

ANSI requires that after the line directive a number has to follow.

Example

```
#line // << ERROR C4445  
  
#line "myFile.c" // << ERROR C4445
```

Tips

Specify a line number greater zero and smaller 32768.

C4446: Missing macro argument(s)

[DISABLE, INFORMATION, WARNING, ERROR]

Description

In a macro 'call', one or more arguments are missing. The pre-processor replaces the parameter string with nothing.

Note: The [pragma MESSAGE](#) does not apply to this message because it is issued in the preprocessing phase.

Example

```
#define f(A, B) int A B
void main(void){
    f(i,)// this statement will be replaced with 'int i;'
        // by the pre-processor.
}
```

Tips

Be careful with empty macro arguments, because the behavior is undefined in ANSI-C. So avoid it if possible.

C4447: Unexpected tokens following preprocessor directive - expected a newline

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The compiler has detected that after a directive there was something unexpected. Directives are normally line oriented, thus the unexpected tokens are just ignored.

Note: The [pragma MESSAGE](#) does not apply to this message because it is issued in the preprocessing phase.

Example

```
#include "myheader.h" something
```

Tips

Remove the unexpected tokens.

C4448: Warning-directive found: <message>

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The preprocessor stops with this message if he encounters an #warning directive.

Note that this directive is only support if [-Ansi](#) is not set.

Note: The [pragma MESSAGE](#) does not apply to this message because it is issued in the preprocessing phase.

Example

```
#warning "warning directive"
```

Tips

Check why the preprocessor evaluates to this warning directive. Maybe you have forgotten to define a macro which has caused this directive.

C4700: Illegal pragma TEST_ERROR

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The pragma TEST_ERROR is for internal use only. It is used to test the message management and also to test error cases in the compiler.

C4701: pragma TEST_ERROR: Message <ErrorNumber> did not occur

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The pragma `TEST_ERROR` is for internal use only. It is used to test the message management and also to test error cases in the compiler.

C4800: Implicit cast in assignment

[DISABLE, INFORMATION, WARNING, ERROR]

Description

An assignment requiring an implicit cast was made.

Tips

Check, if the casting results in correct behavior.

C4801: Too many initializers

[ERROR]

Description

The braced initialization has too many members.

Example

```
char name[4]={'n','a','m','e',0};
```

Tips

Write the correct number of members in the braced initializer.

C4802: String-initializer too large

[ERROR]

Description

The string initializer was too large.

Tips

Take a shorter string, or try to allocate memory for your string in an initialization function of the compilation unit.

C4900: Function differs in return type only

[ERROR] ,C++

Description

The overloaded function has the same parameters, but not the same return type.

Example

```
void f(int);  
void f();  
int f(int); // error
```

Tips

A function redeclaration with the same parameters must have the same return type than the first declaration.

C5000: Following condition fails: sizeof(char) <= sizeof(short) <= sizeof(int) <= sizeof(long) <= sizeof(long long)

[ERROR]

Description

Type sizes has been set to illegal sizes. For compliance with the ANSI-C rules, the type sizes of char, short, int, long and long long has to in a increasing order,

e.g. setting char to a size of two and int to a size of one will violate this ANSI rule.

Example

```
-Tc2i1
```

Character as two bytes and int as one byte is illegal.

Tips

Change the [-T](#) option.

C5001: Following condition fails: sizeof(float) <= sizeof(double) <= sizeof(long double) <= sizeof(long long double)

[ERROR]

Description

Your settings of the Standard Types are wrong!

Example

```
-Tf4d2
```

Float as IEEE64 and double as IEEE32 is illegal.

Tips

Set your Standard Types correctly!

See also

Change the [-T](#) option.

C5002: Illegal type

[ERROR]

Description

A unknown or illegal type occurred.

This error may happen as consequence of another error creating the illegal type.

Tips

Check for other errors happening before.

C5003: Unknown array-size

[ERROR]

Description

A compiler internal error happened!

Tips

Please contact your distributor.

C5004: Unknown struct-union-size

[ERROR]

Description

A compiler internal error happened!

Tips

Please contact your distributor.

C5005: PACE illegal type

[ERROR]

Description

A compiler internal error happened!

Tips

Please contact your distributor.

C5006: Illegal type settings for HIWARE Object File Format

[ERROR]

Description

For HIWARE object file format (option [-Fh](#), [-F7](#) and default if no other object file format is selected) the char type must always be of size 1. This limitation is because there may not be any new types introduced in this format and 1 byte types are used internally in the compiler even if the user only need multibyte characters.

For the strict HIWARE object file format (option [-F7](#)) the additional limitation that the enum type has the size 2 bytes, and must be signed, is checked with this message.

The HIWARE Object File Format ([-Fh](#)) has following limitations:

- The type char is limited to a size of 1 byte
- Symbolic debugging for enumerations is limited to 16bit signed enumerations
- No symbolic debugging for enumerations
- No zero bytes in strings allowed (zero byte marks the end of the string)
- The strict HIWARE V2.7 Object File Format (option [-F7](#)) has some limitations:
 - The type char is limited to a size of 1 byte
 - Enumerations are limited to a size of 2 and has to be signed
 - No symbolic debugging for enumerations
 - The standard type ‘short’ is encoded as ‘int’ in the object file format
 - No zero bytes in strings allowed (zero byte marks the end of the string)

Example

```
COMPOPTIONS= -Te2 -Fh
```

Tips

Use [-Fh](#) HIWARE object file format to change the enum type. To change the char type, only the ELF object file format can be used (if supported).

Note that not all backends allow the change of all types.

See also

[Option for object file format -Fh/-F7/-F1/-F2](#)

Option for Type Setting -T

C5100: Code size too large

```
[ERROR]
```

Description

The code size is too large for this compiler.

Example

```
// a large source file
```

Tips

Split up your source into several compilation units!

See also

Limitations

C5200: 'FileName' file not found

```
[ERROR]
```

Description

The specified source file was not found.

Example

```
#include "notexisting.h"
```

Tips

Specify the correct path and name of your source file!

See also

Input Files

C5250: Error in type settings: <Msg>

[ERROR]

Description

There is an inconsistent state in the type option settings. E.g. it is illegal to have the 'char' size larger than the size for the type 'short'.

Tips

Check the -T option in your configuration files. Check if the option is valid.

See also

Option -T

C5300: Limitation: code size > '<Size>' bytes

[ERROR]

Description

You have a limited version of the compiler or reached the limitation specified in the license file. The actual demo limitation is 1024 bytes of code for 8/16bit targets and 3KByte for 32bit targets (without a license file).

Tips

Check if you have enough licenses if you are using a floating license configuration. Check for the correct location of the license file. Get a license for a full version of the compiler.

C5302: Couldn't open the object file '<FileName>'

[FATAL]

Description

The compiler cannot open the object file for writing.

Tips

Check if there is already an object file with the same name but used by another application. Check if the object file is marked as read-only or locked by another application.

C5320: Cannot open logfile '<FileName>'

[FATAL]

Description

The compiler cannot open the logfile file for writing.

Tips

Check if there is already a file with the same name but used by another application. Check if the file is marked as read-only or locked by another application.

See also

Option -Ll

C5350: Wrong or invalid encrypted file '<File>' (<MagicValue>)

[FATAL]

Description

The compiler cannot read an encrypted file because the encrypted file magic value is wrong.

Tips

Check if the file is a valid encrypted file.

See also

Option -Eencrypt

Option -Ekey

C5351: Wrong encryption file version: '<File>' (<Version>)

[FATAL]

Description

The compiler cannot read the encrypted file because the encryption version does not match.

Tips

Check if you have a valid license for the given encryption version. Check if you use the same license configuration for encryption and encrypted file usage.

See also

Option -Eencrypt

Option -Ekey

C5352: Cannot build encryption destination file: '<FileSpec>'

[FATAL]

Description

Building the encryption destination file name using the <FileSpec> was not possible.

Tips

Check your FileSpec if it is legal.

See also

Option -Eencrypt

Option -Ekey

C5353: Cannot open encryption source file: '<File>'

[FATAL]

Description

It was not possible to open the encryption source file.

Tips

Check if the source file exists.

See also

Option -Eencrypt

Option -Ekey

C5354: Cannot open encryption destination file: '<File>'

[FATAL]

Description

The compiler was not able to write to the encryption destination file.

Tips

Check if you have read/write access to the destination file. Check if the destination file name is a valid one. Check if the destination file is locked by another application.

See also

Option -Eencrypt

Option -Ekey

C5355: Encryption source '<SrcFile>' and destination file '<DstFile>' are the same

[FATAL]

Description

The encryption source file and the destination file are the same. Because it is not possible to overwrite the source file with the destination file, encryption is aborted.

Tips

Change the encryption destination file name specification.

See also

Option -Eencrypt

Option -Ekey

C5356: No valid license for encryption support

[FATAL]

Description

It was not possible to check out the license for encryption support.

Tips

Check your license configuration. Check if you have a valid encryption license.

See also

Option -Lic

C5400: Internal data structure inconsistency (SSA)

[ERROR]

Description

The internal data structure (Static Single Assignment form) of the compiler is wrong. Please extract the problem and send it to HIWARE. This error can be converted to a warning, because in most cases the inconsistency does not lead to wrong target code.

Example

This is a internal error which should not occur.

Tips

Try to find a different formulation as workaround. Contact support@hiware.com about this problem.

See also

Limitations

C5401: Internal optimized data structure inconsistency (SSA)

[ERROR]

Description

The optimized internal data structure (Static Single Assignment form) of the compiler is wrong. Please extract the problem and send it to HIWARE. This error can be converted to a warning, because in most cases the inconsistency does not lead to wrong target code.

Example

This is a internal error which should not occur.

Tips

Try to find a different formulation as workaround.

See also

Limitations

C5403: Trying to take address of register

[ERROR]

Description

The compiler tries to take the address of a register which is not possible.

Example

```
void main(void) {  
    int a, b;  
    int *p;
```

```
    p = &(a+b); (ERROR: result a+b is in register)
}
```

Tips

Do not use the address operator for temporary results.

See also

Limitations

C5500: Incompatible pointer operation

[DISABLE, INFORMATION, WARNING, ERROR]

Description

Two pointers of different sizes are subtracted (pointer difference).

Example

```
void main(void) {
    int *p;
    int *far q;

    *(p-q) = 0; (Error)
}
```

Tips

Cast one of the pointer to get equal size.

See also

Limitations

C5650: Too many locations, try to split up function

[FATAL]

Description

The internal data structure of the compiler blows up. One of your functions is too large.

Tips

Split up the function that causes the message.

See also

Limitations

C5651: Local variable <variable> may be not initialized

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The compiler issues this warning if no dominant definition is found for a local variable when it is referenced. Ignore this message if the local variable is defined implicitly (e.g. by inline assembly statements).

Example

```
int f(int param_i) {
    int local_i;

    if(param_i == 0) {
        local_i = 1;    /* this definition for local_i does
*/
                        /* NOT dominate following usage */
    }
    return local_i;    /* local_i referenced: no dominant */
                        /*definition for local_i found */
}
```

Tips

Review the code and initialize local variables at their declaration (e.g. `local_i = 0`).

C5660: Removed dead code

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The compiler has optimized some unused code away.

Tips

Sometimes these compiler message shows some problem in the C code.

C5661: Not all control paths return a value

[DISABLE, INFORMATION, WARNING, ERROR]

Description

There are one or more control paths without a `return <value>` statement. Your function does not return a value in every case.

C5662: Generic Inline Assembler Error <string>

[ERROR], SICG

Description

An error occurred during intermediate code generation for inline assembly instructions. The particular error is described in textual form.

Example

The inline assembly code taking the address of a local variable, which is not allocated on the stack.

C5700: Internal Error <ErrorNumber> in '<Module>', please report to <Producer>

[FATAL]

Description

The Compiler is in an internal error state. Please report this type of error as described in the chapter [Bug Report](#)

This message is used while the compiler is not investigating a specific function.

Example

no example known.

Tips

Sometimes these compiler bugs occur in wrong C Code. So look in your code for incorrect statements.

Simplify the code as long as the bug exists. With a simpler example, it is often clear what is going wrong and how to avoid this situation.

Try to avoid compiler optimization by using the volatile keyword.

Please report errors for which you do have a work around.

See also

Chapter [Bug Report](#)

C5701: Internal Error #<ErrorNumber> in '<Module>' while compiling

file '<File>', procedure '<Function>', please report to <Producer>

[FATAL]

Description

The Compiler is in an internal error state. Please report this type of error as described in the chapter [Bug Report](#).

This message is used while the compiler is investigating a specific function.

Example

no example known.

Tips

Sometimes these compiler bugs occur in wrong C Code. So look in your code for incorrect statements.

Simplify the code as long as the bug exists. With a simpler example, it is often clear what is going wrong and how to avoid this situation.

Try to avoid compiler optimization by using the volatile keyword.

Please report errors for which you do have a work around.

See also

Chapter [Bug Report](#)

C5702: Local variable '<Variable>' declared in function '<Function>' but not referenced

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The Compiler has detected a local variable which is not used.

Example

```
void main(void) {  
    int i;  
}
```

Tips

Remove the variable if it is never used. If it is used in some situations with conditional compilation, use the same conditions in the declaration as in the usages.

C5703: Parameter '<Parameter>' declared in function '<Function>' but not referenced

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The Compiler has detected a named parameter which is not used.

In C parameters in function definitions must have names. In C++ parameters may have a name. If it has no name, this warning is not issued.

This warning may occur in cases where the interface of a function is given, but not all parameters of all functions are really used.

Example

```
void main(int i) {  
}
```

Tips

If you are using C++, remove the name in the parameter list. If you are using C, use a name which makes clear that this parameter is intentionally not used as, for example "dummy".

C5800: User requested stop

[DISABLE, INFORMATION, WARNING, ERROR]

Description

This message is used when the user presses the stop button in the graphical user interface.

Also when the compiler is closed during a compilation, this message is issued.

Tips

By moving this message to a warning or less, the stop functionality can be disabled.

C5900: Result is zero

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The Compiler has detected operation which results in zero and is optimized.

This message may be generated during tree optimizations (Option [-Ont](#) to switch it off).

Example

```
i = j-j; // optimized to i = 0;
```

Tips

If it is a programming error, correct the statement.

C5901: Result is one

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The Compiler has detected an operation which results in one. This operation is optimized.

This message may be generated during tree optimizations (Option [-Ont](#) to switch it off).

Example

```
i = j/j; // optimized to i = 1;
```

Tips

If it is a programming error, correct the statement.

C5902: Shift count is zero

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The Compiler has detected an operation which results in a shift count of zero. The operation is optimized.

This message may be generated during tree optimizations (Option [-Ont](#) to switch it off).

Example

```
i = j<<(j-j); // optimized to i = j;
```

Tips

If it is a programming error, correct the statement.

C5903: Zero modulus

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The Compiler has detected a % operation with zero. Because the modulus operation implies also a division (division by zero), the compiler issues a warning.

This message may be generated during tree optimizations (Option [-Ont](#) to switch it off).

Example

```
i = j%0; // error
```

Tips

Correct the statement.

C5904: Division by one

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The Compiler has detected a division by one which is optimized.

This message may be generated during tree optimizations (Option [-Ont](#) to switch it off).

Example

```
i = j/1; // optimized to i = j;
```

Tips

If it is a programming error, correct the statement.

C5905: Multiplication with one

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The Compiler has detected a multiplication with one which is optimized.

This message may be generated during tree optimizations (Option [-Ont](#) to switch it off).

Example

```
i = j*1; // optimized to i = j;
```

Tips

If it is a programming error, correct the statement.

C5906: Subtraction with zero

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The Compiler has detected a subtraction with zero which is optimized.

This message may be generated during tree optimizations (Option [-Ont](#) to switch it off).

Example

```
i = j-(j-j); // optimized to i = j;
```

Tips

If it is a programming error, correct the statement.

C5907: Addition replaced with shift

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The Compiler has detected a addition with same left and right expression which is optimized and replaced with a shift operation.

This message may be generated during tree optimizations (Option [-Ont](#) to switch it off).

Example

```
i = j+j; // optimized to i = j<<1;
```

Tips

If it is a programming error, correct the statement.

C5908: Constant switch expression

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The Compiler has detected a constant switch expression. The compiler optimizes and reduces such a switch expression

This message may be generated during tree optimizations (Option [-Ont](#) to switch it off).

Example

```
switch(2){  
  case 1: break;  
  case 2: i = 0; break;  
  case 3: i = 7; break;  
}; // optimized to i = 0;
```

Tips

If it is a programming error, correct the statement.

C5909: Assignment in condition

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The Compiler has detected an assignment in a condition. Such an assignment may result from a missing '=' which is normally a programming error.

This message may be generated during tree optimizations (Option [-Ont](#) to switch it off).

Example

```
if (i = 0) // should be 'i == 0';
```

Tips

If it is a programming error, correct the statement.

C5910: Label removed

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The Compiler has detected a label which can be optimized .

This message may be generated during tree optimizations (Option [-Ont](#) to switch it off).

Example

```
switch(i) {  
  Label: i = 0; // Labeled removed  
  ...  
if (cond) {  
  L2: // L2 not referenced: Label removed  
  ...  
} else {  
}
```

Tips

Do not use normal labels in switch statements. If it is a switch case label, do not forget to add the 'case' keyword.

C5911: Division by zero at runtime

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The Compiler has detected zero division. This is not necessarily an error (see below).

This message may be generated during tree optimizations (Option [-Ont](#) to switch it off).

Example

```
void RaiseDivByZero(void) {  
    int i = i/0; // Division by zero!  
}
```

Tips

Maybe the zero value the divisor results from other compiler optimizations or because a macro evaluates to zero. It is a good idea to map this warning to an error (see Option [-WmsgSe](#)).

C5912: Code in 'if' and 'else' part are the same

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The Compiler has detected that the code in the 'if' and the code in the 'else' part of an 'if-else' construct is the same. Because regardless of the condition in the 'if' part, the executed code is the same, so the compiler replaces the condition with 'TRUE' if the condition does not have any side effects. There is always a couple of this message, one for the 'if' part and one for the 'else' part.

This message may be generated during tree optimizations (Option [-Ont](#) to switch it off).

Example

```
if (condition) { // replaced with 'if (1) {'
  statements; // message C5912 here ...
} else {
  statements; // ... and here
}
```

Tips

Check your code why both parts are the same. Maybe different macros are used in both parts which evaluates to the same values.

C5913: Conditions of 'if' and 'else if' are the same

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The Compiler has detected that the condition in an 'if' and a following 'else if' expression are the same. If the first condition is true, the second one is never evaluated. If the first one is FALSE, the second one is useless, so the compiler replaces the second condition with 'FALSE' if the condition does not have any side effects. There is always a couple of this message, one for the 'if' part and one for the 'if else' part.

This message may be generated during tree optimizations (Option [-Ont](#) to switch it off).

Example

```
if (condition) { // message C5913 here
  ...;
} else if(condition) { // here, condition replaced with 0
  ...
}
```

Tips

Check your code why both conditions are the same. Maybe different macros are used in both conditions which evaluates to the same values.

C5914: Conditions of 'if' and 'else if' are inverted

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The Compiler has detected that the condition in an 'if' and a following 'else if' expression are just inverted. If the first condition is true, the second one is never evaluated (FALSE). If the first one is FALSE, the second one is TRUE, so the compiler replaces the second condition with 'TRUE' if the condition does not have any side effects. There is always a couple of this message, one for the 'if' condition and one for the 'if else' condition.

This message may be generated during tree optimizations (Option [-Ont](#) to switch it off).

Example

```
if (condition) { // message C5914 here ...
    ...;
} else if(!condition) { // here, condition replaced with 1
    ...
}
```

Tips

Check your code why both conditions are inverted. Maybe different macros are used in both parts which evaluates to the same values.

C5915: Nested 'if' with same conditions

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The Compiler has detected that the condition in an ‘if’ and a nested ‘if’ expression have the same condition. If the first condition is true, the second one is always true. If the first one is FALSE, the second one is FALSE too, so the compiler replaces the second condition with ‘TRUE’ if the condition does not have any side effects. There is always a couple of this message, one for the first ‘if’ condition and one for nested ‘if’ condition.

This message may be generated during tree optimizations (Option [-Ont](#) to switch it off).

Example

```
if (condition) { // message C5915 here ...
    if(!condition) { // here, condition replaced with 1
        ...
    }
}
```

Tips

Check your code why both conditions are the same. Maybe different macros are used in both parts which evaluates to the same values.

C5916: Nested 'if' with inverse conditions

[DISABLE, [INFORMATION](#), WARNING, ERROR]

Description

The Compiler has detected that the condition in an ‘if’ and a nested ‘if’ expression have the inverse condition. If the first condition is true, the second one is always false. If the first one is FALSE, the second one is TRUE, so the compiler replaces the second condition with ‘FALSE’ if the condition does not have any side effects. There is always a couple of this message, one for the first ‘if’ condition and one for nested ‘if’ condition.

This message may be generated during tree optimizations (Option [-Ont](#) to switch it off).

Example

```
if (condition) { // message C5916 here ...
    if(!condition) { // here, condition replaced with 0
        ...
    }
}
```

Tips

Check your code why both conditions are the same. Maybe different macros are used in both parts which evaluates to the same values.

C5917: Removed dead assignment

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The Compiler has detected that there is an assignment to a (local) variable which is not used afterwards.

This message may be generated during tree optimizations (Option [-Ont](#) to switch it off).

Example

```
int a;
...
a = 3 // message C5917 here ...
} /* end of function */
```

Tips

If you want to avoid this optimization, you can declare the variable as volatile.

C5918: Removed dead goto

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The Compiler has detected that there is goto jumping to a just following label.

This message may be generated during tree optimizations (Option [-Ont](#) to switch it off).

Example

```
goto Label; // message C5918 here ...
Label:
...
```

Tips

If you want to avoid this optimization, you can declare the variable as volatile.

C5919: Conversion of floating to unsigned integral

[DISABLE, INFORMATION, WARNING, ERROR]

Description

In ANSI-C the result of a conversion operation of a (signed) floating type to a unsigned integral type is undefined. One implementation may return 0, another the maximum value of the unsigned integral type or even something else. Because such behavior may cause porting problems to other compilers, a warning message is issued for this.

Example

```
float f = -2.0;
unsigned long uL = f; // message C5919 here
```

Tips

To avoid the undefined behavior, first assign/cast the floating type to a signed integral type and then to a unsigned integral type.

See also

ISO/IEC 9899:1990 (E), page 35, chapter 6.2.1.3 Floating and integral:

"When a value of floating type is converted to integral type, the fractional part is discarded. the value of the integral part cannot be represented by the integral type, the behavior is undefined."

C5920: Inlining library function <function>

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The compiler has inlined or replaced the indicated library function. Inlining is done with the option [Option -OiLib](#). If you have your own implementation of the indicated library function, maybe you have to disable inlining for this function, because the semantic may be different.

See also

[Option -OiLib](#)

C5921: Shift count out of range

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The compiler has detected that there is a shift count exceeding the object size of the object to be shifted. This is normally not a problem, but can be optimized by the compiler. For right shifts (>>), the compiler will replace the shift count with (sizeofObjectInBits-1), that is a shift of a 16bit object (e.g. a short value) with a right shift by twenty is replaced with a right shift by 15.

This message may be generated during tree optimizations (Option [-Ont](#) to switch it off).

Example

```
unsigned char uch, res;
res = uch >> 9; // uch only has 8 bits, warning here
                // will be optimized to 'res = uch>>7'
```

See also

[Option -Ont](#)

C6000: Creating Asm Include File <file>

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A new file was created containing assembler directives. This file can be included into any assembler file to automatically get information from C header files.

Tips

Use this feature when you have both assembler and C code in your project.

See also

[Option -La](#)

[Create Assembler Include Files](#)

[pragma CREATE_ASM_LISTING](#)

C6001: Could not Open Asm Include File because of <reason>

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The Assembler Include file could not be opened. As reason either occurs the file name, which was tried to open or another description of the problem.

Tips

Try to specify the name directly.

Check the usage of the file name modifiers.

Check if the file exists and is locked by another application

See also

[Option -La](#)

[Create Assembler Include Files](#)

[pragma CREATE_ASM_LISTING](#)

C6002: Illegal pragma CREATE_ASM_LISTING because of <reason>

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The pragma CREATE_ASM_LISTING was used in a ill formed way.

Tips

After the pragma, the may only be a ON or OFF.

ON and OFF are case sensitive and must not be surrounded by double quotes.

For example:

```
#pragma CREATE_ASM_LISTING ON
```

or

```
#pragma CREATE_ASM_LISTING OFF
```

See also

[Option -La](#)

[Create Assembler Include Files](#)

[pragma CREATE_ASM_LISTING](#)

Messages of HC12 Back End

This section contains message descriptions specific for the HC12 compiler.

All messages specific for the HC12 have a number of the form C10XXX or C12XXX, where XXX is a different number for every message.

C10000: Nothing more expected

[ERROR]

Description

At the end of an assembly instruction additional text was found.

Example

```
NOP 1
LDAA 1 1
```

Tips

Use a C style comment to start comments.

Check if it is an illegal or unknown expression.

C10010: Symbol reserved

[ERROR]

Description

Usage of a reserved symbol to define a label.

Example

```
D: ...
A: ...
```

Tips

Use an other identifier.

C10011: ':' expected to delimit label

[ERROR]

Description

The identifier must be followed by a colon to define a label.

Example

```
aLabel ...
```

Tips

Add a colon at the end of the identifier.

```
aLabel: ...
```

C10012: Label multiply defined

[ERROR]

Description

The label is already defined.

Example

```
aLabel: ...  
...  
aLabel: ...
```

Tips

Choose an other identifier for the label.

C10013: Label 'name' is undefined

[ERROR]

Description

The referenced label is not defined.

Example

```
BR notDefined
...
```

Tips

Define this label or reference to an other one.

C10020: Illegal constant value

[ERROR]

Description

An integer is expected.

Example

```
LDAA #1 + 2.3
```

Tips

Use an integral expression.

C10021: ')' expected to close parenthesis

[ERROR]

Description

A close parenthesis is expected to have a valid expression.

Example

```
LDAA #(1 + 2 * 3
```

Tips

Set a close parenthesis at the end of the expression.

C10022: Constant expression expected

[ERROR]

Description

A constant expression is expected.

Example

```
LDAA #(1 + 2 * / 3)
```

Tips

Use a valid constant expression.

C10023: '(' expected to open parenthesis

[ERROR]

Description

An open parenthesis must be used to define the cast with a C type

Example

```
DC.W * int 0x1000
```

Tips

Add an open parenthesis

C10024: Size is not valid

[ERROR]

Description

The specified size is not a valid one

Example

```
DC.W * (void) 0x1000
```

Tips

Use a valid size

C10025: Cast size is too large

[ERROR]

Description

The specified size is too large

Example

```
DC.W * (double) 0x1000
```

Tips

Use a smaller size

C10026: Undefined field

[ERROR]

Description

The specified field does not exist in the corresponding structure

Example

```
struct {  
    int aField1, aField2;  
} aStructure;  
  
...  
DC.W aStructure.aField3
```

Tips

Use a defined field

C10027: Identifier expected

[ERROR]

Description

An identifier is expected to define a field of a structure

Example

```
DC.W aStructure.1
```

Tips

Use a defined field

C10028: Corrupted array

[ERROR]

Description

The value used to index the array is too large

Example

```
int anArray[3];  
...  
DC.W anArray[5]
```

Tips

Use a smaller value as index

C10029: ']' expected to close brackets

[ERROR]

Description

A close bracket is expected to specify a valid access to an array.

Example

```
DC.W anArray[1 + 2
```

Tips

Set a close bracket at the end of the expression.

C10030: Offset out of Object

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The value used to offset the object is too large.

Example

```
int anArray[3];  
...  
DC.W anArray:15
```

Tips

Use a smaller value as offset.

This message can be set as Warning or message with the message move options and pragmas.

C10031: C type is expected

[ERROR]

Description

A valid C type is expected.

Example

```
DC.W * (signed float) 0x1000
```

Tips

Use a valid C type.

C10032: Integer type is expected

[ERROR]

Description

A integral C type is expected.

Example

```
DC.W * (const short signed) 0x1000
```

Tips

Use an integral C type.

C10033: '*' expected to have generic pointer

[ERROR]

Description

A star symbol is expected to define a generic pointer.

Example

```
DC.W * (void) 0x1000
```

Tips

Add a star symbol.

C10034: C or user type expected

[ERROR]

Description

A C type or a user type is expected.

Example

```
DC.W * (aVariable) 0x1000
```

Tips

Use a valid type.

C10035: C object is expected

[ERROR]

Description

A C object is expected.

Example

```
DC.W aLabel.aField
```

Tips

Use a valid object.

C12002: Use DPAGE, PPAGE, EPAGE to specify the page register. Assumed DPAGE

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The compiler did not know which page register should be used for a far access. The compiler may use the DPAGE register implicitly. To avoid this warning, compile this file with the correct page ([-CpDPage](#), [-CpEPage](#) or [-CpPPage](#)) options set.

Example

In the small or banked memory model with no page option:

```
int *far p;
void main(void) {
    *p=1;
}
```

Tips

Compile all your source files with the correct page options ([-CpDPage](#), [-CpEPage](#) or [-CpPPage](#))!

This message does not occur for the large memory model. In this model, all far and default accesses are implemented by runtime routine calls, unless some page register options are present.

C12004: far was ignored for function

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The compiler did find a interrupt function with far calling convention.

The far is ignored for interrupt functions, which always must be accessible by 16 bit interrupts.

Example

```
void interrupt far f(void) {  
}
```

Tips

Interrupt handlers must be in a non far area. Allocate them non banked and remove any far qualifiers for them.

C12005: Non default function pointer are not supported in HIWARE Object File Format

[DISABLE, INFORMATION, WARNING, ERROR]

Description

In the HIWARE Object File Format, it is not possible to have different sizes for function pointers. Therefore the compiler emits an error for such a declaration.

Example

```
void (*far f)(void);
```

Tips

Do one of these things:

- Use the ELF Object File Format, which supports this.
- Use a different memory model.
- Only use the default function pointer size.

C12006: Call from absolute to PIC function

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The Compiler has detected a call from a non PIC (position independent code) function to a PIC function. The compiler calls the ROM version of the function only.

Example

```
#pragma CODE_SEG PIC PIC_CODE
void f(void) {
}

#pragma CODE_SEG DEFAULT
void main(void) {
    f();
}
```

Tips

To call a copied instance of a PIC function from non-PIC code, you must provide the real address.

Example (assumes the copied instance is at address 0x1234)

```
#pragma CODE_SEG PIC PIC_CODE
void f(void) {
}

#pragma CODE_SEG DEFAULT
typedef void (*fkt_ptr)(void);
void main(void) {
    ((fkt_ptr)(0x1234))();
}
```

To calculate the address at runtime, you must convert for the arithmetic the function pointer to a data pointer. To call it, it must be casted back to a function pointer.

Example

```
#pragma CODE_SEG PIC PIC_CODE
void g(void) {
}

void f(void) {
    g();
}

#pragma CODE_SEG DEFAULT
char buf[100];
typedef void (*fkt_ptr)(void);
void main(void) {
    memmove(buf, &g, 100);
    (fkt_ptr)&buf[(char*)&f - (char*)&g]() /* call f */
}
```

C12007: Call from PIC to absolute function

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The compiler has detected a call from a PIC function to a non PIC function.

Note that this message is disabled by default.

Example

```
#pragma CODE_SEG DEFAULT
void f(void) {
}

#pragma CODE_SEG PIC PIC_CODE
void g(void) {
    f();
}
```

Tips

You can enable this message when non-PIC part of your application is not accessible from the PIC code.

C12008: Call from PIC to PIC function in different segment

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The compiler has detected a call from one PIC function to another in a different segment. The actual call is generated with the PIC calling convention. If the callee and the caller have a different distance at runtime than at link time, the call will fail.

Note that this message is disabled by default.

Example

```
#pragma CODE_SEG PIC PIC_CODE1
void f(void) {
}

#pragma CODE_SEG PIC PIC_CODE2
void g(void) {
    f();
}
```

Tips

You can enable this message if you have different independent PIC segments.

C12011: Too many temporaries: simplify expression

[ERROR]

Description

Too many values are active at the same time.

Example

None known.

Tips

Simplify the expression.

C12012: Control flow too complex: simplify control flow

[ERROR]

Description

The control flow is too complex.

Example

None known.

Tips

Avoid goto's. Split up the function.

C12020: Unknown Operand Combination: Instr:<Instruction>/ Opr1:<Add.Mode>/Opr2:<Add.Mode>

[ERROR]

Description

The compiler does not find any possible instruction for the specified address modes.

Example

```
void main(void) {
    __asm {
        LEAS #1234
    }
}
```

returns:

```
ERROR C12020: Unknown Operand Combination: Instr:LEAS/
Opr1:Imm32/Opr2:NoOp.
```

Tips

If this message is issued for inline assembler code, check if this instruction supports this address mode and the spelling.

If this message is issued for C code, it is a compiler error. Please report this bug in this case.

**C12021: Unknown Fixup Combination: Instr:<Instruction>/
Opr1:<Add.Mode>/Opr2:<Add.Mode>**

[ERROR]

Description

The compiler cannot issue a fixup (a link time correction).

Example

```
char buf[100];
char i;

void main(void) {
    __asm {
        MOVB buf,x,i
    }
}
```



```
    }  
}
```

returns:

```
ERROR C12021: Unknown Fixup Combination: Instr:MOVB/  
Opr1:IdxOff5/Opr2:Ext.
```

The 16 bit fixup for buf cannot be placed into the 5 bit IDX source offset of the move.

Tips

If this message is issued for inline assembler code, check if this instruction supports this address mode and the spelling.

If this message is issued for C code, it is a compiler error. Please report this bug in this case.

C12022: Expect a 3 bit value in the range of 1..8

```
[DISABLE, INFORMATION, WARNING, ERROR]
```

Description

The inline assembler has a value which does not fit into the instruction.

Example

```
void main(void) {  
    __asm LDAA 9,X-  
}
```

Tips

Rewrite the inline assembler code with smaller offsets.

C12023: Expected a 5 bit value

```
[DISABLE, INFORMATION, WARNING, ERROR]
```

Description

The inline assembler has a value which does not fit into the instruction.

This may happen because the movb instructions MOV_B and MOV_W do not provide all possible addressing modes.

Example

```
void main(void) {
    long i[20],j[20];
    asm {
        MOVW i,j
    }
}
```

The HC12 compiler either allocates i or j at 0,SP. The other variable is allocated at sizeof(long)*20: SP. This offset does not fit into the 5 bits available for the MOV_B instruction.

Tips

Be careful about the MOV_B and MOV_W instructions in inline assembler. Larger offsets for register indirect are not supported by the HC12. All other instructions have a register indirect addressing mode with 16 bit offset, so this problem will only occur with MOV instructions.

C12024: Expected a 8 bit value

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The inline assembler has a value which does not fit into the instruction.

Example

```
void main(void) {
    __asm MOVB #155663, 645
}
```

Tips

Only use 8 bit values.

C12025: Expected a 9 bit value

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The inline assembler has a value which does not fit into the instruction.

Example

none.

Tips

Only use 9 bit values.

C12026: Expected a 16 bit value

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The inline assembler has a value which does not fit into the instruction.

Example

```
void main(void) {  
    __asm LDAA 34756437  
}
```

Tips

Only use 16 bit values.

For far accesses, you must set the page by a separate inline instruction.

C12040 Parameter larger than 32 bit

[Fatal]

Description

In a internal compiler state, parameters are larger than 32 bit.

With the normal struct passing options, this message must not occur.

Example

none known.

Tips

This is a compiler error. Please report.

C12041 Branch target too far away

[ERROR]

Description

As the compiler automatically adapts the branch distance, this error should not occur for C code.

Example

none known.

Tips

If it is generated from a C code, please report this error.

C12042 Switch selector too large, only considering 16 bits

[DISABLE, INFORMATION, WARNING, ERROR]

Description

As the compiler automatically generates a branch tree for a 32-bit switch selector.

As this is legal this message should not occur.

Example

none known.

Tips

Use the switch configuration options to generate a branch tree.

C12043 Return value larger than 32 bit

[Fatal]

Description

In a internal compiler state, a return value is larger than 32 bit.

With the normal struct return options, this message must not occur.

Example

none known.

Tips

This is a compiler error. Please report.

C12044 Illegal operand size

[Fatal]

Description

In a internal compiler state, a non handled operand size did occur for a specific operation.

This is a internal compiler error, so this message must not occur.

Example

none known.

Tips

This is a compiler error. Please report.

C12045 Wrong Register Preassignment (<Function> in bb# <Num>)

[Fatal]

Description

A internal consistency check did report a problem with the register preassignment.

This is a internal compiler error, so this message must not occur.

Example

none known.

Tips

This is a compiler error. Please report.

C12046 <Page> register used without compiler option -Cp<Option>

[DISABLE, INFORMATION, WARNING, ERROR]

Description

A Page register was used, but the corresponding page option was not specified.

Example

```
#pragma DATA_SEG DPAGE DPAGE_SEGMENT
int i;
#pragma DATA_SEG DEFAULT
void main(void) {
    i=1;
}
```

Tips

Use the page option to tell the compiler the available pages.

C12050 Not handled Operand-Size

[Fatal]

Description

In an internal consistency check, a not handled operand size was discovered.
This is a internal compiler error, so this message must not occur.

Example

none known.

Tips

This is a compiler error. Please report.

C12051 Unknown ICG addressing mode

[Fatal]

Description

In an internal consistency check, an unknown addressing mode was discovered.
This is a internal compiler error, so this message must not occur.

Example

none known.

Tips

This is a compiler error. Please report.

C12052 Illegal Pre/Post Dec/Increment

[Fatal]

Description

In an internal consistency check, an illegal autoincrement / autodecrement was discovered.

This is a internal compiler error, so this message must not occur.

Example

none known.

Tips

This is a compiler error. Please report.

C12053 Stack-pointer change not in debugging-information

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The compiler generates debug information which contains all SP changes.

The debugger uses it to trace the stack and to display local variables.

The compiler has detected an inline assembler instruction which contains an SP change,

it cannot put into the debug info

Example

```
void main(void) {  
    __asm LDS #12345  
}
```


Tips

This kind of SP changes should only be necessary in the startup code and in operating systems for task switches.
check if you can avoid this instruction.

C12054 Illegal operand-location combination (8/16)

[Fatal]

Description

In an internal consistency check, an illegal autoincrement / autodecrement was discovered.

This is a internal compiler error, so this message must not occur.

Example

none known.

Tips

This is a compiler error. Please report.

C12055 TBNE/IBNE,.. used but not allowed

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The compiler provides the option "-px4" to generate no TBNE/IBNE/... instructions.

Nevertheless, the compiler has detected that such an instruction exists.

This instruction may be generated by explicit inline assembler.

Example

With option “-px4”

```
void main(void) {  
    __asm Label:;  
    __asm TBNE A,Label;  
}
```

Tips

Do not use TBNE/... when the option -px4 is present in the inline assembler.

C12056: SP debug info incorrect because of optimization or inline assembler

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The compiler investigates the generated code to detect the current SP value for every instruction. During this process, he detects that two different control flows generate different SP values for a single instruction.

This situation may arise because of different situations:

– inline assembler

In inline assembler code, it is legal to have this situation as long as the stack is correct at the end of the inline assembler block.

– optimization

Especially because of the common code optimization [-Of/-Onf](#) there are situations where this occurs in correct code. It is impossible to generate correct debug info for this optimization in some cases.

The debugger may show local variables and the call chain incorrect for some parts in a function, for which this message occurs. But this message does not mean that the code generated is wrong in any sense.

Previous versions of the compiler did generate this warning in other situations, for which this version generates correct debug info.

Example (for C code):

```
void f(int);
void g(void);
void h(void);

void main(void) {
    f(1); f(2); f(3);
    h();
    f(1); f(2); f(3);
    g();
    f(1); f(2);
}
```

The compiler first detects that "f(1); f(2); f(3);" occurs twice and puts this code separately.

The two code patterns are replaced by a JSR to the new code.

This situation can be thought as the following non C pseudo code (C does not support local functions):

```
void main(void) {
    void tmp0(void) {
        f(1); f(2); f(3);
    }
    tmp0();
    h();
    tmp0();
    g();
    f(1); f(2);
}
```

In a next step, the compiler detects that the code "f(1); f(2);" also occurs twice. So

he generates a second internal function.

```
void main(void) {
    void tmp1(void) {
        f(1); f(2);
    }
    void tmp0(void) {
        tmp1(); f(3);
    }
    tmp0();
    h();
    tmp0();
    g();
}
```

```
    tmp1();  
}
```

Now the new code of the function tmp1 (actually tmp1 is not really a function, it is a part of main!) is called once directly from main and once indirectly by using tmp0. This two call chains now use a different amount of stack and the message "C12056: SP debug info incorrect because of optimization or inline assembler" is issued.

Example (for C inline assembler code)

```
void fun(long a, long b, int i);  
  
#pragma NO_EXIT  
  
void main1(void) { /* warning for debug info */  
    asm {  
        LDY #4  
        CLRA  
        CLRB  
  
L0:  
        PSHD  
        DBNE Y, L0  
        JSR fun      ; calls f with a == b == i== 0  
        LEAS 8,SP  
        RTS  
    }  
}
```

The loop in main1 is looping 4 times and every time two bytes are pushed on the stack.

This loop let the compiler issue this message because at L0 different SP values occur at different times.

To avoid the inconveniences of such debug info, the same code could be written this way:

```
void main2(void) { /* debug info is OK */  
    asm {  
        CLRA  
        CLRB  
        PSHD  
        PSHD  
        PSHD  
        PSHD  
        JSR fun      ; calls f with a == b == i== 0  
    }  
}
```

```
        LEAS 8,SP
        RTS
    }
}
```

Tips

To debug try to switch the common code optimization off with -onf.
For inline assembler avoid this situation.

See also

Option -Onf/-Of

C12057: Offset of PC relative MOV instruction is not adapted

[DISABLE, INFORMATION, WARNING, ERROR]

Description

For a MOV instruction using PC relative addressing mode, the PC used must be specially computed. For all other HC12 instructions, the PC of the next instruction is used. For the MOV's, an additional offset must be added. Use the Motorola HC12 Reference Manual for a table of correction offsets.

Example

The compiler compiles "**MOVB 0x2000,2,PC**" at address 0x1000 into the following opcodes.

0x1000 18 09 C2 20 00 MOVB 0x2000,2,PC

Although the next instruction starts at 0x1005, for the address evaluation of "2,PC",

the PC value 0x1007 is used. So one byte is moved from 0x2000 to 0x1009.

Some assemblers are correcting the "2,PC" offset internally to "0,PC", so that the usual PC evaluation rules take place. This compiler is not adapting the offset.

See also

Motorola CPU12 Reference Manual, Motorola, Inc., 1996, Chapter 3.9.1 Move Instruction

C12062: Ignored directive

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The compiler does not support the directive referenced in this message. Usually this is one of following assembler directives: ALIGN, BASE, CLIST, DCB, DS, END, EQU, EVEN, EXTERNAL, FAIL, GLOBAL, INCLUDE, LIST, LLEN, LONGEVEN, MLIST,

NOL, NOLIST, NOPAGE, ORG, PAGE, PLEN, PUBLIC, RMB, SECTION, SET, SPC, TABS, TITLE, TTL, XDEF, XREF, XREFB.

Example

```
__asm {  
    xdef myVar  
    LDX #myVar  
}
```

Tips

Try to use the C equivalent (e.g. for XDEF)

```
extern short myVar;  
  
__asm {  
    LDX #myVar  
}
```

C12099: Label addressing mode not supported

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The compiler does not support the usage of labels for absolute accesses. Labels are only supported in branch destination operands.

Example

```
char pow2(char exp) {
    __asm {
        TFR B,X
        LDAB table,X
        RTS
    }

table:  DC.B 0x01
        DC.B 0x02
        DC.B 0x04
        DC.B 0x08
        DC.B 0x10
        DC.B 0x20
        DC.B 0x40
        DC.B 0x80
    }
}
```

Tips

For constants, use C constants.

```
char pow2(char exp) {
    static const char table[8]={0x01, 0x02, 0x04, 0x08,
                                0x10, 0x20, 0x40, 0x80};

    __asm {
        TFR B,X
        LDAA table,X
    }
}
```

Alternatively also a fix offset can be specified when known.

C12100: PCR is not supported for this addressing mode

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The name PCR can be used only in register indirect accesses using the PC register, to indicate that the offset has to be computed relative to the PC. It cannot be used in other contexts as for a TFR instruction.

Example

```
void main(void) {
    __asm BSET [29,PCR], 1;
}
```

Tips

Use the register name PC for this register. PCR is only allowed in PC-register indirect accesses.

The BSET instruction does not support the Indirect addressing modes. So the example has to be written with two instructions at least:

```
void main(void) {
    __asm LDY 29,PCR;
    __asm BSET 0,Y,1
}
```

C12101: Offset of page operand is ignored

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The offset used in a page operand is ignored by the compiler. The compiler assumes that one single object is allocated on a single page. Therefore it is not possible to specify an offset into another page. The compiler assumes that a given offset does not change the page.

Example

```
void f(void) {
    __asm LDAA #PAGE(f:10);
}
```

The generated code loads the page of the function f, even if the function is allocated just below page boundary.

C12102: Illegal page operand

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The HC12 high level inline assembler supports page operands only for global objects. Labels and locals cannot be used.

Example

```
void f(void) {
    __asm Label;;
    __asm LDAA #PAGE(Label);
}
```

Tip

Use the name of the function instead of a label.

```
void f(void) {
    __asm LDAA #PAGE(f);
}
```

C12103: Address of this object is not supported

[DISABLE, INFORMATION, WARNING, ERROR]

Description

The address of a local variable or a parameter was used in a context where only link time constants are supported.

Example

```
void strcpy(char* dst, const char* src);

void main(void) {
    char buf[12];
    __asm {
        LDD #buf
        PSHD
    }
```

Messages

Messages of HC12 Back End

```
        LDD    #"Hello World"
        JSR    strcpy
        LEAS  2,SP
    }
}
```

Tips

The address of locals can be taken with the LEAX or LEAY instruction.

```
void strcpy(char* dst, const char* src);

void main(void) {
    char buf[12];
    __asm {
        LEAX  buf
        PSHX
        LDD    #"Hello World"
        JSR    strcpy
        LEAS  2,SP
    }
}
```

C12110: Out of spill locations: Reduce ? - expression

[[ERROR](#)]

Description

This error is issued for code having extremely many temporary locations active at one point. This limit is not reached by normal code.

Tips

Recode this part of the application. Use less ? operators.

ANSI Library Reference

Library Files

Directory Structure

The library files are delivered in the following structure:

```
<install>\lib<target>c\      /* readme files, make files */
<install>\lib<target>c\src /* library source files (C & C++)*/
<install>\lib<target>c\include /* library include files */
<install>\lib<target>c\lib    /* default library files */
<install>\lib<target>c\prm    /* Linker parameter files */
```

Check out the readme.txt located in the library folder with additional information on memory models and library file names.

How to Generate Library

In the directory structure above, a CodeWarrior .mcp files is provided to build all the libraries and the startup code object files. Simply load the .mcp into CodeWarrior and build all the targets.

Common Source Files

[Table 3.1](#) lists the source and header files of the Standard ANSI Library that are not target dependent.

Table 3.1 Standard ANSI Library—Target Independent Source and Header Files

Source File	Header File
alloc.c	
assert.c	assert.h
ctype.c	ctype.h
	errno.h
heap.c	heap.h
	limits.h
math.c, mathf.c	math.h , ieemath.h, float.h
printf.c, scanf.c	stdio.h
signal.c	signal.h
	stdarg.h
	stddef.h
stdlib.c	stdlib.h
string.c	string.h
	time.h

Target Dependent Files for HC12

HC12

[Table 3.2](#) lists the target dependent Standard ANSI Library files.

Table 3.2 Standard ANSI Library—Target Dependent Source and Header Files

Source File	Header File	Description
	default.sgm	Segment file
	hodef.h	HI-CROSS+ specific definitions
	math.h	part of ANSI library
	non_bank.sgm	Segment file
setjmp.c	setjmp.h	part of ANSI library

Table 3.2 Standard ANSI Library—Target Dependent Source and Header Files

Source File	Header File	Description
signal.c		part of ANSI library
start12.c	start12.h	Startup
start12b.c, strt12bp.c, start12s.c, strt12sp.c		copies of start12.c. Actually all startup files are identical. They are only compiled with different options to obtain specific startup code.
	system.h	Runtime prototypes
dadd.c		part of runtime support
dansi.c		part of runtime support
datapage.c		part of runtime support
dcmp.c		part of runtime support
dconv.c	dconf.h	part of runtime support
dconv.c	dconv.h	part of runtime support
dmul.c		part of runtime support
dregs.c	dregs.h	part of runtime support
fadd.c		part of runtime support
fansi.c		part of runtime support
fcmp.c		part of runtime support
fconv.c		part of runtime support
fmul.c		part of runtime support
fregs.c	fregs.h	part of runtime support
rtshc12.c		part of runtime support
	runtime.sgm	Segment declaration for runtime functions
vregs.c	vregs.h	part of runtime support

Startup Files

Because every memory model needs special startup initialization, there are also startup object file compiled with different Compiler option settings (see Compiler options for details).

The correct startup file has to be linked with your application depending on the memory model chosen or depending if your application contains C++ modules with global constructors/destructors or not. The floating point format used does not matter for the startup code.

Note that the library files contain a generic startup written in C as example doing all needed tasks for a startup:

- Zero Out
- Copy Down
- Register initialization
- C++ Constructor calls
- C++ Destructor calls
- Handling ROM libraries

Because not all of the above tasks may be needed for an application and for efficiency reasons, special startup is provided as well (e.g. written in HLI). But the version written in C can be used as well as example: just compile the ‘startup.c’ file with your memory/options settings and link it to your application.

Startup Files for Motorola HC12

Depending on the memory model, a different startup object file has to be linked to the application. See [Table 3.3](#)

Table 3.3 Startup Object File Required by Each Memory Model

Startup Object File	Memory Model	Startup Source File	Compiler Options
start12s.o	Small	start12.c	-Ms
start12b.o	Banked	start12.c	-Mb
start12l.o	Large	start12.c	-Ml
strtl2sp.o	Small ⁽¹⁾	start12.c	-Ms -C++f
strtl2bp.o	Banked ⁽¹⁾	start12.c	-Mb -C++f
strtl2lp.o	Large ⁽¹⁾	start12.c	-Ml -C++f

⁽¹⁾: C++ global constructors are called

Library Files

Most of the object files of the ANSI library are delivered in the form of a object library (see below).

Several Library files are bundled with the Compiler. The reason for different library files are different memory models or floating point formats.

The library files contain all necessary runtime functions used by the compiler and the ANSI Standard Library as well. The list files (extension `.lst`) contains a summary of all objects in the library file.

To link against a modified file which also exists in the library, it must be specified first in the link order.

Please check out the `readme.txt` located in the library structure (`lib<target>c\readme.txt`) for a list of all delivered library files and memory model/options used.

Library Files for Motorola HC12

Note: The floating point runtime routines for the HC12 are written in a reentrant manner. Note that you can have a more efficient `printf` (non-reentrant) using `LIBDEF_REENTRANT_PRINTF` in `'libdefs.h'` library header file.

Special Features

Not everything defined in the ANSI standard library makes sense in embedded systems programming. Therefore, not all functions have been implemented, and some have been left open to be implemented since they strongly depend on the actual setup of the target system.

This chapter describes and explains these points.

NOTE All functions not implemented do a HALT when called. All functions are re-entrant, except [rand](#) and [srand](#) since these use a global variable to store the seed, which might give problems with light-weight processes. Another function using a global variable is [strtok](#), since it has been defined that way in the ANSI standard.

Memory Management - malloc, free, calloc, realloc; alloc.c, heap.c

File 'alloc.c' provides a full implementation of these functions, the only problem remaining is the question of where to put the heap, how big should it be and what should happen when we run out of heap memory.

All these points can be solved in file "heap.c". The heap simply is viewed as a large array, and there's a default error handling function. Feel free to modify this function or the size of the heap to suit your needs.

Signals - signal.c

Signals have been implemented in a very rudimentary way - as traps. This means, function [signal](#) allows you to set a vector to some function of your own (which of course should be a TRAP_PROC), while function [raise](#) is not implemented. If you decide to ignore a certain signal, a default handler doing nothing is installed.

Multi-byte Characters - mblen, mbtowc, wctomb, mbstowcs, wcstombs; stdlib.c

Since the compiler does not support multi-byte characters, all routines in "stdlib.c" dealing with those have not been implemented. If you need them, you'll have to write your own functions.

Program Termination - abort, exit, atexit; stdlib.c

Since programs in embedded systems usually are not expected to terminate, we only provide a minimum implementation of the first two functions, while [atexit](#) is not implemented at all. Both [abort](#) and [exit](#) simply perform a HALT.

I/O - printf.c

The [printf](#) library function is in the current version of the library sets not implemented in the ANSI libraries, but in the file "terminal.c".

This difference has been done because often no terminal is available at all other terminal depends highly on the user hardware.

The ANSI library contains several functions which makes it simple to implement the [printf](#) function with all its special cases in a few lines.

The first, ANSI conform way is to allocate a buffer and then using the ANSI function [vsprintf](#).

Example:

```
int printf(const char *format, ...) {
    char outbuf[MAXLINE];
    int i;
    va_list args;
    va\_start(args, format);
    i = vsprintf(outbuf, format, args);
    va\_end(args);
    WriteString(outbuf);
    return i;
}
```

The value of MAXLINE defines the maximum size of any value of printf. The function WriteString is assumed to write one string to a terminal. There are several disadvantages of this solution:

- A buffer is needed which alone may use a large amount of RAM.
- Unimportant how large the buffer (MAXLINE) is, it is always possible that a buffer overflow occurs. Therefore this solution is not safe.

To avoid both disadvantages, we provide two non ANSI functions [vprintf](#) and [set_printf](#) in its newer library versions.

Because these functions are a non ANSI extension, they are not contained in the "[stdio.h](#)" header file.

Therefore its prototype must be specified before they are used:

```
int vprintf(const char *pformat, va_list args);
void set_printf(void (*f)(char));
```

The [set_printf](#) function installs a call back function, which is later called for every character which should be printed by [vprintf](#).

Remark that the standard ANSI C printf derivatives functions [sprintf](#) and [vsprintf](#) are also implemented by calls to [set_printf](#) and [vprintf](#). This way much of the code for all printf derivatives can be shared across them.

There is also a limitation of the current implementation of [printf](#). Because the callback function is not passed as argument to [vprintf](#), but hold in a global variable, all the [printf](#) derivatives are not reentrant. Even calls to different derivatives at the same time are not allowed.

A simple implementation of a [printf](#) with [vprintf](#) and `set_printf` is for example:

```
int printf(const char *format, ...){
    int i;
    va_list args;

    set_printf(PutChar);
    va_start(args, format);
    i = vprintf(format, args);
    va_end(args);
    return i;
}
```

The function `PutChar` is assumed to print one character to the terminal.

Another remark has to be made about the [printf](#) and [scanf](#) functions. We provides the full source code of all printf derivatives in "printf.c" and of scanf in "scanf.c". Usually many of the features of [printf](#) and [scanf](#) are not used by a specific application. The source code of the library modules printf and scanf contains switches (defines) to allow the use to switch off not used parts of the code. This especially includes the large floating point parts of [vprintf](#) and `vsscanf`.

Locales - locale.*

Has not been implemented.

ctype

ctype contains two sets of implementations for all functions. The standard is a set of macros which translate into accesses to a lookup table.

Since this table uses 257 bytes of memory, we also provide an implementation using real functions. These are accessible if you undefine the macros first (after "#undef isupper", [isupper](#) is translated into a call to function "isupper". Without the "undef", "isupper" is replaced by the corresponding macro.

Using the functions instead of the macros of course saves RAM and code size - at the expense of some additional function call overhead.

String conversions - strtol, strtoul, strtod, stdlib.c

To follow the ANSI requirements for string conversions, range checking has to be done. The variable “errno” is set accordingly and special limit values are returned. The macro “ENABLE_OVERFLOW_CHECK” is set to 1 by default. To reduce code size it’s recommended to switch off this macro (set ENABLE_OVERFLOW_CHECK to 0).

Library Structure

In this section, we will examine the various parts of the ANSI–C standard library, grouped by category. This library not only contains a rich set of functions, but also numerous types and macros.

Error Handling

Error handling in the ANSI library is done using a global variable `errno` that is set by the library routines and may be tested by a user program. There also are a few functions for error handling:

```
void assert (int expr);  
void perror (const char *msg);  
char * strerror (int errno);
```

String Handling Functions

Strings in ANSI-C always are null-terminated character sequences. The ANSI library provides the following functions to manipulate such strings:

```
size_t strlen (const char *s);  
char * strcpy (char *to, const char *from);  
char * strncpy (char *to, const char *from, size_t size);  
char * strcat (char *to, const char *from);  
char * strncat (char *to, const char *from, size_t size);  
int strcmp (const char *p, const char *q);  
int strncmp (const char *p, const char *q, size_t size);  
char * strchr (const char *s, int ch);  
char * strrchr (const char *s, int ch);  
char * strstr (const char *p, const char *q);  
size_t strspn (const char *s, const char *set);  
size_t strcspn (const char *s, const char *set);  
char * strpbrk (const char *s, const char *set);  
char * strtok (char *s, const char *delim);
```

Memory Block Functions

Closely related to the string handling functions are those operating on memory blocks. The main difference to the string functions is that they operate on any block of memory, whether it is null-terminated or not. The length of the block must be given as an additional parameter. Also, the functions work with void pointers instead of char pointers.

```
void * memcpy (void *to, const void *from, size_t size);  
void * memmove (void *to, const void *from, size_t size);  
int memcmp (const void *p, const void *q, size_t size);  
void * memchr (const void *adr, int byte, size_t size);  
void * memset (void *adr, int byte, size_t size);
```

Mathematical Functions

The ANSI library contains a variety of floating point functions. The standard interface, which is defined for type `double`, has been augmented by an alternate interface (and implementation) using type `float`.

```
double acos    (double x);
double asin    (double x);
double atan    (double x);
double atan2   (double x, double y);
double ceil    (double x);
double cos     (double x);
double cosh    (double x);
double exp     (double x);
double fabs    (double x);
double floor   (double x);
double fmod    (double x, double y);
double frexp   (double x, int *exp);
double ldexp   (double x, int exp);
double log     (double x);
double log10   (double x);
double modf    (double x, double *ip);
double pow     (double x, double y);
double sin     (double x);
double sinh    (double x);
double sqrt    (double x);
double tan     (double x);
double tanh    (double x);
```

The functions using type `float` have the same names with an “f” appended.

```
float acosf (float x);
float asinf (float x);
float atanf (float x);
float atan2f (float x, float y);
float ceilf (float x);
float cosf (float x);
float coshf (float x);
float expf (float x);
float fabsf (float x);
float floorf (float x);
float fmodf (float x, float y);
float frexpf (float x, int *exp);
float ldexpf (float x, int exp);
float logf (float x);
float log10f (float x);
float modff (float x, float *ip);
float powf (float x, float y);
float sinf (float x);
float sinhf (float x);
float sqrtf (float x);
float tanf (float x);
float tanhf (float x);
```

Additionally, the ANSI library also defines a couple of functions operating on integral values:

```
int abs (int i);
div_t div (int a, int b);
long labs (long l);
ldiv_t ldiv (long a, long b);
```

Furthermore, it contains a simple pseudo random number generator:

```
int  rand (void);  
void srand (unsigned int seed);
```

Memory Management

To allocate and deallocate memory blocks, the ANSI library provides the following functions:

```
void * malloc (size_t size);  
void * calloc (size_t n, size_t size);  
void * realloc (void *ptr, size_t size);  
void  free   (void *ptr);
```

Since it is not possible to implement these functions in a way that suits all possible target processors and memory configurations, these functions all are based on system module `heap.c`, which can be modified by the user to fit a particular memory layout.

Searching and Sorting

The ANSI library contains both a generalized searching and a generalized sorting procedure:

```
void * bsearch (const void *key, const void *array,  
             size_t n, size_t size, cmp_func f);  
void  qsort(void *array, size_t n, size_t size, cmp_func f);
```

Character Functions

These functions test or convert characters. All these functions are implemented both as macros and as functions, by default, the macros are active. To use the corresponding function, you have to #undefine the macro.

```
int  isalnum (int ch);  
int  isalpha (int ch);  
int  iscntrl (int ch);  
int  isdigit (int ch);  
int  isgraph (int ch);  
int  islower (int ch);  
int  isprint (int ch);  
int  ispunct (int ch);  
int  isspace (int ch);  
int  isupper (int ch);  
int  isxdigit (int ch);  
int  tolower (int ch);  
int  toupper (int ch);
```

The ANSI library also defines an interface for multibyte and wide characters. The Implementation only offers minimum support for this feature: the maximum length of a multibyte character is one byte.

```
int    mblen (char *mbs, size_t n);  
size_t mbstowcs (wchar_t *wcs, const char *mbs, size_t n);  
int    mbtowc (wchar_t *wc, const char *mbc, size_t n);  
size_t wcstombs (char *mbs, const wchar_t *wcs size_t n);  
int    wctomb (char *mbc, wchar_t wc);
```

System Functions

The ANSI standard includes some system functions for raising and responding to signals, non-local jumping and so on.

```
void      abort    (void);
int       atexit   (void(*func) (void));
void      exit     (int status);
char      * getenv  (const char *name);
int       system   (const char *cmd);
int       setjmp   (jmp_buf env);
void      longjmp  (jmp_buf env, int val);
_sig_func signal  (int sig, _sig_func handler);
int       raise    (int sig);
```

To process variable length argument lists, the ANSI library provides the following “functions” (they’re implemented as macros):

```
void va\_start (va_list args, param);
type va\_arg  (va_list args, type);
void va\_end  (va_list args);
```

Time Functions

In the ANSI library, there also are several function to get the current time. In an embedded systems environment, we cannot provide implementations for these functions since different targets may use different ways to count the time.

```
clock_t      clock      (void);
time_t       time       (time_t *time_val);
struct tm * localtime (const time_t *time_val);
time_t       mktime    (struct tm *time_rec);
char *       asctime   (const struct tm *time_rec);
char *       ctime     (const time_t *time_val);
size_t       strftime  (char *s, size_t n,
               const char *format,
               const struct tm *time_rec);
double       difftime (time_t t1, time_t t2);
struct tm * gmtime  (const time_t *time_val);
```

Locale Functions

These functions are for handling locales. The ANSI-C library only supports the minimal “C” environment.

```
struct lconv *localeconv (void);
char *        setlocale (int cat, const char *locale);
int           strcoll  (const char *p, const char *q);
size_t       strxfrm(const char *p, const char *q, size_t n);
```

Conversion Functions

Functions for converting strings to numbers are

```
int          atoi    (const char *s);
long         atol    (const char *s);
double       atof    (const char *s);
long         strtol  (const char *s, char **end, int base);
unsigned long strtoul(const char *s, char **end, int base);
double       strtod  (const char *s, char **end);
```

printf and scanf

More conversions are possible for the C functions for reading and writing formatted data. These functions are:

```
int sprintf (char *s, const char *format, ...);
int vsprintf (char *s, const char *format, va_list args);
int sscanf  (const char *s, const char *format, ...);
```

File I/O

The ANSI-C library contains a fairly large interface for file I/O. In micro-controller applications however, one usually doesn't need file I/O. In the few cases where one would need it, the implementation depends on the actual setup of the target system. It

is therefore impossible for us to provide an implementation for these features, the user has to implement them her/himself.

```
FILE* fopen (const char *name, const char *mode);
FILE* freopen (const char *name, const char *mode, FILE *f);
int fflush (FILE *f);
int fclose (FILE *f);
int feof (FILE *f);
int ferror (FILE *f);
void clearerr(FILE *f);
int remove (const char *name);
int rename (const char *old, const char *new);
FILE* tmpfile (void);
char* tmpnam (char *name);
void setbuf (FILE *f, char *buf);
int setvbuf (FILE *f, char *buf, int mode, size_t size);
```

Functions for writing and reading characters:

```
int fgetc (FILE *f);
char* fgets (char *s, int n, FILE *f);
int fputc (int c, FILE *f);
int fputs (const char *s, FILE *f);
int getc (FILE *f);
int getchar (void);
char* gets (char *s);
int putc (int c, FILE *f);
int putchar (int c);
int puts (const char *s);
int ungetc (int c, FILE *f);
```

Functions for reading and writing blocks of data:

```
size_t fread (void *buf, size_t size, size_t n, FILE *f);
size_t fwrite (void *buf, size_t size, size_t n, FILE *f);
```

Formatted I/O functions on files:

```
int fprintf (FILE *f, const char *format, ...);
int vfprintf (FILE *f, const char *format, va_list args);
int fscanf (FILE *f, const char *format, ...);
int printf (const char *format, ...);
int vprintf (const char *format, va_list args);
int scanf (const char *format, ...);
```

Positioning functions:

```
int fgetpos (FILE *f, fpos_t *pos);
int fsetpos (FILE *f, const fpos_t *pos);
int fseek (FILE *f, long offset, int mode);
long ftell (FILE *f);
void rewind (FILE *f);
```

Types and Macros in the Standard Library

This section discusses all types and macros defined in the ANSI standard library. We cover each of the header files, in alphabetical order.

errno.h

This header file just declared two constants, that are used as error indicators in global variable `errno`.

```
extern int errno;
#define EDOM      -1
#define ERANGE   -2
```

float.h

Defines constants describing the properties of floating point arithmetic. See [Table 3.4](#) and [Table 3.5](#).

Table 3.4 Rounding and Radix Constants

Constant	Description
FLT_ROUNDS	Gives the rounding mode implemented
FLT_RADIX	The base of the exponent

All other constants are prefixed by either FLT_, DBL_ or LDBL_. FLT_ is a constant for type float, DBL_ one for double and LDBL_ one for long double.

Table 3.5 Other Constants Defined in float.h

Constant	Description
DIG	Number of significant digits.
EPSILON	Smallest positive x for which $1.0 + x \neq x$.
MANT_DIG	Number of binary mantissa digits.
MAX	Largest normalized finite value.
MAX_EXP	Maximum exponent such that $\text{FLT_RADIX}^{\text{MAX_EXP}}$ is a finite normalized value.
MAX_10_EXP	Maximum exponent such that $10^{\text{MAX_10_EXP}}$ is a finite normalized value.
MIN	Smallest positive normalized value.
MIN_EXP	Smallest negative exponent such that $\text{FLT_RADIX}^{\text{MIN_EXP}}$ is a normalized value.
MIN_10_EXP	Smallest negative exponent such that $10^{\text{MIN_10_EXP}}$ is a normalized value.

limits.h

Defines a couple of constants for the maximum and minimum values that are allowed for certain types. See [Table 3.6](#).

Table 3.6 Constants Defined in limits.h

Constant	Description
CHAR_BIT	Number of bits in a character
SCHAR_MIN	Minimum value for signed char
SCHAR_MAX	Maximum value for signed char
UCHAR_MAX	Maximum value for unsigned char
CHAR_MIN	Minimum value for char
CHAR_MAX	Maximum value for char
MB_LEN_MAX	Maximum number of bytes for a multi-byte character.
SHRT_MIN	Minimum value for short int
SHRT_MAX	Maximum value for short int
USHRT_MAX	Maximum value for unsigned short int
INT_MIN	Minimum value for int
INT_MAX	Maximum value for int
UINT_MAX	Maximum value for unsigned int
LONG_MIN	Minimum value for long int
LONG_MAX	Maximum value for long int
ULONG_MAX	Maximum value for unsigned long int

locale.h

The header file in [Listing 3.1](#) defines a struct containing all the locale specific values.

Listing 3.1 Local-specific Values

```

struct lconv {
    char *decimal_point;      /* "." */
    /* Decimal point character to use for non-monetary numbers */
    char *thousands_sep;    /* "" */

```

ANSI Library Reference

Types and Macros in the Standard Library

```
/* Character to use to separate digit groups in
   the integral part of a non-monetary number. */
char *grouping;          /* "\CHAR_MAX" */
/* Number of digits that form a group. CHAR_MAX
   means "no grouping", '\0' means take previous
   value.
   E.g. the string "\3\0" specifies the repeated
   use of groups of three digits. */
char *int_curr_symbol;  /* "" */
/* 4-character string for the international
   currency symbol according to ISO 4217. The
   last character is the separator
   between currency symbol and amount. */
char *currency_symbol;  /* "" */
/* National currency symbol. */
char *mon_decimal_point; /* "." */
char *mon_thousands_sep; /* "" */
char *mon_grouping;     /* "\CHAR_MAX" */
/* Same as decimal_point etc., but for monetary numbers. */
char *positive_sign;    /* "" */
/* String to use for positive monetary numbers.*/
char *negative_sign;    /* "" */
/* String to use for negative monetary numbers. */
char int_frac_digits;   /* CHAR_MAX */
/* Number of fractional digits to print in a
   monetary number according to international format. */
char frac_digits;      /* CHAR_MAX */
/* The same for national format. */
char p_cs_precedes;    /* 1 */
/* 1 indicates that the currency symbol is left
   of a positive monetary amount; 0 indicates it's on the right. */
char p_sep_by_space;   /* 1 */
/* 1 indicates that the currency symbol is
   separated from the number by a space for
   positive monetary amounts. */
char n_cs_precedes;    /* 1 */
char n_sep_by_space;   /* 1 */
/* The same for negative monetary amounts. */
char p_sign_posn;      /* 4 */
char n_sign_posn;      /* 4 */
/* Defines the position of the sign for positive
   and negative monetary numbers:
   0 amount and currency are in parentheses
   1 sign comes before amount and currency
   2 sign comes after the amount
```



```
3 sign comes immediately before the currency  
4 sign comes immediately after the currency */  
};
```

There also are several constants that can be used in [setlocale](#) to define which part of the locale should be set. See [Table 3.7](#).

Table 3.7 Constants Used with setlocal()

Constant	Description
LC_ALL	Changes the complete locale.
LC_COLLATE	Only changes the locale for functions strcoll and strxfrm .
LC_MONETARY	Changes the locale for formatting monetary numbers.
LC_NUMERIC	Changes the locale for numeric, i.e. non-monetary formatting.
LC_TIME	Changes the locale for function strftime .
LC_TYPE	Changes the locale for character handling and multi-byte character functions.

This implementation only supports the minimum “C” locale.

math.h

Defines just this constant:

```
HUGE_VAL
```

Large value that is returned if overflow occurs.

setjmp.h

Contains just this type definition:

```
typedef jmp_buf;
```

A buffer for [setjmp](#) to store the current program state.

signal.h

Defines signal handling constants and types. See [Table 3.8](#) and [Table 3.9](#).

```
typedef sig_atomic_t;
```

Table 3.8 Constants Defined in signal.h

Constant	Definition
SIG_DFL	If passed as 2 nd argument to <code>signal</code> , the default response is installed.
SIG_ERR	Return value of signal , if the handler could not be installed.
SIG_IGN	If passed as 2 nd argument to signal , the signal is ignored.

Table 3.9 Signal Type Constants

Constant	Definition
SIGABRT	Abort program abnormally
SIGFPE	Floating point error
SIGILL	Illegal instruction
SIGINT	Interrupt
SIGSEGV	Segmentation violation
SIGTERM	Terminate program normally

stddef.h

Defines a few generally useful types and constants. See [Table 3.10](#).

Table 3.10 Constants Defined in stddef.h

Constant	Description
<code>ptrdiff_t</code>	The result type of the subtraction of two pointers.
<code>size_t</code>	Unsigned type for the result of <code>sizeof</code> .
<code>wchar_t</code>	Integral type for wide characters.

Table 3.10 Constants Defined in `stddef.h`

Constant	Description
<code>#define NULL ((void *) 0)</code>	
<code>size_t offsetof (</code> <code>type,</code> <code>struct_member)</code>	Returns the offset of field <code>struct_member</code> in <code>struct</code> type.

stdio.h

There are two type declarations in this header file. See [Table 3.11](#).

Table 3.11 Type Definitions in `stdio.h`

Type Definition	Description
<code>FILE</code>	Defines a type for a file descriptor.
<code>fpos_t</code>	A type to hold the position in the file as needed by fgetpos and fsetpos .

[Table 3.12](#) lists the constants defined in `stdio.h`.

Table 3.12 Constants Defined in `stdio.h`

Constant	Description
<code>BUFSIZ</code>	Buffer size for setbuf .
<code>EOF</code>	Negative constant to indicate end-of-file.
<code>FILENAME_MAX</code>	Maximum length of a file name.
<code>FOPEN_MAX</code>	Maximum number of open files.
<code>_IOFBF</code>	To set full buffering in setvbuf .
<code>_IOLBF</code>	To set line buffering in setvbuf .
<code>_IONBF</code>	To switch off buffering in setvbuf .
<code>SEEK_CUR</code>	fseek positions relative from current position.
<code>SEEK_END</code>	fseek positions from the end of the file.L
<code>SEEK_SET</code>	fseek positions from the start of the file.
<code>TMP_MAX</code>	Maximum number of unique filenames tmpnam can generate.

Additionally, there are three variables for the standard I/O streams:

```
extern FILE *stderr, *stdin, *stdout;
```

stdlib.h

Besides a redefinition of `NULL`, `size_t` and `wchar_t`, this header file contains the the type definitions listed in [Table 3.13](#).

Table 3.13 Type Definitions in `stdlib.h`

Type Definition	Description
<code>typedef div_t;</code>	A struct for the return value of div .
<code>typedef ldiv_t;</code>	A struct for the return value of ldiv .

[Table 3.14](#) lists the constants defined in `stdlib.h`

Table 3.14 Constants Defined in `stdlib.h`

Constant	Definition
<code>EXIT_FAILURE</code>	Exit code for unsuccessful termination.
<code>EXIT_SUCCESS</code>	Exit code for successful termination.
<code>RAND_MAX</code>	Maximum return value of rand .
<code>MB_LEN_MAX</code>	Maximum number of bytes in a multi byte character.

time.h

This header files defines types and constants for time management. See [Listing 3.2](#).

Listing 3.2 `time.h`—Type Definitions and Constants

```
typedef clock_t;
typedef time_t;

struct tm {
    int tm_sec;           /* Seconds */
    int tm_min;           /* Minutes */
    int tm_hour;          /* Hours */
    int tm_mday;          /* Day of month: 0 .. 31 */
    int tm_mon;           /* Month: 0 .. 11 */
```

```
int tm_year;          /* Year since 1900 */
int tm_wday;          /* Day of week: 0 .. 6 (Sunday == 0) */
int tm_yday;          /* day of year: 0 .. 365 */
int tm_isdst;         /* Daylight saving time flag:
                       > 0      It is DST
                       0       It isn't DST
                       < 0      unknown */
};
```

The constant `CLOCKS_PER_SEC` gives the number of clock ticks per second.

string.h

The file `string.h` defines only functions and not types or special defines.

The functions are explained below together with all other ANSI functions.

assert.h

The file `assert.h` defines the macro [assert](#). If the macro `NDEBUG` is defined, then `assert` does nothing. Otherwise `assert` calls the auxiliary function `_assert` if the one macro parameter of `assert` evaluates to 0 (`FALSE`).

```
#ifdef NDEBUG
#define assert(EX)
#else
#define assert(EX) ((EX) ? 0 : _assert(__LINE__, __FILE__))
#endif
```

stdarg.h

The file `stdarg.h` defines the type `va_list` and the macros [va_arg](#), [va_end](#) and [va_start](#). The type `va_list` implements a pointer to one argument of a open parameter list. The macro [va_start](#) initializes a variable of type `va_list` to point to the first open parameter, given the last explicit parameter and its type as arguments. The macro [va_arg](#) returns one open parameter, given its type and also makes the `va_list` argument pointing to the next parameter. The [va_end](#) macro finally releases the actual pointer. For all implementations, the [va_end](#) macro does nothing because `va_list` is implemented as elementary data type and it must therefore not be released. The [va_start](#) and the [va_arg](#) macro have a type parameter, which is accessed only with `sizeof`. So type, but also variables can be used.

Look at the following example:

```
char sum(long p, ...) {
    char res=0;
    va_list list= va_start(p, long);
    res= va_arg(list, int);    // (*)
    va_end(list);
    return res;
}

void main(void) {
    char c=2;
    if (f(10L, c) != 2) Error();
}
```

In the line (*) `va_arg` must be called with `int`, not with `char`. Because of the default argument promotion rules of C, for integral types at least an `int` is passed and for floating types at least a `double` is passed. In other words, the result of using `va_arg(..., char)` or `va_arg(..., short)` is undefined in C. Especially be careful when using variables instead of types for `va_arg`. In the example above “`res= va_arg(list, res)`” would not be correct unless `res` would have the type `int` and not `char`.

ctype.h

The `ctype.h` file defines functions to check properties of characters, as if a character is a digit ([isdigit](#)), a space ([isspace](#)) and many others. These functions are either implemented as macros, or as real functions. The macro version is used when the compiler option `-Ot` is used or the macro `__OPTIMIZE_FOR_TIME__` is defined. The macros use a table of 257 bytes length called `_ctype`. In this array, all properties tested by the various functions are encoded by single bits, taking the character as indices into the array. The function implementations otherwise do not use this table. They save memory by using the shorter call to the function (compared with the expanded macro).

The functions in [Listing 3.3](#) are explained below together with all other ANSI functions.

Listing 3.3 Macros Defined in `ctypes.h`

```
extern unsigned char  _ctype[];
#define  _U  (1<<0)    /* Upper case      */
#define  _L  (1<<1)    /* Lower case     */
#define  _N  (1<<2)    /* Numeral (digit) */
#define  _S  (1<<3)    /* Spacing character */
#define  _P  (1<<4)    /* Punctuation    */
#define  _C  (1<<5)    /* Control character */
```

```

#define _B (1<<6) /* Blank */
#define _X (1<<7) /* heXadecimal digit */

#ifdef __OPTIMIZE_FOR_TIME__ /* -Ot defines this macro */
#define isalnum(c) (_ctype[(unsigned char)(c+1)] & (_U|_L|_N))
#define isalpha(c) (_ctype[(unsigned char)(c+1)] & (_U|_L))
#define iscntrl(c) (_ctype[(unsigned char)(c+1)] & _C)
#define isdigit(c) (_ctype[(unsigned char)(c+1)] & _N)
#define isgraph(c) (_ctype[(unsigned char)(c+1)] & (_P|_U|_L|_N))
#define islower(c) (_ctype[(unsigned char)(c+1)] & _L)
#define isprint(c) (_ctype[(unsigned char)(c+1)] & (_P|_U|_L|_N|_B))
#define ispunct(c) (_ctype[(unsigned char)(c+1)] & _P)
#define isspace(c) (_ctype[(unsigned char)(c+1)] & _S)
#define isupper(c) (_ctype[(unsigned char)(c+1)] & _U)
#define isxdigit(c) (_ctype[(unsigned char)(c+1)] & _X)
#define tolower(c) (isupper(c) ? ((c) - 'A' + 'a') : (c))
#define toupper(c) (islower(c) ? ((c) - 'a' + 'A') : (c))
#define isascii(c) (!(c) & ~127)
#define toascii(c) (c & 127)
#endif /* __OPTIMIZE_FOR_TIME__ */

```

The Standard Functions

This section describes all the standard functions in the ANSI-C library. Each function description contains the subsections listed in [Table 3.15](#).

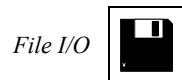
Table 3.15 Function Description Subsections

Subsection	Description
Syntax	Shows the function's prototype and also which header file to include.
Description	A description of how to use the function.
Return	Describes what the function returns in which case. If global variable <code>errno</code> is modified by the function, possible values are described, too.
See also	Contains cross-references to related functions.

Functions not implemented because the implementation would be hardware specific anyway (e.g. [clock](#)) are marked by:



appearing in the right margin next to the function's name. Functions for file I/O, which also depend on your particular hardware's setup and therefore also are not implemented, are marked by:



in the right margin.

abort

Syntax

```
#include <stdlib.h>
void abort (void);
```

Description

`abort()` terminates your program. It does the following (in this order):

- raises signal `SIGABRT`
- flushes all open output streams
- closes all open files
- removes all temporary files
- calls `HALT`

If your application handles `SIGABRT` and the signal handler doesn't return (e.g. because it does a [longjmp](#)), the application is not halted.

See also

[atexit](#), [exit](#), [raise](#), [signal](#)

abs

Syntax

```
#include <stdlib.h>
int abs (int i);
```

Description

`abs()` computes the absolute value of `i`.

Return

The absolute value of `i`, i.e. `i` if `i` is positive and `-i` if `i` is negative. If `i` is `-32768`, this value is returned and `errno` is set to `ERANGE`.

See also

[fabs](#), [labs](#)

acos, acosf

Syntax

```
#include <math.h>
double acos (double x);
float  acosf (float x);
```

Description

`acos()` computes the principal value of the arc cosine of `x`.

Return

The arc cosine $\cos^{-1}(x)$ of `x` in the range between 0 and π if `x` is in the range $-1 \leq x \leq 1$. If `x` is not in this range, `NAN` is returned and `errno` is set to `EDOM`.

See also

[asin](#), [asinf](#), [atan](#), [atanf](#), [atan2](#), [atan2f](#), [cos](#), [cosf](#), [sin](#), [sinf](#),
[tan](#), [tanf](#)

asctime

Hardware
specific



Syntax

```
#include <time.h>
char * asctime (const struct tm* timeptr);
```

Description

asctime() converts the broken down time in timeptr into a string.

Return

A pointer to a string containing the time string.

See also

[localtime](#), [mktime](#), [time](#)

asin, asinf

Syntax

```
#include <math.h>
double asin (double x);
float asinf (float x);
```

Description

asin() computes the principal value of the arc sine of x.

Return

The arc sine $\sin^{-1}(x)$ of x in the range between $-\pi/2$ and $\pi/2$ if x is in the range $-1 \leq x \leq 1$. If x is not in this range, NAN is returned and `errno` is set to `EDOM`.

See also

[acos](#), [acosf](#), [atan](#), [atanf](#), [atan2](#), [atan2f](#), [cos](#), [cosf](#), [sin](#), [sinf](#), [tan](#), [tanf](#)

assert

Syntax

```
#include <assert.h>
void assert (int expr);
```

Description

`assert()` is a macro that indicates expression `expr` is expected to be true at this point in the program. If `expr` is false (0), `assert` halts the program. Compiling with option `-DNDEBUG` or placing the preprocessor control statement

```
#define NDEBUG
```

before the `#include <assert.h>` statement effectively deletes all assertions from the program.

See also

[abort](#), [exit](#)

atan, atanf

Syntax

```
#include <math.h>
double atan (double x);
float atanf (float x);
```

Description

`atan()` computes the principal value of the arc tangent of x .

Return

The arc tangent $\tan^{-1}(x)$, in the range from $-\pi/2$ to $\pi/2$ rad.

See also

[acos](#), [acosf](#), [asin](#), [asinf](#), [atan2](#), [atan2f](#), [cos](#), [cosf](#), [sin](#), [sinf](#), [tan](#), [tanf](#)

atan2, atan2f

Syntax

```
#include <math.h>

double atan2 (double y, double x);
float  atan2f (float y, float x);
```

Description

`atan2()` computes the principal value of the arc tangent of y/x . It uses the sign of both operands to determine the quadrant of the result.

Return

The arc tangent $\tan^{-1}(y/x)$, in the range from $-\pi$ to π rad, if not both x and y are 0. If both x and y are 0, it returns 0.

See also

[acos](#), [acosf](#), [asin](#), [asinf](#), [atan](#), [atanf](#), [cos](#), [cosf](#), [sin](#), [sinf](#), [tan](#), [tanf](#)

atexit

Syntax

```
#include <stdlib.h>
int atexit (void (*func) (void));
```

Description

`atexit()` lets you install a function that is to be executed just before the normal termination of the program. You can register at most 32 functions with `atexit`. These functions are called in the reverse order they were registered.

Return

`atexit` returns 0 if it could register the function, otherwise it returns a non-zero value.

See also

[abort](#), [exit](#)

atof

Syntax

```
#include <stdlib.h>
double atof (const char *s);
```

Description

`atof()` converts the string `s` to a double floating point value, skipping over white space at the beginning of `s`. It stops converting when it reaches either the end of the string or a character that cannot be part of the number. The number format accepted by `atof` is the following:

FloatNum	= Sign {Digit} ["." {Digit}] [Exp].
Sign	= ["+" "-"].
Digit	= <any decimal digit from 0 to 9>.
Exp	= ("e" "E") Sign Digit {Digit}.

Return

`atof` returns the converted double floating point value.

See also

[atoi](#), [atol](#), [strtod](#), [strtol](#), [strtoul](#)

atoi

Syntax

```
#include <stdlib.h>
int atoi (const char *s);
```

Description

`atoi()` converts the string `s` to an integer value, skipping over white space at the beginning of `s`. It stops converting when it reaches either the end of the string or a character that cannot be part of the number. The number format accepted by `atoi` is the following:

Number = ["+"|"-"] Digit {Digit}.

Return

`atoi` returns the converted integer value.

See also

[atof](#), [atol](#), [strtod](#), [strtol](#), [strtoul](#)

atol

Syntax

```
#include <stdlib.h>
long atol (const char *s);
```

Description

`atol()` converts the string `s` to an `long` value, skipping over white space at the beginning of `s`. It stops converting when it reaches either the end of the string or a character that cannot be part of the number. The number format accepted by [atoi](#) is the following:

Number = ["+"|-"] Digit {Digit}.

Return

`atol` returns the converted `long` value.

See also

[atoi](#), [atof](#), [strtod](#), [strtol](#), [strtoul](#)

bsearch

Syntax

```
#include <stdlib.h>

void *bsearch (const void *key,
              const void *array,
              size_t n,
              size_t size,
              cmp_func cmp);
```

Description

`bsearch()` performs a binary search in a sorted array. It calls the comparison function `cmp` with two arguments: a pointer to the key element that is to be found and a pointer to an array element. Thus, the type `cmp_func` can be declared as

```
typedef int (*cmp_func)(const void *key, const void *data);
```

The comparison function should return an integer as follows:

If the key element is...	the return value should be...
less than the array element	less than zero (negative)
equal to the array element	zero
greater than the array element	greater than zero (positive)

The arguments to `bsearch()` are:

Parameter Name	Meaning
<code>key</code>	A pointer to the key data you are looking for
<code>array</code>	A pointer to the beginning (i.e. the first element) of the array you want to search
<code>n</code>	The number of elements in the array
<code>size</code>	The size (in bytes) of one element in the table
<code>cmp</code>	The comparison function

NOTE Make sure the array contains only elements of the same size. `bsearch` also assumes that the array is sorted in ascending order with respect to the comparison function `cmp`.

Return

`bsearch()` returns a pointer to an element of the array that matches the key, if there is one. If the comparison function never returns zero, i.e. there is no matching array element, `bsearch()` returns `NULL`.

calloc

Hardware
specific



Syntax

```
#include <stdlib.h>
void *calloc (size_t n, size_t size);
```

Description

`calloc()` allocates a block of memory for an array containing `n` elements of size `size`. All bytes in the memory block are initialized to zero. To deallocate the block, use [free\(\)](#). The default implementation is not reentrant and should therefore not be used in interrupt routines.

Return

`calloc` returns a pointer to the allocated memory block. If the block couldn't be allocated, the return value is `NULL`.

See also

[free](#), [malloc](#), [realloc](#)

ceil, ceilf

Syntax

```
#include <math.h>
double ceil (double x);
float ceilf (float x);
```

Description

`ceil()` returns the smallest integral number larger than `x`.

See also

[floor](#), [floorf](#), [modf](#), [modff](#)

clearerr

File I/O



Syntax

```
#include <stdio.h>
void clearerr (FILE *f);
```

Description

`clearerr()` resets the error flag and the EOF marker of file `f`.

clock

Hardware
specific



Syntax

```
#include <time.h>
clock_t clock (void);
```

Description

`clock()` determines the amount of time since your system started, in clock ticks. To convert to seconds, divide by `CLOCKS_PER_SEC`.

Return

`clock` returns the amount of time since system startup.

See also

[time](#)

cos, cosf

Syntax

```
#include <math.h>
double cos (double x);
float cosf (float x);
```

Description

`cos()` computes the principal value of the cosine of `x`. `x` should be expressed in radians.

Return

The cosine `cos(x)`.

See also

[acos](#), [acosf](#), [asin](#), [asinf](#), [atan](#), [atanf](#), [atan2](#), [atan2f](#), [sin](#), [sinf](#), [tan](#), [tanf](#)

cosh, coshf

Syntax

```
#include <math.h>
double cosh (double x);
float coshf (float x);
```

Description

`cosh()` computes the hyperbolic cosine of `x`.

Return

The hyperbolic cosine `cosh(x)`. If the computation fails because the value is too large, `HUGE_VAL` is returned and `errno` is set to `ERANGE`.

See also

[cos](#), [cosf](#), [sinh](#), [sinhf](#), [tanh](#), [tanhf](#)

ctime

Hardware
specific



Syntax

```
#include <time.h>
char *ctime (const time_t *timer);
```

Description

`ctime()` converts the calendar time `timer` to a character string.

Return

The string containing the ASCII representation of the date.

See also

[asctime](#), [mktime](#), [time](#)

difftime

Hardware
specific



Syntax

```
#include <time.h>
double difftime (time_t *t1, time_t t0);
```

Description

`difftime()` calculates the number of seconds between any two calendar times.

Return

The number of seconds between the two times, as a double.

See also

[mktime](#), [time_](#)

div

Syntax

```
#include <stdlib.h>
div_t div (int x, int y);
```

Description

`div()` computes both the quotient and the modulus of the division x/y .

Return

A structure with the results of the division.

See also

[ldiv](#)

exit

Syntax

```
#include <stdlib.h>
void exit (int status);
```

Description

`exit()` terminates your program normally. It does the following, in this order:

- executes all functions registered with [atexit](#)
- flushes all open output streams
- closes all open files
- removes all temporary files
- calls HALT

The `status` argument is ignored.

See also

[abort](#), [atexit](#)

exp, expf

Syntax

```
#include <math.h>
double exp (double x);
float expf (float x);
```

Description

`exp()` computes e^x , where e is the base of natural logarithms.

Return

e^x . If the computation fails because the value is too large, `HUGE_VAL` is returned and `errno` is set to `ERANGE`.

See also

[log](#), [logf](#), [log10](#), [log10f](#), [pow](#), [powf](#)

fabs, fabsf

Syntax

```
#include <math.h>

double fabs (double x);
float  fabsf (float x);
```

Description

`fabs()` computes the absolute value of `x`.

Return

The absolute value of `x` for any value of `x`.

See also

[abs](#), [labs](#)

fclose

File I/O



Syntax

```
#include <stdio.h>

int fclose (FILE *f);
```

Description

`fclose()` closes file `f`. Before doing so, it does the following:

- flushes the stream, if the file wasn't opened in read-only mode
 - discards and deallocates any buffers that were allocated automatically, i.e. not using [setbuf](#).
-

Return

Zero, if the function succeeds, EOF otherwise.

See also

[fopen](#), [setbuf](#)

feof

File I/O



Syntax

```
#include <stdio.h>
int feof (FILE *f);
```

Description

`feof()` tests whether previous I/O calls on file `f` tried to do anything beyond the end of the file.

NOTE Calling [clearerr](#) or [fseek](#) clears the file's end-of-file flag, therefore `feof` returns 0.

Return

Zero, if we're not at the end of the file, EOF otherwise.

See also

[clearerr](#), [fseek](#)

ferror

File I/O



Syntax

```
#include <stdio.h>
int ferror (FILE *f);
```

Description

`ferror()` tests whether an error had occurred on file `f`. To clear the error indicator of a file, use [clearerr](#). [rewind](#) automatically resets the file's error flag.

NOTE Do not use [ferror](#) to test for end-of-file. Use [feof](#) instead.

Return

Zero, if there was no error, non-zero otherwise.

See also

[clearerr](#), [feof](#), [rewind](#)

fflush

File I/O



Syntax

```
#include <stdio.h>
int fflush (FILE *f);
```

Description

`fflush()` flushes the I/O buffer of file `f`, letting you switch cleanly between reading and writing the same file. If your program was writing to file `f`, `fflush` writes all buffered data to the file, if it was reading, `fflush` discards any buffered data. If `f` is `NULL`, *all* files open for writing are flushed.

Return

Zero, if there was no error, EOF otherwise.

See also

[setbuf](#), [setvbuf](#)

fgetc

File I/O



Syntax

```
#include <stdio.h>
int fgetc (FILE *f);
```

Description

`fgetc()` reads the next character from file `f`.

NOTE If file `f` had been opened as a text file, the end-of-line character combination is read as one `'\n'` character.

Return

The character read as an integer in the range from 0 to 255. If there was a read error, `fgetc` returns EOF and sets the file's error flag, so that a subsequent call to [ferror](#) will return a non-zero value. If you try to read beyond the end of the file, `fgetc` also returns EOF but sets the end-of-file flag instead of the error flag, so that [feof](#) will return EOF, but [ferror](#) will return 0.

See also

[feof](#), [ferror](#), [fgets](#), [fopen](#), [fread](#), [fscanf](#), [getc](#)

fgetpos

File I/O



Syntax

```
#include <stdio.h>
int fgetpos (FILE *f, fpos_t *pos);
```

Description

`fgetpos()` returns in `*pos` the current file position. You can use this value to later set the position to this one using [fsetpos](#).

NOTE Do *not* assume the value in `*pos` to have any particular meaning such as a byte offset from the beginning of the file. The ANSI standard does not require this, and in fact any value may be put into `*pos` as long as a [fsetpos](#) with that value resets the position in the file correctly.

Return

Non-zero, if there was an error; zero otherwise.

See also

[fseek](#), [fsetpos](#), [ftell](#)

fgets

File I/O



Syntax

```
#include <stdio.h>
char *fgets (char *s, int n, FILE *f);
```

Description

`fgets()` reads a string of at most `n-1` characters from file `f` into `s`. Immediately after the last character read, a `'\0'` is appended. If `fgets` reads a line break (`'\n'`) or reaches the end of the file before having read `n-1` characters, the following happens:

- If `fgets` reads a line break, it adds the `'\n'` plus a `'\0'` to `s` and returns successfully.
- If it reaches the end of the file after having read at least 1 character, it adds a `'\0'` to `s` and returns successfully.
- If it reaches EOF without having read any character, it sets the file's end-of-file flag and returns unsuccessfully. (`s` is left unchanged).

Return

NULL, if there was an error; `s` otherwise.

See also

[fgetc](#), [fputs](#)

floor, floorf

Syntax

```
#include <math.h>

double floor (double x);
float floorf (float x);
```

Description

`floor()` calculates the largest integral number not larger than x .

Return

The largest integral number not larger than x .

See also

[ceil](#), [ceilf](#), [modf](#), [modff](#)

fmod, fmodf

Syntax

```
#include <math.h>

double fmod (double x, double y);
float fmodf (float x, float y);
```

Description

`fmod()` calculates the floating point remainder of x/y .

Return

The floating point remainder of x/y , with the same sign as x . If y is 0, it returns 0 and sets `errno` to `EDOM`.

See also

[div](#), [ldiv](#), [ldexp](#), [ldexpf](#), [modf](#), [modff](#)

fopen

File I/O



Syntax

```
#include <stdio.h>

FILE *fopen (const char *name, const char *mode);
```

Description

`fopen()` opens a file with the given name and mode. It automatically allocates an I/O buffer for the file.

There are three main modes: read, write, and update (i.e. both read and write) accesses. Each can be combined with either text or binary mode to read a text file or update a binary file. Opening a file for text accesses translates the end-of-line character (combination) into `'\n'` when reading and vice versa when writing. The table below lists all possible modes.

Mode	Effect
"r"	Open the file as text file for reading.
"w"	Create a text file and open it for writing.
"a"	Open the file as text file for appending
"rb"	Open the file as binary file for reading.
"wb"	Create a file and open as binary file for writing.
"ab"	Open the file as binary file for appending.
"r+"	Open a text file for updating.
"w+"	Create a text file and open for updating.
"a+"	Open a text file for updating. Append all writes to the end.
"r+b", "rb+"	Open a binary file for updating.
"w+b", "wb+"	Create a binary file and open for updating.
"a+b", "ab+"	Open a binary file for updating, appending all writes to the end.

If the mode contains an “r”, but the file doesn’t exist, `fopen` returns unsuccessfully. Opening a file for appending (mode contains “a”) always appends writing to the end, even if you call [fseek](#), [fsetpos](#) or [rewind](#). Opening a file for updating allows both read and write accesses on the file. However, you must call [fseek](#), [fsetpos](#) or [rewind](#) to write after a read or to read after a write.

Return

A pointer to the file descriptor of the file. If the file could not be created, the function returns `NULL`.

See also

[fclose](#), [freopen](#), [fseek](#), [fsetpos](#), [rewind](#), [setbuf](#), [setvbuf](#)

fprintf

File I/O



Syntax

```
#include <stdio.h>

int fprintf (FILE *f, const char *format, ...);
```

Description

`fprintf()` is the same as [sprintf](#), but the output goes to file `f` instead of a string.

Return

The number of characters written. If some error occurred, `EOF` is returned.

See also

[printf](#), [sprintf](#), [vsprintf](#)

fputc

File I/O



Syntax

```
#include <stdio.h>
int fputc (int ch, FILE *f);
```

Description

`fputc()` writes a character to file `f`.

Return

The integer value of `ch`. If an error occurred, `fputc` returns EOF.

See also

[fputs](#)

fputs

File I/O



Syntax

```
#include <stdio.h>
int fputs (const char *s, FILE *f);
```

Description

`fputs()` writes the zero-terminated string `s` to file `f` (without the terminating `'\0'`).

Return

EOF, if there was an error, zero otherwise.

See also

[fputc](#)

fread

File I/O



Syntax

```
#include <stdio.h>

size_t fread (void *ptr, size_t size, size_t n, FILE *f);
```

Description

`fread()` reads a contiguous block of data. It attempts to read `n` items of size `size` from file `f` and stores them in the array `ptr` points to. If either `n` or `size` is 0, nothing is read from the file and the array is left unchanged.

Return

The number of items successfully read.

See also

[fgetc](#), [fgets](#), [fwrite](#)

free

Hardware
specific



Syntax

```
#include <stdlib.h>

void free (void *ptr);
```

Description

`free()` deallocates a memory block that had previously been allocated by [calloc](#), [malloc](#) or [realloc](#). If `ptr` is `NULL`, nothing happens. The default implementation is not reentrant and should therefore not be used in interrupt routines.

See also

[calloc](#), [malloc](#), [realloc](#)

freopen

File I/O



Syntax

```
#include <stdio.h>

void freopen (const char *name,
             const char *mode,
             FILE *f);
```

Description

`freopen()` opens a file using a specific file descriptor. This can be useful for redirecting `stdin`, `stdout` or `stderr`. About possible modes, see [fopen](#).

See also

[fopen](#), [fclose](#)

frexp, frexpf

Syntax

```
#include <math.h>

double frexp (double x, int *exp);
float  frexpf (float x, int *exp);
```

Description

`frexp()` splits a floating point number into mantissa and exponent. The relation is $x = m * 2^{exp}$. `m` always is normalized to the range $0.5 < m \leq 1.0$. The mantissa has the same sign as `x`.

Return

The mantissa of `x` (the exponent is written to `*exp`). If `x` is `0.0`, both the mantissa (the return value) and the exponent are `0`.

See also

[exp](#), [expf](#), [ldexp](#), [ldexpf](#), [modf](#), [modff](#)

fscanf

File I/O

**Syntax**

```
#include <stdio.h>
int fscanf (FILE *f, const char *format, ...);
```

Description

`fscanf()` is the same as [sscanf](#), but the input comes from file `f` instead of a string.

Return

The number of data arguments read, if any input was converted. If not, it returns EOF.

See also

[fgetc](#), [fgets](#), [scanf](#), [sscanf](#)

fseek

File I/O

**Syntax**

```
#include <stdio.h>
int fseek (FILE *f, long offset, int mode);
```

Description

`fseek()` sets the current position in file `f`.

For binary files, the position can be set in three ways, as shown in this table.

mode	Position is set to...
SEEK_SET	offset bytes from the beginning of the file.
SEEK_CUR	offset bytes from the current position.
SEEK_END	offset bytes from the end of the file.

For text files, either `offset` must be zero or mode is `SEEK_SET` and `offset` a value returned by a previous call to [ftell](#).

If `fseek` is successful, it clears the file's end-of-file flag. You cannot set the position beyond the end of the file.

Return

Zero, if successful; non-zero otherwise.

See also

[fgetpos](#), [fsetpos](#), [ftell](#)

fsetpos

File I/O



Syntax

```
#include <stdio.h>

int fsetpos (FILE *f, const fpos_t *pos);
```

Description

`fsetpos()` set the file position to `pos`, which must be a value returned by a previous call to [fgetpos](#) on the same file. If the function is successful, it clears the file's end-of-file flag.

You cannot set the position beyond the end of the file.

Return

Zero, if it was successful, non-zero otherwise.

See also

[fgetpos](#), [fseek](#), [ftell](#)

ftell

File I/O



Syntax

```
#include <stdio.h>

long ftell (FILE *f);
```

Description

`ftell()` returns the current file position. For binary files, this is the byte offset from the beginning of the file; for text files, this value should not be used except as argument to [fseek](#).

Return

-1, if an error occurred; otherwise the current file position.

See also

[fgetpos](#), [fseek](#), [fsetpos](#)

fwrite

File I/O



Syntax

```
#include <stdio.h>

size_t fwrite (const void *p,
               size_t size,
               size_t n,
               FILE *f);
```

Description

`fwrite()` writes a block of data to file `f`. It writes `n` items of size `size`, starting at address `ptr`.

Return

The number of items successfully written.

See also

[fputc](#), [fputs](#), [fread](#)

getc

File I/O



Syntax

```
#include <stdio.h>
int getc (FILE *f);
```

Description

`getc()` is the same as [fgetc](#), but may be implemented as a macro. Therefore, you should make sure that `f` is not an expression having side effects! See [fgetc](#) for more information.

getchar

File I/O



Syntax

```
#include <stdio.h>
int getchar (void);
```

Description

`getchar()` is the same as [getc](#) (`stdin`). See [fgetc](#) for more information.

getenv

File I/O



Syntax

```
#include <stdio.h>
char *getenv (const char *name);
```

Description

`getenv()` returns the value of environment variable `name`.

Return

NULL

gets

File I/O



Syntax

```
#include <stdio.h>
char *gets (char *s);
```

Description

`gets()` reads a string from `stdin` and stores it in `s`. It stops reading when it reaches a line break or EOF character. This character is not appended to the string. The string is zero-terminated.

If the function reads EOF before any other character, it sets `stdin`'s end-of-file flag and returns unsuccessfully without changing string `s`.

Return

NULL, if there was an error; `s` otherwise.

See also

[fgetc](#), [puts](#)

gmtime

Hardware
specific



Syntax

```
#include <time.h>
struct tm *gmtime (const time_t *time);
```

Description

`gmtime()` converts `*time` to UTC (Universal Coordinated Time), which is equivalent to GMT (Greenwich Mean Time).

Return

NULL, if UTC is not available; a pointer to a struct containing UTC otherwise.

See also

[ctime](#), [time](#)

isalnum, isalpha, iscntrl, isdigit, isgraph, islower, isprint, ispunct, isspace, isupper, isxdigit

Syntax

```
#include <ctype.h>

int isalnum (int ch);
int isalpha (int ch);
...
int isxdigit (int ch);
```

Description

These functions determine whether character `ch` belongs to a certain set of characters. The next table describes the character ranges tested by the functions.

Function	Tests whether <code>ch</code> is in the range...
<code>isalnum</code>	alphanumeric character, i.e. 'A'-'Z', 'a'-'z' or '0'-'9'.
<code>isalpha</code>	an alphabetic character, i.e. 'A'-'Z' or 'a'-'z'.
<code>iscntrl</code>	a control character, i.e. '\000'-' \037' or '\177' (DEL).
<code>isdigit</code>	a decimal digit, i.e. '0'-'9'.
<code>isgraph</code>	a printable character except space ('!'-'~').
<code>islower</code>	a lower case letter, i.e. 'a'-'z'.
<code>isprint</code>	a printable character (' '-'~').

Function	Tests whether ch is in the range...
ispunct	a punctuation character, i.e. '!'-'/' , ':'-'@' , '['-' ' and '{'-'~'.
isspace	a white space character, i.e. ' ' , '\f' , '\n' , '\r' , '\t' and '\v'.
isupper	an upper case letter, i.e. 'A'-'Z'.
isxdigit	a hexadecimal digit, i.e. '0'-'9' , 'A'-'F' or 'a'-'f'.

Return

TRUE (i.e. 1), if ch is in the character class; zero otherwise.

See also

[tolower](#), [toupper](#)

labs

Syntax

```
#include <stdlib.h>
long labs (long i);
```

Description

labs() computes the absolute value of i.

Return

The absolute value of i, i.e. i if i is positive and -i if i is negative. If i is -2147483648, this value is returned and errno is set to ERANGE.

See also

[abs](#), [fabs](#)

ldexp, ldexpf

Syntax

```
#include <math.h>

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

Description

`ldexp()` multiplies `x` by 2^{exp} .

Return

$x * 2^{\text{exp}}$. If it fails because the result would be too large, `HUGE_VAL` is returned and `errno` is set to `ERANGE`.

See also

[exp](#), [expf](#), [frexp](#), [frexpf](#), [log](#), [logf](#), [log10](#), [log10f](#), `mod`, [modf](#), [fabs](#)

ldiv

Syntax

```
#include <stdlib.h>

ldiv_t ldiv (long x, long y);
```

Description

`ldiv()` computes both the quotient and the modulus of the division `x/y`.

Return

A structure with the results of the division.

See also

[div](#)

localeconv

Hardware
specific



Syntax

```
#include <locale.h>
struct lconv *localeconv (void);
```

Description

`localeconv()` returns a pointer to a `struct` containing information about the current locale, e.g. how to format monetary quantities.

Return

A pointer to a `struct` containing the desired information.

See also

[setlocale](#)

localtime

Hardware
specific



Syntax

```
#include <time.h>
struct tm *localtime (const time_t *time);
```

Description

`localtime()` converts `*time` into broken-down time.

Return

A pointer to a `struct` containing the broken-down time.

See also

[asctime](#), [mktime](#), [time](#)

log, logf

Syntax

```
#include <math.h>

double log (double x);
float  logf (float x);
```

Description

`log()` computes the natural logarithm of x .

Return

$\ln(x)$, if x is greater than zero. If x is smaller than zero, NAN is returned, if it's equal zero, `log` returns negative infinity. In both cases, `errno` is set to EDOM.

See also

[exp](#), [expf](#), [log10](#), [log10f](#)

log10, log10f

Syntax

```
#include <math.h>

double log10 (double x);
float  log10f (float x);
```

Description

`log10()` computes the decadic logarithm (the logarithm to base 10) of x .

Return

$\log_{10}(x)$, if x is greater than zero. If x is smaller than zero, NAN is returned, if it's equal zero, `log10` returns negative infinity. In both cases, `errno` is set to EDOM.

See also

[exp](#), [expf](#), [log](#), [logf](#)

longjmp

Syntax

```
#include <setjmp.h>
void longjmp (jmp_buf env, int val);
```

Description

`longjmp()` performs a non-local jump to some location earlier in the call chain. That location must have been marked by a call to [setjmp](#). The environment at the time of that call to [setjmp](#) (`env`, which also must have been the parameter to [setjmp](#)) is restored and your application continues as if the call to [setjmp](#) just had returned value `val`.

See also

[setjmp](#)

malloc

Hardware
specific



Syntax

```
#include <stdlib.h>
void *malloc (size_t size);
```

Description

`malloc()` allocates a block of memory for an object of size `size` bytes. The content of this memory block is undefined. To deallocate the block, use [free\(\)](#). The default implementation is not reentrant and should therefore not be used in interrupt routines.

Return

`malloc` returns a pointer to the allocated memory block. If the block couldn't be allocated, the return value is `NULL`.

See also

[calloc](#), [free](#), [realloc](#)

mblen

Hardware
specific



Syntax

```
#include <stdlib.h>
int mblen (const char *s, size_t n);
```

Description

`mblen()` determines the number of bytes the multi-byte character pointed to by `s` occupies.

Return

0, if `s` is `NULL`.
-1, if the first `n` bytes of `*s` do not form a valid multi-byte character.
`n`, the number of bytes of the multi-byte character otherwise.

See also

[mbtowc](#), [mbstowcs](#)

mbstowcs

Hardware
specific



Syntax

```
#include <stdlib.h>
size_t mbstowcs (wchar_t *wcs,
                 const char *mbs,
                 size_t n);
```

Description

`mbstowcs()` converts a multi-byte character string `mbs` to a wide character string `wcs`. Only the first `n` elements are converted.

Return

The number of elements converted, or `(size_t) -1` if there was an error.

See also

[mblen](#), [mbtowc](#)

mbtowc

Hardware
specific



Syntax

```
#include <stdlib.h>
int mbtowc (wchar_t *wc, const char *s, size_t n);
```

Description

`mbtowc()` converts a multi-byte character `s` to a wide character code `wcs`. Only the first `n` bytes of `*s` are taken into consideration.

Return

The number of bytes of the multi-byte character converted, or `(size_t) -1` if there was an error.

See also

[mblen](#), [mbstowcs](#)

memchr

Syntax

```
#include <string.h>
void *memchr (const void *p, int ch, size_t n);
```

Description

`memchr()` looks for the first occurrence of a byte containing (`ch & 0xFF`) in the first `n` bytes of the memory are pointed to by `p`.

Return

A pointer to the byte found, or `NULL` if no such byte was found.

See also

[memcmp](#), [strchr](#), [strrchr](#)

memcmp

Syntax

```
#include <string.h>

void *memcmp (const void *p,
              const void *q,
              size_t n);
```

Description

`memcmp()` compares the first `n` bytes of the two memory areas pointed to by `p` and `q`.

Return

A positive integer, if `p` is considered greater than `q`; a negative integer if `p` is considered smaller than `q` and zero if the two memory area are equal.

See also

[memchr](#), [strcmp](#), [strncmp](#)

memcpy, memmove

Syntax

```
#include <string.h>

void *memcpy (const void *p,
              const void *q,
              size_t n);

void *memmove (const void *p,
               const void *q,
               size_t n);
```

Description

Both functions copy *n* bytes from *q* to *p*. *memmove* also works if the two memory areas overlap.

Return

p.

See also

[strcpy](#), [strncpy](#)

memset

Syntax

```
#include <string.h>

void *memset (void *p, int val, size_t n);
```

Description

memset() sets the first *n* bytes of the memory area pointed to by *p* to the value (*val* & 0xFF).

Return

p.

See also

[calloc](#), [memmove](#)

mktime

Hardware
specific



Syntax

```
#include <time.h>

time_t mktime (struct tm *time);
```

Description

`mktime()` converts `*time` to a `time_t`. The fields of `*time` may have any value, they're not restricted to the ranges given [time.h](#). If the conversion was successful, `mktime` restricts the fields of `*time` to these ranges and also sets the fields `tm_wday` and `tm_yday` correctly.

Return

`*time` as a `time_t`.

See also

[ctime](#), [gmtime](#), [time](#)

modf, modff

Syntax

```
#include <math.h>

double modf (double x, double *i);
float modff (float x, float *i);
```

Description

`modf()` splits the floating point number `x` into integral part (returned in `*i`) and fractional part. Both parts have the same sign as `x`.

Return

The fractional part of x .

See also

[floor](#), [floorf](#), [fmod](#), [fmodf](#), [frexp](#), [frexpf](#), [ldexp](#), [ldexpf](#)

perror

Syntax

```
#include <stdio.h>
void perror (const char *msg);
```

Description

`perror()` writes an error message appropriate for the current value of `errno` to `stderr`. The character string `msg` is part of `perror`'s output.

See also

[assert](#), [strerror](#)

pow, powf

Syntax

```
#include <math.h>
double pow (double x, double y);
float powf (float x, float y);
```

Description

`pow()` computes x to the power of y , i.e. x^y .

Return

```
 $x^y$ ,    if  $x > 0$ 
1,       if  $y == 0$ 
```

+x, if (x == 0 && y < 0)
NAN, if (x < 0 && y is not integral). Also, errno is set to EDOM.
±x, with the same sign as x, if the result is too large.

See also

[exp](#), [expf](#), [ldexp](#), [ldexpf](#), [log](#), [logf](#), [modf](#), [modff](#)

printf

File I/O



Syntax

```
#include <stdio.h>
int printf (const char *format, ...);
```

Description

printf() is the same as [sprintf](#), but the output goes to stdout instead of a string.

Return

The number of characters written. If some error occurred, EOF is returned.

See also

[fprintf](#), [sprintf](#), [vsprintf](#)

putc

File I/O



Syntax

```
#include <stdio.h>
int putc (char ch, FILE *f);
```

Description

`putc()` is the same as [fputc](#), but may be implemented as a macro. Therefore, you should make sure that `f` is not an expression having side effects! See [fputc](#) for more information.

See also

[fputc](#)

putchar

File I/O



Syntax

```
#include <stdio.h>
int putchar (char ch);
```

Description

`putchar(ch)` is the same as [putc](#) (`ch, stdin`). See “`fputc`” for more information.

See also

[fputc](#)

puts

File I/O



Syntax

```
#include <stdio.h>
int puts (const char *s);
```

Description

`puts()` writes string `s` followed by a newline `'\n'` to `stdout`.

Return

EOF, if there was an error; zero otherwise.

See also

[fputc](#), [putc](#)

qsort

Syntax

```
#include <stdlib.h>

void *qsort (const void *array,
            size_t n,
            size_t size,
            cmp_func cmp);
```

Description

`qsort()` sorts the array according to the ordering implemented by the comparison function. It calls the comparison function `cmp` with two pointers to array elements. Thus, the type `cmp_func` can be declared as

```
typedef int (*cmp_func)(const void *key,
                       const void *other);
```

The comparison function should return an integer as follows:

If the key element is...	The return value should be...
less than the other one	less than zero (negative)
equal to the other one	zero
greater than the other one	greater than zero (positive)

The arguments to `qsort` are:

Argument Name	Meaning
<code>array</code>	A pointer to the beginning (i.e. the first element) of the array you want to sort
<code>n</code>	The number of elements in the array
<code>size</code>	The size (in bytes) of one element in the table
<code>cmp</code>	The comparison function

NOTE Make sure the array contains elements of the same size.

raise

Syntax

```
#include <signal.h>
int raise (int sig);
```

Description

`raise()` raises the given signal, invoking your signal handler or performing the defined response to the signal. If you didn't define a response or install a signal handler, your application is aborted.

Return

Non-zero, if there was an error, zero otherwise.

See also

[signal](#)

rand

Syntax

```
#include <stdlib.h>
int rand (void);
```

Description

`rand()` generates a pseudo random number in the range from 0 to `RAND_MAX`. The numbers are generated are based on a seed, which initially is 1. To change the seed, use [srand](#).

Equal seeds always lead to the same sequence of pseudo random numbers.

Return

A pseudo random integer in the range from 0 to RAND_MAX.

See also

[srand](#)

realloc

Hardware
specific



Syntax

```
#include <stdlib.h>
void *realloc (void *ptr, size_t size);
```

Description

`realloc()` changes the size of a block of memory, preserving its contents. `ptr` must be a pointer returned by [calloc](#), [malloc](#) or `realloc`, or `NULL`. In the latter case, `realloc` is equivalent to [malloc](#).

If the new size of the memory block is smaller than the old size, `realloc` discards that memory at the end of the block. If `size` is zero (and `ptr` not `NULL`), `realloc` frees the whole memory block.

If there's not enough memory to perform the `realloc`, the old memory block is left unchanged and `realloc` returns `NULL`. The default implementation is not reentrant and should therefore not be used in interrupt routines.

Return

`realloc` returns a pointer to the new memory block. If the operation couldn't be performed, the return value is `NULL`.

See also

[calloc](#), [free](#), [malloc](#)

remove

File I/O



Syntax

```
#include <stdio.h>
int remove (const char *filename);
```

Description

`remove()` deletes the file `filename`. If the file is open, `remove` doesn't delete it and returns unsuccessfully.

Return

Non-zero, if there was an error; zero otherwise.

See also

[tmpfile](#), [tmpnam](#)

rename

File I/O



Syntax

```
#include <stdio.h>
int rename (const char *from, const char *to);
```

Description

`rename()` renames file `from` to `to`. If there already is a file `to`, `rename` doesn't change anything and returns with an error code.

Return

Non-zero, if there was an error; zero otherwise.

See also

[tmpfile](#), [tmpnam](#)

rewind

File I/O



Syntax

```
#include <stdio.h>
void rewind (FILE *f);
```

Description

`rewind()` resets the current position in file `f` to the beginning of the file. It also clears the file's error indicator.

See also

[fopen](#), [fseek](#), [fsetpos](#)

scanf

File I/O



Syntax

```
#include <stdio.h>
int scanf (const char *format, ...);
```

Description

`scanf()` is the same as [sscanf](#), but the input comes from `stdin` instead of a string.

Return

The number of data arguments read, if any input was converted. If not, it returns EOF.

See also

[fgetc](#), [fgets](#), [fscanf](#), [sscanf](#)

setbuf

File I/O



Syntax

```
#include <stdio.h>
void setbuf (FILE *f, char *buf);
```

Description

`setbuf()` lets you specify how a file is buffered. If `buf` is `NULL`, the file is unbuffered, i.e. all input or output goes directly to and comes directly from the file. If `buf` is not `NULL`, it is used as a buffer (`buf` should point to an array of `BUFSIZ` bytes).

See also

[fflush](#), [setvbuf](#)

setjmp

Syntax

```
#include <setjmp.h>
int setjmp (jmp_buf env);
```

Description

`setjmp()` saves the current program state in environment buffer `env` and returns zero. This buffer can be used as parameter to a later call to [longjmp](#), which then restores the program state and jumps back to the location of the `setjmp`. This time, `setjmp` returns a non-zero value, which is equal to the second parameter to [longjmp](#).

Return

Zero if called directly, non-zero if called by a [longjmp](#).

See also

[longjmp](#)

setlocale

Hardware
specific



Syntax

```
#include <locale.h>

char *setlocale (int class, const char *loc);
```

Description

`setlocale()` changes the program's locale – either all or just part of it, depending on `class`. The new locale is given by the character string `loc`. The classes allowed are given by the table below.

Class	Changes the locale...
LC_ALL	for all classes.
LC_COLLATE	for the functions strcoll and strxfrm .
LC_MONETARY	for monetary formatting.
LC_NUMERIC	for numeric formatting.
LC_TIME	for function strftime .
LC_TYPE	for character handling and multi-byte character functions.

HI-CROSS supports only the minimum locale “C” (see [locale.h](#)), so this function has no effect.

Return

”C”, if `loc` is “C” or NULL; NULL otherwise.

See also

[localeconv](#), [strcoll](#), [strftime](#), [strxfrm](#)

setvbuf

File I/O



Syntax

```
#include <stdio.h>

void setvbuf (FILE *f,
             char *buf,
             int mode,
             size_t size);
```

Description

`setvbuf()` lets you specify how a file is buffered. `mode` determines how the file is buffered

Mode	Buffering
<code>_IOFBF</code>	Fully buffered
<code>_IOLBF</code>	Line buffered
<code>_IONBF</code>	Unbuffered

To make a file unbuffered, call `setvbuf` with mode `_IONBF`; the other arguments (`buf` and `size`) are ignored.

In all other modes, the file uses buffer `buf` of size `size`. If `buf` is `NULL`, the function allocates a buffer of size `size` itself.

See also

[fflush](#), [setbuf](#)

signal

Syntax

```
#include <signal.h>

_sig_func signal (int sig, _sig_func handler);
```

Description

`signal()` defines how your application shall respond to signal `sig`. The various responses are given by the table below.

Handler	Response to the signal
<code>SIG_IGN</code>	The signal is ignored.
<code>SIG_DFL</code>	The default response (HALT).
a function	The function is called with <code>sig</code> as parameter.

The signal handling function is defined as

```
typedef void (*_sig_func) (int sig);
```

The signal can be raised using function [raise](#). Before the handler is called, the response is reset to `SIG_DFL`.

In HI-CROSS, there are only two signals: `SIGABRT` indicates an abnormal program termination, and `SIGTERM` a normal program termination.

Return

If signal succeeds, it returns the previous response for the signal, otherwise it returns `SIG_ERR` and sets `errno` to a positive non-zero value.

See also

[raise](#)

sin, sinf

Syntax

```
#include <math.h>

double sin (double x);
float  sinf (float x);
```

Description

`sin()` computes the sine of `x`.

Return

The sine $\sin(x)$ of x in radians.

See also

[asin](#), [asinf](#), [acos](#), [acosf](#), [atan](#), [atanf](#), [atan2](#), [atan2f](#), [cos](#), [cosf](#),
[tan](#), [tanf](#)

sinh, sinh

Syntax

```
#include <math.h>
double sinh (double x);
float  sinhf (float x);
```

Description

`sinh()` computes the hyperbolic sine of x .

Return

The hyperbolic sine $\sinh(x)$ of x . If it fails because the value is too large, it returns infinity with the same sign as x and set `errno` to `ERANGE`.

See also

[asin](#), [asinf](#), [cosh](#), [coshf](#), [sin](#), [sinf](#), [tan](#), [tanf](#)

sprintf

Syntax

```
#include <stdio.h>
int sprintf (char *s, const char *format, ...);
```

Description

`printf()` writes formatted output to string `s`. It evaluates the arguments, converts them according to `format` and writes the result to `s`, terminated with a zero character.

The format string contains the text to be printed. Any character sequence in format starting with '%' is a format specifier that are replaced by the corresponding argument. The first format specifier is replace with the first argument after format, the second format specifier by the second argument, and so on.

A format specifier has the form

```
FormatSpec      = "%" {Format} [Width] [Precision]  
                  [Length] Conversion.
```

```
Format          = "-" | "+" | " " | "#" | "0".
```

The format defines justification and sign information (the latter only for numerical arguments). A "-" left justifies the output, a "+" forces output of the sign, and a blank output a blank if the number is positive and a "-" if it's negative. The effect of "#" depends on the conversion character following.

Conversion	Effect of "#"
<code>e, E, f</code>	The value of the argument always is printed with decimal point, even if there are no fractional digits.
<code>g, G</code>	As above, but additionally zeroes are appended to the fraction until the specified width is reached.
<code>o</code>	A zero is printed before the number to indicate an octal value.
<code>x, X</code>	"0x" (if the conversion is "x") or "0X" (if it is "X") is printed before the number to indicate a hexadecimal value.
others	undefined.

A "0" as format specifier adds leading zeroes to the number until the desired width is reached, if the conversion character specifies a numerical argument.

If both " " and "+" are given, only "+" is active; if both "0" and "-" are specified, only "-" is active. If there's a precision specification for integral conversions, "0" is ignored.

```
Width          = "*" | Number.
```

The width defines the minimum field width into which the output is to be put. If the argument is smaller, space is filled as defined by the format characters.

If a "*" is given, the field width is taken from the next argument, which of course must be a number. If that number is negative, output is left justified.

Precision = "." [Number | "*"].

The effect of the precision specification depends on the conversion character.

Conversion	Precision
d, i, o, u, x, X	The minimum number of digits to print.
e, E, f	The number of fractional digits to print.
g, G	The maximum number of significant digits to print.
s	The maximum number of characters to print.
others	undefined.

If the precision specifier is "*", the precision is taken from the next argument, which must be an int. If that value is negative, the precision is ignored.

Length = "h" | "l" | "L".

A length specifier tells `printf`, what type the argument has. The first two length specifiers can be used in connection with all conversion characters for integral numbers. "h" defines `short`, "l" defines `long`. Specifier "L" is used in conjunction with the conversion characters for floating point numbers and specifies `long double`.

Conversion = "c" | "d" | "e" | "E" | "f" | "g" |
 "G" | "i" | "n" | "o" | "p" | "s" |
 "u" | "x" | "X" | "%"

These conversion characters have the following meanings:

Conversion	Description
c	The <code>int</code> argument is converted to <code>unsigned char</code> , the resulting character is printed.
d, i	An <code>int</code> argument is printed.
e, E	The argument must be a <code>double</code> . It is printed in the form <code>[-]d.ddde±dd</code> (scientific notation). The precision determines the number of fractional digits, the digit to the left of the decimal is ! 0 unless the argument is 0.0. Default precision is 6 digits. If precision is zero and the format specifier "#" is not given, no decimal point is printed. The exponent always has at least 2 digits; the conversion character is printed just before the exponent.

Conversion	Description
f	The argument must be a <code>double</code> . It's printed in the form <code>[-]ddd.ddd</code> . See above. If the decimal point is printed, there's at least one digit left of it.
g, G	The argument must be a <code>double</code> . <code>sprintf</code> chooses either format "f" or "e" (or "E" if "G" is given), depending on the magnitude of the value: scientific notation is used only, if the exponent is <-4 or greater or equal to the precision.
n	The argument must be a pointer to an <code>int</code> . <code>sprintf</code> writes the number of characters written so far to that address. If "n" is used together with length specifier "h" or "l", the argument must be a pointer to a <code>short int</code> or a <code>long int</code> .
o	The argument, which must be an <code>unsigned int</code> , is printed in octal notation.
p	The argument must be a pointer; its value is printed in hexadecimal notation.
s	The argument must be a <code>char *</code> ; <code>sprintf</code> writes the string.
u	The argument, which must be an <code>unsigned int</code> , is written in decimal notation.
x, X	The argument, which must be an <code>unsigned int</code> , is written in hexadecimal notation. "x" uses lower case letters "a" to "f", while "X" uses upper case letters.
%	Prints a "%" sign. Should only be given as "%%".

Conversion characters for integral types are "d", "i", "o", "u", "x", "X"; for floating point types "e", "E", "f", "g", "G".

If `sprintf` finds an incorrect format specification, it stops processing, terminates the string with a zero character and returns successfully.

Return

The number of characters written to `s`.

See also

[sscanf](#)

sqrt, sqrtf

Syntax

```
#include <math.h>
double sqrt (double x);
float  sqrtf (float x);
```

Description

`sqrt()` computes the square root of `x`.

Return

The square root of `x`. If `x` is negative, it returns 0 and set `errno` to `EDOM`.

See also

[pow](#)

srand

Syntax

```
#include <stdlib.h>
void srand (unsigned int seed);
```

Description

`srand()` initializes the seed of the random number generator. The default seed is 1.

See also

[rand](#)

sscanf

Syntax

```
#include <stdio.h>

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

Description

`sscanf()` scans string `s` according to the given format, storing the values in the parameters given. Format specifiers in `format` tell `sscanf`, what to expect next. A format specifier has the format

FormatSpec = "%" [Flag] [Width] [Size] Conversion.

Flag = "*"

If the "%" sign which starts a format specification is followed by a "*", the scanned value is not assigned to the corresponding parameter.

Width = Number.

Specifies the maximum number of characters to read when scanning the value. Scanning also stops if a white space or a character not matching the expected syntax is reached.

Size = "h" | "l" | "L"

Specifies the size of the argument to read. The meaning is given in the table below:

Size	Legal Conversions	Parameter Type
h	d, i, n	short int * (instead of int *)
h	o, u, x, X	unsigned short int * (instead of unsigned int *)
l	d, i, n	long int * (instead of int *)
l	o, u, x, X	unsigned long int * (instead of unsigned int *)
l	e, E, f, g, G	double * (instead of float *)
L	e, E, f, g, G	long double * (instead of float *)

```
Conversion      = "c" | "d" | "e" | "E" | "f" | "g" |
                  "G" | "i" | "n" | "o" | "p" | "s" |
                  "u" | "x" | "X" | "%" | Range.
```

These conversion characters tell `sscanf` what to read and how to store it in a parameter. Their meaning is shown in this table:

Conversion	Description
c	Read a string of exactly <code>width</code> characters and stores it in the parameter. If no width is given, one character is read. The argument must be a <code>char *</code> . The string read is <i>not</i> zero-terminated.
d	A decimal number (syntax below) is read and stored in the parameter. The parameter must be a pointer to an integral type.
i	As "d", but also reads octal and hexadecimal numbers (syntax below).
e, E, f, g, G	Reads a floating point number (syntax below). The parameter must be a pointer to a floating point type.
n	The argument must be a pointer to an <code>int</code> . <code>sscanf</code> writes the number of characters read so far to that address. If "n" is used together with length specifier "h" or "l", the argument must be a pointer to a <code>short int</code> or a <code>long int</code> .
o	Reads an octal number (syntax below). The parameter must be a pointer to an integral type.
p	Reads a pointer in the same format as sprintf prints it. The parameter must be a <code>void **</code> .
s	Reads a character string up to the next white space character or at most <code>width</code> characters. The string is zero-terminated. The argument must be of type <code>char *</code> .
u	As "d", but the parameter must be a pointer to an unsigned integral type.
x, X	As "u", but reads a hexadecimal number.
%	Skips a "%" sign in the input. Should only be given as "%%".

```
Range           = "[" [ "^" ] List "]"
List            = Element {Element}
Element        = <any char> ["-" <any char>]
```

You can also use a scan set to read a character string that either contains only the given characters, or that contains only characters not in the set. A scan set always is bracketed by left and right brackets, if the first character in the set is "^", the

set is inverted (i.e. only characters *not* in the set are allowed). You can specify whole character ranges, e.g. "A-Z" specifies all upper case letters. If you want to include a right bracket in the scan set, it must be the first element in the list, a dash ("-") must be either the first or the last element. A "^" that shall be included in the list instead of indicating an inverted list must not be the first character after the left bracket. Some examples are :

```
[A-Za-z] Allows all upper and lower case characters.  
[^A-Z]   Allows any character that's not an  
         upper case character.  
[]abc]   Allows "]" , "a" , "b" and "c".  
[^]abc]  Allows any char except "]" , "a" , "b" and "c".  
[-abc]   Allows "-" , "a" , "b" and "c".
```

A white space in the format string skips all white space characters up to the next non-white-space character. Any other character in the format must be exactly matched by the input, otherwise `sscanf` stops scanning.

The syntax for numbers as scanned by `sscanf` is the following:

```
Number      = FloatNumber | IntNumber.  
IntNumber   = DecNumber | OctNumber | HexNumber.  
DecNumber   = Sign Digit {Digit}.  
OctNumber   = Sign "0" {OctDigit}.  
HexNumber   = "0" ("x"|"X") HexDigit {HexDigit}.  
FloatNumber = Sign {Digit} [ "." {Digit} ] [Exponent].  
Exponent    = ("e"|"E") DecNumber.  
OctDigit    = "0"|"1"|"2"|"3"|"4"|"5"|"6"|"7".  
Digit       = OctDigit | "8"|"9".  
HexDigit    = Digit | "A"|"B"|"C"|"D"|"E"|"F" |  
             "a"|"b"|"c"|"d"|"e"|"f"
```

Return

EOF, if `s` is NULL; otherwise it returns the number of arguments filled in.

NOTE If `sscanf` finds an illegal input (i.e. not matching the required syntax), it simply stops scanning and returns successfully!

See also

[sprintf](#)

strcat

Syntax

```
#include <string.h>
char *strcat (char *p, const char *q);
```

Description

`strcat()` appends string `q` to the end of string `p`. Both strings and the resulting concatenation are zero-terminated.

Return

`p`

See also

[memcpy](#), [memmove](#), [strcpy](#), [strncat](#), [strncpy](#)

strchr

Syntax

```
#include <string.h>
char *strchr (const char *p, int ch);
```

Description

`strchr()` looks for character `ch` in string `p`. If `ch` is `'\0'`, the function looks for the end of the string.

Return

A pointer to the character, if found; if there's no such character in `*p`, `NULL` is returned.

See also

[memchr](#), [strrchr](#), [strstr](#)

strcmp

Syntax

```
#include <string.h>
int strcmp (const char *p, const char *q);
```

Description

`strcmp()` compares the two strings, using the character ordering given by the ASCII character set.

Return

A negative integer, if `p` is smaller than `q`; zero, if both strings are equal, and a positive integer if `p` is greater than `q`.

NOTE The return values of `strcmp` are such that it could be used as comparison function in [bsearch](#) and [qsort](#).

See also

[memcmp](#), [strcoll](#), [strncmp](#)

strcoll

Syntax

```
#include <string.h>
int strcoll (const char *p, const char *q);
```

Description

`strcoll()` compares the two strings interpreting them according to the current locale, using the character ordering given by the ASCII character set.

Return

A negative integer, if *p* is smaller than *q*; zero, if both strings are equal, and a positive integer if *p* is greater than *q*.

See also

[memcmp](#), [strcmp](#), [strncmp](#)

strcpy

Syntax

```
#include <string.h>
char *strcpy (char *p, const char *q);
```

Description

`strcpy()` copies string *q* into string *p* (including the terminating `'\0'`).

Return

p

See also

[memcpy](#), [memmove](#), [strncpy](#)

strcspn

Syntax

```
#include <string.h>
size_t strcspn (const char *p, const char *q);
```

Description

`strcspn()` searches *p* for the first character that also appears in *q*.

Return

The length of the initial segment of `p` that contains only characters *not* in `q`.

See also

[strchr](#), [strpbrk](#), [strrchr](#), [strspn](#)

strerror

Syntax

```
#include <string.h>
char *strerror (int errno);
```

Description

`strerror()` returns an error message appropriate for error number `errno`.

Return

A pointer to the message string.

See also

[perror](#)

strftime

Syntax

```
#include <time.h>
size_t strftime (char *s,
                size_t max,
                const char *format,
                const struct tm *time);
```


Description

`strftime()` converts `time` to a character string `s`. If the conversion results in a string longer than `max` characters (including the terminating `'\0'`), `s` is left unchanged and the function returns unsuccessfully. How the conversion is done is determined by the `format` string. This string contains text, which is copied one-to-one to `s`, and format specifiers. The latter always start with a `'%'` sign and are replaced by the following:

Format	Replaced with
<code>%a</code>	Abbreviated name of the weekday of the current locale, e.g. "Fri".
<code>%A</code>	Full name of the weekday of the current locale, e.g. "Friday".
<code>%b</code>	Abbreviated name of the month of the current locale, e.g. "Feb".
<code>%B</code>	Full name of the month of the current locale, e.g. "February".
<code>%c</code>	Date and time in the form given by the current locale.
<code>%d</code>	Day of the month in the range from 0 to 31.
<code>%H</code>	Hour, in 24-hour-clock format.
<code>%I</code>	Hour, in 12-hour-clock format.
<code>%j</code>	Day of the year, in the range from 0 to 366.
<code>%m</code>	Month, as a decimal number from 0 to 12.
<code>%M</code>	Minutes
<code>%p</code>	AM/PM specification of a 12-hour clock or equivalent of current locale.
<code>%S</code>	Seconds
<code>%U</code>	Week number in the range from 0 to 53, with Sunday as the first day of the first week.
<code>%w</code>	Day of the week (Sunday = 0, Saturday = 6).
<code>%W</code>	Week number in the range from 0 to 53, with Monday as the first day of the first week.
<code>%x</code>	The date in format given by current locale.
<code>%X</code>	The time in format given by current locale.
<code>%y</code>	The year in short format, e.g. "93".
<code>%Y</code>	The year, including the century (e.g. "1993").

Format	Replaced with
%Z	The time zone, if it can be determined.
%%	A single '%' sign.

Return

If the resulting string would have had more than `max` characters, zero is returned, otherwise the length of the created string is returned.

See also

[mktime](#), [setlocale](#), [time](#)

strlen

Syntax

```
#include <string.h>
size_t strlen (const char *s);
```

Description

`strlen()` returns the number of characters in string `s`.

Return

The length of the string.

strncat

Syntax

```
#include <string.h>
char *strncat (char *p, const char *q, size_t n);
```

Description

`strncat()` appends string `q` to string `p`. If `q` contains more than `n` characters, only the first `n` characters of `q` are appended to `p`. The two strings and the result all are zero-terminated.

Return

`p`

See also

[strcat](#)

strncmp

Syntax

```
#include <string.h>
char *strncmp (char *p, const char *q, size_t n);
```

Description

`strncmp()` compares at most the first `n` characters of the two strings.

Return

A negative integer, if `p` is smaller than `q`; zero, if both strings are equal, and a positive integer if `p` is greater than `q`.

See also

[memcmp](#), [strcmp](#)

strncpy

Syntax

```
#include <string.h>
char *strncpy (char *p, const char *q, size_t n);
```

Description

`strncpy()` copies at most the first `n` characters of string `q` to string `p`, overwriting `p`'s previous contents. If `q` contains less than `n` characters, a `'\0'` is appended.

Return

`p`

See also

[memcpy](#), [strcpy](#)

strpbrk

Syntax

```
#include <string.h>
char *strpbrk (const char *p, const char *q);
```

Description

`strpbrk()` searches for the first character in `p` that also appears in `q`.

Return

NULL, if there's no such character in `p`; a pointer to the character otherwise.

See also

[strchr](#), [strcspn](#), [strrchr](#), [strspn](#)

strrchr

Syntax

```
#include <string.h>
char *strrchr (const char *s, int c);
```

Description

`strpbrk()` searches for the last occurrence of character `ch` in `s`.

Return

NULL, if there's no such character in `p`; a pointer to the character otherwise.

See also

[strchr](#), [strcspn](#), [strpbrk](#), [strspn](#)

strspn

Syntax

```
#include <string.h>
size_t strspn (const char *p, const char *q);
```

Description

`strspn()` returns the length of the initial part of `p` that contains only characters also appearing in `q`.

Return

The position of the first character in `p` that's not in `q`.

See also

[strchr](#), [strcspn](#), [strpbrk](#), [strrchr](#)

strstr

Syntax

```
#include <string.h>
char *strstr (const char *p, const char *q);
```

Description

`strstr()` looks for substring `q` appearing in string `p`.

Return

A pointer to the beginning of the first occurrence of string `q` in `p`, or `NULL`, if `q` doesn't appear in `p`.

See also

[strchr](#), [strcspn](#), [strpbrk](#), [strrchr](#), [strspn](#)

strtod

Syntax

```
#include <stdlib.h>
double strtod (const char *s, char **end);
```

Description

`strtod()` converts string `s` into a floating point number, skipping over any white space at the beginning of `s`. It stops scanning when it reaches a character not matching the required syntax and returns a pointer to that character in `*end`. The number format `strtod` accepts is

```
FloatNum   = Sign {Digit} [ "." {Digit} ] [Exp].
Sign       = [ "+" | "-" ].
Exp        = ( "e" | "E" ) Sign Digit {Digit}.
Digit      = <any decimal digit from 0 to 9>.
```

Return

The floating point number read. If an underflow occurred, `0.0` is returned, if the value causes an overflow, `HUGE_VAL` is returned. In both cases, `errno` is set to `ERANGE`.

See also

[atof](#), [sscanf](#), [strtol](#), [strtoul](#)

strtok

Syntax

```
#include <string.h>
char *strtok (char *p, const char *q);
```

Description

`strtok()` breaks string `p` into tokens which are separated by at least one character appearing in `q`. The first time, call `strtok` with the string to break up as first parameter, all following times, pass `NULL` as first parameter: `strtok` will continue at the position it stopped last time (`strtok` saves the string `p` if it isn't `NULL`).

NOTE This function is not re-entrant, because it uses a global variable for saving string `p`. ANSI defines this function in this way.

Return

A pointer to the token found, or `NULL`, if no token was found.

See also

[strchr](#), [strcspn](#), [strpbrk](#), [strrchr](#), [strspn](#), [strstr](#)

strtol

Syntax

```
#include <stdlib.h>
long strtol (const char *s, char **end, int base);
```

Description

`strtol()` converts string `s` into a long int of base `base`, skipping over any white space at the beginning of `s`. It stops scanning when it reaches a character not matching the required syntax (or a character too large for a given base) and

returns a pointer to that character in *end. The number format strtol accepts is

```
IntNumber      = DecNumber | OctNumber |
                HexNumber | OtherNum.
DecNumber      = Sign Digit {Digit}.
OctNumber      = Sign "0" {OctDigit}.
HexNumber      = "0" ("x"|"X") HexDigit {HexDigit}.
OtherNum       = Sign OtherDigit {OtherDigit}.
OctDigit       = "0"|"1"|"2"|"3"|"4"|"5"|"6"|"7".
Digit          = OctDigit |"8"|"9".
HexDigit       = Digit |"A"|"B"|"C"|"D"|"E"|"F" |
                "a"|"b"|"c"|"d"|"e"|"f".
OtherDigit     = HexDigit |
                <any char between 'G' and 'Z'> |
                <any char between 'g' and 'z'>.
```

The base must be 0 or in the range from 2 to 36. If it's between 2 and 36, strtol converts a number in that base (digits larger than 9 are represented by upper or lower case characters from 'A' to 'Z'). If base is zero, the function uses the prefix to find the base. If the prefix is "0", base 8 (octal) is assumed, if it's "0x" or "0X", base 16 (hexadecimal) is taken; any other prefixes make strtol scan a decimal number.

Return

The number read. If no number is found, zero is returned; if the value is smaller than LONG_MIN or larger than LONG_MAX, LONG_MIN or LONG_MAX is returned and errno is set to ERANGE.

See also

[atoi](#), [atol](#), [sscanf](#), [strtod](#), [strtoul](#)

strtoul

Syntax

```
#include <stdlib.h>

unsigned long strtoul (const char *s,
                     char **end,
                     int base);
```


Description

`strtoul()` converts string `s` into an unsigned long int of base `base`, skipping over any white space at the beginning of `s`. It stops scanning when it reaches a character not matching the required syntax (or a character too large for a given base) and returns a pointer to that character in `*end`. The number format `strtoul` accepts is the same as for [strtoul](#) except that the negative sign is not allowed, and so are the possible values for `base`.

Return

The number read. If no number is found, zero is returned; if the value is larger than `ULONG_MAX`, `ULONG_MAX` is returned and `errno` is set to `ERANGE`.

See also

[atoi](#), [atol](#), [sscanf](#), [strtod](#), [strtoul](#)

strxfrm

Syntax

```
#include <string.h>

size_t strxfrm (char *p, const char *q, size_t n);
```

Description

`strxfrm()` transforms string `q` according to the current locale, such that the comparison of two strings converted with `strxfrm` using [strcmp](#) yields the same result as a comparison using [strcoll](#). If the resulting string would be longer than `n` characters, `p` is left unchanged.

Return

The length of the converted string.

See also

[setlocale](#), [strcmp](#), [strcoll](#)

system

Hardware
specific



Syntax

```
#include <string.h>
int system (const char *cmd);
```

Description

`system()` executes the command line `cmd`.

Return

Zero.

tan, tanf

Syntax

```
#include <math.h>
double tan (double x);
float tanf (float x);
```

Description

`tan()` computes the tangent of `x`. `x` should be in radians.

Return

`tan(x)`. If `x` is an odd multiple of $\pi/2$, it returns infinity and sets `errno` to `EDOM`.

See also

[acos](#), [acosf](#), [asin](#), [asinf](#), [atan](#), [atanf](#), [atan2](#), [atan2f](#), [cos](#), [cosf](#),
[sin](#), [sinf](#), [tanh](#), [tanhf](#)

tanh, tanhf

Syntax

```
#include <math.h>
double tanh (double x);
float tanhf (float x);
```

Description

`tanh()` computes the hyperbolic tangent of `x`.

Return

`tanh(x)`.

See also

[atan](#), [atanf](#), [atan2](#), [atan2f](#), [cosh](#), [coshf](#), [sinh](#), [sinhf](#), [tan](#), [tanf](#)

time

*Hardware
specific*



Syntax

```
#include <time.h>
time_t time (time_t *timer);
```

Description

`time()` gets the current calendar time. If `timer` is not `NULL`, it is assigned to it.

Return

The current calendar time.

See also

[clock](#), [mktime](#), [strftime](#)

tmpfile

File I/O



Syntax

```
#include <stdio.h>
FILE *tmpfile (void);
```

Description

`tmpfile()` creates a new temporary file using mode "wb+". Temporary files automatically are deleted when they're closed or the application ends.

Return

A pointer to the file descriptor, if the file could be created, NULL otherwise.

See also

[fopen](#), [tmpnam](#)

tmpnam

File I/O



Syntax

```
#include <stdio.h>
char *tmpnam (char *s);
```

Description

`tmpnam()` creates a new unique file name. If `s` is not NULL, this name is assigned to it.

Return

A unique file name.

See also

[tmpfile](#)

tolower

Syntax

```
#include <ctype.h>
int tolower (int ch);
```

Description

`tolower()` converts any upper case character in the range from 'A' to 'Z' into a lower case character from 'a' to 'z'.

Return

If `ch` is an upper case character, the corresponding lower case letter. Otherwise, `ch` is returned (unchanged).

See also

[islower](#), [isupper](#), [toupper](#)

toupper

Syntax

```
#include <ctype.h>
int toupper (int ch);
```

Description

`toupper()` converts any lower case character in the range from 'a' to 'z' into an upper case character from 'A' to 'Z'.

Return

If `ch` is a lower case character, the corresponding upper case letter. Otherwise, `ch` is returned (unchanged).

See also

[islower](#), [isupper](#), [tolower](#)

ungetc

File I/O



Syntax

```
#include <stdio.h>
int ungetc (int ch, FILE *f);
```

Description

`ungetc()` pushes the single character `ch` back onto the input stream `f`. The next read from `f` will read that character.

Return

`ch`

See also

[fgetc](#), [fopen](#), [getc](#), [getchar](#)

va_arg, va_end, va_start

Syntax

```
#include <stdarg.h>
void va_start (va_list args, param);
type va_arg (va_list args, type);
void va_end (va_list args);
```

Description

These macros can be used to get the parameters in an open parameter list. Calls to `va_arg` get a parameter of the given type. The following example shows how to do it:

```
void my_func (char *s, ...) {
    va_list args;
    int     i;
    char    *q;
```

```
va_start (args, s);  
/* First call to 'va_arg' gets the first arg. */  
i = va_arg (args, int);  
/* Second call gets the second argument. */  
q = va_arg (args, char *);  
...  
va_end (args);  
}
```

vfprintf, vprintf, vsprintf

File I/O



Syntax

```
#include <stdio.h>  
  
int vfprintf (FILE *f,  
             const char *format,  
             va_list args);  
  
int vprintf (const char *format, va_list args);  
  
int vsprintf (char *s,  
             const char *format,  
             va_list args);
```

Description

These functions are the same as [fprintf](#), [printf](#) and [sprintf](#), except that they take a `va_list` instead of an open parameter list as argument.

NOTE	Only <code>vsprintf</code> is implemented, since the other two functions depend on the actual setup and environment of your target.
-------------	---

Return

The number of characters written, if successful; a negative number otherwise.

See also

[fprintf](#), [printf](#), [sprintf](#), [va_arg](#), [va_end](#), [va_start](#)

wctomb

Hardware
specific



Syntax

```
#include <stdlib.h>
int wctomb (char *s, wchar_t wchar);
```

Description

`wctomb()` converts `wchar` to a multi-byte character, stores that character in `s` and returns the length in bytes of `s`.

Return

The length of `s` in bytes after the conversion.

See also

[wcstombs](#)

wcstombs

Hardware
specific



Syntax

```
#include <stdlib.h>
int wcstombs (char *s, const wchar_t *ws, size_t n);
```

Description

`wcstombs()` converts the first `n` wide character codes in `ws` to multi-byte characters, stores them character in `s` and returns the number of wide characters converted.

Return

The number of wide characters converted.

See also

[wctomb](#)

compactC++ Library

C++

Introduction

This chapter describes how to use the cC++ library provided with the compiler.

The library is a subset of the ANSI-C++ standard C++ library draft. It is based on the public domain GNU C++ library (Copyright by GNU).

The STL library is the Hewlett Packard public-domain implementation (Copyright by HP).

So all sources of the library are provided with your compiler.

This chapter is only a short introduction into the C++ library. For further informations please refer to the book "The Draft Standard C++ library" by P.J.Plauger (Prentice Hall, 1995)

Implementation

The cC++ library consists of following source files:

- `random.cpp`
- `tempbuf.cpp`
- `streamb.h, streamb.cpp`
- `iostream.h, iostream.cpp`
- `cstring.h, cstring.cpp`
- `new.h, new.cpp`
- `stderr.cpp`
- `builtin.cpp`
- `regex.cpp`
- `stdstr.cpp`

- `stdstrb.cpp`
- `error.cpp`
- `complex.h, complext.cpp`
- `bitset.h, bitset.cpp`
- `bitstr.cpp`
- `strstrea.h, strstrea.cpp`
- `iopadn.c`
- `iofflush.c`
- `genops.c`
- `bitand.c`
- `bitany.c`
- `bitblt.c`
- `bitclear.c`
- `bitcopy.c`
- `bitcount.c`
- `bitinv.c`
- `bitlcomp.c`
- `bitset1.c`
- `bitxor.c`
- `strops.c`
- `stdiostr.h, stl.h, algo.h, deque.h, function.h, iterator.h, list.h, map.h, memory.h, pair.h, set.h, stack.h, vector.h`

If you write C++ programs needing the C++ library, you have to specify the name of the library built with the desired memory model and options in the “NAMES” section of the link parameter file (`*.prm`) of your project.

I/O Library

Description

This library component makes input and output look simple. It mainly consists of 4 objects:

- `cin`
To control unbuffered standard input stream (as does `stdin` of the ANSI-C library)
- `cout`
To control unbuffered standard output stream (as does `stdout` of the ANSI-C library)
- `cerr`
To control unbuffered standard error stream (as does `stderr` of the ANSI-C library)
- `clog`
To control buffered standard error stream (as does `stderr` of the ANSI-C library)

These objects offer an easy way to perform input and output in a C++ program.

Headers

`iostream.h`

`streamb.h`

`stdiostr.h`

String Library

Description

This library component manages the handling of strings. While the ANSI-C library contains almost nothing to handle strings (see `string.h`), the C++ library provides a class `String` containing many operations on null-terminated sequences (strings), e.g. storage is allocated and freed as necessary by the member functions of the class `String`.

Headers

`cstring.h`

Classes

CString

Example

```
#include "cstring.h"

void main() {
    String s = "Mystring";
    s=s+": Hi!";
    printf(s); // prints out "Mystring: Hi!"
    if(s!="Mystring: Hi!") {
        // an error occurred !
    }
}
```

Memory Library

Description

This library contains the implementation of the operators “new” and “delete”. Those operators are needed to allocate and free memory.

Headers

new.h

Classes

None

Example

```
#include "new.h"

void main() {
    int *p = new int; // calls operator new defined in the
    library
    delete p;
}
```

Complex Library

Description

This library encapsulates complex arithmetic, such as addition, subtraction, multiplication, division, negation and much more. It defines 3 classes, one for each of the three floating-point types of Standard C (float, double, long double).

Headers

complex.h

Classes

float_complex

double_complex

long_double_complex

Example

```
#include "complex.h"
void main() {
    float_complex fc(1,2);
    if(fc.real()!=1) { /* ... error ... */ }
    if(fc.imag()!=2) { /* ... error ... */ }
    float_complex fc2;
    fc2=fc;
}
```

Bitset Library

Description

This library deals with bit arrays. This is useful for working with flags.

Headers

bitset.h

Classes

BitSet

Example

[Listing 4.1](#) shows code that uses the BitSet class.

Listing 4.1

```
#include <bitset.h>

void main() {
    BitSet bs, bs2;
    bs.set(4);
    bs2.set(3);
    bs=bs|bs2;
    if(bs.test(1)!=0) {
        /* Error occurred */
    }
}
```

```
}
if(bs.test(2)!=0) {
    /* Error occurred */
}
if(bs.test(3)==0) {
    /* Error occurred */
}
if(bs.test(4)==0) {
    /* Error occurred */
}
if(bs.test(5)!=0) {
    /* Error occurred */
}
}
```

Strstream Library

Description

This library adapts the mechanism of streams to strings. Instead of having I/O channels, string streams work on a data buffer.

Headers

strstrea.h

Classes

ostrstream

istrstream

strstream

Example: #include <strstrea.h>

```
void main(void) {
    ostrstream os;
    os << "Hello" << endl;
}
```

Porting Tips and FAQs

This appendix describes some FAQ's, and provides tips on how to port your application from a different tool vendor or the syntax of EBNF.

Migration Hints

This section describes the differences between this compiler and the compilers of other vendors. It also provides information about porting sources and how to adapt them.

Allocation of Bit Fields

Allocation of bitfields is very compiler-dependent. Some compilers allocate the bits first from right (LSByte) to left (MSByte), and others allocate from left to right. Also, alignment and byte/word crossing of bitfields is not implemented consistently. You may:

- Check the different allocation strategies.
- Check if there is an option to change the allocation strategy in the compiler.
- Use the compiler defines to hold sources portable:

```
__BITFIELD_LSBIT_FIRST__  
__BITFIELD_MSBIT_FIRST__  
__BITFIELD_LSBYTE_FIRST__  
__BITFIELD_MSBYTE_FIRST__  
__BITFIELD_LSWORD_FIRST__  
__BITFIELD_MSWORD_FIRST__  
__BITFIELD_TYPE_SIZE_REDUCTION__  
__BITFIELD_NO_TYPE_SIZE_REDUCTION__
```

Type Sizes, Sign of Character

Carefully check the type sizes of the compilers. Some compilers implement the sizes for the standard types (char, short, int, long, float, double) in different ways, e.g. int is for some compilers 16bit and for other ones 32bit.

If necessary change the default type settings with the `-l` option.

The sign of plain char is also not consistent over different Compilers. If the software relies that char is signed or unsigned, either change all plain char types to the signed or unsigned ones or change the sign of char with the `-T` option.

@bool Qualifier

Some compiler vendors are providing special keyword `@bool` to specify that a function returns a boolean value:

```
@bool int foo(void);
```

Because this is not supported, you have to remove this `@bool` or to use a define like this:

```
#define _BOOL /*@bool*/  
_BOOL int foo(void);
```

@tiny/@far Qualifier for Variables

Some compiler vendors are providing special keywords to place variables to absolute locations. Such absolute locations can be expressed in ANSI-C as constant pointers:

```
#ifdef __HIWARE__  
#define REG_PTB (*(volatile char*)(0x01))  
#else /* other compiler vendors using non-ANSI features */  
@tiny volatile char REG_PTB @0x01; /* port B */  
#endif
```

The compiler does not need the `@tiny` qualifier directly, the compiler is smart enough to take the right addressing mode depending on the address:

```
/* compiler uses the correct addressing mode */  
volatile char REG_PTB @0x01;
```

Arrays with Unknown Size

Some compilers accept following not-ANSI compliant statement to declare an array with unknown size:

```
extern char buf[0];
```

However, the compiler will issue an error message for this because an object with size zero (even if declared as extern) is illegal. Use the legal versions

```
extern char buf[];
```

Missing Prototype

Many compilers are accepting a function call usage without a prototype. This compiler will issue a warning for this. However if the prototype of a function with open arguments is missing and this function is called with different arguments numbers, this is clearly an error:

```
printf("hello world!"); // compiler assumes `void
printf(char*)'

// error, argument number mismatch!
printf("hello %s!", "world");
```

To avoid such programming bugs use the compiler option [-Wpd](#) and always include/ provide a prototype.

`_asm("sequence")`

Some compilers are using `_asm("string")` to write inline assembly in normal C source: `_asm("nop");`

This can be rewritten with `asm` or `asm {}`: `asm nop;`

Recursive Comments

Some compilers accept recursive comments without any warnings. This compiler will issue a warning for each such recursive comment:

```
/* this is a recursive comment */
    int a;
/* */
```

This compiler will treat the above source completely as one single comment, so the definition of ‘a’ is inside the comment, that is the compiler treats all between the first opening comment ‘/*’ until the closing comment token ‘*/’ as a comment. If there are such recursive comments, correct them.

Interrupt Function, @interrupt

Interrupt functions have to be marked with the #pragma TRAP_PROC or using the interrupt keyword (see Front End, Back End).

```
#ifdef __HIWARE__
    #pragma TRAP_PROC
    void MyTrapProc(void)
#else /* other compiler-vendor non-ANSI declaration of
interrupt
        function */
    @interrupt void MyTrapProc(void)
#endif
{
    /* code follows here */
}
```

Defining Interrupt Functions

This manual entry discusses some important topics related to the handling of interrupt functions:

- Definition of an interrupt function
- Initialization of the vector table
- Placing interrupt function in special sections

Defining an Interrupt Function

The compiler provides two ways to define an interrupt function:

- Using pragma TRAP_PROC.
- Using the keyword interrupt.

Using Pragma “TRAP_PROC”

The pragma TRAP_PROC indicates to the compiler that the following function is an interrupt function. In that case, the compiler should terminate the function by a special interrupt return sequence (for many processors a RTI instead of a RTS).

Example:

```
#pragma TRAP_PROC
void INCcount(void) {
    tcount++;
}
```

Using Keyword “interrupt”

The keyword ‘interrupt’ is not ANSI C standard and as thus is not supported by all ANSI C compiler vendor. In the same way, the syntax for the usage of this keyword may change between different compiler. The keyword interrupt indicates to the compiler that the following function is an interrupt function.

Example:

```
interrupt void INCcount(void) {
    tcount++;
}
```

Initializing the Vector Table

Once the code for an interrupt function has been written, you have to associate this function with an interrupt vector. This is done through initialization of the vector table. The vector table can be initialized in following ways:

- Using the command VECTOR or VECTOR ADDRESS in the PRM file
- Using the keyword “interrupt”.

Using the Linker Commands

The Linker provides two commands to initialize the vector table: VECTOR or VECTOR ADDRESS. The command VECTOR ADDRESS is used to write the address of a function at a specific address in the vector table.

Example:

In order to enter the address of the function INCcount at address 0x8A, insert following command in the application PRM file:

```
VECTOR ADDRESS 0x8A INCcount
```

The command VECTOR is used to associate a function with a specific vector, identified with its number. The mapping from the vector number is target specific.

Example:

In order to associate the address of the function INCcount with the vector number 69, insert following command in the application PRM file:

```
VECTOR ADDRESS 69 INCcount
```

Using the Keyword “interrupt”

When you are using the keyword “interrupt”, you may directly associate your interrupt function with a vector number in the ANSI C source file. In that purpose just specify the vector number next to the keyword interrupt.

Example:

In order to associate the address of the function INCcount with the vector number 69, define your function as follows:

```
interrupt 69 void INCcount(void) {
    int card1;
    tcount++;
}
```

Placing Interrupt Function in Special Sections

For all targets supporting paging, the interrupt function must be allocated in an area which is accessible all the time. This can be obtained by putting the interrupt function into a specific segment.

Defining Functions in a Specific Segment.

In order to define a function in a specific segment, you can use the pragma CODE_SEG.

Example:

```
/* These functions are defined in segment `int_Function'*/
#pragma CODE_SEG Int_Function
#pragma TRAP_PROC
void INCcount(void) {
    tcount++;
}
#pragma CODE_SEG DEFAULT /*Return to default code segment.*/
```


Placing a Specific Segment.

In the PRM file, you can define where you want to allocate each segments you have defined in your source code. In order to place a segment in a specific memory area; just add the segment name in the PLACEMENT block of your PRM file. Be careful, the linker is case sensitive. Take special attention to the upper and lower cases in your segment name.

Example:

```
LINK test.abs

NAMES test.o ... END

SECTIONS
    INTERRUPT_ROM = READ_ONLY      0x4000 TO 0x5FFF;
    MY_RAM        = READ_WRITE     ....

PLACEMENT
    Int_Function          INTO INTERRUPT_ROM;
    DEFAULT_RAM          INTO MY_RAM;
    ....
END
```

How to Use Variables in EEPROM

Placing variables into EEPROM is not explicitly supported in the C/C++ language, but because EEPROM is widely available in embedded processors, a development tools for Embedded Systems has to support it.

The examples are processor-specific. However, it is very easy to adapt them for any other processor.

Linker Parameter File

You have to define your RAM/ROM areas in your linker parameter file. However, you should declare the EEROM memory as NO_INIT to avoid the memory range being initialized during normal startup.

```
LINK test.abs

NAMES test.o startup.o ansi.lib END
SECTIONS
```

Porting Tips and FAQs

How to Use Variables in EEPROM

```
MY_RAM = READ_WRITE 0x800 TO 0x801;
MY_ROM = READ_ONLY  0x810 TO 0xAFF;
MY_STK = READ_WRITE 0xB00 TO 0xBFF;
EEPROM = NO_INIT    0xD00 TO 0xD01;
PLACEMENT
  DEFAULT_ROM INTO MY_ROM;
  DEFAULT_RAM INTO MY_RAM;
  SSTACK INTO MY_STK;
  EEPROM_DATA INTO EEPROM;
END
/* set reset vector to function _Startup defined in startup
code */
VECTOR ADDRESS 0xFFFFE _Startup
```

The Application

The example in [Listing A.1](#) shows an application example erasing or writing a EEPROM word. The example is specific to the processor used, but if you consult your technical documentation about the EEPROM used for your derivative or CPU, it is easy to adapt.

NOTE There are only a limited number of write operations guaranteed for EEPROMs, so avoid writing to a EEPROM cell to frequently.

Listing A.1 Erasing and Writing an EEPROM

```
/*
Definition of a variable in EEPROM.

The variable VAR is located in EEPROM.
- It is defined in a user defined segment EEPROM_DATA
- In the PRM file EEPROM_DATA is placed at address 0xD00.
Be careful, The EEPROM can only be written a limited number of time.
Running this application a long time may reach this limit and your
EEPROM may be unusable afterward.
*/
#include <hidef.h>
#include <stdio.h>
#include <math.h>
/* INIT register. */
typedef struct {
  union {
```

```
    struct {
        unsigned int    bit0:1;
        unsigned int    bit1:1;
        unsigned int    bit2:1;
        unsigned int    bit3:1;
        unsigned int    bit4:1;
        unsigned int    bit5:1;
        unsigned int    bit6:1;
        unsigned int    bit7:1;
    } INITEE_Bits;
    unsigned char INITEE_Byte;
} INITEE;
} INIT;
volatile INIT INITEE @0x0012;
#define EEON INITEE.INITEE.INITEE_Bits.bit0
/* EEPROM register. */
volatile struct {
    unsigned int    EEPROM:1;
    unsigned int    EELAT:1;
    unsigned int    ERASE:1;
    unsigned int    ROW:1;
    unsigned int    BYTE:1;
    unsigned int    dummy1:1;
    unsigned int    dummy2:1;
    unsigned int    BULKP:1;
} EEPROM @0x00F3;
/* EEPROM register. */
volatile struct {
    unsigned int    BPROT0:1;
    unsigned int    BPROT1:1;
    unsigned int    BPROT2:1;
    unsigned int    BPROT3:1;
    unsigned int    BPROT4:1;
    unsigned int    dummy1:1;
    unsigned int    dummy2:1;
    unsigned int    dummy3:1;
} EEPROM @0x00F1;
#pragma DATA_SEG EEPROM_DATA
unsigned int VAR;
#pragma DATA_SEG DEFAULT
void EraseEEPROM(void) {
    /* Function used to erase one word in the EEPROM. */
    unsigned long int i;
    EEPROM.BYTE =1;
    EEPROM.ERASE =1;
}
```

Porting Tips and FAQs

How to Use Variables in EEPROM

```
EEPROM.EELAT =1;
VAR = 0;
EEPROM.EEPGM =1;
for (i = 0; i<4000; i++) {
/* Wait until EEPROM is erased. */
}
EEPROM.EEPGM =0;
EEPROM.EELAT =0;
EEPROM.ERASE =0;
}

void WriteEEPROM(unsigned int val) {
/* Function used to write one word in the EEPROM. */
unsigned long int i;
EraseEEPROM();
EEPROM.ERASE =0;
EEPROM.EELAT =1;
VAR = val;
EEPROM.EEPGM =1;
for (i = 0; i<4000; i++) {
/* Wait until EEPROM is written. */
}
EEPROM.EEPGM =0;
EEPROM.EELAT =0;
}

void func1(void) {
unsigned int i;
unsigned long int ll;
i = 0;
do
{
i++;
WriteEEPROM(i);
for (ll = 0; ll<200000; ll++) {
}
}
while (1);
}

void main(void) {
EEPROM.BPROT4 = 0;
EEON=1;
```

```
WriteEEPROM(0);  
func1();  
}
```

General Optimization Hints

Here are some hints how to reduce your application size:

- Check if you need the full startup code: e.g. if you do not have initialized data, you can ignore/remove the copy-down, if you do not need to have the memory initialized, you can remove the zero-out. And if you do not need both, you may remove the complete startup code, and set up your stack in your main routine directly. Set with `INIT main` in the `prm` file your main routine as application startup/entry
- Check the compiler options: you may use e.g. the [-OdocF](#) function: increases compilation speed, but decreases code size. E.g. you can try `-OdocF="-or"`. Using the option [-Ll](#) to write a log file tells you the effect for each single function.
- Check if you can use both IEEE32 for float and double. See the option [-T](#) how to configure this. Do not forget to link the corresponding ANSI/C++ library.
- Use smaller data types whenever possible (e.g. 16bit instead of 32bit).
- Have a look into the map file check runtime routines which usually have a ‘_’ prefix. Check for 32bit integral routines (e.g. `_LADD`). Check if you need the long arithmetic.
- Enumerations: if you are using enums, by default they have the size of ‘int’. They can be set to an unsigned 8bit (see option [-T](#), or use `-TE1uE`).
- Check if you are using switch tables (have a look into the map file as well). there are options to configure this (see [-CswMinSLB](#) as an example)
- Finally the linker has an option to overlap ROM areas (see `-COCC` option in the linker)

Executing an Application from RAM

For performance reason, it may be interesting to copy an application from ROM to RAM, and to execute it from RAM. This can be achieved following the procedure below.

1. Link your application with code located in RAM.
2. Generate a S Record File.

3. Modify the startup code to copy the application code.
4. Link the application with the S record file previously generated.

Each step is described in the following sections. As an example, we will take the application `fibonacci.abs`.

Link your application with code located in RAM.

We recommend that you generate a ROM library for your application. This allows you to easily debug your final application (including the copying of the code).

ROM Library Startup File

A ROM Library requires a very simple startup file, containing only the definition from the startup structure. Usually a ROM library startup file looks as follows:

```
#include "startup.h"

/* read-only: _startupData is allocated in ROM and ROM
Library PRM File */

struct _tagStartup _startupData;
```

You must generate a PRM file, where the code is placed in RAM. As the compiler generates absolute code, the linker should know the final location of the code in order to generate correct code for the function call.

Additionally, in the PRM file specify the name of the application entry points in the ENTRIES block. The application main function, as well as the function associated with an Interrupt vector, must be specified there.

Example

Suppose you want to copy and execute your code at address `0x7000`. Your PRM file will look as follows:

```
LINK fiboram.abs AS ROM_LIB

NAMES myFibo.o start.o END
SECTIONS
    MY_RAM = READ_WRITE 0x4000 TO 0x43FF;
    MY_ROM = READ_ONLY 0x7000 TO 0xBFFF; /* Destination
Address in RAM area */
PLACEMENT
    DEFAULT_ROM, ROM_VAR, STRINGS INTO MY_ROM;
    DEFAULT_RAM INTO MY_RAM;
END
```

```
ENTRIES
  myMain
END
```

NOTE You cannot use a function `main` in a ROM library. Please use another name for the application entry point. In the example above, we have used "myMain".

Generate an S Record File

A Motorola S record must be generated for the application. In this purpose, the Burner utility can be used.

The file is generated when you click the '1st byte(msb)' button in the burner dialog.

Note: The field 'From' must be initialized with 0 and the field length with a value bigger than the last byte used for the code (if byte `0xFFFF` is used, the Length must be at least 10000).

Modify the startup code

The startup code of the final application must be modified. It should contain code copying the code from RAM to ROM. Additionally, as the application entry point is located in the ROM library, it should call it explicitly.

Application PRM file

The Motorola S file (generated previously) must be linked to the application with an offset.

Example

Suppose the application code must be placed at address `0x800` in ROM and should be copied to address `0x7000` in RAM. The application PRM file looks as follows:

```
LINK fiboram.abs

NAMES mystart.o fiboram.abs ansis.lib END
SECTIONS
  MY_RAM = READ_WRITE 0x5000 TO 0x53FF;
  MY_ROM = READ_ONLY 0x0600 TO 0x07FF;
```

```
PLACEMENT
    DEFAULT_ROM, ROM_VAR, STRINGS INTO MY_ROM;
    DEFAULT_RAM INTO MY_RAM;
END
STACKSIZE 0x100
VECTOR 0 _Startup /* set reset vector on startup function */
HEXFILE fiboram.s1 OFFSET 0xFFFF9800 /* 0x800 - 0x7000 */
```

Note: The offset specified in the HEXFILE command is added to each record in the Motorola S file. The code at address 0x700 will be encoded at address 0x800.

If you are using CodeWarrior, then the CodeWarrior IDE will pass all the names in the NAMES...END part directly to the linker, so then the NAMES...END part will be empty.

Copying Code from ROM to RAM

A function must be implemented, which copy the code from ROM to RAM.

Example

Suppose the application code must be placed at address 0x800 in ROM and should be copied to address 0x7000 in RAM the copy function can be implemented as follows:

```
/* Start address of the application code in ROM. */
#define CODE_SRC 0x800

/* Destination address of the application code in RAM. */
#define CODE_DEST 0x7000

#define CODE_SIZE 0x90 /* Size of the code which must be
copied.*/

void CopyCode(void) {
    unsigned char *ptrSrc, *ptrDest;

    ptrSrc = (unsigned char *)CODE_SRC;
    ptrDest = (unsigned char *)CODE_DEST;
    memcpy (ptrDest, ptrSrc, CODE_SIZE);
}
```


Invoking the Application Entry Point in the Startup Function

The startup code should call the application entry point, which is located in the ROM library. This function must be explicitly called through its name. The best place is just before calling the application main routine.

Example

```
void _Startup(void) {  
    ... set up stack pointer ...  
    ... zero out ...  
    ... copy down ...  
    CopyCode();  
    ... call main ...  
}
```

Defining a Dummy Main Function

The linker cannot link an application if there is no main function available. As in our case, the main function is located in the ROM library; a dummy main function must be defined in the startup module.

Example

```
#pragma NO_ENTRY  
#pragma NO_EXIT  
void main(void) {  
    asm NOP;  
}
```

Frequently Asked Questions (FAQs), Trouble Shooting

This section provides some tips on how to solve the most commonly encountered problems.

Making Applications

If the compiler or linker crashes, isolate the construct causing the crash and send us a bug report. Other common problems are:

The compiler reports an error, but WinEdit doesn't display it.

This means that WinEdit didn't find the EDOUT file, i.e. the compiler wrote it to a place not expected by WinEdit. This can have several reasons. Check that the environment variable [DEFAULTDIR](#) is not set, and that the project directory is set correctly. Also in WinEdit 2.1, make sure that the OUTPUT entry in the file WINEDIT.INI is empty.

Some programs can't find a file.

Make sure your environment is set up correctly. Also check WinEdit's project directory. Read the [Input Files](#) section of this document.

The compiler seems to generate incorrect code.

First make sure the code is incorrect. Sometimes the operator-precedence rules of ANSI-C do not quite give the results one would expect. Apparently faulty code can appear to be correct. Consider the following example:

```
if (x & y != 0) ...
```

is evaluated as

```
if (x & (y != 0)) ...
```

not as:

```
if ((x & y) != 0) ...
```

Another source of unexpected behavior are the integral promotion rules of C, that is to say, that characters are usually (sign-)extended to integers. This can sometimes have quite unexpected effects, e.g. the if-condition below is FALSE:

```
unsigned char a, b;  
b = -8;  
a = ~b;  
if (a == ~b) ...
```

because extending a results in 0x0007, while extending b gives 0x00F8 and the '~' results in 0xFF07. If the code contains a bug, isolate the construct causing it and send us a bug report.

The code seems to be correct, but the application does not work.

Check if the hardware is not set up correctly (e.g. using chip selects). Some memory expansions are accessible only with a special access mode (e.g. only word accesses). If memory is accessible only in a certain way, use inline assembly or use the 'volatile' keyword.

The linker can't handle an object file

Make sure all object files have been compiled with the latest version of the compiler and with the same flags concerning memory models and floating point formats. If not, recompile them.

The make utility doesn't make all of the application.

Most probably you didn't specify the target that is to be made on the command line. In this case, the make utility assumes the target of the first rule is the top target. Either put the rule for your application as the first in the make file, or specify the target on the command line.

The make utility unnecessarily re-compiler a file.

This problem can appear if you have short source files in your application. It is caused by the fact that MS-DOS only saves the time of last modification of a file with an accuracy of ± 2 seconds. If the compiler compiles two files in that time, both will have the same time stamp. The make utility makes the safe assumption that if one file depends on another file with the same time stamp, the first file has to be recompiled. There's no way to solve this problem.

The help file cannot be opened by double clicking on it in the file manager or in the explorer.

The compiler help file is a true Win32 help file. It is not compatible with the windows 3.1 version of WinHelp. The program "winhelp.exe" delivered with Windows 3.1, Windows 95 and Windows NT can only open Windows 3.1 help files. To open the compiler help file, the Winhlp32.exe has to be used.

The program winhlp32.exe resides either in the windows directory (usually c:\windows, c:\win95 or c:\winnt) or in its system (Win32s) or system32 (Windows

95, WinNT) subdirectory. The Winhlp32.exe is also contained in the Win32s distribution.

To change the association with Windows 95 or Windows NT either use the explorer menu "View->Options" and there the "File Types" tab. Or select any help file, press the Shift key. Hold it while opening the context menu by clicking on the right mouse button. Select "Open with ..." from the menu. Enable the "Always using this program" check box and select the winhlp32.exe with the "other" button.

To change the association with the file manager under Windows 3.1 use the "File->Associate..." menu entry.

How can constant objects be allocated in ROM?

Use the [#pragma INTO_ROM](#) and see the compiler option [-Cc](#).

The compiler cannot find my source file. What is wrong?

Check if in the default.env file the path to the source file is set in the environment variable [GENPATH](#). Additionally you can use the compiler option [-I](#) to specify the include file path. With CodeWarrior check the access path in the preference panel.

How can I switch off smart linking?

By adding a '+' after the object in the NAMES list of the prm file.

With CodeWarrior and ELF/Dwarf object file format (see compiler option [-F](#)), Today, you can link all in the object within an `ENTRIES . . . END` directive in the linker prm file:

```
ENTRIES fibo.o:* END
```

This is NOT supported in the HIWARE object file format.

How to avoid announcing 'no access to memory'?

Change in the simulator/debugger the memory configuration mode (menu Simulator > Configure) to 'auto on access'.

How can the same memory configuration be loaded every time the simulator/debugger is started?

Save that memory configuration under default.mem ex: Simulator->Configure-> Save and type in default.mem.

How can a loaded program in the simulator/debugger be started automatically and stop at a specified breakpoint?

Define the file postload.cmd, example:

```
bs &main t  
g
```

How can a project file be set up with WinEdit?

Open Win Edit press Project->Configure->Open and load a *.wpj file.

How can a project file be set up with Codewright?

Open Codewright press Project->New and load a *.pjtc file or create one.

Where can an overview of all options for the compiler be found?

Type in [-H](#) at the command line of the compiler.

How can an own startup be called after reset?

In the prm file use:

```
INIT myStartup
```

How can an own name for main be used?

In the prm file use:

```
MAIN myMain
```

How can the reset vector be set to the beginning of the startup code?

Set in the prm file for example this line:

```
/* set reset vector on _Startup */  
VECTOR ADDRESS 0xFFFFE _Startup
```

How can the compiler be configured for the editor?

Open the compiler press File->Configuration choose Editor Settings.

Where are configuration settings saved?

In the file `project.ini`. With CodeWarrior, the compiler settings are stored in the `.mcp` file.

What is to do when 'error while adding default.env options' appears after starting the compiler?

Adapt the options set by the compiler to the ones set in the `default.env` file and save them by pressing the save button in the compiler into `project.ini`.

After starting up the ICD Debugger an error "Illegal breakpoint detected" appears. What is wrong?

The cable might be too long, the maximal length for unshielded cables is about 20 cm and depends on the electric noise in the environment.

Why can no initialized data be written into the ROM area?

The qualifier `const` must be used and the source must be compiled with option `-Cc`.

Problems in the communication, loosing communication.

The cable might be too long, the maximal length for unshielded cables is about 20 cm and depends on the electric noise in the environment.

What to do if an assertion happens (internal error)?

Extract source where assertion appears and send it as zipped file with all headers, used options and versions of all used tools.

How to get help on an error message?

Either press F1 after clicking on the message to start up the help file or copy the message number, open the pdf manual and make a search on the copied message number.

How to get help on an option?

Open a compiler and type into the commandline [-H](#), a list of all options appears with a short description of it, or look into the manual for detailed information. Another way is to press F1 in the options setting dialog while a option is marked.

I cannot connect to my target board using an ICD Target Interface.

Communication may fail for following reasons:

- Is the parallel port working correctly? Try to print a document using the parallel port. This allows you to ensure that the parallel Port is available and connection.
- Is the BDM connector designed according to the specification from P&E?
- If you are running a Windows NT or Win98 operating system, you need to install an additional driver in order to be able to communicate with the software (See section NT Installation Notice in the debugger ICD Target Interface Manual).
- The original ICD Cable from P&E should not be extended. Extending this cable generates communication problem very often. The cable should not be longer than the original 25 cm.
- Maybe the PC is too fast for the ICD cable. You can slow down the communication between the PC and the Target using the environment variable BMDELAY (Ex. BMDELAY=50).

Bug Reports

If you cannot solve your problem, you may need to contact our Technical Support Department. Isolate the problem – if it's a compiler problem, write a short program reproducing the problem. Then send us a bug report.

Send or fax your bug report to your local distributor, it will be forwarded to the Technical Support Department.

The report type gives us a clue how urgent a bug report is. The classification is:

Information

This section describes things you would like to see improved in a future major release.

Bug

An error for which you have a workaround or would be satisfied for the time being if we could supply a workaround. (If you already have a workaround, we'd like to know it, too!) Of course bugs will be fixed in the next release.

Critical Bug

A grave error that makes it impossible for you to continue with your work.

Electronic Mail (email) or Fax Report Form

If you send the report by fax or email, following template can be used.

REPORT FORM

(Fill this form and send it using:

E-Mail: support_europe@metrowerks.com

Fax : ++(41) 61 690 75 05

)

CUSTOMER INFORMATION

Customer Name :

Company :

Customer Number:

Phone Number:

Fax Number:

Email Address:

PRODUCT INFORMATION

Product:
Host Computer (PC, ...):
OS/Window Manager (WinNT, Win95, ...):
Target Processor:
Language (C, C++, ...):

TOOL INFORMATION

Tool (Compiler, Linker, ...):
Version Nr (Vx.x.xx):
Options Used:
For simulator/debugger only: Target Interface Used:

REPORT INFORMATION

Report Type (Bug, Wish, Information):
Severity Level (0: Higher, ... 5: Lower):
(0 : No workaround, development stopped.
1 : Workaround found, can continue development, problems seems to
be a common one.
2 : Workaround found, problem with very special code.
3 : Has to be improved.
4 : Wish
5 : Information
)
Description:
Source/Preprocessor output:

Technical Support

The best way to get technical support is by using electronic mail (email). It is also possible to attach some examples to the email using a compression utility (e.g. WinZip) or simply uuencode. The email address is:

support_europe@metrowerks.com

To get information about newest updates and product enhancements, visit the web page at:

<http://www.metrowerks.com>

To reach technical support by postal mail, use the address below:

Metrowerks AG
Technical Support
Riehenring 175
4058 Basel (Switzerland)
Phone: ++41 61 690 7505
Fax: ++41 61 690 7501
Email: support_europe@metrowerks.com

Metrowerks
7700 West Parmer Lane
Austin, TX 78729 USA
Email: support@metrowerks.com

EBNF Notation

This chapter gives a short overview of the Extended Backus–Naur Form (EBNF) notation, which is frequently used in this document to describe file formats and syntax rules. A short introduction to EBNF is presented.

EBNF Example

```
ProcDecl    = PROCEDURE "(" ArgList ")".  
ArgList     = Expression { "," Expression }.  
Expression  = Term ( "*" | "/" ) Term.  
Term        = Factor AddOp Factor.  
AddOp       = "+" | "-".  
Factor      = ( [ "-" ] Number ) | "(" Expression ")".
```

The EBNF language is a formalism that can be used to express the syntax of context-free languages. The EBNF grammar consists of a rule set called – *productions* of the form:

```
LeftHandSide = RightHandSide.
```

The left-hand side is a non-terminal symbol. The right-hand side describes how it is composed.

EBNF consists of the symbols discussed in the sections that follow.

Terminal Symbols

Terminal symbols (terminals for short) are the basic symbols which form the language described. In above example, the word `PROCEDURE` is a terminal. Punctuation symbols of the language described (not of EBNF itself) are quoted (they are terminals, too), while other terminal symbols are printed in **boldface**.

Non-Terminal Symbols

Non-terminal symbols (non-terminals) are syntactic variables and have to be defined in a production, i.e. they have to appear on the left hand side of a production somewhere. In above example, there are many non-terminals, e.g. `ArgList` or `AddOp`.

Vertical Bar

The vertical bar "`|`" denotes an alternative, i.e. either the left or the right side of the bar can appear in the language described, but one of them has to. E.g. the 3rd production above means "an expression is a term followed by either a "`*`" or a "`/`" followed by another term".

Brackets

Parts of an EBNF production enclosed by "`[`" and "`]`" are optional. They may appear exactly once in the language, or they may be skipped. The minus sign in the last production above is optional, both `-7` and `7` are allowed.

The repetition is another useful construct. Any part of a production enclosed by "`{`" and "`}`" may appear any number of times in the language described (including zero, i.e. it may also be skipped). `ArgList` above is an example: an argument list is a single expression or a list of any number of expressions separated by commas. (Note that the syntax in the example does not allow empty argument lists...)

Parentheses

For better readability, normal parentheses may be used for grouping EBNF expressions, as is done in the last production of the example. Note the difference between the first and the second left bracket. The first one is part of the EBNF notation. The second one is a terminal symbol (it is quoted) and may appear in the language.

Production End

A production is always terminated by a period.

EBNF-Syntax

The definition of EBNF in EBNF is:

```
Production = NonTerminal "=" Expression ".".
Expression = Term {"|" Term}.
Term       = Factor {Factor}.
Factor     = NonTerminal
           | Terminal
           | "(" Expression ")"
           | "[" Expression "]"
           | "{" Expression }".
Terminal   = Identifier | "\"" <any char> "\".
NonTerminal = Identifier.
```

The identifier for a non-terminal can be any name you like. Terminal symbols are either identifiers appearing in the language described or any character sequence that is quoted.

Extensions

In addition to this standard definition of EBNF, the following notational conventions are used.

The counting repetition: Anything enclosed by "{" and "}" and followed by a superscripted expression x must appear exactly x times. x may also be a non-terminal. In the following example, exactly four stars are allowed:

```
Stars = {"*"}4.
```

The size in bytes. Any identifier immediately followed by a number n in square brackets ("[" and "]") may be assumed to be a binary number with the most significant byte stored first, having exactly n bytes. Example:

```
Struct = RefNo FilePos[4].
```

In some examples, text is enclosed by "<" and ">". This text is a meta-literal, i.e. whatever the text says may be inserted in place of the text. (cf. <any char> in the above example, where any character can be inserted).

Abbreviations, Lexical Conventions

Topic	Description
ANSI	American National Standards Institute
Compilation Unit	Source file to be compiled, includes all included header files
Floating Type	Numerical type with a fractional part, e.g. float, double, long double
HLL	High Level Inline Assembly
Integral Type	Numerical type without fractional part, e.g. char, short, int, long, long long

Number Formats

Valid constant floating number suffixes are 'f' and 'F' for float and 'l' or 'L' for long double. Note that floating constants without suffixes are double constants in ANSI. For exponential numbers 'e' or 'E' has to be used. '-' and '+' can be used for signed representation of the floating number or the exponent.

Following suffixes are supported:

Constant	Suffix	Type
floating	F	float
floating	L	long double
integral	U	unsigned int
integral	uL	unsigned long

Suffixes are not case-sensitive, e.g. 'ul', 'Ul', 'uL' and 'UL' all denote a unsigned long type.

Examples:

```
+3.15f    /* float */
-.125f    /* float */
3.125f    /* float */
.787F     /* float */
7.125     /* double */
3.E7      /* double */
8.E+7     /* double */
9.E-7     /* double */
```

```
3.21      /* long double */
3.2e12L  /* long double */
```

Precedence and Associativity of Operators for ANSI C

The following table gives an overview of the precedence and associativity of operators.

Operators	Associativity
() [] -> .	left to right
! ~ ++ -- + - * & (type) sizeof	right to left
* / %	left to right
+ -	left to right
<< >>	left to right
< <= > >=	left to right
== !=	left to right
&	left to right
^	left to right
	left to right
&&	left to right
	left to right
? :	right to left
= += -= *= /= %= &= ^= = <<= >>=	right to left
,	left to right

NOTE Unary +, - and * have higher precedence than the binary forms.

The precedence and associativity is determined by the ANSI-C syntax (ANSI/ISO 9899-1990, p. 38 and Kernighan/ Ritchie, *“The C Programming Language”*, Second Edition, Appendix Table 2-1).

Examples:

```
if(a == b&& c)
```

is the same as

```
if ((a == b) && c)
```

but

```
if (a == b|c)
```

is the same as

```
if ((a == b) | c)
a = b + c * d;
```

In the example above, operator-precedence causes the product of (c*d) to be added to b, and that sum to be assigned to a.

```
a = b += c += 1;
```

The associativity rules first evaluate c+=1, then assign b to the value of b plus (c+=1), and then the result to a.

List of all Escape Sequences

The following table gives an overview over escape sequences which could be used inside strings (e.g. for printf):

Description	Escape Sequence
Line Feed	\n
Tabulator sign	\t
Vertical Tabulator	\v
Backspace	\b
Carriage Return	\r
Line feed	\f
Bell	\a
Backslash	\\
Question Mark	\?
Quotation Mark	\^

Porting Tips and FAQs

List of all Escape Sequences

Double Quotation Mark	\"
Octal Number	\ooo
Hexadecimal Number	\xhh

Global Configuration File Entries

This appendix documents the entries that can appear in the global configuration file. This file is named `MCUTOOL.INI`.

`MCUTOOLS.INI` can contain these sections:

- [\[Options\] Section](#)
- [\[XXX Compiler\] Section](#)
- [\[Editor\] Section](#)
- [Example](#)

[Options] Section

This section documents the entries that can appear in the `[Options]` section of the file `MCUTOOLS.INI`.

DefaultDir

Arguments

Default Directory to be used.

Description

Specifies the current directory for all tools on a global level (see also environment variable [DEFAULTDIR](#)).

Example

```
DefaultDir=c:\install\project
```

[XXX_Compiler] Section

This section documents the entries that can appear in an [XXX_Compiler] section of the file MCUTOOLS.INI.

NOTE	XXX is a placeholder for the name of the actual backend. For example, for the HC12 compiler, the name of this section would be [HC12_Compiler].
-------------	---

SaveOnExit

Arguments

1/0

Description

Set to 1 if the configuration should be stored when the compiler is closed. Set to 0 if it should not be stored. The compiler does not ask to store a configuration in either case.

SaveAppearance

Arguments

1/0

Description

Set to 1 if the visible topics should be stored when writing a project file. Set to 0 if not. The command line, its history, the windows position, and other topics belong to this entry.

SaveEditor

Arguments

1/0

Description

Set to 1 if the visible topics should be stored when writing a project file. Set to 0 if not. The editor setting contains all information of the editor configuration dialog.

SaveOptions

Arguments

1/0

Description

Set to 1 if the options should be saved when writing a project file. Set to 0 if the options should not be saved. The options also contain the message settings.

RecentProject0, RecentProject1, ...

Arguments

Names of the last and prior project files

Description

This list is updated when a project is loaded or saved. Its current content is shown in the file menu.

Example

```
SaveOnExit=1
SaveAppearance=1
SaveEditor=1
SaveOptions=1
RecentProject0=C:\myprj\project.ini
RecentProject1=C:\otherprj\project.ini
```

TipFilePos

Arguments

Any integer, e.g. 236

Description

Actual position in tip of the day file. Used that different tips are shown at different calls.

Saved

Always saved when saving a configuration file.

ShowTipOfDay

Arguments

0/1

Description

Should the Tip of the Day dialog be shown at startup.

1: it should be shown

0: Only when opened in the help menu

Saved

Always saved when saving a configuration file.

TipTimeStamp

Arguments

date and time

Description

Date and time when the tips were last used.

Saved

Always saved when saving a configuration file.

[Editor] Section

This section documents the entries that can appear in the [Editor] section of the file MCUTOOLS.INI.

Editor_Name

Arguments

The name of the global editor

Description

Specifies the name which is displayed for the global editor. This entry has only a description effect. Its content is not used to start the editor.

Saved

Only with Editor Configuration set in the File->Configuration Save Configuration dialog.

Editor_Exe

Arguments

The name of the executable file of the global editor

Description

Specifies the file name that is called (for showing a text file) when the global editor setting is active. In the editor configuration dialog, the global editor selection is active only when this entry is present and not empty.

Saved

Only with Editor Configuration set in the File->Configuration Save Configuration dialog.

Editor_Opts

Arguments

The options to use the global editor

Description

Specifies options used for the global editor. If this entry is not present or empty, “%f” is used. The command line to launch the editor is built by taking the Editor_Exe content, then appending a space followed by this entry.

Saved

Only with Editor Configuration set in the File->Configuration Save Configuration dialog.

Example

```
[Editor]
editor_name=notepad
editor_exe=C:\windows\notepad.exe
editor_opts=%f
```

Example

[Listing B.1](#) shows a typical MCUTOOLS .INI file.

Listing B.1 A Typical MCUTOOLS.INI File Layout

```
[Installation]
Path=c:\Metrowerks
Group=ANSI-C Compiler

[Editor]
editor_name=notepad
editor_exe=C:\windows\notepad.exe
editor_opts=%f

[Options]
DefaultDir=c:\myprj

[XXXX_Compiler]
SaveOnExit=1
SaveAppearance=1
SaveEditor=1
SaveOptions=1
RecentProject0=c:\myprj\project.ini
RecentProject1=c:\otherprj\project.ini
TipFilePos=0
ShowTipOfDay=1
TipTimeStamp=Jan 21 2000 17:25:16
```

Global Configuration File Entries

Example

Local Configuration File Entries

This appendix documents the entries that can appear in the local configuration file. Usually, you name this file `project.ini`, where `project` is a placeholder for the name of your project.

A `project.ini` file can contains these sections:

- [\[Editor\] Section](#)
- [\[XXX_Compiler\] Section](#)
- [Example](#)

[Editor] Section

Editor_Name

Arguments

The name of the local editor

Description

Specifies the name that is displayed for the local editor. This entry contains only a description effect. Its content is not used to start the editor.

Saved

Only with Editor Configuration set in the File->Configuration Save Configuration dialog. This entry has the same format as the global editor configuration in the `mcutools.ini` file.

Editor_Exe

Arguments

The name of the executable file of the local editor

Description

Specifies the file name that is used for a text file, when the local editor setting is active. In the editor configuration dialog, the local editor selection is only active when this entry is present and not empty.

Saved

Only with Editor Configuration set in the File->Configuration Save Configuration dialog. This entry has the same format as for the global editor configuration in the `mcutools.ini` file.

Editor_Opts

Arguments

Local editor options

Description

Specifies options that should be used for the local editor. If this entry is not present or empty, “%f” is used. The command line to launch the editor is built by taking the Editor_Exe content, then appending a space followed by this entry.

Saved

Only with Editor Configuration set in the File->Configuration Save Configuration dialog. This entry has the same format as the global editor configuration in the `mcutools.ini` file.

Example [Editor] Section

```
[Editor]
editor_name=notepad
editor_exe=C:\windows\notepad.exe
editor_opts=%f
```

[XXX_Compiler] Section

This section documents the entries that can appear in an [XXX_Compiler] section of a *project.ini* file.

NOTE	XXX is a placeholder for the name of the actual backend. For example, for the HC12 compiler, the name of this section would be [HC12_Compiler].
-------------	---

RecentCommandLineX

NOTE	x is a placeholder for an integer.
-------------	------------------------------------

Arguments

String with a command line history entry, e.g. “fibonacci.c”

Description

This list of entries contains the content of the command line history.

Saved

Only with Appearance set in the File->Configuration Save Configuration dialog.

CurrentCommandLine

Arguments

String with the command line, e.g. “`fibonacci.c -w1`”

Description

The currently visible command line content.

Saved

Only with Appearance set in the File->Configuration Save Configuration dialog.

StatusbarEnabled

Arguments

1/0

Special

This entry is only considered at startup. Later load operations do not use it any more.

Description

Is status bar currently enabled.

1: The status bar is visible

0: The status bar is hidden

Saved

Only with Appearance set in the File->Configuration Save Configuration dialog.

ToolbarEnabled

Arguments

1/0

Special

This entry is only considered at startup. Later load operations no longer use it.

Description

Is the toolbar currently enabled.

1: The toolbar is visible

0: The toolbar is hidden

Saved

Only with Appearance set in the File->Configuration Save Configuration dialog.

WindowPos

Arguments

10 integers, e.g. "0,1,-1,-1,-1,-1,390,107,1103,643"

Special

This entry is only considered at startup. Later load operations do not use it any more.

Changes of this entry do not show the "*" in the title.

Description

This number contains the position and the state of the window (maximized) and other flags.

Saved

Only with Appearance set in the File->Configuration Save Configuration dialog.

WindowFont

Arguments

size: == 0 -> generic size, < 0 -> font character height, > 0 font cell height

weight: 400 = normal, 700 = bold (valid values are 0 – 1000)

italic: 0 == no, 1 == yes

font name: max 32 characters.

Description

Font attributes.

Saved

Only with Appearance set in the File->Configuration Save Configuration dialog.

Example

```
WindowFont=-16,500,0,Courier
```

Options

Arguments

-W2

Description

The currently active option string. This entry is quite long as the messages are also stored here.

Saved

Only with Options set in the File->Configuration Save Configuration dialog.

EditorType

Arguments

0/1/2/3

Description

This entry specifies which editor configuration is active.

0: Global editor configuration (in the file `mcutools.ini`)

1: Local editor configuration (the one in this file)

2: Command line editor configuration, entry `EditorCommandLine`

3: DDE editor configuration, entries beginning with `EditorDDE`

For details see [Editor Configuration](#).

Saved

Only with Editor Configuration set in the File->Configuration Save Configuration dialog.

EditorCommandLine

Arguments

Command line for the editor.

Description

Command line content to open a file. For details see [Editor Configuration](#).

Saved

Only with Editor Configuration set in the File->Configuration Save Configuration dialog.

EditorDDEClientName

Arguments

Client command, e.g. “[open (%f)]”

Description

Name of the client for DDE editor configuration. For details see a [Editor Configuration](#).

Saved

Only with Editor Configuration set in the File->Configuration Save Configuration dialog.

EditorDDETopicName

Arguments

Topic name. For example, “system”

Description

Name of the topic for DDE editor configuration. For details see [Editor Configuration](#).

Saved

Only with Editor Configuration set in the File->Configuration Save Configuration dialog.

EditorDDEServiceName

Arguments

Service name. For example, “system”

Description

Name of the service for DDE editor configuration. For details see [Editor Configuration](#).

Saved

Only with Editor Configuration set in the File->Configuration Save Configuration dialog.

Example

[Listing C.1](#) shows a typical configuration file layout (usually *project.ini*):

Listing C.1 A Typical Local Configuration File Layout

```
[Editor]
Editor_Name=notepad
Editor_Exe=C:\windows\notepad.exe
Editor_Opts=%f

[XXX_Compiler]
StatusBarEnabled=1
ToolbarEnabled=1
WindowPos=0,1,-1,-1,-1,-1,390,107,1103,643
WindowFont=-16,500,0,Courier
Options=-w1
EditorType=3
RecentCommandLine0=fibo.c -w2
RecentCommandLine1=fibo.c
CurrentCommandLine=fibo.c -w2
EditorDDEClientName=[open(%f)]
EditorDDETopicName=system
EditorDDEServiceName=msdev
EditorCommandLine=C:\windows\notepad.exe %f
```

Local Configuration File Entries

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