Zilog Developer Studio II— Z8 Encore!®

User Manual

UM013033-0508

Warning: DO NOT USE IN LIFE SUPPORT

Revision History

Date	Revision Level	Section	Description
May 2008	33	All	Updated for the ZDS II 4.11.0 release.
December 2006	32	"Using the Command Processor" appendix on page 408	Updated.
		"Firmware Upgrade (Selected Debug Tool)" on page 118	Added path for Ethernet Smart Cable upgrade information.
		"Uarts" on page 79	Described new Place ISR into PRAM check boxes.
		"New Project" on page 39 and "Debugger Page" on page 96	Added description of the Use Page Erase Before Flashing check
		"Flash Loader" on page 110	Added description of the Use Page Erase check box.
		"Using the Macro Assembler" chapter and "Compatibility Issues" appendix	Deleted PL, PW, PAGEWIDTH, and PAGELENGTH.
		Appendix D, "Using the Command Processor"	Added the `checksum`, `fillmem`, `loadmem`, and `savemem` commands.
		"Structures and Unions in Assembly Code" on page 243	Added new section.
		"ORG" on page 238	Updated section.
		"Memory Window" on page 314	Updated the note about PRAM.
July 2006	31	All	Updated for the ZDS II 4.10.0 release.
September 2005	30	"Optimizer Warning and Error Messages" on page 207	Added new section.
		"Front-End Warning and Error Messages" on page 197	Updated section.
		"Debug Tool" on page 100	Added Ethernet target.
		"Setup" on page 97	Added Ethernet target.

Table of Contents

Introduction

The following sections provide an introduction to the Zilog Developer Studio II:

- "ZDS II System Requirements" on page xvi
- "Zilog Technical Support" on page xx

ZDS II SYSTEM REQUIREMENTS

To effectively use Zilog Developer System II, you need a basic understanding of the C and assembly languages, the device architecture, and Microsoft Windows.

The following sections describe the ZDS II system requirements:

- "Supported Operating Systems" on page xvi
- "Recommended Host System Configuration" on page xvi
- "Minimum Host System Configuration" on page xvii
- "When Using the Serial Smart Cable" on page xvii
- "When Using the USB Smart Cable" on page xvii
- "When Using the Opto-Isolated USB Smart Cable" on page xvii
- "When Using the Ethernet Smart Cable" on page xviii
- "When Using the Z8 Encore! MC Emulator" on page xviii
- "Z8 Encore! Product Support" on page xviii

Supported Operating Systems

- Windows Vista Business**
- Windows XP Professional
- Windows 2000 SP4
- Windows 98 SE

NOTE: **The USB Smart Cable is not supported on 64-bit Windows Vista and Windows XP for ZDS II—Z8 Encore! versions 4.10.1 or earlier.

Recommended Host System Configuration

- Windows XP Professional
- Pentium III 500-MHz processor or higher
- 128 MB RAM or more

- 135 MB hard disk space (includes application and documentation)
- Super VGA video adapter
- CD-ROM drive for installation
- USB high-speed port (when using the USB Smart Cable)
- RS232 communication port with hardware flow control
- Internet browser (Internet Explorer or Netscape)

Minimum Host System Configuration

- Windows 98 SE
- Pentium II 233-MHz processor
- 96 MB RAM
- 35 MB hard disk space (application only)
- Super VGA video adapter
- CD-ROM drive for installation
- USB full-speed port (when using the USB Smart Cable; Windows 98 SE only)
- RS232 communication port with hardware flow control
- Internet browser (Internet Explorer or Netscape)

When Using the Serial Smart Cable

- RS-232 communication port with hardware flow and modem control signals

NOTE: Some USB to RS-232 devices are not compatible because they lack the necessary hardware signals and/or they use proprietary auto-sensing mechanisms which prevent the Smart Cable from connecting.

When Using the USB Smart Cable

- High-speed USB (fully compatible with original USB)
- Root (direct) or self-powered hub connection

NOTE: The USB Smart Cable is a high-power USB device.

Windows NT is not supported.

When Using the Opto-Isolated USB Smart Cable

- High-speed USB (fully compatible with original USB)
- Root (direct) or self-powered hub connection

NOTE: The USB Smart Cable is a high-power USB device.

Windows NT is not supported.

When Using the Ethernet Smart Cable

- Ethernet 10Base-T compatible connection

When Using the Z8 Encore! MC Emulator

- Internet browser (Internet Explorer or Netscape)
- Ethernet 10Base-T compatible connection
- One or more RS-232 communication ports *with hardware flow control*

Z8 Encore! Product Support

CPU Family	CPU	Pin Count	Evaluation Kit Name
Z8Encore_F0830_Series	Z8F013x	20, 28	Not applicable
	Z8F023x		
	Z8F043x		
	Z8F083x		
	Z8F123x		
Z8Encore_F083A_Series	Z8F043A	20, 28	Z8F083A0128ZCOG
	Z8F083A		
Z8Encore_XP_64XX_Series	Z8F1621	40, 44	Z8F64200100KITG
	Z8F1622	64, 68	
	Z8F2421	40, 44	
	Z8F2422	64, 68	
	Z8F3221	40, 44	
	Z8F3222	64, 68	
	Z8F4821	40, 44	
	Z8F4822	64, 68	
	Z8F4823	80	
	Z8F6421	40, 44	
	Z8F6422	64, 68	
	Z8F6423	80	

CPU Family	CPU	Pin Count	Evaluation Kit Name
Z8Encore_XP_F0822_Series	Z8F0411	20	Z8F08200100KITG
	Z8F0412	28	
	Z8F0421	20	
	Z8F0422	28	
	Z8F0811	20	
	Z8F0812	28	
	Z8F0821	20	
	Z8F0822	28	
Z8Encore_XP_F0823_8Pin_Series	Z8F0113XB	8	Z8F04A08100KITG
	Z8F0123XB		
	Z8F0213XB		
	Z8F0223XB		
	Z8F0413XB		
	Z8F0423XB		
	Z8F0813XB		
	Z8F0823XB		
Z8Encore_XP_F0823_Series	Z8F0113	20, 28	Z8F04A28100KITG
	Z8F0123		
	Z8F0213		
	Z8F0223		
	Z8F0413		
	Z8F0423		
	Z8F0813		
	Z8F0823		
Z8Encore_XP_F082A_8Pin_Series	Z8F011AXB	8	Z8F04A08100KITG
	Z8F012AXB		
	Z8F021AXB		
	Z8F022AXB		
	Z8F041AXB		
	Z8F042AXB		
	Z8F081AXB		
	Z8F082AXB		

CPU Family	CPU	Pin Count	Evaluation Kit Name
Z8Encore_XP_F082A_Series	Z8F011A	20, 28	Z8F04A28100KITG
	Z8F012A		
	Z8F021A		
	Z8F022A		
	Z8F041A		
	Z8F042A		
	Z8F081A		Z8F08A28100KITG
	Z8F082A		
Z8Encore_XP_F1680_Series_16K	Z8F1680X Z8F1681X	20, 28, 40, 44	Z8F16800128ZCOG Z8F16800144ZCOG
Z8Encore_XP_F1680_Series_24K	Z8F2480X Z8F2481X	20, 28, 40, 44	Z8F16800128ZCOG Z8F16800144ZCOG
Z8Encore_XP_F1680_Series_8K	Z8F0880X Z8F0881X	20, 28, 40, 44	Z8F16800128ZCOG Z8F16800144ZCOG
Z8Encore_Z8FMC16100_Series	Z8FMC04100	28, 32	Z8FMC160100KITG
	Z8FMC08100		
	Z8FMC16100		

ZILOG TECHNICAL SUPPORT

For technical questions about our products and tools or for design assistance, please use our web page:

`http://www.zilog.com`

You must provide the following information in your support ticket:

- Product release number (Located in the heading of the toolbar)
- Product serial number
- Type of hardware you are using
- Exact wording of any error or warning messages
- Any applicable files attached to the e-mail

Before Using Technical Support

Before you use technical support, consult the following documentation:

- readme.txt file

Refer to the `readme.txt` file in the following directory for last minute tips and information about problems that might occur while installing or running ZDS II:

`ZILOGINSTALL\ZDSII_`*product_version*`\`

where

– *ZILOGINSTALL* is the ZDS II installation directory. For example, the default installation directory is `C:\Program Files\ZiLOG`.
– *product* is the specific Zilog product. For example, *product* can be `Z8Encore!`, `ZNEO`, `eZ80Acclaim!`, `Crimzon`, or `Z8GP`.
– *version* is the ZDS II version number. For example, *version* might be `4.11.0` or `5.0.0`.

- FAQ.html file

  The `FAQ.html` file contains answers to frequently asked questions and other information about good practices for getting the best results from ZDS II. The information in this file does not generally go out of date from release to release as quickly as the information in the `readme.txt` file. You can find the `FAQ.html` file in the following directory:

  `ZILOGINSTALL\ZDSII_`*product_version*`\`

  where

  – *ZILOGINSTALL* is the ZDS II installation directory. For example, the default installation directory is `C:\Program Files\ZiLOG`.
  – *product* is the specific Zilog product. For example, *product* can be `Z8Encore!`, `ZNEO`, `eZ80Acclaim!`, `Crimzon`, or `Z8GP`.
  – *version* is the ZDS II version number. For example, *version* might be `4.11.0` or `5.0.0`.

- Troubleshooting section
  – "Zilog Standard Library Notes and Tips" on page 331

Getting Started

This section provides a tutorial of the developer's environment, so you can be working with the ZDS II graphical user interface in a short time. The following topics are covered:

- "Installing ZDS II" on page 1
- "Developer's Environment Tutorial" on page 1

INSTALLING ZDS II

There are two ways to install ZDS II:

- From a CD
  a. Insert the CD in your CD-ROM drive.
  b. Follow the setup instructions on your screen.
     The installer displays a default location for ZDS II. You can change the location if you want to.
- From `www.zilog.com`
  a. Navigate to `http://www.zilog.com/software/zds2.asp`.
  b. Click on the link for the version that you want to download.
  c. Click **Download**.
  d. In the File Download dialog box, click **Save**.
  e. Navigate to where you want to save ZDS II.
  f. Click **Save**.
  g. Double-click the executable file.
  h. Follow the setup instructions on your screen.
     The installer displays a default location for ZDS II. You can change the location if you want to.

DEVELOPER'S ENVIRONMENT TUTORIAL

This tutorial shows you how to use the Zilog Developer Studio II. To begin this tour, you need a basic understanding of Microsoft Windows. Estimated time for completing this exercise is 15 minutes.

In this tour, you do the following:

- "Create a New Project" on page 2
- "Add a File to the Project" on page 6

- "Set Up the Project" on page 8
- "Save the Project" on page 14

When you complete this tour, you have a `sample.lod` file that is used in debugging.

NOTE: Be sure to read "Using the Integrated Development Environment" on page 15 to learn more about all the dialog boxes and their options discussed in this tutorial.

For the purpose of this quick tour, your Z8 Encore! developer's environment directory will be referred to as <*ZDS Installation Directory*>, which equates to the following path:

<*ZILOGINSTALL*>`\ZDSII_Z8Encore!_`<*version*>`\`

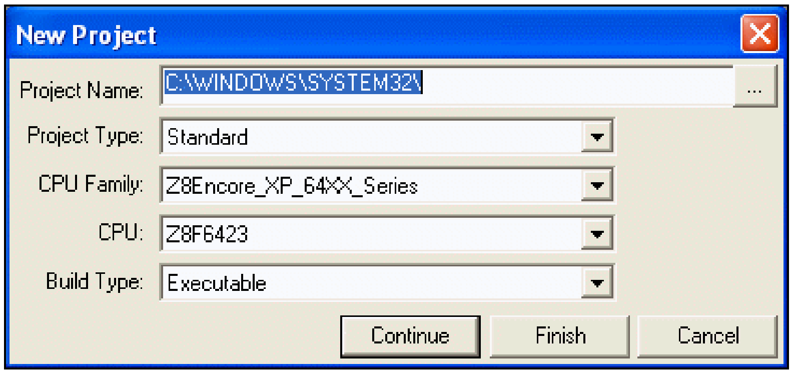
where

- *ZILOGINSTALL* is the ZDS II installation directory. For example, the default installation directory is `C:\Program Files\ZiLOG`.
- *version* is the ZDS II version number. For example, *version* might be `4.11.0` or `5.0.0`.

Create a New Project

1. To create a new project, select **New Project** from the File menu.

   The New Project dialog box is displayed.



Project Name: C:\WINDOWS\SYSTEM32\
Project Type: Standard
CPU Family: Z8Encore_XP_64XX_Series
CPU: Z8F6423
Build Type: Executable

Figure 1. New Project Dialog Box

2. From the New Project dialog box, click on the Browse button (...) to navigate to the directory where you want to save your project.

   The Select Project Name dialog box is displayed.

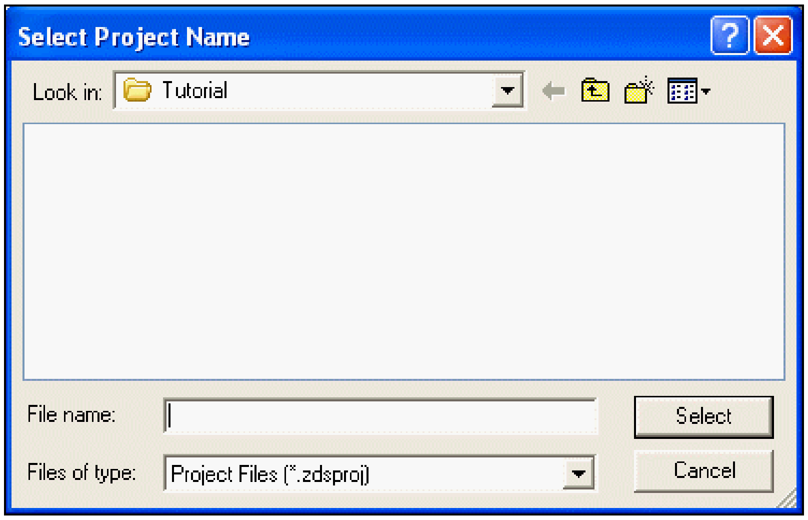


Figure 2. Select Project Name Dialog Box

3. Use the Look In drop-down list box to navigate to the directory where you want to save your project. For this tutorial, place your project in the following directory:

   `<ZDS Installation Directory>\samples\Tutorial`

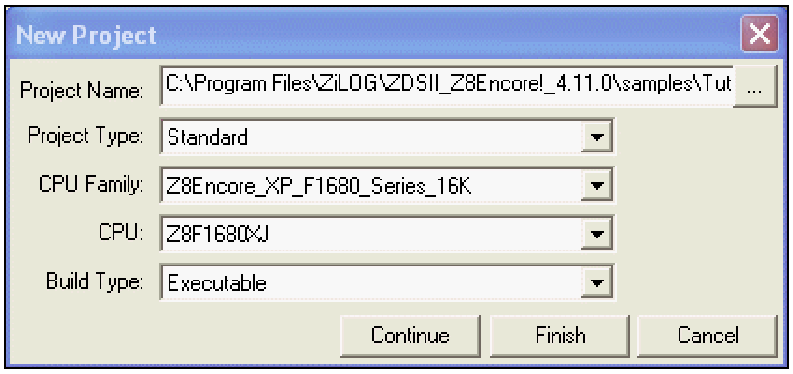
   If Zilog Developer Studio was installed in the default directory, the following is the actual path:

   `C:\Program Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\samples\Tutorial`

NOTE: You can create a new folder where you want to save your project. For example: `C:\`*<New Folder>*

4. In the File Name field, type `sample` for the name of your project.

   The Z8 Encore! developer's environment creates a project file. Project files have the `.zdsproj` extension (for example, *<project name>*`.zdsproj`). You do not have to type the extension `.zdsproj`. It is added automatically.
5. Click **Select** to return to the New Project dialog box.
6. In the Project Type field, select **Standard** because the sample project uses `.c` files.
7. In the CPU Family drop-down list box, select **Z8Encore_XP_F1680_Series_16K**.
8. In the CPU drop-down list box, select **Z8F1680XJ**.
9. In the Build Type drop-down list box, select **Executable** to build an application.


New Project

Project Name: C:\Program Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\samples\Tut

Project Type: Standard

CPU Family: Z8Encore_XP_F1680_Series_16K

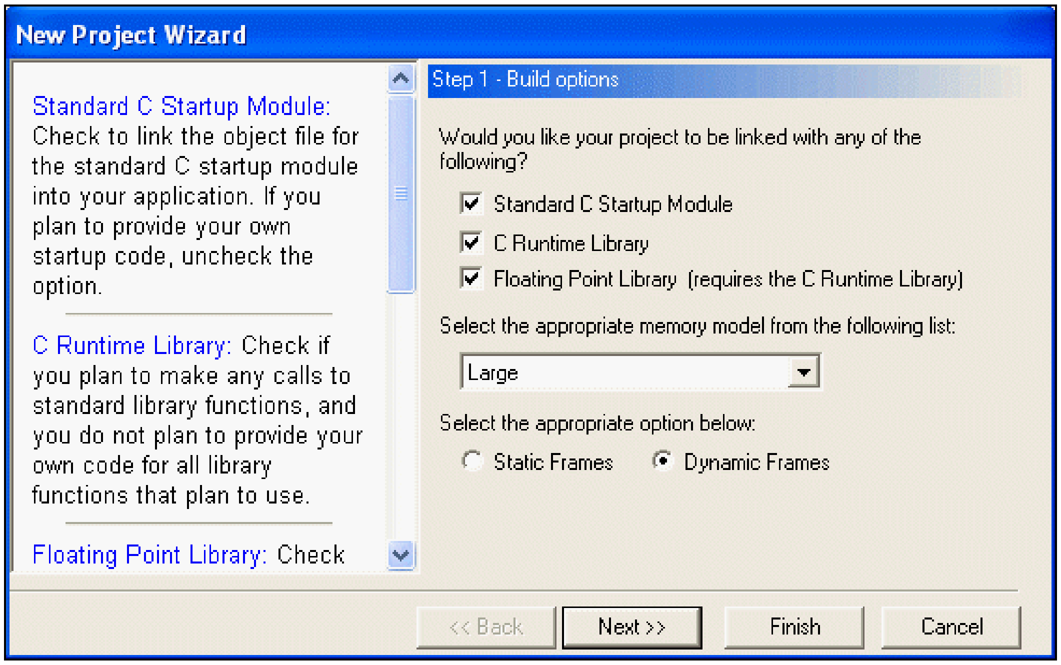
CPU: Z8F1680XJ

Build Type: Executable

Figure 3. New Project Dialog Box

10. Click **Continue**.

    The New Project Wizard dialog box is displayed. It allows you to modify the initial values for some of the project settings during the project creation process.


New Project Wizard

Standard C Startup Module: Check to link the object file for the standard C startup module into your application. If you plan to provide your own startup code, uncheck the option.

C Runtime Library: Check if you plan to make any calls to standard library functions, and you do not plan to provide your own code for all library functions that plan to use.

Floating Point Library: Check

Step 1 - Build options

Would you like your project to be linked with any of the following?

☑ Standard C Startup Module

☑ C Runtime Library

☑ Floating Point Library (requires the C Runtime Library)

Select the appropriate memory model from the following list:

Large

Select the appropriate option below:

Static Frames [✓ Dynamic Frames]

Figure 4. New Project Wizard Dialog Box—Build Options Step

11. Accept the defaults by clicking **Next**.

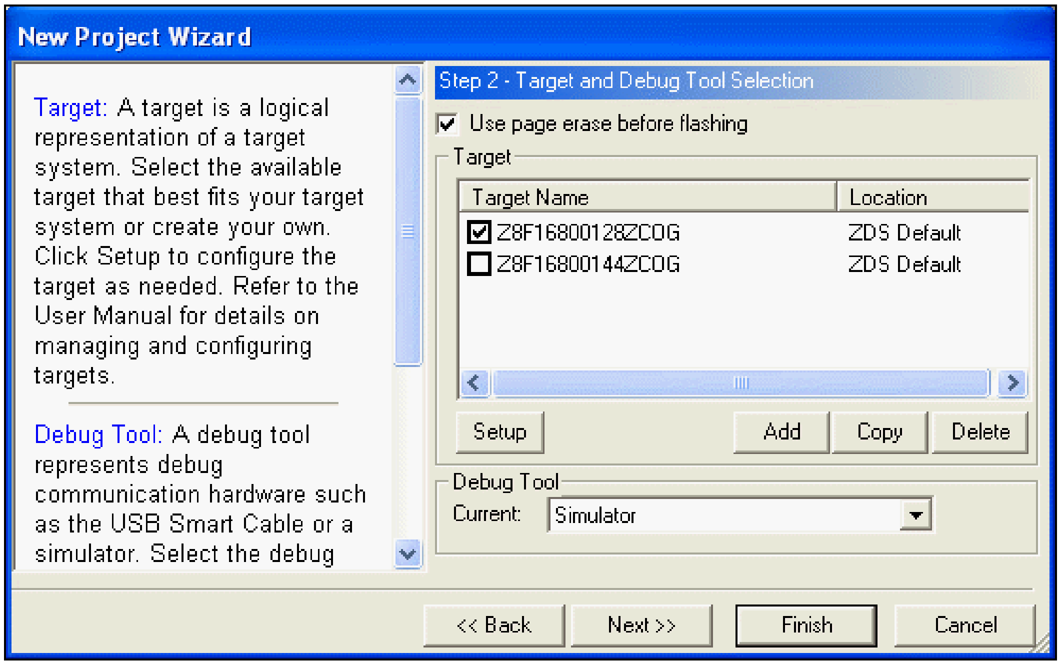
The Target and Debug Tool Selection step of the New Project Wizard dialog box is displayed.

The options displayed in the Configure Target dialog box depend on the CPU you selected in the New Project dialog box (see “New Project” on page 39) or the General page of the Project Settings dialog box (see “General Page” on page 56). For this tutorial project, there are two targets displayed. Z8F16800128ZCOG is the Z8F1680 28-Pin Development Kit’s evaluation board; Z8F16800144ZCOG is the Z8F1680 Dual 44-Pin Development Kit’s evaluation board. For more information about which products each target supports, see “Z8 Encore! Product Support” on page xviii.

Clicking **Setup** in the Target area displays the Configure Target dialog box. The Configure Target dialog box allows you to select the clock source and the appropriate clock frequency. For the emulator, this frequency must match the clock oscillator on Y4. For the development kit, this frequency must match the clock oscillator on Y1. For more information about configuring the target, see “Setup” on page 97.

For details about the available debug tools and how to configure them, see “Debug Tool” on page 100.

12. Select the Z8F16800128ZCOG check box.



Target: A target is a logical representation of a target system. Select the available target that best fits your target system or create your own. Click Setup to configure the target as needed. Refer to the User Manual for details on managing and configuring targets.

Debug Tool: A debug tool represents debug communication hardware such as the USB Smart Cable or a simulator. Select the debug

☑ Use page erase before flashing

Target

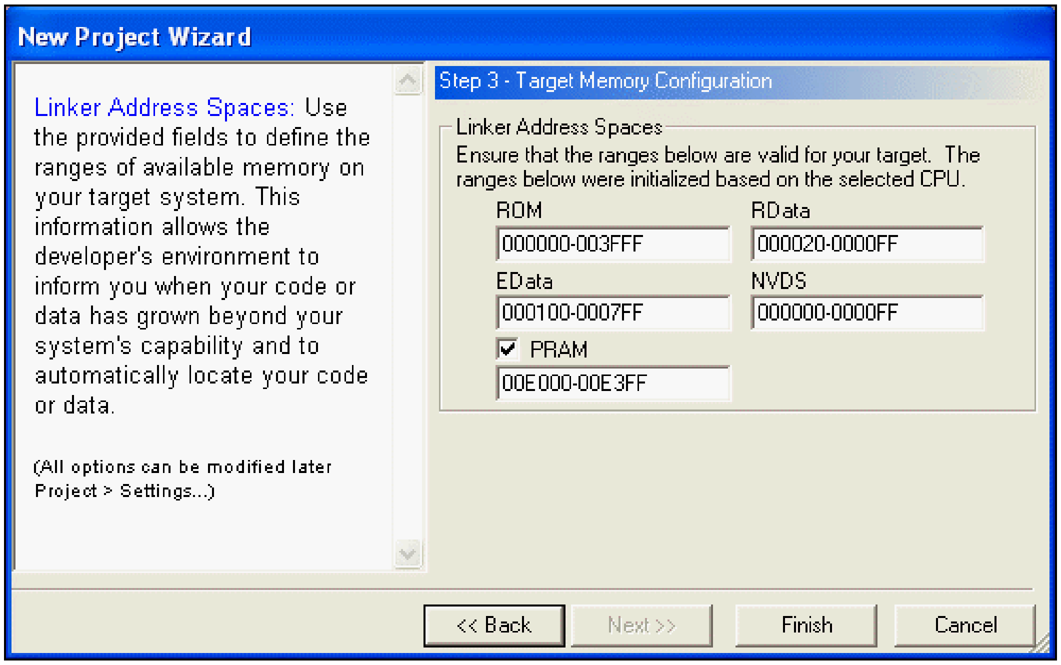
Target Name	Location
☑ Z8F16800128ZCOG	ZDS Default
☐ Z8F16800144ZCOG	ZDS Default

Debug Tool
Current: Simulator

Figure 5. New Project Wizard Dialog Box—Target and Debug Tool Selection Step

13. Click **Next**.

The Target Memory Configuration step of the New Project Wizard dialog box is displayed.



Linker Address Spaces: Use the provided fields to define the ranges of available memory on your target system. This information allows the developer's environment to inform you when your code or data has grown beyond your system's capability and to automatically locate your code or data.

(All options can be modified later Project > Settings...)

Linker Address Spaces

Ensure that the ranges below are valid for your target. The ranges below were initialized based on the selected CPU.

ROM: 000000-003FFF
RData: 000020-0000FF
EData: 000100-0007FF
NVDS: 000000-0000FF
[✓] PRAM: 00E000-00E3FF

Figure 6. New Project Wizard Dialog Box—Target Memory Configuration Step

14. Click **Finish**.

    ZDS II creates a new project named `sample`. Two empty folders are displayed in the Project Workspace window (Standard Project Files and External Dependencies) on the left side of the integrated development environment (IDE).

Add a File to the Project

In this section, you add the provided C source file `main.c` file to the `sample` project.

1. From the Project menu, select **Add Files**.

   The Add Files to Project dialog box is displayed.

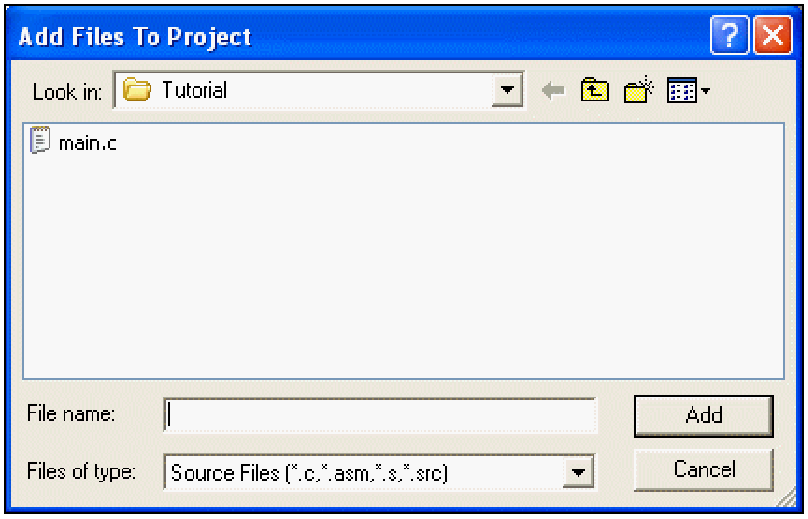


Figure 7. Add Files to Project Dialog Box

2. In the Add Files to Project dialog box, use the Look In drop-down list box to navigate to the tutorial directory:

   `<ZDS Installation Directory>\samples\Tutorial`

3. Select the `main.c` file and click **Add**.

   The `main.c` file is displayed under the Standard Project Files folder in the Project Workspace window on the left side of the IDE.

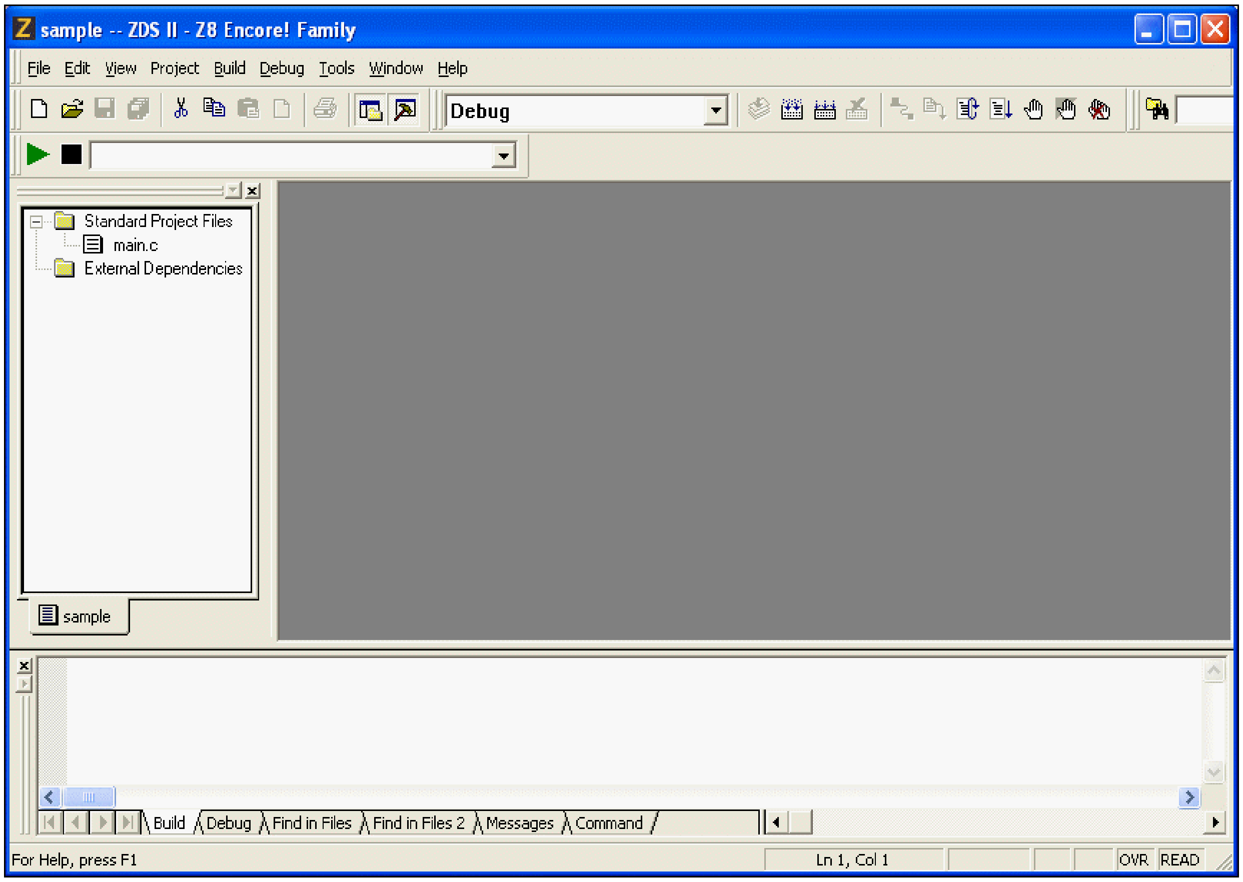

sample -- ZDS II - Z8 Encore! Family
File Edit View Project Build Debug Tools Window Help
Debug
Standard Project Files
main.c
External Dependencies
sample
Build Debug Find in Files Find in Files 2 Messages Command
For Help, press F1
Ln 1, Col 1
OVR READ

Figure 8. Sample Project

NOTE: To view any of the files in the Edit window during the quick tour, double-click on the file in the Project Workspace window.

Set Up the Project

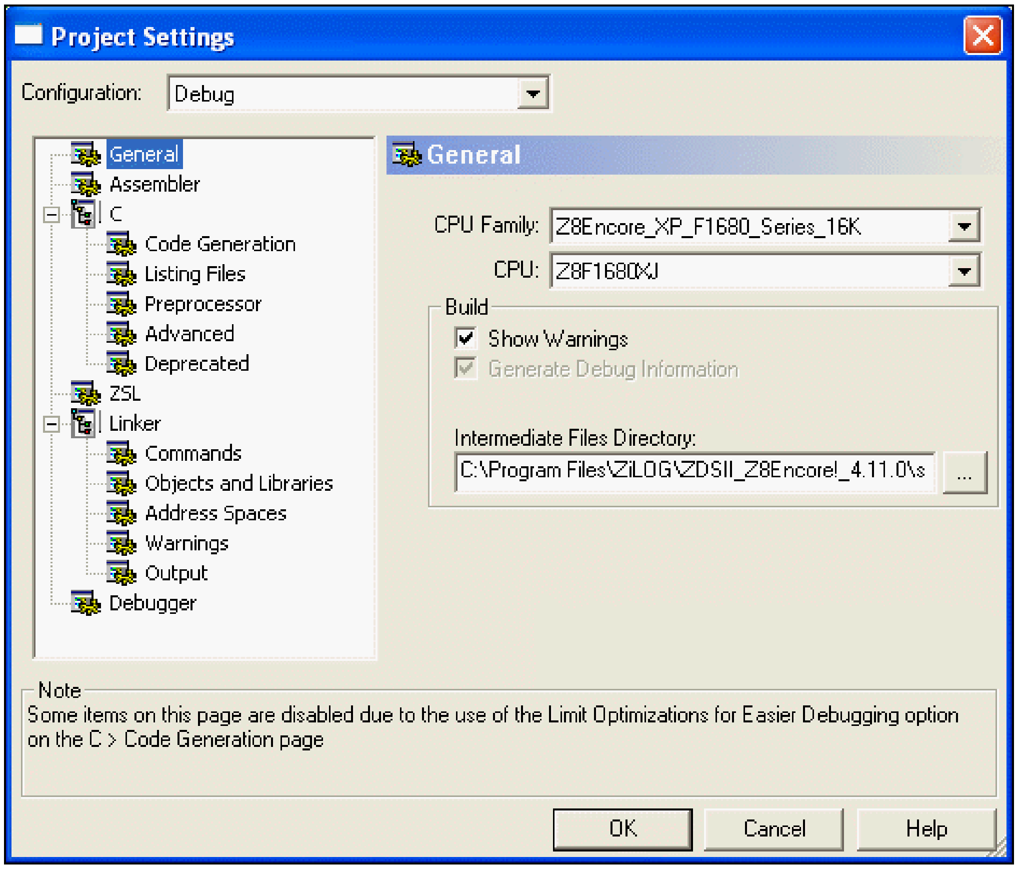
Before you save and build the `sample` project, check the settings in the Project Settings dialog box.

1. From the Project menu, select **Settings**.

   The Project Settings dialog box is displayed. It provides various project configuration pages that can be accessed by selecting the page name in the pane on the left side of the dialog box. There are several pages grouped together for the C (Compiler) and Linker that allow you to set up subsettings for those tools. For more information, see “Settings” on page 55.

2. In the Configuration drop-down list box, make sure that the **Debug** build configuration is selected.

   For your convenience, the Debug configuration is a predefined configuration of defaults set for debugging. For more information on project configurations such as adding your own configuration, see "Set Active Configuration" on page 103.



Configuration: Debug

CPU Family: Z8Encore_XP_F1680_Series_16K

CPU: Z8F1680XJ

☑ Show Warnings

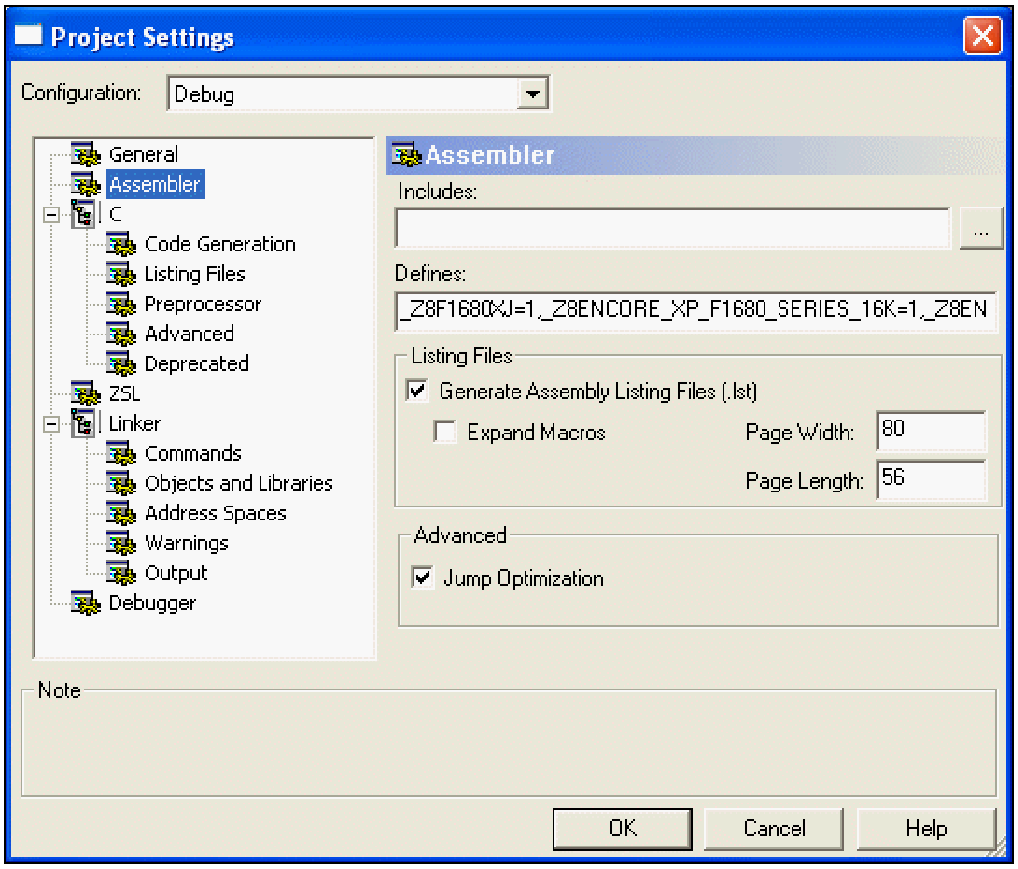
☑ Generate Debug Information

Intermediate Files Directory: C:\Program Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\s

Note
Some items on this page are disabled due to the use of the Limit Optimizations for Easier Debugging option on the C > Code Generation page

Figure 9. General Page of the Project Settings Dialog Box

3. Select the Assembler page.
4. Make sure that the Generate Assembly Listing Files (.lst) check box is selected.


Project Settings

Configuration: Debug

Assembler

Includes:

Defines: _Z8F1680XJ=1,_Z8ENCORE_XP_F1680_SERIES_16K=1,_Z8EN

Listing Files

[✓] Generate Assembly Listing Files (.lst)

[ ] Expand Macros

Page Width: 80

Page Length: 56

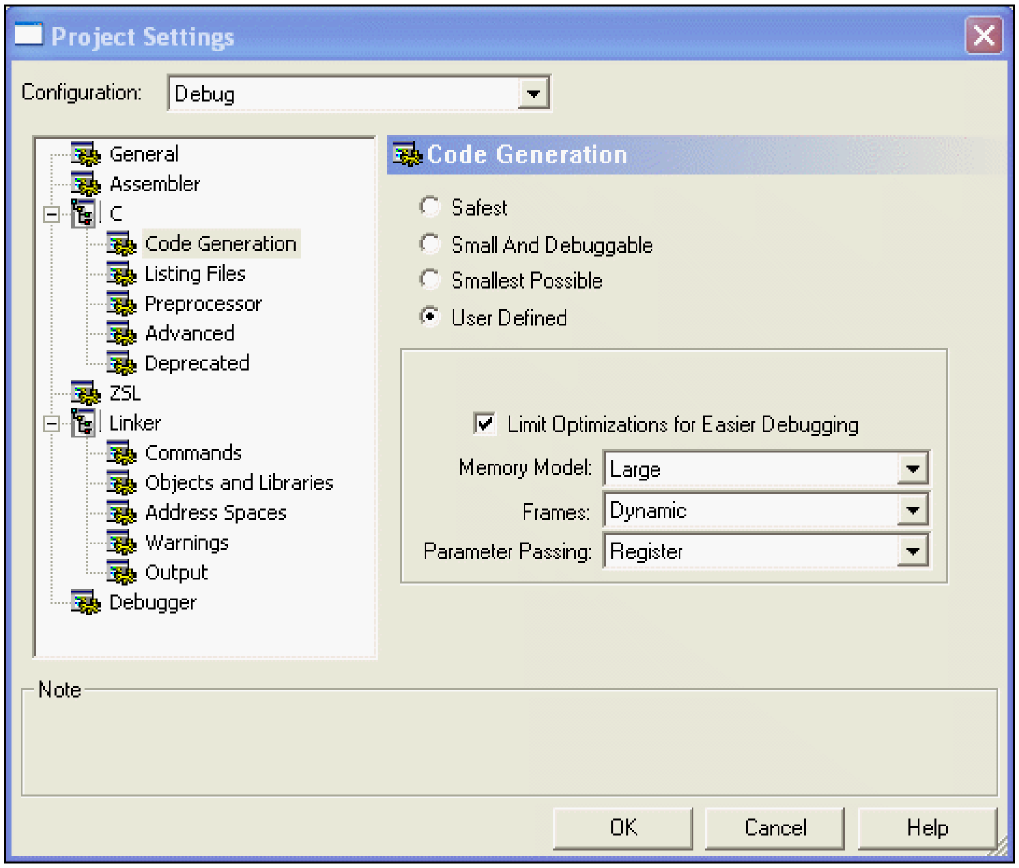
Advanced

[✓] Jump Optimization

Note

Figure 10. Assembler Page of the Project Settings Dialog Box

5. Select the Code Generation page.
6. Make sure that the Limit Optimizations for Easier Debugging check box is selected.



Configuration: Debug

Code Generation

Safest
Small And Debuggable
Smallest Possible
[✓ User Defined]

[✓] Limit Optimizations for Easier Debugging

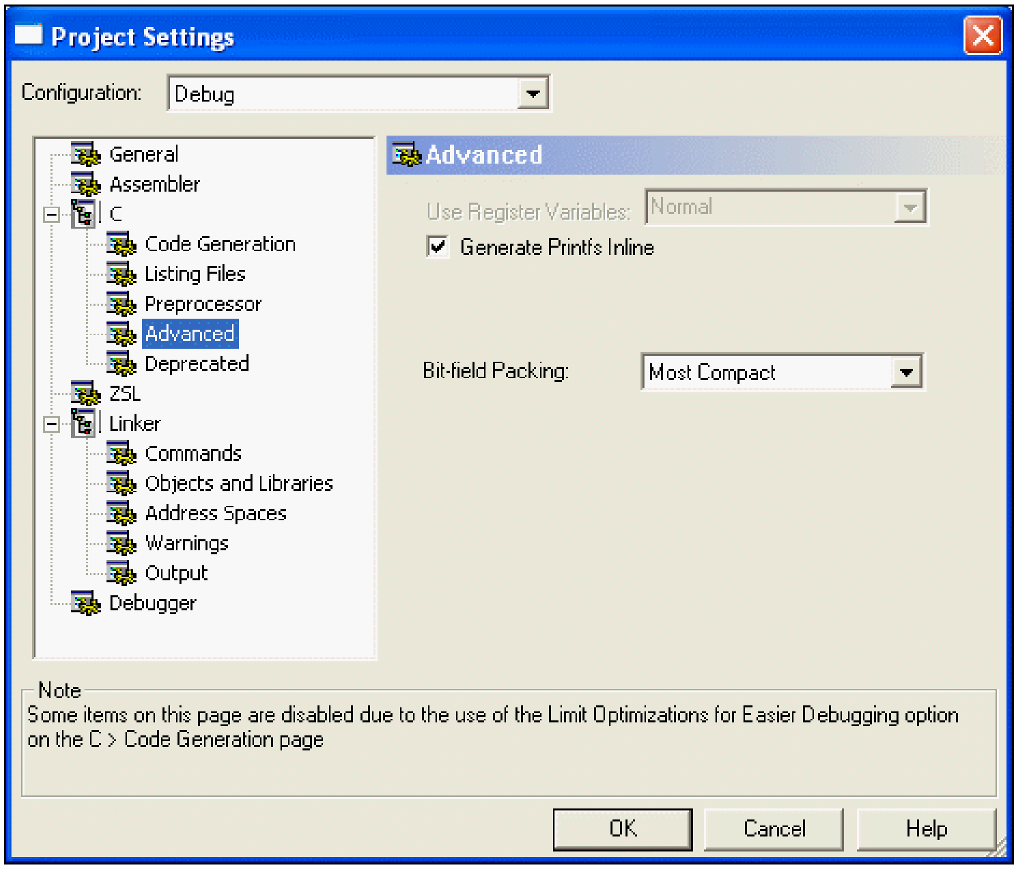
Memory Model: Large

Frames: Dynamic

Parameter Passing: Register

Figure 11. Code Generation Page of the Project Settings Dialog Box

7. Select the Advanced page.
8. Make certain that the Generate Printfs Inline check box is selected.



Configuration: Debug

Use Register Variables: Normal

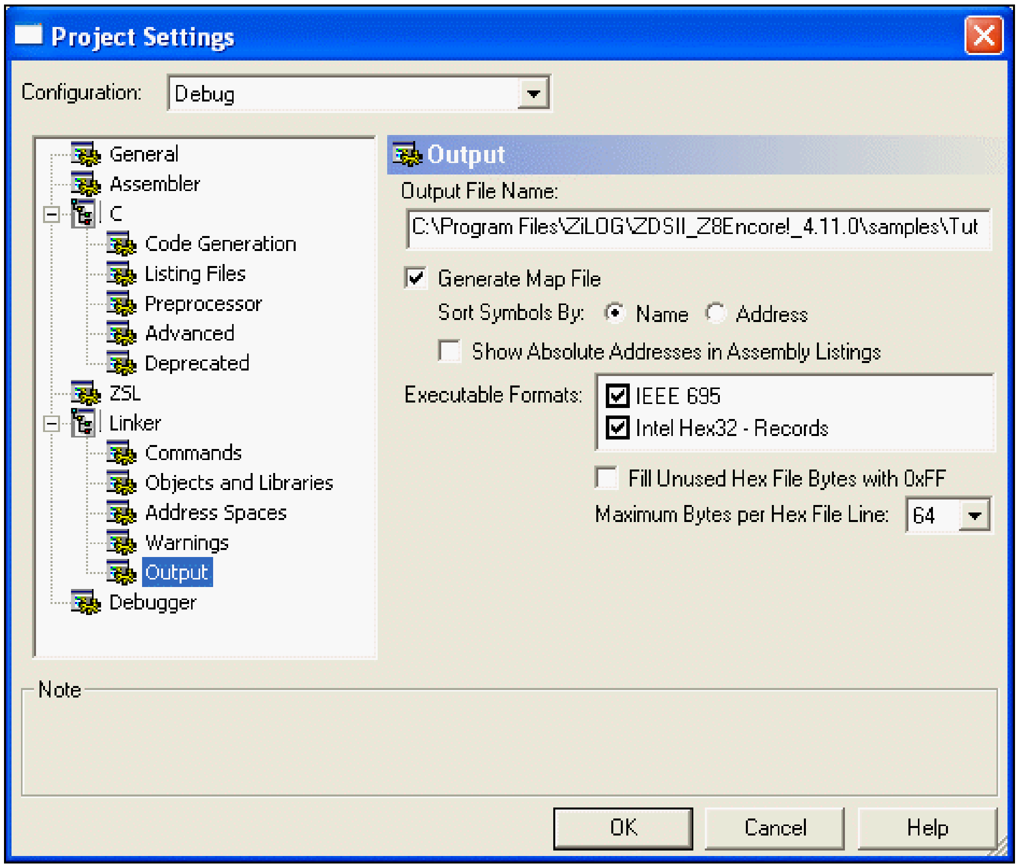
[✓] Generate Printfs Inline

Bit-field Packing: Most Compact

Note
Some items on this page are disabled due to the use of the Limit Optimizations for Easier Debugging option on the C > Code Generation page

Figure 12. Advanced Page of the Project Settings Dialog Box

9. Select the Output page.
10. Make certain that both the IEEE 695 and Intel Hex32 - Records check boxes are selected.



Configuration: Debug

Output

Output File Name: C:\Program Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\samples\Tut

[✓] Generate Map File

Sort Symbols By: [● Name] ○ Address

[ ] Show Absolute Addresses in Assembly Listings

Executable Formats: [✓] IEEE 695 [✓] Intel Hex32 - Records

[ ] Fill Unused Hex File Bytes with 0xFF

Maximum Bytes per Hex File Line: 64

Figure 13. Output Page of the Project Settings Dialog Box

The executable format defaults to **IEEE 695** when you create an executable project (`.lod`). To change the executable format, see “Linker: Output Page” on page 93.

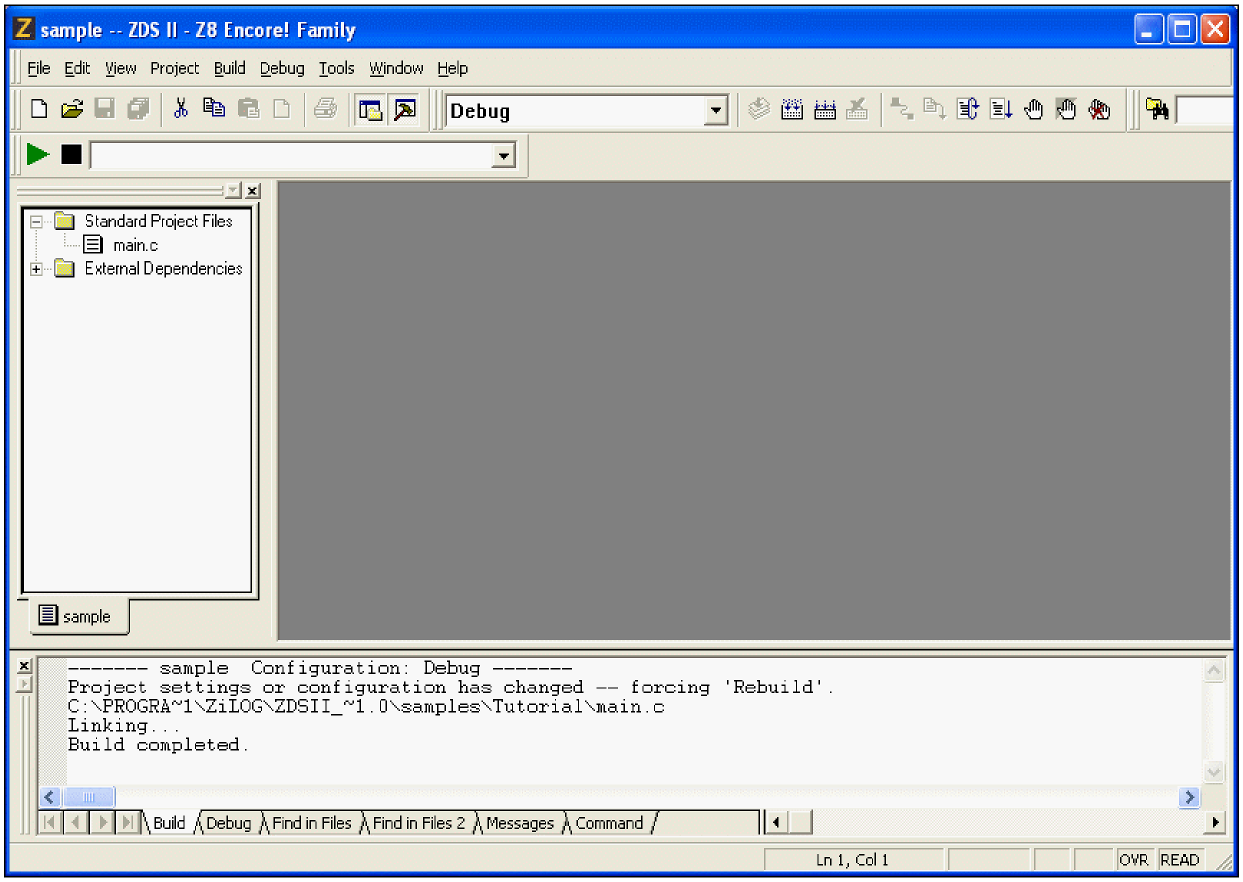
11. Click **OK** to save all the settings on the Project Settings dialog box.

    The Development Environment prompts you to build the project when changes are made to the project settings that would effect the resulting build program. The message is as follows: “`The project settings have changed since the last build. Would you like to rebuild the affected files?`”

12. Click **Yes** to build the project.

    The developer’s environment builds the `sample` project.

13. Watch the compilation process in the Build Output window.


sample -- ZDS II - Z8 Encore! Family
File Edit View Project Build Debug Tools Window Help
Debug
Standard Project Files
main.c
External Dependencies
sample
Build Debug Find in Files Find in Files 2 Messages Command
Ln 1, Col 1
OVR READ

```
------- sample  Configuration: Debug -------
Project settings or configuration has changed -- forcing 'Rebuild'.
C:\PROGRA~1\ZiLOG\ZDSII_~1.0\samples\Tutorial\main.c
Linking...
Build completed.
```

Figure 14. Build Output Window

When the `Build completed` message is displayed in the Build Output window, you have successfully built the sample project and created a `sample.lod` file to debug.

Save the Project

You need to save your project. From the File menu, select **Save Project**.

Using the Integrated Development Environment

The following sections discuss how to use the integrated development environment (IDE):

- "Toolbars" on page 16
- "Windows" on page 29
- "Menu Bar" on page 37
- "Shortcut Keys" on page 129

To effectively understand how to use the developer's environment, be sure to go through the tutorial in "Getting Started" on page 1.

After the discussion of the toolbars and windows, this section discusses the menu bar from left to right—File, Edit, View, Project, Build, Debug, Tools, Window, and Help—and the dialog boxes accessed from the menus. For example, the Project Settings dialog box is discussed as a part of the Project menu section.

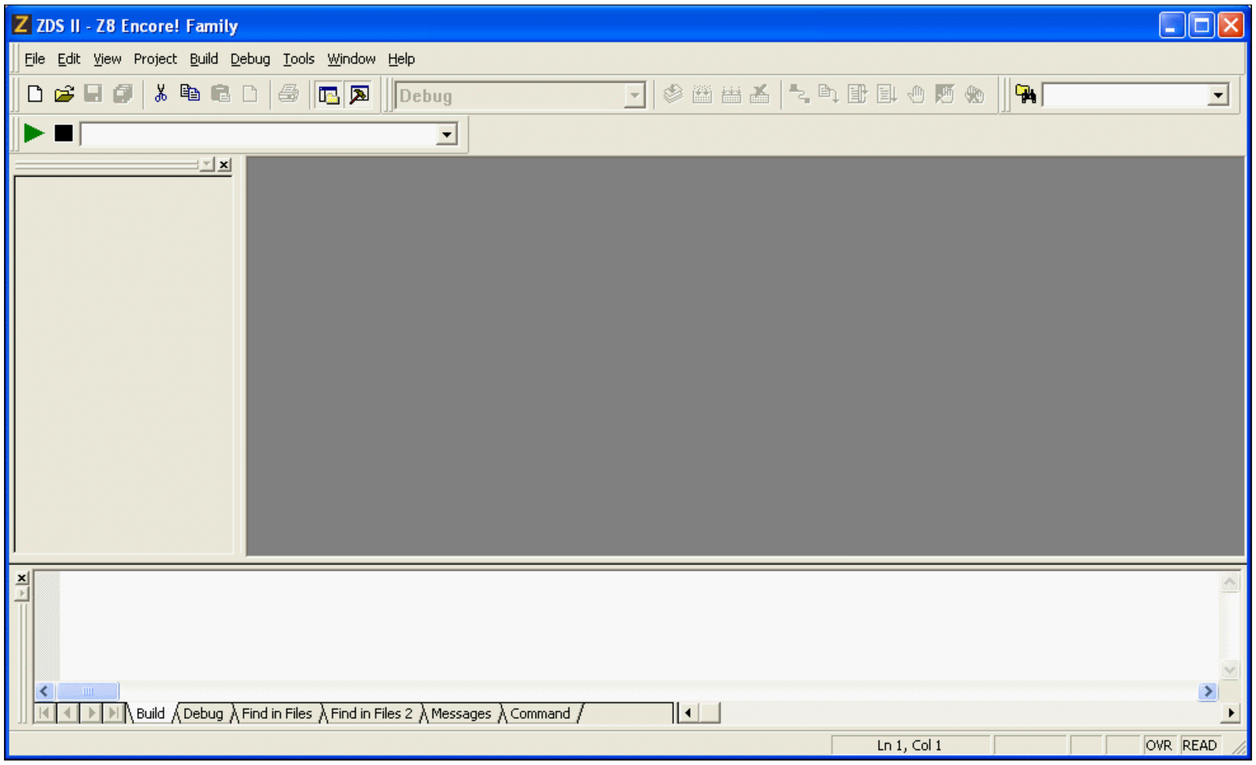

ZDS II - Z8 Encore! Family
File Edit View Project Build Debug Tools Window Help
Debug
Build
Debug
Find in Files
Find in Files 2
Messages
Command
Ln 1, Col 1
OVR
READ

Figure 15. Z8 Encore! Integrated Development Environment Window

For a table of all the shortcuts used in the Z8 Encore! developer's environment, see "Shortcut Keys" on page 129.

TOOLBARS

The toolbars give you quick access to most features of the Z8 Encore! developer's environment. You can use these buttons to perform any task.

NOTE: There are cue cards for the toolbars. As you move the mouse pointer across the toolbars, the main function of the button is displayed. Also, you can drag and move the toolbars to different areas on the screen.

The following toolbars are available:

- "File Toolbar" on page 16
- "Build Toolbar" on page 18
- "Find Toolbar" on page 21
- "Command Processor Toolbar" on page 22
- "Bookmarks Toolbar" on page 22
- "Debug Toolbar" on page 23
- "Debug Windows Toolbar" on page 27

NOTE: For more information on Debugging, see "Using the Debugger" on page 309.

File Toolbar

The File toolbar allows you to perform basic functions with your files using the following buttons:

- "New Button" on page 17
- "Open Button" on page 17
- "Save Button" on page 17
- "Save All Button" on page 17
- "Cut Button" on page 17
- "Copy Button" on page 17
- "Paste Button" on page 17
- "Delete Button" on page 17
- "Print Button" on page 17
- "Workspace Window Button" on page 17

- “Output Window Button” on page 18

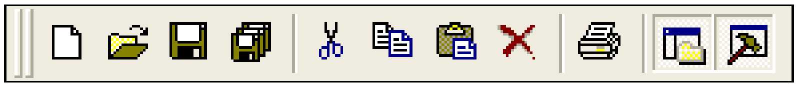


Figure 16. File Toolbar

New Button

The New button creates a new file.

Open Button

The Open button opens an existing file.

Save Button

The Save button saves the active file.

Save All Button

The Save All button saves all open files and the currently loaded project.

Cut Button

The Cut button deletes selected text from the active file and puts it on the Windows clipboard.

Copy Button

The Copy button copies selected text from the active file and puts it on the Windows clipboard.

Paste Button

The Paste button pastes the current contents of the clipboard into the active file at the current cursor position.

Delete Button

The Delete button deletes selected text from the active file.

Print Button

The Print button prints the active file.

Workspace Window Button

The Workspace Window button shows or hides the Project Workspace window.

Output Window Button

The Output Window button shows or hides the Output window.

Build Toolbar

The Build toolbar allows you to build your project, set breakpoints, and select a project configuration with the following controls and buttons:

- "Select Build Configuration List Box" on page 18
- "Compile/Assemble File Button" on page 18
- "Build Button" on page 18
- "Rebuild All Button" on page 18
- "Stop Build Button" on page 19
- "Connect to Target Button" on page 19
- "Download Code Button" on page 19
- "Reset Button" on page 25
- "Go Button" on page 20
- "Insert/Remove Breakpoint Button" on page 21
- "Enable/Disable Breakpoint Button" on page 21
- "Remove All Breakpoints Button" on page 21

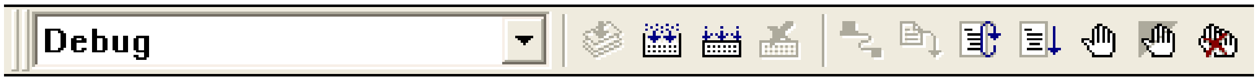


Figure 17. Build Toolbar

Select Build Configuration List Box

The Select Build Configuration drop-down list box lets you activate the build configuration for your project. See "Set Active Configuration" on page 103 for more information.

Compile/Assemble File Button

The Compile/Assemble File button compiles or assembles the active source file.

Build Button

The Build button builds your project by compiling and/or assembling any files that have changed since the last build and then links the project.

Rebuild All Button

The Rebuild All button rebuilds all files and links the project.

Stop Build Button

The Stop Build button stops a build in progress.

Connect to Target Button

The Connect to Target button starts a debug session using the following process:

1. Initializes the communication to the target hardware.
2. Resets the device.
3. Configures the device using the settings in the Configure Target dialog box.
4. Configures and executes the debugger options selected in the Debugger tab of the Options dialog box. The following options are ignored if selected:
   – Reset to Symbol 'main' (Where Applicable) check box
   – Verify File Downloads—Read After Write check box
   – Verify File Downloads—Upon Completion check box

This button does not download the software. Use this button to access target registers, memory, and so on without loading new code or to avoid overwriting the target's code with the same code. This button is not enabled when the target is the simulator. This button is available only when not in Debug mode.

For the Serial Smart Cable, ZDS II performs an on-chip debugger reset and resets the CPU at the vector reset location.

Download Code Button

The Download Code button downloads the executable file for the currently open project to the target for debugging. The button also initializes the communication to the target hardware if it has not been done yet. Starting in version 4.10.0, the Download Code button can also program Flash memory. A page erase is done instead of a mass erase for both internal and external Flash memory. Use this button anytime during a debug session. This button is not enabled when the target is the simulator.

NOTE: The current code on the target is overwritten.

If ZDS II is not in Debug mode when the Download Code button is clicked, the following process is executed:

1. Initializes the communication to the target hardware.
2. Resets the device with a hardware reset by driving pin #2 of the debug header low.
3. Configures the device using the settings in the Configure Target dialog box.
4. Downloads the program.
5. Issues a software reset through the debug header serial interface.

6. Configures and executes the debugger options selected in the Debugger tab of the Options dialog box. If it is a C project, ZDS II resets to the main function if it is found.

If ZDS II is already in Debug mode when the Download Code button is clicked, the following process is executed:

1. Resets the device using a software reset.
2. Downloads the program.

You might need to reset the device before execution because the program counter might have been changed after the download.

Reset Button

Click the Reset button in the Build or Debug toolbar to reset the program counter to the beginning of the program.

If ZDS II is not in Debug mode, the Reset button starts a debug session using the following process:

1. Initializes the communication to the target hardware.
2. Resets the device.
3. Configures the device using the settings in the Configure Target dialog box.
4. Downloads the program.
5. Configures and executes the debugger options selected in the Debugger tab of the Options dialog box. If it is a C project, ZDS II resets to the main function if it is found.

If ZDS II is already in Debug mode, the Reset button uses the following process:

1. ZDS II performs a hardware reset.
2. Configures the device using the settings in the Configure Target dialog box.
3. If files have been modified, ZDS II asks, “Would you like to rebuild the project?” before downloading the modified program. If there has been no file modification, the code is not reloaded.

For the Serial Smart Cable, ZDS II performs an on-chip debugger reset.

Go Button

Click the Go button to execute project code from the current program counter.

If not in Debug mode when the Go button is clicked, the following process is executed:

1. Initializes the communication to the target hardware.
2. Resets the device.
3. Configures the device using the settings in the Configure Target dialog box.

4. Downloads the program.
5. Configures and executes the debugger options selected in the Debugger tab of the Options dialog box. If it is a C project, ZDS II resets to the main function if it is found.
6. Executes the program from the reset location.

Insert/Remove Breakpoint Button

The Insert/Remove Breakpoint button sets a new breakpoint or removes an existing breakpoint at the line containing the cursor in the active file or the Disassembly window. A breakpoint must be placed on a valid code line (a C source line with a blue dot displayed in the gutter or any instruction line in the Disassembly window). For more information on breakpoints, see “Using Breakpoints” on page 326.

Enable/Disable Breakpoint Button

The Enable/Disable Breakpoint button activates or deactivates the existing breakpoint at the line containing the cursor in the active file or the Disassembly window. A red octagon indicates an enabled breakpoint; a white octagon indicates a disabled breakpoint. For more information on breakpoints, see “Using Breakpoints” on page 326.

Remove All Breakpoints Button

The Remove All Breakpoints button deletes all breakpoints in the currently loaded project. To deactivate breakpoints in your program, use the Disable All Breakpoints button.

Find Toolbar

The Find toolbar provides access to text search functions with the following controls:

- “Find in Files Button” on page 21
- “Find Field” on page 21

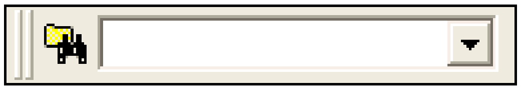


Figure 18. Find Toolbar

Find in Files Button

This button opens the Find in Files dialog box, allowing you to search for text in multiple files.

Find Field

To locate text in the active file, type the text in the Find field and press the Enter key. The search term is highlighted in the file. To search again, press the Enter key again.

Command Processor Toolbar

The Command Processor toolbar allows you to execute IDE and debugger commands with the following controls:

- "Run Command Button" on page 22
- "Stop Command Button" on page 22
- "Command Field" on page 22

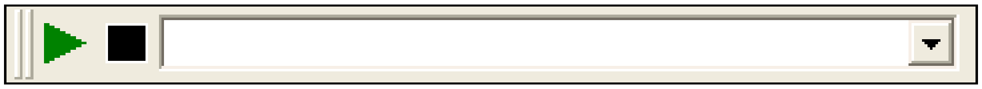


Figure 19. Command Processor Toolbar

See "Supported Script File Commands" on page 413 for a list of supported commands.

Run Command Button

The Run Command button executes the command in the Command field. Output from the execution of the command is displayed in the Command tab of the Output window.

Stop Command Button

The Stop Command button stops any currently running commands.

Command Field

The Command field allows you to enter a new command. Click the Run Command button or press the Enter key to execute the command. Output from the execution of the command is displayed in the Command tab of the Output window.

To modify the width of the Command field, do the following:

1. Select Customize from the Tools menu.
2. Click in the Command field.

   A hatched rectangle highlights the Command field.
3. Use your mouse to select and drag the side of the hatched rectangle.

   The new size of the Command field is saved with the project settings.

Bookmarks Toolbar

The Bookmarks toolbar allows you to set, remove, and find bookmarks with the following buttons:

- "Set Bookmark Button" on page 23
- "Next Bookmark Button" on page 23

- "Previous Bookmark Button" on page 23
- "Delete Bookmarks Button" on page 23

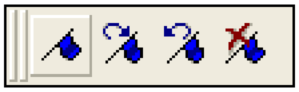


Figure 20. Bookmarks Toolbar

NOTE: This toolbar is not displayed in the default IDE window.

Set Bookmark Button

Click the Set Bookmark button to insert a bookmark in the active file for the line where your cursor is located.

Next Bookmark Button

Click the Next Bookmark button to position the cursor at the line where the next bookmark in the active file is located.

Previous Bookmark Button

Click the Previous Bookmark button to position the cursor at the line where the next bookmark in the active file is located.

Delete Bookmarks Button

Click the Delete Bookmarks button to remove all of the bookmarks in the currently loaded project.

Debug Toolbar

The Debug toolbar allows you to perform debugger functions with the following buttons:

- "Download Code Button" on page 24
- "Verify Download Button" on page 25
- "Reset Button" on page 25
- "Stop Debugging Button" on page 25
- "Go Button" on page 25
- "Run to Cursor Button" on page 26
- "Break Button" on page 26
- "Step Into Button" on page 26
- "Step Over Button" on page 26

- “Step Out Button” on page 26
- “Set Next Instruction Button” on page 26
- “Insert/Remove Breakpoint Button” on page 21
- “Enable/Disable Breakpoint Button” on page 21
- “Disable All Breakpoints Button” on page 27
- “Remove All Breakpoints Button” on page 27

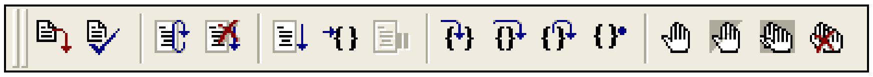


Figure 21. Debug Toolbar

Download Code Button

The Download Code button downloads the executable file for the currently open project to the target for debugging. The button also initializes the communication to the target hardware if it has not been done yet. Starting in version 4.10.0, the Download Code button can also program Flash memory. A page erase is done instead of a mass erase for both internal and external Flash memory. Use this button anytime during a debug session. This button is not enabled when the target is the simulator.

NOTE: The current code on the target is overwritten.

If ZDS II is not in Debug mode when the Download Code button is clicked, the following process is executed:

1. Initializes the communication to the target hardware.
2. Resets the device with a hardware reset by driving pin #2 of the debug header low.
3. Configures the device using the settings in the Configure Target dialog box.
4. Downloads the program.
5. Issues a software reset through the debug header serial interface.
6. Configures and executes the debugger options selected in the Debugger tab of the Options dialog box. If it is a C project, ZDS II resets to the main function if it is found.

If ZDS II is already in Debug mode when the Download Code button is clicked, the following process is executed:

1. Resets the device using a software reset.
2. Downloads the program.

NOTE: You might need to reset the device before execution because the program counter might have been changed after the download.

Verify Download Button

The Verify Download button determines download correctness by comparing executable file contents to target memory.

Reset Button

Click the Reset button in the Build or Debug toolbar to reset the program counter to the beginning of the program.

If ZDS II is not in Debug mode, the Reset button starts a debug session using the following process:

1. Initializes the communication to the target hardware.
2. Resets the device.
3. Configures the device using the settings in the Configure Target dialog box.
4. Downloads the program.
5. Configures and executes the debugger options selected in the Debugger tab of the Options dialog box. If it is a C project, ZDS II resets to the main function if it is found.

If ZDS II is already in Debug mode, the Reset button uses the following process:

1. ZDS II performs a hardware reset.
2. Configures the device using the settings in the Configure Target dialog box.
3. If files have been modified, ZDS II asks, "Would you like to rebuild the project?" before downloading the modified program. If there has been no file modification, the code is not reloaded.

For the Serial Smart Cable, ZDS II performs an on-chip debugger reset.

Stop Debugging Button

The Stop Debugging button ends the current debug session.

To stop program execution, click the Break button.

Go Button

Click the Go button to execute project code from the current program counter.

If not in Debug mode when the Go button is clicked, the following process is executed:

1. Initializes the communication to the target hardware.
2. Resets the device.
3. Configures the device using the settings in the Configure Target dialog box.
4. Downloads the program.

5. Configures and executes the debugger options selected in the Debugger tab of the Options dialog box. If it is a C project, ZDS II resets to the main function if it is found.
6. Executes the program from the reset location.

Run to Cursor Button

The Run to Cursor button executes the program code from the current program counter to the line containing the cursor in the active file or the Disassembly window. The cursor must be placed on a valid code line (a C source line with a blue dot displayed in the gutter or any instruction line in the Disassembly window).

Break Button

The Break button stops program execution at the current program counter.

Step Into Button

The Step Into button executes one statement or instruction from the current program counter, following the execution into function calls. When complete, the program counter resides at the next program statement or instruction unless a function was entered, in which case the program counter resides at the first statement or instruction in the function.

Step Over Button

The Step Over button executes one statement or instruction from the current program counter without following the execution into function calls. When complete, the program counter resides at the next program statement or instruction.

Step Out Button

The Step Out button executes the remaining statements or instructions in the current function and returns to the statement or instruction following the call to the current function.

Set Next Instruction Button

The Set Next Instruction button sets the program counter to the line containing the cursor in the active file or the Disassembly window.

Insert/Remove Breakpoint Button

The Insert/Remove Breakpoint button sets a new breakpoint or removes an existing breakpoint at the line containing the cursor in the active file or the Disassembly window. A breakpoint must be placed on a valid code line (a C source line with a blue dot displayed in the gutter or any instruction line in the Disassembly window). For more information on breakpoints, see “Using Breakpoints” on page 326.

Enable/Disable Breakpoint Button

The Enable/Disable Breakpoint button activates or deactivates the existing breakpoint at the line containing the cursor in the active file or the Disassembly window. A red octagon indicates an enabled breakpoint; a white octagon indicates a disabled breakpoint. For more information on breakpoints, see "Using Breakpoints" on page 326.

Disable All Breakpoints Button

The Disable All Breakpoints button deactivates all breakpoints in the currently loaded project. To delete breakpoints from your program, use the Remove All Breakpoints button.

Remove All Breakpoints Button

The Remove All Breakpoints button deletes all breakpoints in the currently loaded project. To deactivate breakpoints in your program, use the Disable All Breakpoints button.

Debug Windows Toolbar

The Debug Windows toolbar allows you to display the Debug windows with the following buttons:

- "Registers Window Button" on page 27
- "Special Function Registers Window Button" on page 28
- "Clock Window Button" on page 28
- "Memory Window Button" on page 28
- "Watch Window Button" on page 28
- "Locals Window Button" on page 28
- "Call Stack Window Button" on page 28
- "Symbols Window Button" on page 28
- "Disassembly Window Button" on page 28
- "Simulated UART Output Window Button" on page 28

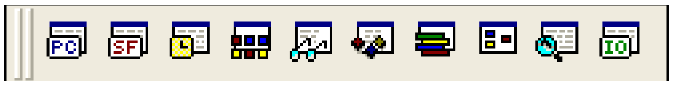


Figure 22. Debug Windows Toolbar

Registers Window Button

The Registers Window button displays or hides the Registers window. This window is described in "Registers Window" on page 312.

Special Function Registers Window Button

The Special Function Registers Window button displays or hides the Special Function Registers window. This window is described in “Special Function Registers Window” on page 313.

Clock Window Button

The Clock Window button displays or hides the Clock window. This window is described in “Clock Window” on page 313.

Memory Window Button

The Memory Window button displays or hides the Memory window. This window is described in “Memory Window” on page 314.

Watch Window Button

The Watch Window button displays or hides the Watch window. This window is described in “Watch Window” on page 320.

Locals Window Button

The Locals Window button displays or hides the Locals window. This window is described in “Locals Window” on page 322.

Call Stack Window Button

The Call Stack Window button displays or hides the Call Stack window. This window is described in “Call Stack Window” on page 323.

Symbols Window Button

The Symbols Window button displays or hides the Symbols window. This window is described in “Symbols Window” on page 324.

Disassembly Window Button

The Disassembly Window button displays or hides the Disassembly window. This window is described in “Disassembly Window” on page 325.

Simulated UART Output Window Button

The Simulated UART Output Window button displays or hides the Simulated UART Output window. This window is described in “Simulated UART Output Window” on page 326.

WINDOWS

The following ZDS II windows allow you to see various aspects of the tools while working with your project:

- "Project Workspace Window" on page 29
- "Edit Window" on page 30
- "Output Windows" on page 35

Project Workspace Window

The Project Workspace window on the left side of the developer's environment allows you to view your project files.

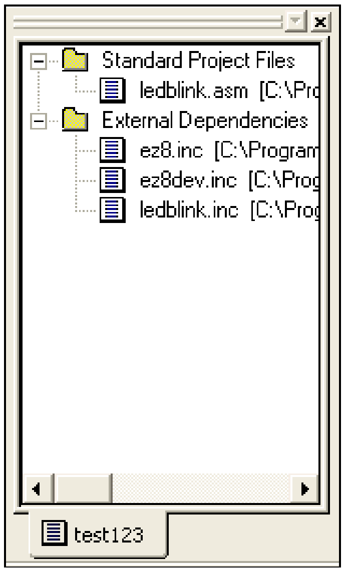


Figure 23. Project Workspace Window for Standard Projects

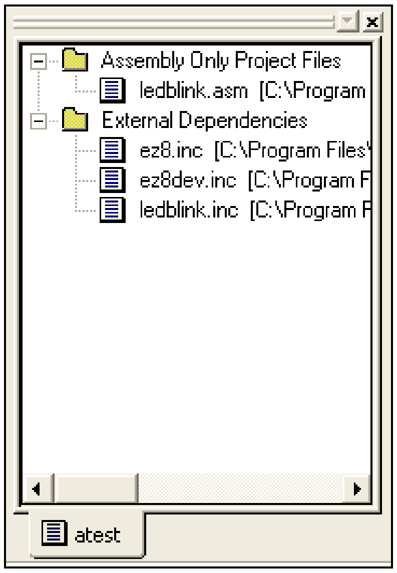

Assembly Only Project Files
ledblink.asm [C:\Program
External Dependencies
ez8.inc [C:\Program Files\
ez8dev.inc [C:\Program F
ledblink.inc [C:\Program F
atest

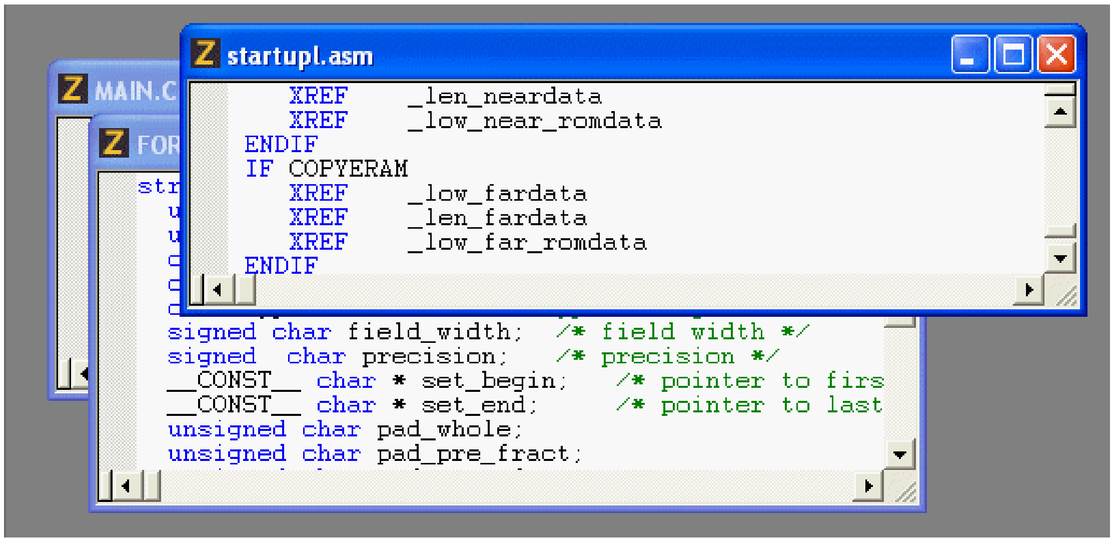
Figure 24. Project Workspace Window for Assembly Only Projects

The Project Workspace window provides access to related functions using context menus. To access context menus, right-click a file or folder in the window. Depending on which file or folder is highlighted, the context menu allows you to do the following:

- Dock the Project Workspace window
- Hide the Project Workspace window
- Add files to the project
- Remove the highlighted file from the project
- Build project files or external dependencies
- Assemble or compile the highlighted file
- Undock the Project Workspace window, allowing it to float in the Edit window

Edit Window

The Edit window on the right side of the developer's environment allows you to edit the files in your project.



```
    XREF     _len_neardata
    XREF     _low_near_romdata
ENDIF
IF COPYERAM
    XREF     _low_fardata
    XREF     _len_fardata
    XREF     _low_far_romdata
ENDIF
```

```
signed char field_width;  /* field width */
signed char precision;   /* precision */
__CONST__ char * set_begin;   /* pointer to firs
__CONST__ char * set_end;     /* pointer to last
unsigned char pad_whole;
unsigned char pad_pre_fract;
```

Figure 25. Edit Window

The Edit window supports the following shortcuts:

Function	Shortcuts
Undo	Ctrl + Z
Redo	Ctrl + Y
Cut	Ctrl + X
Copy	Ctrl + C
Paste	Ctrl + V
Find	Ctrl + F
Repeat the previous search	F3
Go to	Ctrl + G
Go to matching { or }. Place your cursor at the right or left of an opening or closing brace and press Ctrl + E or Ctrl +] to move the cursor to the matching opening or closing brace.	Ctrl + E Ctrl +]

This section covers the following topics:

- "Using the Context Menus" on page 32
- "Using Bookmarks" on page 32

Using the Context Menus

There are two context menus in the Edit window, depending on where you click.

When you right-click in a file, the context menu allows you to do the following (depending on whether you are running in Debug mode):

- Cut, copy, and paste text
- Show whitespace
- Go to the Disassembly window
- Show the program counter
- Insert, edit, enable, disable, or remove breakpoints
- Reset the debugger
- Stop debugging
- Start or continue running the program (Go)
- Run to the cursor
- Pause the debugging (Break)
- Step into, over, or out of program instructions
- Set the next instruction at the current line
- Insert or remove bookmarks (see “Using Bookmarks” on page 32)

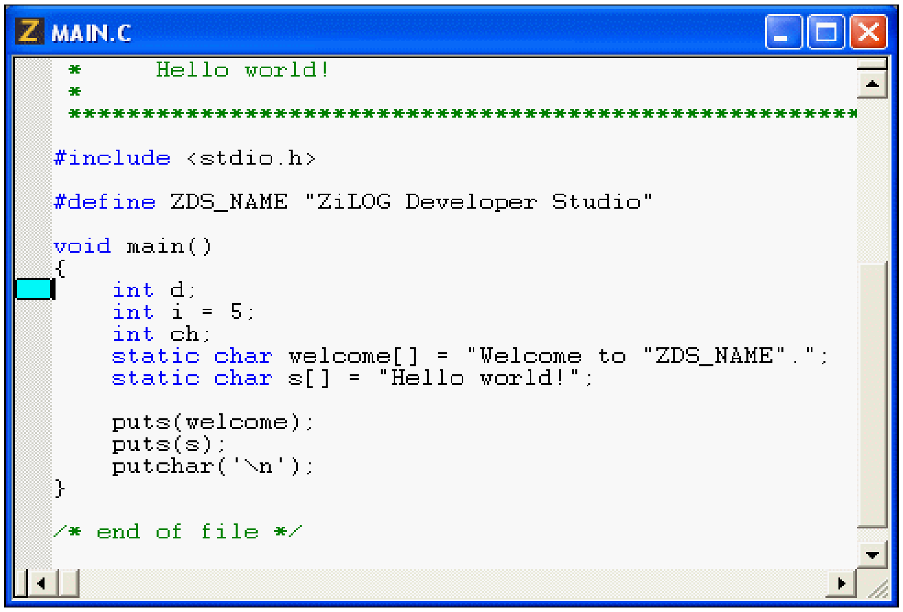
When you right-click outside of all files, the context menu allows you to do the following:

- Show or hide the Output windows, Project Workspace window, status bar, File toolbar, Build toolbar, Find toolbar, Command Processor toolbar, Debug toolbar, Debug Windows toolbar
- Toggle Workbook Mode

  When in Workbook Mode, each open file has an associated tab along the bottom of the Edit windows area.
- Customize the buttons and toolbars

Using Bookmarks

A bookmark is a marker that identifies a position within a file. Bookmarks appear as cyan boxes in the gutter portion (left) of the file window. The cursor can be quickly positioned on a lines containing bookmarks.

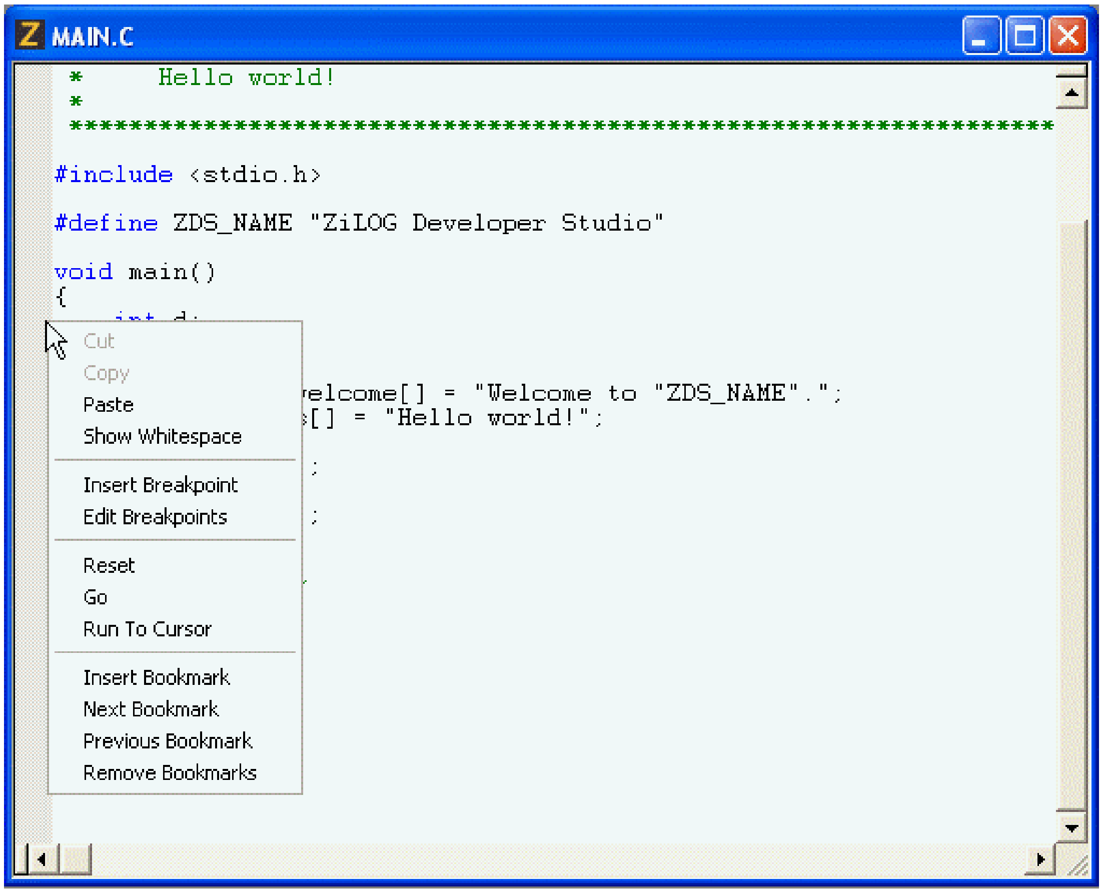


```
 *      Hello world!
 *
 ****************************************************

#include <stdio.h>

#define ZDS_NAME "ZiLOG Developer Studio"

void main()
{
    int d;
    int i = 5;
    int ch;
    static char welcome[] = "Welcome to "ZDS_NAME".";
    static char s[] = "Hello world!";

    puts(welcome);
    puts(s);
    putchar('\n');
}

/* end of file */
```

Figure 26. Bookmark Example

To insert a bookmark, position the cursor on the desired line of the active file and perform one of the following actions:

- Right-click in the Edit window and select **Insert Bookmark** from the resulting context menu.
- Select **Toggle Bookmark** from the Edit menu.
- Type Ctrl+F2.



```
 *      Hello world!
 *
 ***********************************************************************

#include <stdio.h>

#define ZDS_NAME "ZiLOG Developer Studio"

void main()
{
    int d;

              elcome[] = "Welcome to "ZDS_NAME".";
              s[] = "Hello world!";
```

Figure 27. Inserting a Bookmark

To remove a bookmark, position the cursor on the line of the active file containing the bookmark to be removed and perform one of the following actions:

- Right-click in the Edit window and select **Remove Bookmark** from the resulting context menu.
- Select **Toggle Bookmark** from the Edit menu.
- Type Ctrl+F2.

To remove all bookmarks in the active file, right-click in the Edit window and select **Remove Bookmarks** from the resulting context menu.

To remove all bookmarks in the current project, select **Remove All Bookmarks** from the Edit menu.

To position the cursor at the next bookmark in the active file, perform one of the following actions:

- Right-click in the Edit window and select **Next Bookmark** from the resulting context menu.
- Select **Next Bookmark** from the Edit menu.
- Press the F2 key.

  The cursor moves forward through the file, starting at its current position and beginning again when the end of file is reached, until a bookmark is encountered. If no bookmarks are set in the active file, this function has no effect.

To position the cursor at the previous bookmark in the active file, perform one of the following actions:

- Right-click in the Edit window and select **Previous Bookmark** from the resulting context menu.
- Select **Previous Bookmark** from the Edit menu.
- Press Shift+F2.

  The cursor moves backwards through the file, starting at its current position and starting again at the end of the file when the file beginning is reached, until a bookmark is encountered. If no bookmarks are set in the active file, this function has no effect.

Output Windows

The Output windows display output, errors, and other feedback from various components of the Integrated Development Environment.

Select one of the tabs at the bottom of the Output window to select one of following the Output windows:

- “Build Output Window” on page 36
- “Debug Output Window” on page 36
- “Find in Files Output Windows” on page 36
- “Messages Output Window” on page 37
- “Command Output Window” on page 37

To dock the Output window with another window, click and hold the window’s grip bar and then move the window.

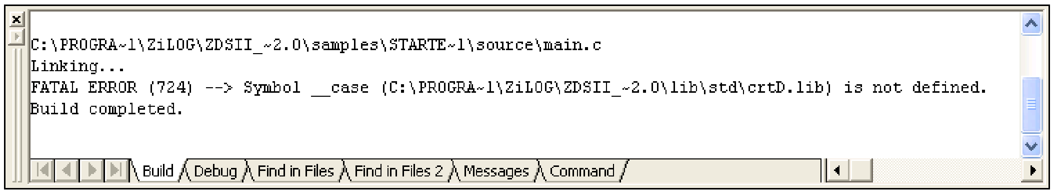
Double-click on the window's grip bar to cause it to become a floating window.

Double-click on the floating window's title bar to change it to a dockable window.

Use the context menu to copy text from or to delete all text in the Output window.

Build Output Window

The Build Output window holds all text messages generated by the compiler, assembler, librarian, and linker, including error and warning messages.

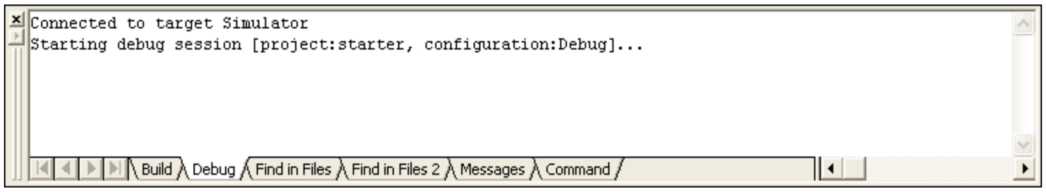


```
C:\PROGRA~1\ZiLOG\ZDSII_~2.0\samples\STARTE~1\source\main.c
Linking...
FATAL ERROR (724) --> Symbol __case (C:\PROGRA~1\ZiLOG\ZDSII_~2.0\lib\std\crtD.lib) is not defined.
Build completed.
```

Figure 28. Build Output Window

Debug Output Window

The Debug Output window holds all text messages generated by the debugger while you are in Debug mode. The Debug Output window also displays the chip revision identifier and the Smart Cable firmware version.

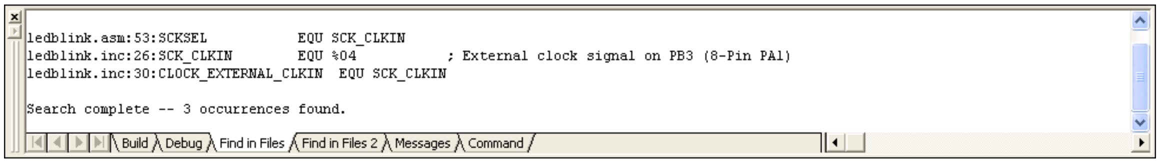


```
Connected to target Simulator
Starting debug session [project:starter, configuration:Debug]...
```

Figure 29. Debug Output Window

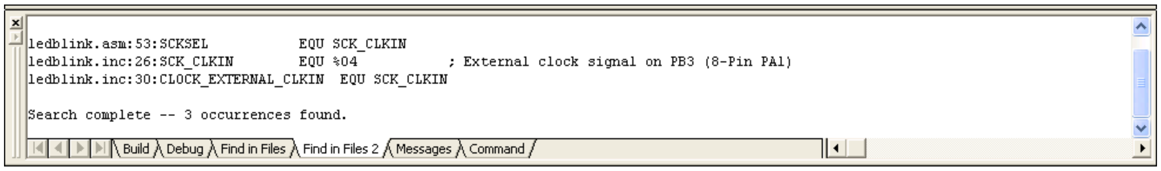
Find in Files Output Windows

The two Find in Files Output windows display the results of the Find in Files command (available from the Edit menu and the Find toolbar). The File in Files 2 window is used when the Output to Pane 2 check box is selected in the Find in File dialog box (see "Find in Files" on page 49).



```
ledblink.asm:53:SCKSEL           EQU SCK_CLKIN
ledblink.inc:26:SCK_CLKIN        EQU %04           ; External clock signal on PB3 (8-Pin PA1)
ledblink.inc:30:CLOCK_EXTERNAL_CLKIN  EQU SCK_CLKIN

Search complete -- 3 occurrences found.
```

Figure 30. Find in Files Output Window

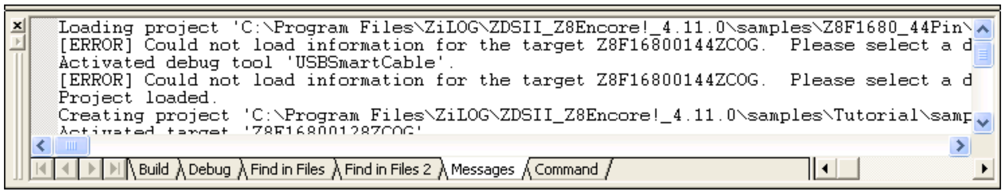


```
ledblink.asm:53:SCKSEL          EQU SCK_CLKIN
ledblink.inc:26:SCK_CLKIN       EQU %04          ; External clock signal on PB3 (8-Pin PA1)
ledblink.inc:30:CLOCK_EXTERNAL_CLKIN  EQU SCK_CLKIN

Search complete -- 3 occurrences found.
```

Figure 31. Find in Files 2 Output Window

Messages Output Window

The Messages Output window holds informational messages intended for the user. The Message Output window is activated (given focus) when error messages are added to the window's display. Warning and informational messages do not automatically activate the Message Output window.

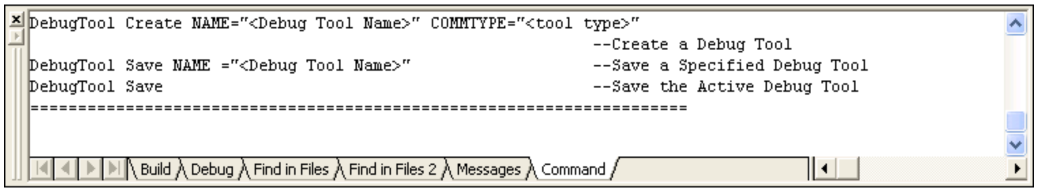


```
Loading project 'C:\Program Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\samples\Z8F1680_44Pin\
[ERROR] Could not load information for the target Z8F16800144ZCOG.  Please select a d
Activated debug tool 'USBSmartCable'.
[ERROR] Could not load information for the target Z8F16800144ZCOG.  Please select a d
Project loaded.
Creating project 'C:\Program Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\samples\Tutorial\samp
Activated target 'Z8F16800128ZCOG'
```

Figure 32. Messages Output Window

Command Output Window

The Command Output window holds the output from the execution of commands.



```
DebugTool Create NAME="<Debug Tool Name>" COMMTYPE="<tool type>"
                                                          --Create a Debug Tool
DebugTool Save NAME ="<Debug Tool Name>"                  --Save a Specified Debug Tool
DebugTool Save                                            --Save the Active Debug Tool
====================================================================
```

Figure 33. Command Output Window

MENU BAR

The menu bar lists menu items that you use in the Z8 Encore! developer's environment. Each menu bar item, when selected, displays a list of selection items. If an option on a menu item ends with an ellipsis (...), selecting the option displays a dialog box. The following items are listed on the menu bar:

- "File Menu" on page 38
- "Edit Menu" on page 47
- "View Menu" on page 53

- “Project Menu” on page 54
- “Build Menu” on page 102
- “Debug Menu” on page 106
- “Tools Menu” on page 110
- “Window Menu” on page 127
- “Help Menu” on page 128

File Menu

The File menu enables you to perform basic commands in the developer’s environment:

- “New File” on page 38
- “Open File” on page 38
- “Close File” on page 39
- “New Project” on page 39
- “Open Project” on page 43
- “Save Project” on page 44
- “Close Project” on page 45
- “Save” on page 45
- “Save As” on page 45
- “Save All” on page 45
- “Print” on page 45
- “Print Preview” on page 46
- “Print Setup” on page 47
- “Recent Files” on page 47
- “Recent Projects” on page 47
- “Exit” on page 47

New File

Select **New File** from the File menu to create a new file in the Edit window.

Open File

Select **Open File** from the File menu to display the Open dialog box, which allows you to open the files for your project.

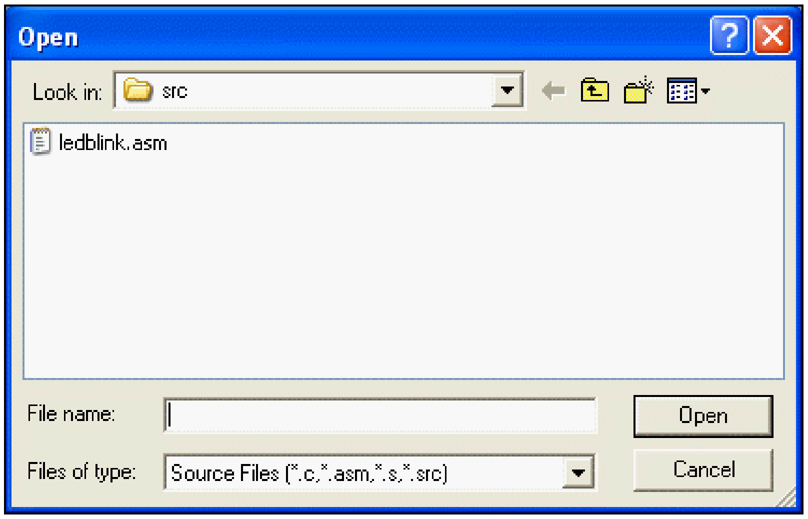


Figure 34. Open Dialog Box

NOTE: To delete a file from your project, use the Open Project dialog box. Highlight the file and press the Delete key. Answer the prompt accordingly.

Close File

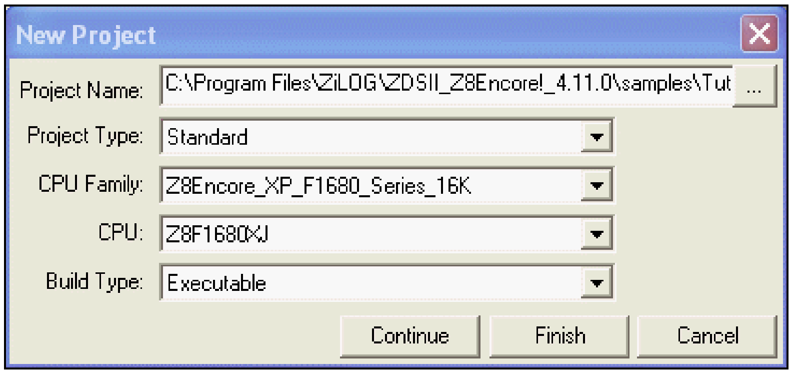
Select **Close File** from the File menu to close the selected file.

New Project

To create a new project, do the following:

1. Select **New Project** from the File menu.

   The New Project dialog box is displayed.



New Project

Project Name: C:\Program Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\samples\Tut

Project Type: Standard

CPU Family: Z8Encore_XP_F1680_Series_16K

CPU: Z8F1680XJ

Build Type: Executable

Figure 35. New Project Dialog Box

2. From the New Project dialog box, click on the Browse button (...) to navigate to the directory where you want to save your project.

   The Select Project Name dialog box is displayed.

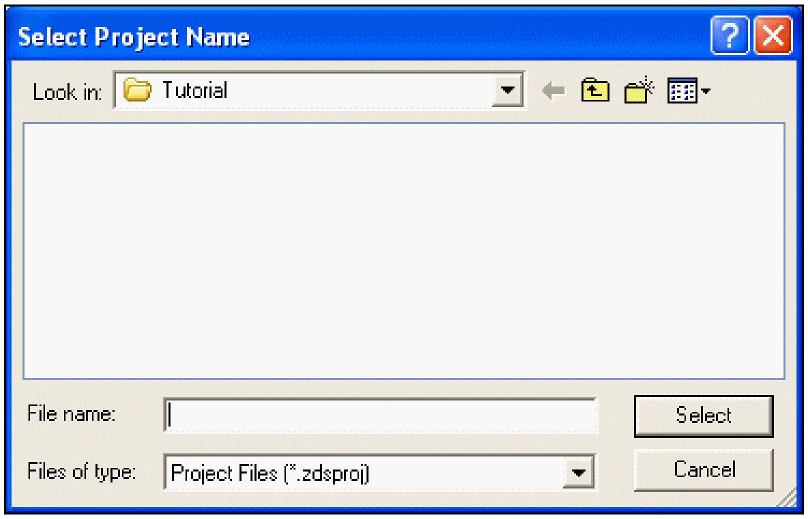


Figure 36. Select Project Name Dialog Box

3. Use the Look In drop-down list box to navigate to the directory where you want to save your project.
4. In the File Name field, type the name of your project.

   You do not have to type the extension `.zdsproj`. The extension is added automatically.

NOTE: The following characters cannot be used in a project name: ( ) $, . - + [ ] ' &

5. Click **Select** to return to the New Project dialog box.
6. In the Project Type field, select **Standard** for a project that will include C language source code. Select **Assembly Only** for a project that will include only assembly source code.
7. In the CPU Family drop-down list box, select a product family.
8. In the CPU drop-down list box, select a CPU.
9. In the Build Type drop-down list box, select **Executable** to build an application or select **Static Library** to build a static library.

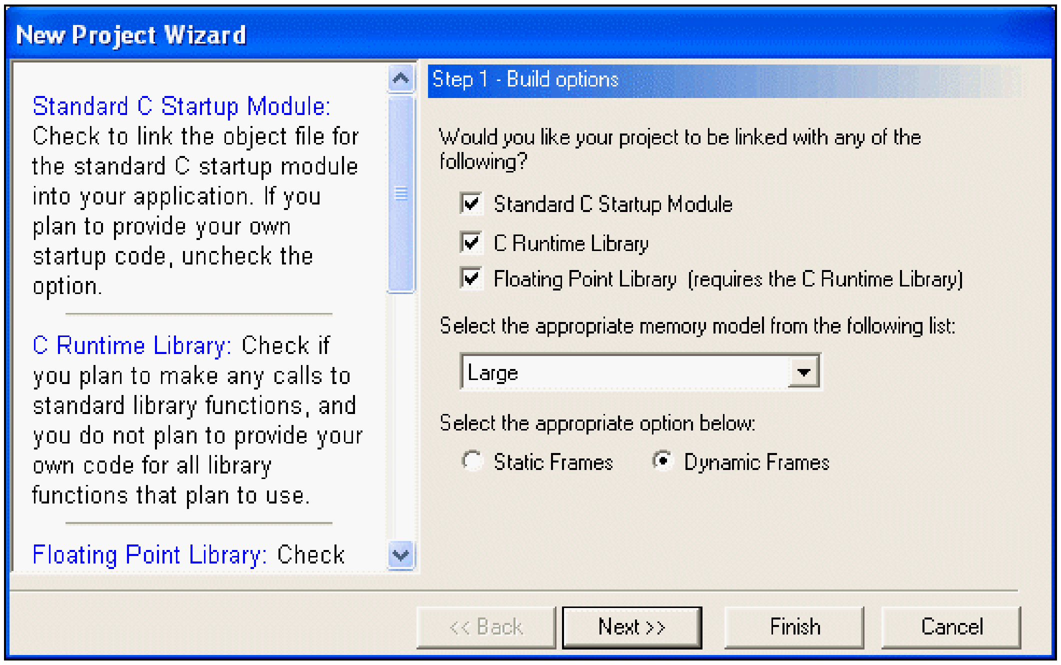
   The default is **Executable**, which creates an IEEE 695 executable format (`.lod`). For more information, see “Linker: Output Page” on page 93.

10. Click **Continue** to change the default project settings using the New Project Wizard.

    To accept all default settings, click **Finish**.

NOTE: For static libraries, click **Finish**.

For a Standard project, the New Project Wizard dialog box is displayed. For Assembly-Only executable projects, continue to step 12.



Standard C Startup Module: Check to link the object file for the standard C startup module into your application. If you plan to provide your own startup code, uncheck the option.

C Runtime Library: Check if you plan to make any calls to standard library functions, and you do not plan to provide your own code for all library functions that plan to use.

Floating Point Library: Check

Step 1 - Build options

Would you like your project to be linked with any of the following?

- [✓] Standard C Startup Module
- [✓] C Runtime Library
- [✓] Floating Point Library (requires the C Runtime Library)

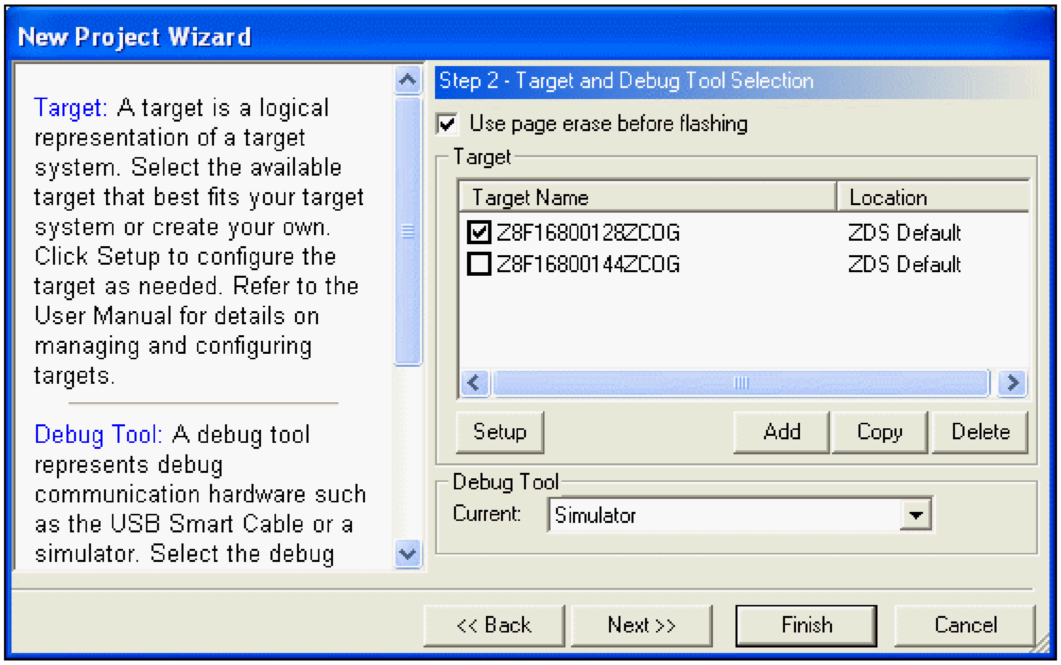
Select the appropriate memory model from the following list: Large

Select the appropriate option below: Static Frames [✓ Dynamic Frames]

Figure 37. New Project Dialog Box—Build Options

11. Select whether your project is linked to the standard C startup module, C run-time library, and floating-point library; select a small or large memory model (see "Memory Models" on page 137); select static or dynamic frames (see "Call Frames" on page 138); and click **Next**.

    For executable projects, the Target and Debug Tool Selection step of the New Project Wizard dialog box is displayed.


New Project Wizard

Target: A target is a logical representation of a target system. Select the available target that best fits your target system or create your own. Click Setup to configure the target as needed. Refer to the User Manual for details on managing and configuring targets.

Debug Tool: A debug tool represents debug communication hardware such as the USB Smart Cable or a simulator. Select the debug

Step 2 - Target and Debug Tool Selection

☑ Use page erase before flashing

Target

Target Name	Location
☑ Z8F1680128ZCOG	ZDS Default
☐ Z8F1680144ZCOG	ZDS Default

Debug Tool
Current: Simulator

Figure 38. New Project Wizard Dialog Box—Target and Debug Tool Selection

12. Select the Use Page Erase Before Flashing check box if you want the internal Flash to be page-erased. Deselect this check box if you want the internal Flash to be mass-erased.
13. Select the appropriate target from the Target list box.
14. Click **Setup** in the Target area.

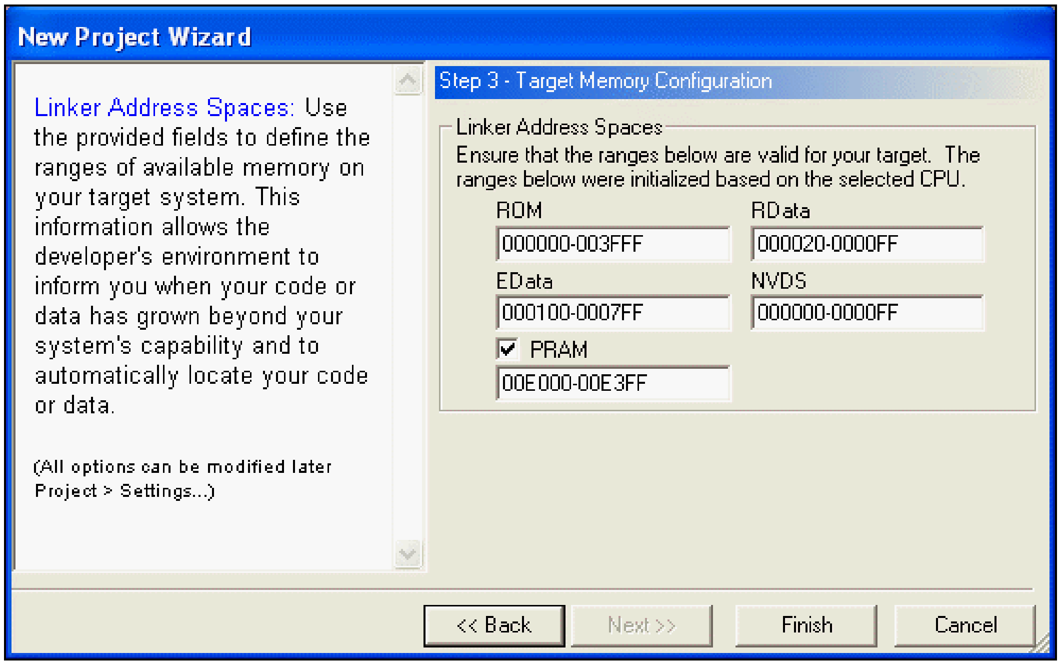
    Refer to “Setup” on page 97 for details on configuring a target.

NOTE: Click **Add** to create a new target (see “Add” on page 98) or click **Copy** to copy an existing target (see “Copy” on page 99).

15. Select the appropriate debug tool and (if you have not selected the Simulator) click **Setup** in the Debug Tool area.

    Refer to “Debug Tool” on page 100 for details about the available debug tools and how to configure them.
16. Click **Next**.

    The Target Memory Configuration step of the New Project Wizard dialog box is displayed.



Linker Address Spaces: Use the provided fields to define the ranges of available memory on your target system. This information allows the developer's environment to inform you when your code or data has grown beyond your system's capability and to automatically locate your code or data.

(All options can be modified later Project > Settings...)

Linker Address Spaces

Ensure that the ranges below are valid for your target. The ranges below were initialized based on the selected CPU.

ROM: 000000-003FFF
RData: 000020-0000FF
EData: 000100-0007FF
NVDS: 000000-0000FF
[✓] PRAM: 00E000-00E3FF

Figure 39. New Project Wizard Dialog Box—Target Memory Configuration

17. Enter the memory ranges appropriate for the target CPU.
18. Click **Finish**.

Open Project

To open an existing project, use the following procedure:

1. Select **Open Project** from the File menu.

   The Open Project dialog box is displayed.

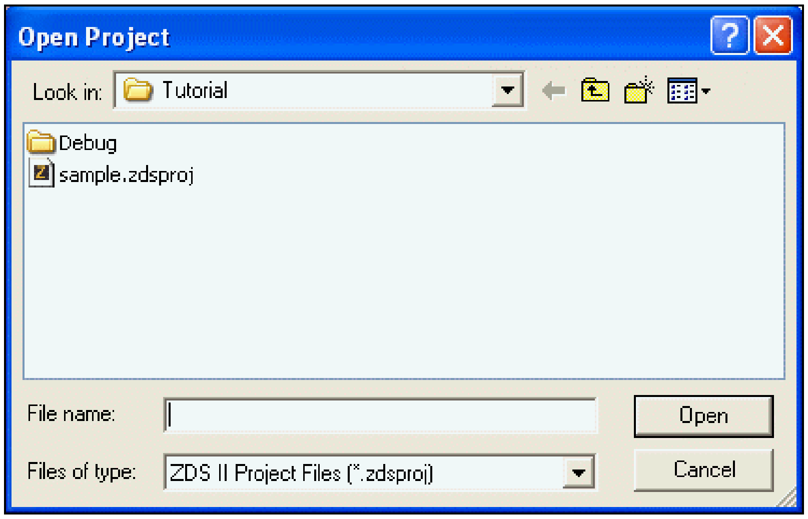


Figure 40. Open Project Dialog Box

2. Use the Look In drop-down list box to navigate to the appropriate directory where your project is located.
3. Select the project to be opened.
4. Click **Open** to open to open your project.

NOTE: To quickly open a project you were working in recently, see "Recent Projects" on page 47.

To delete a project file, use the Open Project dialog box. Highlight the file and press the Delete key. Answer the prompt accordingly.

Save Project

Select **Save Project** from the File menu to save the currently active project. By default, project files and configuration information are saved in a file named <*project name*>`.zdsproj`. An alternate file extension is used if provided when the project is created.

NOTE: The <*project name*>`.zdsproj`.file contains all project data. If deleted, the project is no longer available.

If the Save/Restore Project Workspace check box is selected (see "Options—General Tab" on page 122), a file named <*project name*>`.wsp` is also created or updated with workspace information such as window locations and bookmark details. The `.wsp` file supplements the project information. If it is deleted, the last known workspace data is lost, but this does not affect or harm the project.

Close Project

Select **Close Project** from the File menu to close the currently active project.

Save

Select **Save** from the File menu to save the active file.

Save As

To save a selected file with a new name, perform the following steps:

1. Select **Save As** from the File menu.

   The Save As dialog box is displayed.

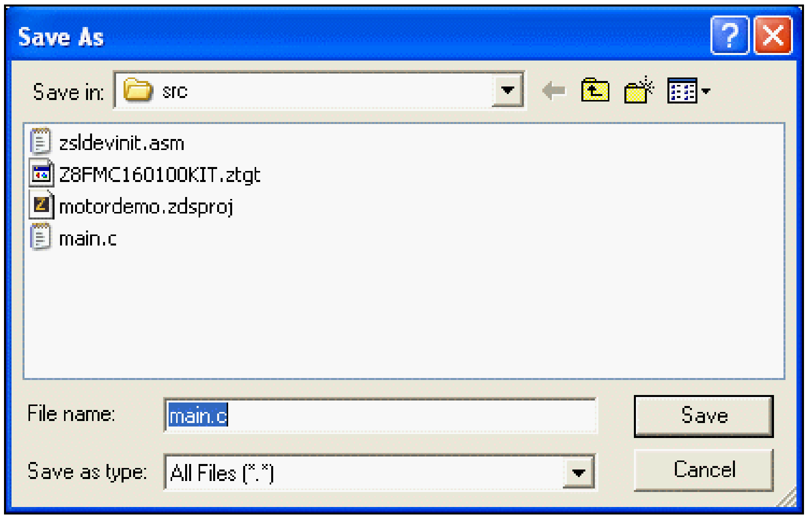


Figure 41. Save As Dialog Box

2. Use the Save In drop-down list box to navigate to the appropriate folder.
3. Enter the new file name in the File Name field.
4. Use the Save as Type drop-down list box to select the file type.
5. Click **Save**.

   A copy of the file is saved with the name you entered.

Save All

Select **Save All** from the File menu to save all open files and the currently loaded project.

Print

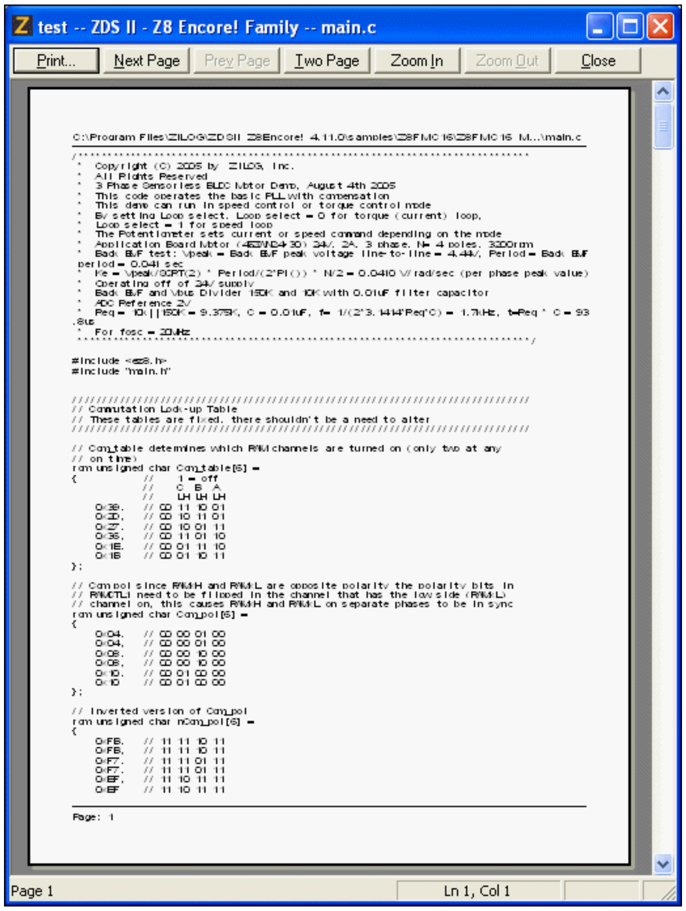
Select **Print** from the File menu to print the active file.

Print Preview

Select **Print Preview** from the File menu to display the file you want to print in Preview mode in a new window.

1. In the Edit window, highlight the file you want to show a Print Preview.
2. From the File menu, select **Print Preview**.

   The file is shown in Print Preview in a new window. As shown in the following figure, `main.c` is in Print Preview mode.



```
C:\Program Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\samples\Z8FMC16\Z8FMC16_M...\main.c
/***************************************************************************
 *   Copyright (C) 2005 by  ZILOG, Inc.
 *   All Rights Reserved
 *   3 Phase Sensorless BLDC Motor Demo, August 4th 2005
 *   This code operates the basic PLL with compensation
 *   This demo can run in speed control or torque control mode
 *   By setting Loop select. Loop select = 0 for torque (current) loop,
 *   Loop select = 1 for speed loop
 *   The Potentiometer sets current or speed command depending on the mode
 *   Application Board Motor ([illegible]) 24V, 2A, 3 phase, N= 4 poles, 3200rpm
 *   Back EMF test: Vpeak = Back EMF peak voltage line-to-line = 4.44V, Period = Back EMF
 period = 0.041 sec
 *   Ke = Vpeak/SQRT(2) * Period/(2*PI()) * N/2 = 0.0410 V/rad/sec (per phase peak value)
 *   Operating off of 24V supply
 *   Back EMF and Vbus Divider 150K and 10K with 0.01uF filter capacitor
 *   ADC Reference 2V
 *   Req = 10k||150K = 9.375K, C = 0.01uF, f= 1/(2*3.1414*Req*C) = 1.7kHz, t=Req * C = 93
.8us
 *   For fosc = 20MHz
 ***************************************************************************/

#include <ez8.h>
#include "main.h"


////////////////////////////////////////////////////////////////////////////////
// Commutation Look-up Table
// These tables are fixed. there shouldn't be a need to alter
////////////////////////////////////////////////////////////////////////////////

// Com_table determines which PWM channels are turned on (only two at any
// on time)
rom unsigned char Com_table[6] =
{           //    1 = off
            //    C  B  A
            //    LH LH LH
    0x39,   // 00 11 10 01
    0x2D,   // 00 10 11 01
    0x27,   // 00 10 01 11
    0x36,   // 00 11 01 10
    0x1E,   // 00 01 11 10
    0x1B    // 00 01 10 11
};

// Com_pol since PWMH and PWML are opposite polarity the polarity bits in
// PWMCTL1 need to be flipped in the channel that has the low side (PWML)
// channel on, this causes PWMH and PWML on separate phases to be in sync
rom unsigned char Com_pol[6] =
{
    0x04,   // 00 00 01 00
    0x04,   // 00 00 01 00
    0x08,   // 00 00 10 00
    0x08,   // 00 00 10 00
    0x10,   // 00 01 00 00
    0x10    // 00 01 00 00
};

// Inverted version of Com_pol
rom unsigned char nCom_pol[6] =
{
    0xFB,   // 11 11 10 11
    0xFB,   // 11 11 10 11
    0xF7,   // 11 11 01 11
    0xF7,   // 11 11 01 11
    0xEF,   // 11 10 11 11
    0xEF    // 11 10 11 11

Page: 1
```

Figure 42. Print Preview Window

3. To print the file, click **Print**.

   To cancel the print preview, click **Close**. The file returns to its edit mode in the Edit window.

Print Setup

Select **Print Setup** from the File menu to display the Print Setup dialog box, which allows you to determine the printer's setup before you print the file.

Recent Files

Select **Recent Files** from the File menu and then select a file from the resulting submenu to open a recently opened file.

Recent Projects

Select **Recent Projects** from the File menu and then select a project file from the resulting submenu to quickly open a recently opened project.

Exit

Select **Exit** from the File menu to exit the application.

Edit Menu

The Edit menu provides access to basic editing, text search, and breakpoint and bookmark manipulation features. The following options are available:

- "Undo" on page 48
- "Redo" on page 48
- "Cut" on page 48
- "Copy" on page 48
- "Paste" on page 48
- "Delete" on page 48
- "Select All" on page 48
- "Show Whitespaces" on page 48
- "Find" on page 48
- "Find Again" on page 49
- "Find in Files" on page 49
- "Replace" on page 50
- "Go to Line" on page 51
- "Manage Breakpoints" on page 52
- "Toggle Bookmark" on page 53
- "Next Bookmark" on page 53

- “Previous Bookmark” on page 53
- “Remove All Bookmarks” on page 53

Undo

Select **Undo** from the Edit menu to undo the last edit made to the active file.

Redo

Select **Redo** from the Edit menu to redo the last edit made to the active file.

Cut

Select **Cut** from the Edit menu to delete selected text from the active file and put it on the Windows clipboard.

Copy

Select **Copy** from the Edit menu to copy selected text from the active file and put it on the Windows clipboard.

Paste

Select **Paste** from the Edit menu to paste the current contents of the clipboard into the active file at the current cursor position.

Delete

Select **Delete** from the Edit menu to delete selected text from the active file.

Select All

Select **Select All** from the Edit menu to highlight all text in the active file.

Show Whitespaces

Select **Show Whitespaces** from the Edit menu to display all whitespace characters like spaces and tabs in the active file.

Find

To find text in the active file, use the following procedure:

1. Select **Find** from the Edit menu.

   The Find dialog box is displayed.

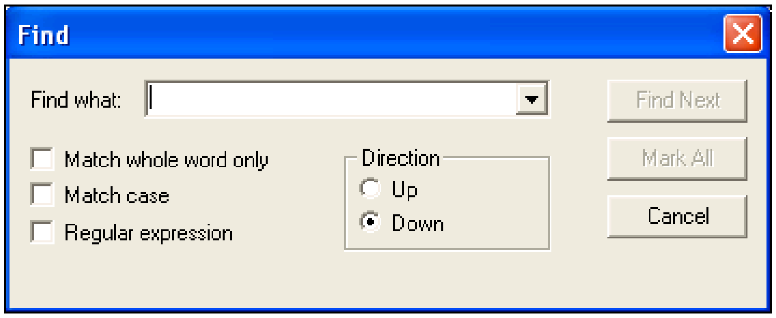


Figure 43. Find Dialog Box

2. Enter the text to search for in the Find What field or select a recent entry from the Find What drop-down list box. (By default, the currently selected text in a source file or the text where your cursor is located in a source file is displayed in the Find What field.)
3. Select the Match Whole Word Only check box if you want to ignore the search text when it occurs as part of longer words.
4. Select the Match Case check box if you want the search to be case sensitive
5. Select the Regular Expression check box if you want to use regular expressions.
6. Select the direction of the search with the Up or Down button.
7. Click **Find Next** to jump to the next occurrence of the search text or click **Mark All** to display a cyan box next to each line containing the search text.

NOTE: After clicking **Find Next**, the dialog box closes. You can press the F3 key or use the **Find Again** command to find the next occurrence of the search term without displaying the Find dialog box again.

Find Again

Select **Find Again** from the Edit menu to continue searching in the active file for text previously entered in the Find dialog box.

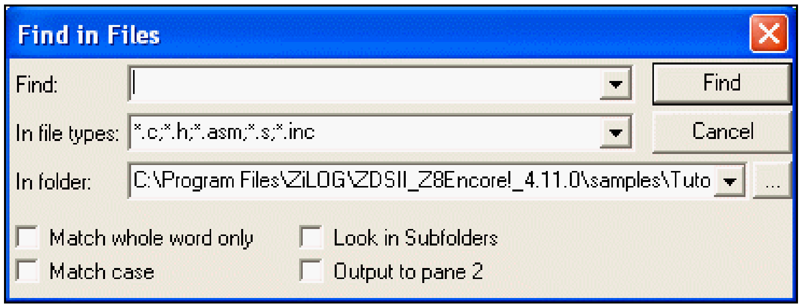
Find in Files

NOTE: This function searches the contents of the files on disk; therefore, unsaved data in open files are not searched.

To find text in multiple files, use the following procedure:

1. Select **Find in Files** from the Edit menu.

   The Find in Files dialog box is displayed.



.c;.h;*.asm;*.s;*.inc

C:\Program Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\samples\Tuto

Figure 44. Find in Files Dialog Box

2. Enter the text to search for in the Find field or select a recent entry from the Find drop-down list box. (If you select text in a source file before displaying the Find dialog box, the text is displayed in the Find field.)
3. Select or enter the file type(s) to search for in the In File Types drop-down list box. Separate multiple file types with semicolons.
4. Use the Browse button (...) or the In Folder drop-down list box to select where the files are located that you want to search.
5. Select the Match Whole Word Only check box if you want to ignore the search text when it occurs as part of longer words.
6. Select the Match Case check box if you want the search to be case sensitive.
7. Select the Look in Subfolders check box if you want to search within subfolders.
8. Select the Output to Pane 2 check box if you want the search results displayed in the Find in Files 2 Output window. If this button is not selected, the search results are displayed in the Find in Files Output window.
9. Click **Find** to start the search.

Replace

To find and replace text in an active file, use the following procedure:

1. Select **Replace** from the Edit menu.

   The Replace dialog box is displayed.

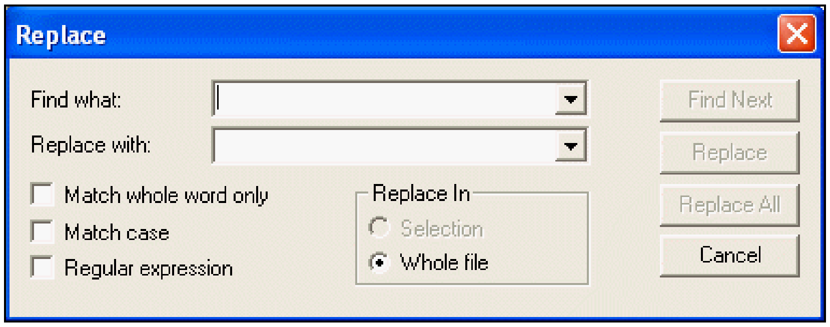


Figure 45. Replace Dialog Box

2. Enter the text to search for in the Find What field or select a recent entry from the Find What drop-down list box. (By default, the currently selected text in a source file or the text where your cursor is located in a source file is displayed in the Find What field.)
3. Enter the replacement text in the Replace With field or select a recent entry from the Replace With drop-down list box.
4. Select the Match Whole Word Only check box if you want to ignore the search text when it occurs as part of longer words.
5. Select the Match Case check box if you want the search to be case sensitive.
6. Select the Regular Expression check box if you want to use regular expressions.
7. Select whether you want the text to be replaced in text currently selected or in the whole file.
8. Click **Find Next** to jump to the next occurrence of the search text and then click **Replace** to replace the highlighted text or click **Replace All** to automatically replace all instances of the search text.

Go to Line

To position the cursor at a specific line in the active file, select **Go to Line** from the Edit menu to display the Go to Line Number dialog box.

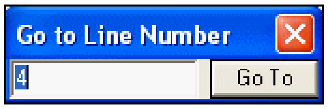
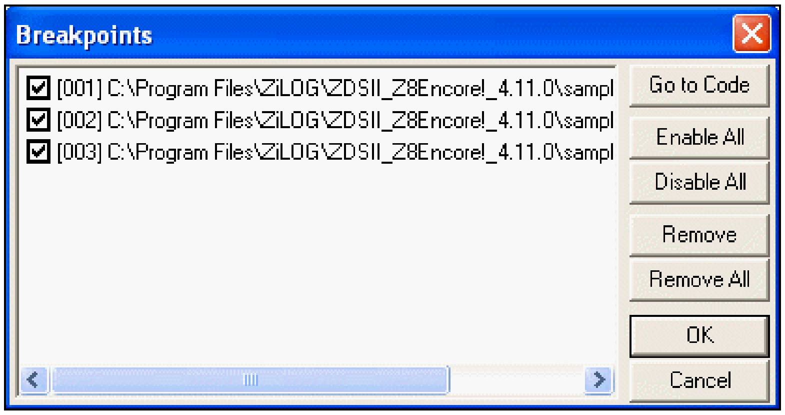


Figure 46. Go to Line Number Dialog Box

Enter the desired line number in the edit field and click **Go To**.

Manage Breakpoints

To view, go to, or remove breakpoints, select **Manage Breakpoints** from the Edit menu. You can access the dialog box during Debug mode and Edit mode.



☑ [001] C:\Program Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\sampl
☑ [002] C:\Program Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\sampl
☑ [003] C:\Program Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\sampl

Figure 47. Breakpoints Dialog Box

The Breakpoints dialog box lists all existing breakpoints for the currently loaded project. A check mark in the box to the left of the breakpoint description indicates that the breakpoint is enabled.

Go to Code

To move the cursor to a particular breakpoint you have set in a file, highlight the breakpoint in the Breakpoints dialog box and click **Go to Code**.

Enable All

To make all listed breakpoints active, click **Enable All**. Individual breakpoints can be enabled by clicking in the box to the left of the breakpoint description. Enabled breakpoints are indicated by a check mark in the box to the left of the breakpoint description.

Disable All

To make all listed breakpoints inactive, click **Disable All**. Individual breakpoints can be disabled by clicking in the box to the left of the breakpoint description. Disabled breakpoints are indicated by an empty box to the left of the breakpoint description.

Remove

To delete a particular breakpoint, highlight the breakpoint in the Breakpoints dialog box and click **Remove**.

Remove All

To delete all of the listed breakpoints, click **Remove All**.

NOTE: For more information on breakpoints, see "Using Breakpoints" on page 326.

Toggle Bookmark

Select **Toggle Bookmark** from the Edit menu to insert a bookmark in the active file for the line where your cursor is located or to remove the bookmark for the line where your cursor is located.

Next Bookmark

Select **Next Bookmark** from the Edit menu to position the cursor at the line where the next bookmark in the active file is located.

NOTE: The search for the next bookmark does not stop at the end of the file; the next bookmark might be the first bookmark in the file.

Previous Bookmark

Select **Previous Bookmark** from the Edit menu to position the cursor at the line where the previous bookmark in the active file is located.

NOTE: The search for the previous bookmark does not stop at the beginning of the file; the previous bookmark might be the last bookmark in the file.

Remove All Bookmarks

Select **Remove All Bookmarks** from the Edit menu to delete all of the bookmarks in the currently loaded project.

View Menu

The View menu allows you to select the windows you want on the Z8 Encore! developer's environment.

The View menu contains these options:

- "Debug Windows" on page 53
- "Workspace" on page 54
- "Output" on page 54
- "Status Bar" on page 54

Debug Windows

When you are in Debug mode (running the debugger), you can select any of the ten Debug windows. From the View menu, select **Debug Windows** and then the appropriate Debug window.

The Debug Windows submenu contains the following:

- "Registers Window" on page 312

- “Special Function Registers Window” on page 313
- “Clock Window” on page 313
- “Memory Window” on page 314
- “Watch Window” on page 320
- “Locals Window” on page 322
- “Call Stack Window” on page 323
- “Symbols Window” on page 324
- “Disassembly Window” on page 325
- “Simulated UART Output Window” on page 326

Workspace

Select **Workspace** from the View menu to display or hide the Project Workspace window.

Output

Select **Output** from the View menu to display or hide the Output windows.

Status Bar

Select **Status Bar** from the View menu to display or hide the status bar, which resides beneath the Output windows.

Project Menu

The Project menu allows you to add to your project, remove files from your project, set configurations for your project, and export a make file.

The Project menu contains the following options:

- “Add Files” on page 54
- “Remove Selected File(s)” on page 55
- “Settings” on page 55
- “Export Makefile” on page 101

Add Files

To add files to your project, use the following procedure:

1. From the Project menu, select **Add Files**.

   The Add Files to Project dialog box is displayed.

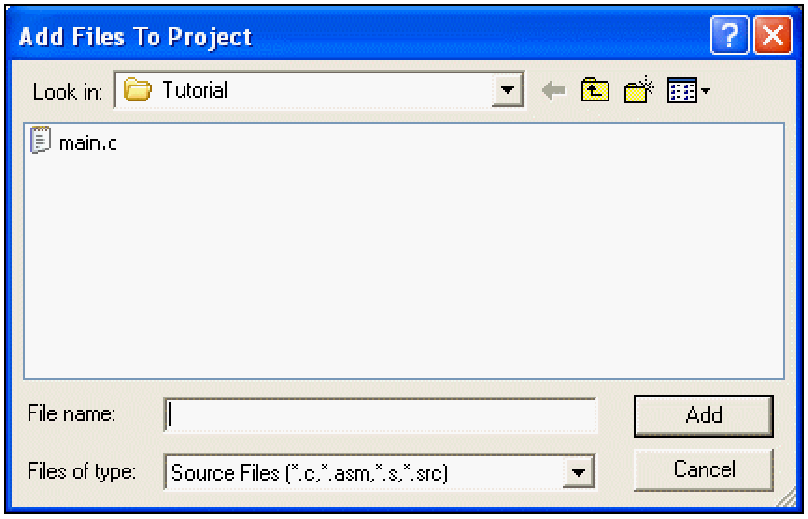


Figure 48. Add Files to Project Dialog Box

2. Use the Look In drop-down list box to navigate to the appropriate directory where the files you want to add are saved.
3. Click on the file you want to add or highlight multiple files by clicking on each file while holding down the Shift or Ctrl key.
4. Click **Add** to add these files to your project.

Remove Selected File(s)

Select **Remove Selected File(s)** from the Project menu to delete highlighted files in the Project Workspace window.

Settings

Select **Settings** from the Project menu to display the Project Settings dialog box, which allows you to change your active configuration as well as set up your project.

Select the active configuration for the project in the Configuration drop-down list box in the upper left corner of the Project Settings dialog box. For your convenience, the Debug and Release configurations are predefined. For more information on project configurations such as adding your own configuration, see “Set Active Configuration” on page 103.

The Project Settings dialog box has different pages you must use to set up the project:

- “General Page” on page 56
- “Assembler Page” on page 59
- “C: Code Generation Page” on page 61 (not available for Assembly Only projects)
- “C: Listing Files Page” on page 65 (not available for Assembly Only projects)

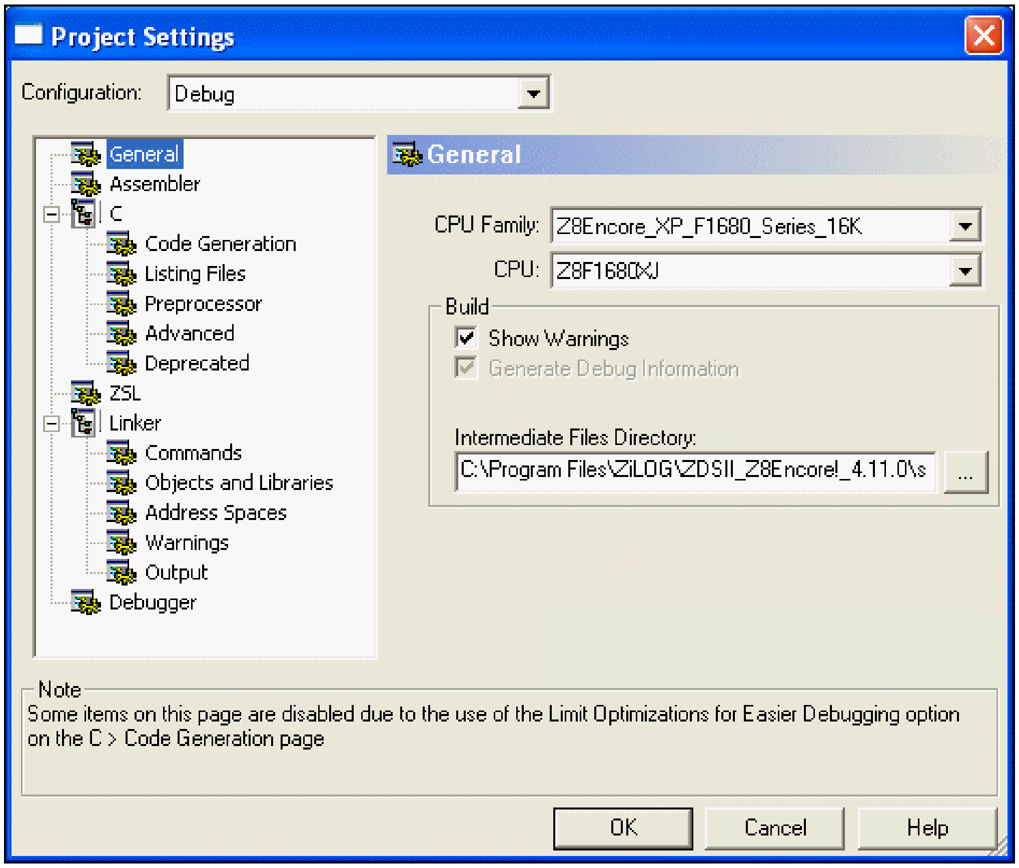
- "C: Preprocessor Page" on page 67 (not available for Assembly Only projects)
- "C: Advanced Page" on page 69 (not available for Assembly Only projects)
- "C: Deprecated Page" on page 72 (not available for Assembly Only projects)
- "Librarian Page" on page 77 (available for Static Library projects only)
- "ZSL Page" on page 78 (not available for Assembly Only projects)
- "Linker: Commands Page" on page 80 (available for Executable projects only)
- "Linker: Objects and Libraries Page" on page 84 (available for Executable projects only)
- "Linker: Address Spaces Page" on page 89 (available for Executable projects only)
- "Linker: Warnings Page" on page 91 (available for Executable projects only)
- "Linker: Output Page" on page 93 (available for Executable projects only)
- "Debugger Page" on page 96 (available for Executable projects only)

The Project Settings dialog box provides various project configuration pages that can be accessed by selecting the page name in the pane on the left side of the dialog box. There are several pages grouped together for the C (Compiler) and Linker that allow you to set up subsettings for those tools.

NOTE: If you change project settings that affect the build, the following message is displayed when you click **OK** to exit the Project Settings dialog box: "`The project settings have changed since the last build. Would you like to rebuild the affected files?`" Click **Yes** to save and then rebuild the project.

General Page

From the Project Settings dialog box, select the General page. The options on the General page are described in this section.



Configuration: Debug

CPU Family: Z8Encore_XP_F1680_Series_16K

CPU: Z8F1680XJ

Build

- [✓] Show Warnings
- [✓] Generate Debug Information

Intermediate Files Directory: C:\Program Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\s

Note
Some items on this page are disabled due to the use of the Limit Optimizations for Easier Debugging option on the C > Code Generation page

Figure 49. General Page of the Project Settings Dialog Box

CPU Family

The CPU Family drop-down list box allows you to select the appropriate Z8 Encore! family. For a list of CPU families, see “Z8 Encore! Product Support” on page xviii.

CPU

The CPU drop-down list box defines which CPU you want to define for the target. For a list of CPUs, see “Z8 Encore! Product Support” on page xviii.

To change the CPU for your project, select the appropriate CPU in the CPU drop-down list box.

NOTE: Selecting a CPU does not automatically select include files for your C or assembly source code. Include files must be manually included in your code. Selecting a new CPU automatically updates the compiler preprocessor defines, assembler defines, and, where necessary, the linker address space ranges and selected debugger target based on the selected CPU.

Show Warnings

The Show Warnings check box controls the display of warning messages during all phases of the build. If the check box is enabled, warning messages from the assembler, compiler, librarian, and linker are displayed during the build. If the check box is disabled, all these warnings are suppressed.

Generate Debug Information

The Generate Debug Information check box makes the build generate debug information that can be used by the debugger to allow symbolic debugging. Enable this option if you are planning to debug your code using the debugger. The check box enables debug information in the assembler, compiler, and linker.

Enabling this option usually increases your overall code size by a moderate amount for two reasons. First, if your code makes any calls to the C run-time libraries, the library version used is the one that was built using the Limit Optimizations for Easier Debugging setting (see the "Limit Optimizations for Easier Debugging" on page 63). Second, the generated code sets up the stack frame for every function in your own program. Many functions (those whose parameters and local variables are not too numerous and do not have their addresses taken in your code) would not otherwise require a stack frame in the Z8 Encore! architecture, so the code for these functions is slightly smaller if this check box is disabled.

NOTE: This check box interacts with the Limit Optimizations for Easier Debugging check box on the Code Generation page (see "Limit Optimizations for Easier Debugging" on page 63). When the Limit Optimizations for Easier Debugging check box is selected, debug information is always generated so that debugging can be performed. The Generate Debug Information check box is grayed out (disabled) when the Limit Optimizations for Easier Debugging check box is selected. If the Limit Optimizations for Easier Debugging check box is later deselected (even in a later ZDS II session), the Generate Debug Information check box returns to the setting it had before the Limit Optimizations for Easier Debugging check box was selected.

Ignore Case of Symbols

When the Ignore Case of Symbols check box is enabled, the assembler and linker ignore the case of symbols when generating and linking code. This check box is occasionally needed when a project contains source files with case-insensitive labels. This check box is only available for Assembly Only projects with no C code.

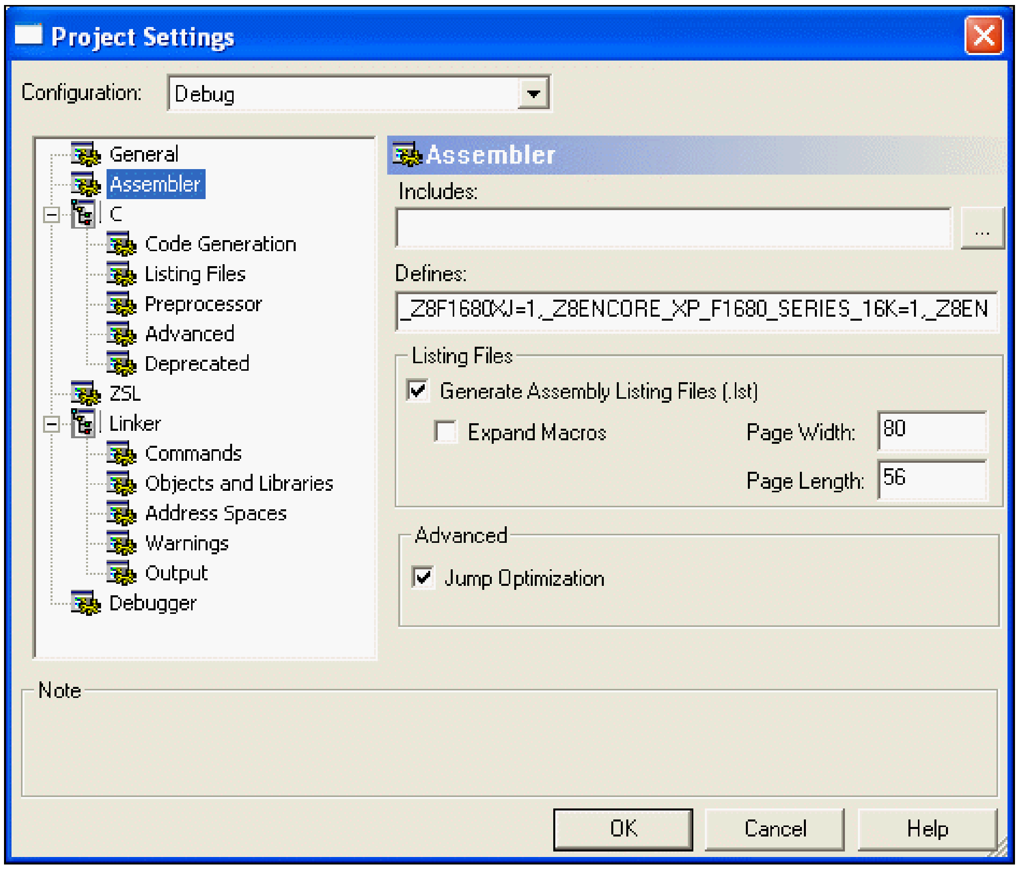
Intermediate Files Directory

This directory specifies the location where all intermediate files produced during the build will be located. These files include make files, object files, and generated assembly source files and listings that are generated from C source code. This field is provided primarily for the convenience of users who might want to delete these files after building a project, while retaining the built executable and other, more permanent files. Those files are placed into a separate directory specified in the Output page (see “Linker: Output Page” on page 93).

Assembler Page

In the Project Settings dialog box, select the Assembler page. The assembler uses the contents of the Assembler page to determine which options are to be applied to the files assembled.

The options on the Assembler page are described in this section.



Configuration: Debug

Includes:

Defines: _Z8F1680XJ=1,_Z8ENCORE_XP_F1680_SERIES_16K=1,_Z8EN

[✓] Generate Assembly Listing Files (.lst)

[ ] Expand Macros

Page Width: 80

Page Length: 56

[✓] Jump Optimization

Figure 50. Assembler Page of the Project Settings Dialog Box

Includes

The Includes field allows you to specify the series of paths for the assembler to use when searching for include files. The assembler first checks the current directory, then the paths in the Includes field, and finally on the default ZDS II include directories.

The following is the ZDS II default include directory:

<*ZDS Installation Directory*>`\include\std`

where <*ZDS Installation Directory*> is the directory in which Zilog Developer Studio was installed. By default, this is

`C:\Program Files\ZiLOG\ZDSII_Z8Encore!_<version>`

where <*version*> might be `4.11.0` or `5.0.0`.

Defines

The Defines field is equivalent to placing <*symbol*> `EQU` <*value*> in your assembly source code. It is useful for conditionally built code. Each defined symbol must have a corresponding value (<*name*>=<*value*>). Multiple symbols can be defined and must be separated by commas.

Generate Assembly Listing Files (.lst)

When selected, the Generate Assembly Listing Files (.lst) check box tells the assembler to create an assembly listing file for each assembly source code module. This file displays the assembly code and directives, as well as the hexadecimal addresses and op codes of the generated machine code. The assembly listing files are saved in the directory specified by the Intermediate Files Directory field in the General page (see "Intermediate Files Directory" on page 58). By default, this check box is selected.

Expand Macros

When selected, the Expand Macros check box tells the assembler to expand macros in the assembly listing file.

Page Width

When the assembler generates the listing file, the Page Width field sets the maximum number of characters on a line. The default is 80; the maximum width is 132.

Page Length

When the assembler generates the listing file, the Page Length field sets the maximum number of lines between page breaks. The default is 56.

Jump Optimization

When selected, the Jump Optimization check box allows the assembler to replace relative jump instructions (JR and DJNZ) with absolute jump instructions when the target label is either

- outside of the +127 to –128 range

  For example, when the target is out of range, the assembler changes

```
DJNZ r0, lab
```

to

```
DJNZ r0, lab1
JR lab2
lab1:JP lab
lab2:
```

- external to the assembly file

  When the target label is external to the assembly file, the assembler always assumes that the target address is out of range.

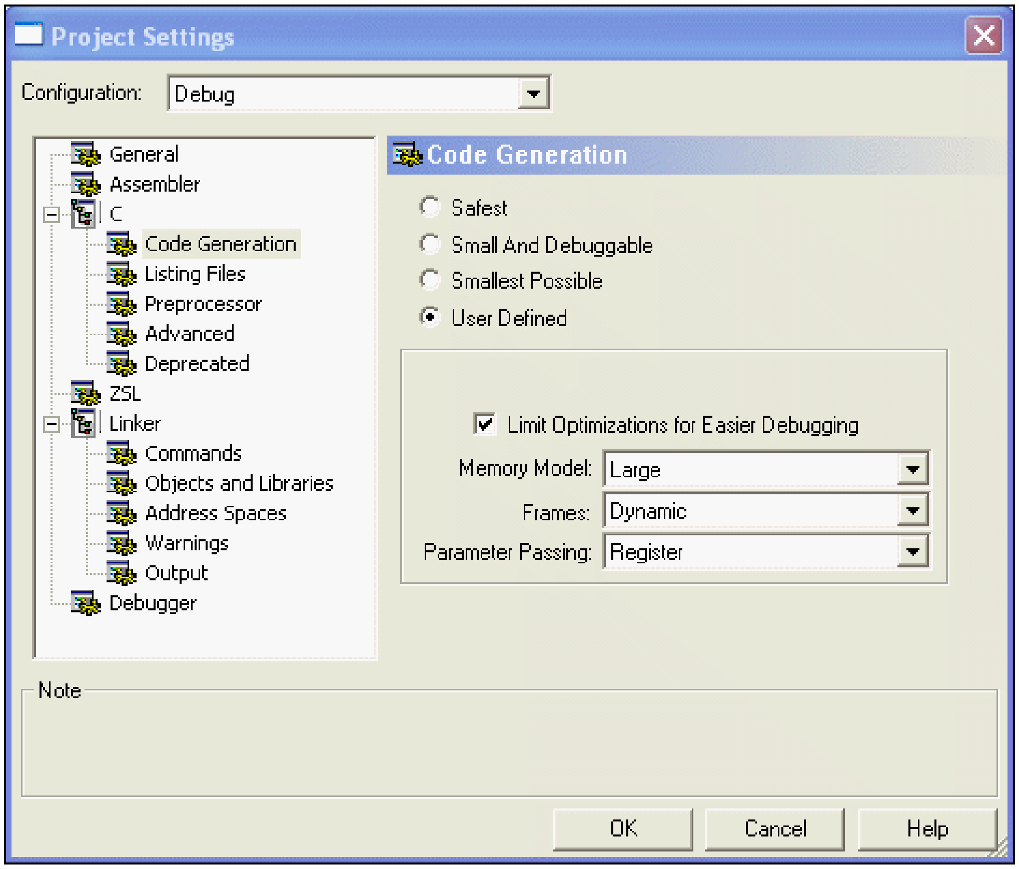
It is usually preferable to allow the assembler to make these replacements because if the target of the jump is out of range, the assembler would otherwise not be able to generate correct code for the jump. However, if you are very concerned about monitoring the code size of your assembled application, you can deselect the Jump Optimization check box. You will then get an error message (from the assembler if the target label is in the same assembly file or from the linker if it is not) every time the assembler is unable to reach the target label with a relative jump. This might give you an opportunity to try to tune your code for greater efficiency.

The default is checked.

C: Code Generation Page

NOTE: For Assembly Only projects, the Code Generation page is not available.

The options in the Code Generation page are described in this section.



Configuration: Debug

( ) Safest
( ) Small And Debuggable
( ) Smallest Possible
(●) User Defined

☑ Limit Optimizations for Easier Debugging

Memory Model: Large
Frames: Dynamic
Parameter Passing: Register

Figure 51. Code Generation Page of the Project Settings Dialog Box

When this page is selected, the fundamental options related to code generation are shown at the bottom of the dialog box: Limit Optimizations for Easier Debugging, Memory Model, and Frames. For convenience, three of the most commonly used combinations of these options can be obtained by clicking one of the radio buttons: Safest, Small and Debuggable, or Smallest Possible. When one of these radio button settings is selected, the fundamental options in the bottom of the dialog box are updated to show their new values, but they are not available for individual editing. To edit the fundamental options individually, select the User Defined button. You can then update the fundamental settings to any combination you like.

Safest

The Safest configuration sets the following values for the individual options: the Limit Optimizations for Easier Debugging check box is selected; the large memory model is used, if available (see "Memory Model" on page 64); the frames are dynamic. This is the "safest possible" configuration in that using the large model avoids possible problems with running out of data space in the small model, and using dynamic frames avoids potential problems with static frames due to the use of recursion or function pointers. Also, because the optimizations are limited, you can proceed to debug your application with ease. However, this configuration definitely produces larger code than other combinations. Many users select this configuration initially when porting applications to Z8 Encore! so that they do not have to worry immediately about whether their projects can meet the requirements for using the small model or static frames. Particularly large and complex applications also often must use this configuration (perhaps deselecting the Limit Optimizations for Easier Debugging check box for production builds).

Small and Debuggable

The Small and Debuggable configuration sets the following values for the individual options: Limit Optimizations for Easier Debugging check box is selected; the memory model is small; the frames are static. This is the same as the Smallest Possible configuration, except that optimizations are reduced to allow easier debugging. The other caveats to using the Smallest Possible configuration also apply to this configuration. If you can meet the other restrictions required by the Smallest Possible configuration, you might find it useful to work with this configuration when you are debugging the code and then switch to the Smallest Possible configuration for a production build.

Smallest Possible

This configuration sets the following values for the individual options: Limit Optimizations for Easier Debugging check box is deselected; the memory model is small; the frames are static. This configuration generates the smallest possible code size, but this configuration does not work for every project. It is your responsibility to make sure these settings will work for you.

There are three issues to be aware of. First, all optimizations are applied, which can make debugging somewhat confusing; if this becomes troublesome, try changing to the Small But Debuggable configuration. Second, the use of the small model restricts the amount of data space that is available, which could cause problems; see “Memory Models” on page 137 for details. Third, static frames can only be used if your entire application obeys certain restrictions, which are described in “Call Frames” on page 138.

User Defined

When the User Defined configuration is selected, the individual settings for the Limit Optimizations for Easier Debugging, Memory Model, and Frames options can be changed individually. This gives you the maximum freedom to set up your project as you choose and to experiment with all possible settings.

Limit Optimizations for Easier Debugging

Selecting this check box causes the compiler to generate code in which certain optimizations are turned off. These optimizations can cause confusion when debugging. For example, they might rearrange the order of instructions so that they are no longer exactly correlated with the order of source code statements or remove code or variables that are not used. You can still use the debugger to debug your code without selecting this check box, but it might difficult because of the changes that these optimizations make in the assembly code generated by the compiler.

Selecting this check box makes it more straightforward to debug your code and interpret what you see in the various Debug windows. However, selecting this check box also causes a moderate increase in code size. Many users select this check box until they are ready to go to production code and then deselect it.

Selecting this check box can also increase the data size required by your application. This happens because this option turns off the use of register variables (see "Use Register Variables" on page 69). The variables that are no longer stored in registers must instead be stored in memory (and on the stack if dynamic frames are in use), thereby increasing the overall data storage requirements of your application. Usually this increase is fairly small.

You *can* debug your application when this check box is deselected. The debugger continues to function normally, but debugging might be more confusing due to the factors described earlier.

NOTE: This check box interacts with the Generate Debug Information check box (see "Generate Debug Information" on page 58).

Memory Model

The Memory Model drop-down list box allows you to choose between the two memory models, **Small** or **Large**. Select **Small** for a small memory model or select **Large** for a large memory model. Using the small model results in more compact code and might reduce the RAM requirements as well. However, the small model places constraints on the data space size (not on the code space size) of your application. Some applications might not be able to fit into the small model's data space size; the large model is provided to support such applications. See "Memory Models" on page 137 for full details of the memory models.

Frames

Select **Static** for static frames or select **Dynamic** for dynamic frames. The use of static frames generally helps reduce code size, but this option can only be used if your code obeys certain restrictions. Specifically, recursive function calls (either direct or indirect) and calls made with function pointers cannot be used with static frames, except by the selective application of the `reentrant` keyword. More detailed information on the tradeoffs between static and dynamic frames can be found in "Call Frames" on page 138.

Parameter Passing

When you select **Memory**, the parameters are placed on the stack for dynamic frame functions. For static frame functions, the parameters are placed in static memory (register file).

See “Function Call Mechanism: Dynamic Frame” on page 152 and “Function Call Mechanism: Static Frame” on page 153 for further details.

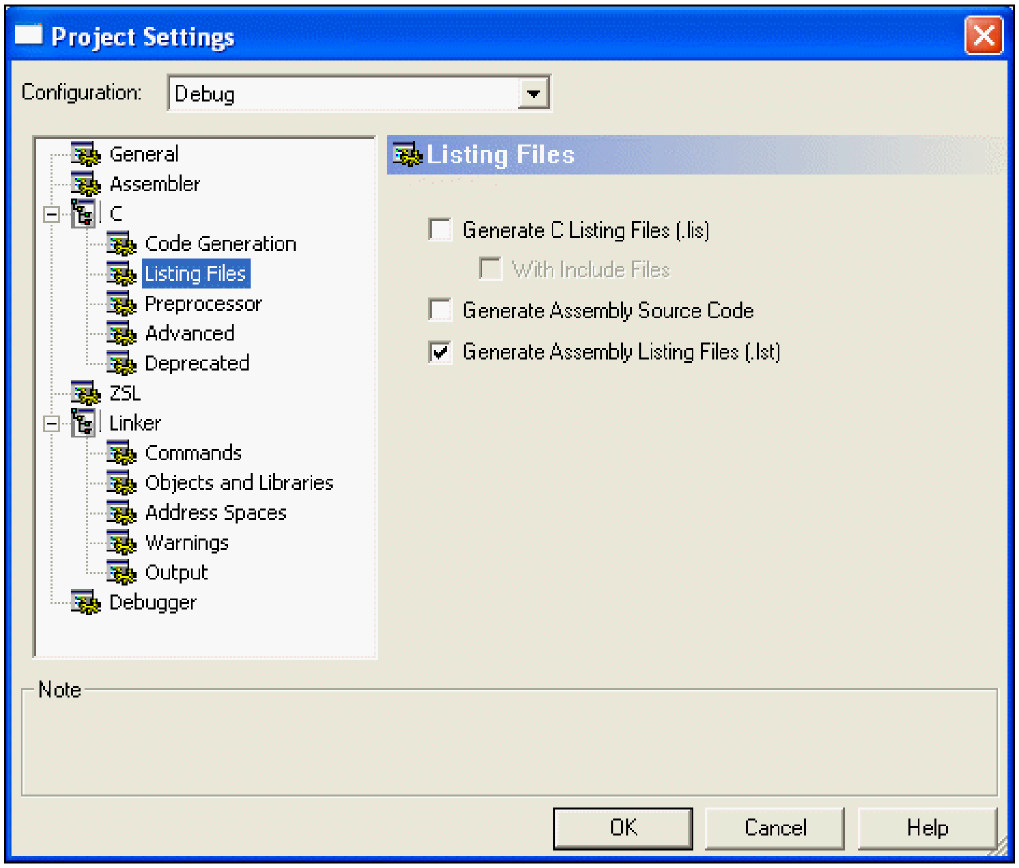
When you select **Register**, the working registers R8-R13 are used to place the scalar parameters of function. The rest of the parameters are placed in memory. See “Function Call Mechanism: Register Parameter Passing” on page 155 for further details.

In most cases, selecting **Register** results in a smaller overall code size for your application, but this is not guaranteed; check your results using the map file to make certain. Also, if your application uses both C and assembly code, and the assembly code accesses any parameters to a C function, you must make sure that the location of those C parameters that is assumed in the assembly code continues to match the option you have selected for Parameter Passing. See “Calling Conventions” on page 151 for more details.

C: Listing Files Page

NOTE: For Assembly Only projects, the Listing Files page is not available.

The options in the Listing Files page are described in this section.



Listing Files

- [ ] Generate C Listing Files (.lis)
  - [ ] With Include Files
- [ ] Generate Assembly Source Code
- [✓] Generate Assembly Listing Files (.lst)

Figure 52. Listing Files Page of the Project Settings Dialog Box

Generate C Listing Files (.lis)

When selected, the Generate C Listing Files (.lis) check box tells the compiler to create a listing file for each C source code file in your project. All source lines are duplicated in this file, as are any errors encountered by the compiler.

With Include Files

When this check box is selected, the compiler duplicates the contents of all files included using the `#include` preprocessor directive in the compiler listing file. This can be helpful if there are errors in included files.

Generate Assembly Source Code

When this check box is selected, the compiler generates, for each C source code file, a corresponding file of assembler source code. In this file (which is a legal assembly file that the assembler will accept), the C source code (commented out) is interleaved with the generated assembly code and the compiler-generated assembly directives. This file is placed in the directory specified by the Intermediate Files Directory check box in the General page. See "Intermediate Files Directory" on page 58.

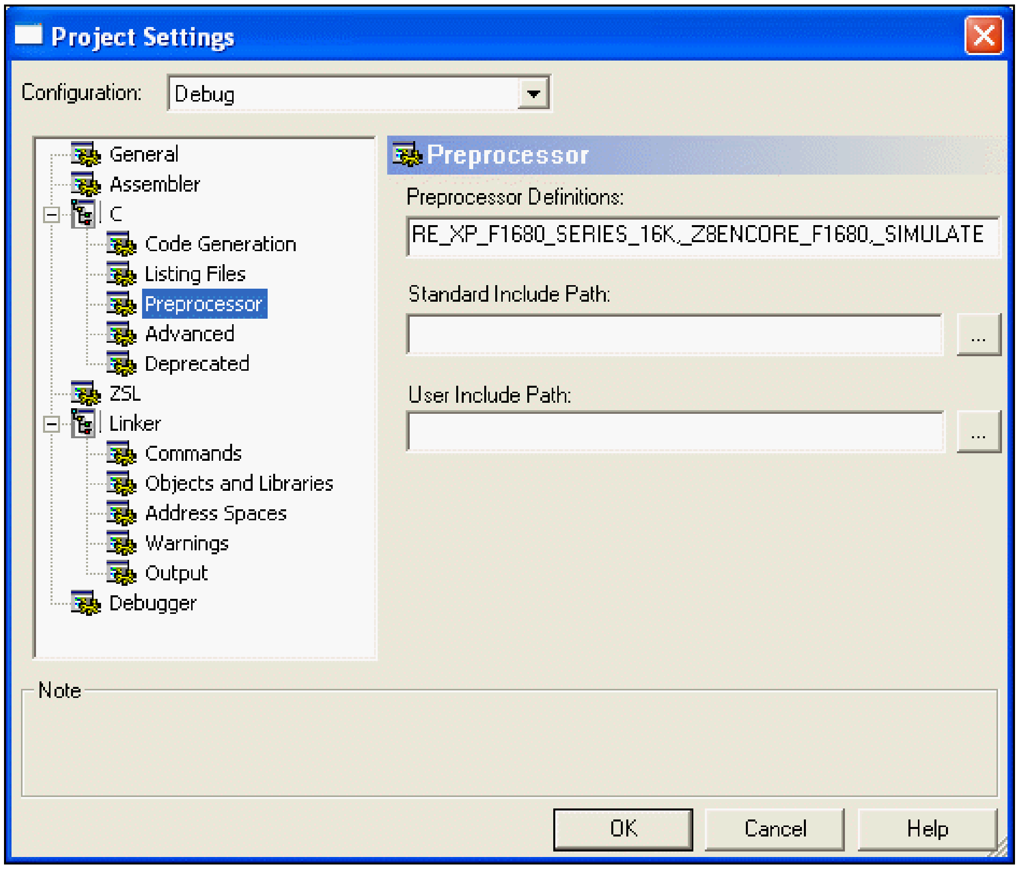
Generate Assembly Listing Files (.lst)

When this check box is selected, the compiler generates, for each C source code file, a corresponding assembly listing file. In this file, the C source code is displayed, interleaved with the generated assembly code and the compiler-generated assembly directives. This file also displays the hexadecimal addresses and op codes of the generated machine code. This file is placed in the directory specified by the Intermediate Files Directory field in the General page. See "Intermediate Files Directory" on page 58.

C: Preprocessor Page

NOTE: For Assembly Only projects, the Preprocessor page is not available.

The options in the Preprocessor page are described in this section.



Preprocessor Definitions: RE_XP_F1680_SERIES_16K,_Z8ENCORE_F1680,_SIMULATE
Standard Include Path:
User Include Path:

Figure 53. Preprocessor Page of the Project Settings Dialog Box

Preprocessor Definitions

The Preprocessor Definitions field is equivalent to placing `#define` preprocessor directives before any lines of code in your program. It is useful for conditionally compiling code. Do *not* put a space between the *symbol\name* and equal sign; however, multiple symbols can be defined and must be separated by commas.

Standard Include Path

The Standard Include Path field allows you to specify the series of paths for the compiler to use when searching for standard include files. Standard include files are those included with the `#include` <*file*`.h`> preprocessor directive. If more than one path is used, the paths are separated by semicolons (;). For example:

```
c:\rtl;c:\myinc
```

In this example, the compiler looks for the include file in

1. the project directory
2. the `c:\rtl` directory
3. the `c:\myinc` directory
4. the default directory

The default standard includes are located in the following directories:

<*ZDS Installation Directory*>`\include\std`
<*ZDS Installation Directory*>`\include\zilog`

where <*ZDS Installation Directory*> is the directory in which Zilog Developer Studio was installed. By default, this is `C:\Program Files\ZiLOG\ZDSII_Z8Encore!_<version>`, where <*version*> might be `4.11.0` or `5.0.0`.

User Include Path

The User Include Path field allows you to specify the series of paths for the compiler to use when searching for user include files. User include files are those included with the `#include "`*file*`.h"` in the compiler. If more than one path is used, the paths are separated by semicolons (;). For example:

```
c:\rtl;c:\myinc"
```

In this example, the compiler looks for the include file in

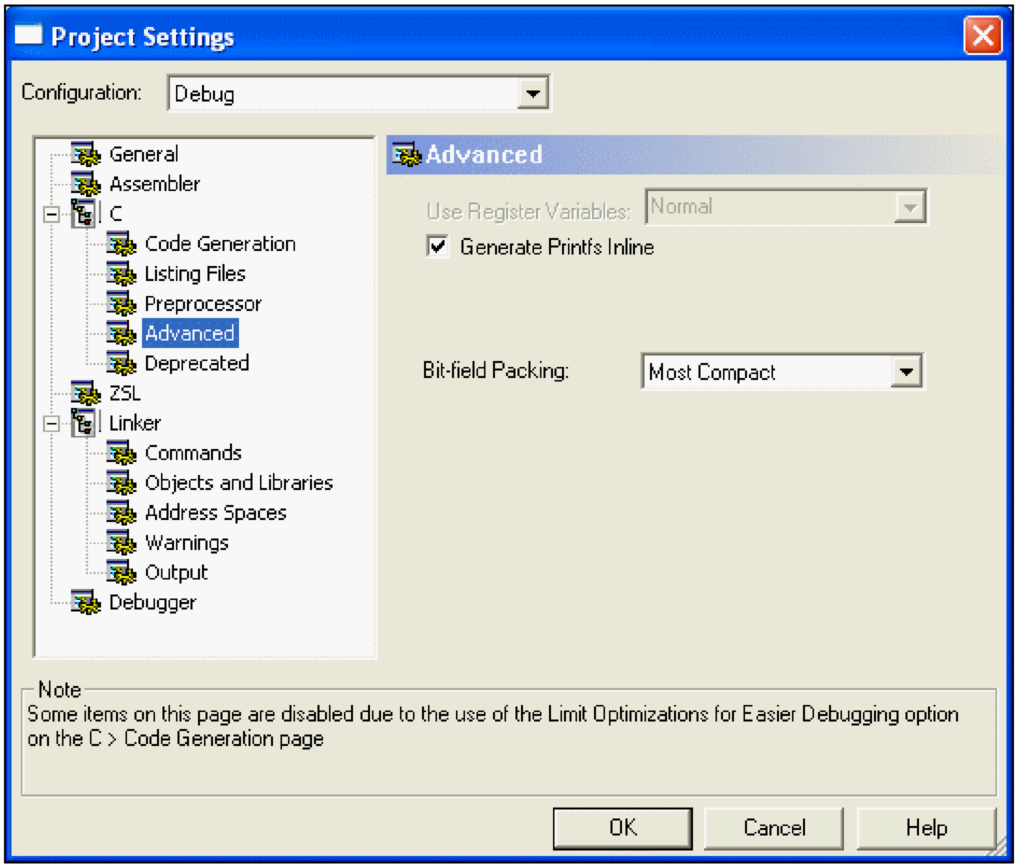
1. the project directory
2. the `c:\rtl` directory
3. the `c:\myinc` directory
4. the directory of the file from where the file is included

5. the directories listed under the `-stdinc` command
6. the default directory

C: Advanced Page

NOTE: For Assembly Only projects, the Advanced page is not available.

The Advanced page is used for options that most users will rarely need to change from their default settings.



Configuration: Debug

Use Register Variables: Normal

[✓] Generate Printfs Inline

Bit-field Packing: Most Compact

Note
Some items on this page are disabled due to the use of the Limit Optimizations for Easier Debugging option on the C > Code Generation page

Figure 54. Advanced Page of the Project Settings Dialog Box

Use Register Variables

Setting this drop-down list box to **Normal** or **Aggressive** allows the compiler to allocate local variables in registers, rather than on the stack, when possible. This usually makes the resulting code smaller and faster and, therefore, the default is that this drop-down list box is enabled. However, in some applications, this drop-down list box might produce larger and slower code when a function contains a large number of local variables.

The effect of this drop-down list box on overall program size and speed can only be assessed globally across the entire application, which the compiler cannot do automatically. Usually the overall application size is smaller but there can be exceptions to that rule. For example, in an application that contains 50 functions, this drop-down list box might make 2 functions larger and the other 48 functions smaller. Also, if those two functions run slower with the drop-down list box enabled but the others run faster, then whether the overall program speed is improved or worsened depends on how much time the application spends in each function.

Because the effect of applying this drop-down list box must be evaluated across an application as a whole, user experimentation is required to test this for an individual application. Only a small fraction of applications benefit from setting the Use Register Variables drop-down list box to **Off**.

NOTE: This drop-down list box interacts with the Limit Optimizations for Easier Debugging check box on the C page (see "Limit Optimizations for Easier Debugging" on page 63). When the Limit Optimizations for Easier Debugging check box is selected, register variables are not used because they can cause confusion when debugging. The Use Register Variables drop-down list box is disabled (grayed out) when the Limit Optimizations for Easier Debugging check box is selected. If the Limit Optimizations for Easier Debugging check box is later deselected (even in a later ZDS II session), the Use Register Variables drop-down list box returns to the setting it had before the Limit Optimizations for Easier Debugging check box was selected.

Using register variables can complicate debugging in at least two ways. One way is that register variables are more likely to be optimized away by the compiler. If variables you want to observe while debugging are being optimized away, you can usually prevent this by any of the following actions:

- Select the Limit Optimizations for Easier Debugging check box (see "Limit Optimizations for Easier Debugging" on page 63).
- Set the Use Register Variables drop-down list box to **Off**.
- Rewrite your code so that the variables in question become global rather than local.

The other way that register variables can lead to confusing behavior when debugging is that the same register can be used for different variables or temporary results at different times in the execution of your code. Because the debugger is not always aware of these multiple uses, sometimes a value for a register variable might be shown in the Watch window that is not actually related to that variable at all.

Generate Printfs Inline

Normally, a call to `printf()` or `sprintf()` parses the format string at run time to generate the required output. When the Generate Printfs Inline check box is selected, the format string is parsed at compile time, and direct inline calls to the lower level helper functions are generated. This results in significantly smaller overall code size because the top-level routines to parse a format string are not linked into the project, and only those lower level routines that are actually used are linked in, rather than every routine that could be used by a call to `printf`. The code size of each routine that calls `printf()` or `sprintf()` is slightly larger than if the Generate Printfs Inline check box is deselected, but this is more than offset by the significant reduction in the size of library functions that are linked to your application.

To reduce overall code size by selecting this check box, the following conditions are necessary:

- All calls to `printf()` and `sprintf()` must use string literals, rather than `char*` variables, as parameters. For example, the following code allows the compiler to reduce the code size:

  ```
  sprintf ("Timer will be reset in %d seconds", reset_time);
  ```

  But code like the following results in larger code:

  ```
  char * timerWarningMessage;
  ...
  sprintf (timerWarningMessage, reset_time);
  ```

- The `vprintf()` and `vsprintf()` functions cannot be used, even if the format string is a string literal.

If the Generate Printfs Inline check box is selected and these conditions are not met, the compiler warns you that the code size cannot be reduced. In this case, the compiler generates correct code, and the execution is significantly faster than with normal `printf` calls. However, there is a net increase in code size because the generated inline calls to lower level functions require more space with no compensating savings from removing the top-level functions.

In addition, an application that makes over 100 separate calls of `printf` or `sprintf` might result in larger code size with the Generate Printfs Inline check box selected because of the cumulative effect of all the inline calls. The compiler cannot warn about this situation. If in doubt, simply compile the application both ways and compare the resulting code sizes.

The Generate Printfs Inline check box is selected by default.

Bit-field Packing

This drop-down list box can be set to **Backward Compatible**, **Most Compact**, or **Normal**. The **Most Compact** setting, which is the default for new projects, packs the bit-fields as tightly as possible. This packing saves data space in your application. The **Normal** setting preserves the declared type of all the individual bit-fields. That is, in an example like the following:

```
typedef struct {
```

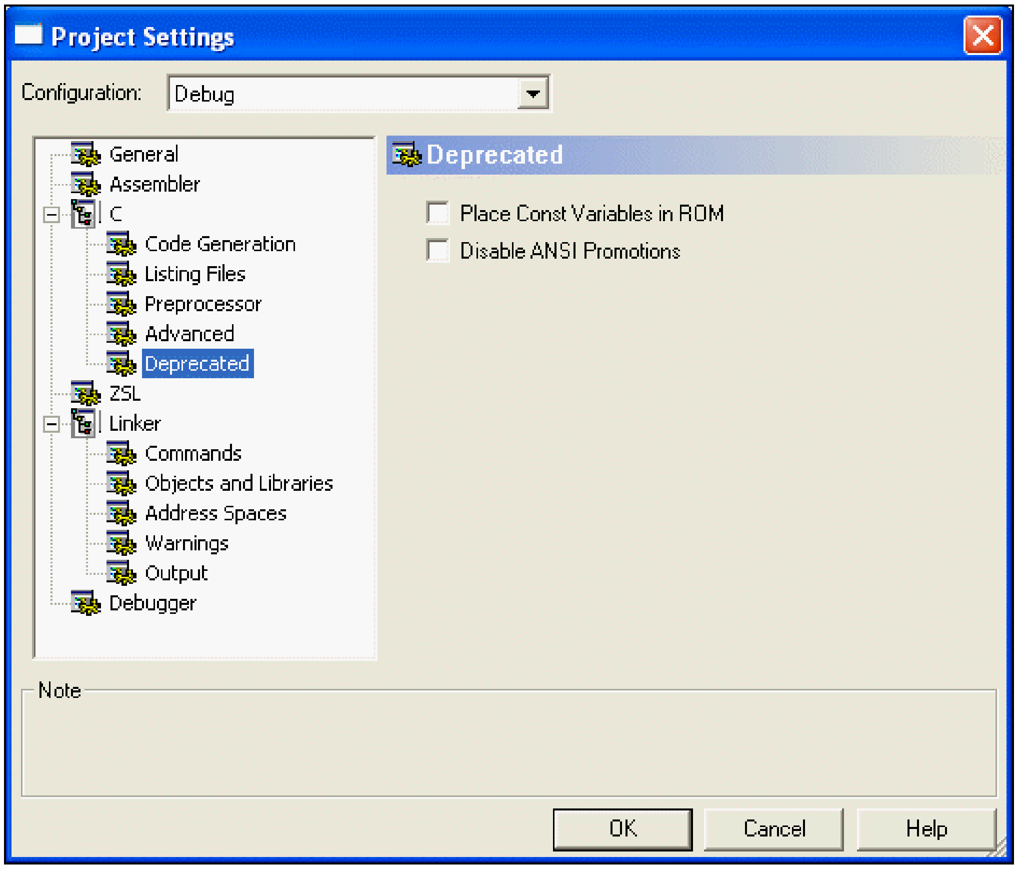
```
  char bf1:6;
  short bf2:9;
  long bf3:17;
} bf_struct;
```

the **Normal** setting sets aside 1 byte (the size of a char) for `bf1`, 2 bytes (the size of a short) for `bf2`, and 4 bytes (the size of a long) for `bf3`. This packing is sometimes easier to use when writing both C and assembly code to access the same bit-field structures because the sizes and offsets are more readily predictable. Finally, the **Backward Compatible** setting preserves a somewhat more complicated packing scheme that was used by the Z8 Encore! compiler before release 4.11.0. That previous scheme remains unchanged when **Backward Compatible** is selected, except to correct a problem in the handling of mixed bit-fields (that is, those in which bit-fields of different nominal types are included in the same structure, as in the example above). If you have a legacy application in which you access the same bit-fields using both C and assembly code, you need to either use the **Backward Compatible** setting or rewrite your assembly code to access the bit-fields using one of the new bit-field packing options.

C: Deprecated Page

NOTE: For Assembly Only projects, the Deprecated page is not available.

The Deprecated page contains options from older releases of ZDS II that, because of issues found in extended experience with those particular options across many applications, are no longer recommended for use. Zilog strongly recommends that you not use these features in new projects. If you have older projects that use these options, they will continue to be supported as in previous applications. However, Zilog recommends removing them from your projects over time to avoid the issues that have caused these features to be deprecated.



Place Const Variables in ROM
Disable ANSI Promotions

Figure 55. Deprecated Page of the Project Settings Dialog Box

Place Const Variables in ROM

In ZDS II releases before 4.10.0, an option was provided to place all variables that were declared `const` in ROM memory (in other words, in the ROM address space; see "Linker: Address Spaces Page" on page 89). This option has now been deprecated. The heart of the problem with this feature lies in the nature of Z8 Encore! as a Harvard architecture, that is, one in which different address spaces are used for read-only memory (used for things like code and ROM data storage) and memory that is writable (used for most "data" in the program). The ANSI Standard, and more fundamentally the design of the C language, was written with the implicit assumption that only von Neumann architectures (in which a single address space is used for all memory) will be considered. Harvard architectures are, of course, quite common in embedded system processors to give better performance within the constraints of the limited resources available to these processors.

In the Harvard architecture, pointers to the normal "data" space and pointers into ROM space are generally required to be distinct types. In Z8 Encore!, this difference can also be seen at the machine instruction level where a separate instruction, `LDC`, must be generated by the compiler to load data from the ROM space. That means that if constants are placed in ROM, a different function must be called if a `const` pointer is used as a function parameter than the function that is called for a non-`const` pointer type. For example, consider the following code:

```
char const *quote = “Ask not ...”;
char buffer[80];
rom_src_strcpy(buffer,quote);    // OK if CONST = ROM;
                         // parameter type mismatch
                         // if not
strcpy(buffer,quote);     // Parameter type mismatch
                         // if const = ROM, OK otherwise.
```

The top form shown here calls a function whose signature is

```
char * rom_src_strcpy (void * dest, rom  void * source)
```

whereas the standard function `strcpy` has the more usual signature

```
char * strcpy (void * dest, const  void * source)
```

The top form succeeds in this code snippet when the `const=ROM` option has been selected, and fails otherwise (when `const` data is stored in RAM). The bottom form fails when `const=ROM` but succeeds otherwise. There can never be a case when both calls succeed, because the second pointer argument of `rom_src_strcpy()` is a fundamentally different type, pointing into a different space, than the second pointer argument of `strcpy()`.

In short, the result of these architectural constraints is that if the Place Const Variables in ROM check box is selected, it is impossible for the compiler to treat the `const` keyword in a way that complies with the ANSI C Standard.

It is better to *not* select this deprecated option and let the compiler use `const` variables in RAM when needed and to use the `rom` keyword explicitly to declare any data such as tables that you really do want to locate in ROM.

Disable ANSI Promotions

The option of enabling or disabling ANSI promotions refers to promoting `char` and `short` values to `int`s when doing computations, as described in more detail in this section. Disabling the promotions was made a user option in earlier releases of ZDS II with the goal of reducing code size because the promotions called for by the ANSI C standard are often unnecessary and can lead to considerable code bloat. However, over time, several problems were found in the compiler’s ability to apply this option consistently and correctly in all cases. Therefore, Zilog no longer recommends the use of this feature and, to address the original code size issue, has expended more effort to reduce code size and remove truly unnecessary promotions while observing the ANSI standard. For this reason, the Disable ANSI Promotions check box is now available only as a deprecated feature. It remains available because some users have carefully created working code that might depend on the old behavior and might have to expend additional effort now to keep their code working without the deprecated feature.

When the Disable ANSI Promotions check box is deselected, the compiler performs integer type promotions when necessary so that the program's observed behavior is as defined by the ANSI C Standard. Integer type promotions are conversions that occur automatically when a smaller (for example, 8 bits) variable is used in an expression involving larger (for example, 16 bits) variables. For example, when mixing chars and ints in an expression, the compiler casts the chars into ints. Conversions of this kind are always done, regardless of the setting of the Disable ANSI Promotions check box.

The ANSI Standard has special rules for the handling of chars (and shorts), and it is the application of these special rules that is disabled when the check box is selected. The special rules dictate that chars (both signed and unsigned) must always be promoted to ints before being used in arithmetic or relational (such as < and ==) operations. By selecting the ANSI Promotions check box, these rules are disregarded, and the compiler can operate on char entities without promoting them. This can make for smaller code because the compiler does not have to create extra code to do the promotions and then to operate on larger values. In making this a deprecated feature, Zilog has worked to make the compiler more efficient at avoiding truly needless promotions so that the code size penalty for observing the standard is negligible.

Disabling the promotions can often be a safe optimization to invoke, but this is subject to several exceptions. One exception is when an arithmetic overflow of the smaller variable is possible. (For example, the result of adding `(char)10` to `(char) 126` does not fit within an 8-bit `char` variable, so the result is `(char) -120`.) In such cases, you get different results depending on whether ANSI promotions are enabled or disabled. If you write

```
char a = 126;
char b = 10;
int i = a + b:
```

then with ANSI promotions enabled, you get the right answer: 136. With ANSI promotions disabled, you get the wrong answer: -120. The reason for the different result is that while in both cases there is a conversion from `char` to `int`, the conversion is applied earlier or later depending on this setting. With ANSI promotions enabled, the conversion is done as soon as possible, so it occurs before the addition, and the result is correct even though it is too large to fit into a `char`. With ANSI promotions disabled, the conversion is not done until a larger type is explicitly called for in the code. Therefore, the addition is done with `chars`, the overflow occurs, and only after that is the result converted to `int`.

By the ANSI Standard, these special promotions are only applied to `chars` and `shorts`. If you have the analogous code with the sum of two `ints` being assigned into a `long`, the compiler does not automatically promote the ints to longs before adding them, and if the sum overflows the `int` size, then the result is always wrong whether ANSI promotions are in effect or not. In this sense, the ANSI promotions make the handling of char types inconsistent compared to the treatment of other integer types.

It is better coding practice to show such promotions explicitly, as in the following:

```
int i = (int) a + (int) b;
```

Then, you get the same answer whether promotions are enabled or disabled. If instead, you write:

```
char c = a + b;
```

then even with ANSI promotions enabled, you do not get the right answer. You did not anticipate that the arithmetic operation can overflow an 8-bit value. With ANSI promotions disabled, the value of the expression (136) is truncated to fit into the 8-bit result, again yielding the value (char) -120. With ANSI promotions enabled, the expression evaluates directly to (char) -120.

There are two more types of code constructs that behave differently from the ANSI Standard when the ANSI promotions are disabled. These occur when an expression involving unsigned chars is then assigned to a signed int result and when relational operators are used to compare an unsigned char to a signed char. Both of these are generally poor programming practice due to the likelihood of operand signs not being handled consistently.

The following code illustrates the cases where the code behaves differently depending on the setting of the Disable ANSI Promotions check box. When ANSI promotions are on, the code prints the following:

```
START
EQUAL
SIGNED
DONE
```

When ANSI promotions are off, the code prints the following:

```
START
NOT EQUAL
UNSIGNED
DONE
```

In every case, the difference occurs because when promotions are on, the unsigned chars are first promoted to signed ints, and then the operation occurs; with promotions off, the operations occur first, and then the promotion happens afterward. In every case except the second test, the code with promotions off has to invoke the ANSI Standard's rules for how to convert a negative result into an unsigned type—another indication that it is generally poorly written code for which this setting makes a difference in program behavior.

```
#include <stdio.h>

unsigned char uch1 = 1;
unsigned char uch2 = 2;
unsigned char uch3 = 128;
int int1;
char ch1 = -2;
```

```
int main(void)
{
   puts("START");

   int1 = uch1 - uch2;
   if (int1 != -1)
      puts("NOT EQUAL");   //nopromote:00FFh != FFFFh
   else
      puts("EQUAL");       //promote:  FFFFh == FFFFh

   if (uch3 < ch1)
      puts("UNSIGNED");    //nopromote:(uchar)80h < (uchar)FEh
   else
      puts("SIGNED");      //promote:  (int)  128 > (int)  -2

   puts("DONE.");
}
```

The following recommended programming practices are good practice in any case for producing code that is both correct and efficient. These practices are especially important to avoid trouble if you are using the deprecated Disable ANSI Promotions option:

- Use variables of type char or unsigned char wherever the expected range of values for the variable is [-128..127] or [0..255], respectively.
- Use explicit casts (to int, unsigned int, long or unsigned long) where the result of an expression is expected to overflow the larger of the two operand types. (Even with ANSI promotions disabled, the compiler automatically promotes a smaller operand so that the types of the operands match.)
- It is good programming practice to use explicit casts, even where automatic promotions are expected.
- Explicitly cast constant expressions that you want to be evaluated as char (for example, `(char)0xFF`).

Librarian Page

NOTE: This page is available for Static Library projects only.

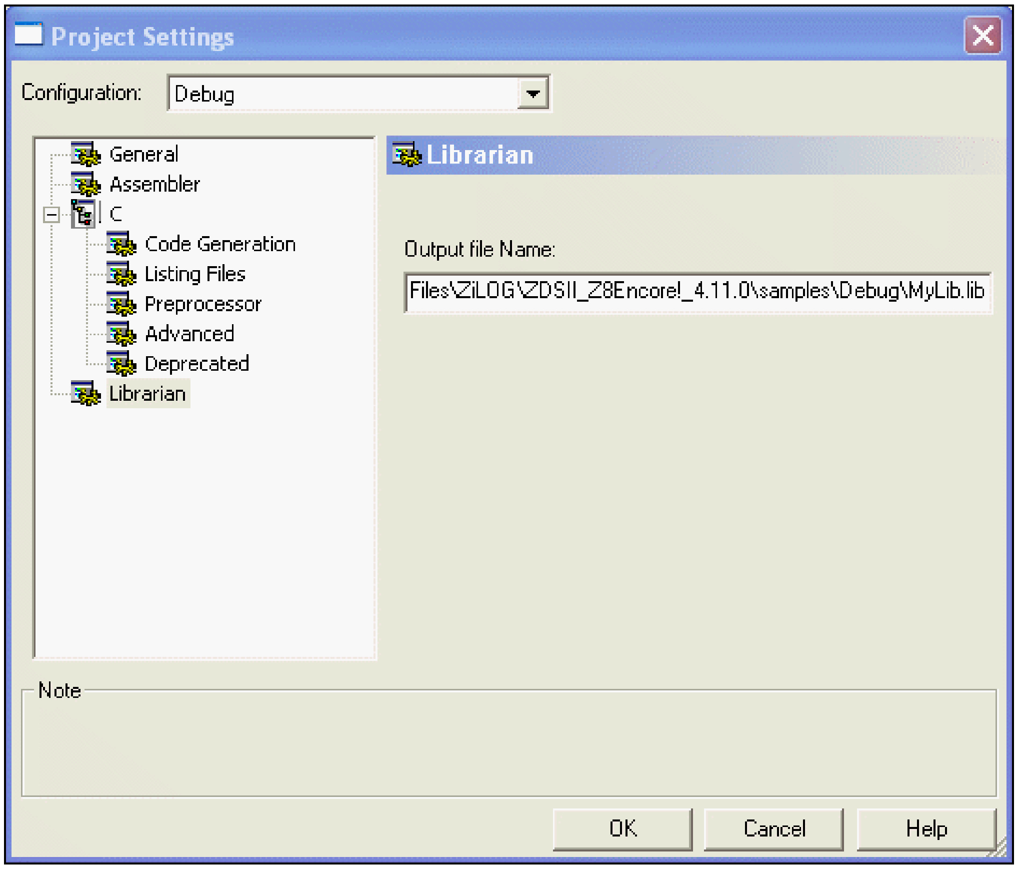
The options in the Librarian page are described in this section.

To configure the librarian, use the following procedure:

1. Select **Settings** from the Project menu.

   The Project Settings dialog box is displayed.

2. Select the Librarian page.



Configuration: Debug

Librarian

Output file Name:
Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\samples\Debug\MyLib.lib

Figure 56. Librarian Page of the Project Settings Dialog Box

3. Use the Output File Name field to specify where your static library file is saved.

ZSL Page

In the Project Settings dialog box, select the ZSL page. The ZSL page allows you to use the Zilog Standard Library (ZSL) in addition to the run-time library (described in “Using the ANSI C-Compiler” on page 132). The ZSL page contains functions for controlling the UART device driver and GPIO ports.

The options on the ZSL page are described in this section.

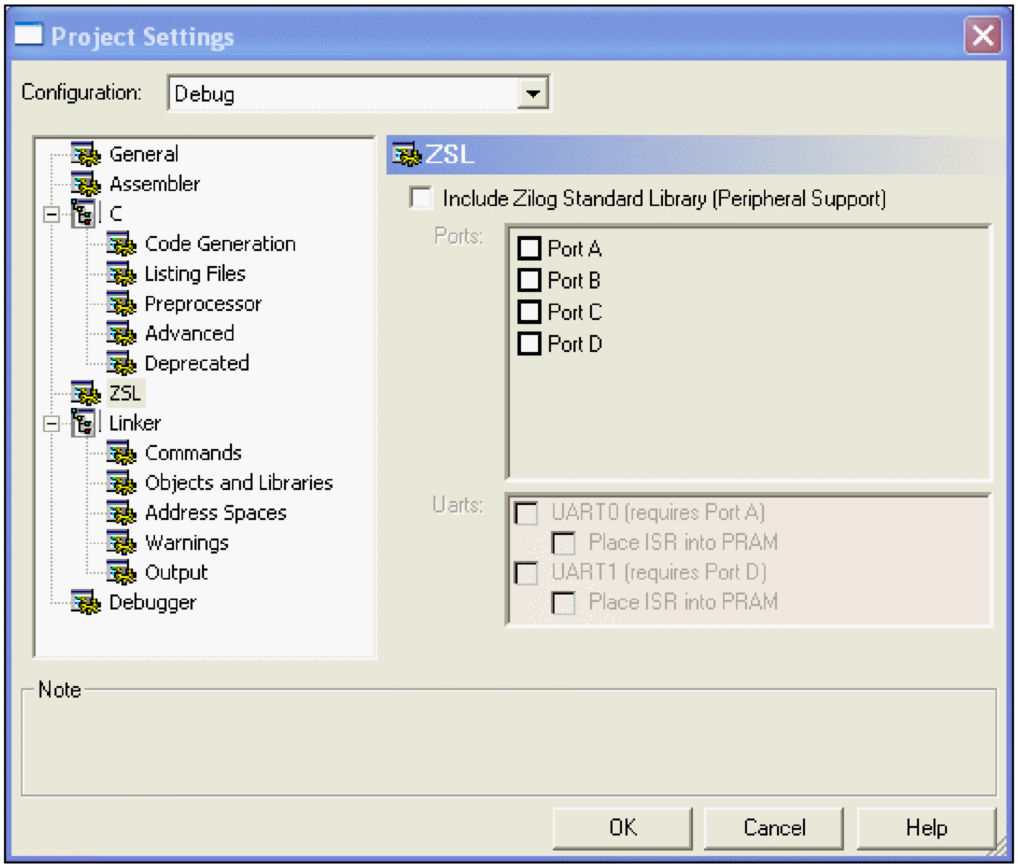


Figure 57. ZSL Page (Z8 Encore! XP F1680 Series) of the Project Settings Dialog Box

Include Zilog Standard Library (Peripheral Support)

Select the Include Zilog Standard Library (Peripheral Support) check box to use the functions contained in the Zilog Standard Library. Some of the functions in the C Standard Library, especially I/O functions like `printf()`, rely on lower-level functions that they call to eventually interact with hardware devices such as UARTs. The Zilog Standard Library provides these lower-level support functions, specialized to Z8 Encore!. Therefore, if you choose to deselect this check box and avoid using the functions of the ZSL, you must provide your own replacements for them or else rewrite the calling functions in the C run-time library so that the ZSL functions are not called.

Ports

In the Ports area, select the check boxes for the ports that you are going to use.

Uarts

In the Uarts area, select the check boxes for the UARTs that you are going to use.

The Z8 Encore! XP F1680 Series has a user-controlled Program RAM (PRAM) area to store interrupt service routines (ISRs) of high-frequency interrupts. Program RAM ensures low average current and a quick response for high-frequency interrupts. To use this feature, the ISRs in the ZSL UART must be provided with the option of being placed in the PRAM segment. When you select the Place ISR into PRAM check box, ZDS II addresses the `zslF1680U0XXX.lib` library, `zslF1680U1XXX.lib` library, or both libraries to place ISRs for UART0 and UART1 in PRAM.

You can place ISRs in PRAM only when the UART is set in interrupt mode. To set the UART in interrupt mode, edit the `include\zilog\uartcontrol.h` header file by defining the UART0_MODE/UART1_MODE symbol as MODE_INTERRUPT and rebuilding the libraries. For more information on rebuilding the ZSL, see the *Zilog Standard Library API Reference Manual* (RM0038).

For the Z8 Encore! XP F1680 Series, the default ZSL libraries are in the `zslF1680XXX.lib` files.

The following functions are placed in PRAM segment within each library:

`zslF1680U0XXX.lib`

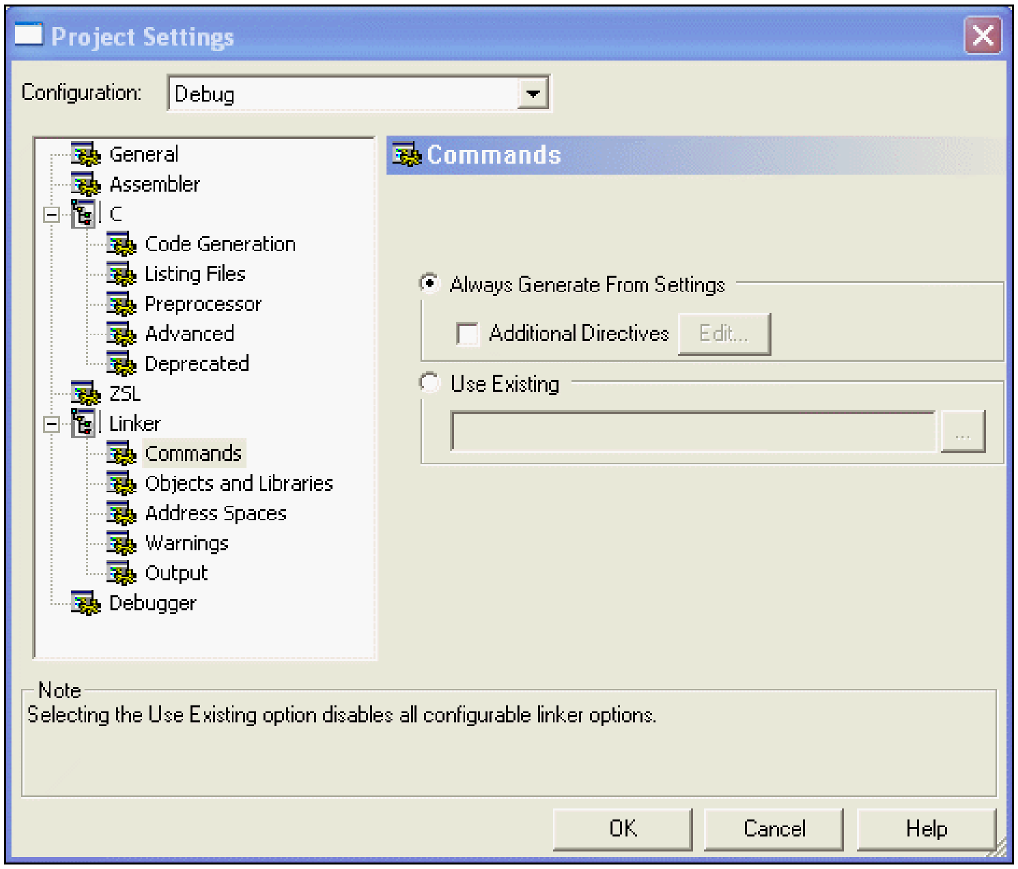
- `VOID isr_UART0_RX( VOID )`
- `VOID isr_UART0_TX( VOID )`

`zslF1680U1XXX.lib`

- `VOID isr_UART1_RX( VOID )`
- `VOID isr_UART1_TX( VOID )`

Linker: Commands Page

The options in the Commands page are described in this section.



Note
Selecting the Use Existing option disables all configurable linker options.

Figure 58. Commands Page of the Project Settings Dialog Box

Always Generate from Settings

When this button is selected, the linker command file is generated afresh each time you build your project; the linker command file uses the project settings that are in effect at the time. This button is selected by default, which is the preferred setting for most users. Selecting this button means that all changes you make in your project, such as adding more files to the project or changing project settings, are automatically reflected in the linker command file that controls the final linking stage of the build. If you do not want the linker command file generated each time your project builds, select the Use Existing button (see “Use Existing” on page 83).

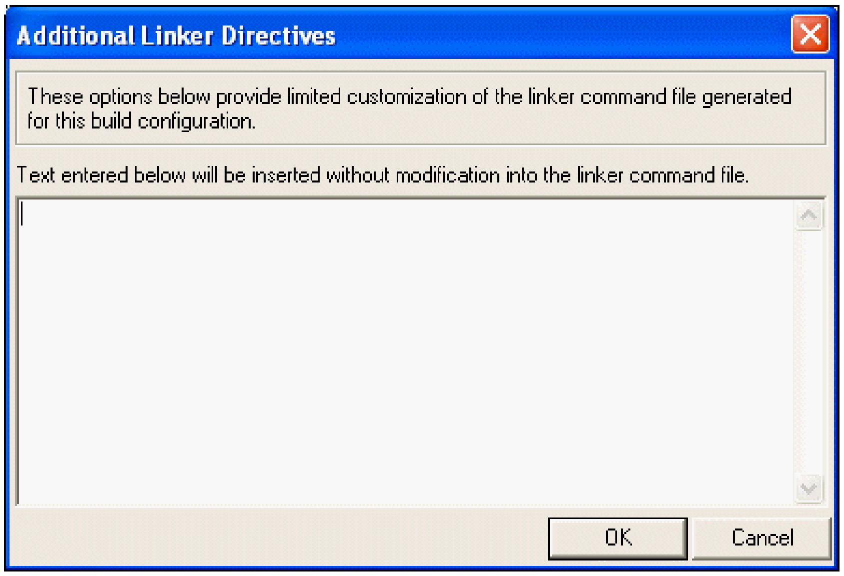
NOTE: Even though selecting the Always Generate from Settings check box causes a new linker command file to be generated when you build your project, any directives that you have specified in the Additional Linker Directives dialog box are not erased or overridden.

Additional Directives

To specify additional linker directives that are to be added to those that the linker generates from your settings when the Always Generate from Settings button is selected, do the following:

1. Select the Additional Directives check box.
2. Click **Edit**.

   The Additional Linker Directives dialog box is displayed.



These options below provide limited customization of the linker command file generated for this build configuration.

Text entered below will be inserted without modification into the linker command file.

Figure 59. Additional Linker Directives Dialog Box

3. Add new directives or edit existing directives.
4. Click **OK**.

You can use the Additional Directives check box if you need to make some modifications or additions to the settings that are automatically generated from your project settings, but you still want all your project settings and newly added project files to take effect automatically on each new build.

You can add or edit your additional directives in the Additional Linker Directives dialog box. The manually inserted directives are always placed in the same place in your linker command file: after most of the automatically generated directives and just before the final directive that gives the name of the executable to be built and the modules to be included in the build. This position makes your manually inserted directives override any conflicting directives that occur earlier in the file, so it allows you to override particular directives that are autogenerated from the project settings. (The RANGE and ORDER linker directives are exceptions to this rule; they do not override earlier RANGE and ORDER directives but combine with them.) Use caution with this override capability because some of the autogenerated directives might interact with other directives and because there is no visual indication to remind you that some of your project settings might not be fully taking effect on later builds. If you need to create a complex linker command file, contact Zilog Technical Support for assistance. See "Zilog Technical Support" on page xx.

If you have selected the Additional Directives check box, your manually inserted directives are not erased when you build your project. They are retained and re-inserted into the same location in each newly created linker command file every time you build your project.

NOTE: In earlier releases of ZDS II, it was necessary to manually insert a number of directives if you had a C project and did not select the Standard C Startup Module. This is no longer necessary. The directives needed to support a C startup module are now always added to the linker command file. The only time these directives are not added is if the project is an Assembly Only project.

Use Existing

Use the following procedure if you do not want a new linker command file to be generated when you build your project:

1. Select the Use Existing button.
2. Click on the Browse button (...).

   The Select Linker Command File dialog box is displayed.

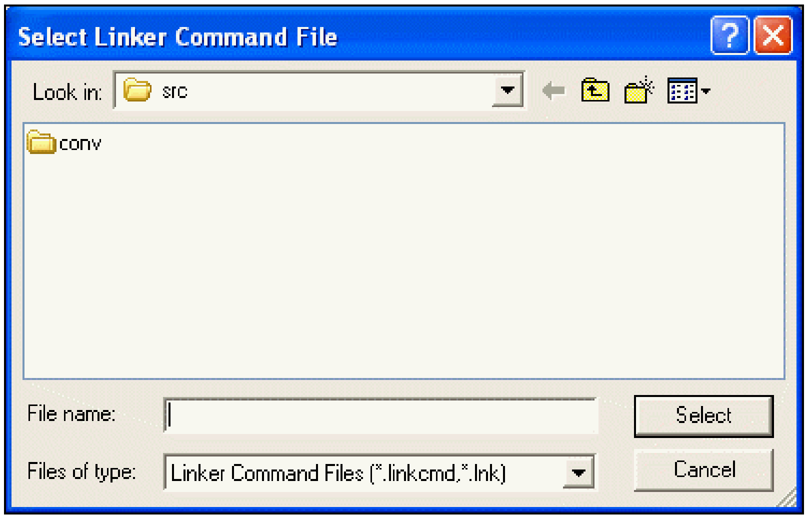

Select Linker Command File
Look in:
src
conv
File name:
Select
Files of type:
Linker Command Files (*.linkcmd,*.lnk)
Cancel

Figure 60. Select Linker Command File Dialog Box

3. Use the Look In drop-down list box to navigate to the linker command file that you want to use.

4. Click **Select**.

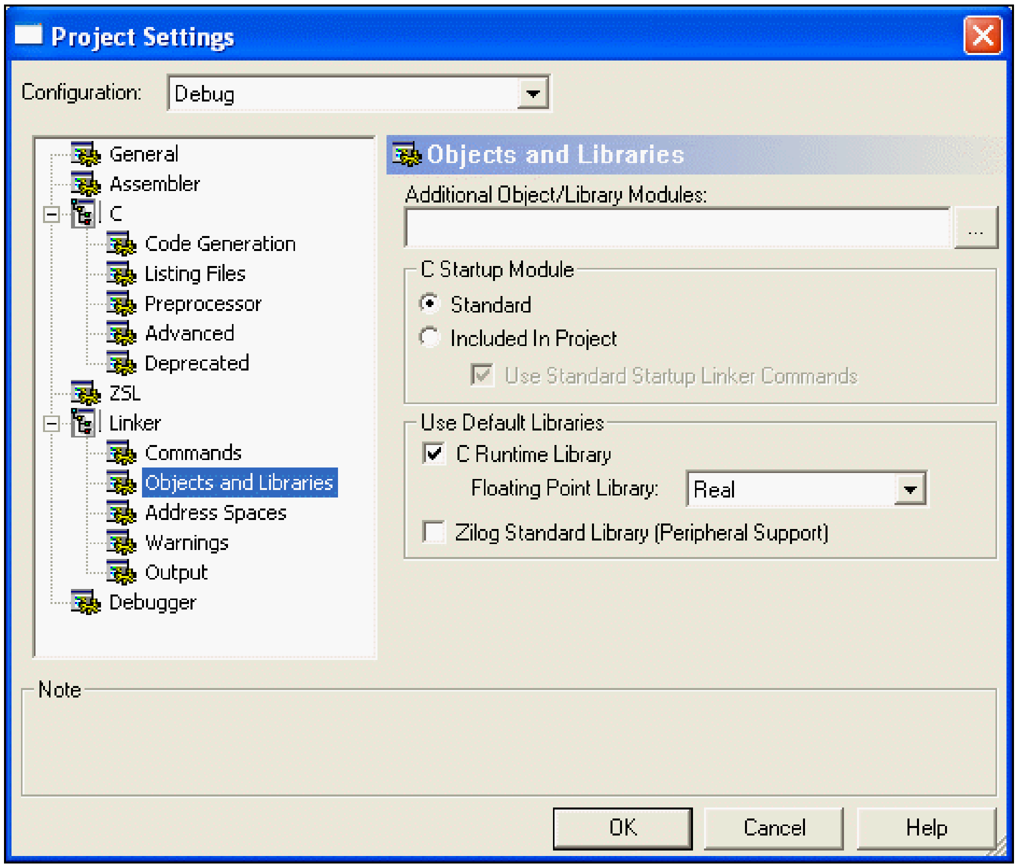
The Use Existing button is the alternative to the Always Generate from Settings button (see "Always Generate from Settings" on page 81). When this button is selected, a new linker command file is not generated when you build your project. Instead, the linker command file that you specify in this field is applied every time.

When the Use Existing button is selected, many project settings are grayed out, including all the settings on the Linker pages. These settings are disabled because when you have specified that an existing linker command file is to be used, those settings have no effect.

NOTE: When the Use Existing button is selected, some other changes that you make in your project such as adding new files to the project also do not automatically take effect. To add new files to the project, you must not only add them to the Project Workspace window (see "Project Workspace Window" on page 29), but you must also edit your linker command file to add the corresponding object modules to the list of linked modules at the end of the linker command file.

Linker: Objects and Libraries Page

The options in the Objects and Libraries page are described in this section.


Project Settings

Configuration: Debug

- General
- Assembler
- C
  - Code Generation
  - Listing Files
  - Preprocessor
  - Advanced
  - Deprecated
- ZSL
- Linker
  - Commands
  - Objects and Libraries
  - Address Spaces
  - Warnings
  - Output
- Debugger

Objects and Libraries

Additional Object/Library Modules:

C Startup Module
- (●) Standard
- ( ) Included In Project
- [✓] Use Standard Startup Linker Commands

Use Default Libraries
- [✓] C Runtime Library
- Floating Point Library: Real
- [ ] Zilog Standard Library (Peripheral Support)

Note

OK Cancel Help

Figure 61. Objects and Libraries Page of the Project Settings Dialog Box

Additional Object/Library Modules

Click on the Browse button (…) next to the Additional Object/Library Modules field to navigate to the directory where additional object files and modules that you want linked with your application are located. You do not need to add modules that are otherwise specified in your project, such as the object modules of your source code files that appear in the Project Workspace window, the C startup module, and the Zilog default libraries listed in the Objects and Libraries page. Separate multiple module names with commas.

NOTE: Modules listed in this field are linked before the Zilog default libraries. Therefore, if there is a name conflict between symbols in one of these user-specified additional modules and in a Zilog default library, the user-specified module takes precedence and its version of the symbol is the one used in linking. You can take advantage of this to provide your own replacement for one or more functions (for example, C run-time library functions) by compiling the function and then including the object module name in this field. This is an alternative to including the source code for the revised function explicitly in your project, which would also override the function in the default run-time library.

C Startup Module

The buttons and check box in this area (which are not available for Assembly Only projects) control which startup module is linked to your application. All C programs require some initialization before the main function is called, which is typically done in a startup module.

Standard

If the Standard button is selected, the precompiled startup module shipped with ZDS II is used. This standard startup module performs a minimum amount of initialization to prepare the run-time environment as required by the ANSI C Standard and also does some Z8 Encore!-specific configuration such as interrupt vector table initialization. See “Language Extensions” on page 132 for full details of the operations performed in the standard startup module.

Some of these steps carried out in the standard startup module might not be required for every application, so if code space is extremely tight, you might want to make some judicious modifications to the startup code. The source code for the startup module is located in the following file:

<ZDS Installation Directory>`\src\boot\common\startupX.asm`

Here, *<ZDS Installation Directory>* is the directory in which Zilog Developer Studio was installed. By default, this is `C:\Program Files\ZiLOG\ZDSII_Z8Encore!_<version>`, where *<version>* might be `4.11.0` or `5.0.0`. The `X` in `startupX.asm` is `s` for the small model or `l` for the large model.

Included in Project

If the Included in Project button is selected, then the standard startup module is not linked to your application. In this case, you are responsible for including suitable startup code, either by including the source code in the Project Workspace window or by including a precompiled object module in the Additional Object/Library Modules field. If you modify the standard startup module to tailor it to your project, you need to select the Included in Project button for your changes to take effect.

While you are responsible for writing your own startup code when selecting this option, ZDS II automatically inserts some needed linker commands into your linker command file. These commands are helpful in getting your project properly configured and initialized because all C startup modules have to do many of the same tasks.

The standard startup commands define a number of linker symbols that are used in the standard startup module for initializing the C run-time environment. You do not have to refer to those symbols in your own startup module, but many users will find it useful to do so, especially since user-customized startup modules are often derived from modifying the standard startup module. There are also a few linker commands (such as `CHANGE`, `COPY`, `ORDER`, and `GROUP`) that are used to configure your memory map. See "Linker Commands" on page 277 for a description of these commands.

Use Standard Startup Linker Commands

If you select this check box, the same linker commands that support the standard startup module are inserted into your linker command file, even though you have chosen to include your own, nonstandard startup module in the project. This option is usually helpful in getting your project properly configured and initialized because all C startup modules have to do most of the same tasks. Formerly, these linker commands had to be inserted manually when you were not using the standard startup.

The standard startup commands define a number of linker symbols that are used in the standard startup module for initializing the C run-time environment. You do not have to refer to those symbols in your own startup module, but many users will find it useful to do so, especially since user-customized startup modules are often derived from modifying the standard startup module. There are also a few linker commands (such as `CHANGE`, `COPY`, `ORDER`, and `GROUP`) that are used to configure your memory map. See "Linker Commands" on page 277 for a description of these commands.

This option is only available when the Included in Project button has been selected. The default for newly created projects is that this check box, if available, is selected.

Use Default Libraries

These controls determine whether the available default libraries that are shipped with Zilog Developer Studio II are to be linked with your application. For Z8 Encore!, there are two available libraries, the C run-time library and the Zilog Standard Library (ZSL). The subset of the run-time library dedicated to floating-point operations also has a separate control to allow for special handling, as explained in "Floating Point Library" on page 88.

NOTE: None of the libraries mentioned here are available for Assembly Only projects.

C Runtime Library

The C run-time library included with ZDS II provides selected functions and macros from the Standard C Library. Zilog's version of the C run-time library supports a subset of the Standard Library adapted for embedded applications, as described more fully in "Using the ANSI C-Compiler" on page 132. If your project makes any calls to standard library functions, you need to select the C Runtime Library check box unless you prefer to provide your own code for all library functions that you call. As noted in "Additional Object/Library Modules" on page 85, you can also set up your application to call a mixture of Zilog-provided functions and your own customized library functions. To do so, select the C Runtime Library check box. Calls to standard library functions will then call the functions in the Zilog default library except when your own customized versions exist.

Zilog's version of the C run-time library is organized with a separate module for each function or, in a few cases, for a few closely related functions. Therefore, the linker links only those functions that you actually call in your code. This means that there is no unnecessary code size penalty when you select the C Runtime Library check box; only functions you call in your application are linked into your application.

Floating Point Library

The Floating Point Library drop-down list box allows you to choose which version of the subset of the C run-time library that deals with the floating-point operations will be linked to your application:

- Real

  If you select **Real**, the true floating-point functions are linked in, and you can perform any floating-point operations you want in your code.

- Dummy

  If you select **Dummy**, your application is linked with alternate versions that are stubbed out and do not actually carry out any floating-point operations. This dummy floating-point library has been developed to reduce code bloat caused by including calls to `printf()` and related functions such as `sprintf()`. Those functions in turn make calls to floating-point functions for help with formatting floating-point expressions, but those calls are unnecessary unless you actually need to format floating-point values. For most users, this problem has now been resolved by the Generate Printfs Inline check box (see "Generate Printfs Inline" on page 70 for a full discussion). You only need to select the dummy floating-point library if you have to disable the Generate Printfs Inline check box and your application uses no floating-point operations. In that case, selecting **Dummy** keeps your code size from bloating unnecessarily.

- None

  If you select **None**, no floating-point functions are linked to your application at all. This can be a way of ensuring that your code does not inadvertently make any floating-point calls, because, if it does and this option is selected, you receive an error or warning message about an undefined symbol.

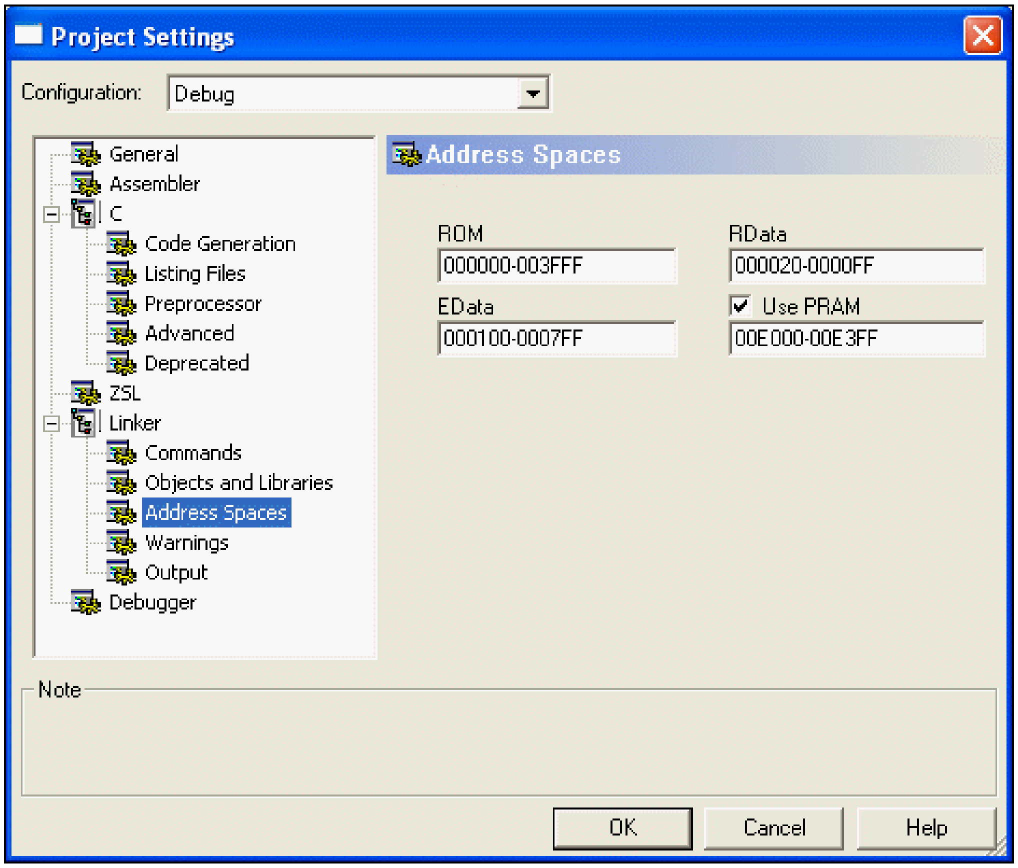
Zilog Standard Library (Peripheral Support)

Select this check box to use the Zilog Standard Library (ZSL) in addition to the run-time library (described in the "Using the ANSI C-Compiler" chapter). The ZSL contains functions for controlling the UART device driver and GPIO ports.

NOTE: In the ZDS II 4.10.0 release, the ZSL page is unavailable if you have selected one of the CPUs in the F1680 CPU family. For these parts, only basic UART support is available at this time. This basic support consists of support for only those functions that are required to support I/O functions in the C standard library such as `printf()`. If you need this type of UART support for the F1680 family of CPUs, select the C Runtime Library check box (see “C Runtime Library” on page 87).

Linker: Address Spaces Page

The options on the Address Spaces page are described in this section.



Configuration: Debug

ROM: 000000-003FFF

RData: 000020-0000FF

EData: 000100-0007FF

[✓] Use PRAM: 00E000-00E3FF

Figure 62. Address Spaces Page of the Project Settings Dialog Box

Memory ranges are used to determine the amount of memory available on your target system. Using this information, Z8 Encore! developer’s environment lets you know when your code or data has grown beyond your system’s capability. The system also uses memory ranges to automatically locate your code or data.

The Address Spaces fields define the memory layout of your target system. The Address Spaces page of the Project Settings dialog box allows you to configure the ranges of memory available on your target Z8 Encore! microcontroller. These ranges vary from processor to processor, as well as from target system to target system.

ZDS II divides Z8 Encore! memory into several spaces, some of which are available only on selected processor types:

- ROM

  The ROM space is used for code storage and can also be used for the storage of constant data. The ROM memory is located at program addresses `0000H`–*xxxx*`H`, where *xxxx*`H` is the highest location in program memory.

- RData (register data)

  The RData memory is located in `00H`–`FFH` and is used for a small memory model.The low boundary is set to `10H` by default. The low boundary needs to be set by `10H` higher for one level of interrupts. For example, for a non-nesting interrupt, set the low boundary to `20H`; for two levels of interrupts, set the low boundary to `30H`; and so on. For more information about interrupts, see "SET_VECTOR" on page 172.

- EData (extended data)

  EData is used for default data storage in the large memory model. The EData memory begins at data address `100H` and extends to a maximum of `EFFH`. Some CPUs provide less data memory, so the upper bound of this range will be less than `EFFH`. This reduced upper bound is displayed by default in the GUI when one of those parts is selected as the CPU in your project. See the product specification for your particular CPU to find out how much on-chip RAM is provided.

NOTE: If your CPU is one of the Z8 Encore! XP F1680 Series devices that has PRAM and you choose not to use the PRAM memory (by deselecting the Use PRAM check box), then the 512 or 1024 bytes that could have been used for PRAM will instead be available as additional EData memory and will be mapped onto the end of EData. If you want to use this additional data storage, you must modify the upper bound of your EData range to add the extra memory. For example, if your upper EData bound previously was `3FF` and you choose not to use the available 512 bytes (`200H`) of PRAM, you can increase the upper bound of your EData range to `5FF`.

- NVDS

  The Z8 Encore! XP 4K and 16K devices contain a Non-Volatile Data Storage (NVDS) element with a size of up to 128 bytes. This memory features an endurance of 100,000 write cycles. For more information about NVDS, see the "Non-Volatile Data Storage" chapter of the Z8 Encore! XP 4K Series Product Specification.

- PRAM (Program RAM)

  The Z8 Encore! XP F1680 Series devices feature an area of Program RAM that can be used for storing some code in RAM. This area can be used to help keep device operating power low by, for example, storing interrupt service routines here that would activate the code in Flash memory when some external event has occurred.

PRAM, when available, is an optional feature. If you want to use this memory as Program RAM, select the Use PRAM check box and then adjust the address range in the PRAM field. PRAM begins at data address `E000` and can have a maximum size of 512 or 1024 bytes, depending on your device. If you deselect the PRAM check box, this memory is not available as PRAM but instead can be mapped as additional EData memory (see the EData memory discussion).

NOTE: It is your responsibility to set the Flash option bytes to reflect whether you are using this memory as PRAM or as EData. This needs to be done inside your program so that the part will still get configured correctly even when the hex file is downloaded outside of ZDS II. The PRAM_M bit is bit 1 of Flash option byte 1 (see the product specification). Writing to the Flash option bytes must be done only once and takes effect when your hex file is downloaded to Flash. Therefore, if you wanted to set all the other bits of Flash option byte 1 to their default value of 1, but set the PRAM_M bit to 0 to indicate that you will not be using this memory as Program RAM, use the following code in your program:

```
#include <eZ8.h>
FLASH_OPTION1 = 0xFD;
```

This example is only for illustration, of course; it is your responsibility to make sure that all bits of the Flash option bytes are set as you need them for your application.

NOTE: Data addresses `F00` through `FFF` are reserved for special function registers (SFRs).

Address ranges are set in the Address Spaces fields. The following is the syntax of a memory range:

<*low address*> – <*high address*> [,<*low address*> – <*high address*>] ...

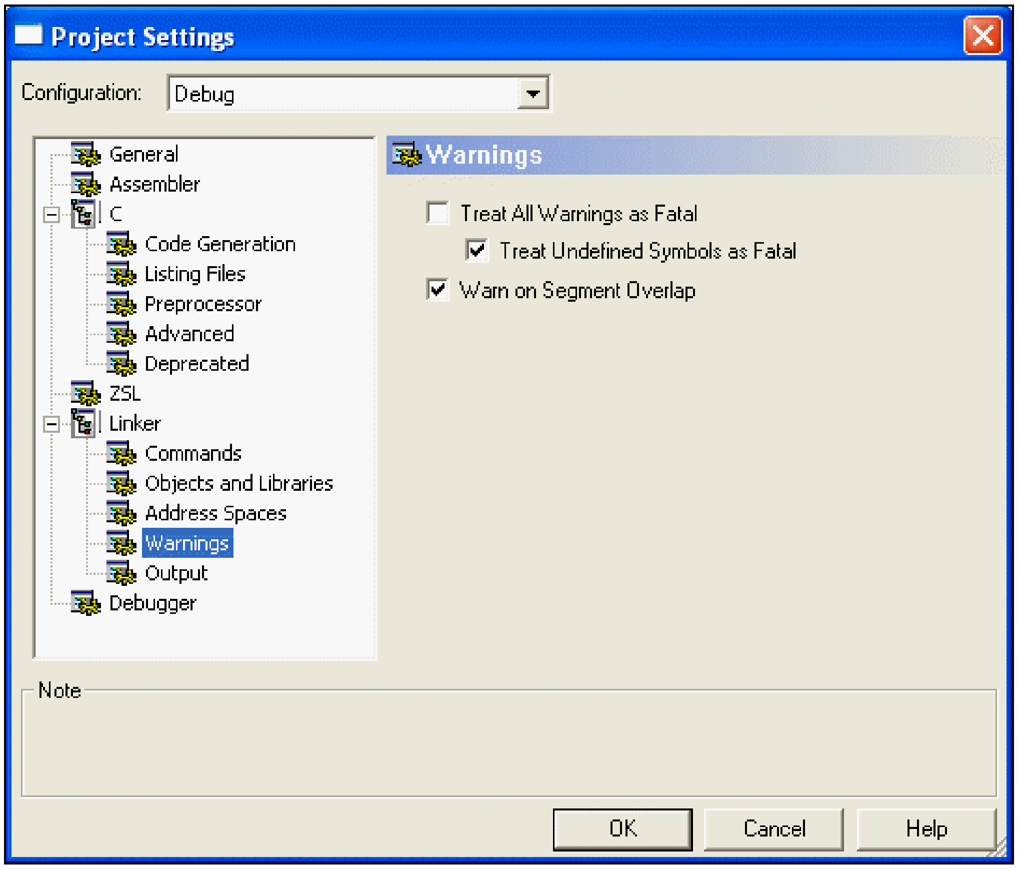
where <*low address*> is the hexadecimal lower boundary of a range and <*high address*> is the hexadecimal higher boundary of the range. The following are legal memory ranges:

```
00-df

0000-ffff

0000-1fff,4000-5fff
```

Holes in your memory can be defined for the linker using this mechanism. The linker does not place any code or data outside of the ranges specified here. If your code or data cannot be placed within the ranges, a range error is generated.

Linker: Warnings Page

The options in the Warnings page are described in this section.


Project Settings

Configuration: Debug

Warnings

[ ] Treat All Warnings as Fatal

[✓] Treat Undefined Symbols as Fatal

[✓] Warn on Segment Overlap

Figure 63. Warnings Page of the Project Settings Dialog Box

Treat All Warnings as Fatal

When selected, this check box causes the linker to treat all warning messages as fatal errors. When the check box is selected, the linker does not generate output file(s) if there are any warnings while linking. By default, this check box is deselected, and the linker proceeds with generating output files even if there are warnings.

NOTE: Selecting this check box displays any warning (as errors), regardless of the state of the Show Warnings check box in the General page (see “Show Warnings” on page 58).

Treat Undefined Symbols as Fatal

When selected, this check box causes the linker to treat “undefined external symbol” warnings as fatal errors. If this check box is selected, the linker quits generating output files and terminates with an error message immediately if the linker cannot resolve any undefined symbol. By default, this check box is selected because a completely valid executable cannot be built when the program contains references to undefined external symbols. If this check box is deselected, the linker proceeds with generating output files even if there are undefined symbols.

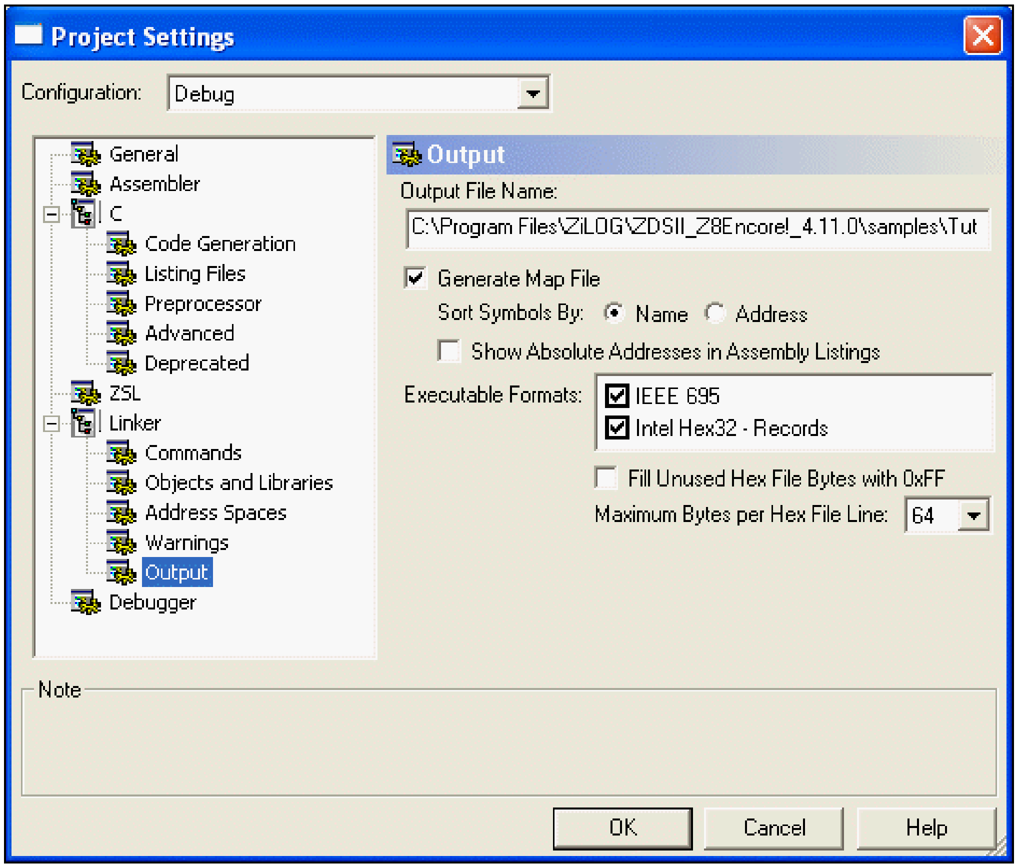
NOTE: Selecting this check box displays any warning (as errors), regardless of the state of the Show Warnings check box in the General page (see “Show Warnings” on page 58).

Warn on Segment Overlap

This check box enables or disables warnings when overlap occurs while binding segments. By default, the check box is selected, which is the recommended setting for Z8 Encore!. An overlap condition usually indicates an error in project configuration that must be corrected; however, the linker creates deliberate overlays for some functions when using static frames, and these overlays are not reported as warnings. These errors in Z8 Encore! can be caused either by user assembly code that erroneously assigns two or more segments to overlapping address ranges or by user code defining the same interrupt vector segment in two or more places.

Linker: Output Page

The options in the Output page are described in this section.



Output File Name: C:\Program Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\samples\Tut

[✓] Generate Map File

Sort Symbols By: [✓ Name] Address

[ ] Show Absolute Addresses in Assembly Listings

Executable Formats: [✓] IEEE 695 [✓] Intel Hex32 - Records

[ ] Fill Unused Hex File Bytes with 0xFF

Maximum Bytes per Hex File Line: 64

Figure 64. Output Page of the Project Settings Dialog Box

Output File Name

You can change the name of your executable (including the full path name) in the Output File Name field. After your program is linked, the appropriate extension is added.

Generate Map File

This check box determines whether the linker generates a link map file each time it is run. The link map file is named with your project's name with the `.map` extension and is placed in the same directory as the executable output file. See "MAP" on page 282. Inside the map file, symbols are listed in the order specified by the Sort Symbols By area (see "Sort Symbols By" on page 95).

NOTE: The link map is an important place to look for memory restriction or layout problems.

Sort Symbols By

You can choose whether to have symbols in the link map file sorted by name or address.

Show Absolute Addresses in Assembly Listings

When this check box is selected, all assembly listing files that are generated in your build are adjusted to show the absolute addresses of the assembly code statements. If this check box is deselected, assembly listing files use relative addresses beginning at zero.

For this option to be applied to listing files generated from assembly source files, the Generate Assembly Listing Files (.lst) check box in the Assembler page of the Project Settings dialog box must be selected.

For this option to be applied to listing files generated from C source files, both the Generate Assembly Source Code and Generate Assembly Listing Files (.lst) check boxes in the Listing Files page of the Project Settings dialog box must be selected.

Executable Formats

These check boxes determine which object format is used when the linker generates an executable file. The linker supports the following formats: IEEE 695 (`.lod`) and Intel Hex32 (`.hex`), which is a backward-compatible superset of the Intel Hex16 format. IEEE 695 is the default format for debugging in ZDS II, and the Intel hex format is useful for compatibility with some third-party tools. You can also select both check boxes, which produces executable files in both formats.

Fill Unused Hex File Bytes with 0xFF

This check box is available only when the Intel Hex32 Records executable format is selected. When the Fill Unused Hex File Bytes with 0xFF check box is selected, all unused bytes of the hex file are filled with the value 0xFF. This option is sometimes required for compatibility with other tools that set otherwise uninitialized bytes to 0xFF so that the hex file checksum calculated in ZDS II matches the checksum calculated in the other tools.

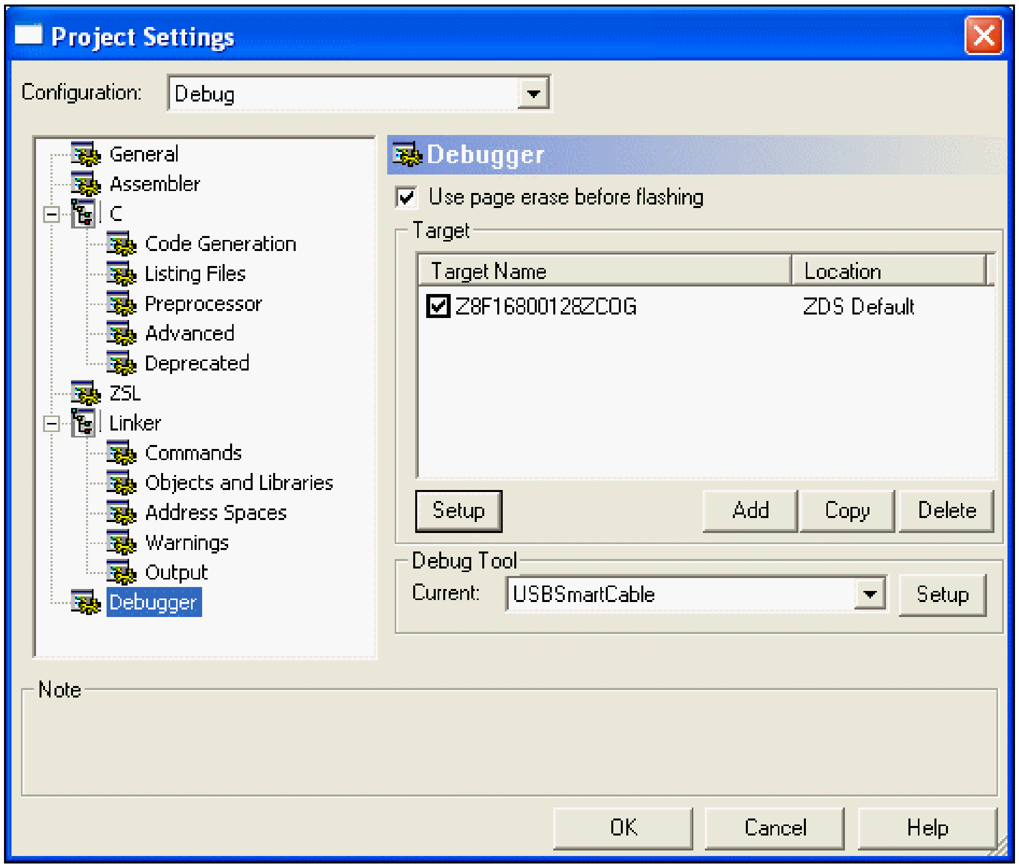
NOTE: Use caution when selecting this option. The resulting hex file begins at the first hex address (`0x0000`) and ends at the last page address that the program requires. This significantly increases the programming time when using the resulting output hex file. The hex file might try to fill nonexistent external memory locations with `0xFF`.

Maximum Bytes per Hex File Line

This option is available only when the Intel Hex32 Records executable format is selected. This drop-down list box sets the maximum length of a hex file record. This option is provided for compatibility with third-party or other tools that might have restrictions on the length of hex file records. This option is available only when the Intel Hex32 Records executable format is selected.

Debugger Page

In the Project Settings dialog box, select the Debugger page.



Configuration: Debug

Debugger

☑ Use page erase before flashing

Target Name	Location
☑ Z8F1680128ZCOG	ZDS Default

Debug Tool Current: USBSmartCable

Figure 65. Debugger Page of the Project Settings Dialog Box

The source-level debugger is a program that allows you to find problems in your code at the C or assembly level. The Windows interface is quick and easy to use. You can also write batch files to automate debugger tasks.

Your understanding of the debugger design can improve your productivity because it affects your view of how things work. The debugger requires target and debug tool settings that correspond to the physical hardware being used during the debug session. A target is a logical representation of a target board. A debug tool represents debug communication hardware such as the USB Smart Cable or an emulator. A simulator is a software debug tool that does not require the existence of physical hardware. Currently, the debugger supports debug tools for the Z8 Encore! simulator, the USB Smart Cable, the serial Smart Cable, and the Ethernet Smart Cable.

Use Page Erase Before Flashing

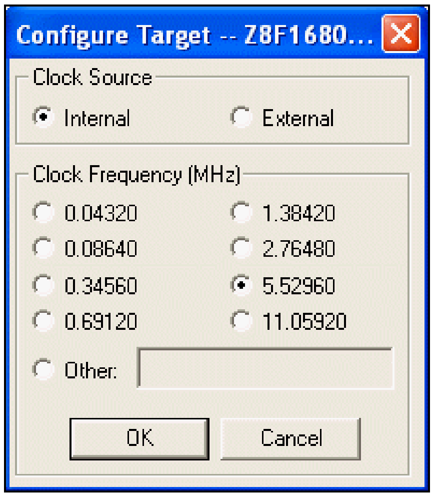
Select the Use Page Erase Before Flashing check box if you want the internal Flash to be page-erased. Deselect this check box if you want the internal Flash to be mass-erased.

Target

Select the appropriate target from the Target list box. The selected target name is displayed in the Debug output window after you click the Reset button (available from the Build toolbar or Debug toolbar).

Setup

Click **Setup** in the Target area to display the Configure Target dialog box.


Configure Target -- Z8F1680...

Clock Source: [✓ Internal] External

Clock Frequency (MHz): 0.04320, 0.08640, 0.34560, 0.69120, 1.38420, 2.76480, [✓ 5.52960], 11.05920, Other:

Figure 66. Configure Target Dialog Box

NOTE: The options displayed in the Configure Target dialog box depend on the CPU you selected in the New Project dialog box (see “New Project” on page 39) or the General page of the Project Settings dialog box (see “General Page” on page 56).

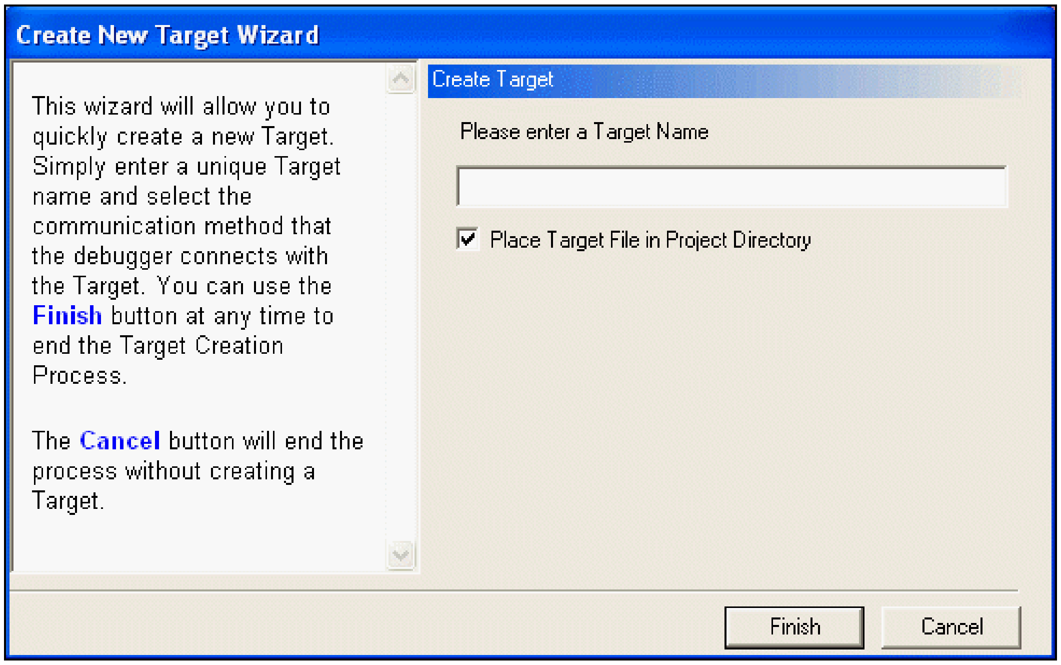
1. Select the internal or external clock source.
2. Select the appropriate clock frequency in the Clock Frequency (MHz) area or enter the clock frequency in the Other field. For the emulator, this frequency must match the clock oscillator on Y4. For the development kit, this frequency must match the clock oscillator on Y1. The emulator clock cannot be supplied from the target application board.

NOTE: The clock frequency value is used even when the Simulator is selected as the debug tool. The frequency is used when converting clock cycles to elapsed times in seconds, which can be viewed in the Debug Clock window when running the simulator.

3. Click **OK**.

Add

Click **Add** to display the Create New Target Wizard dialog box.



This wizard will allow you to quickly create a new Target. Simply enter a unique Target name and select the communication method that the debugger connects with the Target. You can use the Finish button at any time to end the Target Creation Process.

The Cancel button will end the process without creating a Target.

Please enter a Target Name

☑ Place Target File in Project Directory

Figure 67. Create New Target Wizard Dialog Box

Type a unique target name in the field, select the Place Target File in Project Directory check box if you want your new target file to be saved in the same directory as the currently active project, and click **Finish**.

Copy

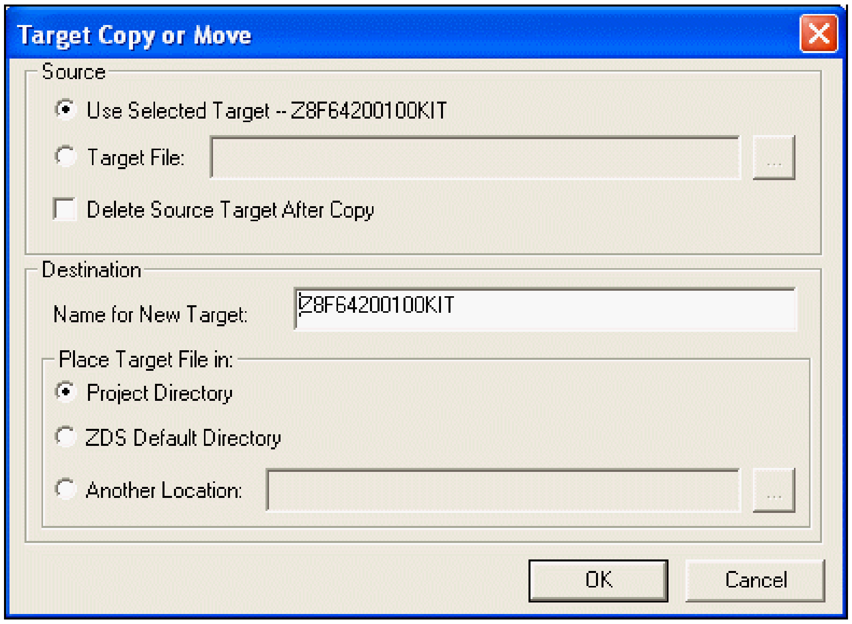


Figure 68. Target Copy or Move Dialog Box

1. Select a target in the Target area of the Debugger page.
2. Click **Copy**.
3. Select the Use Selected Target button if you want to use the target listed to the right of this button description or select the Target File button to use the Browse button (...) to navigate to an existing target file.

   If you select the Use Selected Target button, enter the name for the name for the new target in the Name for New Target field.
4. Select the Delete Source Target After Copy check box if you do not want to keep the original target.
5. In the Place Target File In area, select the location where you want the new target file saved: in the project directory, ZDS default directory, or another location.
6. Click **OK**.

Delete

Click **Delete** to remove the currently highlighted target

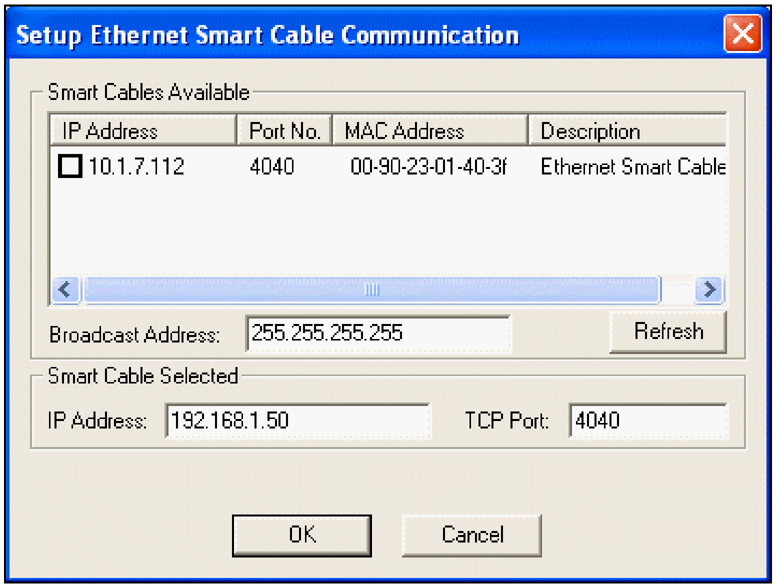
The following message is displayed: "`Delete` *target_name* `Target?`". Click **Yes** to delete the target or **No** to cancel the command.

Debug Tool

Select the appropriate debug tool from the Current drop-down list box:

- If you select **EthernetSmartCable** and click **Setup** in the Debug Tool area, the Setup Ethernet Smart Cable Communication dialog box is displayed.

NOTE: If a Windows Security Alert is displayed with the following message: "`Do you want to keep blocking this program?`", click **Unblock.**



Setup Ethernet Smart Cable Communication

Smart Cables Available

IP Address	Port No.	MAC Address	Description
☐ 10.1.7.112	4040	00-90-23-01-40-3f	Ethernet Smart Cable

Broadcast Address: 255.255.255.255

Smart Cable Selected

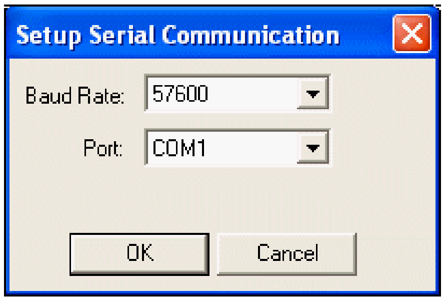
IP Address: 192.168.1.50 TCP Port: 4040

Figure 69. Setup Ethernet Smart Cable Communication Dialog Box

- Click **Refresh** to search the network and update the list of available Ethernet Smart Cables. The number in the Broadcast Address field is the destination address to which ZDS sends the scan message to determine which Ethernet Smart Cables are accessible. The default value of `255.255.255.255` can be used if the Ethernet Smart Cable is connected to your local network. Other values such as `192.168.1.255` or `192.168.1.50` can be used to direct or focus the search. ZDS uses the default broadcast address if the Broadcast Address field is empty.

  Select an Ethernet Smart Cable from the list of available Ethernet Smart Cables by checking the box next to the Smart Cable you want to use. Alternately, select the Ethernet Smart Cable by entering a known Ethernet Smart Cable IP address in the IP Address field.
- Type the port number in the TCP Port field.
- Click **OK**.

- If you select **SerialSmartCable** and click **Setup** in the Debug Tool area, the Setup Serial Communication dialog box is displayed.



Baud Rate: 57600

Port: COM1

Figure 70. Setup Serial Communication Dialog Box

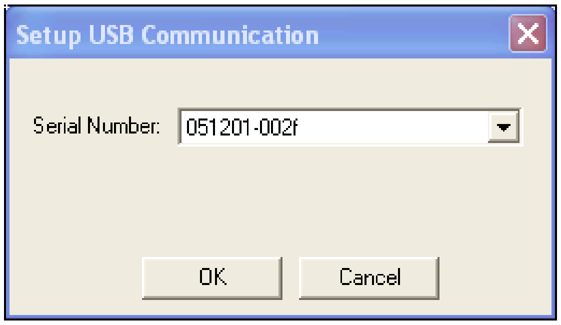
– Use the Baud Rate drop-down list box to select the appropriate baud rate: 19200, 38400, 57600, or 115200. The default is 57600.

– Select the host COM port connected to your target.

NOTE: ZDS II sets the COM port settings for data, parity, stop, and flow control. You do not need to set these.

– Click **OK**.

- If you select **USBSmartCable** and click **Setup** in the Debug Tool area, the Setup USB Communication dialog box is displayed.



Serial Number: 051201-002f

Figure 71. Setup USB Communication Dialog Box

– Use the Serial Number drop-down list box to select the appropriate serial number.

– Click **OK**.

Export Makefile

Export Makefile exports a buildable project in external make file format. To do this, complete the following procedure:

1. From the Project menu, select **Export Makefile**.

   The Save As dialog box is displayed.

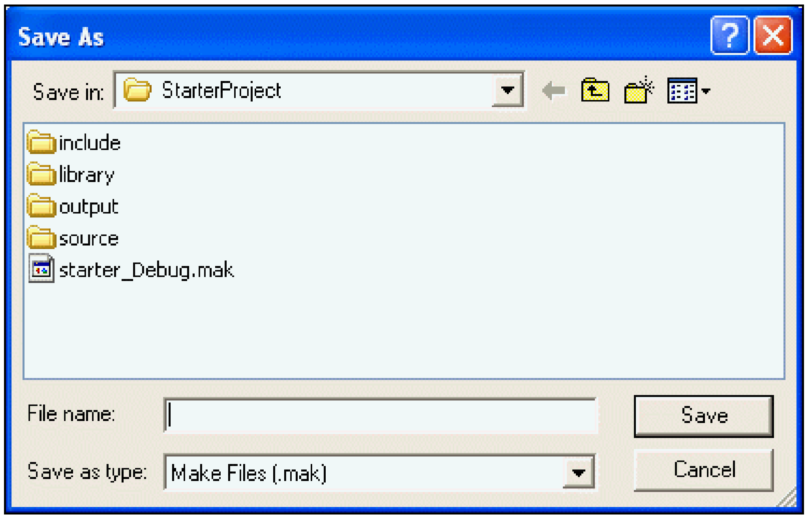


Figure 72. Save As Dialog Box

2. Use the Save In drop-down list box to navigate to the directory where you want to save your project.

   The default location is in your project directory.

3. Type the make file name in the File Name field.

   You do not have to type the extension `.mak`. The extension is added automatically.

4. Click **Save**

   The project is now available as an external make file.

Build Menu

With the Build menu, you can build individual files as well as your project. You can also use this menu to select or add configurations for your project.

The Build menu has the following commands:

- "Compile" on page 103
- "Build" on page 103
- "Rebuild All" on page 103
- "Stop Build" on page 103
- "Clean" on page 103
- "Update All Dependencies" on page 103
- "Set Active Configuration" on page 103

- "Manage Configurations" on page 104

Compile

Select **Compile** from the Build menu to compile or assemble the active file in the Edit window.

Build

Select **Build** from the Build menu to build your project. The build compiles and/or assembles any files that have changed since the last build and then links the project.

Rebuild All

Select **Rebuild All** from the Build menu to rebuild *all* of the files in your project. This option also links the project.

Stop Build

Select **Stop Build** from the Build menu to stop a build in progress.

Clean

Select **Clean** from the Build menu to remove intermediate build files.

Update All Dependencies

Select **Update All Dependencies** from the Build menu to update your source file dependencies.

Set Active Configuration

You can use the Select Configuration dialog box to select the active build configuration you want.

1. From the Build menu, select **Set Active Configuration** to display the Select Configuration dialog box.

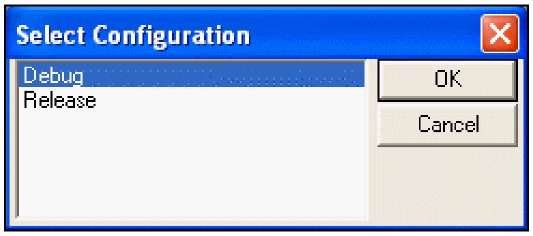


Figure 73. Select Configuration Dialog Box

2. Highlight the configuration that you want to use and click **OK**.

There are two standard configuration settings:

- Debug

  This configuration contains all the project settings for running the project in Debug mode.

- Release

  This configuration contains all the project settings for creating a Release version of the project.

For each project, you can modify the settings, or you can create your own configurations. These configurations allow you to easily switch between project setting types without having to remember all the setting changes that need to be made for each type of build that might be necessary during the creation of a project. All changes to project settings are stored in the current configuration setting.

NOTE: To add your own configuration(s), see "Manage Configurations" on page 104.

Use one of the following methods to activate a build configuration:

- Using the Select Configuration dialog box

  See "Set Active Configuration" on page 103.

- Using the Build toolbar

  See "Select Build Configuration List Box" on page 18.

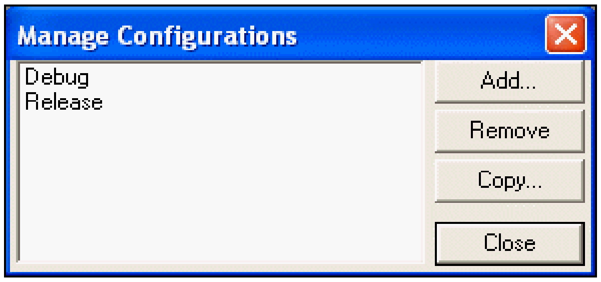
Use the Project Settings dialog box to modify build configuration settings. See "Settings" on page 55.

Manage Configurations

For your specific needs, you can add or copy different configurations for your projects. To add a customized configuration, do the following:

1. From the Build menu, select **Manage Configurations**.

   The Manage Configurations dialog box is displayed.



Debug
Release

Figure 74. Manage Configurations Dialog Box

2. From the Manage Configurations dialog box, click **Add**.

   The Add Project Configuration dialog box is displayed.

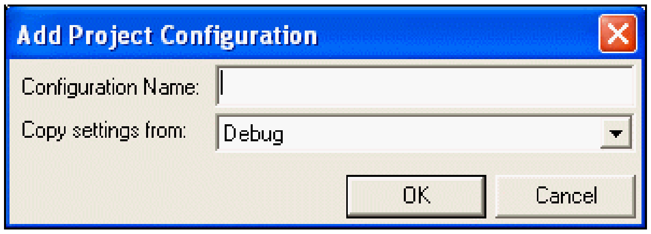


Figure 75. Add Project Configuration Dialog Box

3. Type the name of the new configuration in the Configuration Name field.
4. Select a similar configuration from the Copy Settings From drop-down list box.
5. Click **OK**.

   Your new configuration is displayed in the configurations list in the Manage Configurations dialog box.

6. Click **Close**.

   The new configuration is the current configuration as shown in the Select Build Configuration drop-down list box on the Build toolbar.

   Now that you have created a blank template, you are ready to select the settings for this new configuration.

7. From the Project menu, select **Settings**.

   The Project Settings dialog box is displayed.

8. Select the settings for the new configuration and click **OK**.
9. From the File menu, select **Save All**.

To copy the settings from an existing configuration to an existing configuration, do the following:

1. From the Build menu, select **Manage Configurations**.

   The Manage Configurations dialog box is displayed.

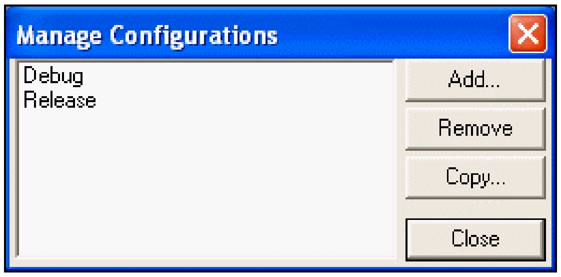
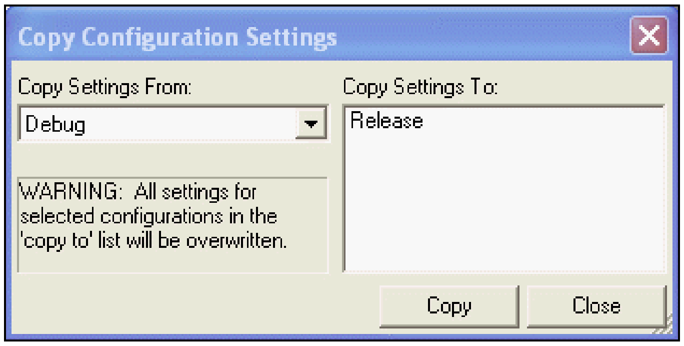


Figure 76. Manage Configurations Dialog Box

2. From the Manage Configurations dialog box, click **Copy**.

   The Copy Configuration Settings dialog box is displayed.



WARNING: All settings for selected configurations in the 'copy to' list will be overwritten.

Figure 77. Copy Configuration Settings Dialog Box

3. Select the configuration with the desired settings from the Copy Settings From drop-down list box.
4. Highlight the configuration(s) in the Copy Settings To field that you want to change.
5. Click **Copy**.

Debug Menu

Use the Debug menu to access the following functions for the debugger:

- “Connect to Target” on page 107
- “Download Code” on page 107
- “Verify Download” on page 108
- “Stop Debugging” on page 108
- “Reset” on page 108
- “Go” on page 109

- “Run to Cursor” on page 109
- “Break” on page 109
- “Step Into” on page 109
- “Step Over” on page 110
- “Step Out” on page 110
- “Set Next Instruction” on page 110

NOTE: For more information on the debugger, see “Using the Debugger” on page 309.

Connect to Target

The Connect to Target command starts a debug session using the following process:

1. Initializes the communication to the target hardware.
2. Resets the device.
3. Configures the device using the settings in the Configure Target dialog box.
4. Configures and executes the debugger options selected in the Debugger tab of the Options dialog box. The following options are ignored if selected:
   - Reset to Symbol 'main' (Where Applicable) check box
   - Verify File Downloads—Read After Write check box
   - Verify File Downloads—Upon Completion check box

This command does not download the software. Use this command to access target registers, memory, and so on without loading new code or to avoid overwriting the target’s code with the same code. This command is not enabled when the target is the simulator. This command is available only when not in Debug mode.

For the Serial Smart Cable, ZDS II performs an on-chip debugger reset and resets the CPU at the vector reset location.

Download Code

The Download Code command downloads the executable file for the currently open project to the target for debugging. The command also initializes the communication to the target hardware if it has not been done yet. Starting in version 4.10.0, the Download Code command can also program Flash memory. A page erase is done instead of a mass erase for both internal and external Flash memory. Use this command anytime during a debug session. This command is not enabled when the debug tool is the simulator.

NOTE: The current code on the target is overwritten.

If ZDS II is not in Debug mode when the Download Code command is selected, the following process is executed:

1. Initializes the communication to the target hardware.
2. Resets the device with a hardware reset by driving pin #2 of the debug header low.
3. Configures the device using the settings in the Configure Target dialog box.
4. Downloads the program.
5. Issues a software reset through the debug header serial interface.
6. Configures and executes the debugger options selected in the Debugger tab of the Options dialog box. If it is a C project, ZDS II resets to the main function if it is found.

If ZDS II is already in Debug mode when the Download Code command is selected, the following process is executed:

1. Resets the device using a software reset.
2. Downloads the program.

You might need to reset the device before execution because the program counter might have been changed after the download.

Verify Download

Select **Verify Download** from the Debug menu to determine download correctness by comparing executable file contents to target memory.

Stop Debugging

Select **Stop Debugging** from the Debug menu to exit Debug mode.

To stop program execution, select the Break command.

Reset

Select **Reset** from the Debug menu to reset the program counter to the beginning of the program.

If ZDS II is not in Debug mode, the Reset command starts a debug session using the following process:

1. Initializes the communication to the target hardware.
2. Resets the device.
3. Configures the device using the settings in the Configure Target dialog box.
4. Downloads the program.
5. Configures and executes the debugger options selected in the Debugger tab of the Options dialog box. If it is a C project, ZDS II resets to the main function if it is found.

If ZDS II is already in Debug mode, the Reset command uses the following process:

1. ZDS II performs a hardware reset.
2. Configures the device using the settings in the Configure Target dialog box.
3. If files have been modified, ZDS II asks, "Would you like to rebuild the project?" before downloading the modified program. If there has been no file modification, the code is not reloaded.

The Serial Smart Cable performs an on-chip debugger reset.

Go

Select **Go** from the Debug menu to execute project code from the current program counter.

If not in Debug mode when the Go command is selected, the following process is executed:

1. Initializes the communication to the target hardware.
2. Resets the device.
3. Configures the device using the settings in the Configure Target dialog box.
4. Downloads the program.
5. Configures and executes the debugger options selected in the Debugger tab of the Options dialog box. If it is a C project, ZDS II resets to the main function if it is found.
6. Executes the program from the reset location.

Run to Cursor

Select **Run to Cursor** from the Debug menu to execute the program code from the current program counter to the line containing the cursor in the active file or the Disassembly window. The cursor must be placed on a valid code line (a C source line with a blue dot displayed in the gutter or any instruction line in the Disassembly window).

Break

Select **Break** from the Debug menu to stop program execution at the current program counter.

Step Into

Select **Step Into** from the Debug menu to execute one statement or instruction from the current program counter, following execution into function calls. When complete, the program counter resides at the next program statement or instruction unless a function was entered, in which case the program counter resides at the first statement or instruction in the function.

Step Over

Select **Step Over** from the Debug menu to execute one statement or instruction from the current program counter without following execution into function calls. When complete, the program counter resides at the next program statement or instruction.

Step Out

Select **Step Out** from the Debug menu to execute the remaining statements or instructions in the current function and returns to the statement or instruction following the call to the current function.

Set Next Instruction

Select **Set Next Instruction** from the Debug menu to set the program counter to the line containing the cursor in the active file or the Disassembly window.

Tools Menu

The Tools menu lets you set up the Flash Loader, calculate a file checksum, update the firmware, and customize of the Z8 Encore! developer's environment.

The Tools menu has the following options:

- "Flash Loader" on page 110
- "Calculate File Checksum" on page 117
- "Firmware Upgrade (Selected Debug Tool)" on page 118
- "Show CRC" on page 119
- "Customize" on page 119
- "Options" on page 122

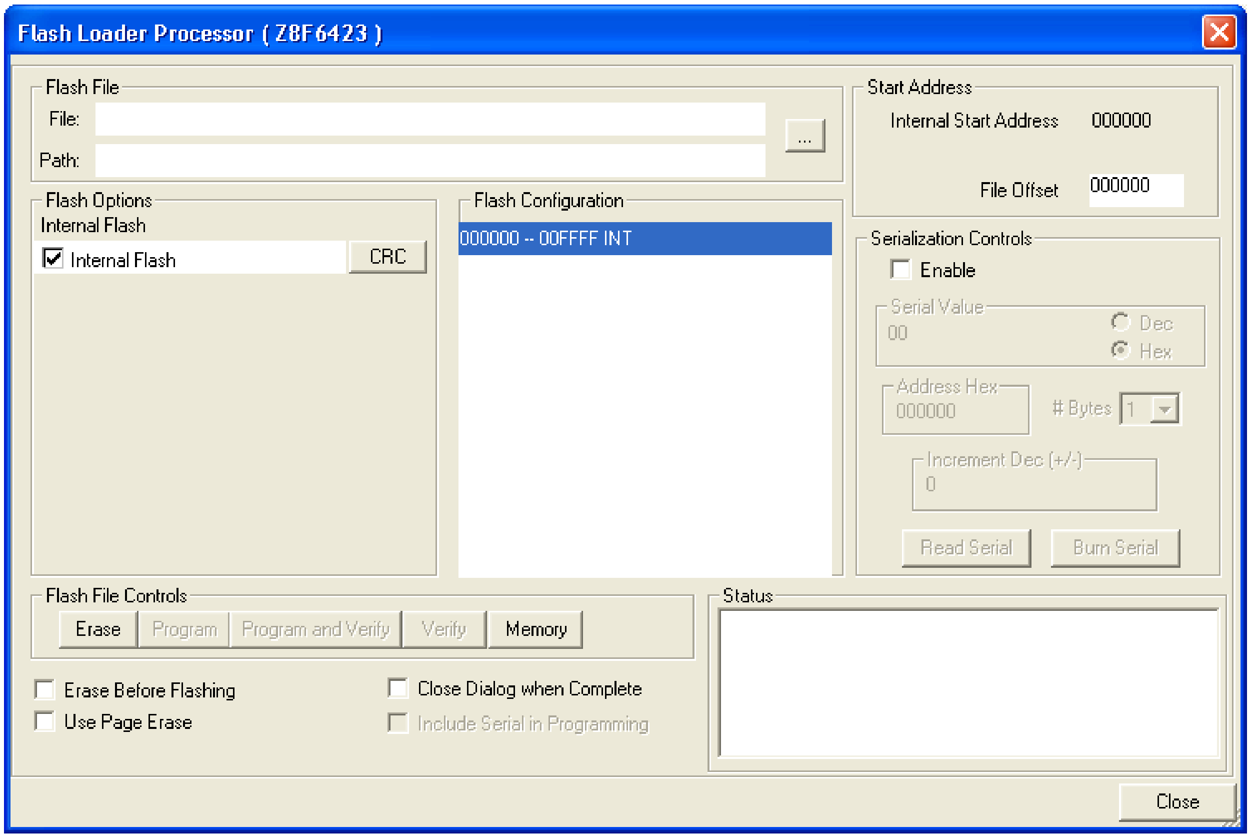
Flash Loader

NOTE: The Flash Loader dialog box needs to be closed and then opened again whenever a new chip is inserted or the power is cycled on the target board.

Use the following procedure to program internal Flash for the Z8 Encore!:

1. Ensure that the target board is powered up and the Z8 Encore! target hardware is connected and operating properly.
2. Select **Flash Loader** from the Tools menu.

   The Flash Loader connects to the target and sets up communication. The Flash Loader Processor dialog box is displayed with the appropriate Flash target options for the selected CPU.


Flash Loader Processor (Z8F6423)

Flash File
File:
Path:

Flash Options
Internal Flash
☑ Internal Flash   CRC

Flash Configuration
000000 -- 00FFFF INT

Start Address
Internal Start Address 000000
File Offset 000000

Serialization Controls
☐ Enable
Serial Value 00   Dec [✓ Hex]
Address Hex 000000   # Bytes 1
Increment Dec (+/-) 0
Read Serial   Burn Serial

Flash File Controls
Erase   Program   Program and Verify   Verify   Memory

☐ Erase Before Flashing
☐ Use Page Erase
☐ Close Dialog when Complete
☐ Include Serial in Programming

Status

Close

Figure 78. Flash Loader Processor Dialog Box

3. Click on the Browse button (...) to navigate to the hex file to be flashed.

NOTE: The Flash Loader is unable to identify, erase, or write to a page of Flash that is protected through hardware. For example, a target might have a write enable jumper to protect the boot block. In this case, the write enable jumper must be set before flashing the area of Flash. The Flash Loader displays this page as disabled.

4. Select the Internal Flash check box in the Flash Options area.

   The internal Flash memory configuration is defined in the `CpuFlashDevice.xml` file. The device is the currently selected microcontroller or microprocessor. When the internal Flash is selected, the address range is displayed in the Flash Configuration area with an INT extension.

5. To perform a cyclic redundancy check on the whole internal Flash memory, click **CRC**.

   The 16-bit CRC-CCITT polynomial ($x^{16} + x^{12} + x^5 + 1$) is used for the CRC. The CRC is preset to all 1s. The least-significant bit of the data is shifted through the polynomial first. The CRC is inverted when it is transmitted. If the device is not in Debug mode, this command returns `FFFFH` for the CRC value. The on-chip debugger reads the program memory, calculates the CRC value, and displays the result in the Status area.

6. Select the pages to erase before flashing in the Flash Configuration area.

   Pages that are grayed out are not available.

7. Type the appropriate offset values in the File Offset field to offset the base address of the hex file.

NOTE: The hex file address is shifted by the offset defined in the Start Address area. You need to allow for the shift in any defined jump table index. This offset value also shifts the erase range for the Flash.

8. To check the memory, click **Memory**.

   The View/Edit Memory dialog box is displayed. In the View/Edit Memory window, you can do the following:

   – Select the appropriate memory space from the Space drop-down list box.
   – Move to a different address by typing the address in the address field and pressing the Enter key.
   – "Fill Memory" on page 114
   – "Save Memory to a File" on page 115
   – "Load a File into Memory" on page 116
   – "Perform a Cyclic Redundancy Check" on page 117

9. Select the Erase Before Flashing check box to erase all Flash memory before writing the hex file to Flash memory.

Caution You can also delete the Flash memory by clicking **ERASE**. Clicking **ERASE** deletes only the pages that are selected.

10. Select the Use Page Erase check box if you want the internal Flash to be page-erased. Deselect this check box if you want the internal Flash to be mass-erased.

11. Select the Close Dialog When Flash Complete check box to close the dialog box after writing the hex file to Flash memory.

12. If you want to use the serialization feature or want to check a serial number that has already been programmed at an address, see "Serialization" on page 113.

13. Program the Flash memory by clicking one of the following buttons:
    - Click **Program** to write the hex file to Flash memory and perform no checking while writing.
    - Click **Program and Verify** to write the hex file to Flash memory by writing a segment of data and then reading back the segment and verifying that it has been written correctly.
14. Verify the Flash memory by clicking **Verify**.

    When you click **Verify**, the Flash Loader reads and compares the hex file contents with the current contents of Flash memory. This function does not change target Flash memory.

NOTE: If you want to run the program that you just flashed, use the following procedure:

15. After you see “Flashing complete” in the Status area of the Flash Loader Processor dialog box, click **Close** to close the dialog box.
16. Remove the power supply, followed by the USB Smart Cable.
17. Reconnect the power supply.

Serialization

The general procedure to write a serial number to a Flash device involves the following steps:

1. Choose a location for the serial number inside or outside of the address range defined in the hex file.

NOTE: The serial number must be written to a location that is not being written to by the hex file.

2. Erase the Flash device.
3. Write the hex file to the Flash device and then write the serial number

   or

   write the serial number to the Flash device and then write the hex file.

Use the following procedure if you want to use the serialization feature:

1. Select the Enable check box.
2. Select the Include Serial in Programming check box.

   This option programs the serial number after the selected hex file has been written to Flash.
3. Type the start value for the serial number in the Serial Value field and select the Dec button for a decimal serial number or the Hex button for a hexadecimal serial number.

4. Type the location you want the serial number located in the Address Hex field.
5. Select the number of bytes that you want the serial number to occupy in the # Bytes drop-down list box.
6. Type the decimal interval that you want the serial number incremented by in the Increment Dec (+/-) field. If you want the serial number to be decremented, type in a negative number. After the current serial number is programmed, the serial number is then incremented or decremented by the amount in the Increment Dec (+/-) field.
7. Select the Erase Before Flashing check box.

   This option erases the Flash before writing the serial number.
8. Click **Burn Serial** to write the serial number to the current device or click **Program** or **Program and Verify** to program the Flash memory with the specified hex file and then write the serial number.

If you want to check a serial number that has already been programmed at an address, do the following:

1. Select the Enable check box.
2. Type the address that you want to read in the Address Hex field.
3. Select the number of bytes to read from # Bytes drop-down list box.
4. Click **Read Serial** to check the serial number for the current device.

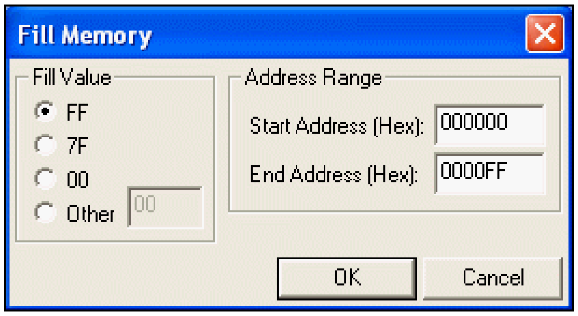
Fill Memory

Use this procedure to write a common value in all the memory spaces in the specified address range, for example, to clear memory for the specified address range. This operation actually flashes the device.

To fill a specified address range of memory, do the following:

1. Select the memory space in the Space drop-down list box.
2. Right-click in the list box to display the context menu.
3. Select **Fill Memory**.

   The Fill Memory dialog box is displayed.



Fill Value: [✓ FF] 7F 00 Other 00

Start Address (Hex): 000000

End Address (Hex): 0000FF

Figure 79. Fill Memory Dialog Box

4. In the Fill Value area, select the characters to fill memory with or select the Other button.

   If you select the Other button, type the fill characters in the Other field.

5. Type the start address in hexadecimal format in the Start Address (Hex) field and type the end address in hexadecimal format in the End Address (Hex) field.

   This address range is used to fill memory with the specified value.

6. Click **OK** to fill the selected memory.

Save Memory to a File

Use this procedure to save memory specified by an address range to a binary, hexadecimal, or text file.

Perform the following steps to save memory to a file:

1. Select the memory space in the Space drop-down list box.
2. Right-click in the list box to display the context menu.
3. Select **Save to File**.

   The Save to File dialog box is displayed.

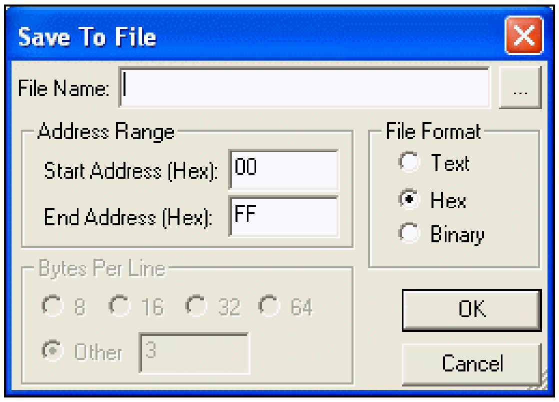


Figure 80. Save to File Dialog Box

4. In the File Name field, enter the path and name of the file you want to save the memory to or click the Browse button (...) to search for a file or directory.
5. Type the start address in hexadecimal format in the Start Address (Hex) field and type the end address in hexadecimal format in the End Address (Hex) field.

   This specifies the address range of memory to save to the specified file.
6. Select whether to save the file as text, hex (hexadecimal), or binary.
7. Select how many bytes per line or enter the number of bytes in the Other field.
8. Click **OK** to save the memory to the specified file.

Load a File into Memory

Use this procedure to load or to initialize memory from an existing binary, hexadecimal, or text file.

Perform the following steps to load a file into memory:

1. Select the memory space in the Space drop-down list box.
2. Right-click in the list box to display the context menu.
3. Select **Load from File**.

   The Load from File dialog box is displayed.

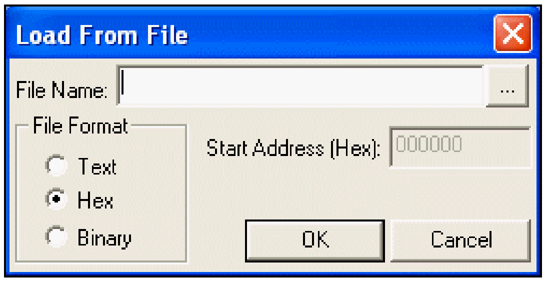


Figure 81. Load from File Dialog Box

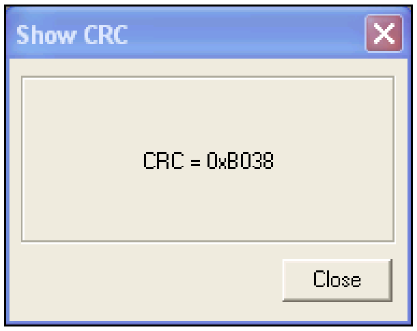
4. In the File Name field, enter the path and name of the file to load or

   click the Browse button (...) to search for the file.
5. In the Start Address (Hex) field, enter the start address.
6. Select whether to load the file as text, hex (hexadecimal), or binary.

   Click **OK** to load the file's contents into the selected memory.

Perform a Cyclic Redundancy Check

To perform a cyclic redundancy check (CRC), select **Show CRC** from the context menu. The checksum is displayed in the Show CRC dialog box.



CRC = 0xB038

Figure 82. Show CRC Dialog Box

Calculate File Checksum

Use the following procedure to calculate the file checksum:

1. Select **Calculate File Checksum** from the Tools menu.

   The Calculate Checksum dialog box is displayed.

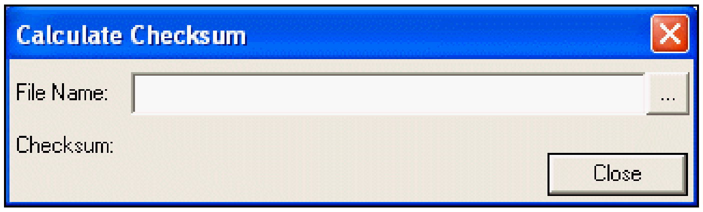
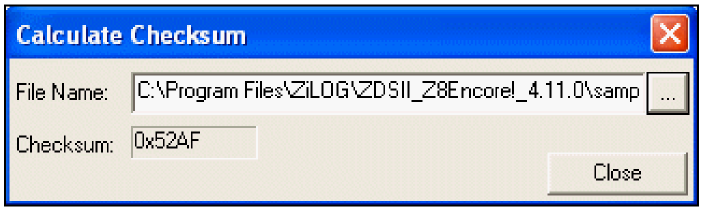


Figure 83. Calculate Checksum Dialog Box

2. Click on the Browse button (...) to select the `.hex` file for which you want to calculate the checksum.

   The IDE adds the bytes in the files and displays the result in the Checksum field.



File Name: C:\Program Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\samp

Checksum: 0x52AF

Figure 84. Calculate Checksum Dialog Box

3. Click **Close**.

Firmware Upgrade (Selected Debug Tool)

NOTE: This command is available only when a supporting debug tool is selected (see "Debug Tool" on page 100).

Use one of the following files for instructions on how to upgrade your firmware:

- USB Smart Cable

  <ZDS Installation Directory>`\bin\firmware\USBSmartCable\USBSmartCable upgrade information.txt`

- Ethernet Smart Cable

  <ZDS Installation Directory>`\bin\firmware\EthernetSmartCable\EthernetSmartCable upgrade information.txt`

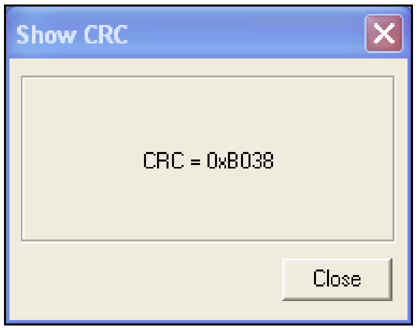
Show CRC

NOTE: This command is only available when the target is not a simulator.

Use the following procedure to perform a cyclic redundancy check (CRC) for the whole internal Flash memory:

1. Select **Show CRC** from the Tools menu.

   The Show CRC dialog box is displayed with the result.



CRC = 0xB038

Figure 85. Show CRC Dialog Box

Customize

The Customize dialog box contains the following tabs:

- "Customize—Toolbars Tab" on page 119
- "Customize—Commands Tab" on page 121

Customize—Toolbars Tab

The Toolbars tab lets you select the toolbars you want to display on the Z8 Encore! developer's environment, change the way the toolbars are displayed, or create a new toolbar.

NOTE: You cannot delete, customize, or change the name of the default toolbars.

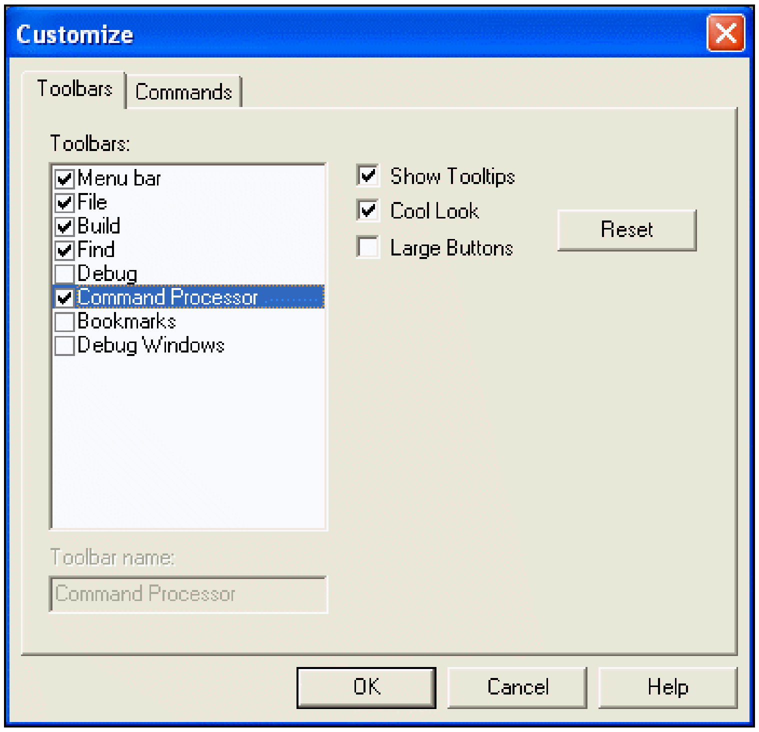


Figure 86. Customize Dialog Box–Toolbars Tab

To display, hide, or change the appearance of toolbars, use the following procedure:

1. Select **Customize** from the Tools menu.

   The Customize dialog box is displayed.

2. Click on the Toolbars tab.

3. In the Toolbars list box, select the toolbars that you want displayed and deselect toolbars that you want hidden.

4. Select the Show Tooltips check box if you want to display cue cards (short descriptions of the main function of buttons) when your mouse cursor is over a button.

5. Select the Cool Look check box to change how the buttons are displayed.

6. Select the Large Buttons check box to increase the size of the buttons.

7. Click **Reset** to restore the defaults.

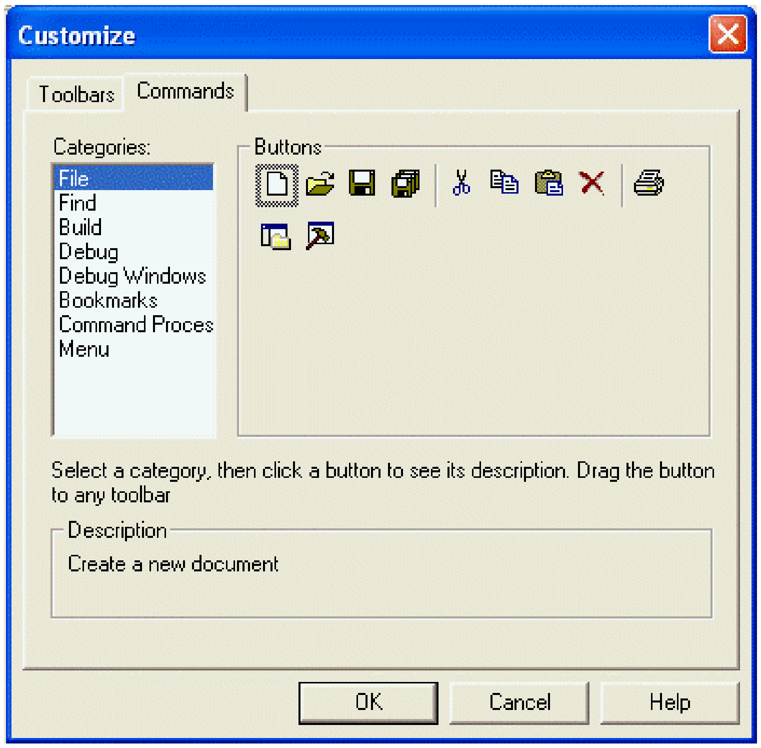
8. Click **OK** to apply your changes or **Cancel** to close the dialog box without making any changes.

Customize—Commands Tab

The Commands tab lets you modify the following by selecting the category:

- “File Toolbar” on page 16
- “Find Toolbar” on page 21
- “Build Toolbar” on page 18
- “Debug Toolbar” on page 23
- “Debug Windows Toolbar” on page 27
- “Bookmarks Toolbar” on page 22
- “Command Processor Toolbar” on page 22
- “Menu Bar” on page 37

To see a description of each button on the toolbars, highlight the icon as shown in the following figure.



Select a category, then click a button to see its description. Drag the button to any toolbar

Description

Create a new document

Figure 87. Customize Dialog Box—Commands Tab

Options

The Options dialog box contains the following tabs:

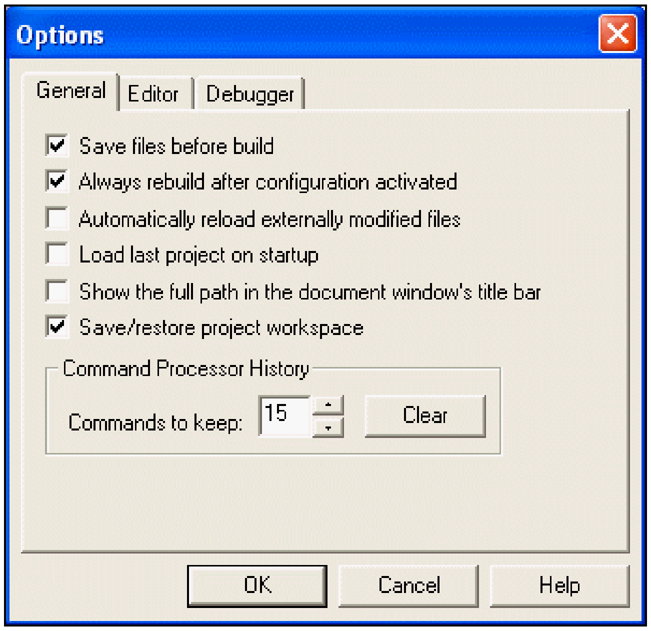
- “Options—General Tab” on page 122
- “Options—Editor Tab” on page 123
- “Options—Debugger Tab” on page 126

Options—General Tab

The General tab has the following check boxes:

- Select the Save Files Before Build check box to save files before you build. This option is selected by default.
- Select the Always Rebuild After Configuration Activated check box to ensure that the first build after a project configuration (such as Debug or Release) is activated results in the reprocessing of all of the active project’s source files. A project configuration is activated by being selected (using the Select Configuration dialog box or the Select Build Configuration drop-down list box) or created (using the Manage Configurations dialog box). This option is not selected by default.
- Select the Automatically Reload Externally Modified Files check box to automatically reload externally modified files. This option is not selected by default.
- Select the Load Last Project on Startup check box to load the most recently active project when you start ZDS II. This option is not selected by default.
- Select the Show the Full Path in the Document Window’s Title Bar check box to add the complete path to the name of each file open in the Edit window.
- Select the Save/Restore Project Workspace check box to save the project workspace settings each time you exit from ZDS II. This option is selected by default.

Select a number of commands to save in the Commands to Keep field or click **Clear** to delete the saved commands.



- [✓] Save files before build
- [✓] Always rebuild after configuration activated
- [ ] Automatically reload externally modified files
- [ ] Load last project on startup
- [ ] Show the full path in the document window's title bar
- [✓] Save/restore project workspace

Command Processor History
Commands to keep: 15

Figure 88. Options Dialog Box—General Tab

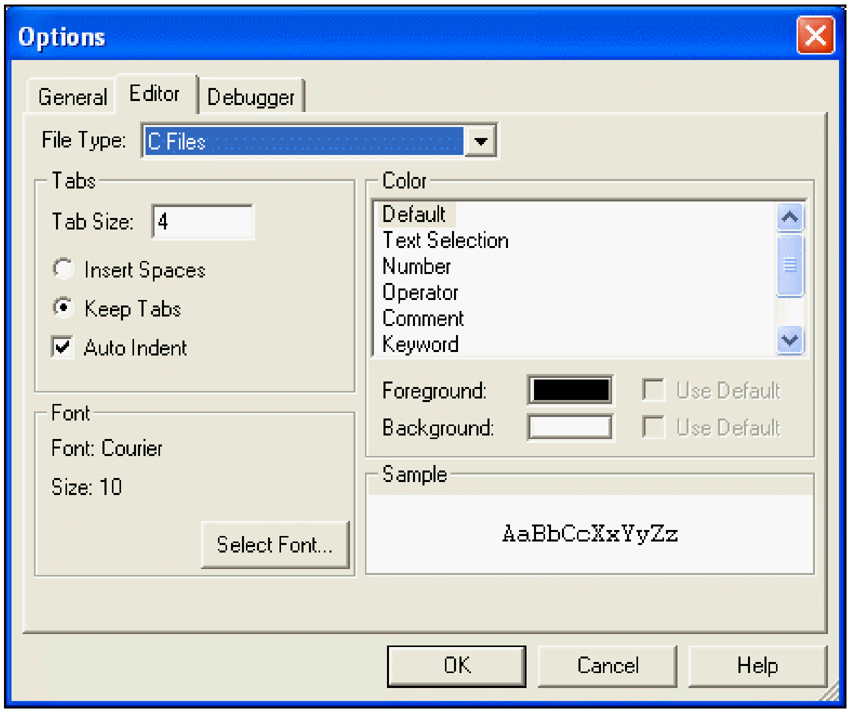
Options—Editor Tab

Use the Editor tab to change the default settings of the editor for your assembly, C, and default files:

1. From the Tools menu, select **Options**.

   The Options dialog box is displayed.

2. Click on the Editor tab.



File Type: C Files

Tabs
Tab Size: 4
Insert Spaces [✓ Keep Tabs]
[✓] Auto Indent

Font
Font: Courier
Size: 10

Color
Default
Text Selection
Number
Operator
Comment
Keyword

Foreground: ■ Use Default
Background: □ Use Default

Sample
AaBbCcXxYyZz

Figure 89. Options Dialog Box—Editor Tab

3. Select a file type from the File Type drop-down list box.

   You can select C files, assembly files, or other files and windows.

4. In the Tabs area, do the following:
   – Use the Tab Size field to change the number of spaces that a tab indents code.
   – Select the Insert Spaces button or the Keep Tabs button to indicate how to format indented lines.
   – Select the Auto Indent check box if you want the IDE to automatically add indentation to your files.

5. If you want to change the color for any of the items in the Color list box, click the item, make sure the Use Default check boxes are not selected, and then click on the color in the Foreground or Background field to display the Color dialog box (see following figure). If you want to use the default foreground or background color for the selected item, enable the Use Default check box next to the Foreground or Background check box (see preceding figure).

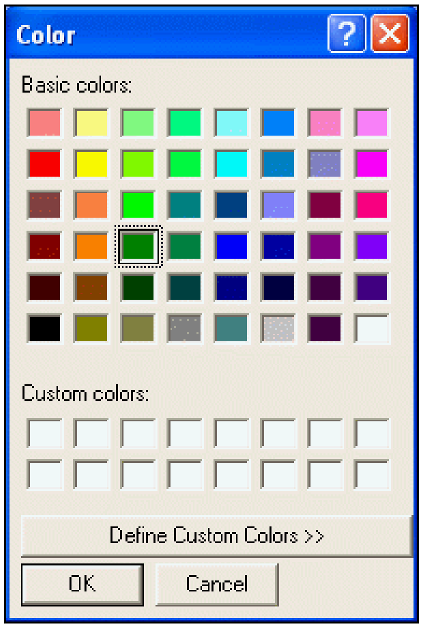


Figure 90. Color Dialog Box

6. Click **OK** to close the Color dialog box.
7. To change the default font and font size, click **Select Font**.

   The Font dialog box is displayed.

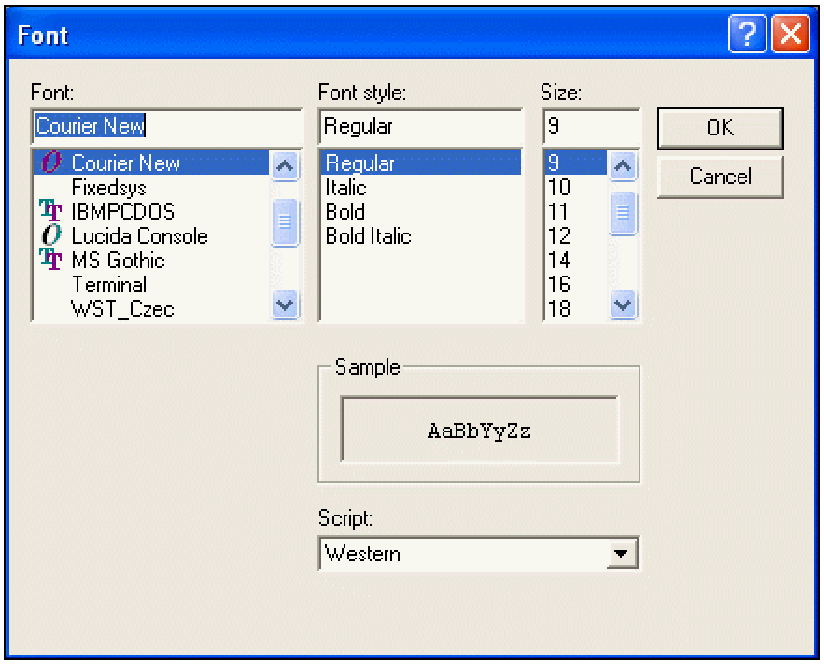


Figure 91. Font Dialog Box

You can change the font, font style, font size, and script style.

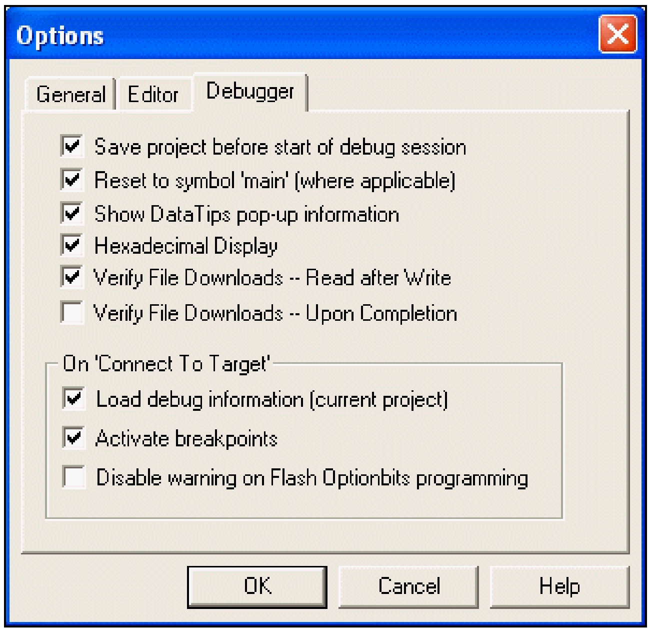
8. Click **OK** to close the Font dialog box.
9. Click **OK** to close the Options dialog box.

Options—Debugger Tab

The Debugger tab contains the following check boxes:

- Select the Save Project Before Start of Debug Session check box to save the current project before entering the Debug mode. This option is selected by default.
- Select the Reset to Symbol 'main' (Where Applicable) check box to skip the startup (boot) code and start debugging at the main function for a project that includes a C language main function. When this check box is selected, a user reset (clicking the Reset button on the Build and Debug toolbars, selecting **Reset** from the Debug menu, or using the `reset` script command) results in the program counter (PC) pointing to the beginning of the main function. When this check box is not selected, a user reset results in the PC pointing to the first line of the program (the first line of the startup code).
- When the Show DataTips Pop-Up Information check box is selected, holding the cursor over a variable in a C file in the Edit window in Debug mode displays the value.

- Select the Hexadecimal Display check box to change the values in the Watch and Locals windows to hexadecimal format. Deselect the check box to change the values in the Watch and Locals windows to decimal format.
- Select the Verify File Downloads—Read After Write check box to perform a read after write verify of the Code Download function. Selecting this check box increases the time taken for the code download to complete.
- Select the Verify File Downloads—Upon Completion check box to verify the code that you downloaded after it has downloaded.
- Select the Load Debug Information (Current Project) check box to load the debug information for the currently open project when the Connect to Target command is executed (from the Debug menu or from the Connect to Target button). This option is selected by default.
- Select the Activate Breakpoints check box for the breakpoints in the current project to be active when the Connect to Target command is executed (from the Debug menu or from the Connect to Target button). This option is selected by default.
- Select the Disable Warning on Flash Optionbits Programming check box to prevent messages from being displayed before programming Flash option bits.



[✓] Save project before start of debug session
[✓] Reset to symbol 'main' (where applicable)
[✓] Show DataTips pop-up information
[✓] Hexadecimal Display
[✓] Verify File Downloads -- Read after Write
[ ] Verify File Downloads -- Upon Completion

On 'Connect To Target'
[✓] Load debug information (current project)
[✓] Activate breakpoints
[ ] Disable warning on Flash Optionbits programming

Figure 92. Options Dialog Box—Debugger Tab

Window Menu

The Window menu allows you to select the ways you want to arrange your files in the Edit window and allows you to activate the Project Workspace window or the Output window.

The Window menu contains the following options:

- “New Window” on page 128
- “Close” on page 128
- “Close All” on page 128
- “Cascade” on page 128
- “Tile” on page 128
- “Arrange Icons” on page 128

New Window

Select **New Window** to create a copy of the file you have active in the Edit window.

Close

Select **Close** to close the active file in the Edit window.

Close All

Select **Close All** to close all the files in the Edit window.

Cascade

Select **Cascade** to cascade the files in the Edit window. Use this option to display all open windows whenever you cannot locate a window.

Tile

Select **Tile** to tile the files in the Edit window so that you can see all of them at once.

Arrange Icons

Select **Arrange Icons** to arrange the files alphabetically in the Edit window.

Help Menu

The Help menu contains the following options:

- “Help Topics” on page 128
- “Technical Support” on page 129
- “About” on page 129

Help Topics

Select **Help Topics** to display the ZDS II online help.

Technical Support

Select **Technical Support** to access Zilog's Technical Support web site.

About

Select **About** to display installed product and component version information.

SHORTCUT KEYS

The following sections list the shortcut keys for the Zilog Developer Studio II:

- "File Menu Shortcuts" on page 129
- "Edit Menu Shortcuts" on page 129
- "Project Menu Shortcuts" on page 130
- "Build Menu Shortcuts" on page 130
- "Debug Menu Shortcuts" on page 131

File Menu Shortcuts

These are the shortcuts for the options on the File menu.

Option	Shortcut	Description
New File	Ctrl+N	To create a new file in the Edit window.
Open File	Ctrl+O	To display the Open dialog box for you to find the appropriate file.
Save	Ctrl+S	To save the file.
Save All	Ctrl+Alt+L	To save all files in the project.
Print	Ctrl+P	To print a file.

Edit Menu Shortcuts

These are the shortcuts for the options on the Edit menu.

Option	Shortcut	Description
Undo	Ctrl+Z	To undo the last command, action you performed.
Redo	Ctrl+Y	To redo the last command, action you performed.
Cut	Ctrl+X	To delete selected text from a file and put it on the clipboard.
Copy	Ctrl+C	To copy selected text from a file and put it on the clipboard.
Paste	Ctrl+V	To paste the current contents of the clipboard into a file.

Option	Shortcut	Description
Select All	Ctrl+A	To highlight all text in the active file.
Show Whitespaces	Ctrl+Shift+8	To display all whitespace characters like spaces and tabs.
Find	Ctrl+F	To find a specific value in the designated file.
Find Again	F3	To repeat the previous search.
Find in Files	Ctrl+Shift+F3	To find text in multiple files.
Replace	Ctrl+H	To replace a specific value to the designated file.
Go to Line	Ctrl+G	To jump to a specified line in the current file.
Toggle Bookmark	Ctrl+F2	To insert a bookmark in the active file for the line where your cursor is located or to remove the bookmark for the line where your cursor is located.
Next Bookmark	F2	To position the cursor at the line where the next bookmark in the active file is located. The search for the next bookmark does not stop at the end of the file; the next bookmark might be the first bookmark in the file.
Previous Bookmark	Shift+F2	To position the cursor at the line where the previous bookmark in the active file is located. The search for the previous bookmark does not stop at the beginning of the file; the previous bookmark might be the last bookmark in the file.
Remove All Bookmarks	Ctrl+Shift+F2	To delete all of the bookmarks in the currently loaded project.

Project Menu Shortcuts

There is one shortcut for the options on the Project menu.

Option	Shortcut	Description
Settings	Alt+F7	To display the Project Settings dialog box.

Build Menu Shortcuts

These are the shortcuts for the options on the Build menu.

Option	Shortcut	Description
Build	F7	To build your file and/or project.
Stop Build	Ctrl+Break	To stop the build of your file and/or project.

Debug Menu Shortcuts

These are the shortcuts for the options on the Debug menu.

Option	Shortcut	Description
Stop Debugging	Shift+F5	To stop debugging of your program.
Reset	Ctrl+Shift+F5	To reset the debugger.
Go	F5	To invoke the debugger (go into Debug mode).
Run to Cursor	Ctrl+F10	To make the debugger run to the line containing the cursor.
Break	Ctrl+F5	To break the program execution.
Step Into	F11	To execute the code one statement at a time.
Step Over	F10	To step to the next statement regardless of whether the current statement is a call to another function.
Step Out	Shift+F11	To execute the remaining lines in the current function and return to execute the next statement in the caller function.
Set Next Instruction	Shift+F10	To set the next instruction at the current line.

Using the ANSI C-Compiler

The following sections provide you information on writing C programs with the ANSI C-Compiler:

For more information on using the compiler in the developer's environment, refer to "Getting Started" on page 1 and "Using the Integrated Development Environment" on page 15.

NOTE: The Command Processor allows you to use commands or script files to automate the execution of a significant portion of the IDE's functionality. For more information about using the Command Processor, see "Using the Command Processor" on page 408.

LANGUAGE EXTENSIONS

To give you additional control over the way the Z8 Encore! C-Compiler allocates storage and to enhance its ability to handle common real-time constructs, the compiler implements the following extensions to the ANSI C standard:

- "Additional Keywords for Storage Specification" on page 134

  The compiler divides the Z8 Encore! CPU memory into three memory spaces: ROM, RData (near RAM), and EData (far RAM). It provides the following keywords with which you can control the storage location of data in these memory spaces:

  - `near`

  - `far`
  - `rom`

  These keywords can also be used to specify the memory space to which a pointer is pointing to.

- "Memory Models" on page 137

  The compiler supports two memory models: small and large. These models allow you to control where data are stored by default. Each application can only use one model. The model can affect the efficiency of your application. Some of the memory allocation defaults associated with a memory model can be overridden using the keywords for storage specification.

- "Call Frames" on page 138

  Call frames hold the arguments, local variables, and other pertinent information of an instantiation of a procedure or function at a time. The Zilog Z8 Encore! compiler supports two types of call frames: static and dynamic. Dynamic call frames are allocated on the run-time stack. Static call frames are allocated in static memory. The call frame can affect the efficiency of your application.

- "Interrupt Support" on page 140

  The Z8 Encore! CPU supports various interrupts. The C-Compiler provides language extensions to designate a function as an interrupt service routine and provides features to set each interrupt vector.

- "Monitor Function Support" on page 141

  The C-Compiler provides a special function type to be used in monitor applications to support efforts to create a real-time operating system kernel for Z8 Encore!.

- "String Placement" on page 142

  Because the Z8 Encore! CPU has multiple address spaces, the C-Compiler provides language extensions to specify the storage for string constants.

- "Inline Assembly" on page 143

  The C-Compiler provides directives for embedding assembly instructions and directives into the C program.

- "Placement Directives" on page 143

  The placement directives allow users to place objects at specific hardware addresses and align objects at a given alignment.

- "Char and Short Enumerations" on page 144

  The enumeration data type is defined as `int` as per ANSI C. The C-Compiler provides language extensions to specify the enumeration data type to be other than `int`.

- "Setting Flash Option Bytes in C" on page 145

  The Z8 Encore! CPU has two Flash option bytes. The C-Compiler provides language extensions to define these Flash option bytes.
- "Program RAM Support (Z8 Encore! XP 16K Series Only)" on page 146

  The Z8 Encore! XP 16K Series devices have additional RAM that can be used as Program RAM (PRAM) optionally. The Z8 Encore! C-Compiler provides syntax to place code for a function in PRAM.
- "Preprocessor #warning Directive Support" on page 147

  The C-Compiler supports `#warning` directives in addition to `#error` directives for diagnostic message generation.
- "Supported New Features from the 1999 Standard" on page 147

  The Z8 Encore! C-Compiler is based on the 1989 ANSI C standard. Some new features from the 1999 standard are supported in this compiler for ease of use.

Additional Keywords for Storage Specification

The `near`, `far`, and `rom` keywords are storage class specifiers and are used to control the allocation of data objects by the compiler. They can be used on individual data objects similar to the `const` and `volatile` keywords in the ANSI C standard. The storage specifiers can only be used to control the allocation of global and static data. The allocation of local data (nonstatic local) and function parameters is decided by the compiler and is described in later sections. Any storage specifier used on local and parameter data is ignored by the compiler.

The data allocation for various storage class specifiers is as follows:

- `near`

  A variable declared with the `near` storage specifier is allocated in the 8-bit addressable RData (near RAM) address space. The address range for these variables is `00-FF`. The corresponding assembler address space for these variables is RData. You can set this address range within `00-FF` based on device type and application requirement. For example:

  ```
  near int ni;  /* ni is placed in RData address space */
  ```
- `far`

  A variable declared with the `far` storage specifier is allocated in the 12-bit addressable EData (far RAM) address space. The address range for these variables is `100-FFF`. The corresponding assembler address space for these variables is EData. You can set this address range within `100-FFF` based on device type and application requirement. For example:

  ```
  far int fi;  /* fi is placed in EData address space */
  ```

NOTE: In the Z8 Encore! compiler, the peripheral registers (address: `F00-FFF`) are also mapped to the `far` storage specifier; no separate keyword is provided. For example:

```
#define T0CTL0    (*(unsigned char volatile far*)0xF06)

T0CTL0 = 0x12;
```

- `rom`

  A variable declared with the `rom` storage specifier is allocated in the 16-bit addressable nonvolatile memory. The address range for these variables is `0000-FFFF`. The lower portion of this address space is used for the Flash option bytes and interrupt vector table. The corresponding assembler address space for these variables is ROM. You can set this address range within `0000-FFFF` based on his device type and application requirement. For example:

  ```
  rom int ri;  /* ri is placed in ROM address space */
  ```

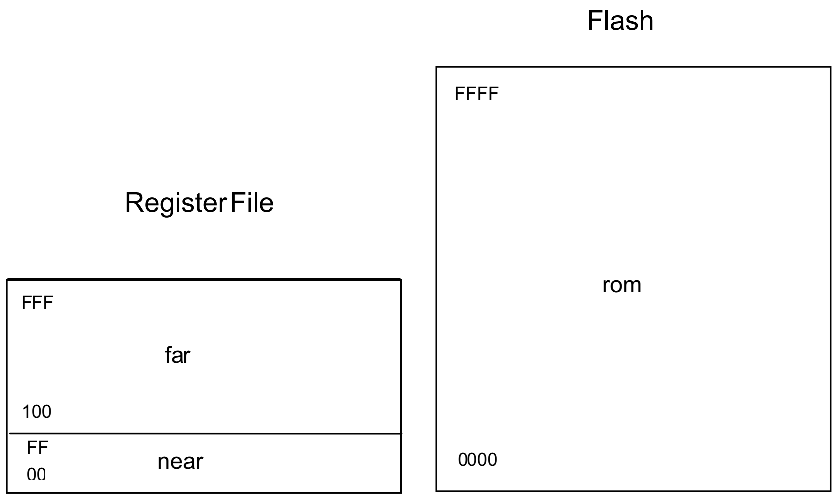


Figure 93. Z8 Encore! Memory Layout

Storage Specification for Pointers

To properly access `near`, `far`, and `rom` objects using a pointer, the compiler provides the ability to associate the storage specifier with the pointer type:

- near pointer

  A near pointer points to `near` data.

- far pointer

  A far pointer points to `far` data.

- rom pointer

  A rom pointer points to `rom` data.

For example:

```
char *p;               /* p is a pointer to a :
                       near char : small model
                       far char : large model. */
char far *fp;          /* fp is a pointer to a far char,
                       fp itself is stored in:
                       near memory for small model
                       far memory for large model. */
char far * far fpf;    /* fpf is a pointer to a far char,
                       fpf itself is stored in far
                       memory. */
char * near pn;        /* pn is a pointer to a:
                       near char : small model
                       far char : large model
                       pn itself is stored in near
                       memory. */
char near * far npf;   /* npf is a pointer to a near char,
                       npf itself is stored in far
                       memory. */
char rom * near cpn;   /* cpn is a pointer to a rom char,
                       cpn itself is stored in near
                       memory. */
```

Default Storage Specifiers

The default storage specifier is applied if none is specified. The default storage specifier for a given type of data depends on the memory model chosen. See the following table for the default storage specifiers for each model type.

Table 1. Default Storage Specifiers

	Function	Globals	Locals	String	Const	Parameters	Pointer
Small (S)	rom	near	near	near	near	near	near
Large (L)	rom	far	far	far	far	far	far

When the deprecated `-const=ROM` option is selected, the default storage specifier for `const` qualified variables is rom in both the small and large models. Zilog recommends that you use the `rom` keyword to explicitly place a variable in the rom address space when desired, rather than use that deprecated option (see "Place Const Variables in ROM" on page 73).

Space Specifier on Structure and Union Members Ignored

The space specifier for a structure or union takes precedence over any space specifier declared for an individual member of the structure. When the space specifier of a member does not match the space specifier of its structure or union, the space specifier of the member is ignored. For example:

```
struct{
near char num;   /* Warning: near space specifier is ignored. */
near char * ptr; /* Correct: ptr points to a char in near memory.
            ptr itself is stored in the memory space of structure (far). */
} far  mystruct; /* All of mystruct is allocated in far memory.*/
```

Memory Models

The Z8 Encore! C-Compiler provides two memory models:

- "Small Memory Model" on page 137
- "Large Memory Model" on page 138

Each of these models directs the compiler where to place data in memory by default, to maximize the efficiency of an application. This feature allows you to control where global and static data are allocated, as well as where frames containing local and parameter data are stored.

Small Memory Model

In the small memory model, global variables are allocated in the RData address space. The address of these variables is 8 bits. The locals and parameters are allocated on the stack, which is also located in the RData address space. The address of a local or parameter is an 8-bit address. Global variables can be manually placed into the EData or ROM address space by using the address specifiers `far` and `rom`, respectively. Local (nonstatic) variables and parameters are always allocated in the RData address space, and any address specifiers used in their declarations are ignored. Use of the small memory model does not impose any restriction on your code size; only data memory is affected by the choice of model.

The small memory model always produces more efficient code than the large model if your application can use it. The use of the small model places stringent limits on the data space available for the stack and data. It does help to produce smaller code, by enabling the compiler to use shorter instructions with more compact addressing modes. If you are near but slightly over the data-space limits of the small model, you might still be able to use the small model by declaring enough selected global or static variables as `far` to get your use of RData down to the available space. The code used to access those `far` variables is less efficient than the default data-access code, so, if you follow this plan, you need to choose variables that are seldom accessed to be `far`.

NOTE: `printf()` usually cannot be used with the small model because the stack grows too large and corrupts the data.

Large Memory Model

In the large memory model, global variables are allocated in the EData address space. The address of these variables is 16 bits. The locals and parameters are allocated on the stack, which is also located in the EData address space. The address of a local or parameter is a 16-bit address. Global variables can be manually placed into the RData or ROM address space by using the address specifiers `near` or `rom`, respectively. Local (nonstatic) variables and parameters are always allocated in the EData address space, and any address specifiers used in their declarations are ignored.

If you are forced to use the large model because of your data space and stack requirements, you can still get some of the benefit of the more efficient code that is typical of the small model. To do so, carefully choose the most frequently used global or static variables and declare them `near`. This helps with both code size and even more so with execution speed because more frequently executed code is more efficient.

One way of minimizing the amount of data space (RData and EData) your application needs is to allocate a single buffer in data space to hold, for example, the largest of a number of strings you might need to display. The numerous strings are stored permanently in ROM where space is often less limited. Each string, in turn, is then copied from ROM to data space at the moment when it is needed.

Another way of saving space when data space (RData and EData) is at a premium is to declare initialized tables that are not modified in the code with the `rom` keyword. The tradeoff here is that the execution speed is likely to be somewhat slower because the number of addressing modes available to the compiler for accessing `rom` variables is very small.

Call Frames

Call frames hold the arguments, local variables, and other pertinent information of an instantiation of a procedure or function at a time. The Zilog Z8 Encore! C-Compiler supports two types of call frames:

- “Static Frames” on page 138
- “Dynamic Frames” on page 139

Static Frames

In the static frames scheme, for each function in the program, a single frame is statically allocated at compile time for storing the call frame containing the parameters and local variables of the function.

Static call frames can significantly increase code efficiency. However, this is a restrictive call-frame scheme. This option must be used with some care because errors ensue if it is applied blindly and your code uses either recursion or calls through function pointers. You can avoid those errors by finding the functions that use those language features and declaring them reentrant. In the case of function pointers, it is the functions to which the pointers refer, not the functions that make the calls that must be marked as reentrant.

The advantage of static frames is that because the compiler knows the absolute address of each function parameter, it can generate more compact code to access parameters than in dynamic frames where they must be accessed by offsetting from the stack pointer. For the Z8 Encore! instruction set architecture, this code size savings is substantial. The savings comes primarily not from using less space for frames, but from using less code to access data in the frames. Thus, it is primarily a savings in code space, not in data space. It could actually require more data space, although to mitigate this, the Z8 Encore! linker uses call-graph techniques to overlay some function frames that cannot be simultaneously active.

The disadvantages of static frames are that they do not support two features of the C language: recursion and making calls through function pointers. To allow a broader range of applications to get the benefits of using static frames, the Z8 Encore! compiler provides the `reentrant` keyword as another C language extension.

Dynamic Frames

The most familiar type of call frames, used exclusively by most desktop-oriented compilers, are dynamic frames: when a function is called, space is dynamically allocated on the stack to hold its return address, function parameters, and local variables.

Dynamic frames hold arguments and local variables on the run-time stack, allow recursion, and allow reentrancy. Dynamic frames are the usual way of storing information about an instance of a function call. Passing argument in dynamic frames is done by pushing the arguments on the stack in reverse (right to left) order.

Reentrant Keyword

This keyword notifies the compiler that in an application that otherwise uses static frames, a dynamic frame must be used for any function declared reentrant. For example, to declare the `recursive_fn` function as using a dynamic call frame, use the following syntax:

```
reentrant int recursive_fn (int k)
{
    if (k == 0)
       return 1;
   return ( k * recursive_fn (k-1));
}
```

When the static call frame option is selected, all call frames are assumed static by the compiler unless the `reentrant` storage class is used in the function declaration. Obviously, if large numbers of functions in an application must be declared reentrant, the benefit of using static frames diminishes proportionately.

When the dynamic call frame option is selected, all call frames are assumed reentrant by the compiler.

Interrupt Support

To support interrupts, the Z8 Encore! C-Compiler provides the following features:

- "interrupt Keyword" on page 140
- "Interrupt Vector Setup" on page 140

interrupt Keyword

Functions that are preceded by `#pragma interrupt` or are associated with the interrupt storage class are designated as interrupt handlers. These functions should neither take parameters nor return a value. The compiler stores the machine state at the beginning of these functions and restores the machine state at the end of these functions. Also, the compiler uses the `iret` instruction to return from these functions. For example:

```
void interrupt isr_timer0(void)
{
}
```

or

```
#pragma interrupt
void isr_timer0(void)
{
}
```

Interrupt Vector Setup

The compiler provides two mechanisms for interrupt vector setup:

- "SET_VECTOR Intrinsic Function" on page 140
- "_At Keyword" on page 141

SET_VECTOR Intrinsic Function

SET_VECTOR can be used to specify the address of an interrupt handler for an interrupt vector. Because the interrupt vectors of the Z8 Encore! microcontroller are usually in ROM, they cannot be modified at run time. The SET_VECTOR function works by switching to a special segment and placing the address of the interrupt handler in the vector table. No executable code is generated for this statement.

The following is the `SET_VECTOR` intrinsic function prototype:

```
intrinsic void SET_VECTOR(int vectnum,void (*hndlr)(void));
```

An example of the use of `SET_VECTOR` is as follows:

```
#include <eZ8.h>
extern void interrupt isr_timer0(void);
void main(void)
{
     SET_VECTOR(TIMER0, isr_timer0);
}
```

See “SET_VECTOR” on page 172 for supported values of *vectnum*.

_At Keyword

The `_At` keyword (described in “Placement Directives” on page 143) can be used in conjunction with the `interrupt` keyword to associate an interrupt handler with an interrupt vector. Because the interrupt vectors of the Z8 Encore! microcontroller are usually in ROM, only one handler can be associated with an interrupt vector. For example:

```
#include <eZ8.h>
void interrupt isr_timer0(void)  _At TIMER0
{
}
```

Monitor Function Support

A special function qualifier type is provided to support users who are interested in creating a real-time operating system (RTOS) kernel for the Z8 Encore!. Functions defined with this qualifier are treated differently from other functions at the point of function entry and function exit. At function entry, the global interrupt status is saved on the stack and interrupts are then disabled, before any other action is taken including the setup of the normal stack frame, if any. Upon exit from a monitor function, the last thing that happens before returning from the function is that the previous interrupt state is restored from the stack. These operations are useful or perhaps even critical in designing an RTOS and also provide the fastest possible way of disabling interrupts in a critical section of kernel code.

To define a function of this type, use the `_monitor` pragma, as in the following code:

```
#pragma _monitor
void my_kernel_fn (void)
{ … }
```

This feature does not work properly for functions that are also declared as interrupt service routines. Avoid combining the use of the `_monitor` and interrupt qualifiers for the same function.

NOTE: The `#pragma _monitor` declaration has function scope and will affect the next function *definition* (as opposed to a function *declaration*, that is, a function *prototype*) that the compiler encounters. For this reason, quite unexpected results can ensue if this pragma is used in a function prototype, especially when function declarations and definitions are grouped separately as is common practice. In the case of `_monitor`, these results might cause serious problems in your application by disabling interrupts in a function where this was not your intention. Therefore, it is recommended that you avoid using this `#pragma` in function prototypes.

String Placement

When string constants (literals) like `"mystring"` are used in a C program, they are stored by the C-Compiler in the RData address space for the small memory model and in the EData address space for the large memory model. However, sometimes this default placement of string constants does not allow you adequate control over your memory use. Therefore, language extensions are provided to give you more control over string placement:

- `N"`*`mystring`*`"`

  This defines a near string constant. The string is stored in RData. The address of the string is a near pointer.

- `F"`*`mystring`*`"`

  This defines a far string constant. The string is stored in EData. The address of the string is a far pointer.

- `R"`*`mystring`*`"`

  This defines a rom string constant. The string is stored in ROM. The address of the string is a rom pointer.

The following is an example of string placement:

```
#include <sio.h>
void funcn (near char *str)
{
 while (*str)
      putch (*str++);
 putch ('\n');
}


void funcf (far char *str)
{
 while (*str)
       putch (*str++);
 putch ('\n');
}


void funcr (rom char *str)
{
 while (*str)
       putch (*str++);
 putch ('\n');
}


void main (void)
{
 funcn (N"nstr");
 funcf (F"fstr");
 funcr (R"rstr");
}
```

Inline Assembly

There are two methods of inserting assembly language within C code:

- "Inline Assembly Using the Pragma Directive" on page 143
- "Inline Assembly Using the asm Statement" on page 143

Inline Assembly Using the Pragma Directive

The first method uses the `#pragma` feature of ANSI C with the following syntax:

```
#pragma asm "<assembly line>"
```

This `#pragma` can be inserted anywhere within the C source file. The contents of <*assembly line*> must be legal assembly language syntax. The usual C escape sequences (such as `\n`, `\t`, and `\r`) are properly translated. The compiler does not process the <*assembly line*>. Except for escape sequences, it is passed through the compiler verbatim.

Inline Assembly Using the asm Statement

The second method of inserting assembly language uses the `asm` statement:

```
asm("<assembly line>");
```

The `asm` statement cannot be within an expression and can be used only within the body of a function.

The <*assembly line*> can be any string.The compiler does *not* check the legality of the string.

As with the `#pragma asm` form, the compiler does not process the <*assembly line*> except for translating the standard C escape sequences.

The compiler prefixes the name of every global variable with "_". Global variables can therefore be accessed in inline assembly by prefixing their name with "_ ". The local variables and parameters cannot be accessed in inline assembly.

Placement Directives

The Zilog C-Compiler provides language extensions for the following:

- "Placement of a Variable" on page 144
- "Placement of Consecutive Variables" on page 144
- "Alignment of a Variable" on page 144

Placement of a Variable

The following syntax can be used to declare a global or static variable at an address:

```
char placed_char _At 0xff; // placed_char is assigned an address 0xff.
far struct {
            char ch;
            int ii;
} ss _At 0xeff;         // ss is assigned an address 0xeff

rom char init_char _At 0xffff = 33;
                        // init_char is in rom and initialized to 33
```

NOTE: Only placed variables with `rom` storage class specifier can be initialized. The placed variables with `near` and `far` storage class specifier cannot be initialized. The uninitialized placed variables are not initialized to zero by the compiler startup routine.

Placement of Consecutive Variables

The compiler also provides syntax to place several variables at consecutive addresses. For example:

```
char ch1 _At 0xef0;
char ch2 _At …;
char ch3 _At …;
```

This places `ch1` at address `0xef0`, `ch2` at the next address (`0xef1`) after `ch1`, and `ch3` at the next address (`0xef2`) after `ch2`. The `_At …` directive can only be used after a previous `_At` or `_Align` directive.

Alignment of a Variable

The following syntax can be used to declare a global or static variable aligned at a specified alignment:

```
char ch2 _Align 2;   // ch2 is aligned at even boundary
char ch4 _Align 4;   // ch4 is aligned at a four byte boundary
```

NOTE: Only aligned variables with the `rom` storage class specifier can be initialized. The aligned variables with the `near` and `far` storage class specifiers cannot be initialized. The uninitialized aligned variables are not initialized to zero by the compiler startup routine.

Char and Short Enumerations

The enumeration data type is defined as `int` as per ANSI C. The C-Compiler provides language extensions to specify the enumeration data type to be other than `int` to save space. The following syntax is provided by the C-Compiler to declare them as `char` or `short`:

```
char enum
{
    RED = 0,
    YELLOW,
    BLUE,
    INVALID
} color;

short enum
{
    NEW= 0,
    OPEN,
    FIXED,
    VERIFIED,
    CLOSED
} status;

void main(void)
{
    if (color == RED)
        status = FIXED;
    else
        status = OPEN;
}
```

Setting Flash Option Bytes in C

The Z8 Encore! CPU provides up to two Flash option bytes to configure the device. These Flash option bytes can be set in C, using the following syntax:

```
#include <eZ8.h>
FLASH_OPTION1 = val;
FLASH_OPTION2 = val;
```

where

- FLASH_OPTION1 is the Flash option byte at address 0
- FLASH_OPTION2 is the Flash option byte at address 1

For example:

```
#include <eZ8.h>
FLASH_OPTION1 = 0xFF;
FLASH_OPTION2 = 0xFF;
```

```
void main (void)
{
}
```

This example sets the Flash option bytes at addresses 0 and 1 as `0xFF`. The Flash option bytes can be written only once in a program. They are set at load time. When you set these bytes, you need to make sure that the settings match the actual hardware.

Program RAM Support (Z8 Encore! XP 16K Series Only)

The Z8 Encore! XP 16K Series devices have additional RAM that can optionally be used as Program RAM (PRAM). The Z8 Encore! C-Compiler provides syntax to place code for a function in PRAM. This feature can be useful for keeping device power consumption low by arranging that frequently activated code be placed in PRAM so that the main body of code, which often only needs to be executed at rare intervals, remains in the more power-intensive Flash memory.

The compiler provides a pragma (`#pragma PRAM`) for this purpose. This pragma has function scope and can only be used just before a function definition. The code for such functions is then placed in a special segment called PRAMSEG. For example:

```
#pragma PRAM
int func(void)
{
      return 2;
}
```

The code for the `func` function is placed in the `PRAMSEG` segment. Multiple functions in a program can be designated as PRAM functions by preceding each of them with `#pragma PRAM`. A copy of the PRAMSEG is kept in ROM and copied to PRAM by the C startup module. For more details, see “Linker Command Files for C Programs” on page 181 and “Startup Files” on page 177.

Only the code for the function designated as PRAM is placed by the compiler in PRAMSEG. Any functions called by such function are not automatically placed by the compiler in PRAMSEG. For example:

```
#pragma PRAM
int func(void)
{
      return anotherfunc();
}
```

In the preceding example, only the code for `func` is placed in PRAMSEG. The code for `anotherfunc` is placed in a segment in ROM. To place `anotherfunc` in PRAM, you need to precede it with `#pragma PRAM` also. For example:

```
#pragma PRAM

int anotherfunc(void)
```

```
{
        return 2;
}
```

The same is true for any library functions called from such functions. If you want to avoid having these functions executed from Flash (which might partially defeat the power-saving goal of placing the functions that call them in PRAM), you need to include the source for the library function in your project and precede the library function with `#pragma PRAM` if it is a C function or if it is an assembly function, change the segment of the function to PRAMSEG using the `segment PRAMSEG` assembler directive.

NOTE: The `#pragma PRAM` declaration has function scope and will affect the next function *definition* (as opposed to a function *declaration*, that is, a function *prototype*) that the compiler encounters. For this reason, quite unexpected results can ensue if this pragma is used in a function prototype, especially when function declarations and definitions are grouped separately as is common practice. Therefore it is recommended that you avoid using this `#pragma` in function prototypes.

Preprocessor #warning Directive Support

A preprocessor line of the form

`#warning` *token-sequence*

causes the compiler to write a warning message consisting of the *token-sequence*. The compiler continues the compilation process with `#warning` as opposed to `#error`. For example, the following line in the C source

```
#warning  This is a test message
```

causes the compiler to generate the following warning:

```
Test.c  (2,9) :     WARNING (38) "This is a test message"
```

Supported New Features from the 1999 Standard

The Z8 Encore! compiler implements the following new features introduced in the ANSI 1999 standard, also known as ISO/IEC 9899:1999:

- "C++ Style Comments" on page 147
- "Trailing Comma in Enum" on page 148
- "Empty Macro Arguments" on page 148
- "Long Long Int Type" on page 148

C++ Style Comments

Comments preceded by `//` and terminated by the end of a line, as in C++, are supported.

Trailing Comma in Enum

A trailing comma in `enum` declarations is allowed. This essentially allows a common syntactic error that does no harm. Thus, a declaration such as

```
enum color {red, green, blue,} col;
```

is allowed (note the extra comma after `blue`).

Empty Macro Arguments

Preprocessor macros that take arguments are allowed to be invoked with one or more arguments empty, as in this example:

```
#define cat3(a,b,c) a b c
printf("%s\n", cat3("Hello ", ,”World"));
                            // ^ Empty arg
```

Long Long Int Type

The `long long int` type is allowed. (In the Z8 Encore! C-Compiler, this type is treated as the same as `long`, which is allowed by the standard.)

TYPE SIZES

The type sizes for the basic data types on the Z8 Encore! C-Compiler are as follows:

`int`	16 bits
`short int`	16 bits
`char`	8 bits
`long`	32 bits
`float`	32 bits
`double`	32 bits

The type sizes for the pointer data types on the Z8 Encore! C-Compiler are as follows:

near pointer	8 bits
far pointer	16 bits
rom pointer	16 bits

All data are aligned on a byte boundary. Avoid writing code that depends on how data are aligned.)

PREDEFINED MACROS

The Z8 Encore! C-Compiler comes with the following standard predefined macro names:

__AUS_SIZED_BY_TYPE__	Defined on all Zilog compilers and set to 0 or 1 as to whether the size of a bitfield depends on the type(s) of the bitfield members.
__BACKWARD_COMPATIBLE_BITFIELDS__	Defined on all Zilog compilers and set to 0 or 1 as to whether the implementation of bitfields is compatible with that used before January 2007.
__BITFIELDS_OVERLAP_AUS__	Defined on all Zilog compilers and set to 0 or 1 as to whether a bitfield member that requires more bits than remains in the current byte must begin a new byte. (A 0 indicates that it does.)
__BITFIELDS_PACK_L2R__	Defined on all Zilog compilers and set to 0 or 1 as to whether bitfields back left to right, that is, from most significant to least significant bit.
__CONST_IN_RAM__	Defined if const objects are placed in RAM memory.
__CONST_IN_ROM__	Defined if const objects are placed in ROM memory.
__CPU_NAME__	Defined on all Zilog compilers and expands to the CPU name as passed on the compile line.
__DATE__	This macro expands to the current date in the format “Mmm dd yyyy” (a character string literal), where the names of the months are the same as those generated by the `asctime` function and the first character of dd is a space character if the value is less than 10.
__FILE__	This macro expands to the current source file name (a string literal).
__LINE__	This macro expands to the current line number (a decimal constant).
__NEW_AU_AT_TYPE_CHANGE__	Defined on all Zilog compilers and set to 0 or 1 as to whether a change in the type of bit field members requires beginning a new byte in the bitfield packing. (A 1 indicates that it does.)
__STDC__	This macro is defined as the decimal constant 1 and indicates conformance with ANSI C.
__TIME__	This macro expands to the compilation time in the format “hh:mm:ss” (a string literal).

__UNSIGNED_CHARS__	Defined if the type char is equivalent to the type unsigned char.

None of these macro names can be the subject of a `#define` or a `#undef` preprocessing directive. The values of these predefined macros (except for `__LINE__` and `__FILE__`) remain constant throughout the translation unit.

The following additional macros are predefined by the Z8 Encore! C-Compiler:

`__CONST_IN_RAM__`	This macro is defined if the `-const=ram` command line compilation option is used.
`__CONST_IN_ROM__`	This macro is defined if the `-const=rom` command line compilation option is used.
`__ENCORE__`	This macro is defined and set to `1` for the Z8 Encore! compiler and is otherwise undefined.
`__EZ8__`	This macro is defined and set to `1` for the Z8 Encore! compiler and is otherwise undefined.
`__FPLIB__`	This macro is defined on all Zilog compilers and indicates whether the floating-point library is available. If the floating-point library is available, the macro expands to `1`; otherwise, it expands to `0`.
`__MODEL__`	This macro indicates the memory model used by the compiler as follows: 0 Small model 3 Large model
`__ZDATE__`	This macro expands to the build date of the compiler in the format YYYYMMDD. For example, if the compiler were built on May 31, 2006, then __ZDATE__ expands to 20060531. This macro gives a means to test for a particular Zilog release or to test that you are using a version of the compiler that was released after a particular new feature has been added.
`__ZILOG__`	This macro is defined and set to `1` on all Zilog compilers to indicate that the compiler is provided by Zilog.

All predefined macro names begin with two underscores and end with two underscores. The following sections describe predefined macros:

- “Examples” on page 151
- “Macros Generated by the IDE” on page 151

Examples

The following program illustrates the use of some of these predefined macros:

```
#include <stdio.h>
void main()
{
#ifdef __ZILOG__
    printf("Zilog Compiler ");
#endif
#ifdef __ENCORE__
    printf("for Z8 Encore! ");
#endif
#ifdef __EZ8__
    printf("with eZ8 Cpu ");
#endif
#ifdef __ZDATE__
    printf("built on %d.\n", __ZDATE__);
#endif
}
```

Macros Generated by the IDE

In addition to the above predefined macros, the ZDS II IDE generates the following macros:

_DEBUG	Generated for DEBUG builds. This macro can be tested to insert additional code in debug builds for sanity checking or to simplify debugging.
NDEBUG	Generated for release builds. This macro, if defined, prevents the `assert` macro from generating any code.
_*<cpu>*	Where *<cpu>* is the CPU name, for example, `_Z8F1680` or `_Z8F0830`.
_*<variant>*	Where *<variant>* is the specific variant of the CPU, for example, _Z8F2480XX20XXSG or _Z8F0880XX20XXEG.

The macros generated by the IDE can be checked, and added to, by going to the Preprocessor page of the Project Settings dialog box (see “C: Preprocessor Page” on page 67).

CALLING CONVENTIONS

The Z8 Encore! C-Compiler imposes a strict set of rules on function calls. Except for special run-time support functions, any function that calls or is called by a C function must follow these rules. Failure to adhere to these rules can disrupt the C environment and cause a C program to fail.The following sections describe the calling conventions:

- “Function Call Mechanism: Dynamic Frame” on page 152

- “Function Call Mechanism: Static Frame” on page 153
- “Function Call Mechanism: Register Parameter Passing” on page 155
- “Return Value” on page 156
- “Special Cases” on page 157

Function Call Mechanism: Dynamic Frame

A function (caller function) performs the following tasks when it calls another function that has a dynamic call frame (called function):

1. Push parameters on the stack in reverse order (the rightmost declared argument is pushed first, and the leftmost is pushed last). This places the leftmost argument on top of the stack when the function is called.
2. Then call the function. The call instruction pushes the return address on the top of the stack.
3. On return from the called function, caller pops the arguments off the stack or increments the stack pointer.

The called function performs the following tasks:

1. If the called function is a monitor function only, push the existing value of the interrupt control register IRQCTL on the stack and disable interrupts.
2. Push the frame pointer onto the stack and allocate the local frame:
    a. Set the frame pointer to the current value of the stack pointer.
    b. Decrement the stack pointer by the size of locals and temporaries, if required.
3. Execute the code for the function.
4. If the function returns a scalar value, place it in the return value registers. For functions returning an aggregate, see “Special Cases” on page 157.
5. Deallocate the local frame (set the stack pointer to the current value of frame pointer) and restore the frame pointer from stack.
6. If the called function is a monitor function only, restore the interrupt control register IRQCTL from the stack.
7. Return.

All registers, other than the return register, are considered as “caller” save; that is, they are saved and restored by the caller function. The flag register is not saved and restored by the caller function.

The function call mechanism described in this section is a dynamic call mechanism. In a dynamic call mechanism, each function allocates memory on the stack for its locals and temporaries during the run time of the program. When the function has returned, the memory that it was using is freed from the stack. The following figure shows a diagram of the Z8 Encore! C-Compiler dynamic call frame layout.

NOTE: For functions that are declared to be monitor functions by the use of `#pragma _monitor`, the saved value of the interrupt control register (IRQCTL) will be inserted on the stack between the caller's frame pointer and the return address.

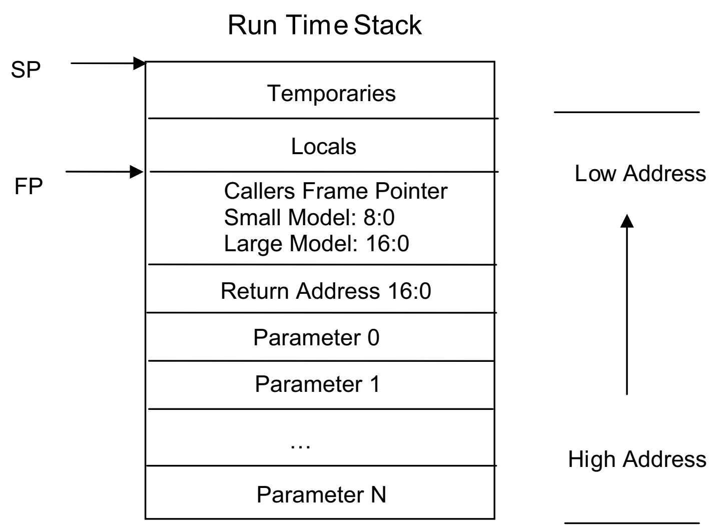


Figure 94. Dynamic Call Frame Layout

Function Call Mechanism: Static Frame

A function (caller function) performs the following tasks when it calls another function which has a static call frame (called function):

1. For a non-`varargs` function, load parameters into the corresponding static locations for the function. For a `varargs` function, a dynamic frame is always used, and all parameters are pushed on the stack in reverse order.
2. Then call the function. The call instruction pushes the return address on the top of the stack.
3. On return from the function, the return address is automatically popped from the stack by the `ret` instruction.

The called function performs the following tasks:

1. If the called function is a monitor function only, push the existing value of the interrupt control register IRQCTL on the stack and disable interrupts.

2. Push the frame pointer onto the stack and set the frame pointer to the current value of the stack pointer.
3. Execute the code for the function.
4. If the function returns a scalar value, place it in the return registers. For functions returning an aggregate, see “Special Cases” on page 157.
5. Set the stack pointer to the current value of the frame pointer and restore the frame pointer from the stack.
6. If the called function is a monitor function only, restore the interrupt control register IRQCTL from the stack.
7. Return.

For a static frame function, steps 2 and 5 are only done if the `-debug` (Debug) or `-reduceopt` (Limit Optimizations for Easier Debugging) option is selected. All registers, other than the return register, are considered as “caller” save, that is, they are saved and restored by the caller function. The flag register is not saved and restored by the caller function.

The preceding function call mechanism is a static call mechanism. The structure of a static call frame is described in “Structure of a Static Call Frame” on page 154.

Structure of a Static Call Frame

For the static frame function `fun`, the local variables and parameters are allocated in a frame labeled `_f_fun` for a large model and `_n_fun` for a small model. The parameters are numbered from left to right and are named as `_`*x*`_fun`, where *x* indicates the number associated with the parameter. In the following example, `_0_fun` represents the leftmost parameter (`ch1`), and `_1_fun` represents the next parameter (`ch2`).

C Source, Small Model

```
void fun(char ch1, char ch2) { }
```

Static Frame in Generated Assembly

```
      .FRAME _n_fun,?_n_fun,RDATA
_1_fun:
      DS 1
_0_fun:
      DS 1
```

The `.FRAME` directive defines the beginning of the static call frame of a function. It continues to the next segment directive in assembly and has the following form:

`.FRAME` <*framename*>, <*segname*>, <*space*>

where

- <*framename*> is the name of the frame being declared.
- <*segname*> is the name of the local and parameter segment.
- <*space*> is the address space that holds the static frame.

If the static frame function calls other functions, then they must be referred to within the `.FRAME` segment of the static frame function. This reference is done by including the `.FCALL` directive. The `.FCALL` directive helps the linker to optimally allocate the static call frames using the call-graph technique.

`.FCALL` <*framename*>

where <*framename*> is the name of the frame of the function called from the static frame function.

For example:

```
 void fun(char ch1, char ch2) {
 fun1(ch1);
 }


      .FRAME _n_fun,?_n_fun,RDATA
      .FCALL _n_fun1
_1_fun:
      DS 1
_0_fun:
      DS 1
```

Function Call Mechanism: Register Parameter Passing

A function (caller function) performs the following tasks when it calls another function using the register parameter passing scheme with a dynamic or static frame:

1. For a non-`varargs` function, place the scalar parameters (not structures or unions) of the called function in registers R8–R13 starting from left to right. Push the remaining parameters including the non-scalar parameters on the stack for dynamic frame functions or load into the static locations for static frame functions.

   For a `varargs` function, a dynamic frame is always used, no parameter is passed in register, and all parameters are pushed on the stack in reverse order.

2. Then call the function. The call instruction pushes the return address on the top of the stack.
3. On return from the function, the return address is automatically popped from the stack by the `ret` instruction.
4. On return from the called function, if there were any stack parameters, caller pops them off the stack or increments the stack pointer.

The called function performs the following tasks:

1. If the called function is a monitor function only, push the existing value of the interrupt control register IRQCTL on the stack and disable interrupts.
2. Push the frame pointer onto the stack and allocate the local frame:
    a. Set the frame pointer to the current value of the stack pointer.
    b. Decrement the stack pointer by the size of locals and temporaries on stack, if required.
3. Execute the code for the function.
4. If the function returns a scalar value, place it in the return value registers. For functions returning an aggregate, see "Special Cases" on page 157.
5. Deallocate the local frame (set the stack pointer to the current value of frame pointer), if required, and restore the frame pointer from stack.
6. If the called function is a monitor function only, restore the interrupt control register IRQCTL from the stack.
7. Return.

All registers, other than the return register, are considered as "caller" save; that is, they are saved and restored by the caller function. The flag register is not saved and restored by the caller function. For a static frame function, steps 2 and 5 are only done if the `-debug` (Debug) or `-reduceopt` (Limit Optimizations for Easier Debugging) option is selected.

NOTE: In the case of a monitor function, add (-1) to the offsets of all arguments on the stack to take into account the insertion of the saved interrupt control register IRQCTL on the stack.

Return Value

The compiler places the return values of a function in the following registers:

Return Type	**Return Value Registers**
char	R0
short	R0,R1
int	R0,R1
long	R0,R1,R2,R3
float	R0,R1,R2,R3
double	R0,R1,R2,R3

Return Type	Return Value Registers
near *	R0
far *	R0,R1
rom *	R0,R1

For functions returning an aggregate, see “Special Cases” on page 157 for details on how they are returned.

Special Cases

Some function calls do not follow the mechanism described in “Function Call Mechanism: Dynamic Frame” on page 152. Such cases are described in the following sections:

- “Returning Structure” on page 157
- “Not Allocating a Local Frame” on page 157

Returning Structure

If the function returns a structure, the caller allocates the space for the structure and then passes the address of the return space to the called function as an additional and first argument. To return a structure, the called function then copies the structure to the memory block pointed to by this argument.

Not Allocating a Local Frame

The compiler does not allocate a local frame for a function in the following case:

- The function does not have any local stack variables, stack arguments, or compiler-generated temporaries.

and

- The function does not return a structure.

and

- The function is compiled without the debug option.

CALLING ASSEMBLY FUNCTIONS FROM C

The Z8 Encore! C-Compiler allows mixed C and assembly programming. A function written in assembly can be called from C if the assembly function follows the C calling conventions as described in “Calling Conventions” on page 151.

This section covers the following topics:

- “Function Naming Convention” on page 158

- “Argument Locations” on page 158
- “Return Values” on page 159
- “Preserving Registers” on page 159

Function Naming Convention

Assembly function names must be preceded with an _ (underscore). The compiler prefixes the function names with an underscore in the generated assembly. For example, a call to `myfunc()` in C is translated to a call to `_myfunc` in generated assembly by the compiler.

Argument Locations

The assembly function must assign the location of the arguments following the C calling conventions as described in “Calling Conventions” on page 151.

For example, if you are using the following C prototype:

```
void myfunc(short arga, long argb, char argc, short * argd)
```

The location of the arguments must be as follows for a static frame function:

arga : _0_myfunc

argb: _1_myfunc

argc: _2_myfunc

argd: _3_myfunc

The location of the arguments must be as follows for a static frame function with register parameter passing:

arga: R8, R9

argb: R10, R11, R12, R13

argc: _0_myfunc

argd: _1_myfunc

For a dynamic frame function, the arguments will be on stack. Their offsets from the stack pointer at the entry point of the assembly function are as follows:

arga: -2

argb: -4

argc: -8

argd: -9

For a dynamic frame function with register parameter passing, some of the arguments will be in registers and some on stack. Their registers/offsets from the stack pointer at the entry point of the assembly function are as follows:

arga: R8, R9

argb: R10, R11, R12, R13

argc: -2

argd: -3

Return Values

The assembly function must return the value in the location specified by the C calling convention as described in “Calling Conventions” on page 151.

For example, if you are using the following C prototype:

```
long  myfunc(short arga, long argb, short *argc)
```

The assembly function must return the long value in registers R0, R1, R2, and R3.

Preserving Registers

The Z8 Encore! C-Compiler implements a caller save scheme. The caller function preserves the registers, and the called assembly function is not expected to save and restore any registers that it uses.

CALLING C FUNCTIONS FROM ASSEMBLY

The C functions that are provided with the compiler library can also be used to add functionality to an assembly program. You can also create your own C functions and call them from an assembly program.

In the C functions, all registers, other than return registers, are considered as “caller” save. Therefore, the caller assembly function must make sure that it saves on the stack any registers that are in use before calling the C function and which also need to be available after the call. The caller assembly procedure then restores those registers after the return from the C function. The flag register need not be saved and restored by the caller assembly function.

The following example (“Assembly File” on page 160 and “Referenced C Function Prototype” on page 160) shows an assembly source file referencing the `sin` function written in the large, dynamic model. The `sin` function is defined in the C run-time library (`crtldd.lib`).

NOTE: The C-Compiler precedes the function names with an underscore in the generated assembly. See “Function Naming Convention” on page 158.

Assembly File

```
            globals on

            xref _sin

            segment far_data
val:dl %3F060A96   ; 0.523599
res:dl 0

            segment code
_main:

            PUSHX   _val+3
            PUSHX   _val+2
            PUSHX   _val+1
            PUSHX   _val         ; Load the argument, LSB first, MSB last
            CALL     _sin        ; Call the function, the result is in R0, R1, R2, R3
            POP       R4
            POP       R4
            POP       R4
            POP       R4          ; Pop the argument from stack
            LDX      _res,R0      ; Save the result, MSB from R0, LSB from R3
            LDX      _res+1,R1
            LDX      _res+2,R2
            LDX      _res+3,R3
            ret
```

Referenced C Function Prototype

```
double sin(double arg);
// double is the same as float on Z8 Encore! C-Compiler
```

COMMAND LINE OPTIONS

The compiler, like the other tools in ZDS II, can be run from the command line for processing inside a script, and so on. See “Compiler Command Line Options” on page 404 for the list of compiler commands that are available from the command line.

RUN-TIME LIBRARY

The C-Compiler provides a collection of run-time libraries. The largest section of these libraries consists of an implementation of much of the C Standard Library. A small library of functions specific to Zilog or to Z8 Encore! is also provided.

You can run the `buildrtl.bat` batch file to generate the libraries from the RTL source (that might have been modified by you) directly into the following directory:

ZILOGINSTALL`\ZDSII`*_product_version*`\lib\std`

where

- *ZILOGINSTALL* is the ZDS II installation directory. For example, the default installation directory is `C:\Program Files\ZiLOG`.
- *version* is the ZDS II version number. For example, *version* might be `4.11.0` or `5.0.0`.

The Z8 Encore! C-Compiler is a conforming freestanding 1989 ANSI C implementation with some exceptions. In accordance with the definition of a freestanding implementation, the compiler supports the required standard header files `<float.h>`, `<limits.h>`, `<stdarg.h>`, and `<stddef.h>`. It also supports additional standard header files and Zilog-specific nonstandard header files.

The standard header files and functions are, with minor exceptions, fully compliant with the ANSI C Standard. They are described in detail in "C Standard Library" on page 337. The deviations from the ANSI Standard in these files are summarized in "Library Files Not Required for Freestanding Implementation" on page 193.

The ZDS II for Z8 Encore! microcontrollers comes with additional Zilog-specific functions to program the Z8 Encore! peripherals. These additional functions together form the Zilog Standard Library (ZSL) and are described in the *Z8 Encore! Using Zilog Standard Library (ZSL) White Paper* (WP0010).

The following sections describe the use and format of the nonstandard, Zilog-specific runtime libraries:

- "Zilog Header Files" on page 162
- "Zilog Functions" on page 164

The Zilog-specific header files provided with the compiler are listed in the following table and described in "Zilog Header Files" on page 162.

Table 2. Nonstandard Header Files

Header	Description
`<eZ8.h>`	Z8 Encore! defines and functions
`<sio.h>`	Serial input/output functions

NOTE: The Zilog-specific header files are located in the following directory:

<ZDS Installation Directory>`\include\zilog`

where *<ZDS Installation Directory>* is the directory in which Zilog Developer Studio was installed. By default, this is `C:\Program Files\ZiLOG\ZDSII_Z8ENCORE!_<version>`, where <*version*> might be `4.11.0` or `5.0.0`.

NOTE: All external identifiers declared in any of the headers are reserved, whether or not the associated header is included. All external identifiers and macro names that begin with an underscore are also reserved. If the program redefines a reserved external identifier, even with a semantically equivalent form, the behavior is indeterminate.

Zilog Header Files

The Zilog header files are described in the following sections:

- "Architecture-Specific Functions <eZ8.H>" on page 162
- "Nonstandard I/O Functions <sio.h>" on page 163

Architecture-Specific Functions <eZ8.H>

A Z8 Encore!-specific header file `<eZ8.h>` is provided that has prototypes for Zilog-specific C library functions and macro definitions.

Macros

`<eZ8.h>` has the macro definitions for all Z8 Encore! microcontroller peripheral registers. For example:

T0H	Expands to (*(unsigned char volatile near*)0xF00)

Refer to the Z8 Encore! product specifications for the list of peripheral registers supported.

`<eZ8.h>` also has the macro definition for the Z8 Encore! Flash option bytes:

FLASH_OPTION1	Expands to a rom char at address 0x0.
FLASH_OPTION2	Expands to a rom char at address 0x1.

`<eZ8.h>` also has a macro for interrupt vector addresses:

RESET	Expands to Reset vector number.

Refer to the Z8 Encore! product specifications for the list of interrupt vectors supported.

Functions

intrinsic void EI(void);	Enable interrupts.
intrinsic void DI(void);	Disable interrupts.
intrinsic SET_VECTOR(int,void (* func) (void));	Set interrupt vector.
void reentrant INIT_FLASH(unsigned short freq);	Initialize Flash frequency.
char reentrant READ_FLASH(rom const void *addr);	Read Flash memory.
void reentrant WRITE_FLASH(rom const void *addr,char val);	Write Flash memory.
char reentrant READ_NVDS(char addr);	Read NVDS memory.
int reentrant WRITE_NVDS(char value, char addr);	Write NVDS memory.
int reentrant READ_NVDS_GET_STATUS(char addr);	Read NVDS, get status.
char reentrant WRITE_NVDS_GET_STATUS(char value, char addr);	Write NVDS, get status.
intrinsic void RI(unsigned char istat);	Restores interrupts.
intrinsic unsigned char TDI(void);	Tests and disables interrupts.

Nonstandard I/O Functions <sio.h>

This header contains nonstandard Z8 Encore! specific input/output macros and functions.

Macros

_DEFFREQ	Expands to unsigned long default frequency.
_DEFBAUD	Expands to unsigned long default baud rate.
_UART0	Expands to an integer indicating UART0.
_UART1	Expands to an integer indicating UART1.

Functions

int getch(void) ;	Returns the data byte available in the selected UART.
int init_uart(int port,unsigned long freq, unsigned long baud);	Initializes the selected UART for specified settings and returns the error status.
unsigned char kbhit(void);	Checks the receive data available on selected UART.
reentrant unsigned char putch(char) ;	Sends a character to the selected UART and returns the error status.
int select_port(int port);	Selects the UART. Default is _UART0.

NOTE: These I/O functions are provided in each of two libraries:

- A limited C Serial IO library
- A full-fledged Zilog Standard Library (ZSL)

When you select ZSL, these functions are linked from ZSL; otherwise, these functions are linked from the C Serial IO library.

Zilog Functions

The following functions are Zilog specific:

- “DI” on page 164
- “EI” on page 165
- “getch” on page 165
- “INIT_FLASH” on page 166
- “init_uart” on page 167
- “kbhit” on page 167
- “putch” on page 168
- “READ_FLASH” on page 168
- “READ_NVDS” on page 169
- “READ_NVDS_GET_STATUS” on page 170
- “RI” on page 171
- “select_port” on page 171
- “SET_VECTOR” on page 172
- “TDI” on page 174
- “WRITE_FLASH” on page 175
- “WRITE_NVDS” on page 176
- “WRITE_NVDS_GET_STATUS” on page 176

DI

The DI function is a Zilog function that disables all interrupts. This is an intrinsic function and is inline expanded.

Synopsis

```
#include <eZ8.h>
intrinsic void DI(void);
```

Example

```
#include <eZ8.h>

void main(void)
{
      DI(); /* Disable interrupts */
}
```

EI

The `EI` function is a Zilog function that enables all interrupts. This is an intrinsic function and is inline expanded.

Synopsis

```
#include <eZ8.h>
intrinsic void EI(void);
```

Example

```
#include <eZ8.h>

void main(void)
{
      EI(); /* Enable interrupts */
}
```

getch

The `getch` function is a ZILOG function that waits for the next character to appear at the serial port and returns its value. This function does not wait for end-of-line to return as `getchar` does. `getch` does not echo the character received.

Synopsis

```
#include <sio.h>
int getch(void) ;
```

Returns

The next character that is received at the selected UART.

Example

```
#include <sio.h>
int val;
void main()
{
      init_uart(_UART0,_DEFFREQ,_DEFBAUD);
      val = getch(); // Get character from _UART0
}
```

NOTE: Before using this function, the `init_uart()` function needs to be called to initialize and select the UART. The default UART is _UART0.

INIT_FLASH

The INIT_FLASH function is a Zilog function that sets the target clock frequency for Flash write. The following target clock frequencies are predefined in `eZ8.h` for convenience:

`FREQ20000`	/* for 20 MHz */
`FREQ18432`	/* for 18.432 MHz */
`FREQ16000`	/* for 16 MHz */
`FREQ14000`	/* for 14 MHz */
`FREQ12000`	/* for 12 MHz */
`FREQ08000`	/* for 8 MHz */
`FREQ04000`	/* for 4 MHz */

Synopsis

```
#include <eZ8.h>
void reentrant INIT_FLASH(unsigned short freq);
```

Returns

None.

Example

```
#include <eZ8.h>
char x;
void main()
{
   INIT_FLASH(FREQ18432);              /* Target clock frequency */
   WRITE_FLASH((rom const *)0x2f00,x); /* write to Flash */
   X = READ_FLASH((rom const *)0x2f00); /* read from Flash */
}
```

NOTE: Do not write to Flash memory more than twice. To write to Flash memory more than twice, you need to do a page erase.

Beginning with the ZDS II for Z8 Encore! release 4.8, there is a slight change in the function prototype for INIT_FLASH.

Previous Prototype

```
#if   defined(_Z8F642)
void reentrant INIT_FLASH(unsigned short freq);
#else
void intrinsic reentrant INIT_FLASH(unsigned short freq);
#endif
```

New Prototype

```
void reentrant INIT_FLASH(unsigned short freq);
```

For most Z8 Encore! microcontroller variants, the `intrinsic` keyword has been deleted in the ZDS II release 4.8.0. This change is taken care of automatically as long as you are using the standard Zilog library version of INIT_FLASH and including the standard header file `ez8.h`. However, since the new standard header uses the new prototype, if you have customized INIT_FLASH in your application, you need to make modifications so that the header and function declarations agree.

init_uart

The `init_uart` function is a Zilog function that selects the specified UART and initializes it for specified settings and returns the error status.

Synopsis

```
#include <sio.h>
int init_uart(int port, unsigned long freq, unsigned long baud);
```

Returns

Returns 0 if initialization is successful and 1 otherwise.

Example

```
#include <stdio.h>
#include <sio.h>
void main()
{
      init_uart(_UART0,_DEFFREQ,_DEFBAUD);
      printf("Hello UART0\n"); // Write to _UART0
}
```

_DEFFREQ is automatically set from the IDE based on the clock frequency setting in the Configure Target dialog box. See “Setup” on page 97.

kbhit

The `kbhit` function is a Zilog function that determines whether there is receive data available on the selected UART.

Synopsis

```
#include <sio.h>
unsigned char kbhit( void ) ;
```

Returns

Returns 1 if there is receive data available on the selected UART; otherwise, it returns 0.

Example

```
#include <sio.h>
unsigned char  hit;
void main()
{
   init_uart(_UART0,_DEFFREQ,_DEFBAUD);
   hit = kbhit( ) ; // Check if any character available on _UART0
}
```

NOTE: Before using this function, the `init_uart()` function needs to be called to initialize and select the UART. The default UART is _UART0.

putch

The `putch` function is a Zilog function that sends a character to the selected UART and returns the error status.

Synopsis

```
#include <sio.h>
reentrant unsigned char putch( char ch ) ;
```

Returns

A zero is returned on success; a nonzero is returned on failure.

Example

```
#include <sio.h>
char ch = 'c' ;
unsigned char  err;
void main()
{
      init_uart(_UART0,_DEFFREQ,_DEFBAUD);
      err = putch( ch ) ;       // Send character to _UART0
}
```

NOTE: Before using this function, the `init_uart()` function needs to be called to initialize and select the UART. The default UART is _UART0.

READ_FLASH

The READ_FLASH function is a Zilog function that reads a value from Flash memory at the specified address.

Synopsis

```
#include <eZ8.h>
char reentrant READ_FLASH(rom const void *addr);
```

Returns

The function returns data read from the specified address addr.

Example

```
#include <eZ8.h>
char x;
void main()
{
    INIT_FLASH(_DEFFREQ); /* Target clock frequency */
    WRITE_FLASH((rom const *)0x2f00,x); /* write to Flash */
    x = READ_FLASH((rom const *)0x2f00); /* read from Flash */
}
```

NOTE: Beginning with the ZDS II for Z8 Encore! release 4.8, there is a slight change in the function prototype for READ_FLASH.

Previous Prototype

```
#if   defined(_Z8F642)
char reentrant READ_FLASH(rom const void *addr);
#else
char intrinsic reentrant READ_FLASH(rom const void *addr);
#endif
```

New Prototype

```
char reentrant READ_FLASH(rom const void *addr);
```

For most Z8 Encore! processor variants, the `intrinsic` keyword has been deleted in the ZDS II release 4.8.0. This change is taken care of automatically as long as you are using the standard Zilog library version of READ_FLASH and including the standard header file `ez8.h`. However, since the new standard header uses the new prototype, if you have customized READ_FLASH in your application, you need to make modifications so that the header and function declarations agree.

READ_NVDS

The READ_NVDS function is a Zilog function that reads a value from NVDS memory at the specified address.

Synopsis

```
#include <ez8.h>
reentrant char READ_NVDS(char address)
reentrant char nvds_read(char address)
```

Returns

The function returns the character read from NVDS at the address specified.

Example

```
#include <eZ8.h>
char x;
void main()
{
  INIT_FLASH(_DEFFREQ);      /* Target clock frequency */
  WRITE_NVDS(x, 0x10);       /* write x to NVDS at address 0x10 */
  x = READ_NVDS(0x10);       /* read NVDS at address 0x10 */
}
```

`_DEFFREQ` is automatically set from the IDE based on the clock frequency setting in the Configure Target dialog box.

READ_NVDS_GET_STATUS

The READ_NVDS_GET_STATUS function is a Zilog function that reads a value from NVDS memory at the specified address and gets the status.

Synopsis

```
#include <ez8.h>
int reentrant READ_NVDS_GET_STATUS(char addr);
int reentrant nvds_read_get_status (char addr);
```

Returns

The function returns the value read and the status of NVDS read as per the device specification. The status is in the lower byte of the return value. The upper byte of the return value contains the data read.

Example

```
#include <eZ8.h>

char x, wstatus, rstatus;
unsigned int val;

void main()
{
    wstatus = WRITE_NVDS_GET_STATUS(x, 0x10);
    /* write x to NVDS at address 0x10, and get the status */
    val = READ_NVDS_GET_STATUS(0x10); /* read NVDS at address 0x10 */
    x = (val >> 8) & 0xFF;            /* extract data */
    rstatus = val & 0xFF;             /* extract read status */
}
```

RI

RI (restore interrupt) is a Zilog intrinsic function that restores interrupt status. It is intended to be paired with an earlier call to TDI(), which has previously saved the existing interrupt status. See "TDI" on page 174 for a discussion of that function. The interrupt status to be restored is passed as a parameter to RI(). This function is an intrinsic function and is inline expanded.

Synopsis

```
#include <eZ8.h>
intrinsic void RI(unsigned char istat);
```

Example

```
#include <eZ8.h>

void main(void)
{
   unsigned char istat;
   istat = TDI();     /* Test and Disable Interrupts */
   /* Do Something */
   RI(istat);         /* Restore Interrupts */
}
```

select_port

The `select_port` function is a Zilog function that selects the UART. The default is _UART0. The `init_uart` function can be used to configure either _UART0 or _UART1 and select the UART passed as the current one for use. All calls to `putch`, `getch`, and `kbhit` use the selected UART. You can also change the selected UART using the `select_port` function without having to reinitialize the UART.

Synopsis

```
#include <sio.h>
int select_port( int port ) ;
```

Returns

A zero is returned on success; a nonzero is returned on failure.

Example

```
#include <stdio.h>
#include <sio.h>
void main(void)
{
      init_uart(_UART0,_DEFFREQ,_DEFBAUD);
      init_uart(_UART1,_DEFFREQ,_DEFBAUD);
      select_port(_UART0);
      printf("Hello UART0\n"); // Write to uart0
      select_port(_UART1);
      printf("Hello UART1\n"); // Write to uart1
}
```

SET_VECTOR

`SET_VECTOR` is a Zilog intrinsic function provided by the compiler to specify the address of an interrupt handler for an interrupt vector. Because the interrupt vectors of the Z8 Encore! microcontroller are usually in ROM, they cannot be modified at run time. The `SET_VECTOR` function works by switching to a special segment and placing the address of the interrupt handler in the vector table. No executable code is generated for this statement. Calls to the `SET_VECTOR` intrinsic function must be placed within a function body.

Synopsis

```
#include <eZ8.h>
intrinsic void SET_VECTOR(int vectnum,void (*hndlr)(void));
```

where

- `vectnum` is the interrupt vector number for which the interrupt handler `hndlr` is to be set.
- `hndlr` is the interrupt handler function pointer. The `hndlr` function must be declared to be of type interrupt with no parameters and return `void` (no parameters and no return).

The following values for `vectnum` are supported for most Z8 Encore! parts (all those that do not fall into the more specific categories covered in the next two tables):

RESET	P4AD
WDT	P3AD
TRAP	P2AD
TIMER2	P1AD
TIMER1	P0AD
TIMER0	TIMER3
UART0_RX	UART1_RX
UART0_TX	UART1_TX
I2C	DMA
SPI	C3
ADC	C2
P7AD	C1
P6AD	C0
P5AD	

The following values for `vectnum` are supported for Z8 Encore! Motor Control CPUs:

RESET	C0
WDT	PB
TRAP	P7A
PWMTIMER	P3A
PWMFAULT	P6A
ADC	P2A
CMP	P5A
TIMER0	P1A
UART0_RX	P4A
UART0_TX	P0A
SPI	POTRAP
I2C	WOTRAP

The following values for `vectnum` are supported for the Z8 Encore! XP 16K Series:

RESET	P4AD
WDT	P3AD
TRAP	P2AD
TIMER2	P1AD
TIMER1	P0AD
TIMER0	MCT
UART0_RX	UART1_RX
UART0_TX	UART1_TX
I2C	C3
SPI	C2
ADC	C1
P7AD	C0
P6AD	POTRAP
P5AD	WOTRAP

Returns

None

Example

```
#include <eZ8.h>

extern void interrupt  isr_timer0(void);

void main(void)

{

      SET_VECTOR(TIMER0, isr_timer0); /* setup TIMER0 vector */

}
```

TDI

TDI (test and disable interrupts) is a Zilog intrinsic function that supports users creating their own critical sections of code. It saves the previous interrupt status and disables interrupts. The previous interrupt status is returned from TDI(). This function is intended to be paired with a later call to RI(), which restores the previously existing interrupt status. See "RI" on page 171 for a discussion of that function. The TDI function is an intrinsic function and is inline expanded.

Synopsis

```
#include <eZ8.h>
intrinsic unsigned char TDI(void);
```

Example

```
#include <eZ8.h>

void main(void)
{
   unsigned char istat;
   istat = TDI();     /* Test and Disable Interrupts */
   /* Do Something */
   RI(istat);         /* Restore Interrupts */
}
```

WRITE_FLASH

The WRITE_FLASH function is a Zilog function that writes a value to Flash memory at the specified address.

Synopsis

```
#include <ez8.h>
void reentrant WRITE_FLASH(rom const void *addr,char val);
```

Returns

If successful, the function returns zero; otherwise, it returns a nonzero value.

Example

```
#include <eZ8.h>
char x;
void main()
{
    INIT_FLASH(_DEFFREQ); /* Target clock frequency */
    WRITE_FLASH((rom const *)0x2f00,x); /* write to Flash */
    x = READ_FLASH((rom const *)0x2f00); /* read from Flash */
}
```

NOTE: Do not write to Flash memory more than twice. To write to Flash memory more than twice, you need to do a page erase.

When you use the WRITE_FLASH function to write to Flash, the target clock frequency needs to be initialized using the INIT_FLASH function (see page 166).

Beginning with the ZDS II for Z8 Encore! release 4.8, there is a slight change in the function prototype for WRITE_FLASH.

Previous Prototype

```
#if defined(_Z8F642)
void reentrant WRITE_FLASH(rom const void *addr,char val);
#else
```

```
void intrinsic reentrant WRITE_FLASH(rom const void *addr,char val);
#endif
```

New Prototype

```
void reentrant WRITE_FLASH(rom const void *addr,char val);
```

For most Z8 Encore! microcontroller variants, the `intrinsic` keyword has been deleted in the ZDS II release 4.8.0. This change is taken care of automatically as long as you are using the standard Zilog library version of WRITE_FLASH and including the standard header file `ez8.h`. However, since the new standard header uses the new prototype, if you have customized WRITE_FLASH in your application, you need to make modifications so that the header and function declarations agree.

WRITE_NVDS

The WRITE_NVDS function is a Zilog function that writes a value to NVDS memory at the specified address.

Synopsis

```
#include <ez8.h>
reentrant int WRITE_NVDS(char value, char address)
reentrant int nvds_write(char value, char address)
```

Returns

If successful, the function returns zero; otherwise, it returns a nonzero value.

Example

```
#include <eZ8.h>
char x;
void main()
{
  INIT_FLASH(_DEFFREQ);      /* Target clock frequency */
  WRITE_NVDS(x, 0x10);       /* write x to NVDS at address 0x10 */
  x = READ_NVDS(0x10);       /* read NVDS at address 0x10 */
}
```

`_DEFFREQ` is automatically set from the IDE based on the clock frequency setting in the Configure Target dialog box.

WRITE_NVDS_GET_STATUS

The WRITE_NVDS_GET_STATUS function is a Zilog function that writes a value to NVDS memory at the specified address and gets the status.

Synopsis

```
#include <ez8.h>
char reentrant WRITE_NVDS_GET_STATUS(char value, char addr);
char reentrant nvds_write_get_status (char value, char addr);
```

Returns

The function returns the status of NVDS write as per the device specification.

Example

```
#include <eZ8.h>

char x, wstatus, rstatus;
unsigned int val;

void main()
{
    wstatus = WRITE_NVDS_GET_STATUS(x, 0x10);
    /* write x to NVDS at address 0x10, and get the status */
    val = READ_NVDS_GET_STATUS(0x10); /* read NVDS at address 0x10 */
    x = (val >> 8) & 0xFF;            /* extract data */
    rstatus = val & 0xFF;             /* extract read status */
}
```

STARTUP FILES

The startup or C run-time initialization file is an assembly program that performs required startup functions and then calls `main`, which is the C entry point. The startup program performs the following C run-time initializations:

- Initialize the register pointer and stack pointer.
- Clear the near and far uninitialized variables to zero.
- Set the initialized near and far variables to their initial value from rom.
- For Z8 Encore! XP 16K only, initialize the segment pramseg from rom.
- Set the initial value of the interrupt register pointer.
- Allocate space for interrupt vectors and Flash option bytes.
- Allocate space for the errno variable used by the C run-time libraries.

The following table lists the startup files provided with the Z8 Encore! C-Compiler.

Table 3. Z8 Encore! Startup Files

Name	Description
`lib\zilog\startups.obj`	C startup object file for small model
`src\boot\common\startups.asm`	C startup source file for small model
`lib\zilog\startupl.obj`	C startup object file for large model
`src\boot\common\startupl.asm`	C startup source file for large model
`lib\zilog\startupf01as.obj`	C Startup object file for 1K XP small model
`lib\zilog\startupf01al.obj`	C Startup object file for 1K XP large model
`lib\zilog\startupf04as.obj`	C Startup object file for 4K XP small model
`lib\zilog\startupf04al.obj`	C Startup object file for 4K XP large model
`lib\zilog\startupf1680s.obj`	C Startup object file for 16K XP small model
`lib\zilog\startupf1680l.obj`	C Startup object file for 16K XP large model

Customizing Startup Files

The C startup object files provided with the Z8 Encore! C Compiler are generic files and can be tailored to meet the application requirements. Before modifying the C startup module, perform the following steps:

1. Copy the corresponding C startup source file to a new file in your project directory. For the small model, use `startups.asm` as the file from which you copy; for the large model, use `startupl.asm`.
2. Add the newly copied C startup file to your project files by using the Add Files command from the Project menu.
3. Select the Settings command from the Project menu.

   The Project Settings dialog box is displayed.
4. Select the Objects and Libraries page.
5. Select the Included in Project and Use Standard Startup Linker Commands check boxes.

Use the following guidelines when customizing the C startup file:

- If you do not have any uninitialized global or static variables in near memory, the startup file does not have to clear the near uninitialized variables to zero.

  For example, for the large model:

```
near int val; // Not OK to skip clearing uninitialized near data:
      // Uninitialized global in near memory
```

```
int val ; // OK to skip clearing uninitialized near data:
      // Uninitialized global in far memory
```

For the small model:

```
int val; // Not OK to skip clearing uninitialized near data:
      // Uninitialized global in near memory
far int val ; // OK to skip clearing uninitialized near data:
      // Uninitialized global in far memory
```

Alternatively, if your application does not assume that the near uninitialized global or static variables are initialized to zero by the C startup module, the startup code does not have to perform this function.

This can be achieved by adding the following code just before `segment startup`:

```
CLRRRAM SET FALSE
```

- If you do not have any initialized global or static variables in near memory, the startup code does not have to set the initialized global and static near variables to their initial value from rom.

  For example, for the large model:

  ```
  near int val = 20; // Not OK to skip initializing near data:
        // Initialized global in near memory
  int val = 20; // OK to skip initializing near data:
        // Initialized global in far memory
  ```

  For the small model:

  ```
  int val = 20; // Not OK to skip initializing near data:
        // Initialized global in near memory
  far int val = 20; // OK to skip initializing near data:
        // Initialized global in far memory
  ```

  Alternatively, if your application does require global or static variables in near memory to have initialized values and you perform the initialization in your program as part of the code, the startup code does not have to perform this function. For example:

  ```
  near int val;


  void main (void)
  {
      val = 20; // Initialization performed as part of the code
  }
  ```

  This can be achieved by adding the following just before `segment startup`.

  ```
  COPYRRAM SET FALSE
  ```

- If you do not have any uninitialized global or static variables in far memory, the startup code does not have to clear the far uninitialized variables to zero.

For example, for the small model:

```
far int val; // Not OK to skip clearing uninitialized far data:
      // Uninitialized global in far memory
int val ; // OK to skip clearing uninitialized far data:
      // Uninitialized global in near memory
```

For the large model:

```
int val; // Not OK to skip clearing un-initialized far data:
      // Uninitialized global in far memory
near int val ; // OK to skip clearing un-initialized far data:
      // Uninitialized global in near memory
```

Alternatively, if your application does not assume that the far uninitialized global or static variables are initialized to zero by the C startup module, the startup code does not have to perform this function.

This can be achieved by adding the following code just before `segment startup`.

```
CLRERAM SET FALSE
```

- If you do not have any initialized global or static variables in far memory, the startup code does not have to set the initialized global and static far variables to their initial value from rom.

For example, for the small model:

```
far int val = 20; // Not OK to skip initializing far data:
      // Initialized global in far memory
int val = 20; // OK to skip initializing far data:
      // Initialized global in near memory
```

For the large model:

```
int val = 20; // Not OK to skip initializing far data:
      // Initialized global in far memory
near int val = 20; // OK to skip initializing far data:
      // Initialized global in near memory
```

Alternatively, if your application does require global or static variables in far memory to have initialized values and you perform the initialization in your program as part of the code, the startup code does not have to perform this function. For example:

```
far int val;


void main (void)
{
   val = 20; // Initialization performed as part of the code
}
```

This can be achieved by adding the following code just before `segment startup`:

```
COPYERAM SET FALSE
```

- For the Z8 Encore! 16K XP Series CPUs, if you do not have any code in PRAM, the startup code does not have to copy the PRAM code from rom to its PRAM location.

  This can be achieved by adding the following code just before `segment startup`:

  ```
  COPYPRAM SET FALSE
  ```

For Z8 Encore! microcontroller devices with small Flash memory sizes especially, the preceding steps can be very useful to reduce the code size of the C startup module.

SEGMENT NAMING

The compiler places code and data into separate segments in the object file. The different segments used by the compiler are listed in the following table.

Table 4. Segments

Segment	Description
NEAR_DATA	near initialized global and static data
NEAR_BSS	near uninitialized global and static data
NEAR_TEXT	near constant strings
FAR_DATA	far initialized global and static data
FAR_BSS	far uninitialized global and static data
FAR_TEXT	far constant strings
ROM_DATA	rom global and static data
ROM_TEXT	rom constant strings
PRAMSEG	Program ram code
fname_TEXT	rom code for file fname (fname is translated in some cases)
__VECTORS_*nnn*	rom interrupt vector at address *nnn*
STARTUP	rom C startup

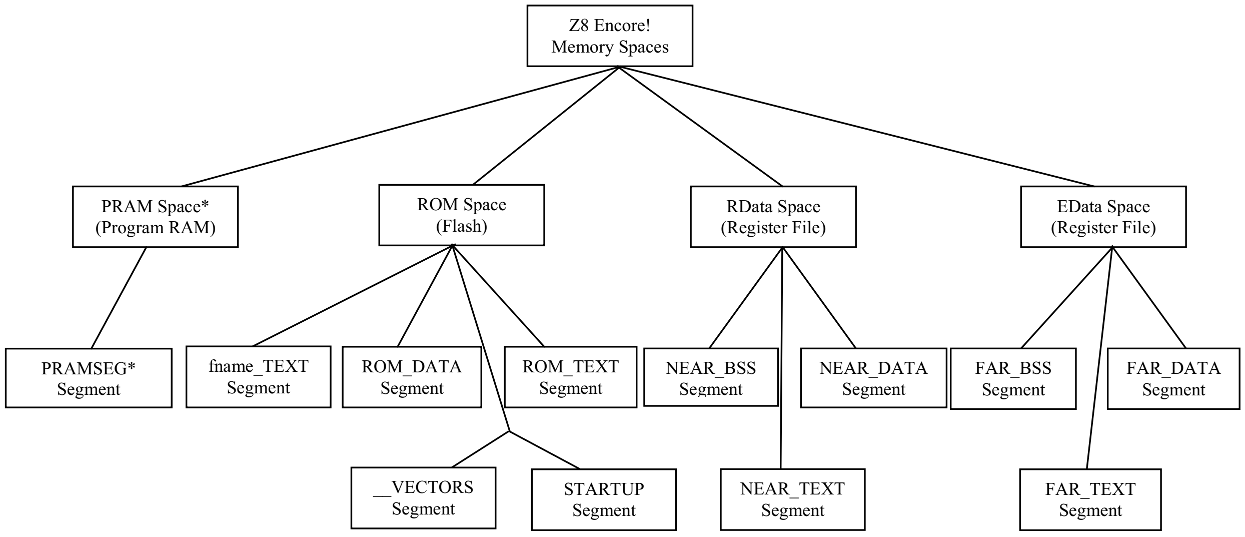
LINKER COMMAND FILES FOR C PROGRAMS

This section describes how the Z8 Encore! linker is used to link a C program. For a more detailed description of the linker and the various commands it supports, see "Using the Linker/Locator" on page 275. A C program consists of compiled and assembled object module files, compiler libraries, user-created libraries, and special object module files used for C run-time initializations. These files are linked based on the commands given in the linker command file. Because the linker command file coordinates the actions of the compiler and linker, it is appropriate to discuss this topic in this section.

The default linker command file is automatically generated by the ZDS II IDE whenever a `build` command is issued. It has information about the ranges of various address spaces for the selected device, the assignment of segments to spaces, order of linking, and so on. The default linker command file can be overridden by the user.

The linker processes the object modules (in the order in which they are specified in the linker command file), resolves the external references between the modules, and then locates the segments into the appropriate address spaces as per the linker command file.

The linker depicts the memory of the Z8 Encore! CPU using a hierarchical memory model containing spaces and segments. Each memory region of the CPU is associated with a space. Multiple segments can belong to a given space. Each space has a range associated with it that identifies valid addresses for that space. The hierarchical memory model for the Z8 Encore! CPU is shown in the following figure. The next figure depicts how the linker links and locates segments in different object modules.



Note: * PRAM and PRAMSEG are only available on Z8 Encore! 16K XP devices.

Figure 95. Z8 Encore! Hierarchical Memory Model

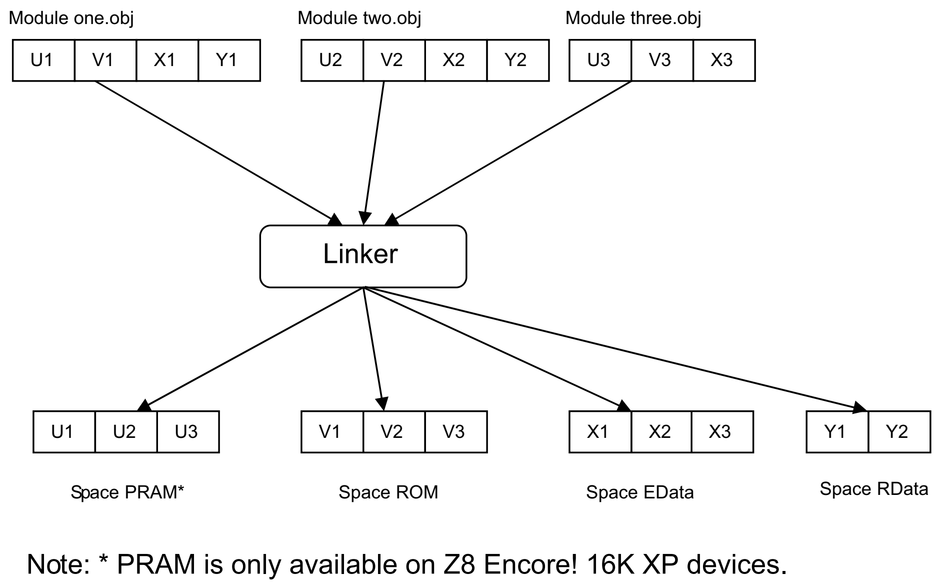


Figure 96. Multiple File Linking

Linker Referenced Files

The default linker command file generated by the ZDS II IDE references system object files and libraries based on the compilation memory model that you selected. A list of the system object files and libraries is given in the following table. The linker command file automatically selects and links to the appropriate version of the C run-time and (if necessary) floating-point libraries from the list shown in the following table, based on your project settings.

Table 5. Linker Referenced Files

File	Description
startups.obj	C startup for small model.
startupl.obj	C startup for large model.
startupf01as.obj	C startup object file for 1K XP small model.
startupf01al.obj	C startup object file for 1K XP large model.
startupf04as.obj	C startup object file for 4K XP small model.
startupf04al.obj	C startup object file for 4K XP large model.
Startupf1680s.obj	C startup object file for 16K XP small model.
Startupf1680l.obj	C startup object file for 16K XP large model.

Table 5. Linker Referenced Files (Continued)

File	Description
fpdumyl.lib	Floating-point do-nothing stubs for large model, no debug information.
fpdumyld.lib	Floating-point do-nothing stubs for large model, with debug information.
fpdumys.lib	Floating-point do-nothing stubs for small model, no debug information.
fpdumysd.lib	Floating-point do-nothing stubs for small model, with debug information.
chelp.lib	Code generator helper routines, no debug information.
chelpd.lib	Code generator helper routines, with debug information.
pchelp.lib	Code generator helper routines in pram, no debug information.
pchelpd.lib	Code generator helper routines in pram, with debug information.
crtld.lib	C run-time library for large dynamic model, no debug information.
crtldd.lib	C run-time library for large dynamic model, with debug information.
crtls.lib	C run-time library for large static model, no debug information.
crtlsd.lib	C run-time library for large static model, with debug information.
crtsd.lib	C run-time library for small dynamic model, no debug information.
crtsdd.lib	C run-time library for small dynamic model, with debug information.
crtss.lib	C run-time library for small static model, no debug information.
crtssd.lib	C run-time library for small static model, with debug information.
fpld.lib	Floating point library for large dynamic model, no debug information.
fpldd.lib	Floating-point library for large dynamic model, with debug information.
fpls.lib	Floating-point library for large static model, no debug information.
fplsd.lib	Floating-point library for large static model, with debug information.
fpsd.lib	Floating-point library for small dynamic model, no debug information.
fpsdd.lib	Floating-point library for small dynamic model, with debug information.
fpss.lib	Floating-point library for small static model, no debug information.
fpssd.lib	Floating-point library for small static model, with debug information.
csiold.lib	C serial IO library for large dynamic model, no debug information.
csioldd.lib	C serial IO library for large dynamic model, with debug information.
csiols.lib	C serial IO library for large static model, no debug information.
csiolsd.lib	C serial IO library for large static model, with debug information.
csiosd.lib	C serial IO library for small dynamic model, no debug information.
csiosdd.lib	C serial IO library for small dynamic model, with debug information.

Table 5. Linker Referenced Files (Continued)

File	Description
csioss.lib	C serial IO library for small static model, no debug information.
csiossd.lib	C serial IO library for small static model, with debug information.
crtf04ald.lib	C run-time library for XP large dynamic model, no debug information.
crtf04aldd.lib	C run-time library for XP large dynamic model, with debug information.
crtf04als.lib	C run-time library for XP large static model, no debug information.
crtf04alsd.lib	C run-time library for XP large static model, with debug information.
crtf04asd.lib	C run-time library for XP small dynamic model, no debug information.
crtf04asdd.lib	C run-time library for XP small dynamic model, with debug information.
crtf04ass.lib	C run-time library for XP small static model, no debug information.
crtf04assd.lib	C run-time library for XP small static model, with debug information.
csiof1680ld.lib	C serial IO library for 16K XP large dynamic model, no debug information.
csiof1680ldd.lib	C serial IO library for 16K XP large dynamic model, with debug information.
csiof1680ls.lib	C serial IO library for 16K XP large static model, no debug information.
csiof1680lsd.lib	C serial IO library for 16K XP large static model, with debug information.
csiof1680sd.lib	C serial IO library for 16K XP small dynamic model, no debug information.
csiof1680sdd.lib	C serial IO library for 16K XP small dynamic model, with debug information.
csiof1680ss.lib	C serial IO library for 16K XP small static model, no debug information.
csiof1680ssd.lib	C serial IO library for 16K XP small static model, with debug information.
csiofmcld.lib	C serial IO library for MC large dynamic model, no debug information.
csiofmcldd.lib	C serial IO library for MC large dynamic model, with debug information.
csiofmcls.lib	C serial IO library for MC large static model, no debug information.
csiofmclsd.lib	C serial IO library for MC large static model, with debug information.
csiofmcsd.lib	C serial IO library for MC small dynamic model, no debug information.
csiofmcsdd.lib	C serial IO library for MC small dynamic model, with debug information.
csiofmcss.lib	C serial IO library for MC small static model, no debug information.
csiofmcssd.lib	C serial IO library for MC small static model, with debug information.
csiof8pinld.lib	C serial IO library for 8-pin large dynamic model, no debug information.
csiof8pinldd.lib	C serial IO library for 8-pin large dynamic model, with debug information.
csiof8pinls.lib	C serial IO library for 8-pin large static model, no debug information.
csiof8pinlsd.lib	C serial IO library for 8-pin large static model, with debug information.

Table 5. Linker Referenced Files (Continued)

File	Description
csiof8pinsd.lib	C serial IO library for 8-pin small dynamic model, no debug information.
csiof8pinsdd.lib	C serial IO library for 8-pin small dynamic model, with debug information.
csiof8pinss.lib	C serial IO library for 8-pin small static model, no debug information.
csiof8pinssd.lib	C serial IO library for 8-pin small static model, with debug information.

Linker Symbols

The default linker command file defines some system symbols, which are used by the C startup file to initialize the stack pointer, clear the uninitialized variables to zero, set the initialized variables to their initial value, set the heap base, and so on. The following table shows the list of symbols that might be defined in the linker command file, depending on the compilation memory model that you selected.

Table 6. Linker Symbols

Symbol	Description
`_low_neardata`	Base of near_data segment after linking
`_len_neardata`	Length of near_data segment after linking
`_low_near_romdata`	Base of the rom copy of near_data segment after linking
`_low_fardata`	Base of far_data segment after linking
`_len_fardata`	Length of far_data segment after linking
`_low_far_romdata`	Base of the rom copy of far_data segment after linking
`_low_pramseg`	Base of pramseg segment after linking
`_len_pramseg`	Length of pramseg segment after linking
`_low_pram_romdata`	Base of the rom copy of pramseg segment after linking
`_low_nearbss`	Base of near_bss segment after linking
`_len_nearbss`	Length of near_bss segment after linking
`_low_farbss`	Base of far_bss segment after linking
`_len_farbss`	Length of far_bss segment after linking
`_far_stack`	Top of stack for large model is set as highest address of EData
`_near_stack`	Top of stack for small model is set as highest address of RData
`_far_heapbot`	Base of heap for large model is set as highest allocated EData address
`_near_heapbot`	Base of heap for small model is set as highest allocated RData address

Table 6. Linker Symbols (Continued)

Symbol	Description
`_far_heaptop`	Top of heap for large model is set as highest address of EData
`_near_heaptop`	Top of heap for small model is set as highest address of RData

Sample Linker Command File

The sample default linker command file for a project using the large dynamic compilation model is discussed here as a good example of the contents of a linker command file in practice and how the linker commands it contains work to configure your load file. The default linker command file is automatically generated by the ZDS II IDE. If the project name is `test.zdsproj`, for example, the default linker command file name is `test_debug.linkcmd`. You can add additional directives to the linking process by specifying them in the Additional Linker Directives dialog box (see “Additional Directives” on page 82). Alternatively, you can define your own linker command file by selecting the Use Existing button (see “Use Existing” on page 83).

The most important of the linker commands and options in the default linker command file are now discussed individually, in the order in which they are typically found in the linker command file:

```
-FORMAT=OMF695, INTEL32
-map -maxhexlen=64 -quiet -warnoverlap -NOxref -unresolved=fatal
-sort NAME=ascending -warn -debug -NOigcase
```

In this command, the linker output file format is selected to be OMF695, which is based on the IEEE 695 object file format, and INTEL32, which is the Intel Hex 32 format. This setting is generated from options selected in the Output page (see “Linker: Output Page” on page 93). The `-map` (Generate Map File), `-sort` (Sort Symbols By Address), and `-maxhexlen` (Maximum Bytes per Hex File Line) settings are also generated from options selected in the Output page.

The `-warnoverlap` (Warn on Segment Overlap) and `-unresolved` (Treat Undefined Symbols as Fatal) options are generated from options selected in the Warnings page (see “Linker: Warnings Page” on page 91).

The other options shown here are all generated from the settings selected in the General page of the Project Settings dialog box (see “General Page” on page 56).

```
RANGE ROM $0 : $FFFF
RANGE RDATA $20 : $FF
RANGE EDATA $100 : $EFF
```

The ranges for the three address spaces are defined here. These ranges are taken from the settings in Address Spaces page (see “Linker: Address Spaces Page” on page 89).

```
CHANGE NEAR_TEXT=NEAR_DATA
CHANGE FAR_TEXT=FAR_DATA
```

The NEAR_TEXT and FAR_TEXT segments are renamed to NEAR_DATA and FAR_DATA segments, respectively, by the preceding commands. The NEAR_TEXT and FAR_TEXT segments contain constant strings in RData and EData, respectively. This reduces the number of initialized segments from four to two, and the C startup then only needs to initialize two segments.

```
ORDER FAR_BSS, FAR_DATA
ORDER NEAR_BSS,NEAR_DATA
```

These ORDER commands specify the link order of these segments. The FAR_BSS segment is placed at lower addresses with the FAR_DATA segment immediately following it in the EData space. Similarly, NEAR_DATA follows after NEAR_BSS in the RData space.

```
COPY NEAR_DATA ROM
COPY FAR_DATA ROM
```

This COPY command is a linker directive to make the linker place a copy of the initialized data segments NEAR_DATA and FAR_DATA into the ROM address space. At run time, the C startup module then copies the initialized data back from the ROM address space to the RData (NEAR_DATA segment) and EData (FAR_DATA segment) address spaces. This is the standard method to ensure that variables get their required initialization from a nonvolatile stored copy in a typical embedded application where there is no offline memory such as disk storage from which initialized variables can be loaded.

```
define _low_near_romdata = copy base of NEAR_DATA
define _low_neardata = base of NEAR_DATA
define _len_neardata = length of NEAR_DATA
define _low_far_romdata = copy base of FAR_DATA
define _low_fardata = base of FAR_DATA
define _len_fardata = length of FAR_DATA
define _low_pram_romdata = copy base of PRAMSEG
define _low_pramseg = base of PRAMSEG
define _len_pramseg = length of PRAMSEG
define _low_nearbss = base of NEAR_BSS
define _len_nearbss = length of NEAR_BSS
define _low_farbss = base of FAR_BSS
define _len_farbss = length of FAR_BSS
define _far_heapbot = top of EData
define _far_heaptop = highaddr of EData
define _far_stack = highaddr of EData
define _near_heapbot = top of RData
define _near_heaptop = highaddr of RData
define _near_stack = highaddr of RData
```

These are the linker symbol definitions described in Table 6. They allow the compiler to know the bounds of the different memory areas that must be initialized in different ways by the C startup module.

```
"c:\sample\test"= \
 C:\PROGRA~1\ZiLOG\ZD3E4C~1.0\lib\startupl.obj, \
 .\foo.obj, \
C:\PROGRA~1\ZiLOG\ZD3E4C~1.0\lib\chelpd.lib, \
 C:\PROGRA~1\ZiLOG\ZD3E4C~1.0\lib\crtldd.lib, \
 C:\PROGRA~1\ZiLOG\ZD3E4C~1.0\lib\fpldd.lib, \
C:\PROGRA~1\ZiLOG\ZD3E4C~1.0\zilog\csioldd.lib
```

This final command shows that, in this example, the linker output file is named `test.lod`. The source object file (`foo.obj`) is to be linked with the other modules that are required to make a complete executable load file. In this case, those other modules are the C startup modules for the large model (`startupl.obj`), the code generator helper library (`chelpd.lib`), the C run-time library for the large dynamic model with debug (`crtldd.lib`), the floating-point library (`fpldd.lib`), and the C Serial IO library for that same configuration (`csioldd.lib`).

An important point to understand in using the linker is that the linker intelligently links in only those object modules that are necessary to resolve its list of unresolved symbols. Also, the Zilog version of the C Standard Library is organized so that each module contains only a single function or, in a few cases, a few closely related functions. So, although the C run-time library contains a very large number of functions from the C Standard Library, if your application only calls two of those functions, then only those two are linked into your application (plus any functions that are called by those two functions in turn). This means it is safe for you to simply link in a large library, like crtldd.lib and fpldd.lib in this example. No unnecessary code is linked in, and you avoid the extra work of painstakingly finding the unresolved symbols and linking only to those specific functions.

ANSI STANDARD COMPLIANCE

The Zilog Z8 Encore! C-Compiler is a freestanding ANSI C compiler (see “Freestanding Implementation” on page 189), complying with the 1989 ISO standard, which is also known as ANSI Standard X3.159-1989 with some deviations, which are described in “Deviations from ANSI C” on page 190.

Freestanding Implementation

A “freestanding” implementation of the C language is a concept defined in the ANSI standard itself, to accommodate the needs of embedded applications that cannot be expected to provide all the services of the typical desktop execution environment (which is called a hosted environment in the terms of the standard). In particular, it is presumed that there are no file system and no operating system. The use of the standard term “freestanding implementation” means that the compiler must contain, at least, a specific subset of the full

ANSI C features. This subset consists of those basic language features appropriate to embedded applications. Specifically, the list of required header files and associated library functions is minimal, namely <`float.h`>, <`limits.h`>, <`stdarg.h`>, and <`stddef.h`>. A freestanding implementation is allowed to additionally support all or parts of other standard header files but is not required to. The Z8 Encore! C-Compiler, for example, supports a number of additional headers from the standard library, as specified in "Library Files Not Required for Freestanding Implementation" on page 193.

A "conforming implementation" (that is, compiler) is allowed to provide extensions, as long as they do not alter the behavior of any program that uses only the standard features of the language. The Zilog Z8 Encore! C-Compiler uses this concept to provide language extensions that are useful for developing embedded applications and for making efficient use of the resources of the Z8 Encore! CPU. These extensions are described in "Language Extensions" on page 132.

Deviations from ANSI C

The differences between the Zilog Z8 Encore! C-Compiler and the freestanding implementation of ANSI C Standard consist of both extensions to the ANSI standard and deviations from the behavior described by the standard. The extensions to the ANSI standard are explained in "Language Extensions" on page 132.

There are a small number of areas in which the Z8 Encore! C-Compiler does not behave as specified by the standard. These areas are described in the following sections:

- "Prototype of Main" on page 190
- "Double Treated as Float" on page 191
- "const Keyword and ROM" on page 191
- "Const Correctness in the Standard Header Files" on page 192
- "ANSI Promotions Disabled" on page 192
- "Library Files Not Required for Freestanding Implementation" on page 193

Prototype of Main

As per ANSI C, in a freestanding environment, the name and type of the function called at program startup are implementation defined. Also, the effect of program termination is implementation defined.

For compatibility with hosted applications, the Z8 Encore! C-Compiler uses `main()` as the function called at program startup. Because the Z8 Encore! compiler provides a freestanding execution environment, there are a few differences in the syntax for `main()`. The most important of these is that, in a typical small embedded application, `main()` never executes a return because there is no operating system for a value to be returned to and it is also not intended to terminate. If `main()` does terminate and the standard Zilog Z8 Encore! C startup module is in use, control simply goes to the following statement:

```
_exit:
      JR _exit
```

For this reason, in the Z8 Encore! C-Compiler, `main()` needs to be of type `void`; any returned value is ignored. Also, `main()` is not passed any arguments. In short, the following is the prototype for `main()`:

```
void main (void);
```

Unlike the hosted environment in which the closest allowed form for main is as follows:

```
int main (void);
```

Double Treated as Float

The Z8 Encore! C-Compiler does not support a double-precision floating-point type. The type `double` is accepted but is treated as if it were `float`.

const Keyword and ROM

The Z8 Encore! C-Compiler by default assumes `const` in RAM and places `const` variables without any storage qualifications in RData for the small model and EData for the large model. With the `const` in RAM option in affect, the C-Compiler follows the ANSI C standard rules for `const` parameters.

However, the C-Compiler also provides a deprecated option to place such `const` variables in ROM memory instead. When this option is selected, the treatment of the `const` keyword is emphatically non-ANSI. Specifically, when this option is selected, the `const` keyword is treated as equivalent to `rom`. Then, the function prototype

```
void foo (const char* src);
```

implies that the `src` string is in ROM memory, and any code that calls `foo` should pass only a `const` or `rom` string as `src` string argument. This restriction comes because the Z8 Encore! microcontroller has different machine instructions for accessing its different memory spaces (LDC, LD, and LDX). This is a deviation from ANSI C. The compiler reports an “Incompatible data types” error for code that does not follow the preceding restriction.

Under the ANSI standard, the `const` qualification on a parameter merely implies that the function cannot modify the parameter and a non-`const` qualified argument can be passed as the corresponding parameter.

The effect of this deviation from the standard is primarily that, in code that must be portable for all options of the compiler and linker (such as the source code for library functions provided by the compiler), parameters cannot be declared `const`.

On new applications, Zilog discourages this use of the `const` keyword to place data in ROM. Zilog recommends declaring constant data (such as tables) using the `rom` keyword instead. Where portability is a consideration, this can easily be done by preprocessor macros. For example:

```
#ifdef __EZ8__
# define ROM rom
#else
# define ROM const
#endif
ROM struct TableElement[] table = { /* stuff */};
```

Const Correctness in the Standard Header Files

In general, Zilog header files are not `const` correct due to the issue raised in “const Keyword and ROM” on page 191. For example, in the Zilog library, `strcpy` is (effectively) declared as

```
char* strcpy( char* dst, char* src);
```

but the ANSI standard requires

```
char* strcpy( char* dst, const char* src);
```

As noted, this is done to avoid compile-time errors if the deprecated `const` variables in ROM compilation option were selected and then `strcpy()` was called with an argument for `src` that had not been declared `const`.

ANSI Promotions Disabled

The ANSI standard requires that integer variables smaller than `int` (such as `char`) always be promoted to `int` before any computation.

The Z8 Encore! C-Compiler is ANSI compliant in this regard when ANSI promotions are enabled. The C-Compiler analyzes and promotes variables smaller than `int` to `int`, only where necessary to mimic the ANSI behavior. For example, for the following statement:

```
char ch1, ch2, ch3;


ch1 = ch2 * ch3;
```

The compiler does not promote `ch2` and `ch3` to `int` before the multiplication operation, so the `char` result is not affected.

For the following statement:

```
char ch2, ch3;
int ii;

ii = ch2 * ch3;
```

The compiler promotes `ch2` and `ch3` to `int` before the multiplication operation, so the result is of type `int`.

The Z8 Encore! C-Compiler also provides a deprecated option to disable ANSI promotions. The ANSI behavior is not guaranteed when this option is selected, and Zilog does not recommend using this option.

Library Files Not Required for Freestanding Implementation

As noted in “Freestanding Implementation” on page 189, only four of the standard library header files are required by the standard to be supported in a freestanding compiler such as the Z8 Encore! C-Compiler. However, the compiler does support many of the other standard library headers as well. The supported headers are listed here. The support offered in the Zilog libraries is fully compliant with the standard except as noted here:

- `<assert.h>`
- `<ctype.h>`
- `<errno.h>`
- `<math.h>`

  The Zilog implementation of this library is not fully ANSI compliant in the general limitations of the handling of floating-point numbers: namely, Zilog does not fully support floating-point NANs, INFINITYs, and related special values. These special values are part of the full ANSI/IEEE 754-1985 floating-point standard that is referenced in the ANSI C Standard.
- `<stddef.h>`
- `<stdio.h>`

  Zilog supports only the portions of `stdio.h` that make sense in the embedded environment. Specifically, Zilog defines the ANSI required functions that do not depend on a file system. For example, `printf` and `sprintf` are supplied but not `fprintf`.
- `<stdlib.h>`

  This header is ANSI compliant in the Zilog library except that the following functions of limited or no use in an embedded environment are not supplied:

  ```
  strtoul()
  _Exit()
  atexit()
  ```

WARNING AND ERROR MESSAGES

NOTE: If you see an internal error message, please report it to Technical Support at `http://support.zilog.com`. Zilog staff will use the information to diagnose or log the problem.

This section covers the following:

- “Preprocessor Warning and Error Messages” on page 194
- “Front-End Warning and Error Messages” on page 197
- “Optimizer Warning and Error Messages” on page 207
- “Code Generator Warning and Error Messages” on page 209

Preprocessor Warning and Error Messages

000 Illegal constant expression in directive.

A constant expression made up of constants and macros that evaluate to constants can be the only operands of an expression used in a preprocessor directive.

001 Concatenation at end-of-file. Ignored.

An attempt was made to concatenate lines with a backslash when the line is the last line of the file.

002 Illegal token.

An unrecognizable token or non-ASCII character was encountered.

003 Illegal redefinition of macro <*name*>.

An attempt was made to redefine a macro, and the tokens in the macro definition do not match those of the previous definition.

004 Incorrect number of arguments for macro <*name*>.

An attempt was made to call a macro, but too few or too many arguments were given.

005 Unbalanced parentheses in macro call “<*name*>”.

An attempt was made to call <*name*> macro with a parenthesis embedded in the argument list that did not match up.

006 Cannot redefine <*name*> keyword.

An attempt was made to redefine a keyword as a macro.

007 Illegal directive.

The syntax of a preprocessor directive is incorrect.

008 Illegal "#if" directive syntax.

The syntax of a `#if` preprocessor directive is incorrect.

009 Bad preprocessor file. Aborted.

An unrecognizable source file was given to the compiler.

010 Illegal macro call syntax.

An attempt was made to call a macro that does not conform to the syntax rules of the language.

011 Integer constant too large.

An integer constant that has a binary value too large to be stored in 32 bits was encountered.

012 Identifier <*name*> is undefined

The syntax of the identifier is incorrect.

013 Illegal #include argument.

The argument to a `#include` directive must be of the form "*pathname*" or <*filename*>.

014 Macro "<*name*>" requires arguments.

An attempt was made to call a macro defined to have arguments and was given none.

015 Illegal "#define" directive syntax.

The syntax of the `#define` directive is incorrect.

016 Unterminated comment in preprocessor directive.

Within a comment, an end of line was encountered.

017 Unterminated quoted string.

Within a quoted string, an end of line was encountered.

018 Escape sequence ASCII code too large to fit in char.

The binary value of an escape sequence requires more than 8 bits of storage.

019 Character not within radix.

An integer constant was encountered with a character greater than the radix of the constant.

020 More than four characters in string constant.

A string constant was encountered having more than four ASCII characters.

021 End of file encountered before end of macro call.

The end of file is reached before right parenthesis of macro call.

022 Macro expansion caused line to be too long.

The line needs to be shortened.

023 "##" cannot be first or last token in replacement string.

The macro definition cannot have “##” operator in the beginning or end.

024 "#" must be followed by an argument name.

In a macro definition, "#" operator must be followed by an argument.

025 Illegal "#line" directive syntax.

In `#line` <*linenum*> directive, <*linenum*> must be an integer after macro expansion.

026 Cannot undefine macro "*name*".

The syntax of the macro is incorrect.

027 End-of-file found before "#endif" directive.

`#if` directive was not terminated with a corresponding `#endif` directive.

028 "#else" not within #if and #endif directives.

`#else` directive was encountered before a corresponding `#if` directive.

029 Illegal constant expression.

The constant expression in preprocessing directive has invalid type or syntax.

030 Illegal macro name <*name*>.

The macro name does not have a valid identifier syntax.

031 Extra "#endif" found.

`#endif` directive without a corresponding `#if` directive was found.

032 Division by zero encountered.

Divide by zero in constant expression found.

033 Floating point constant over/underflow.

In the process of evaluating a floating-point expression, the value became too large to be stored.

034 Concatenated string too long.

Shorten the concatenated string.

035 Identifier longer than 32 characters.

Identifiers must be 32 characters or shorter.

036 Unsupported CPU "*name*" in pragma.

An unknown CPU encountered.

037 Unsupported or poorly formed pragma.

An unknown `#pragma` directive encountered.

038 (*User-supplied text*)

A user-created `#error` or `#warning` directive has been encountered. The user-supplied text from the directive is printed with the error/warning message.

039 Unexpected end of file

An end of file encountered with in a comment, string or character.

040 Unmatched "#else" found

`#else` directive without a corresponding `#if` directive was found.

041 Unmatched "#elif" found

`#elif` directive without a corresponding `#if` directive was found.

042 "#" preceded by non whitespace character

The preprocessor line has characters other than white space (blanks, tabs, new lines, comments etc) before '`#`'.

043 Unterminated quoted character

An end of line was encountered within a quoted character.

044 Empty file encountered

The source file contains only white spaces (blanks, tabs, new lines, comments, and so on) after preprocessing.

Front-End Warning and Error Messages

100 Syntax error.

A syntactically incorrect statement, declaration, or expression was encountered.

101 Function "<*name*>" already declared.

An attempt was made to define two functions with the same name.

102 Constant integer expression expected.

A non-integral expression was encountered where only an integral expression can be.

103 Constant expression overflow.

In the process of evaluating a constant expression, value became too large to be stored in 32 bits.

104 Function return type mismatch for "<*name*>".

A function prototype or function declaration was encountered that has a different result from a previous declaration.

105 Argument type mismatch for argument <*name*>.

The type of an actual parameter does not match the type of the formal parameter of the function called.

106 Cannot take address of un-subscripted array.

An attempt was made to take the address of an array with no index. The address of the array is already implicitly calculated.

107 Function call argument cannot be void type.

An attempt was made to pass an argument to a function that has type void.

108 Identifier "<*name*>" is not a variable or enumeration constant name.

In a declaration, a reference to an identifier was made that was not a variable name or an enumeration constant name.

109 Cannot return a value from a function returning "void".

An attempt was made to use a function defined as returning void in an expression.

110 Expression must be arithmetic, structure, union or pointer type.

The type of an operand to a conditional expression was not arithmetic, structure, union or pointer type.

111 Integer constant too large

Reduce the size of the integer constant.

112 Expression not compatible with function return type.

An attempt was made to return a value from function that cannot be promoted to the type defined by the function declaration.

113 Function cannot return value of type array or function.

An attempt was made to return a value of type array or function.

114 Structure or union member may not be of function type.

An attempt was made to define a member of structure or union that has type function.

115 Cannot declare a typedef within a structure or union.

An attempt was made to declare a typedef within a structure or union.

116 Illegal bit field declaration.

An attempt was made to declare a structure or union member that is a bit field and is syntactically incorrect.

117 Unterminated quoted string

Within a quoted string, an end of line was encountered.

118 Escape sequence ASCII code too large to fit in char

The binary value of an escape sequence requires more than 8 bits of storage.

119 Character not within radix

An integer constant was encountered with a character greater than the radix of the constant.

120 More than one character in string constant

A string constant was encountered having more than one ASCII character.

121 Illegal declaration specifier.

An attempt was made to declare an object with an illegal declaration specifier.

122 Only type qualifiers may be specified with a struct, union, enum, or typedef.

An attempt was made to declare a struct, union, enum, or typedef with a declaration specifier other than const and volatile.

123 Cannot specify both long and short in declaration specifier.

An attempt was made to specify both long and short in the declaration of an object.

124 Only "const" and "volatile" may be specified within pointer declarations.

An attempt was made to declare a pointer with a declaration specifier other than const and volatile.

125 Identifier "<*name*>" already declared within current scope.

An attempt was made to declare two objects of the same name in the same scope.

126 Identifier "<*name*>" not in function argument list, ignored.

An attempt was made to declare an argument that is not in the list of arguments when using the old style argument declaration syntax.

127 Name of formal parameter not given.

The type of a formal parameter was given in the new style of argument declarations without giving an identifier name.

128 Identifier "<*name*>" not defined within current scope.

An identifier was encountered that is not defined within the current scope.

129 Cannot have more than one default per switch statement.

More than one default statements were found in a single switch statement.

130 Label "<*name*>" is already declared.

An attempt was made to define two labels of the same name in the same scope.

131 Label "<*name*> not declared.

A `goto` statement was encountered with an undefined label.

132 "continue" statement not within loop body.

A `continue` statement was found outside a body of any loop.

133 "break" statement not within switch body or loop body.

A `break` statement was found outside the body of any loop.

134 "case" statement must be within switch body.

A `case` statement was found outside the body of any switch statement.

135 "default" statement must be within switch body.

A `default` statement was found outside the body of any switch statement.

136 Case value <*name*> already declared.

An attempt was made to declare two cases with the same value.

137 Expression is not a pointer.

An attempt was made to dereference value of an expression whose type is not a pointer.

138 Expression is not a function locator.

An attempt was made to use an expression as the address of a function call that does not have a type pointer to function.

139 Expression to left of "." or "->" is not a structure or union.

An attempt was made to use an expression as a structure or union, or a pointer to a structure or union, whose type was neither a structure or union, or a pointer to a structure or union.

140 Identifier "<*name*>" is not a member of <*name*> structure.

An attempt was made to reference a member of a structure that does not belong to the structure.

141 Object cannot be subscripted.

An attempt was made to use an expression as the address of an array or a pointer that was not an array or pointer.

142 Array subscript must be of integral type.

An attempt was made to subscript an array with a non integral expression.

143 Cannot dereference a pointer to "void".

An attempt was made to dereference a pointer to void.

144 Cannot compare a pointer to a non-pointer.

An attempt was made to compare a pointer to a non-pointer.

145 Pointers to different types may not be compared.

An attempt was made to compare pointers to different types.

146 Pointers may not be added.

It is not legal to add two pointers.

147 A pointer and a non-integral may not be subtracted.

It is not legal to subtract a non-integral expression from a pointer.

148 Pointers to different types may not be subtracted.

It is not legal to subtract two pointers of different types.

149 Unexpected end of file encountered.

In the process of parsing the input file, end of file was reached during the evaluation of an expression, statement, or declaration.

150 Unrecoverable parse error detected.

The compiler became confused beyond the point of recovery.

151 Operand must be a modifiable lvalue.

An attempt was made to assign a value to an expression that was not modifiable.

152 Operands are not assignment compatible.

An attempt was made to assign a value whose type cannot be promoted to the type of the destination.

153 "<*name*>" must be arithmetic type.

An expression was encountered whose type was not arithmetic where only arithmetic types are allowed.

154 "<*name*>" must be integral type.

An expression was encountered whose type was not integral where only integral types are allowed.

155 "<*name*>" must be arithmetic or pointer type.

An expression was encountered whose type was not pointer or arithmetic where only pointer and arithmetic types are allowed.

156 Expression must be an lvalue.

An expression was encountered that is not an lvalue where only an lvalue is allowed.

157 Cannot assign to an object of constant type.

An attempt was made to assign a value to an object defined as having constant type.

158 Cannot subtract a pointer from an arithmetic expression.

An attempt was made to subtract a pointer from an arithmetic expression.

159 An array is not a legal lvalue.

Cannot assign an array to an array.

160 Cannot take address of a bit field.

An attempt was made to take the address of a bit field.

161 Cannot take address of variable with register storage class.

An attempt was made to take the address of a variable with register storage class.

162 Conditional expression operands are not compatible.

One operand of a conditional expression cannot be promoted to the type of the other operand.

163 Casting a non-pointer to a pointer.

An attempt was made to promote a non-pointer to a pointer.

164 Type name of cast must be scalar type.

An attempt was made to cast an expression to a non-scalar type.

165 Operand to cast must be scalar type.

An attempt was made to cast an expression whose type was not scalar.

166 Expression is not a structure or union.

An expression was encountered whose type was not structure or union where only a structure or union is allowed.

167 Expression is not a pointer to a structure or union.

An attempt was made to dereference a pointer with the arrow operator, and the expression's type was not pointer to a structure or union.

168 Cannot take size of void, function, or bit field types.

An attempt was made to take the size of an expression whose type is void, function, or bit field.

169 Actual parameter has no corresponding formal parameter.

An attempt was made to call a function whose formal parameter list has fewer elements than the number of arguments in the call.

170 Formal parameter has no corresponding actual parameter.

An attempt was made to call a function whose formal parameter list has more elements than the number of arguments in the call.

171 Argument type is not compatible with formal parameter.

An attempt was made to call a function with an argument whose type is not compatible with the type of the corresponding formal parameter.

172 Identifier "<*name*>" is not a structure or union tag.

An attempt was made to use the dot operator on an expression whose type was not structure or union.

173 Identifier "<*name*>" is not a structure tag.

The tag of a declaration of a structure object does not have type structure.

174 Identifier "<*name*>" is not a union tag.

The tag of a declaration of a union object does not have type union.

175 Structure or union tag "<*name*>" is not defined.

The tag of a declaration of a structure or union object is not defined.

176 Only one storage class may be given in a declaration.

An attempt was made to give more than one storage class in a declaration.

177 Type specifier cannot have both "unsigned" and "signed".

An attempt was made to give both `unsigned` and `signed` type specifiers in a declaration.

178 "unsigned" and "signed" may be used in conjunction only with "int", "long" or "char".

An attempt was made to use signed or unsigned in conjunction with a type specifier other than `int`, `long`, or `char`.

179 "long" may be used in conjunction only with "int" or "double".

An attempt was made to use long in conjunction with a type specifier other than int or double.

180 Illegal bit field length.

The length of a bit field was outside of the range 0-32.

181 Too many initializers for object.

An attempt was made to initialize an object with more elements than the object contains.

182 Static objects can be initialized with constant expressions only.

An attempt was made to initialize a static object with a non-constant expression.

183 Array "<*name*>" has too many initializers.

An attempt was made to initialize an array with more elements than the array contains.

184 Structure "<*name*>" has too many initializers.

An attempt was made to initialize a structure with more elements than the structure has members.

185 Dimension size may not be zero, negative or omitted.

An attempt was made to omit the dimension of an array, which is not the rightmost dimension, or any dimension of the array was set as less than or equal to zero.

186 First dimension of "<*name*>" may not be omitted.

An attempt was made to omit the first dimension of an array which is not external and is not initialized.

187 Dimension size must be greater than zero.

An attempt was made to declare an array with a dimension size of zero.

188 Only "register" storage class is allowed for formal parameter.

An attempt was made to declare a formal parameter with storage class other than register.

189 Cannot take size of array with missing dimension size.

An attempt was made to take the size of an array with an omitted dimension.

190 Identifier "<*name*>" already declared with different type or linkage.

An attempt was made to declare a tentative declaration with a different type than a declaration of the same name; or, an attempt was made to declare an object with a different type from a previous tentative declaration.

191 Cannot perform pointer arithmetic on pointer to void.

An attempt was made to perform pointer arithmetic on pointer to void.

192 Cannot initialize object with "extern" storage class.

An attempt was made to initialize variable with `extern` storage class.

193 Missing "<*name*>" detected.

An attempt was made to use a variable without any previous definition or declaration.

194 Recursive structure declaration.

A structure member cannot be of same type as the structure itself.

195 Initializer is not assignment compatible.

The initializer type does not match with the variable being initialized.

196 Empty parameter list is an obsolescent feature.

Empty parameter lists are not allowed.

197 No function prototype "<*name*>" in scope.

The function <*name*> is called without any previous definition or declaration.

198 "old style" formal parameter declarations are obsolescent.

Change the parameter declarations.

201 Only one memory space can be specified

An attempt was made to declare a variable with multiple memory space specifier.

202 Unrecognized/invalid type specifier

A type specifier was expected, and something different (like a label or symbol) was read. Or, a valid type specifier was read but cannot be used in this context.

204 Ignoring space specifier (e.g. near, far, rom) on local, parameter or struct member

An attempt was made to declare a local, parameter, or struct member with a memory space specifier. The space specifier for a local or parameter is decided based on the memory model chosen. The space specifier for a struct member is decided based on the space specifier of the entire struct. Any space specifier on local, parameter, or struct member is ignored.

205 Ignoring const or volatile qualifier

An attempt was made to assign a pointer to a type with const qualifier to a pointer to a type with no const qualifier.

or

An attempt was made to assign a pointer to a type with volatile qualifier to a pointer to a type with no volatile qualifier.

206 Cannot initialize typedef

An attempt was made to initialize a typedef.

207 Aggregate or union objects may be initialized with constant expressions only

An attempt was made to initialize an array element, a structure, or union member with an expression that cannot be evaluated at compile time.

208 Operands are not cast compatible

An attempt was made to cast an operand to an incompatible type, for example, casting a rom pointer to a far pointer.

209 Ignoring space specifier (e.g. near, far) on function

An attempt was made to declare a function as near or far.

210 Invalid use of placement or alignment option

An attempt was made to use a placement or alignment option on a local or parameter.

212 No previous use of placement or alignment options

An attempt was made to use the _At … directive without any previous use of the _At address directive.

213 Function "<*name*>" must return a value

An attempt was made to return from a non void function without providing a return value.

214 Function return type defaults to int

The return type of the function was not specified so the default return type was assumed. A function that does not return anything should be declared as void.

215 Signed/unsigned mismatch

An attempt was made to assign a pointer to a signed type with a pointer to an unsigned type and vice versa.

216 “<*name*>” Initialization needs curly braces

An attempt is made to initialize a structure of union without enclosing the initialization in curly braces ‘`{`’ and ‘`}`’.

217 Cannot open include file “<*name*>”

An attempt to open the include file <*name*> failed. Check the path of <*name*> in combination with the `-usrinc` and `-stdinc` command line options for the existence of the file.

218 Function definition declared auto

An attempt is made to define a function with auto storage class.

219 Parameter type given in both old style and new style

While defining a function, an attempt is made to specify the parameter type in both old style and new style.

220 Cannot perform pointer arithmetic on function pointer

An attempt is made to perform pointer arithmetic (+, -) on function pointer.

221 Type defaults to int

A variable declared with no type is treated as of type `int`. A function declared with no return type is treated as a function returning `int`.

222 Statement has no effect

If the statement is not modifying any variables and only reading them, this warning is generated. If the variable read is a `volatile` variable, this warning is not generated.

223 Indirectly called function must be of reentrant type

In Static frame applications, any indirectly called function must be specified as the `reentrant` type using the `reentrant` keyword.

224 Conflicting string placement directive in string constant

There are multiple string placement directives in a string constant that attempt to direct the placement of the string in different address spaces.

Optimizer Warning and Error Messages

250 Missing format parameter to (s)printf

This message is generated when a call to printf or sprintf is missing the format parameter and the inline generation of printf calls is requested. For example, a call of the form

```
printf();
```

251 Can't preprocess format to (s)printf

This message is generated when the format parameter to printf or sprintf is not a string literal and the inline generation of printf calls is requested. For example, the following code causes this warning:

```
static char msg1 = "x = %4d";
char buff[sizeof(msg1)+4];
sprintf(buff,msg1,x); // WARNING HERE
```

This warning is generated because the line of code is processed by the real printf or sprintf function, so that the primary goal of the inline processing, reducing the code size by removing these functions, is not met.

When this message is displayed, you have three options:

- Deselect the Generate Printfs Inline check box (see “C: Advanced Page” on page 69) so that all calls to `printf` and `sprintf` are handled by the real `printf` or `sprintf` functions.
- Recode to pass a string literal. For example, the code in the example can be revised as follows:

  ```
  define MSG1 "x = %4d"
  char buff[sizeof(MSG1)+4];
  sprintf(buff,MSG1,x);       // OK
  ```
- Keep the Generate Printfs Inline check box selected and ignore the warning. This loses the primary goal of the option but results in the faster execution of the calls

to printf or sprintf that can be processed at compile time, a secondary goal of the option.

252 Bad format string passed to (s)printf

This warning occurs when the compiler is unable to parse the string literal format and the inline generation of `printf` calls is requested. A normal call to `printf` or `sprintf` is generated (which might also be unable to parse the format).

253 Too few parameters for (s)printf format

This error is generated when there are fewer parameters to a call to printf or sprintf than the format string calls for and the inline generation of printf calls is requested. For example:

```
printf("x = %4d\n");
```

254 Too many parameters for (s)printf format

This warning is generated when there are more parameters to a call to printf or sprintf than the format string calls for and the inline generation of printf calls is requested. For example:

```
printf("x = %4d\n", x, y);
```

The format string is parsed, and the extra arguments are ignored.

255 Missing declaration of (s)printf helper function, variable, or field

This warning is generated when the compiler has not seen the prototypes for the printf or sprintf helper functions it generates calls to. This occurs if the standard include file stdio.h has not been included or if stdio.h from a different release of ZDS II has been included.

256 Can't preprocess calls to vprintf or vsprintf

This message is generated when the code contains calls to vprintf or vsprintf and the inline generation of printf calls is requested. The reason for this warning and the solutions are similar to the ones for message 201: Can’t preprocess format to (s)printf.

257 Not all paths through “<*name*>” return a value

The function declared with a return type is not returning any value at least on one path in the function.

258 Variable "<*name*>" may be used before it is defined

If there is at least one path through the function that uses a local variable before it is defined, this warning is reported.

Code Generator Warning and Error Messages

303 Case value <*number*> already defined.

If a case value consists of an expression containing a `sizeof`, its value is not known until code generation time. Thus, it is possible to have two cases with the same value not caught by the front end. Review the `switch` statement closely.

308 Excessive Registers required at line <*num*> of function <*func*>.

Excessive Page 0 registers are required at line number **<***num***>**. The compiler does not perform register spilling, so complex expressions that generate this error must be factored into two or more expressions.

309 Interrupt function <*name*> cannot have arguments.

A function declared as an interrupt function cannot have function arguments.

310 Index out of range, truncating index of <*num*> to 255.

The compiler detected an array access outside of the 0.255 byte range. Use a temporary variable if you need to access an array element outside of this range.

312 Aggregate Copy out of range, truncating copy size of <*num*> to 255.

The compiler limits structure sizes to 255 bytes. An attempt was made to copy structures greater than 255 bytes. Use the `memcpy` library function if structures greater than 255 bytes are required.

313 Bitfield Length exceeds *x* bits.

The compiler only accepts bit-field lengths of 8 bits or less for `char` bit-fields, 16 bits or less for `short` and `int` bit-fields, and 32 bits or less for `long` bit-fields.

Using the Macro Assembler

You use the Macro Assembler to translate Z8 Encore! assembly language files with the `.asm` extension into relocatable object modules with the `.obj` extension. After your relocatable object modules are complete, you convert them into an executable program using the linker/locator. The Macro Assembler can be configured using the Assembler page of the Project Settings dialog box (see "Assembler Page" on page 59).

NOTE: The Command Processor allows you to use commands or script files to automate the execution of a significant portion of the IDE's functionality. For more information about the Command Processor, see the "Using the Command Processor" appendix on page 408.

The following topics are covered in this section:

- "Address Spaces and Segments" on page 211
- "Output Files" on page 214
- "Source Language Structure" on page 215
- "Expressions" on page 220
- "Directives" on page 226
- "Structured Assembly" on page 248
- "Conditional Assembly" on page 256
- "Macros" on page 259
- "Labels" on page 263
- "Source Language Syntax" on page 264
- "Compatibility Issues" on page 268
- "Warning and Error Messages" on page 269

NOTE: For more information about Z8 Encore! CPU instructions, see the "eZ8 CPU Instruction Set Description" section in the *eZ8 CPU User Manual* (UM0128).

ADDRESS SPACES AND SEGMENTS

You access the memory regions of the Z8 Encore! microcontroller by using segment directives. A segment is a contiguous set of memory locations. All segments are attached to exactly one memory space. The Z8 Encore! Assembler has predefined spaces and segments. The following sections describe address spaces and segments:

- "Allocating Processor Memory" on page 211
- "Address Spaces" on page 211
- "Segments" on page 211
- "Assigning Memory at Link Time" on page 214

Allocating Processor Memory

All memory locations, whether data or code, must be defined within a segment. There are two types of segments:

- Absolute segments

  An absolute segment is any segment with a fixed origin. The origin of a segment can be defined with the ORG directive. All data and code in an absolute segment are located at the specified physical memory address.

- Relocatable segments

  A relocatable segment is a segment without a specified origin. At link time, linker commands are used to specify where relocatable segments are to be located within their space. Relocatable segments can be assigned to different physical memory locations without re-assembling.

Address Spaces

The memory regions for the Z8 Encore! microprocessor are represented by the address spaces listed in "Linker: Address Spaces Page" on page 89. Briefly, the main address spaces are the ROM space (used for program storage and some constant data) and the data spaces RData and EData. Both RData and EData are used to store nonconstant data; RData is 8-bit addressable memory with a maximum range of `00H-FFH`, and EData is 12-bit addressable memory with a maximum range of `100H-EFFH`. Some CPUs also have specialized NVDS (Non-Volatile Data Storage) and PRAM (Program RAM) spaces, which are described more fully in "Linker: Address Spaces Page" on page 89.

Code and data are allocated to these spaces by using segments attached to the space.

Segments

Segments are used to represent regions of memory. Only one segment is considered active at any time during the assembly process. A segment must be defined before setting it as the current segment. Every segment is associated with one and only one address space.

The following sections describe segments:

- "Predefined Segments" on page 212
- "User-Defined Segments" on page 213

Predefined Segments

For convenience, the segments listed in the following table are predefined by the assembler. Each segment gets assigned to one of the address spaces. All of the predefined segments listed here can be aligned on any byte boundary.

Table 7. Predefined Segments

Segment ID	Space	Contents	Default Origin
near_bss	RData	Uninitialized data	Relocatable
far_bss	EData	Uninitialized data	Relocatable
near_data	RData	Initialized data	Relocatable
far_data	EData	Initialized data	Relocatable
rom_data	ROM	Initialized data	Relocatable
near_txt	RData	String constants	Relocatable
far_txt	EData	String constants	Relocatable
rom_text	ROM	String constants	Relocatable
code	ROM	Code	Relocatable
text	RData	Initialized data	Relocatable
__vectors_*nnn*	ROM	Interrupt vectors	Absolute
pramseg	PRAM	Code	Relocatable

NOTE: Initialized segments in RDATA or EDATA, such as NEAR_BSS or FAR_DATA, require startup code to initialize them because only segments in ROM or EROM can actually be initialized by the assembler/linker. For an example of how to do this, study the C startup code, in `*ZILOGINSTALL*\ZDSII_*product_version*\src\rtl\common\startups.asm`, and the linker command files automatically generated for a C project.

The predefined segment `text` is generated by the compiler, which moves it to either the `near_data` or `far_data` segment, depending on the memory model that is in use. See "Memory Models" on page 137.

NOTE: For every vector directive that locates an interrupt vector at address *nnn* (where *n* represents a hexadecimal digit), the assembler generates an absolute segment in ROM named `__vectors_`*nnn*.

NOTE: The `pramseg` segment is available only for the subset of Z8 Encore! CPUs that support the PRAM (Program RAM) address space.

User-Defined Segments

You can define a new segment using the following directives:

```
DEFINE MYSEG,SPACE=ROM
SEGMENT MYSEG
```

MYSEG becomes the current segment when the assembler processes the `SEGMENT` directive, and *MYSEG* remains the current segment until a new `SEGMENT` directive appears. *MYSEG* can be used as a segment name in the linker command file.

You can define a new segment in RAM using the following directives:

```
DEFINE MYDATA,SPACE=RDATA
SEGMENT MYDATA
```

or

```
DEFINE MYDATA,SPACE=EDATA
SEGMENT MYDATA
```

The `DEFINE` directive creates a new segment and attaches it to a space. For more information about using the DEFINE directive, see “DEFINE” on page 233. The `SEGMENT` directive attaches code and data to a segment. The `SEGMENT` directive makes that segment the current segment. Any code or data following the directive resides in the segment until another `SEGMENT` directive is encountered. For more information about the SEGMENT directive, see “SEGMENT” on page 238.

A segment can also be defined with a boundary alignment and/or origin.

- Alignment

  Aligning a segment tells the linker to place all instances of the segment in your program on the specified boundary.

NOTE: Although a module can enter and leave a segment many times, each module still has only one instance of a segment.

- Origin

  When a segment is defined with an origin, the segment becomes an absolute segment, and the linker places it at the specified physical address in memory.

Assigning Memory at Link Time

At link time, the linker groups those segments of code and data that have the same name and places the resulting segment in the address space to which it is attached. However, the linker handles relocatable segments and absolute segments differently:

- Relocatable segments

  If a segment is relocatable, the linker decides where in the address space to place the segment.

- Absolute segments

  If a segment is absolute, the linker places the segment at the absolute address specified as its origin.

NOTE: At link time, you can redefine segments with the appropriate linker commands. For more information about link commands, see "Linker Commands" on page 277.

OUTPUT FILES

The assembler creates the following files and names them the name of the source file but with a different extension:

- <*source*>`.lst` contains a readable version of the source and object code generated by the assembler. The assembler creates <*source*>`.lst` unless you deselect the Generate Assembly Listing Files (.lst) check box in the Assembler page of the Project Settings dialog box. See "Generate Assembly Listing Files (.lst)" on page 67.
- <*source*>`.obj` is an object file in relocatable OMF695 format. The assembler creates <*source*>`.obj`.

Caution Do *not* use source input files with `.lst` or `.obj` extensions. The assembler does not assemble files with these extensions; therefore, the data contained in the files is lost.

Source Listing (.lst) Format

The listing file name is the same as the source file name with a `.lst` file extension. Assembly directives allow you to tailor the content and amount of output from the assembler.

Each page of the listing file (`.lst`) contains the following:

- Heading with the assembler version number
- Source input file name
- Date and time of assembly

Source lines in the listing file are preceded by the following:

- Include level
- Plus sign (+) if the source line contains a macro
- Line number
- Location of the object code created
- Object code

The include level starts at level A and works its way down the alphabet to indicate nested includes. The format and content of the listing file can be controlled with directives included in the source file:

- NEWPAGE
- TITLE
- NOLIST
- LIST
- MACLIST ON/OFF
- CONDLIST ON/OFF

NOTE: Error and warning messages follow the source line containing the error(s). A count of the errors and warnings detected is included at the end of the listing output file.

The addresses in the assembly listing are relative. To convert the relative addresses into absolute addresses, select the Show Absolute Addresses in Assembly Listings check box on the Output page (see “Show Absolute Addresses in Assembly Listings” on page 95). This option uses the information in the `.src` file (generated by the compiler when the `-keepasm` option is used or when the Generate Assembly Source check box is selected [see “Generate Assembly Source Code” on page 66]) and the `.map` file to change all of the relative addresses in the assembly listing into absolute addresses.

Object Code (.obj) File

The object code output file name is the same as the source file name with an `.obj` extension. This file contains the relocatable object code in OMF695 format and is ready to be processed by the linker and librarian.

SOURCE LANGUAGE STRUCTURE

The following sections describe the form of an assembly source file:

- “General Structure” on page 216
- “Assembler Rules” on page 217

General Structure

Every nonblank line in an assembly source file is either a source line or a comment line. The assembler ignores blank lines. Each line of input consists of ASCII characters terminated by a carriage return. An input line cannot exceed 512 characters.

A backslash (\) at the end of a line is a line continuation. The following line is concatenated onto the end of the line with the backslash, as in the C programming language. Place a space or any other character after the backslash if you do not want the line to be continued.

The following sections describe the general source language structure:

- "Source Line" on page 216
- "Comment Line" on page 216
- "Label Field" on page 216
- "Instruction" on page 217
- "Directive" on page 217
- "Case Sensitivity" on page 217

Source Line

A source line is composed of an optional label followed by an instruction or a directive. It is possible for a source line to contain only a label field.

Comment Line

A semicolon (;) terminates the scanning action of the assembler. Any text following the semicolon is treated as a comment. A semicolon that appears as the first character causes the entire line to be treated as comment.

Label Field

A label must meet at least one of the following conditions:

- It must be followed by a colon.
- It must start at the beginning of the line with no preceding white space (start in column 1).
- It can be defined by an `EQU` directive using the following syntax:

  <label> `EQU` *<expression>*

  See "EQU" on page 236 for more information on this type of label definition.

NOTE:

- Any instruction followed by a colon is treated as a label.

- Any instruction not followed by a colon is treated as an instruction, even if it starts in the first column.

The first character of a label can be a letter, an underscore _ , a dollar sign ($), a question mark (?), a period (.), or pound sign (#). Following characters can include letters, digits, underscores, dollar signs ($), question marks (?), periods (.), or pound signs (#). The label can be followed by a colon (:) that completes the label definition. A label can only be defined once. The maximum label length is 129 characters.

Labels that can be interpreted as hexadecimal numbers are not allowed. For example,

```
ADH:
ABEFH:
```

cannot be used as labels.

See "Labels" on page 263 and "Hexadecimal Numbers" on page 223 for more information.

Instruction

An instruction contains one valid assembler instruction that consists of a mnemonic and its arguments. When an instruction is in the first column, it is treated as an instruction and not a label. Use commas to separate the operands. Use a semicolon or carriage return to terminate the instruction. For more information about Z8 Encore! CPU instructions, see the "eZ8 CPU Instruction Set Description" section in the *eZ8 CPU User Manual* (UM0128).

Directive

A directive tells the assembler to perform a specified task. Use a semicolon or carriage return to terminate the directive. Use spaces or tabs to separate the directive from its operands. See "Directives" on page 226 for more information.

Case Sensitivity

In the default mode, the assembler treats all symbols as case sensitive. Select the Ignore Case of Symbols check box of the General page in the Project Settings dialog box to invoke the assembler and ignore the case of user-defined identifiers (see "Ignore Case of Symbols" on page 58). Assembler reserved words are not case sensitive.

Assembler Rules

The following sections describe the assembler rules:

- "Reserved Words" on page 218
- "Assembler Numeric Representation" on page 219
- "Character Strings" on page 220

Reserved Words

The following list contains reserved words that the assembler uses. You cannot use these words as symbol names or variable names. Also, reserved words are not case sensitive.

.align	.ascii	.asciz	.ASECT	.ASG
.assume	.bes	.block	.bss	.byte
.copy	.data	.def	.ELIF	.ELSE
.ELSEIF	.emsg	.ENDIF	.ENDM	.ENDMAC
.ENDMACRO	.ENDSTRUCT	.ENDWITH	.EQU	.ER
.even	.extern	.FCALL	.file	.FRAME
.global	.IF	.include	.int	.LIST
.long	.MACEND	.MACRO	.MLIST	.mmsg
.MNOLIST	.NEWBLOCK	.ORG	.PAGE	.public
.R	.ref	.RR	.SBLOCK	.sect
.SET	.space	.STRING	.STRUCT	.TAG
.text	.UNION	.USECT	.VAR	.WITH
.wmsg	.word	.WRG	_ER	_R
_RR	_WRG	ADC	ALIGN	ASCII
ASCIZ	ASECT	ASSUME	BES	BFRACT
BLKB	BLKL	BLKP	BLKW	BSS
byte	C	C0	C1	C2
C3	CHIP	COMMENT	CONDLIST	COPY
CPU	DATA	DB	DBYTE	DD
DEFB	DEFINE	DF	DL	DMA
DOT_IDENT	DPTR	DS	DW	DW24
ELSEIF	END	ENDC	ENDM	ENDMACRO
ENDMODULE	ENDS	ENDSTRUCT	EQ	ERROR
ESECT	EXIT	F	FCALL	FCB
FILE	FLAGS	FRACT	FRAME	GE
GLOBAL	GLOBALS	GREGISTER	GT	HIGH
I2C	IFDIFF	IFE	IFFALSE	IFNDEF
IFNDIFF	IFNMA	IFNSAME	IFNTRUE	IFZ
IGNORE	INCLUDE	LE	LEADZERO	LFRACT
LIST	long	LONGREG	LOW	LT
MACCNTR	MACDELIM	MACEND	MACEXIT	MACFIRST
MACLIST	MACNOTE	MESSAGE	MI	MLIST

MNOLIST	MODULE	NC	NE	NEWBLOCK
NEWPAGE	NOCONDLIST	NOLIST	NOMACLIST	NOSPAN
NOV	NZ	OFF	ON	ORG
ORIGIN	OV	PAGELENGTH	PAGEWIDTH	PL
POPSEG	PP_ASG	PP_CONCAT	PP_DEF	PP_ELIF
PP_ELSE	PP_ENDIF	PP_ENDMAC	PP_EQU	PP_EVAL
PP_EXPRESSION	PP_GREG	PP_IF	PP_IFDEF	PP_IFMA
PP_IFNDEF	PP_IFNMA	PP_LOCAL	PP_MACEXIT	PP_MACRO
PP_NOSAME	PP_NIF	PP_SAME	PP_SBLOCK	PP_VAR
PRINT	PT	PUSHSEG	PW	r0
r10	r11	r12	r13	r14
r15	r2	r3	r4	r5
r6	r7	r8	r9	RESET
RP	rr0	rr10	rr12	rr14
rr2	rr4	rr6	rr8	SCOPE
SEGMENT	SET	SHORTREG	SPH	SPI
STRING	STRUCT	SUBTITLE	T	TAG
TEXT	TIMER0	TIMER1	TIMER2	TIMER3
TITLE	TRAP	UART0_RX	UART0_TX	UART1_RX
UART1_TX	UBFRACT	UFRACT	UGE	UGT
ULE	ULFRACT	ULT	UN_IF	UNSUPPORTED
USER_ERROR	USER_EXIT	USER_WARNING	VAR	VECTOR
WARNING	WDT	word	XDEF	XREF
Z	ZBREAK	ZCONTINUE	ZELSE	ZELSEIF
ZENDIF	ZIF	ZIGNORE	ZREPEAT	ZSECT
ZUSECT	ZWEND	ZWHILE	ZUNTIL	

NOTE: Additionally, do *not* use the instruction mnemonics or assembler directives as symbol or variable names.

Assembler Numeric Representation

Numbers are represented internally as signed 32-bit integers. Floating-point numbers are 32-bit IEEE standard single-precision values. The assembler detects an expression operand that is out of range for the intended field and generates appropriate error messages.

Character Strings

Character strings consist of printable ASCII characters enclosed by double (`"`) or single (`'`) quotes. A double quote used within a string delimited by double quotes and a single quote used within a string delimited by single quotes must be preceded by a back slash (\). A single quoted string consisting of a single character is treated as a character constant. The assembler does not automatically insert null character (0's) at the end of a text string. A character string cannot be used as an operand. For example:

```
DB "STRING" ; a string
DB 'STRING',0 ; C printable string
DB "STRING\"S" ; embedded quote
DB 'a','b','c' ; character constants
```

EXPRESSIONS

In most cases, where a single integer or float value can be used as an operand, an expression can also be used. The assembler evaluates expressions in 32-bit signed arithmetic or 64-bit floating-point arithmetic. Logical expressions are bitwise operators.

The assembler detects overflow and division-by-zero errors. The following sections describe the syntax of writing an expression:

- “Arithmetic Operators” on page 221
- “Relational Operators” on page 221
- “Boolean Operators” on page 221
- “HIGH and LOW Operators” on page 222
- “HIGH16 and LOW16 Operators” on page 222
- “.FTOL Operator” on page 222
- “.LTOF Operator” on page 223
- “Decimal Numbers” on page 223
- “Hexadecimal Numbers” on page 223
- “Binary Numbers” on page 223
- “Octal Numbers” on page 224
- “Character Constants” on page 224
- “Operator Precedence” on page 224
- “Automatic Working Register Definitions” on page 225

Arithmetic Operators

`<<`	Left Shift
`>>`	Arithmetic Right Shift
`**`	Exponentiation
`*`	Multiplication
`/`	Division
`%`	Modulus
`+`	Addition
`-`	Subtraction

NOTE: You must put spaces before and after the modulus operator to separate it from the rest of the expression.

Relational Operators

For use only in conditional assembly expressions.

`==`	Equal	Synonyms: `.eq.`, `.EQ.`
`!=`	Not Equal	Synonyms: `.ne.`, `.NE.`
`>`	Greater Than	Synonyms: `.gt.`, `.GT.`
`<`	Less Than	Synonyms: `.lt.`, `.LT.`
`>=`	Greater Than or Equal	Synonyms: `.ge.`, `.GE.`
`<=`	Less Than or Equal	Synonyms: `.le.`, `.LE.`

Boolean Operators

`&`	Bitwise AND	Synonyms: `.and.`, `.AND.`
`|`	Bitwise inclusive OR	Synonyms: `.or.`, `.OR.`
`^`	Bitwise exclusive XOR	Synonyms: `.xor.`, `.XOR.`
`~`	Complement	
`!`	Boolean NOT	Synonyms: `.not.`, `.NOT.`

HIGH and LOW Operators

The HIGH and LOW operators can be used to extract specific bytes from an integer expression. The LOW operator extracts the byte starting at bit 0 of the expression, while the HIGH operator extracts the byte starting at bit 8 of the expression.

HIGH and LOW can also be used to extract portions of a floating-point value.

For example:

```
# LOW (X) ; 8 least significant bits of X
# HIGH (X) ; 8 most significant bits of X
```

NOTE: The following is the syntax of these operators:

<*operator*> <*expression*>

For example:

`HIGH` <*expression*>

`HIGH` (and `LOW`) takes the entire expression to the right of it as its operand. This means that an expression such as

```
HIGH(PAOUT)|LOW(PAOUT&%f0)
```

is parsed as, in effect,

```
HIGH((PAOUT | LOW(PAOUT & %f0)))
```

If `HIGH` is only intended to operate on `PAOUT` in this example, its operation must be restricted with parentheses. For example:

```
(HIGH(PAOUT))|LOW(PAOUT&%f0)
```

HIGH16 and LOW16 Operators

The `HIGH16` and `LOW16` operators can be used to extract specific 16-bit words from an integer expression. The `LOW16` operator extracts the word starting at bit 0 of the expression; the `HIGH16` operator extracts the word starting at bit 16 of the expression.

`HIGH16` and `LOW16` can also be used to extract portions of a floating-point value.

For example:

```
# LOW16 (X) ; 16 least significant bits of X
# HIGH16 (X) ; 16 most significant bits of X
```

.FTOL Operator

The `.FTOL` operator can be used to convert a floating-point value to an integer. For example:

```
fval equ 12.34
```

```
   segment CODE
   LD r0,#.FTOL(fval)       ; 12 is loaded into r0.
```

.LTOF Operator

The `.LTOF` operator can be used to convert an integer value to a floating-point value. For example:

```
val equ 12
fval DF .LTOF(val)
```

Decimal Numbers

Decimal numbers are signed 32-bit integers consisting of the characters `0`–`9` inclusive between `-2147483648` and `2147483647`. Positive numbers are indicated by the absence of a sign. Negative numbers are indicated by a minus sign (`-`) preceding the number. Underscores (_) can be inserted between digits to improve readability. For example:

```
1234 ; decimal
-123_456 ; negative decimal
1_000_000; decimal number with underscores
_123_;  NOT an integer but a name.  Underscore can be neither first
    nor last character.
12E-45 ; decimal float
-123.456 ; decimal float
123.45E6 ; decimal float
```

Hexadecimal Numbers

Hexadecimal numbers are signed 32-bit integers ending with the `h` or `H` suffix (or starting with the `%` prefix) and consisting of the characters `0`–`9` and `A`–`F`. A hexadecimal number can have 1 to 8 characters. Positive numbers are indicated by the absence of a sign. Negative numbers are indicated by a minus sign (`-`) preceding the number. Underscores (_) can be inserted between hexadecimal digits to improve readability, but only when the `%` prefix is used instead of the `H` suffix. For example:

```
ABCDEFFFH ; hexadecimal
%ABCDEFFF ; hexadecimal
-0FFFFh ; negative hexadecimal
%ABCD_EFFF; hexadecimal number with underscore
ADC0D_H; NOT a hexadecimal number but a name
    ; underscores not allowed with the H suffix
```

Binary Numbers

Binary numbers are signed 32-bit integers ending with the character `b` or `B` and consisting of the characters `0` and `1`. A binary number can have 32 characters. Positive numbers are indicated by the absence of a sign. Negative numbers are indicated by a minus sign (`-`)

preceding the number. Underscores (_) can be inserted between binary digits to improve readability. For example:

```
-0101b ; negative binary number
0010_1100_1010_1111B; binary number with underscores
```

Octal Numbers

Octal numbers are signed 32-bit integers ending with the character `o` or `O` and consisting of the characters `0–7`. An octal number can have 1 to 11 characters. Positive numbers are indicated by the absence of a sign. Negative numbers are indicated by a minus sign (`-`) preceding the number. Underscores (_) can be inserted between octal digits to improve readability. For example:

```
1234o ; octal number
-1234o ; negative octal number
1_234o; octal number with underscore
```

Character Constants

A single printable ASCII character enclosed by single quotes (`'`) can be used to represent an ASCII value. This value can be used as an operand value. For example:

```
'A' ; ASCII code for "A"
'3' ; ASCII code for "3"
```

Operator Precedence

The following table shows the operator precedence in descending order, with operators of equal precedence on the same line. Operators of equal precedence are evaluated left to right. Parentheses can be used to alter the order of evaluation.

Table 8. Operator Precedence

Level 1	`()`						
Level 2	`~`	`unary-`	`!`	`high`	`low`		
Level 3	`**`	`*`	`/`	`%`			
Level 4	`+`	`-`	`&`	`|`	`^`	`>>`	`<<`
Level 5	`<`	`>`	`<=`	`>=`	`==`	`!=`	

NOTE: Shift Left (<<) and OR (|) have the same operator precedence and are evaluated from left to right. If you need to alter the order of evaluation, add parentheses to ensure the desired operator precedence. For example:

```
ld a,  1<<2 | 1<<2 | 1<<1
```

The constant expression in the preceding instruction evaluates to 2A H.

If you want to perform the Shift Left operations before the OR operation, use parentheses as follows:

```
ld a, #(1<<2)|(1<<2)|(1<<1)
```

The modified constant expression evaluates to `6 H`.

Automatic Working Register Definitions

Z8 Encore! supports 4-, 8-, and 12-bit addressing of registers. Automatic working register definitions allow you to specify which mode the assembler uses. The default is 12-bit mode.

`.ER`	Indicates that the enclosed address is to be encoded as a 8-bit register pair address. Only valid in `ldx` instruction.
`.R`	Indicates that the lower nibble of the enclosed label has to be encoded in the instruction.
`.RR`	Indicates that the enclosed label is at the even boundary and the lower nibble is to be encoded in the instruction.
`.WRG`	Computes the value to store in the RP register so that the given label can be accessed using the 4- or 8-bit addressing mode.

The following examples show how to use automatic working register definitions:

`lab equ %54`
`ldx @r1,@.ER(lab)` is encoded as `8754E1`
`ldx @.ER(lab),@r2` is encoded as `97E254`

```
ldx rp, #.WRG(wbase)
```

If `wbase` is at `%234`, this is equivalent to the following:

```
ldx rp, #%32
```

```
ld r0,.R(reg)
```

If `reg` is at `%43`, this is equivalent to the following:

```
ld r0, r3
```

```
ldc r2,@.RR(rreg)
```

If `rreg` is at `%46`, this is equivalent to the following:

```
ldc r2,@rr6
```

```
   Define Bank0, Space = RData, org =0
   segment Bank0


testme  ds   1
   segment Code
      srp #.WRG(testme)
      incw .RR(testme)
```

NOTE: You must be careful if you want to use escaped mode addressing with 8-bit addresses in extended addressing instructions such as `LDX`, `ADDX`, and `ANDX`, as described in the *eZ8 CPU User Manual* (UM0128). This is sometimes referred to as `RP`-based page addressing because the upper 4 bits of the address are taken from `RP[0:3]` and a "page" from `00H` to `FFH` of addressing is taken from the low 8 bits of the operand. The point to be careful about is that to use this type of addressing, you have to use the hexadecimal digit `E` as the top nibble of your instruction. For example,

```
LDX %E25,%213
```

writes to a destination address whose lower 8 bits are `25H` and whose upper 4 bits are taken from the `RP`, as intended. Conversely, if you write

```
LDX %25,%213
```

this latter instruction is converted by the assembler into the only accepted form of `LDX` that matches the operands that are given; specifically, `%25` is taken to be the 12-bit operand `025H`, and that is used as the destination of the load.

DIRECTIVES

Directives control the assembly process by providing the assembler with commands and information. These directives are instructions to the assembler itself and are not part of the microprocessor instruction set. The following sections provide details for each of the supported assembler directives:

- "ALIGN" on page 227
- ".COMMENT" on page 227
- "CPU" on page 228
- "Data Directives" on page 228
- "DEFINE" on page 233
- "DS" on page 235
- "END" on page 235
- "EQU" on page 236

ALIGN

Forces the object following to be aligned on a byte boundary that is a multiple of <*value*>.

Synonym

`align`

Syntax

<*align_directive*> = > `ALIGN` <*value*>

Example

```
ALIGN 2
DW EVEN_LABEL
```

.COMMENT

The `.COMMENT` assembler directive classifies a stream of characters as a comment.

The `.COMMENT` assembler directive causes the assembler to treat an arbitrary stream of characters as a comment. The delimiter can be any printable ASCII character. The assembler treats as comments all text between the initial and final delimiter, as well as all text on the same line as the final delimiter.

You must not use a label on this directive.

Synonym

`COMMENT`

Syntax

`.COMMENT` *delimiter* [*text*] *delimiter*

Example

```
.COMMENT $ An insightful comment
      of great meaning $
```

This text is a comment, delimited by a dollar sign, and spanning multiple source lines. The dollar sign (`$`) is a delimiter that marks the line as the end of the comment block.

CPU

Defines to the assembler which member of the Z8 Encore! family is targeted. From this directive, the assembler can determine which instructions are legal as well as the locations of the interrupt vectors within the CODE space.

NOTE: The `CPU` directive is used to determine the physical location of the interrupt vectors.

Syntax

<*cpu_definition*> = > `CPU` = <*cpu_name*>

Example

```
CPU = Z8F6423
```

Data Directives

Data directives allow you to reserve space for specified types of data. The following data directives are available:

- “BFRACT and UBFRACT Declaration Types” on page 229
- “FRACT and UFRACT Declaration Types” on page 230
- “BLKB Declaration Type” on page 230
- “BLKL Declaration Type” on page 230
- “BLKW Declaration Type” on page 230
- “DB Declaration Type” on page 231
- “DD Declaration Type” on page 231
- “DF Declaration Type” on page 231
- “DL Declaration Type” on page 232

- "DW Declaration Type" on page 232
- "DW24 Declaration Type" on page 232

Syntax

```
<data directive> = > <type> <value_list>
<type>  =>  BFRACT
        =>  BLKB
        =>  BLKL
        =>  BLKW
        =>  DB
        =>  DD
        =>  DF
        =>  DL
        =>  DW
        =>  DW24
        =>  FRACT
        =>  UBFRACT
        =>  UFRACT
<value_list> => <value>
             => <value_list>,<value>
<value> => <expression>|<string_const>
```

The BLKB, BLKL, and BLKW directives can be used to allocate a block of byte, long, or word data, respectively.

BFRACT and UBFRACT Declaration Types

Syntax

BFRACT	signed fractional (8 bits)
UBFRACT	unsigned fractional (8 bits)

Examples

```
BFRACT [3]0.1, [2]0.2 ; Reserve space for five 8-bit
      ; signed fractional numbers.
       ; Initialize first 3 with 0.1,
       ; last 2 with a 0.2.
UBFRACT [50]0.1,[50]0.2 ; Reserve space for 100 8-bit
       ; unsigned fractional numbers.
       ; Initialize first 50 with a
       ; 0.1, second 50 with a 0.2
BFRACT 0.5 ; Reserve space for one 8-bit signed, fractional number
       ; and initialize it to 0.5.
```

FRACT and UFRACT Declaration Types

Syntax

`FRACT`	signed fractional (8 bits)
`UFRACT`	unsigned fractional (8 bits)

Examples

```
FRACT [3]0.1, [2]0.2 ; Reserve space for five 16-bit
       ; signed fractional numbers.
       ; Initialize first 3 with 0.1,
       ; last 2 with a 0.2.
UFRACT [50]0.1,[50]0.2 ; Reserve space for 100 16-bit
       ; unsigned fractional numbers.
       ; Initialize first 50 with a
       ; 0.1, second 50 with a 0.2
FRACT 0.5 ; Reserve space for one 16-bit signed, fractional number
       ; and initialize it to 0.5.
```

BLKB Declaration Type

Syntax

`BLKB`	number of bytes (8 bits each) [, <*init_value*>]

Examples

```
BLKB 16 ; Allocate 16 uninitialized bytes.
BLKB 16, -1 ; Allocate 16 bytes and initialize them to -1.
```

BLKL Declaration Type

Syntax

`BLKL`	number of longs (32 bits each) [, <*init_value*>]

Examples

```
BLKL 16 ; Allocate 16 uninitialized longs.
BLKL 16, -1 ; Allocate 16 longs and initialize them to -1.
```

BLKW Declaration Type

Syntax

`BLKW`	number of words (16 bits each) [, <*init_value*>]

Examples

```
BLKW 16 ; Allocate 16 uninitialized words.
BLKW 16, -1 ; Allocate 16 words and initialize them to -1.
```

DB Declaration Type

Synonyms

`.byte`, `.ascii`, `.asciz`, `DEFB`, `FCB`, `STRING`, `.STRING`, `byte`

Syntax

`DB` byte data (8 bits)

Examples

```
DB "Hello World" ; Reserve and initialize 11 bytes.
DB 1,2 ; Reserve 2 bytes. Initialize the
       ; first word with a 1 and the second with a 2.
DB %12 ; Reserve 1 byte. Initialize it with ; %12.
```

NOTE: There is no trailing null for the DB declaration type, except that a trailing null is added for the otherwise identical `.asciz` declaration type.

DD Declaration Type

Synonym

`.double`

Syntax

`DD` double signed floating-point value (32 bits)

Example

```
DD 0.1, -16.42 ; Reserve space for 2 64-bit double-precision
      ; signed floating-point numbers.  Initialize the
      ; first with 0.1 and the last with -16.42.
```

DF Declaration Type

Synonym

`.float`

Syntax

`DF` word signed floating-point constant (32 bits)

Example

```
DF 0.1,0.2 ; Reserve space for 2 32-bit single-precision signed
       ; floating-point numbers. Initialize the
       ; first with 0.1 and the last with 0.2.
```

```
DF .5 ; Reserve space for 1 word signed
       ; floating-point number and initialize it to 0.5.
```

DL Declaration Type

Synonyms

`.long, long`

Syntax

`DL` long (32 bits)

Examples

```
DL 1,2 ; Reserve 2 long words. Initialize the
      ; first with a 1 and last with a 2.
DL %12345678 ; Reserve space for 1 long word and
       ; initialize it to %12345678.
```

DW Declaration Type

Synonyms

`.word, word, .int`

Syntax

`DW` word data (16 bits)

Examples

```
DW "Hello World" ; Reserve and initialize 11 words.
DW 1,2 ; Reserve 2 words. Initialize the
       ; first word with a 1 and the second with a 2.
DW %1234 ; Reserve 1 word and initialize it with %1234.
```

NOTE: There is no trailing null for the DW declaration type. When used for an ASCII character string as in the first example here, each letter gets 16 bits with the upper 8 bits zero.

DW24 Declaration Type

Synonyms

`.word24, .trio, .DW24`

Syntax

`DW24` word data (24 bits)

Examples

```
dw24 %123456     ; Reserve one 24-bit entity and initialize it with %123456
.trio %789abc    ; Reserve one 24-bit entity and initialize it with %798abc
```

DEFINE

Defines a segment with its associated address space, alignment, and origin. You must define a segment before you can use it, unless it is a predefined segment. If a clause is not given, use the default for that definition. For more information on the `SEGMENT` directive, see "SEGMENT" on page 238; for a list of predefined segments, see "Predefined Segments" on page 212.

The following sections describe the supported clauses:

- "ALIGN Clause" on page 233
- "MAYINIT Clause" on page 234
- "ORG Clause" on page 234
- "SPACE Clause" on page 235

Synonym

`.define`

Syntax

<*segment_definition*> =>
`DEFINE`<*ident*>[<*space_clause*>][*align_clause*>][<*org_clause*>][<*mayinit_clause*>]

Examples

```
DEFINE near_code ; Uses the defaults of the current
       ; space, byte alignment and relocatable.
DEFINE irq_table,ORG=%FFF8 ; Uses current space, byte alignment,
       ; and absolute starting address at
       ; memory location %FFF8.
```

ALIGN Clause

Allows you to select the alignment boundary for a segment. The linker places modules in this segment on the defined boundary. The boundary, expressed in bytes, must be a power of two (1, 2, 4, 8, and so on).

Syntax

<*align_clause*> => ,`ALIGN` = <*int_const*>

Example

```
DEFINE fdata,SPACE = EData,ALIGN = 2
; Aligns on 2-byte boundary, relocatable.
```

MAYINIT Clause

A MAYINIT clause explicitly allows data in the segment to be initialized by, for example, DB directives. Only segments in ROM or EROM can be directly initialized by assembler, and the MAYINIT clause is not necessary for segments in these spaces. The initialization of segments in RDATA or EDATA requires coordination of the assembler, linker, and startup code. If you need to initialize data in a segment in RDATA or EDATA, use the MAYINIT clause to enable the initialization directives in that segment. See the note in "Predefined Segments" on page 212 on how to use startup code to complete the initialization.

Syntax

<*mayinit_clause*> => `, MAYINIT`

Example

```
DEFINE mySeg, SPACE=EDATA, MAYINIT
```

ORG Clause

Allows you to specify where the segment is to be located, making the segment an absolute segment. The linker places the segment at the memory location specified by the `ORG` clause. The default is no `ORG,` and thus the segment is relocatable.

Syntax

<*org_clause*> => ,`ORG` = <*int_const*>

Synonym

`ORIGIN`

Example

```
DEFINE near_code,ORG = %FFF8
      ; Uses current space, byte alignment, and absolute starting
      ; address at memory location %FFF8.
```

SPACE Clause

A SPACE clause defines the address space in which the segment resides. The linker groups together segments with the same space identification. See "Address Spaces" on page 211 for available spaces.

Syntax

<*space_clause*> => ,SPACE = <*ident*>

Examples

```
DEFINE fdata,SPACE = EData,ALIGN = 2
      ; Aligns on 2-byte boundary, relocatable.
```

DS

Defines storage locations that do not need to be initialized.

Synonym

```
.block
```

Syntax

<*define_storage*> => DS <*value*>

Examples

```
NAME:  DS 10 ; Reserve 10 bytes of storage.
DS 22  ; Reserve 22 bytes of storage.
```

END

Informs the assembler of the end of the source input file. If the operand field is present, it defines the start address of the program. During the linking process, only one module can have a start address; otherwise, an error results. The END directive is optional for those modules that do not need a start address.

NOTE: Any text found after an END directive is ignored.

Synonym

```
.end
```

Syntax

<*end_directive*> => END[<*expression*>]

Example

```
END start ; Use the value of start as the program start address.
```

EQU

Assigns symbolic names to numeric or string values. Any name used to define an equate must not have been previously defined. Other equates and label symbols are allowed in the expression, provided they are previously defined. Labels are not allowed in the expression.

NOTE: There are restrictions on exporting `EQU`-defined symbolic names using the `XDEF` directive or importing them using `XREF`. Specifically, a floating-point, string or symbolic register name `EQU` cannot be exported. In the following example, `length`, `width`, and `area` can be exported, but `myreg` cannot.

Synonyms

`.equ`, `.EQU`, `EQUAL`, `.EQUAL`

Syntax

<*label*> `EQU` <*expression*>

Examples

```
length EQU 6 ; first dimension of rectangle
width  EQU 11; second dimension of rectangle
area   EQU length * width; area of the rectangle
myreg EQU rr4 ; symbolic name of a register pair
```

INCLUDE

Allows the insertion of source code from another file into the current source file during assembly. The included file is assembled into the current source file immediately after the directive. When the EOF (End of File) of the included file is reached, the assembly resumes on the line after the `INCLUDE` directive.

The file to include is named in the string constant after the `INCLUDE` directive. The file name can contain a path. If the file does not exist, an error results and the assembly is aborted. A recursive `INCLUDE` also results in an error.

`INCLUDE` files are contained in the listing (`.lst`) file unless a `NOLIST` directive is active.

Synonyms

`.include`, `.copy, copy`

Syntax

<*include_directive*> => `INCLUDE`[<*string_const*>]

Examples

```
INCLUDE "calc.inc" ; include calc header file
INCLUDE "\test\calc.inc" ; contains a path name
INCLUDE calc.inc ; ERROR, use string constant
```

LIST

Instructs the assembler to send output to the listing file. This mode stays in effect until a `NOLIST` directive is encountered. No operand field is allowed. This mode is the default mode.

Synonyms

`.list`, `.LIST`

Syntax

<*list_directive*> => `LIST`

Example

```
LIST
NOLIST
```

NEWPAGE

Causes the assembler to start a new page in the output listing. This directive has no effect if `NOLIST` is active. No operand is allowed.

Synonyms

`.page`, `PAGE`

Syntax

<*newpage_directive*> => `NEWPAGE`

Example

```
NEWPAGE
```

NOLIST

Turns off the generation of the listing file. This mode remains in effect until a `LIST` directive is encountered. No operand is allowed.

Synonym

`.NOLIST`

Syntax

<*nolist_directive*> => `NOLIST`

Example

```
LIST
NOLIST
```

ORG

The `ORG` assembler directive sets the assembler location counter to a specified value in the address space of the current segment.

The `ORG` directive must be followed by an integer constant, which is the value of the new origin.

Synonyms

`ORIGIN`, `.ORG`

Syntax

<*org_directive*> => `ORG` <*int_const*>

Examples

```
ORG %1000  ; Sets the location counter at %1000 in the address space of current segment
ORG LOOP    ; ERROR, use an absolute constant
```

On encountering the `ORG` assembler directive, the assembler creates a new absolute segment with a name starting with `$$$org`. This new segment is placed in the address space of the current segment, with origin at the specified value and alignment as 1.

NOTE: Zilog recommends that segments requiring the use of `ORG` be declared as absolute segments from the outset by including an `ORG` clause in the `DEFINE` directive for the segment.

SEGMENT

Specifies entry into a previously defined segment.

The `SEGMENT` directive must be followed by the segment identifier. The default segment is used until the assembler encounters a `SEGMENT` directive. The internal assembler program counter is reset to the previous program counter of the segment when a `SEGMENT` directive is encountered. See Table 7, “Predefined Segments,” on page 212 for the names of predefined segments.

Synonyms

`.section, SECTION`

Syntax

<*segment_directive*> => `SEGMENT` <*ident*>

Example

```
SEGMENT code ; predefined segment
DEFINE data ; user-defined
```

SUBTITLE

Causes a user-defined subtitle to be displayed below the TITLE on each page of the listing file. The new subtitle remains in effect until the next SUBTITLE directive. The operand must be a string constant.

Syntax

<*subtitle_directive*> => `SUBTITLE` <*string_const*>

Example

```
SUBTITLE "My Project Subtitle"
```

TITLE

Causes a user-defined `TITLE` to be displayed in the listing file. The new title remains in effect until the next `TITLE` directive. The operand must be a string constant.

Synonym

```
.title
```

Syntax

<*title_directive*> => `TITLE` <*string_const*>

Example

```
TITLE "My Title"
```

VAR

The `VAR` directive works just like an `EQU` directive except you are allowed to change the value of the label. In the following example, `STRVAR` is assigned three different values. This causes an error if `EQU` was used instead of `VAR`.

Synonym

```
.VAR, SET, .SET
```

Syntax

<*label*> VAR <*expression*>

Example

```
                         A     6            SEGMENT NEAR_DATA
                         A     7            ALIGN 2
       000000FF          A     8    STRVAR                VAR FFH
000000 FF                A     9            DB            STRVAR
                         A    10            SEGMENT TEXT
000000                   A    11    L__0:
000000 4641494C 4544     A    12            DB            "FAILED"
000006 00                A    13            DB            0
                         A    14            SEGMENT NEAR_DATA
                         A    15            ALIGN 2
       00000000          A    16    STRVAR VAR L__0
                         A    17
000002                   A    18    _fail_str:
000002 00                A    19            DB            STRVAR
                         A    20            SEGMENT TEXT
000007                   A    21    L__1:
000007 50415353 4544     A    22            DB            "PASSED"
00000D 00                A    23            DB            0
       00000007          A    24    STRVAR VAR L__1
                         A    25            SEGMENT NEAR_DATA
                         A    26            ALIGN 2
000004                   A    27    _pass_str:
000004 07                A    28            DB            STRVAR
```

VECTOR

Initializes an interrupt or reset vector to a program address. <*vector name*> specifies which vector is being selected. Except for Z8 Encore! MC^{TM} or 16K XP parts, which are covered in the succeeding tables, <*vector name*> must be one of the following:

RESET	P3AD
WDT	P2AD
TRAP	P1AD
TIMER2	P0AD
TIMER1	TIMER3
TIMER0	UART1_RX
UART0_RX	UART1_TX
UART0_TX	DMA
I2C	C3
SPI	C2
ADC	C1
P7AD	C0
P6AD	POTRAP (primary oscillator fail trap—for Z8F04A series)
P5AD	WOTRAP (watchdog oscillator fail trap—for Z8F04A series)
P4AD	

For Z8 Encore! MC^{TM} (Motor Control) CPUs, <*vector name*> must be one of the following:

RESET	SPI
WDT	12C
TRAP	C0
PWMTIMER	PB
PWMFAULT	P7A, P31
ADC	P6A, P2A
CMP	P5A, P1A
TIMER0	P4A, P0A
UART0_RX	POTRAP
UART0_TX	WOTRAP

For the Z8 Encore! 16K XP CPUs, <*vector name*> must be one of the following:

RESET	P4AD
WDT	P3AD
TRAP	P2AD
TIMER2	P1AD
TIMER1	P0AD
TIMER0	MCT
UART0_RX	UART1_RX
UART0_TX	UART1_TX
I2C	C3
SPI	C2
ADC	C1
P7AD	C0
P6AD	POTRAP
P5AD	WOTRAP

Syntax

<*vector_directive*> => `VECTOR` <*vector name*> = <*expression*>

Examples

```
VECTOR WDT = irq0_handler
VECTOR TRAP = irq1_handler
```

XDEF

Defines a list of labels in the current module as an external symbol that are to be made publicly visible to other modules at link time. The operands must be labels that are defined somewhere in the assembly file.

Synonyms

`.global`, `GLOBAL`, `.GLOBAL`, `.public`, `.def`, `public`

Syntax

<*xdef_directive*> => `XDEF` <*ident list*>

Examples

```
XDEF label
XDEF label1,label2,label3
```

XREF

Specifies that a list of labels in the operand field are defined in another module. The reference is resolved by the linker. The labels must not be defined in the current module. This directive optionally specifies the address space in which the label resides.

Synonyms

`.extern`, `EXTERN`, `EXTERNAL`, `.ref`

Syntax

<xref_directive> => `XREF` *<ident_space_list>*
<ident_space_list> => *<ident_space>*
=> *<ident_space_list>*, *<ident_space>*
<ident_space> => *<ident>* [:*<space>*]

Examples

```
XREF label
XREF label1,label2,label3
XREF label:ROM
```

Structures and Unions in Assembly Code

The assembler provides a set of directives to group data elements together, similar to high-level programming language constructs like a C structure or a Pascal record. These directives allow you to declare a structure or union type consisting of various elements, assign labels to be of previously declared structure or union type, and provide multiple ways to access elements at an offset from such labels.

The assembler directives associated with structure and union support are listed in the following table:

Assembler Directive	Description
`.STRUCT`	Group data elements in a structure type
`.ENDSTRUCT`	Denotes end of structure or union type
`.UNION`	Group data elements in a union type
`.TAG`	Associate label with a structure or union type
`.WITH`	A section in which the specified label or structure tag is implicit
`.ENDWITH`	Denotes end of with section

The structure and union directives are described in the following sections:

- ".STRUCT and .ENDSTRUCT Directives" on page 244

- “.TAG Directive” on page 245
- “.UNION Directive” on page 247
- “.WITH and .ENDWITH Directives” on page 247

.STRUCT and .ENDSTRUCT Directives

A structure is a collection of various elements grouped together under a single name for convenient handling. The `.STRUCT` and `.ENDSTRUCT` directives can be used to define the layout for a structure in assembly by identifying the various elements and their sizes. The `.STRUCT` directive assigns symbolic offsets to the elements of a structure. It does not allocate memory. It merely creates a symbolic template that can be used repeatedly.

The `.STRUCT` and `.ENDSTRUCT` directives have the following form:

[*stag*] `.STRUCT` [*offset* | : *parent*]

[*name_1*] `DS` *count1*

[*name_2*] `DS` *count2*

[*tname*] `.TAG` *stagx* [*count*]

...

[*name_n*] `DS` *count3*

[*ssize*] `.ENDSTRUCT` [*stag*]

The label *stag* defines a symbol to use to reference the structure; the expression *offset*, if used, indicates a starting offset value to use for the first element encountered; otherwise, the starting offset defaults to zero.

If *parent* is specified rather than *offset*, the *parent* must be the name of a previously defined structure, and the *offset* is the size of the parent structure. In addition, each name in the *parent* structure is inserted in the new structure.

Each element can have an optional label, such as *name_1*, which is assigned the value of the element’s offset into the structure and which can be used as the symbolic offset. If *stag* is missing, these element names become global symbols; otherwise, they are referenced using the syntax `stag.name`. The directives following the optional label can be any space reserving directive such as `DS`, or the `.TAG` directive (defined below), and the structure offset is adjusted accordingly.

The label *ssize*, if provided, is a label in the global name space and is assigned the size of the structure.

If a label *stag* is specified with the `.ENDSTRUCT` directive, it must match the label that is used for the `.STRUCT` directive. The intent is to allow for code readability with some checking by the assembler.

An example structure definition is as follows:

DATE `.STRUCT`

MONTH `DS` *1*

DAY `DS` *1*

YEAR `DS` *2*

DSIZE `.ENDSTRUCT` *DATE*

NOTE: Directives allowed between `.STRUCT` and `.ENDSTRUCT` are directives that specify size, principally `DS`, `ALIGN`, `ORG`, and `.TAG` and their aliases. Also, `BLKB`, `BLKW`, and `BLKL` directives with one parameter are allowed because they indicate only size.

The following directives are not allowed within `.STRUCT` and `.ENDSTRUCT`:

- Initialization directives (`DB`, `DW`, `DL`, `DF`, and `DD`) and their aliases
- `BLKB`, `BLKW`, and `BLKL` with two parameters because they perform initialization
- Equates (`EQU` and `SET`)
- Macro definitions (`MACRO`)
- Segment directives (`SEGMENT` and `FRAME`)
- Nested `.STRUCT` and `.UNION` directives
- CPU instructions (for example, `LD` and `NOP`)

.TAG Directive

The `.TAG` assembler declares or assigns a label to have a structure type. This directive can also be used to define a structure/union element within a structure. The `.TAG` directive does not allocate memory.

The `.TAG` directive to define a structure/union element has the following form:

[*stag*] `.STRUCT` [*offset* | : *parent*]

[*name_1*] `DS` *count1*

[*name_2*] `DS` *count2*

...

[*tname*] `.TAG` *stagx* [*count*]

...

[*ssize*] `.ENDSTRUCT` [*stag*]

The .TAG directive to assign a label to have a structure type has the following form:

[*tname*] .TAG *stag* ; Apply *stag* to *tname*

[*tname*] DS *ssize* ; Allocate space for *tname*

Once applied to label *tname*, the individual structure elements are applied to *tname* to produce the desired offsets using *tname* as the structure base. For example, the label `tname.name_2` is created and assigned the value `tname + stag.name_2`. If there are any alignment requirements with the structure, the .TAG directive attaches the required alignment to the label. The optional *count* on the .TAG directive is meaningful only inside a structure definition and implies an array of the .TAG structure.

NOTE: Keeping the space allocation separate allows you to place the .TAG declarations that assign structure to a label in the header file in a similar fashion to the .STRUCT and XREF directives. You can then include the header file in multiple source files wherever the label is used. Make sure to perform the space allocation for the label in only one source file.

Examples of the .TAG directive are as follows:

```
DATE   .STRUCT
MONTH   DS 1
DAYDS 1
YEAR    DS 2
DSIZE   .ENDSTRUCT DATE


NAMELEN EQU 30


EMPLOYEE .STRUCT
NAME    DS  NAMELEN
SOCIAL   DS  10
START    .TAG DATE
SALARY   DS 1
ESIZE   .ENDSTRUCT EMPLOYEE


NEWYEARS .TAG DATE
NEWYEARS DS DSIZE
```

The .TAG directive in the last example above creates the symbols NEWYEARS.MONTH, NEWYEARS.DAY, and NEWYEARS.YEAR. The space for NEWYEARS is allocated by the DS directive.

.UNION Directive

The `.UNION` directive is similar to the `.STRUCT` directive, except that the offset is reset to zero on each label. A `.UNION` directive cannot have an offset or parent union. The keyword to terminate a `.UNION` definition is `.ENDSTRUCT`.

The .UNION directive has the following form:

[*stag*] `.UNION`

[*name_1*] `DS` *count1*

[*name_2*] `DS` *count2*

[*tname*] `.TAG` *stagx* [*count*]

...

[*name_n*] `DS` *count3*

[*ssize*] `.ENDSTRUCT` [*stag*]

An example of the `.UNION` directive usage is as follows:

```
BYTES   .STRUCT
B0   DS 1
B1   DS 1
B2   DS 1
B3   DS 1
BSIZE   .ENDSTRUCT BYTES


LONGBYTES   .UNION
LDATA   BLKL 1
BDATA   .TAG BYTES
LSIZE   .ENDSTRUCT LONGBYTES
```

.WITH and .ENDWITH Directives

Using the fully qualified names for fields within a structure can result in very long names. The `.WITH` directive allows the initial part of the name to be dropped.

The `.WITH` and `.ENDWITH` directives have the following form:

`.WITH` *name*

; *directives*

`.ENDWITH` [*name*]

The identifier name may be the name of a previously defined `.STRUCT` or `.UNION`, or an ordinary label to which a structure has been attached using a `.TAG` directive. It can also be the name of an equate or label with no structure attached. Within the `.WITH` section, the assembler attempts to prepend “*name*.” to each identifier encountered, and selects the modified name if the result matches a name created by the `.STRUCT`, `.UNION`, or `.TAG` directives.

The `.WITH` directives can be nested, in which case the search is from the deepest level of nesting outward. In the event that multiple names are found, a warning is generated and the first such name is used.

If name is specified with the `.ENDWITH` directive, the name must match that used for the `.WITH` directive. The intent is to allow for code readability with some checking by the assembler.

For example, the `COMPUTE_PAY` routine below:

```
COMPUTE_PAY:
;  Enter with pointer to an EMPLOYEE in R2, days in R1
;  Return with pay in R0,R1


LD      R0,EMPLOYEE.SALARY(R2)
MULT    RR0
RET
```

could be written using the `.WITH` directive as follows:

```
COMPUTE_PAY:
;  Enter with pointer to an EMPLOYEE in R2, days in R1
;  Return with pay in R0,R1


.WITH EMPLOYEE
LD      R0, SALARY(R2)
MULT    RR0
RET
.ENDWITH EMPLOYEE
```

STRUCTURED ASSEMBLY

Structured assembly supports execution-time selection of sequences of source statements based on execution-time conditions. The structured assembly directives test for a specified condition and execute a block of statements only if the condition is true.

The structured assembly directives, when used in conjunction with the ability to assembly and link modules independently, facilitate structured programming in assembly language. It can be difficult to assimilate the logical structure of a traditional, nonstructured assembly language program. Structured assembly language programs are generally easier to read and understand than nonstructured programs. They might also be easier to debug and change. The following sections describe structured assembly:

- "Structured Assembly Inputs" on page 250
- "Structured Assembly Processing" on page 254

The assembler directives associated with structured assembly are summarized in the following table.

Table 9. Assembler Directives for Structured Assembly

Assembler Directive	Description
.$IF, .$REPEAT, .$WHILE	Structured assembly test primary
$ELSEIF	Structured assembly test alternate
.$ELSE	Structured assembly test default
.$BREAK, .$CONTINUE	Structured assembly test control
.$ENDIF, .$UNTIL, .$WEND	Structured assembly test end

The assembler directives shown in the table are known collectively as structured assembly test directives and are always used together to form a homogeneous structured assembly block. The assembler supports one decision structure (`.$IF`) and two looping structures (`.$WHILE` and `.$REPEAT`).

The assembler supports a decision structure with the `.$IF`, `.$ELSEIF`, `.$ELSE`, and `.$ENDIF` directives. These directives generate code to test one or more execution-time conditions and execute a block of statements based on the result of the tests.

For example, for the following decision structure:

```
.$if (r0 == #0)
      ld r0,r1
.$else
      ld r0,r2
.$endif
```

the assembler generates the following code:

```
000000 A6E000       A  2    .$if (r0 == #0)
000003 EB 05
000005 E4E1E0       A  3    ld     r0,r1
000008 8B 03        A  4    .$else
00000A E4E2E0       A  5    ld     r0,r2
00000D              A  6    .$endif
```

The assembler supports two types of looping structures with the `.$WHILE`, `.$WEND`, and `.$REPEAT`, `.$UNTIL` directive pairs. The `.$WHILE` directive generates code to test an execution-time condition and executes a block of statements while the condition is true. Since the test is performed before executing the block, the block might not be executed.

For example, for the following looping structure:

```
.$while (r0 != #0)
      ld  r2,@r0
      dec r0
.$wend
```

the assembler generates the following code:

```
00000D A6E000     A  10   .$while (r0 == #0)
000010 6B 06
000012 E320       A  11   ld     r2,@r0
000014 30E0       A  12   dec    r0
000016 8B F5      A  13   .$wend
000018            A  14
```

The `.$REPEAT` directive generates code to test an execution-time condition after executing a block of statements and repeatedly executes the block until the condition is true. Because the test is performed after executing the block, the block is executed at least once.

For example, for the following looping structure:

```
.$repeat
      ld  r1,@r0
      dec r0
.$until (eq)
```

the assembler generates the following code:

```
000018 A6E000       A  17   .$repeat
000018 6B 06        A  18   ld     r1,@r0
00001A E320         A  19   dec    r0
00001C 30E0         A  20   .$until (eq)
00001E 8B F5        A  21
```

Structured Assembly Inputs

The following sections describe the structured assembly input requirements:

- "IF Structured Assembly Block Inputs" on page 250
- "REPEAT Structured Assembly Block Inputs" on page 252
- "WHILE Structured Assembly Block Inputs" on page 253

IF Structured Assembly Block Inputs

The `.$IF`, `.$ELSEIF`, `.$ELSE`, and `.$ENDIF` assembler directives are used to test execution-time conditions and conditionally execute object code based on the results of the test.

Syntax

`.$IF` *condition1* [; *comment*]
      statements
[`.$ELSEIF` *condition2* [; *comment*]]
      [*statements*]
.

```
.
.
[  .$ELSE [; comment ] ]
        [ statements ]
.$ENDIF [; comment ]
```

The following qualifications elaborate the syntax and semantics of the structured assembly test directives. Unless otherwise specified, violations of these qualifications cause the assembly to fail.

- The `.$IF`, `.$ELSEIF`, `.$ELSE`, and `.$ENDIF` assembler directives must be specified in that order.
- The `.$ELSEIF` assembler directive is optional. It can be specified an arbitrary number of times between the `.$IF` and `.$ENDIF` assembler directives.
- The `.$ELSE` assembler directive is optional. It can be specified at most once between the `.$IF` and `.$ENDIF` directives.
- If used, the `.$ELSE` assembler directive must be coded after any `.$ELSEIF` directives.
- Any valid assembler statement can appear in the statements sections of the structured assembly test directives. This means, among other things, that structured assembly test directives can be nested. The structured assembly test directives can be nested up to 255 levels.
- Nested `.$ELSEIF` and `.$ELSE` directives are associated with the most recent `.$IF` directive.
- There is no preset limit on the number of statements that can appear in the statements sections; there can be any number of assembler statements in each statements section, including zero. The operating system file system might impose limitations on file sizes, and the user needs to consult the appropriate operating system users guide for such limitations.
- Each expression must be a conditional expression. See “Expressions” on page 220.
- The `.$IF` and `.$ENDIF` directives must be coded in matching pairs. That is, it is not legal to code an `.$IF` directive without a matching `.$ENDIF` directive appearing later in the source module; nor is it legal to code an `.$ENDIF` directive without a matching `.$IF` directive appearing earlier in the source module.
- The `.$ELSEIF` and `.$ELSE` assembler directives can only appear between enclosing `.$IF` and `.$ENDIF` directives. It is not valid for the `.$ELSEIF` and `.$ELSE` directives to appear in any other context.
- The `.$ELSE` directive does not have any parameters.
- The `.$ENDIF` directive does not have any parameters.

- None of the `.$IF`, `.$ELSEIF`, `.$ELSE`, and `.$ENDIF` assembler directives can be labeled. If a label is specified, a warning message is issued, and the label is discarded.

REPEAT Structured Assembly Block Inputs

The `.$REPEAT`, `.$BREAK`, `.$CONTINUE`, and `.$UNTIL` assembler directives are used to test execution-time conditions and conditionally execute object code based on the results of the test.

Syntax

`.$REPEAT` [; *comment*]
    statements
[`.$BREAK` [.$IF *condition2*] [; *comment*]]
    [*statements*]
[`.$CONTINUE` [.$IF *condition3*] [; *comment*]]
    [*statements*]
`.$UNTIL` *condition1* [; *comment*]

The following qualifications elaborate the syntax and semantics of the structured assembly test directives. Unless otherwise specified, violations of these qualifications cause the assembly to fail.

- The `.$REPEAT` and `.$UNTIL` assembler directives must be specified in that order.
- The `.$BREAK` assembler directive is optional. It can be specified an arbitrary number of times between the `.$REPEAT` and `.$UNTIL` assembler directives.
- The `.$CONTINUE` assembler directive is optional. It can be specified an arbitrary number of times between the `.$REPEAT` and `.$UNTIL` directives.
- Any valid assembler statement can appear in the statements sections of the structured assembly test directives. This means, among other things, that structured assembly test directives can be nested. The structured assembly test directives can be nested up to 255 levels.
- Nested `.$BREAK` and `.$CONTINUE` directives are associated with the most recent `.$REPEAT` directive.
- There is no preset limit on the number of statements that can appear in the statements sections; there can be any number of assembler statements in each statements section, including zero. The operating system file system might impose limitations on file sizes, and the user needs to consult the appropriate operating system users guide for such limitations.
- The `.$REPEAT` and `.$UNTIL` directives must be coded in matching pairs. That is, it is not legal to code a `.$REPEAT` directive without a matching `.$UNTIL` directive appearing later in the source module nor is it legal to code an `.$UNTIL` directive without a matching `.$REPEAT` directive appearing earlier in the source module.

- The `.$BREAK` and `.$CONTINUE` assembler directives can only appear between enclosing `.$REPEAT` and `.$UNTIL` directives (or between `.$WHILE` and `.$WEND` directives). It is not valid for the `.$BREAK` and `.$CONTINUE` directives to appear in any other context.
- The `.$BREAK` directive has an optional `.$IF` conditional parameter.
- The `.$CONTINUE` directive has an optional `.$IF` conditional parameter.
- None of the `.$REPEAT`, `.$BREAK`, `.$CONTINUE`, and `.$UNTIL` assembler directives can be labeled. If a label is specified, a warning message is issued, and the label is discarded.

WHILE Structured Assembly Block Inputs

The `.$WHILE`, `.$BREAK`, `.$CONTINUE`, and `.$WEND` assembler directives are used to test execution-time conditions and conditionally execute object code based on the results of the test.

Syntax

`.$WHILE` *condition1* [; *comment*]

statements

[`.$BREAK` [.$IF *condition2*] [; *comment*]]

[*statements*]

[`.$CONTINUE` [.$IF *condition3*] [; *comment*]]

[*statements*]

`.$WEND` [; *comment*]

The following qualifications elaborate the syntax and semantics of the structured assembly test directives. Unless otherwise specified, violations of these qualifications cause the assembly to fail.

- The `.$WHILE` and `.$WEND` assembler directives must be specified in that order.
- The `.$BREAK` assembler directive is optional. It can be specified an arbitrary number of times between the `.$WHILE` and `.$WEND` assembler directives.
- The `.$CONTINUE` assembler directive is optional. It can be specified an arbitrary number of times between the `.$WHILE` and `.$WEND` directives.
- Any valid assembler statement can appear in the statements sections of the structured assembly test directives. This means, among other things, that structured assembly test directives can be nested. The structured assembly test directives can be nested up to 255 levels.

- Nested `.$BREAK` and `.$CONTINUE` directives are associated with the most recent `.$WHILE` directive.
- There is no preset limit on the number of statements that can appear in the statements sections; there can be any number of assembler statements in each statements section, including zero. The operating system file system might impose limitations on file sizes, and the user needs to consult the appropriate operating system users guide for such limitations.
- The `.$WHILE` and `.$WEND` directives must be coded in matching pairs. That is, it is not legal to code a `.$WHILE` directive without a matching `.$WEND` directive appearing later in the source module nor is it legal to code an `.$WEND` directive without a matching `.$WHILE` directive appearing earlier in the source module.
- The `.$BREAK` and `.$CONTINUE` assembler directives can only appear between enclosing `.$WHILE` and `.$WEND` directives (or between `.$REPEAT` and `.$UNTIL` directives). It is not valid for the `.$BREAK` and `.$CONTINUE` directives to appear in any other context.
- The `.$BREAK` directive has an optional `.$IF` conditional parameter.
- The `.$CONTINUE` directive has an optional `.$IF` conditional parameter.
- None of the `.$WHILE`, `.$BREAK`, `.$CONTINUE`, and `.$WEND` assembler directives can be labeled. If a label is specified, a warning message is issued, and the label is discarded.

Structured Assembly Processing

The following sections describe the assembly-time processing of structured assembly directives:

- "Validity Checks" on page 254
- "Sequence of Operations" on page 255

Validity Checks

The following validity checks are performed on the structured assembly block input data. Unless otherwise specified, violations cause the assembly to fail.

- The syntax of the structured assembly block must conform to the requirements specified in "Structured Assembly Inputs" on page 250.
- The `.$IF` and `.$ENDIF` directives must be properly balanced, that is, there must be exactly one `.$ENDIF` directive for each `.$IF` directive, and the `.$IF` directive must precede its corresponding `.$ENDIF` directive.
- The `.$REPEAT` and `.$UNTIL` directives must be properly balanced, that is, there must be exactly one `.$UNTIL` directive for each `.$REPEAT` directive, and the `.$REPEAT` directive must precede its corresponding `.$UNTIL` directive.

- The `.$WHILE` and `.$WEND` directives must be properly balanced, that is, there must be exactly one `.$WEND` directive for each `.$WHILE` directive, and the `.$WHILE` directive must precede its corresponding `.$WEND` directive.
- The structured assembly block must be completely specified with a single assembly unit. An assembly unit is a single source file or a single macro definition.

Sequence of Operations

The following sequences of operations are performed in processing structured assembly test directives:

- ".$IF Sequence of Operations" on page 255
- ".$REPEAT Sequence of Operations" on page 255
- ".$WHILE Sequence of Operations" on page 256

.$IF Sequence of Operations

The following sequence of operations is performed in processing the `.$IF` structured assembly test directives:

1. The assembler generates object code to evaluate the conditions specified on the `.$IF` directive and on any optional `.$ELSEIF` directives. If the condition is true at execution time, the object code generated from the statements associated with the `.$IF` directive are executed.
2. If the condition specified on the `.$IF` directive is false at execution-time, the assembler-generated object code successively evaluates the conditions specified on the `.$ELSEIF` directives, if there are any, until a true condition is evaluated. On evaluating a true `.$ELSEIF` condition, the object code generated from the statements associated with the `.$ELSEIF` directive are executed.
3. If all conditions on the `.$IF` and `.$ELSEIF` directives are false at execution-time, and an `.$ELSE` directive is present, the object code generated from the statements associated with the `.$ELSE` directive are executed.
4. If no tested condition is true, and if no `.$ELSE` directive is specified, no statements in the structured assembly block are executed.

.$REPEAT Sequence of Operations

The following sequence of operations is performed in processing the `.$REPEAT` structured assembly test directives:

1. The assembler generates object code to evaluate the conditions specified on the `.$UNTIL` directive and on any optional `.$BREAK` and `.$CONTINUE` directives.
2. At execution-time, the object code generated from statements in the structured assembly block are executed until the specified condition is true.

3. At execution time, object code generated from `.$BREAK` directives is executed at the point where it appears in the block. If no condition is specified on the `.$BREAK` condition, or if the condition is true, the `.$REPEAT` loop is exited.
4. At execution time, object code generated from `.$CONTINUE` directives is executed at the point where it appears in the block. If no condition is specified on the `.$CONTINUE` condition, or if the condition is true, execution of code generated from statements in the block resumes at the beginning of the block.

.$WHILE Sequence of Operations

The following sequence of operations is performed in processing the `.$WHILE` structured assembly test directives:

1. The assembler generates object code to evaluate the conditions specified on the `.$WHILE` directive and on any optional `.$BREAK` and `.$CONTINUE` directives.
2. At execution time, the object code generated from statements in the structured assembly block are executed while the specified condition is true.
3. At execution time, object code generated from `.$BREAK` directives is executed at the point where it appears in the block. If no condition is specified on the `.$BREAK` condition or if the condition is true, the `.$WHILE` loop is exited.
4. At execution time, object code generated from `.$CONTINUE` directives is executed at the point where it appears in the block. If no condition is specified on the `.$CONTINUE` condition or if the condition is true, execution of code generated from statements in the block resumes at the beginning of the block.

CONDITIONAL ASSEMBLY

Conditional assembly is used to control the assembly of blocks of code. Entire blocks of code can be enabled or disabled using conditional assembly directives.

The following conditional assembly directives are allowed:

- "IF" on page 257
- "IFDEF" on page 258
- "IFSAME" on page 258
- "IFMA" on page 259

Any symbol used in a conditional directive must be previously defined by an `EQU` or `VAR` directive. Relational operators can be used in the expression. Relational expressions evaluate to 1 if true, and 0 if false.

If a condition is true, the code body is processed. Otherwise, the code body after an `ELSE` is processed, if included.

The `ELIF` directive allows a case-like structure to be implemented.

NOTE: Conditional assembly can be nested.

IF

Evaluates a Boolean expression. If the expression evaluates to 0, the result is false; otherwise, the result is true.

Synonyms

`.if`, `.IF`, `IFN`, `IFNZ`, `COND`, `IFTRUE`, `IFNFALSE`, `$.IF`, `.$if`, `.IFTRUE`

Syntax

`IF` [<*cond_expression*> <*code_body*>]
[`ELIF` <*cond_expression*> <*code_body*>]
[`ELSE` <*code_body*>]
`ENDIF`

Example

```
IF XYZ ; process code body 0 if XYZ is not 0
.
.
.
<Code Body 0>
.
.
ENDIF
IF XYZ !=3 ; process code body 1 if XYZ is not 3
.
.
.
<Code Body 1>
.
.
.
ELIF ABC ; process code body 2 if XYZ=3 and ABC is not 0
.
.
.
<Code Body 2>
.
.
.
ELSE ; otherwise process code body 3
.
.
```

```
.
<Code Body 3>
.
.
.
ENDIF
```

IFDEF

Checks for label definition. Only a single label can be used with this conditional. If the label is defined, the result is true; otherwise, the result if false.

Syntax

```
IFDEF <label>
 <code_body>
[ELSE
 <code_body>]
ENDIF
```

Example

```
IFDEF XYZ ; process code body if XYZ is defined
.
.
.
<Code Body>
.
.
.
ENDIF
```

IFSAME

Checks to see if two string constants are the same. If the strings are the same, the result is true; otherwise, the result is false. If the strings are not enclosed by quotes, the comma is used as the separator.

Syntax

```
IFSAME <string_const> , <string_const>
 <code_body>
[ELSE
 <code_body>]
ENDIF
```

IFMA

Used only within a macro, this directive checks to determine if a macro argument has been defined. If the argument is defined, the result is true. Otherwise, the result is false. If <*arg_number*> is 0, the result is TRUE if no arguments were provided; otherwise, the result is FALSE.

Syntax

```
IFMA <arg_number>
  <code_body>
[ELSE
  <code_body>]
ENDIF
```

MACROS

Macros allow a sequence of assembly source lines to be represented by a single assembler symbol. In addition, arguments can be supplied to the macro in order to specify or alter the assembler source lines generated once the macro is expanded. The following sections describe how to define and invoke macros:

- "Macro Definition" on page 259
- "Concatenation" on page 260
- "Macro Invocation" on page 260
- "Local Macro Labels" on page 261
- "Optional Macro Arguments" on page 261
- "Exiting a Macro" on page 262
- "Delimiting Macro Arguments" on page 262

Macro Definition

A macro definition must precede the use of the macro. The macro name must be the same for both the definition and the `ENDMACRO` line. The argument list contains the formal arguments that are substituted with actual arguments when the macro is expanded. The arguments can be optionally prefixed with the substitution character (\) in the macro body.

During the invocation of the macro, a token substitution is performed, replacing the formal arguments (including the substitution character, if present) with the actual arguments.

Syntax

```
<macroname>[:]MACRO[<arg>(,<arg>)...]
  <macro_body>
ENDMAC[RO]<macroname>
```

Example

```
store: MACRO reg1,reg2,reg3
      ADD reg1,reg2
      LD reg3,reg1
      ENDMAC store
```

Concatenation

To facilitate unambiguous symbol substitution during macro expansion, the concatenation character (&) can be suffixed to symbol names. The concatenation character is a syntactic device for delimiting symbol names that are points of substitution and is devoid of semantic content. The concatenation character, therefore, is discarded by the assembler, when the character has delimited a symbol name. For example:

```
val_part1 equ 55h
val_part2 equ 33h
```

The assembly is:

```
value  macro par1, par2
      DB par1&_&par2
      macend

      value val,part1
      value val,part2
```

The generated list file is:

```
                           A      9         value val,part1
000000 55                  A+     9         DB val_part1
                           A+     9         macend
                           A     10         value val,part2
000001 33                  A+    10         DB val_part2
                           A+    10         macend
```

Macro Invocation

A macro is invoked by specifying the macro name, and following the name with the desired arguments. Use commas to separate the arguments.

Syntax

<*macroname*>[<*arg*>[(,<*arg*>)]...]

Example

```
store R1,R2,R3
```

This macro invocation, when used after the macro is defined as in “Macro Definition” on page 259, causes registers R1 and R2 to be added and the result stored in register R3.

Local Macro Labels

Local macro labels allow labels to be used within multiple macro expansions without duplication. When used within the body of a macro, symbols preceded by two dollar signs (`$$`) are considered local to the scope of the macro and therefore are guaranteed to be unique. The two dollars signs are replaced by an underscore followed by a macro invocation number.

Syntax

`$$` *<label>*

Example

```
LJMP: MACRO cc,label
      JR cc,$$lab
      JP label
$$lab: ENDMAC
```

Optional Macro Arguments

A macro can be defined to handle omitted arguments using the `IFMA` (if macro argument) conditional directive within the macro. The conditional directive can be used to detect if an argument was supplied with the invocation.

Example

```
MISSING_ARG: MACRO ARG0,ARG1,ARG2
      IFMA 2
      LD ARG0,ARG1
      ELSE
      LD ARG0,ARG2
      ENDIF
      ENDMACRO MISSING_ARG
```

Invocation

```
MISSING_ARG R1, ,@R2 ; missing second arg
```

Result

```
LD R1,@R2
```

NOTE: `IFMA` refers to argument numbers that are one based (that is, the first argument is numbered one).

Exiting a Macro

The MACEXIT directive is used to immediately exit a macro. No further processing is performed. However, the assembler checks for proper if-then conditional directives. A MACEXIT directive is normally used to terminate a recursive macro.

The following example is a recursive macro that demonstrates using MAXEXIT to terminate the macro.

Example

```
RECURS_MAC: MACRO ARG1,ARG2
      IF ARG1==0
            MACEXIT
      ELSE
            RECURS_MAC ARG1-1, ARG2
            DB ARG2
      ENDIF
      ENDMACRO RECURS_MAC
RECURS_MAC 1, ’a’
```

Delimiting Macro Arguments

Macro arguments can be delimited by using the current macro delimiter characters defined using the MACDELIM directive. The delimiters can be used to include commas and spaces that are not normally allowed as part of an argument. The default delimiters are brackets { }, but braces [ ] and parentheses ( ) are also allowed.

Example 1

```
; Delimiter changed to [

MACDELIM [

BRA: MACRO ARG1
      JP ARG1
      ENDMACRO

LAB: BRA [NE,LAB]
```

Example 2

```
; Using default delimiter
BRA: MACRO ARG1
      JP ARG1
      ENDMACRO

LAB: BRA {NE,LAB}
```

LABELS

Labels are considered symbolic representations of memory locations and can be used to reference that memory location within an expression. See "Label Field" on page 216 for the form of a legal label.

The following sections describe labels:

- "Anonymous Labels" on page 263
- "Local Labels" on page 263
- "Importing and Exporting Labels" on page 264
- "Label Spaces" on page 264
- "Label Checks" on page 264

Anonymous Labels

The ZDS II assembler supports anonymous labels. The following table lists the reserved symbols provided for this purpose.

Table 10. Anonymous Labels

Symbol	Description
$$	Anonymous label. This symbol can be used as a label an arbitrary number of times.
$B	Anonymous label backward reference. This symbol references the most recent anonymous label defined before the reference.
$F	Anonymous label forward reference. This symbol references the next anonymous label defined after the reference.

Local Labels

Any label beginning with a dollar sign (`$`) or ending with a question mark (`?`) is considered to be a local label. The scope of a local label ends when a `SCOPE` directive is encountered, thus allowing the label name to be reused. A local label cannot be imported or exported.

Example

```
$LOOP:    JP $LOOP    ; Infinite branch to $LOOP
LAB?:     JP LAB?     ; Infinite branch to LAB?
          SCOPE       ; New local label scope
$LOOP:    JP $LOOP    ; Reuse $LOOP
LAB?:     JP LAB?     ; Reuse LAB?
```

Importing and Exporting Labels

Labels can be imported from other modules using the `EXTERN` or `XREF` directive. A space can be provided in the directive to indicate the label's location. Otherwise, the space of the current segment is used as the location of the label.

Labels can be exported to other modules by use of the `PUBLIC` or `XDEF` directive.

Label Spaces

The assembler makes use of a label's space when checking the validity of instruction operands. Certain instruction operands require that a label be located in a specific space because that instruction can only operate on data located in that space. A label is assigned to a space by one of the following methods:

- The space of the segment in which the label is defined.
- The space provided in the `EXTERN` or `XREF` directive.
- If no space is provided with the `EXTERN` or `XREF` directive, the space of the segment where the EXTERN directive was encountered is used as the location of the label.

Label Checks

The assembler performs location checks when a label is used as an operand, including forward referenced labels. Thus, when a label that is not located in the proper space is used as an operand, the assembler flags a warning.

Example

```
EXTERN label1:ROM
JP label1 ; valid
ld r0, label1 ; invalid
```

SOURCE LANGUAGE SYNTAX

The syntax description that follows is given to outline the general assembler syntax. It does not define assembly language instructions.

<source_line>	=>	*<if_statement>*
	=>	[*<Label_field>*]*<instruction_field><EOL>*
	=>	[*<Label_field>*]*<directive_field><EOL>*
	=>	*<Label_field><EOL>*
	=>	*<EOL>*
<if_statement>	=>	*<if_section>*
	=>	[*<else_statement>*]
	=>	`ENDIF`
<if_section>	=>	*<if_conditional>*
		<*code*-body>

```
<if_conditional>      =>   IF<cond_expression>|
                           IFDEF<ident>|
                           IFSAME<string_const>,<string_const>|
                           IFMA<int_const>

<else_statement>      =>   ELSE <code_body>|
                           ELIF<cond_expression>
                           <code_body>
                           [<else_statement>]

<cond_expression>     =>   <expression>|
                           <expression><relop><expression>

<relop>               =>   == | < | > | <= | => | !=

<code_body>           =>   <source_line>@

<label_field>         =>   <ident>:

<instruction_field>   =>   <mnemonic>[<operand>]@

<directive_field>     =>   <directive>

<mnemonic>            =>   valid instruction mnemonic

<operand>             =>   <addressing_mode>
                      =>   <expression>

<addressing_mode>     =>   valid instruction addressing mode
```

<directive>	=>	ALIGN<int_const>
	=>	<array_definition>
	=>	CONDLIST(ON|OFF)
	=>	END[<expression>]
	=>	ENDWITH [<ident>]
	=>	ENDSTRUCT <ident>
	=>	<ident>EQU<expression>
	=>	ERROR<string_const>
	=>	EXIT<string_const>
	=>	.FCALL<ident>
	=>	FILE<string_const>
	=>	.FRAME<ident>,<ident>,<space>
	=>	GLOBALS (ON|OFF)
	=>	INCLUDE<string_const>
	=>	LIST (ON|OFF)
	=>	<macro_def>
	=>	<macro_invoc>
	=>	MACDELIM<char_const>
	=>	MACLIST (ON|OFF)
	=>	NEWPAGE
	=>	NOLIST
	=>	ORG<int_const>
	=>	<public_definition>
	=>	<scalar_definition>
	=>	SCOPE
	=>	<segment_definition>
	=>	SEGMENT<ident>
	=>	SUBTITLE<string_const>
	=>	SYNTAX=<target_microprocessor>
	=>	TAG <ident> [<int_const>]
	=>	TITLE<string_const>
	=>	UNION
	=>	<ident>VAR<expression>
	=>	WARNING<string_const>
	=>	WITH <ident>
<array_definition>	=>	<type>'['<elements>']'
	=>	[<initvalue>(,<initvalue>)@]

<*type*>	=>	BFRACT
	=>	BLKB
	=>	BLKL
	=>	BLKW
	=>	DB
	=>	DD
	=>	DF
	=>	DL
	=>	DW
	=>	DW24
	=>	FRACT
	=>	UBFRACT
	=>	UFRACT
<*elements*>	=>	[<*int_const*>]
<*initvalue*>	=>	['['<*instances*>']']<*value*>
<*instances*>	=>	<*int_const*>
<*value*>	=>	<*expression*>|<*string_const*>
<*expression*>	=>	'('<*expression*>')'
	=>	<*expression*><*binary_op*><*expression*>
	=>	<*unary_op*><*expression*>
	=>	<*int_const*>
	=>	<*float_const*>
	=>	<*label*>
	=>	HIGH<*expression*>
	=>	LOW<*expression*>
	=>	OFFSET<*expression*>
<*binary_op*>	=>	+
	=>	-
	=>	*
	=>	/
	=>	>>
	=>	<<
	=>	&
	=>	|
	=>	^
<*unary_op*>	=>	-
	=>	~
	=>	!
<*int_const*>	=>	*digit*(*digit*|'_')@
	=>	*hexdigit*(*hexdigit*|'_')@H
	=>	*bindigit*(*bindigit*|'_')@B
	=>	<*char_const*>
<*char_const*>	=>	'*any*'

<float_const>	=>	*<decfloat>*
<decfloat>	=>	*<float_frac>*|*<float_power>*
<float_frac>	=>	*<float_const>*[*<exp_part>*]
<frac_const>	=>	*digit*|'_') . (*digit*|'_')`@`
<exp_part>	=>	`E`['+'|-]*digit+*
<float_power>	=>	*digit*(*digit*|'_')`@`*<exp_part>*
<label>	=>	*<ident>*
<string_const>	=>	`"`('\"'|*any*)`@"`
<ident>	=>	(*letter*|'_')(*letter*|'_'|*digit*|'.')`@`
<ident_list>	=>	*<ident>*(,*<ident>*)`@`
<macro_def>	=>	*<ident>*`MACRO`[*<arg>*(*<arg>*)] *<code_body>* `ENDMAC`[`RO`]*<macname>*
<macro_invoc>	=>	*<macname>*[*<arg>*](,*<arg>*)]
<arg>	=>	*macro argument*
<public_definition>	=>	`PUBLIC`*<ident list>* `EXTERN`*<ident list>*
<scalar_definition>	=>	*<type>*[*<value>*]
<segment_definition>	=>	`DEFINE`*<ident>*[*<space_clause>*] [*<align_clause>*][*<org_clause>*]
<space_clause>	=>	`,SPACE=`*<space>*
<align_clause>	=>	`,ALIGN=`*<int_const>*
<org_clause>	=>	`,ORG=`*<int_const>*
<mayinit_clause>	=>	`,MAYINIT`
<space>	=>	(`RDATA|EDATA|ROM|PRAM`)

COMPATIBILITY ISSUES

Compatibility between Z8 Encore! assembler directives and those of other assemblers supported by the Z8 Encore! assembler are listed in "Compatibility Issues" on page 437. If you are developing new code for the Z8 Encore!, Zilog recommends that you use the Z8 Encore! directives described previously in this chapter because the behavior of these directives is thoroughly validated with each release of the Z8 Encore! assembler.

WARNING AND ERROR MESSAGES

This section covers warning and error messages for the assembler.

400 Symbol already defined.

The symbol has been previously defined.

401 Syntax error.

General-purpose error when the assembler recognizes only part of a source line. The assembler might generate multiple syntax errors per source line.

402 Symbol XREF'd and XDEF'd.

Label previously marked as externally defined or referenced. This error occurs when an attempt is made to both XREF and XDEF a label.

403 Symbol not a segment.

The segment has not been previously defined or is defined as some other symbol type.

404 Illegal EQU.

The name used to define an equate has been previously defined or equates and label symbols in an equate expression have not been previously defined.

405 Label not defined.

The label has not been defined, either by an XREF or a label definition.

406 Illegal use of XREF's symbol.

XDEF defines a list of labels in the current module as an external symbol that are to be made publicly visible to other modules at link time; XREF specifies that a list of labels in the operand field are defined in another module.

407 Illegal constant expression.

The constant expression is not valid in this particular context. This error normally occurs when an expression requires a constant value that does not contain labels.

408 Memory allocation error.

Not enough memory is available in the specified memory range.

409 Illegal `.elif` directive.

There is no matching `.if` for the `.elif` directive.

410 Illegal `.else` directive.

There is no matching `.if` for the `.else` directive.

411 Illegal `.endif` directive.

There is no matching `.if` for the `.endif` directive.

412 EOF encountered within an `.if`

End-of-file encountered within a conditional directive.

413 Illegal floating point expression.

An illegal value was found in a floating-point expression. This error is normally caused by the use of labels in the expression.

414 Illegal floating point initializer in scalar directive.

You cannot use floating-point values in scalar storage directives.

415 Illegal relocatable initialization in float directive.

You cannot use relocatable labels in a float storage directive.

416 Unsupported/illegal directives.

General-purpose error when the assembler recognizes only part of a source line. The assembler might generate multiple errors for the directive.

417 Unterminated quoted string.

You must terminate a string with a double quote.

418 Illegal symbol name.

There are illegal characters in a symbol name.

419 Unrecognized token.

The assembler has encountered illegal/unknown character(s).

420 Constant expression overflow.

A constant expression exceeded the range of –2147483648 to 2147483648.

421 Division by zero.

The divisor equals zero in an expression.

422 Address space not defined.

The address space is not one of the defined spaces.

423 File not found.

The file cannot be found in the specified path, or, if no path is specified, the file cannot be located in the current directory.

424 XREF or XDEF label in const exp.

You cannot use an XREF or XDEF label in an EQU directive.

425 EOF found in macro definition

End of file encountered before ENDMAC(RO) reached.

426 MACRO/ENDMACRO name mismatch.

The declared MACRO name does not match the ENDMAC(RO) name.

427 Invalid MACRO arguments.

The argument is not valid in this particular instance.

428 Nesting same segment.

You cannot nest a segment within a segment of the same name.

429 Macro call depth too deep.

You cannot exceed a macro call depth of 25.

430 Illegal ENDMACRO found.

No macro definition for the ENDMAC(RO) encountered.

431 Recursive macro call.

Macro calls cannot be recursive.

432 Recursive include file.

Include directives cannot be recursive.

433 ORG to bad address.

The ORG clause specifies an invalid address for the segment.

434 Symbol name too long.

The maximum symbol length (33 characters) has been exceeded.

435 Operand out-of-range error.

The assembler detects an expression operand that is out of range for the intended field and generates appropriate error messages.

437 Invalid array index.

A negative number or zero has been used for an array instance index. You must use positive numbers.

438 Label in improper space.

Instruction requires label argument to be located in certain address space. The most common error is to have a code label when a data label is needed or vice versa.

439 Vector not recognized.

The vector name must be among those listed under the VECTOR directive.

442 Missing delay slot instruction.

Add a delay slot instruction such as BRANCH or LD.

444 Too many initializers.

Initializers for array data allocation exceeds array element size.

445 Missing `.$endif` at EOF.

There is no matching `.$endif` for the .$`if` directive.

446 Missing `.$wend` at EOF.

There is no `.$wend` directive.

447 Missing `.$repeat` at EOF.

There is no matching `.$repeat` for the `.$while` directive.

448 Segment stack overflow.

Do not allocate returned structures on the stack.

450 Floating point precision error.

The floating-point value cannot be represented to the precision given. The value is rounded to fit within the allowed precision.

451 Floating point over/under flow.

The floating-point value cannot be represented.

452 General floating point error.

The assembler detects an expression operand that is out of range for the intended field and generates appropriate error messages.

453 Fractional number too big/small.

The fractional number cannot be represented.

461 Unexpected end-of-file in comment.

End-of-file encountered in a multi-line comment

462 Macro redefinition.

The macro has been redefined.

464 Obsolete feature encountered.

An obsolete feature was encountered.

470 Missing token error.

A token needs to be added.

475 User error.

General-purpose error.

476 Reference to external label may not always fit in the offset field of that jump instruction.

You have used a jump instruction to jump to an external label, but the type of jump instruction you have used might not provide a large enough displacement. If you want to keep this type of jump instruction, you must check manually to make sure that the desired jump is within the available range. Alternatively, you can either change to a different type of jump instruction or enable jump optimization, which will automatically change the type of jump instruction when the destination is an external label.

480 Relist map file error.

A map file will not be generated.

481 Relist file not found error.

The map file cannot be found in the specified path, or, if no path is specified, the map file cannot be located in the current directory.

482 Relist symbol not found.

Any symbol used in a conditional directive must be previously defined by an `EQU` or `VAR` directive.

483 Relist aborted.

A map file will not be generated.

490 Stall or hazard conflict found.

A stall or hazard conflict was encountered.

499 General purpose switch error.

There was an illegal or improperly formed command line option.

500 Instruction not supported.

The instruction is not supported on the specified CPU.

501 CPU not specified.

The CPU has not been specified.

502 Symbol not a struct/union.

The name of a structure of union is required.

503 STRUCT/ENDSTRUCT name mismatch.

The optional name on a ENDSTRUCT or ENDWITH directive does not match the name on the opening STRUCT or WITH directive.

504 Directive not permitted in struct.

Attempt to use a directive not permitted inside a STRUCT or UNION definition.

505 Nested STRUCT directive.

Attempt to nest STRUCT directives.

506 No active WITH statement.

ENDWITH directive does not have a matching WITH directive.

507 WITH symbol resolves ambiguously.

A symbol matches more than one name inside a nested WITH directive.

508 Unused COUNT on TAG directive.

Attempt to specify a repeat count on a TAG directive used outside of a STRUCT or UNION directive.

509 Label previously declared in different space.

A label has been previously declared (on an XREF directive) in a different space than it is being defined in.

Using the Linker/Locator

The linker/locator in the Z8 Encore! developer's environment creates a single executable file from a set of object modules and object libraries. It acts as a linker by linking together object modules and resolving external references to public symbols. It also acts as a locator because it allows you to specify where code and data is stored in the target processor at run time. The executable file generated by the linker can be loaded onto the target system and debugged using the Zilog Developer Studio II.

This section describes the following:

- "Linker Functions" on page 275
- "Invoking the Linker" on page 276
- "Linker Commands" on page 277
- "Linker Expressions" on page 288
- "Sample Linker Map File" on page 294
- "Warning and Error Messages" on page 305

LINKER FUNCTIONS

The following five major types of objects are manipulated during the linking process:

- Libraries

  Object libraries are collections of object modules created by the Librarian.

- Modules

  Modules are created by assembling a file with the assembler or compiling a file with the compiler.

- Address spaces

  Each module consists of various address spaces. Address spaces correspond to either a physical or logical block of memory on the target processor. For example, a Harvard architecture that physically divides memory into program and data stores has two physical blocks—each with its own set of addresses. Logical address spaces are often used to divide a large contiguous block of memory in order to separate data and code. In this case, the address spaces partition the physical memory into two logical address spaces. The memory range for each address space depends on the particular Z8 Encore! family member. For more information about address spaces, see "Address Spaces" on page 211.

- Groups

  A group is a collection of logical address spaces. They are typically used for convenience of locating a set of address spaces.
- Segments

  Each address space consists of various segments. Segments are named logical partitions of data or code that form a continuous block of memory. Segments with the same name residing in different modules are concatenated together at link time. Segments are assigned to an address space and can be relocatable or absolute. Relocatable segments can be randomly allocated by the linker; absolute segments are assigned a physical address within its address space. See "Segments" on page 211 for more information about using predefined segments, defining new segments, and attaching code and data to segments.

The linker performs the following functions:

- Reads in relocatable object modules and library files and linker commands.
- Resolves external references.
- Assigns absolute addresses to relocatable segments of each address space and group.
- Generates a single executable module to download into the target system.
- Generates a map file.

INVOKING THE LINKER

The linker is automatically invoked when your project is open and you click the Build button or Rebuild All button on the Build toolbar (see "Build Toolbar" on page 18). The linker then links the corresponding object modules of the various source files in your project and any additional object/library modules specified in the Objects and Libraries page of the Project Settings dialog box (see "Linker: Objects and Libraries Page" on page 84).The linker uses the linker command file to control how these object modules and libraries are linked. The linker command file is automatically generated by ZDS II if the Always Generate from Settings button is selected (see "Always Generate from Settings" on page 81). You can add additional linker commands by selecting the Additional Directives check box and clicking **Edit** (see "Additional Directives" on page 82). If you want to override the automatically generated linker command file, select the Use Existing button (see "Use Existing" on page 83).

The linker can also be invoked from the DOS command line or through the ZDS II Command Processor. For more information on invoking the linker from the DOS command line, see "Running ZDS II from the Command Line" on page 399. To invoke the linker through the ZDS II Command Processor, see "Using the Command Processor" on page 408.

LINKER COMMANDS

The following sections describe the commands of a linker command file:

NOTE: Only the <*outputfile*>=<*module list*> and the `FORMAT` commands are required. All commands and operators are *not* case sensitive.

<outputfile>=<module list>

This command defines the executable file, object modules, and libraries involved in the linking process. The default extension is `.lod` as specified by the FORMAT command.

<*module list*> is a list of object module or library path names to be linked together to create the output file.

Example

```
sample=c:\ZDSII_Z8 Encore!_4.11.0\lib\zilog\startups.obj, \
       test.obj, \
       c:\ZDSII_Z8 Encore!_4.11.0\lib\std\chelpd.lib, \
       c:\ZDSII_Z8 Encore!_4.11.0\lib\std\crtsdd.lib, \
       c:\ZDSII_Z8 Encore!_4.11.0\lib\std\fpsdd.lib
```

The preceding command links the two object modules and three library modules to generate the linked output file `sample.lod` in IEEE 695 format when the `format=OMF695` command is present.

NOTE: In the preceding example, the `\` (backslash) at the end of the first line allows the <*module list*> to extend over several lines in a linker command file.

The backslash to continue the <*module list*> over multiple lines is not supported when this command is entered on the DOS command line.

CHANGE

The `CHANGE` command is used to rename a group, address space, or segment. The `CHANGE` command can also be used to move an address space to another group or to move a segment to another address space.

Syntax

`CHANGE` <*name*> = <*newname*>

<*name*> can be a group, address space, or segment.

<*newname*> is the new name to be used in renaming a group, address space, or segment; the name of the group where an address space is to be moved; or the name of the address space where a segment is to be moved.

NOTE: The linker recognizes the special space `NULL`. `NULL` is not one of the spaces that an object file or library can reside in. If a segment name is changed to `NULL` using the CHANGE command to the linker, the segment is deleted from the linking process. This can be useful if you need to link only part of an executable or not write out a particular part of the executable. The predefined space `NULL` can also be used to prevent initialization of data while reserving the segment in the original space using the COPY command. See also the examples for the `COPY` command ("COPY" on page 279).

Examples

To change the name of a segment (for example, `strseg`) to another segment name (for example, `codeseg`), use the following command:

```
CHANGE strseg=codeseg
```

To move a segment (for example, `dataseg`) to a different address space (for example, EDATA), use the following command:

```
CHANGE dataseg=EDATA
```

To not allocate a segment (for example, `dataseg`), use the following command:

```
CHANGE dataseg=NULL
```

COPY

The `COPY` command is used to make a copy of a segment into a specified address space. This is most often used to make a copy of initialized RAM (RDATA, EDATA) in ROM so that it can be initialized at run time.

Syntax

`COPY` *<segment> <name>[at<expression>]*

<segment> can only be a segment.
<name> can only be an address space.

NOTE: The linker recognizes the special space `NULL`. `NULL` is not one of the spaces that an object file or library can reside in. If a segment name is changed to `NULL` using the CHANGE command to the linker, the segment is deleted from the linking process. This can be useful if you need to link only part of an executable or not write out a particular part of the executable. The predefined space `NULL` can also be used to prevent initialization of data while reserving the segment in the original space using the COPY command.

Examples

Example 1

To make a copy of a data segment in ROM, use the following procedure:

1. In the assembly code, define a data segment (for example, `dataseg`) to be a segment located in RDATA. This is the run-time location of `dataseg`.
2. Use the following linker command:

   ```
   COPY dataseg ROM
   ```

   The linker places the actual contents associated with `dataseg` in ROM (the load time location) and associates RDATA (the run-time location) addresses with labels in `dataseg`.

NOTE: You need to copy the `dataseg` contents from ROM to RDATA at run time as part of the startup routine. You can use the `COPY BASE OF` and `COPY TOP OF` linker expressions to get the base address and top address of the contents in ROM. You can use the BASE OF and TOP OF linker expressions to get the base address and top address of `dataseg`.

Example 2

To copy multiple segments to ROM, use the following procedure:

1. In the assembly code, define the segments (for example, `strseg`, `text`, and `dataseg`) to be segments located in RDATA. This is the run-time location of the segments.
2. Use the following linker commands:

   ```
   CHANGE strseg=dataseg
   CHANGE text=dataseg
   COPY dataseg ROM
   ```

   The linker renames `strseg` and `text` as `dataseg` and performs linking as described in the previous example. You need to write only one loop to perform the copy from ROM to RDATA at run time, instead of three (one loop each for `strseg`, `text`, and `dataseg`).

Example 3

To allocate a string segment in ROM but not generate the initialization:

1. In the assembly code, define the string segment (for example, `strsect`) to be a segment located in ROM.
2. Use the following linker command:

   ```
   COPY strsect NULL
   ```

   The linker associates all the labels in `strsect` with an address in ROM and does not generate any loadable data for `strsect`. This is useful when ROM is already programmed separately, and the address information is needed for linking and debugging.

Example 4

To generate debug information without generating code:

Use the COPY command in the linker to copy the segment to the predefined NULL space. If you copy the segment to the NULL space, the region is still allocated but no data is written for it.

```
COPY     myseg   NULL
```

DEBUG

The `DEBUG` command causes the linker to generate debug information for the debugger. This option is applicable only if the executable file is IEEE 695.

Syntax

```
-DEBUG
```

DEFINE

The `DEFINE` command creates a user-defined public symbol at link time. This command is used to resolve external references (`XREF`) used in assemble time.

Syntax

`DEFINE` <*symbol name*> `=` <*expression*>

<*symbol name*> is the name assigned to the public symbol.

<*expression*> is the value assigned to the public symbol.

Example

```
DEFINE copy_size = copy top of data_seg - copy base of data_seg
```

NOTE: Refer to "Linker Expressions" on page 288 for the format to write an expression.

FORMAT

The `FORMAT` command sets the executable file of the linker according to the following table.

File Type	Option	File Extension
IEEE 695 format	`OMF695`	`.lod`
Intel 32-bit format	`INTEL32`	`.hex`

The default setting is `IEEE 695`.

Syntax

[-]`FORMAT=`<*type*>

Example

```
FORMAT = OMF695, INTEL32
```

GROUP

The `GROUP` command provides a method of collecting multiple address spaces into a single manageable entity.

Syntax

`GROUP` <*groupname*> = <*name*>*[,<name>]*

<*groupname*> can only be a group.

<*name*> can only be an address space.

HEADING

The `HEADING` command enables or disables the form feed (`\f`) characters in the map file output.

Syntax

```
-[NO]heading
```

LOCATE

The `LOCATE` command specifies the address where a group, address space, or segment is to be located. If multiple locates are specified for the same space, the last specification takes precedence. A warning is flagged on a `LOCATE` of an absolute segment.

NOTE: The `LOCATE` of a segment overrides the `LOCATE` of an address space. A `LOCATE` does not override an absolute segment.

Syntax

`LOCATE` <*name*> *AT* <*expression*>

<*name*> can be a group, address space, or segment.

<*expression*> is the address to begin loading.

Example

```
LOCATE ROM AT $10000
```

NOTE: Refer to "Linker Expressions" on page 288 for the format to write an expression.

MAP

The `MAP` command causes the linker to create a link map file. The link map file contains the location of address spaces, segments, and symbols. The default is to create a link map file. `NOMAP` suppresses the generation of a link map file.

Syntax

[-]`MAP` [= <*mapfile*>]

mapfile has the same name as the executable file with the `.map` extension unless an optional <*mapfile*> is specified.

Example

```
MAP = myfile.map
```

Link Map File

A sample map file is shown in “Sample Linker Map File” on page 294.

NOTE: The link map file base name is the same as your executable file with the `.map` extension and resides in the same directory as the executable file. The link map has a wealth of information about the memory requirements of your program. Views of memory use from the space, segment, and module perspective are given as are the names and locations of all public symbols. For the Z8 Encore! link map file, the C prefix indicates ROM, the E prefix indicates EDATA, the R prefix indicates RDATA, and the P prefix indicates PRAM. For additional information, see also “Generate Map File” on page 94.

MAXHEXLEN

The `MAXHEXLEN` command causes the linker to fix the maximum data record size for the Intel hex output. The default is 64 bytes.

Syntax

```
[-]MAXHEXLEN < IS | = >  < 16 | 32 | 64 | 128 | 255 >
```

Examples

```
-maxhexlen=16
```

or

```
MAXHEXLEN IS 16
```

MAXLENGTH

The `MAXLENGTH` command causes a warning message to be issued if a group, address space, or segment is longer than the specified size. The `RANGE` command sets address boundaries. The `MAXLENGTH` command allows further control of these boundaries.

Syntax

`MAXLENGTH` <*name*> <*expression*>

<*name*> can be a group, address space, or segment.

<*expression*> is the maximum size.

Example

`MAXLENGTH CODE $FF`

NOTE: Refer to “Linker Expressions” on page 288 for the format to write an expression.

NODEBUG

The `NODEBUG` command suppresses the linker from generating debug information. This option is applicable only if the executable file is IEEE 695.

Syntax

[-]`NODEBUG`

NOMAP

The `NOMAP` command suppresses generation of a link map file. The default is to generate a link map file.

Syntax

[-]`NOMAP`

NOWARN

The `NOWARN` command suppresses warning messages. The default is to generate warning messages.

Syntax

[-]`NOWARN`

ORDER

The `ORDER` command establishes a linking sequence and sets up a dynamic `RANGE` for contiguously mapped address spaces. The base of the `RANGE` of each consecutive address space is set to the top of its predecessor.

Syntax

`ORDER` *<name>[,<name-list>]*

<*name*> can be a group, address space, or segment. <*name-list*> is a comma-separated list of other groups, address spaces, or segments. However, a `RANGE` is established only for an address space.

Example

```
ORDER GDATA,GTEXT
```

where `GDATA` and `GTEXT` are groups.

In this example, all address spaces associated with `GDATA` are located before (that is, at lower addresses than) address spaces associated with `GTEXT`.

RANGE

The `RANGE` command sets the lower and upper bounds of a group, address space, or segment. If an address falls outside of the specified `RANGE`, the system displays a message.

NOTE: You must use white space to separate the colon from the `RANGE` command operands.

Syntax

RANGE *<name><expression> : <expression>[,<expression> : <expression>...]*

<name> can be a group, address space, or segment. The first *<expression>* marks the lower boundary for a specified address `RANGE`. The second *<expression>* marks the upper boundary for a specified address `RANGE`.

Example

```
RANGE ROM $0000 : $0FFF,$4000 : $4FFF
```

If a `RANGE` is specified for a segment, this range must be within any `RANGE` specified by that segment's address space.

NOTE: Refer to "Linker Expressions" on page 288 for the format to write an expression.

SEARCHPATH

The `SEARCHPATH` command establishes an additional search path to be specified in locating files. The search order is as follows:

1. Current directory
2. Environment path
3. Search path

Syntax

`SEARCHPATH ="`*<path>*`"`

Example

```
SEARCHPATH="C:\ZDSII_Z8Encore!_4.11.0\lib\std"
```

SEQUENCE

The `SEQUENCE` command forces the linker to allocate a group, address space, or segment in the order specified.

Syntax

`SEQUENCE` <*name*>[,<*name_list*>]

<*name*> is either a group, address space, or segment.

<*name_list*> is a comma-separated list of group, address space, or segment names.

Example

```
SEQUENCE NEAR_DATA,NEAR_TEXT,NEAR_BSS
```

NOTE: If the sequenced segments do *not* all receive space allocation in the first pass through the available address ranges, then the sequence of segments is *not* maintained.

SORT

The `SORT` command sorts the external symbol listing in the map file by name or address order. The default is to sort in ascending order by name.

Syntax

```
[-]SORT  <ADDRESS | NAME> [IS | =] <ASCENDING | UP | DESCENDING | DOWN>
```

`NAME` indicates sorting by symbol name.

`ADDRESS` indicates sorting by symbol address.

Examples

The following examples show how to sort the symbol listing by the address in ascending order:

```
SORT ADDRESS ASCENDING
```

or

```
-SORT ADDRESS = UP
```

SPLITTABLE

The `SPLITTABLE` command allows (but does not force) the linker to split a segment into noncontiguous pieces to fit into available memory slots. Splitting segments can be helpful in reducing the overall memory requirements of the project. However, problems can arise if a noncontiguous segment is copied from one space to another using the `COPY` command. The linker issues a warning if it is asked to `COPY` any noncontiguous segment.

If `SPLITTABLE` is not specified for a given segment, the linker allocates the entire segment contiguously.

The SPLITTABLE command takes precedence over the ORDER and SEQUENCE commands.

By default, ZDS II segments are nonsplittable. When multiple segments are made splittable, the linker might re-order segments regardless of what is specified in the ORDER (or SEQUENCE) command. In this case, you need to do one of following actions:

- Modify the memory map of the system so there is only one discontinuity and only one splittable segment in which case the ORDER command is followed.
- Modify the project so a specific ordering of segments is not needed, in which case multiple segments can be marked splittable.

Syntax

`SPLITTABLE` *segment_list*

Example

```
SPLITTABLE CODE, ROM_TEXT
```

UNRESOLVED IS FATAL

The `UNRESOLVED IS FATAL` command causes the linker to treat “undefined external symbol” warnings as fatal errors. The linker quits generating output files immediately if the linker cannot resolve any undefined symbol. By default, the linker proceeds with generating output files if there are any undefined symbols.

Syntax

```
[-] < UNRESOLVED > < IS | = > <FATAL>
```

Examples

```
-unresolved=fatal
```

or

```
UNRESOLVED IS FATAL
```

WARN

The `WARN` command specifies that warning messages are to be generated. An optional warning file can be specified to redirect messages. The default setting is to generate warning messages on the screen and in the map file.

Syntax

[-]`WARN` = *[<warn filename>]*

Example

```
-WARN=warnfile.txt
```

WARNING IS FATAL

The `WARNING IS FATAL` command causes the linker to treat all warning messages as fatal errors. The linker does not generate output file(s) if there are any warnings while linking. By default, the linker proceeds with generating output files even if there are warnings.

Syntax

```
[-]< WARNING | WARN> < IS | = > <FATAL>
```

Examples

```
-warn=fatal
```

or

```
WARNING IS FATAL
```

WARNOVERLAP

The `WARNOVERLAP` command enables or disables the warnings when overlap occurs while binding segments. The default is to display the warnings whenever a segment gets overlapped.

Syntax

```
-[NO]warnoverlap
```

LINKER EXPRESSIONS

This section describes the operators and their operands that form legal linker expressions:

- "+ (Add)" on page 289
- "& (And)" on page 289
- "BASE OF" on page 290
- "COPY BASE" on page 291
- "COPY TOP" on page 291
- "/ (Divide)" on page 291
- "FREEMEM" on page 291
- "HIGHADDR" on page 291
- "LENGTH" on page 292

- “LOWADDR” on page 292
- “* (Multiply)” on page 292
- “Decimal Numeric Values” on page 292
- “Hexadecimal Numeric Values” on page 293
- “| (Or)” on page 293
- “<< (Shift Left)” on page 293
- “>> (Shift Right)” on page 293
- “- (Subtract)” on page 293
- “TOP OF” on page 293
- “^ (Bitwise Exclusive Or)” on page 294
- “~ (Not)” on page 294

The following note applies to many of the <*expression*> commands discussed in this section.

NOTE: To use BASE, TOP, COPY BASE, COPY TOP, LOWADDR, HIGHADDR, LENGTH, and FREEMEM <*expression*> commands, you must have completed the calculations on the expression. This is done using the SEQUENCE and ORDER commands. Do not use an expression of the segment or space itself to locate the object in question.

Examples

```
/* Correct example using segments */
SEQUENCE seg2, seg1 /* Calculate seg2 before seg1 */
LOCATE  seg1  AT TOP OF seg2 + 1


/* Do not do this: cannot use expression of seg1 to locate seg1 */
LOCATE seg1 AT (TOP OF seg2 - LENGTH OF seg1)
```

+ (Add)

The + (Add) operator is used to perform addition of two expressions.

Syntax

<*expression*> + <*expression*>

& (And)

The & (And) operator is used to perform a bitwise & of two expressions.

Syntax

<expression> & *<expression>*

BASE OF

The BASE OF operator provides the lowest used address of a group, address space, or segment, excluding any segment copies when <*name*> is a segment. The value of BASE OF is treated as an expression value.

Syntax

BASE OF <*name*>

<*name*> can be a group, address space, or segment.

BASE OF Versus LOWADDR OF

By default, allocation for a given memory group, address space, or segment starts at the lowest defined address for that memory group, address space, or segment. If you explicitly define an assignment within that memory space, allocation for that space begins at that defined point and then occupies subsequent memory locations; the explicit allocation becomes the default BASE OF value. BASE OF <*name*> gives the lowest *allocated* address in the space; LOWADDR OF <*name*> gives the lowest *physical* address in the space.

For example:

```
RANGE ROM $0 : $7FFF
RANGE EDATA $800 : $BFF


/* RAM allocation */
LOCATE s_uninit_data at $800
LOCATE s_nvrblock at $900
DEFINE __low_data = BASE OF s_uninit_data
```

Using

```
LOCATE s_uninit_data at $800
```

or

```
LOCATE s_uninit_data at LOWADDR OF EDATA
```

gives the same address (the lowest possible address) when `RANGE EDATA $800:$BFF`.

If

```
LOCATE s_uninit_data at $800
```

is changed to

```
LOCATE s_uninit_data at BASE OF EDATA
```

the lowest used address is `$900` (because `LOCATE s_nvrblock at $900` and `s_nvrblock` is in `EDATA`).

COPY BASE

The COPY BASE operator provides the lowest used address of a copy segment, group, or address space. The value of COPY BASE is treated as an expression value.

Syntax

`COPY BASE OF` <*name*>

<*name*> can be either a group, address space, or segment.

COPY TOP

The `COPY TOP` operator provides the highest used address of a copy segment, group, or address space. The value of COPY TOP is treated as an expression value.

Syntax

`COPY TOP OF` <*name*>

<*name*> can be a group, address space, or segment.

/ (Divide)

The / (Divide) operator is used to perform division.

Syntax

<expression> / <expression>

FREEMEM

The FREEMEM operator provides the lowest address of unallocated memory of a group, address space, or segment. The value of FREEMEM is treated as an expression value.

Syntax

FREEMEM OF <*name*>

<*name*> can be a group, address space, or segment.

HIGHADDR

The HIGHADDR operator provides the highest possible address of a group, address space, or segment. The value of HIGHADDR is treated as an expression value.

Syntax

`HIGHADDR OF` <*name*>

<*name*> can be a group, address space, or segment.

LENGTH

The LENGTH operator provides the length of a group, address space, or segment. The value of LENGTH is treated as an expression value.

Syntax

`LENGTH OF` <*name*>

<*name*> can be a group, address space, or segment.

LOWADDR

The LOWADDR operator provides the lowest possible address of a group, address space, or segment. The value of LOWADDR is treated as an expression value.

Syntax

`LOWADDR OF` <*name*>

<*name*> can be a group, address space, or segment.

NOTE: See “BASE OF Versus LOWADDR OF” on page 290 for an explanation of the difference between these two operators.

* (Multiply)

The * (Multiply) operator is used to multiply two expressions.

Syntax

<*expression*> * <*expression*>

Decimal Numeric Values

Decimal numeric constant values can be used as an expression or part of an expression. Digits are collections of numeric digits from 0 to 9.

Syntax

<*digits*>

Hexadecimal Numeric Values

Hexadecimal numeric constant values can be used as an expression or part of an expression. Hex digits are collections of numeric digits from 0 to 9 or A to F.

Syntax

$<*hexdigits*>

| (Or)

The | (Or) operator is used to perform a bitwise inclusive | (Or) of two expressions.

Syntax

<*expression*> | <*expression*>

<< (Shift Left)

The << (Shift Left) operator is used to perform a left shift. The first expression to the left of << is the value to be shifted. The second expression is the number of bits to the left the value is to be shifted.

Syntax

<*expression*> << <*expression*>

>> (Shift Right)

The >> (Shift Right) operator is used to perform a right shift. The first expression to the left of >> is the value to be shifted. The second expression is the number of bits to the right the value is to be shifted.

Syntax

<*expression*> >> <*expression*>

- (Subtract)

The - (Subtract) operator is used to subtract one expression from another.

Syntax

<*expression*> - <*expression*>

TOP OF

The TOP OF operator provides the highest allocated address of a group, address space, or segment, excluding any segment copies when <*name*> is a segment. The value of TOP OF is treated as an expression value.

Syntax

`TOP OF` <*name*>

<*name*> can be a group, address space, or segment.

If you declare a segment to begin at `TOP OF` another segment, the two segments share one memory location. `TOP OF` give the address of the last used memory location in a segment, not the address of the next available memory location. For example,

```
LOCATE segment2 at TOP OF segment1
```

starts `segment2` at the address of the last used location of `segment1`. To avoid both segments sharing one memory location, use the following syntax:

```
LOCATE segment2 at (TOP OF segment1) + 1
```

^ (Bitwise Exclusive Or)

The ^ operator is used to perform a bitwise exclusive OR on two expressions.

Syntax

<*expression*> ^ <*expression*>

~ (Not)

The ~ (Not) operator is used to perform a one's complement of an expression.

Syntax

~ <*expression*>

SAMPLE LINKER MAP FILE

```
IEEE 695 OMF Linker Version 6.21 (06050201_eng)
Copyright (C) 1999-2004 ZiLOG, Inc. All Rights Reserved

LINK MAP:

DATE:      Wed May 03 10:58:46 2006
PROCESSOR: assembler
FILES:     C:\PROGRA~1\ZiLOG\ZDSII_~3.0\lib\zilog\startupL.obj
           .\main.obj
           C:\PROGRA~1\ZiLOG\ZDSII_~3.0\lib\std\chelpD.lib
           C:\PROGRA~1\ZiLOG\ZDSII_~3.0\lib\std\crtLDD.lib
           C:\PROGRA~1\ZiLOG\ZDSII_~3.0\lib\std\fpLDD.lib
           C:\PROGRA~1\ZiLOG\ZDSII_~3.0\lib\zilog\csioLDD.lib
           C:\PROGRA~1\ZiLOG\ZDSII_~3.0\lib\zilog\zsldevinitdummy.obj
```

```
COMMAND LIST:
=============
/* Linker Command File - sample Debug */

/* Generated by: */
/*  ZDS II - Z8 Encore! Family 4.10.0 (Build 06050301_eng) */
/*  IDE component: b:4.10:06050201_eng */

/* compiler options */
/* -const:RAM -define:_Z8F6423 -define:_Z8ENCORE_64K_SERIES */
/* -define:_Z8ENCORE_F642X -define:_SIMULATE -genprintf -NOkeepasm */
/* -NOkeeplst -NOlist -NOlistinc -model:L -NOoptlink -promote */
/* -regvar:8 -reduceopt */
/* -
stdinc:"C:\PROGRA~1\ZiLOG\ZDSII_~3.0\include\std;C:\PROGRA~1\ZiLOG\ZDSII_~3.0\
include\zilog;C:\PROGRA~1\ZiLOG\ZDSII_~3.0\include\zilog\Z8ENCO~2" */
/* -debug -NOrevaa -cpu:Z8F6423 */
/* -asmsw:" -cpu:Z8F6423 -define:_Z8F6423=1 -define:_Z8ENCORE_64K_SERIES=1 -
define:_Z8ENCORE_F642X=1 -define:_SIMULATE=1 -
include:C:\PROGRA~1\ZiLOG\ZDSII_~3.0\include\std;C:\PROGRA~1\ZiLOG\ZDSII_~3.0\
include\zilog;C:\PROGRA~1\ZiLOG\ZDSII_~3.0\include\zilog\Z8Encore_F642X -
NOrevaa" */

/* assembler options */
/* -define:_Z8F6423=1 -define:_Z8ENCORE_64K_SERIES=1 */
/* -define:_Z8ENCORE_F642X=1 -define:_SIMULATE=1 */
/* -
include:"C:\PROGRA~1\ZiLOG\ZDSII_~3.0\include\std;C:\PROGRA~1\ZiLOG\ZDSII_~3.0
\include\zilog;C:\PROGRA~1\ZiLOG\ZDSII_~3.0\include\zilog\Z8ENCO~2" */
/* -list -NOlistmac -name -pagelen:56 -pagewidth:80 -quiet -sdiopt */
/* -warn -debug -NOigcase -NOrevaa -cpu:Z8F6423 */

-FORMAT=OMF695,INTEL32
-map -maxhexlen=64 -NOquiet -sort name=ascending -unresolved=fatal
-NOwarnoverlap -NOxref -warn -debug -NOigcase

RANGE ROM $000000 : $00FFFF
RANGE RDATA $000020 : $0000FF
RANGE EDATA $000100 : $000EFF

CHANGE TEXT=EDATA
CHANGE TEXT=FAR_DATA
change NEAR_TXT=NEAR_DATA
change FAR_TXT=FAR_DATA
ORDER FAR_BSS, FAR_DATA
ORDER NEAR_BSS,NEAR_DATA
COPY NEAR_DATA ROM
COPY FAR_DATA ROM

define _low_near_romdata = copy base of NEAR_DATA
define _low_neardata = base of NEAR_DATA
define _len_neardata = length of NEAR_DATA
define _low_far_romdata = copy base of FAR_DATA
define _low_fardata = base of FAR_DATA
define _len_fardata = length of FAR_DATA
define _low_nearbss = base of NEAR_BSS
define _len_nearbss = length of NEAR_BSS
define _low_farbss = base of FAR_BSS
define _len_farbss = length of FAR_BSS
define _far_heaptop = highaddr of EDATA
define _far_stack = highaddr of EDATA
define _near_stack = highaddr of RDATA
define _far_heapbot = top of EDATA
define _near_heaptop = highaddr of RDATA
define _near_heapbot = top of RDATA
define _low_pramseg = base of PRAMSEG
define _len_pramseg = length of PRAMSEG
define _low_pram_romdata = copy base of PRAMSEG
define _READ_NVDS=$1000
define _WRITE_NVDS=$10B3
define _READ_NVDS_GET_STATUS=$1000
define _WRITE_NVDS_GET_STATUS=$10B3
/* Set frequency to 18432000 Hz */
define __user_frequency = 18432000

"C:\sample\sample"=  C:\PROGRA~1\ZiLOG\ZDSII_~3.0\lib\zilog\startupL.obj,
.\main.obj,  C:\PROGRA~1\ZiLOG\ZDSII_~3.0\lib\std\chelpD.lib,
C:\PROGRA~1\ZiLOG\ZDSII_~3.0\lib\std\crtLDD.lib,
C:\PROGRA~1\ZiLOG\ZDSII_~3.0\lib\std\fpLDD.lib,
C:\PROGRA~1\ZiLOG\ZDSII_~3.0\lib\zilog\csioLDD.lib,
C:\PROGRA~1\ZiLOG\ZDSII_~3.0\lib\zilog\zsldevinitdummy.obj



SPACE ALLOCATION:
=================

Space                Base        Top         Size
------------------ ----------- ----------- ---------
EDATA                   E:0100      E:0102        3h
RDATA                     R:E0        R:EF       10h
ROM                     C:0000      C:00E7       e8h


SEGMENTS WITHIN SPACE:
```

```
======================

EDATA               Type                 Base        Top         Size
------------------- -------------------- ----------- ----------- ---------
FAR_BSS             normal data               E:0100      E:0102        3h


RDATA               Type                 Base        Top         Size
------------------- -------------------- ----------- ----------- ---------
workingreg          absolute data               R:E0        R:EF       10h


ROM                 Type                 Base        Top         Size
------------------- -------------------- ----------- ----------- ---------
___flash_option1_s absolute data              C:0000      C:0000        1h
___flash_option2_s absolute data              C:0001      C:0001        1h
__VECTORS_002       absolute data             C:0002      C:0003        2h
__VECTORS_004       absolute data             C:0004      C:0005        2h
__VECTORS_006       absolute data             C:0006      C:0007        2h
__VECTORS_008       absolute data             C:0008      C:0009        2h
__VECTORS_00A       absolute data             C:000A      C:000B        2h
__VECTORS_00C       absolute data             C:000C      C:000D        2h
__VECTORS_00E       absolute data             C:000E      C:000F        2h
__VECTORS_010       absolute data             C:0010      C:0011        2h
__VECTORS_012       absolute data             C:0012      C:0013        2h
__VECTORS_014       absolute data             C:0014      C:0015        2h
__VECTORS_016       absolute data             C:0016      C:0017        2h
__VECTORS_018       absolute data             C:0018      C:0019        2h
__VECTORS_01A       absolute data             C:001A      C:001B        2h
__VECTORS_01C       absolute data             C:001C      C:001D        2h
__VECTORS_01E       absolute data             C:001E      C:001F        2h
__VECTORS_020       absolute data             C:0020      C:0021        2h
__VECTORS_022       absolute data             C:0022      C:0023        2h
__VECTORS_024       absolute data             C:0024      C:0025        2h
__VECTORS_026       absolute data             C:0026      C:0027        2h
__VECTORS_028       absolute data             C:0028      C:0029        2h
__VECTORS_02A       absolute data             C:002A      C:002B        2h
__VECTORS_02C       absolute data             C:002C      C:002D        2h
__VECTORS_02E       absolute data             C:002E      C:002F        2h
__VECTORS_030       absolute data             C:0030      C:0031        2h
__VECTORS_032       absolute data             C:0032      C:0033        2h
__VECTORS_034       absolute data             C:0034      C:0035        2h
__VECTORS_036       absolute data             C:0036      C:0037        2h
CODE                normal data               C:0038      C:006B       34h
main_TEXT           normal data               C:00E1      C:00E7        7h
startup             normal data               C:006C      C:00E0       75h
```

```
SEGMENTS WITHIN MODULES:
========================

Module: ..\..\src\boot\common\startupl.asm (File: startupL.obj) Version: 1:0
05/03/2006 09:11:37

    Name                                       Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_002                       C:0002      C:0003        2h
    Segment: FAR_BSS                             E:0100      E:0102        3h
    Segment: startup                             C:006C      C:00E0       75h
    Segment: workingreg                            R:E0        R:EF       10h


Module: .\MAIN.C (File: main.obj) Version: 1:0 05/03/2006 10:58:46

    Name                                       Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: main_TEXT                           C:00E1      C:00E7        7h


Module: COMMON\FLASH1.C (Library: chelpD.lib) Version: 1:0 05/03/2006 09:17:42

    Name                                       Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: ___flash_option1_segment            C:0000      C:0000        1h


Module: COMMON\FLASH2.C (Library: chelpD.lib) Version: 1:0 05/03/2006 09:17:42

    Name                                       Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: ___flash_option2_segment            C:0001      C:0001        1h


Module: common\frame.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:42

    Name                                       Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: CODE                                C:0039      C:005C       24h


Module: common\framer.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:42

    Name                                       Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: CODE                              C:005D      C:006B        fh


Module: common\vect04.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                      Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_004                     C:0004      C:0005        2h


Module: common\vect06.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                      Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_006                     C:0006      C:0007        2h


Module: common\vect08.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                      Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_008                     C:0008      C:0009        2h


Module: common\vect0a.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                      Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_00A                     C:000A      C:000B        2h


Module: common\vect0c.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                      Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_00C                     C:000C      C:000D        2h


Module: common\vect0e.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                      Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_00E                       C:000E      C:000F        2h


Module: common\vect10.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                        Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_010                       C:0010      C:0011        2h


Module: common\vect12.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                        Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_012                       C:0012      C:0013        2h


Module: common\vect14.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                        Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_014                       C:0014      C:0015        2h


Module: common\vect16.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                        Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_016                       C:0016      C:0017        2h


Module: common\vect18.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                        Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_018                       C:0018      C:0019        2h


Module: common\vect1a.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                        Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_01A                          C:001A      C:001B        2h


Module: common\vect1c.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                           Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_01C                          C:001C      C:001D        2h


Module: common\vect1e.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                           Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_01E                          C:001E      C:001F        2h


Module: common\vect20.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                           Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_020                          C:0020      C:0021        2h


Module: common\vect22.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                           Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_022                          C:0022      C:0023        2h


Module: common\vect24.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                           Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_024                          C:0024      C:0025        2h


Module: common\vect26.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                           Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_026                         C:0026      C:0027        2h


Module: common\vect28.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                          Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_028                         C:0028      C:0029        2h


Module: common\vect2a.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                          Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_02A                         C:002A      C:002B        2h


Module: common\vect2c.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                          Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_02C                         C:002C      C:002D        2h


Module: common\vect2e.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                          Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_02E                         C:002E      C:002F        2h


Module: common\vect30.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                          Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_030                         C:0030      C:0031        2h


Module: common\vect32.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                          Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_032                       C:0032      C:0033        2h


Module: common\vect34.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                       Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_034                       C:0034      C:0035        2h


Module: common\vect36.asm (Library: chelpD.lib) Version: 1:0 05/03/2006
09:17:43

    Name                                       Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: __VECTORS_036                       C:0036      C:0037        2h


Module: zsldevinitdummy.asm (File: zsldevinitdummy.obj) Version: 1:0 05/03/
2006 09:26:51

    Name                                       Base        Top      Size
    --------------------------------------- ----------- ----------- ---------
    Segment: CODE                                C:0038      C:0038        1h

EXTERNAL DEFINITIONS:
=====================

Symbol                              Address   Module          Segment
-------------------------------- ----------- --------------- ------------------
---------------
__close_periphdevice              C:0038 zsldevinitdummy CODE
__framereset                      C:005D framer        CODE
__frameset                        C:0045 frame         CODE
__frameset0                       C:0043 frame         CODE
__frameset00                      C:0041 frame         CODE
__iframeset00                     C:0039 frame         CODE
__intrp                           E:0102 startupl      FAR_BSS
__open_periphdevice               C:0038 zsldevinitdummy CODE
__user_frequency                      01194000  (User Defined)
__VECTOR_002                      C:0000 startupl      __VECTORS_002
__VECTOR_004                      C:0004 vect04        __VECTORS_004
__VECTOR_006                      C:0006 vect06        __VECTORS_006
__VECTOR_008                      C:0008 vect08        __VECTORS_008
__VECTOR_00A                      C:000A vect0a        __VECTORS_00A
__VECTOR_00C                      C:000C vect0c        __VECTORS_00C
__VECTOR_00E                      C:000E vect0e        __VECTORS_00E
```

```
__VECTOR_010                    C:0010 vect10        __VECTORS_010
__VECTOR_012                    C:0012 vect12        __VECTORS_012
__VECTOR_014                    C:0014 vect14        __VECTORS_014
__VECTOR_016                    C:0016 vect16        __VECTORS_016
__VECTOR_018                    C:0018 vect18        __VECTORS_018
__VECTOR_01A                    C:001A vect1a        __VECTORS_01A
__VECTOR_01C                    C:001C vect1c        __VECTORS_01C
__VECTOR_01E                    C:001E vect1e        __VECTORS_01E
__VECTOR_020                    C:0020 vect20        __VECTORS_020
__VECTOR_022                    C:0022 vect22        __VECTORS_022
__VECTOR_024                    C:0024 vect24        __VECTORS_024
__VECTOR_026                    C:0026 vect26        __VECTORS_026
__VECTOR_028                    C:0028 vect28        __VECTORS_028
__VECTOR_02A                    C:002A vect2a        __VECTORS_02A
__VECTOR_02C                    C:002C vect2c        __VECTORS_02C
__VECTOR_02E                    C:002E vect2e        __VECTORS_02E
__VECTOR_030                    C:0030 vect30        __VECTORS_030
__VECTOR_032                    C:0032 vect32        __VECTORS_032
__VECTOR_034                    C:0034 vect34        __VECTORS_034
__VECTOR_036                    C:0036 vect36        __VECTORS_036
__VECTOR_reset                  C:0000 startupl      __VECTORS_002
_c_startup                      C:006C startupl      startup
_close_periphdevice              C:0038 zsldevinitdummy CODE
_errno                          E:0100 startupl      FAR_BSS
_exit                           C:00DF startupl      startup
_far_heapbot                         00000102 (User Defined)
_far_heaptop                         00000EFF (User Defined)
_far_stack                           00000EFF (User Defined)
_flash_option1               C:0000 FLASH1   flash_option1_segment
_flash_option2                        C:0001 FLASH2    flash_option2_segment
_len_farbss                          00000003 (User Defined)
_len_fardata                         00000000 (User Defined)
_len_nearbss                         00000000 (User Defined)
_len_neardata                        00000000 (User Defined)
_len_pramseg                         00000000 (User Defined)
_low_far_romdata                     00000000 (User Defined)
_low_farbss                          00000100 (User Defined)
_low_fardata                         00000000 (User Defined)
_low_near_romdata                    00000000 (User Defined)
_low_nearbss                         00000000 (User Defined)
_low_neardata                        00000000 (User Defined)
_low_pram_romdata                    00000000 (User Defined)
_low_pramseg                         00000000 (User Defined)
_main                           C:00E1 MAIN          main_TEXT
_near_heapbot                        000000EF (User Defined)
_near_heaptop                        000000FF (User Defined)
_near_stack                          000000FF (User Defined)
_open_periphdevice               C:0038 zsldevinitdummy CODE
```

```
_READ_NVDS                          00001000 (User Defined)
_READ_NVDS_GET_STATUS               00001000 (User Defined)
_WRITE_NVDS                         000010B3 (User Defined)
_WRITE_NVDS_GET_STATUS              000010B3 (User Defined)

68 external symbol(s).


START ADDRESS:
==============
(C:006C) set in module ..\..\src\boot\common\startupl.asm.


END OF LINK MAP:
================
0 Errors
0 Warnings
```

WARNING AND ERROR MESSAGES

NOTE: If you see an internal error message, please report it to Technical Support at `http://support.zilog.com`. Zilog staff will use the information to diagnose or log the problem.

This section covers warning and error messages for the linker/locator.

700 Absolute segment "<*name*>" is not on a MAU boundary.

The named segment is not aligned on a minimum addressable unit (MAU) of memory boundary. Padding or a correctly aligned absolute location must be supplied.

701 <*address range error message*>.

A group, section, or address space is larger than is specified maximum length.

704 Locate of a type is invalid. Type "<*typename*>".

It is not permitted to specify an absolute location for a type.

708 "<*name*>" is not a valid group, space, or segment.

An invalid record type was encountered. Most likely, the object or library file is corrupted.

710 Merging two located spaces "<*space1*> <*space2*>" is not allowed.

When merging two or more address spaces, at most one of them can be located absolutely.

711 Merging two located groups "<*group1*> <*group2*>".

When merging two or more groups, at most one can be located absolutely.

712 Space "<*space*>" is not located on a segment base.

The address space is not aligned with a segment boundary.

713 Space "<*space*>" is not defined.

The named address space is not defined.

714 Multiple locates for "<*name*>" have been specified.

Multiple absolute locations have been specified for the named group, section, or address space.

715 Module "<*name*>" contains errors or warnings.

Compilation of the named module produced a nonzero exit code.

717 Invalid expression.

An expression specifying a symbol value could not be parsed.

718 "<*segment*>" is not in the specified range.

The named segment is not within the allowed address range.

719 "<*segment*>" is an absolute or located segment. Relocation was ignored.

An attempt was made to relocate an absolutely located segment.

720 "<*name*> calls <*name*>" graph node which is not defined.

This message provides detailed information on how an undefined function name is called.

721 Help file "<*name*>" not found.

The named help file could not be found. You may need to reinstall the development system software.

723 "<*name*>" has not been ordered.

The named group, section, or address space does not have an order assigned to it.

724 Symbol <*name*> (<*file*>) is not defined.

The named symbol is referenced in the given file, but not defined. Only the name of the file containing the first reference is listed within the parentheses; it can also be referenced in other files.

726 Expression structure could not be stored. Out of memory.

Memory to store an expression structure could not be allocated.

727 Group structure could not be stored. Out of memory.

Memory to store a group structure could not be allocated.

730 Range structure could not be stored. Out of memory.

Memory to store a range structure could not be allocated.

731 File "<*file*>" is not found.

The named input file or a library file name or the structure containing a library file name was not found.

732 Error encountered opening file "<*file*>".

The named file could not be opened.

736 Recursion is present in call graph.

A loop has been found in the call graph, indicating recursion.

738 Segment "<*segment*>" is not defined.

The referenced segment name has not been defined.

739 Invalid space "<*space*>" is defined.

The named address space is not valid. It must be either a group or an address space.

740 Space "<*space*>" is not defined.

The referenced space name is not defined.

742 <*error message*>

A general-purpose error message.

743 Vector "<*vector*>" not defined.

The named interrupt vector could not be found in the symbol table.

745 Configuration bits mismatch in file <*file*>.

The mode bit in the current input file differs from previous input files.

746 Symbol <*name*> not attached to a valid segment.

The named symbol is not assigned to a valid segment.

747 <*message*>

General-purpose error message for reporting out-of-range errors. An address does not fit within the valid range.

748 <*message*>

General-purpose error message for OMF695 to OMF251 conversion. The requested translation could not proceed.

749 Could not allocate global register.

A global register was requested, but no register of the desired size remains available.

751 Error opening output file "<*outfile*>".

The named load module file could not be opened.

753 Segment '<*segment*>' being copied is splittable

A segment, which is to be copied, is being marked as splittable, but startup code might assume that it is contiguous.

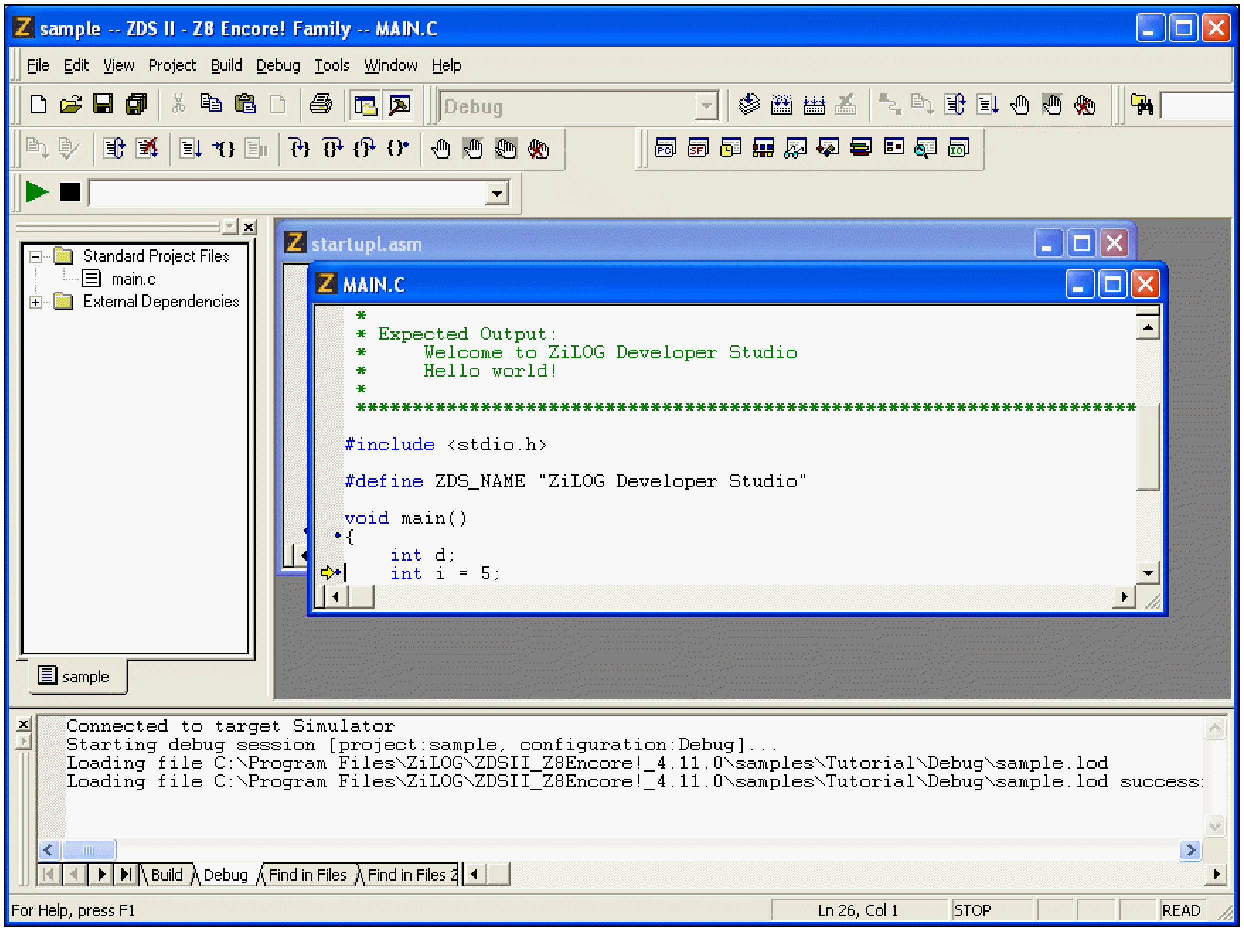
Using the Debugger

The source-level debugger is a program that allows you to find problems in your code at the C or assembly level. You can also write batch files to automate debugger tasks (see "Using the Command Processor" on page 408). The following topics are covered in this section:

- "Status Bar" on page 310
- "Code Line Indicators" on page 311
- "Debug Windows" on page 311
- "Using Breakpoints" on page 326

From the Debug menu, select **Reset** (or any other execution command) to enter Debug mode.

You are now in Debug mode as shown in the Output window (Debug tab). The Debug toolbar and Debug Windows toolbar are displayed as shown in the following figure.



```
 *
 * Expected Output:
 *     Welcome to ZiLOG Developer Studio
 *     Hello world!
 *
 ************************************************************************

#include <stdio.h>

#define ZDS_NAME "ZiLOG Developer Studio"

void main()
{
    int d;
    int i = 5;
```

```
Connected to target Simulator
Starting debug session [project:sample, configuration:Debug]...
Loading file C:\Program Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\samples\Tutorial\Debug\sample.lod
Loading file C:\Program Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\samples\Tutorial\Debug\sample.lod success:
```

Figure 97. Debug and Debug Window Toolbars

NOTE: Project code cannot be rebuilt while in Debug mode. The Development Environment will prompt you if you request a build during a debug session. If you edit code during a debug session and then attempt to execute the code, the Development Environment will stop the current debug session, rebuild the project, and then attempt to start a new debug session if you elect to do so when prompted.

STATUS BAR

The status bar displays the current status of your program's execution. The status can be STOP, STEP, or RUN. The STOP mode indicates that your program is not executing. The STEP mode indicates that a Step operation (using the Step Into, Step Over, or Step Out command) is in progress. The RUN mode indicates that the program is executing after a Go command has been issued. In RUN mode, the following debug operations are available: Reset, Stop Debugging, and Break.

NOTE: When the program is in RUN mode, disabling a breakpoint temporarily stops and resumes program execution. If a breakpoint is reached before it is disabled, program execution does not resume. When the program is in RUN mode, enabling the breakpoint also temporarily stops and resumes program execution but, if the program reaches a breakpoint after you enable it, the program stops or breaks. You must press the Go button again to continue the program execution. See "Using Breakpoints" on page 326 for more information about breakpoints.

View/read memory, Step Into, Step Over, Step Out, and Go are disabled in RUN mode.

NOTE: The status bar is either a box displayed in the upper right corner under the title bar or a horizontal bar under the buttons, depending on your screen resolution.

CODE LINE INDICATORS

The Edit window displays your source code with line numbers and code line indicators. The debugger indicates the status of each line visually with the following code line indicators:

- A red octagon indicates an active breakpoint at the code line; a white octagon indicates a disabled breakpoint.
- Blue dots are displayed to the left of all valid code lines; these are lines where breakpoints can be set, the program can be run to, and so on.

NOTE: Some source lines do not have blue dots because the code has been optimized out of the executable (and the corresponding debug information).

- A program counter code line indicator (yellow arrow) indicates a code line at which the program counter is located.
- A program counter code line indicator on a breakpoint (yellow arrow on a red octagon) indicates the program counter has stopped on a breakpoint.

If the program counter steps into another file in your program, the Edit window switches to the new file automatically.

DEBUG WINDOWS

The Debug Windows toolbar allows you to display the following Debug windows:

- "Registers Window" on page 312
- "Special Function Registers Window" on page 313
- "Clock Window" on page 313
- "Memory Window" on page 314
- "Watch Window" on page 320

- "Locals Window" on page 322
- "Call Stack Window" on page 323
- "Symbols Window" on page 324
- "Disassembly Window" on page 325
- "Simulated UART Output Window" on page 326

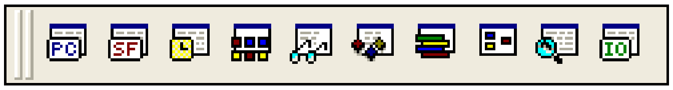
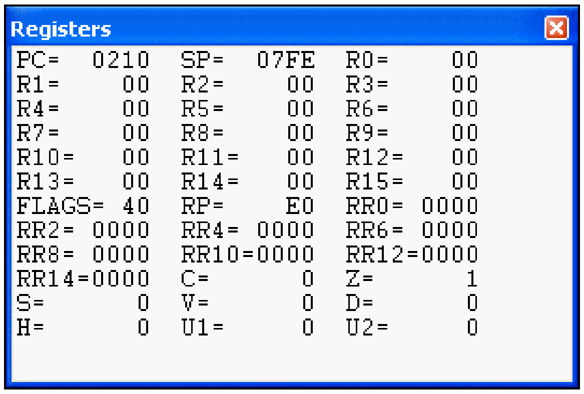


Figure 98. Debug Windows Toolbar

Registers Window

NOTE: You cannot modify the registers or memory while in run mode.

Click the Registers Window button to show or hide the Registers window. The Registers window displays all the registers in the standard Z8 Encore! architecture.



```
PC=   0210  SP=   07FE  R0=     00
R1=     00  R2=     00  R3=     00
R4=     00  R5=     00  R6=     00
R7=     00  R8=     00  R9=     00
R10=    00  R11=    00  R12=    00
R13=    00  R14=    00  R15=    00
FLAGS=  40  RP=     E0  RR0=  0000
RR2=  0000  RR4=  0000  RR6=  0000
RR8=  0000  RR10=0000   RR12=0000
RR14=0000   C=       0  Z=       1
S=       0  V=       0  D=       0
H=       0  U1=      0  U2=      0
```

Figure 99. Registers Window

To change register values, do the following:

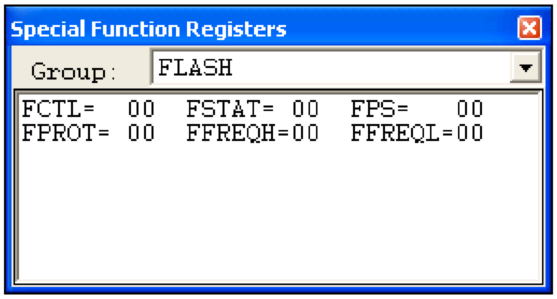
1. In the Registers window, highlight the value you want to change.
2. Type the new value and press the Enter key.

   The changed value is displayed in red.

Special Function Registers Window

Click the Special Function Registers Window button to open one of ten Special Function Registers windows. The Special Function Registers window displays all the special function registers in the standard Z8 Encore! architecture. Addresses `F00` through `FFF` are reserved for special function registers (SFRs).

Use the Group drop-down list to view a particular group of SFRs.



```
FCTL=  00  FSTAT= 00  FPS=   00
FPROT= 00  FFREQH=00  FFREQL=00
```

Figure 100. Special Function Registers Window

NOTE: There are several SFRs that when read are cleared or clear an associated register. To prevent the debugger from changing the behavior of the code, a special group of SFRs was created that groups these state changing registers. The group is called SPECIAL_CASE. If this group is selected, the behavior of the code changes, and the program must be reset.

To use the FLASH_OPTIONBITS group, you need to reset the device for the changes to take effect. Use the FLASH_OPTIONBITS group to view the values of all of the Flash option bit registers except the following:

– Temperature sensor trim registers
– Precision oscillator trim registers
– Flash capacity configuration registers

To change special function register values, do the following:

1. In the Special Function Registers window, highlight the value you want to change.
2. Type the new value and press the Enter key.

   The changed value is displayed in red.

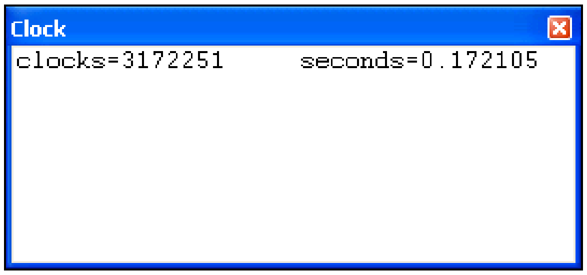
Clock Window

Click the Clock Window button to show or hide the Clock window.

The Clock window displays the number of states executed since the last reset. You can reset the contents of the Clock window at any time by selecting the number of cycles

(`3172251` in the following figure), type `0`, and press the Enter key. Updated values are displayed in red.

NOTE: The Clock window will only display clock data when the Simulator is the active debug tool.

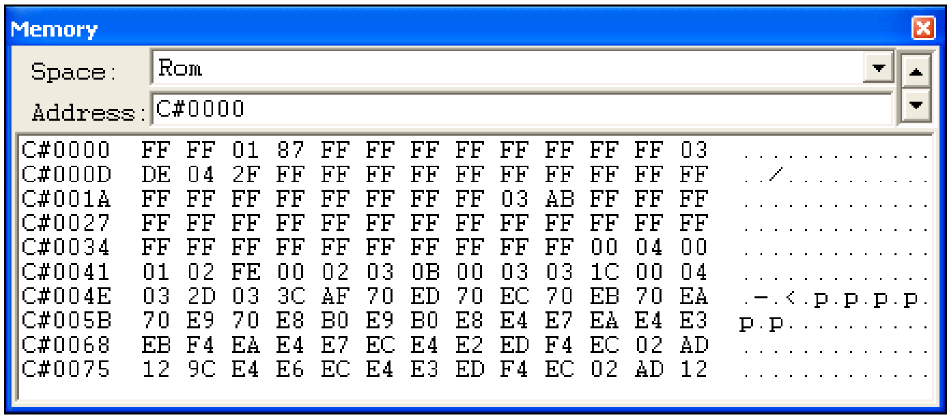


```
clocks=3172251      seconds=0.172105
```

Figure 101. Clock Window

Memory Window

Click the Memory Window button to open one of ten Memory windows.



```
Space:   Rom
Address: C#0000

C#0000  FF FF 01 87 FF FF FF FF FF FF FF FF 03  .............
C#000D  DE 04 2F FF FF FF FF FF FF FF FF FF FF  ../..........
C#001A  FF FF FF FF FF FF FF FF 03 AB FF FF FF  .............
C#0027  FF FF FF FF FF FF FF FF FF FF FF FF FF  .............
C#0034  FF FF FF FF FF FF FF FF FF FF 00 04 00  .............
C#0041  01 02 FE 00 02 03 0B 00 03 03 1C 00 04  .............
C#004E  03 2D 03 3C AF 70 ED 70 EC 70 EB 70 EA  .-.<.p.p.p.p.
C#005B  70 E9 70 E8 B0 E9 B0 E8 E4 E7 EA E4 E3  p.p..........
C#0068  EB F4 EA E4 E7 EC E4 E2 ED F4 EC 02 AD  .............
C#0075  12 9C E4 E6 EC E4 E3 ED F4 EC 02 AD 12  .............
```

Figure 102. Memory Window

Each Memory window displays data located in the target's memory. The ASCII text for memory values is shown in the last column. The address is displayed in the far left column with a C# to denote the code address space, with an R# to denote the RData address space, or with an N# to denote the NVDS address space.

NOTE: For RData, the Memory window shows the whole internal data memory.

The Z8 Encore! XP F082A Series and non-24K F1680 devices contain a Non-Volatile Data Storage (NVDS) element with a size of up to 128 bytes. This memory features an endurance of 100,000 write cycles. For more information about NVDS, see the "Non-Volatile Data Storage" chapter of the *Z8 Encore! XP F082A Series*

Product Specification (PS0228).

The Z8 Encore! XP F1680 Series devices feature an area of Program RAM that can be used for storing some code in RAM. This area can be used to help keep device operating power low by, for example, storing interrupt service routines here that would activate the code in Flash memory when some external event has occurred. PRAM, when available, is an optional feature. If you want to use this memory as Program RAM, set the desired address range in the PRAM field in the Address Spaces page of the Project Settings dialog box. PRAM begins at data address `E000` and can have a maximum size of 512 or 1024 bytes, depending on your device. If you deselect the PRAM check box, this memory is not available to the compiler. Also, the compiler does not know if this memory is reconfigured as additional Register RAM memory without the user expanding the Linker Address EData range as described below.

The PRAM can be used as additional on-chip Register RAM by setting the PRAM_M option bit low in the device option bits. When the PRAM_M option bit is set the low, the PRAM at `0xE000` is no longer available and the memory is used as additional Register RAM. If you want to map PRAM to Register RAM, you need to increase the range for EData (in the Address Spaces page) to include the appropriate amount of PRAM and set the option bit low. For example:

```
FLASH_OPTION1 = 0xFD;
```

Then, if your device supports `0x800` bytes of Register RAM and `0x400` bytes of PRAM, the EData range can be extended to `0xBFF` by mapping the PRAM to Register RAM. In this example, the new address range for Rdata is `0x0-0xFF`, and the new address range for Edata is `0x100-0xBFF`. When the address range is extended, the complier takes full advantage of the extra memory.

The following sections describe how to use the Memory window:

- “Changing Values” on page 316
- “Viewing Addresses” on page 316
- “Filling Memory” on page 317
- “Saving to a File” on page 318
- “Loading from a File” on page 319
- “Performing a Cyclic Redundancy Check” on page 319

NOTE: The Page Up and Page Down keys (on your keyboard) are not functional in the Memory window. Instead, use the up and down arrow buttons to the right of the Space and Address fields.

Changing Values

To change the values in the Memory window, do the following:

1. In the window, highlight the value you want to change.

   The values begin in the second column after the Address column.

2. Type the new value and press the Enter key.

   The changed value is displayed in red.

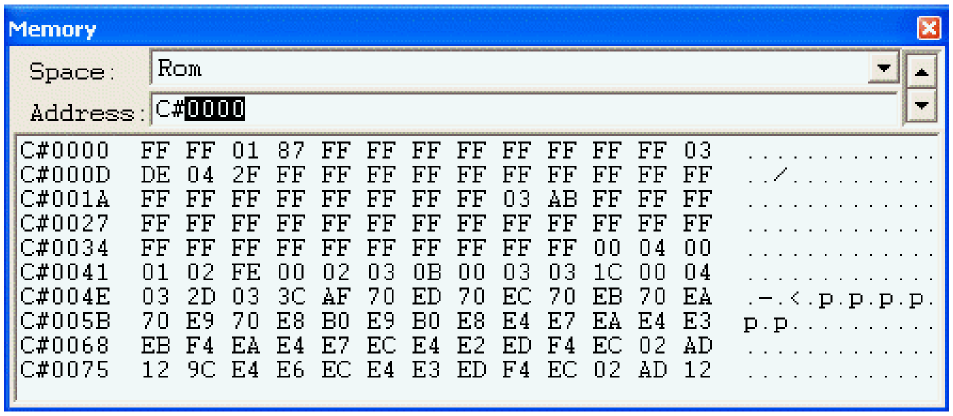
NOTE: The ASCII text for the value is shown in the last column.

Viewing Addresses

To quickly view or search for an address in the Memory window, do the following:

1. In the Memory window, highlight the address in the Address field, as shown in the following figure.

NOTE: To view the values for other memory spaces, replace the C with a different valid memory prefix. You can also change the current memory space by selecting the space name in the Space drop-down list box.



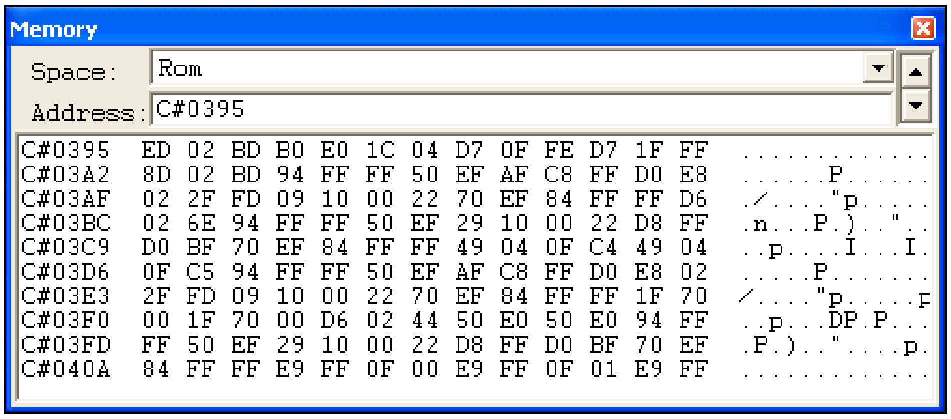
```
Space:   Rom
Address: C#0000
C#0000  FF FF 01 87 FF FF FF FF FF FF FF FF 03   .............
C#000D  DE 04 2F FF FF FF FF FF FF FF FF FF FF   ../..........
C#001A  FF FF FF FF FF FF FF FF 03 AB FF FF FF   .............
C#0027  FF FF FF FF FF FF FF FF FF FF FF FF FF   .............
C#0034  FF FF FF FF FF FF FF FF FF FF 00 04 00   .............
C#0041  01 02 FE 00 02 03 0B 00 03 03 1C 00 04   .............
C#004E  03 2D 03 3C AF 70 ED 70 EC 70 EB 70 EA   .-.<.p.p.p.p.
C#005B  70 E9 70 E8 B0 E9 B0 E8 E4 E7 EA E4 E3   p.p..........
C#0068  EB F4 EA E4 E7 EC E4 E2 ED F4 EC 02 AD   .............
C#0075  12 9C E4 E6 EC E4 E3 ED F4 EC 02 AD 12   .............
```

Figure 103. Memory Window—Starting Address

2. Type the address you want to find and press the Enter key.

   For example, find `0395`.

   The system moves the selected address to the top of the Memory window, as shown in the following figure.



Space: Rom
Address: C#0395

```
C#0395  ED 02 BD B0 E0 1C 04 D7 0F FE D7 1F FF  .............
C#03A2  8D 02 BD 94 FF FF 50 EF AF C8 FF D0 E8  ......P......
C#03AF  02 2F FD 09 10 00 22 70 EF 84 FF FF D6  ./....."p....
C#03BC  02 6E 94 FF FF 50 EF 29 10 00 22 D8 FF  .n...P.)..".. 
C#03C9  D0 BF 70 EF 84 FF FF 49 04 0F C4 49 04  ..p....I...I.
C#03D6  0F C5 94 FF FF 50 EF AF C8 FF D0 E8 02  .....P.......
C#03E3  2F FD 09 10 00 22 70 EF 84 FF FF 1F 70  /...."p.....p
C#03F0  00 1F 70 00 D6 02 44 50 E0 50 E0 94 FF  ..p...DP.P...
C#03FD  FF 50 EF 29 10 00 22 D8 FF D0 BF 70 EF  .P.)..."....p.
C#040A  84 FF FF E9 FF 0F 00 E9 FF 0F 01 E9 FF  .............
```

Figure 104. Memory Window—Requested Address

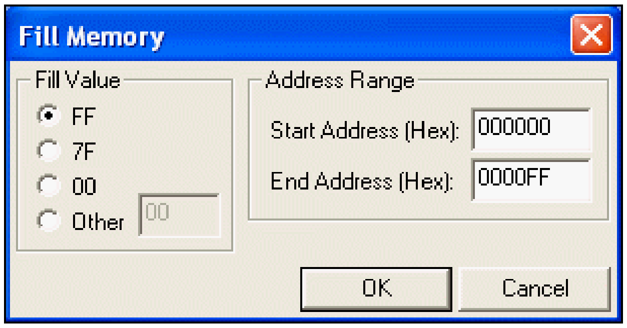
Filling Memory

Use this procedure to write a common value in all the memory spaces in the specified address range, for example, to clear memory for the specified address range.

To fill a specified address range of memory, do the following:

1. Select the memory space in the Space drop-down list.
2. Right-click in the Memory window list box to display the context menu.
3. Select **Fill Memory**.

   The Fill Memory dialog box is displayed.



Start Address (Hex): 000000
End Address (Hex): 0000FF

Figure 105. Fill Memory Dialog Box

4. In the Fill Value area, select the characters to fill memory with or select the Other button.

   If you select the Other button, type the fill characters in the Other field.

5. Type the start address in hexadecimal format in the Start Address (Hex) field and type the end address in hexadecimal format in the End Address (Hex) field.

This address range is used to fill memory with the specified value.

6. Click **OK** to fill the selected memory.

Saving to a File

Use this procedure to save memory specified by an address range to a binary, hexadecimal, or text file.

Perform the following steps to save memory to a file:

1. Select the memory space in the Space drop-down list.
2. Right-click in the Memory window list box to display the context menu.
3. Select **Save to File**.

   The Save to File dialog box is displayed.

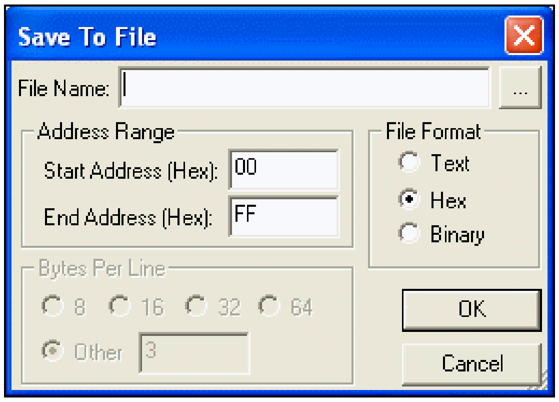


Figure 106. Save to File Dialog Box

4. In the File Name field, enter the path and name of the file you want to

   save the memory to or click the Browse button (...) to search for a file or directory.
5. Type the start address in hexadecimal format in the Start Address (Hex) field and type the end address in hexadecimal format in the End Address (Hex) field.

   This specifies the address range of memory to save to the specified file.
6. Select whether to save the file as text, hex (hexadecimal), or binary.
7. If the file format is text, select the number of bytes per line or enter a number in the Other field.
8. Click **OK** to save the memory to the specified file.

Loading from a File

Use this procedure to load or to initialize memory from an existing binary, hexadecimal, or text file.

Perform the following steps to load a file into the code's memory:

1. Select the memory space in the Space drop-down list.
2. Right-click in the Memory window list box to display the context menu.
3. Select **Load from File**.

   The Load from File dialog box is displayed.

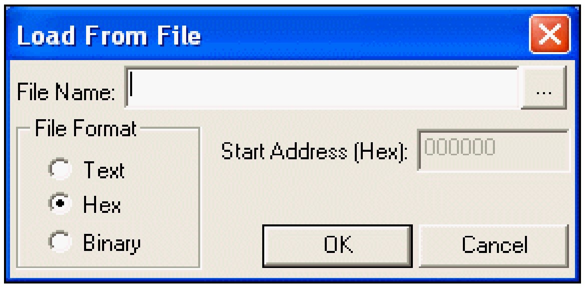


Figure 107. Load from File Dialog Box

4. In the File Name field, enter the path and name of the file to load or

   click the Browse button (...) to search for the file.
5. In the Start Address (Hex) field, enter the start address.
6. Select whether to load the file as text, hex (hexadecimal), or binary.
7. Click **OK** to load the file's contents into the selected memory.

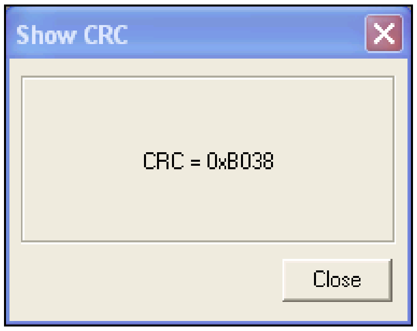
Performing a Cyclic Redundancy Check

NOTE: The Show CRC command is not available if the active debug tool is the Simulator.

Use the following procedure to perform a cyclic redundancy check (CRC) for the whole internal Flash memory:

1. Select the Rom space in the Space drop-down list.
2. Right-click in the Memory window list box to display the context menu.
3. Select **Show CRC**.

   The Show CRC dialog box is displayed with the result.

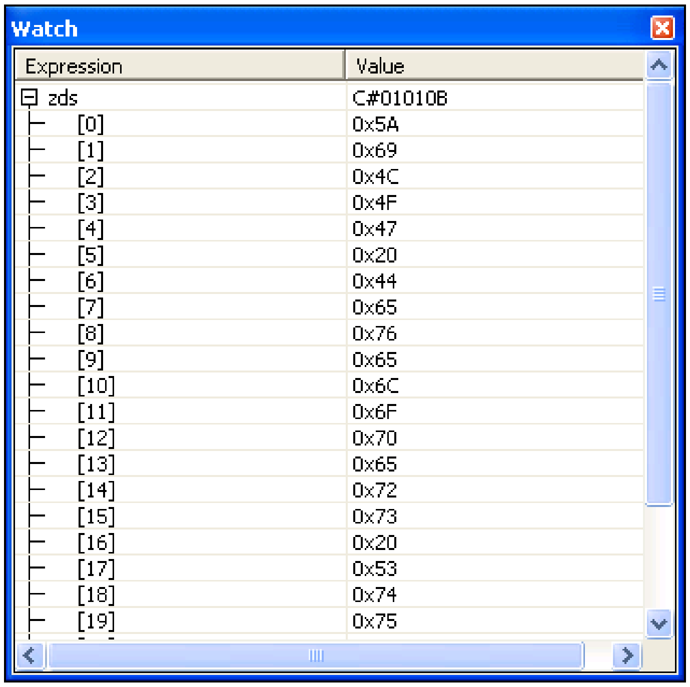


CRC = 0xB038

Figure 108. Show CRC Dialog Box

Watch Window

Click the Watch Window button to show or hide the Watch window.



Expression	Value
zds	C#01010B
[0]	0x5A
[1]	0x69
[2]	0x4C
[3]	0x4F
[4]	0x47
[5]	0x20
[6]	0x44
[7]	0x65
[8]	0x76
[9]	0x65
[10]	0x6C
[11]	0x6F
[12]	0x70
[13]	0x65
[14]	0x72
[15]	0x73
[16]	0x20
[17]	0x53
[18]	0x74
[19]	0x75

Figure 109. Watch Window

The Watch window displays all the variables and their values defined using the WATCH command. If the variable is not in scope, the variable is not displayed. The values in the Watch window change as the program executes. Updated values appear in red.

The `0x` prefix indicates that the values are displayed in hexadecimal format. If you want the values to be displayed in decimal format, select **Hexadecimal Display** from the context menu.

NOTE: If the Watch window displays unexpected values, deselect the Use Register Variables check box on the Advanced page of the Project Settings dialog box. See "Use Register Variables" on page 69.

The following sections describe how to use the Watch window:

- "Adding New Variables" on page 321
- "Changing Values" on page 321
- "Removing an Expression" on page 321
- "Viewing a Hexadecimal Value" on page 322
- "Viewing a Decimal Value" on page 322
- "Viewing an ASCII Value" on page 322
- "Viewing a NULL-Terminated ASCII (ASCIZ) String" on page 322

Adding New Variables

To add new variables in the Watch window, select the variable in the source file, drag, and drop it into the window. Another way to add new variables is to use the following procedure:

1. Click once on `<new watch>` in the Expression column.

   This activates the column so that you can type the expression accurately.

2. Type the expression and press the Enter key.

   The value is displayed in the Value column.

Changing Values

To change values in the Watch window, do the following:

1. In the window, highlight the value you want to change.
2. Type the new value and press the Enter key.

   The changed value is displayed in red.

Removing an Expression

To remove an expression from the Watch window, do the following:

1. In the Expression column, click once on the expression you want to remove.
2. Press the Delete key to clear both columns.

Viewing a Hexadecimal Value

To view the hexadecimal values of an expression, type `hex` *expression* in the Expression column and press the Enter key. For example, type `hex tens`. The hexadecimal value displays in the Value column.

To view the hexadecimal values for all expressions, select **Hexadecimal Display** from the context menu.

NOTE: You can also type just the expression (for example, type `tens`) to view the hexadecimal value of any expression. Hexadecimal format is the default.

Viewing a Decimal Value

To view the decimal values of an expression, type `dec` *expression* in the Expression column and press the Enter key. For example, type `dec huns`. The decimal value displays in the Value column.

To view the decimal values for all expressions, select **Hexadecimal Display** from the context menu.

Viewing an ASCII Value

To view the ASCII values of an expression, type `ascii` *expression* in the Expression column and press the Enter key. For example, type `ascii ones`. The ASCII value displays in the Value column.

Viewing a NULL-Terminated ASCII (ASCIZ) String

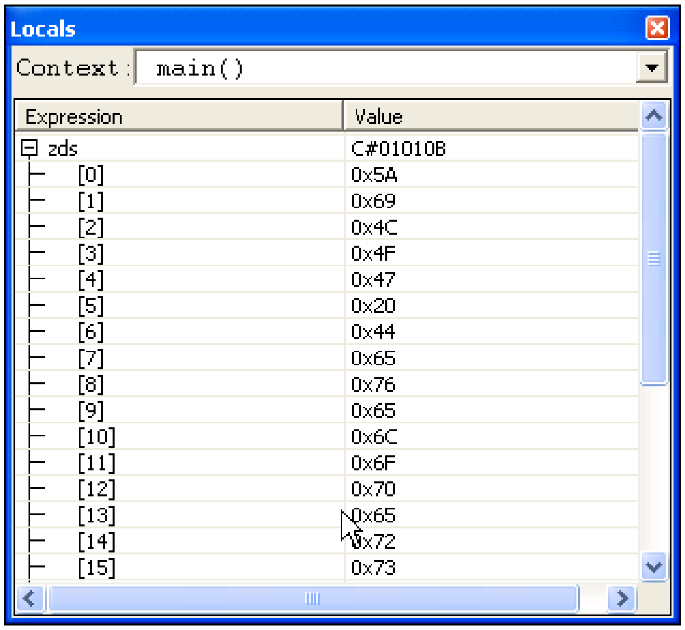
To view the NULL-terminated ASCII (ASCIZ) values of an expression, type `asciz` *expression* in the Expression column and press the Enter key. For example, type `asciz ones`. The ASCIZ value displays in the Value column.

Locals Window

Click the Locals Window button to show or hide the Locals window. The Locals window displays all local variables that are currently in scope. Updated values appear in red.

The `0x` prefix indicates that the values are displayed in hexadecimal format. If you want the values to be displayed in decimal format, select **Hexadecimal Display** from the context menu.

NOTE: If the Locals window displays unexpected values, deselect the Use Register Variables check box on the Advanced page of the Project Settings dialog box. See "Use Register Variables" on page 69.



Locals

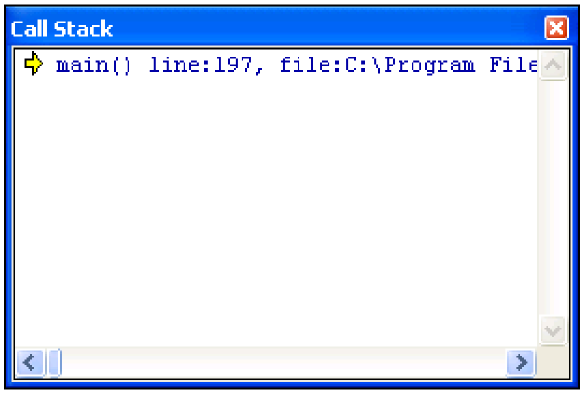
Context: main()

Expression	Value
zds	C#01010B
[0]	0x5A
[1]	0x69
[2]	0x4C
[3]	0x4F
[4]	0x47
[5]	0x20
[6]	0x44
[7]	0x65
[8]	0x76
[9]	0x65
[10]	0x6C
[11]	0x6F
[12]	0x70
[13]	0x65
[14]	0x72
[15]	0x73

Figure 110. Locals Window

Call Stack Window

Click the Call Stack Window button to show or hide the Call Stack window. If you want to copy text from the Call Stack Window, select the text and then select **Copy** from the context menu.



Call Stack

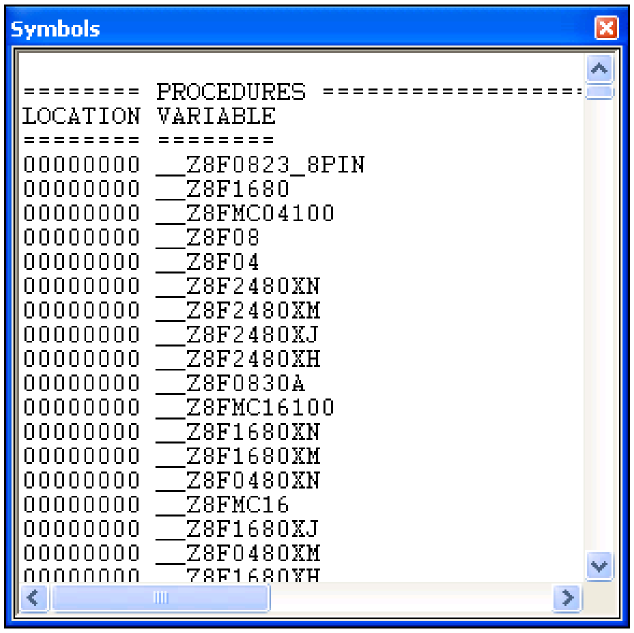
```
main() line:197, file:C:\Program File
```

Figure 111. Call Stack Window

The Call Stack window allows you to view function frames that have been pushed onto the stack. Information in the Call Stack window is updated every time a debug operation is processed.

Symbols Window

Click the Symbols Window button to show or hide the Symbols window.



```
======== PROCEDURES =================
LOCATION VARIABLE
======== ========
00000000 __Z8F0823_8PIN
00000000 __Z8F1680
00000000 __Z8FMC04100
00000000 __Z8F08
00000000 __Z8F04
00000000 __Z8F2480XN
00000000 __Z8F2480XM
00000000 __Z8F2480XJ
00000000 __Z8F2480XH
00000000 __Z8F0830A
00000000 __Z8FMC16100
00000000 __Z8F1680XN
00000000 __Z8F1680XM
00000000 __Z8F0480XN
00000000 __Z8FMC16
00000000 __Z8F1680XJ
00000000 __Z8F0480XM
00000000 __Z8F1680XH
```

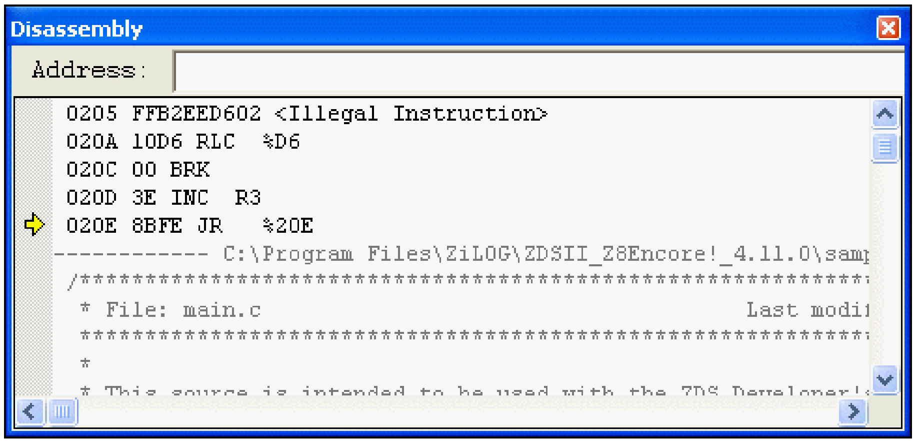
Figure 112. Symbols Window

NOTE: Close the Symbols window before running a command script.

The Symbols window displays the address for each symbol in the program.

Disassembly Window

Click the Disassembly Window button to show or hide the Disassembly window.



```
0205 FFB2EED602 <Illegal Instruction>
020A 10D6 RLC   %D6
020C 00 BRK
020D 3E INC   R3
020E 8BFE JR   %20E
------------ C:\Program Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\samp
/***************************************************************
 * File: main.c                                       Last modi
 ***************************************************************
 *
 * This source is intended to be used with the ZDS Developer's
```

Figure 113. Disassembly Window

The Disassembly window displays the assembly code associated with the code shown in the Code window. For each line in this window, the address location, the machine code, the assembly instruction, and its operands are displayed.

After performing a reset, the Disassembly window is sometimes displayed for one of the following reasons:

- The project was not built with debug information enabled. You can enable the debug information with the Generate Debug Information check box on the General page of the Project Settings dialog box.
- An Assembly Only project includes `VECTOR RESET = xxx`, which has no associated debug information.

When you right-click in the Disassembly window, the context menu allows you to do the following:

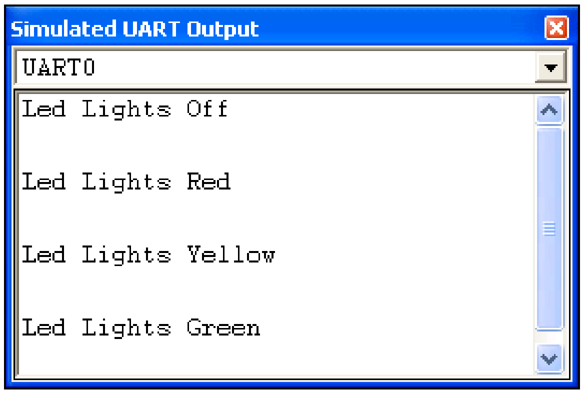
- Copy text
- Go to the source code
- Insert, edit, enable, disable, or remove breakpoints

  For more information on breakpoints, see “Using Breakpoints” on page 326.
- Reset the debugger
- Stop debugging
- Start or continue running the program (Go)
- Run to the cursor

- Pause the debugging (Break)
- Step into, over, or out of program instructions
- Set the next instruction at the current line
- Enable and disable source annotation and source line numbers

Simulated UART Output Window

Click the Simulated UART Output Window button to show or hide the Simulated UART Output window.



```
Led Lights Off

Led Lights Red

Led Lights Yellow

Led Lights Green
```

Figure 114. Simulated UART Output Window

The Simulated UART Output window displays the simulated output of the selected UART. Use the drop-down list to view the output for a particular UART.

Right-clicking in the Simulated UART Output window displays a context menu that provides access to the following features:

- Clear the buffered output for the selected UART.
- Copy selected text to the Windows clipboard.

NOTE: The Simulated UART Output window is available only when the Simulator is the active debug tool.

USING BREAKPOINTS

This section to describes how to work with breakpoints while you are debugging. The following topics are covered:

- "Inserting Breakpoints" on page 327
- "Viewing Breakpoints" on page 328
- "Moving to a Breakpoint" on page 328

- “Enabling Breakpoints” on page 328
- “Disabling Breakpoints” on page 329
- “Removing Breakpoints” on page 329

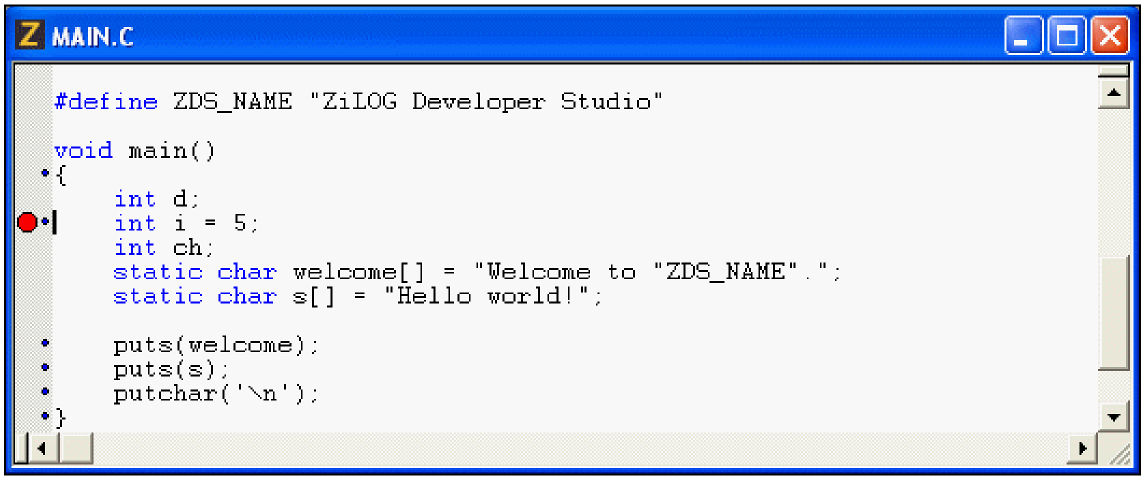
Inserting Breakpoints

There are three ways to place a breakpoint in your file:

- Click on the line of code where you want to insert an active breakpoint. You can set an active breakpoint in any line with a blue dot displayed to the left of the line (the blue dots are displayed after clicking the Reset button to enter Debug mode).

  Click the Insert/Remove Breakpoint button ( ) on the Build or Debug toolbar.
- Click on the line where you want to add an active breakpoint, right-click to display the context menu, and select **Insert Breakpoint**. You can set an active breakpoint in any line with a blue dot displayed to the left of the line (the blue dots are displayed after clicking the Reset button to enter Debug mode).
- Double-click in the gutter to the left of the line where you want to add an active breakpoint. You can set an active breakpoint in any line with a blue dot displayed to the left of the line (the blue dots are displayed after clicking the Reset button to enter Debug mode). Inactive breakpoints can be placed on any line but cannot be made active.

A red octagon shows that you have set a breakpoint at that location.



```
#define ZDS_NAME "ZiLOG Developer Studio"

void main()
{
    int d;
    int i = 5;
    int ch;
    static char welcome[] = "Welcome to "ZDS_NAME".";
    static char s[] = "Hello world!";

    puts(welcome);
    puts(s);
    putchar('\n');
}
```

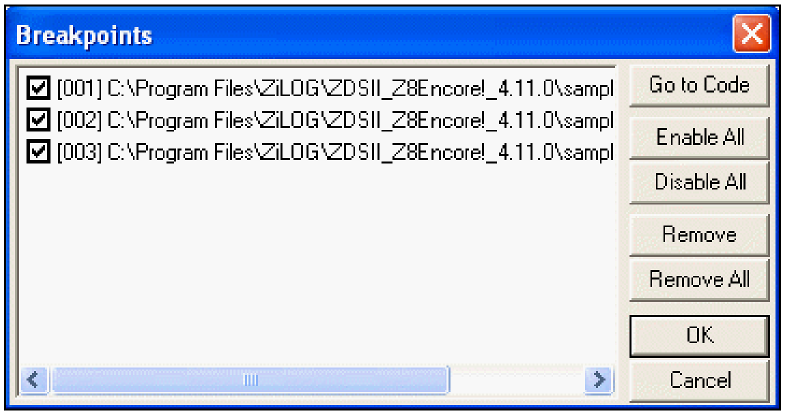
Figure 115. Setting a Breakpoint

Viewing Breakpoints

There are two ways to view breakpoints in your project:

- Select **Manage Breakpoints** from the Edit menu to display the Breakpoints dialog box.
- Right-click in the Edit window to display the context menu; select **Edit Breakpoints** to display the Breakpoints dialog box.

You can use the Breakpoints dialog box to view, go to, enable, disable, or remove breakpoints in an active project when in or out of Debug mode.



[001] C:\Program Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\sampl
[002] C:\Program Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\sampl
[003] C:\Program Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\sampl

Figure 116. Viewing Breakpoints

Moving to a Breakpoint

To quickly move the cursor to a breakpoint you have previously set in your project, do the following:

1. Select **Manage Breakpoints** from the Edit menu.

   The Breakpoints dialog box is displayed.
2. Highlight the breakpoint you want.
3. Click **Go to Code**.

   Your cursor moves to the line where the breakpoint is set.

Enabling Breakpoints

To make all breakpoints in a project active, do the following:

1. Select **Manage Breakpoints** from the Edit menu.

   The Breakpoints dialog box is displayed.
2. Click **Enable All**.

Check marks are displayed to the left of all enabled breakpoints.

3. Click **OK**.

There are three ways to enable one breakpoint:

- Double-click on the white octagon to remove the breakpoint and then double-click where the octagon was to enable the breakpoint.
- Place your cursor in the line in the file where you want to activate a disabled breakpoint and click the Enable/Disable Breakpoint button on the Build or Debug toolbar.
- Place your cursor in the line in the file where you want to activate a disabled breakpoint, right-click to display the context menu, and select **Enable Breakpoint**.

The white octagon becomes a red octagon to indicate that the breakpoint is enabled.

Disabling Breakpoints

There are two ways to make all breakpoints in a project inactive:

- Select **Manage Breakpoints** from the Edit menu to display the Breakpoints dialog box. Click **Disable All**. Disabled breakpoints are still listed in the Breakpoints dialog box. Click **OK**.
- Click the Disable All Breakpoints button on the Debug toolbar.

There are two ways to disable one breakpoint:

- Place your cursor in the line in the file where you want to deactivate an active breakpoint and click the Enable/Disable Breakpoint button on the Build or Debug toolbar.
- Place your cursor in the line in the file where you want to deactivate an active breakpoint, right-click to display the context menu, and select **Disable Breakpoint**.

The red octagon becomes a white octagon to indicate that the breakpoint is disabled.

Removing Breakpoints

There are two ways to delete all breakpoints in a project:

- Select **Manage Breakpoints** from the Edit menu to display the Breakpoints dialog box. Click **Remove All** and then click **OK**. All breakpoints are removed from the Breakpoints dialog box and all project files.
- Click the Remove All Breakpoints button on the Build or Debug toolbar.

There are four ways to delete a single breakpoint:

- Double-click on the red octagon to remove the breakpoint.

- Select **Manage Breakpoints** from the Edit menu to display the Breakpoints dialog box. Click **Remove** and then click **OK**. The breakpoint is removed from the Breakpoints dialog box and the file.
- Place your cursor in the line in the file where there is a breakpoint and click the Insert/ Remove Breakpoint button on the Build or Debug toolbar.
- Place your cursor in the line in the file where there is a breakpoint, right-click to display the context menu, and select **Remove Breakpoint**.

Zilog Standard Library Notes and Tips

Review these questions to learn more about the Zilog Standard Library (ZSL):

- "What is ZSL?" on page 332
- "Which on-chip peripherals are supported?" on page 332
- "Where can I find the header files related to Zilog Standard Libraries?" on page 332
- "What is the zsldevinit.asm file?" on page 332
- "What initializations are performed in the zsldevinit.asm file?" on page 332
- "What calls the open_periphdevice() function?" on page 332
- "When I use Zilog Standard Libraries in my application and build from the command line, why do I see unresolved errors?" on page 333
- "I do not use the standard boot-up module, but I have manually included Zilog Standard Libraries. When I link my code with the library, why do I get an unresolved symbols error?" on page 333
- "Where can I get the ZSL source files?" on page 333
- "I need to change the ZSL source code. How can I generate a new library with these changes included?" on page 333
- "How can I use standard I/O calls like printf() and getch()?" on page 334
- "What is the difference between the Interrupt mode and the Poll mode in the UARTs?" on page 335
- "What are the default settings for the UART device?" on page 335
- "How can I change the default UART settings for my application?" on page 335
- "I am using the UART in the interrupt mode. Why do I seem to lose some of the data when I try to print or try to receive a large amount of data?" on page 335
- "When I call open_UARTx() function by configuring it in INTERRUPT mode, the control never comes back to my program and my program behaves indifferently. Why is this?" on page 335
- "Where can I find sample applications that demonstrate the use of ZSL?" on page 335
- "I have used init_uart() and other functions provided in the RTL. Do I need to change my source code because of ZSL?" on page 336

WHAT IS ZSL?

The Zilog Standard Library (ZSL) is a set of library files that provides an interface between the user application and the on-chip peripherals of the ZDS II microprocessors/controllers.

WHICH ON-CHIP PERIPHERALS ARE SUPPORTED?

Version 1.0 of ZSL supports UARTs and GPIO peripherals.

WHERE CAN I FIND THE HEADER FILES RELATED TO ZILOG STANDARD LIBRARIES?

The header files related to Zilog Standard Libraries can be found under the following directory:

`ZILOGINSTALL\ZDSII_product_version\include\zilog`

where

- *ZILOGINSTALL* is the ZDS II installation directory. For example, the default installation directory is `C:\Program Files\ZiLOG`.
- *product* is the specific Zilog product. For example, *product* can be `Z8Encore!`, `ZNEO`, `eZ80Acclaim!`, `Crimzon`, or `Z8GP`.
- *version* is the ZDS II version number. For example, *version* might be `4.11.0` or `5.0.0`.

WHAT IS THE ZSLDEVINIT.ASM FILE?

`zsldevinit.asm` is a device initialization file. It contains routines to initialize the devices you have selected in the ZSL page of the Project Settings dialog box.

WHAT INITIALIZATIONS ARE PERFORMED IN THE ZSLDEVINIT.ASM FILE?

The `open_periphdevice()` routine in `zsldevinit.asm` initializes the GPIO ports and UART devices. The functions in the file also initialize other dependent parameters like the clock speeds and UART FIFO sizes.

WHAT CALLS THE OPEN_PERIPHDEVICE() FUNCTION?

If the standard startup files are used, the `open_periphdevice()` function is called by the startup routine just before calling the main function.

WHEN I USE ZILOG STANDARD LIBRARIES IN MY APPLICATION AND BUILD FROM THE COMMAND LINE, WHY DO I SEE UNRESOLVED ERRORS?

Include `zsldevinit.asm` in your project.

The `open_periphdevice()` function has some external definitions (for example, clock speed) that are used to calculate the baud rate for the UARTs.

I DO NOT USE THE STANDARD BOOT-UP MODULE, BUT I HAVE MANUALLY INCLUDED ZILOG STANDARD LIBRARIES. WHEN I LINK MY CODE WITH THE LIBRARY, WHY DO I GET AN UNRESOLVED SYMBOLS ERROR?

Include `zsldevinit.asm` in your project.

The `open_periphdevice()` function has some external definitions (for example, clock speed) that are used to calculate the baud rate for the UARTs.

WHERE CAN I GET THE ZSL SOURCE FILES?

The source files for ZSL can be found under the following directory:

ZILOGINSTALL`\ZDSII_`*product_version*`\src`

where

- *ZILOGINSTALL* is the ZDS II installation directory. For example, the default installation directory is `C:\Program Files\ZiLOG`.
- *product* is the specific Zilog product. For example, *product* can be `Z8Encore!`, `ZNEO`, `eZ80Acclaim!`, `Crimzon`, or `Z8GP`.
- *version* is the ZDS II version number. For example, *version* might be `4.11.0` or `5.0.0`.

I NEED TO CHANGE THE ZSL SOURCE CODE. HOW CAN I GENERATE A NEW LIBRARY WITH THESE CHANGES INCLUDED?

The installation contains the batch file `buildallzsl.bat` under the following directory:

ZILOGINSTALL`\ZDSII_`*product_version*`\src`

where

- *ZILOGINSTALL* is the ZDS II installation directory. For example, the default installation directory is `C:\Program Files\ZiLOG`.
- *product* is the specific Zilog product. For example, *product* can be `Z8Encore!`, `ZNEO`, `eZ80Acclaim!`, `Crimzon`, or `Z8GP`.

- *version* is the ZDS II version number. For example, *version* might be `4.11.0` or `5.0.0`.

Generate a new set of libraries by building the project using ZDS II and copy the library files generated under the project directory to the following directory:

> *ZILOGINSTALL*`\ZDSII_`*product_version*`\lib\zilog`

Alternatively, you can run the batch file `buildallzsl.bat` to generate the libraries directly into the following directory:

> *ZILOGINSTALL*`\ZDSII_`*product_version*`\lib\zilog`

Refer to the *Zilog Standard Library API Reference Manual* (RM0038) for more details.

HOW CAN I USE STANDARD I/O CALLS LIKE PRINTF() AND GETCH()?

The standard I/O calls—such as `printf()`, `getch()`, and `putch()`—are routed to UART0 by default. You can route them to UART1 by setting the UART1 as the default device.

To do so, open the `uartcontrol.h` file and change the macro value for DEFAULT_UART from UART0 to UART1 and rebuild the library. The `uartcontrol.h` file is in the following directory:

> *ZILOGINSTALL*`\ZDSII_`*product_version*`\include\zilog`

where

- *ZILOGINSTALL* is the ZDS II installation directory. For example, the default installation directory is `C:\Program Files\ZiLOG`.
- *product* is the specific Zilog product. For example, *product* can be `Z8Encore!`, `ZNEO`, `eZ80Acclaim!`, `Crimzon`, or `Z8GP`.
- *version* is the ZDS II version number. For example, *version* might be `4.11.0` or `4.11.0`.

You can run the `buildallzsl.bat` batch file to generate the libraries directly into the following directory:

> *ZILOGINSTALL*`\ZDSII_`*product_version*`\lib\zilog`

The `buildallzsl.bat` batch file is in the following directory:

> *ZILOGINSTALL*`\ZDSII_`*product_version*`\src`

Refer to the *Zilog Standard Library API Reference Manual* (RM0038) for more details.

WHAT IS THE DIFFERENCE BETWEEN THE INTERRUPT MODE AND THE POLL MODE IN THE UARTS?

In INTERRUPT mode, the API uses UART interrupts to transmit and receive characters to and from the UARTs, so the operation is asynchronous. In POLL mode, the API polls the UART device for the transmission and reception of data, so the operation is synchronous (blocking) in nature.

WHAT ARE THE DEFAULT SETTINGS FOR THE UART DEVICE?

UART devices are initialized with 38400 baud, 8 data bits, 1 stop bit and no parity. Also, the UART by default is configured to work in poll mode.

HOW CAN I CHANGE THE DEFAULT UART SETTINGS FOR MY APPLICATION?

UARTs can be initialized to the required settings by passing the appropriate parameters in the `control_UARTx()` API. Refer to the *Zilog Standard Library API Reference Manual* (RM0038) for more details.

I AM USING THE UART IN THE INTERRUPT MODE. WHY DO I SEEM TO LOSE SOME OF THE DATA WHEN I TRY TO PRINT OR TRY TO RECEIVE A LARGE AMOUNT OF DATA?

One of the reasons could be that the software FIFO buffer size is small. Try increasing the size to a bigger value. The default size of the software FIFO is 64. The software FIFO size is defined in the `zsldevinit.asm` file as the BUFF_SIZE macro.

WHEN I CALL OPEN_UARTX() FUNCTION BY CONFIGURING IT IN INTERRUPT MODE, THE CONTROL NEVER COMES BACK TO MY PROGRAM AND MY PROGRAM BEHAVES INDIFFERENTLY. WHY IS THIS?

The `open_UARTx()` function calls the `control_UARTx()` function, which enables the UART interrupt. As a result of this, the UARTx transmit empty interrupt is generated immediately. If the ISR for UART is not installed, the control on the program might be lost. So install the ISR before calling `open_UARTx()` in the INTERRUPT mode. This is not a problem when the standard boot module is used.

WHERE CAN I FIND SAMPLE APPLICATIONS THAT DEMONSTRATE THE USE OF ZSL?

The ZDS II installation includes two different directories called Applications and Samples. In both of these directories, all projects using devices supported by ZSL are configured to use it. The main difference between the directories is that the applications demonstrate the use of direct ZSL APIs, and the samples demonstrate the indirect use of ZSL using RTL calls.

I HAVE USED INIT_UART() AND OTHER FUNCTIONS PROVIDED IN THE RTL. DO I NEED TO CHANGE MY SOURCE CODE BECAUSE OF ZSL?

No. The `sio.c` file of RTL has been modified to call ZSL APIs, so you can continue to use the run-time library (RTL) without changing your source code. But Zilog advises you to change your source code to make direct calls to ZSL. This is recommended for the following reasons:

- The calls in RTL support only one UART (UART0 or UART1) at any given time in the library. You cannot switch between the UARTs dynamically.
- There is a small code size increase in the RTL due to the additional overhead of calling ZSL APIs from `sio.c`.
- Future releases of RTL might or might not continue to support this method of indirectly accessing the UARTs via ZSL.

C Standard Library

The ANSI C-Compiler provides a collection of run-time libraries for use with your C programs. The largest section of these libraries consists of an implementation of much of the C Standard Library.

The Z8 Encore! C-Compiler is a conforming freestanding 1989 ANSI C implementation with some exceptions. In accordance with the definition of a freestanding implementation, the compiler supports the required standard header files `<float.h>`, `<limits.h>`, `<stdarg.h>`, and `<stddef.h>`. It also supports additional standard header files and Zilog-specific nonstandard header files. The latter are described in “Run-Time Library” on page 160.

The standard header files and functions are, with minor exceptions, fully compliant with the ANSI C Standard. The deviations from the ANSI Standard in these files are summarized in “Library Files Not Required for Freestanding Implementation” on page 193. The standard header files provided with the compiler are listed in the following table and described in detail in “Standard Header Files” on page 338. The following sections describe the use and format of the standard portions of the run-time libraries:

- “Standard Header Files” on page 338
- “Standard Functions” on page 351

Table 11. Standard Headers

Header	Description
`<assert.h>`	Diagnostics
`<ctype.h>`	Character-handling functions
`<errno.h>`	Error numbers
`<float.h>`	Floating-point limits
`<limits.h>`	Integer limits
`<math.h>`	Math functions
`<setjmp.h>`	Nonlocal jump functions
`<stdarg.h>`	Variable arguments functions
`<stddef.h>`	Standard defines
`<stdio.h>`	Standard input/output functions
`<stdlib.h>`	General utilities functions
`<string.h>`	String-handling functions

NOTE: The standard include header files are located in the following directory:

<ZDS Installation Directory>`\include\std`

where *<ZDS Installation Directory>* is the directory in which Zilog Developer Studio was installed. By default, this would be `C:\Program Files\ZiLOG\ZDSII_Z8Encore!_`*`<version>`*, where *<version>* might be `4.11.0` or `5.0.0`.

STANDARD HEADER FILES

The following sections describe the standard header files:

- "Diagnostics <assert.h>" on page 338
- "Character Handling <ctype.h>" on page 339
- "Errors <errno.h>" on page 340
- "Floating Point <float.h>" on page 340
- "Limits <limits.h>" on page 342
- "Mathematics <math.h>" on page 343
- "Nonlocal Jumps <setjmp.h>" on page 345
- "Variable Arguments <stdarg.h>" on page 345
- "Standard Definitions <stddef.h>" on page 346
- "Input/Output <stdio.h>" on page 346
- "General Utilities <stdlib.h>" on page 347
- "String Handling <string.h>" on page 349

Diagnostics <assert.h>

The <`assert.h`> header declares one macro and refers to another macro.

Macro

```
void assert(int expression);
```

The behavior of the `assert()` macro depends on whether the `NDEBUG` macro has been defined or not. On Debug builds (those for which `NDEBUG` is *not* defined), the `assert` macro puts diagnostics into programs. When it is executed, if `expression` is false (that is, evaluates to zero), the `assert` macro writes information about the particular call that failed (including the text of the argument, the name of the source file, and the source line number—the latter are respectively the values of the preprocessing macros `__FILE__` and `__LINE__`) on the serial port. It then calls `abort()`, which calls `exit()`. If `expression` is true (that is, evaluates to nonzero), the `assert` macro returns no value.

On Release builds (strictly speaking, when `NDEBUG` is defined on the compile line), the `assert` macro has no effect.

Example

```
#include <assert.h>
char str[] = "COMPASS";
int main(void)
{
      assert(str[0] == 'C');  // OK, nothing happens
      assert(str[0] == 'B');  // Oops, something wrong here
      return 0;
}
```

Character Handling <ctype.h>

The `<ctype.h>` header declares several macros and functions useful for testing and mapping characters. In all cases, the argument is an `int`, the value of which is represented as an `unsigned char` or equals the value of the EOF macro. If the argument has any other value, the behavior is undefined.

Macros

TRUE	Expands to a constant 1.
FALSE	Expands to a constant 0.

Functions

The functions in this section return nonzero (true) if, and only if, the value of the argument c conforms to that in the description of the function. The term *printing character* refers to a member of a set of characters, each of which occupies one printing position on a display device. The term *control character* refers to a member of a set of characters that are not printing characters.

Character Testing

int isalnum(int c);	Tests for alphanumeric character.
int isalpha(int c);	Tests for alphabetic character.
int iscntrl(int c);	Tests for control character.
int isdigit(int c);	Tests for decimal digit.
int isgraph(int c);	Tests for printable character except space.
int islower(int c);	Tests for lowercase character.
int isprint(int c);	Tests for printable character.
int ispunct(int c);	Tests for punctuation character.

int isspace(int c);	Tests for white-space character.
int isupper(int c);	Tests for uppercase character.
int isxdigit(int c);	Tests for hexadecimal digit.

Character Case Mapping

int tolower(int c);	Tests character and converts to lowercase if uppercase.
int toupper(int c);	Tests character and converts to uppercase if lowercase.

Errors <errno.h>

The `<errno.h>` header defines macros relating to the reporting of error conditions.

Macros

EDOM	Expands to a distinct nonzero integral constant expression.
ERANGE	Expands to a distinct nonzero integral constant expression.
errno	A modifiable value that has type int. Several libraries set errno to a positive value to indicate an error. errno is initialized to zero at program startup, but it is never set to zero by any library function. The value of errno can be set to nonzero by a library function even if there is no error, depending on the behavior specified for the library function in the ANSI Standard.

Additional macro definitions, beginning with E and an uppercase letter, can also be specified by the implementation.

Floating Point <float.h>

The `<float.h>` header defines macros that expand to various limits and parameters.

Macros

DBL_DIG	Number of decimal digits of precision.
DBL_MANT_DIG	Number of base-FLT_RADIX digits in the floating-point mantissa.
DBL_MAX	Maximum represented floating-point numbers.
DBL_MAX_EXP	Maximum integer such that FLT_RADIX raised to that power approximates a floating-point number in the range of represented numbers.
DBL_MAX_10_EXP	Maximum integer such that 10 raised to that power approximates a floating-point number in the range of represented value (`(int)log10(DBL_MAX)`, and so on).
DBL_MIN	Minimum represented positive floating-point numbers.

DBL_MIN_EXP	Minimum negative integer such that FLT_RADIX raised to that power approximates a positive floating-point number in the range of represented numbers.
DBL_MIN_10_EXP	Minimum negative integer such that 10 raised to that power approximates a positive floating-point number in the range of represented values `((int)log10(DBL_MIN)`, and so on).
FLT_DIG	Number of decimal digits of precision.
FLT_MANT_DIG	Number of base-FLT_RADIX digits in the floating-point mantissa.
FLT_MAX	Maximum represented floating-point numbers.
FLT_MAX_EXP	Maximum integer such that FLT_RADIX raised to that power approximates a floating-point number in the range of represented numbers.
FLT_MAX_10_EXP	Maximum integer such that 10 raised to that power approximates a floating-point number in the range of represented value `((int)log10(FLT_MAX)`, and so on).
FLT_MIN	Minimum represented positive floating-point numbers.
FLT_MIN_EXP	Minimum negative integer such that FLT_RADIX raised to that power approximates a positive floating-point number in the range of represented numbers
FLT_MIN_10_EXP	Minimum negative integer such that 10 raised to that power approximates a positive floating-point number in the range of represented values `((int)log10(FLT_MIN)`, and so on).
FLT_RADIX	Radix of exponent representation.
FLT_ROUND	Rounding mode for floating-point addition. -1 indeterminable 0 toward zero 1 to nearest 2 toward positive infinity 3 toward negative infinity
LDBL_DIG	Number of decimal digits of precision.
LDBL_MANT_DIG	Number of base-FLT_RADIX digits in the floating-point mantissa.
LDBL_MAX	Maximum represented floating-point numbers.
LDBL_MAX_EXP	Maximum integer such that FLT_RADIX raised to that power approximates a floating-point number in the range of represented numbers.
LDBL_MAX_10_EXP	Maximum integer such that 10 raised to that power approximates a floating-point number in the range of represented value `((int)log10(LDBL_MAX)`, and so on).
LDBL_MIN	Minimum represented positive floating-point numbers.

LDBL_MIN_EXP	Minimum negative integer such that FLT_RADIX raised to that power approximates a positive floating-point number in the range of represented numbers.
LDBL_MIN_10_EXP	Minimum negative integer such that 10 raised to that power approximates a positive floating-point number in the range of represented values (`(int)log10(LDBL_MIN)`, and so on).

NOTE: The limits for the `double` and `long double` data types are the same as that for the `float` data type for the Z8 Encore! C-Compiler.

Limits <limits.h>

The `<limits.h>` header defines macros that expand to various limits and parameters.

Macros

CHAR_BIT	Maximum number of bits for smallest object that is not a bit-field (byte).
CHAR_MAX	Maximum value for an object of type `char`.
CHAR_MIN	Minimum value for an object of type `char`.
INT_MAX	Maximum value for an object of type `int`.
INT_MIN	Minimum value for an object of type `int`.
LONG_MAX	Maximum value for an object of type long `int`.
LONG_MIN	Minimum value for an object of type long `int`.
SCHAR_MAX	Maximum value for an object of type `signed char`.
SCHAR_MIN	Minimum value for an object of type `signed char`.
SHRT_MAX	Maximum value for an object of type `short int`.
SHRT_MIN	Minimum value for an object of type `short int`.
UCHAR_MAX	Maximum value for an object of type `unsigned char`.
UINT_MAX	Maximum value for an object of type `unsigned int`.
ULONG_MAX	Maximum value for an object of type `unsigned long int`.
USHRT_MAX	Maximum value for an object of type `unsigned short int`.
MB_LEN_MAX	Maximum number of bytes in a multibyte character.

If the value of an object of type `char` sign-extends when used in an expression, the value of CHAR_MIN is the same as that of SCHAR_MIN, and the value of CHAR_MAX is the same as that of SCHAR_MAX. If the value of an object of type `char` does not sign-extend when used in an expression, the value of CHAR_MIN is 0, and the value of CHAR_MAX is the same as that of UCHAR_MAX.

Mathematics <math.h>

The `<math.h>` header declares several mathematical functions and defines one macro. The functions take double-precision arguments and return double-precision values. Integer arithmetic functions and conversion functions are discussed later.

NOTE: The `double` data type is implemented as `float` in the Z8 Encore! C-Compiler.

Macro

HUGE_VAL	Expands to a positive double expression, not necessarily represented as a float.

Treatment of Error Conditions

The behavior of each of these functions is defined for all values of its arguments. Each function must return as if it were a single operation, without generating any externally visible exceptions.

For all functions, a domain error occurs if an input argument to the function is outside the domain over which the function is defined. On a domain error, the function returns a specified value; the integer expression errno acquires the value of the EDOM macro.

Similarly, a range error occurs if the result of the function cannot be represented as a double value. If the result overflows (the magnitude of the result is so large that it cannot be represented in an object of the specified type), the function returns the value of the HUGE_VAL macro, with the same sign as the correct value of the function; the integer expression errno acquires the value of the ERANGE macro. If the result underflows (the magnitude of the result is so small that it cannot be represented in an object of the specified type), the function returns zero.

Functions

The following sections list and briefly describe the mathematics functions:

- “Trigonometric” on page 344
- “Hyperbolic” on page 344
- “Exponential and Logarithmic” on page 344
- “Power” on page 345
- “Nearest Integer” on page 345

Trigonometric

double acos(double x);	Calculates arc cosine of x.
double asin(double x)	Calculates arc sine of x.
double atan(double x);	Calculates arc tangent of x.
double atan2(double y, double x);	Calculates arc tangent of y/x.
double cos(double x);	Calculates cosine of x.
double sin(double x);	Calculates sine of x.
double tan(double x);	Calculates tangent of x.

Hyperbolic

double cosh(double x);	Calculates hyperbolic cosine of x.
double sinh(double x);	Calculates hyperbolic sine of x.
double tanh(double x);	Calculates hyperbolic tangent of x.

Exponential and Logarithmic

double exp(double x);	Calculates exponential function of x.
double frexp(double value, int *exp);	Shows x as product of mantissa (the value returned by frexp) and 2 to the n.
double ldexp(double x, int exp);	Calculates x times 2 to the exp.
double log(double x);	Calculates natural logarithm of x.
double log10(double x);	Calculates base 10 logarithm of x.
double modf(double value, double *iptr);	Breaks down x into integer (the value returned by modf) and fractional (n) parts.

Power

double pow(double x, double y);	Calculates x to the y.
double sqrt(double x);	Finds square root of x.

Nearest Integer

double ceil(double x);	Finds integer ceiling of x.
double fabs(double x);	Finds absolute value of x.
double floor(double x);	Finds largest integer less than or equal to x.
double fmod(double x,double y);	Finds floating-point remainder of x/y.

Nonlocal Jumps <setjmp.h>

The `<setjmp.h>` header declares two functions and one type for bypassing the normal function call and return discipline.

Type

jmp_buf	An array type suitable for holding the information needed to restore a calling environment.

Functions

int setjmp(jmp_buf env);	Saves a stack environment.
void longjmp(jmp_buf env, int val);	Restores a saved stack environment.

Variable Arguments <stdarg.h>

The `<stdarg.h>` header declares a type and a function and defines two macros for advancing through a list of arguments whose number and types are not known to the called function when it is translated.

A function can be called with a variable number of arguments of varying types. The "Function Definitions" parameter list contains one or more parameters. The rightmost parameter plays a special role in the access mechanism and is designated parmN in this description.

Type

va_list	An array type suitable for holding information needed by the macro va_arg and the va_end function. The called function declares a variable (referred to as ap in this section) having type va_list. The variable ap can be passed as an argument to another function.

Variable Argument List Access Macros and Function

The va_start and va_arg macros described in this section are implemented as macros, not as real functions. If `#undef` is used to remove a macro definition and obtain access to a real function, the behavior is undefined.

Functions

void va_start(va_list ap, parmN);	Sets ap to the beginning of argument list.
type va_arg (va_list ap, type);	Returns the next argument from list.
void va_end(va_list ap);	Should mark the end of usage of ap (but has no effect in Zilog implementation).

Standard Definitions <stddef.h>

The following types and macros are defined in several headers referred to in the descriptions of the functions declared in that header, as well as the common `<stddef.h>` standard header.

Macros

NULL	Expands to a null pointer constant.
offsetof (type, identifier)	Expands to an integral constant expression that has type size_t and provides the offset in bytes, from the beginning of a structure designated by type to the member designated by identifier.

Types

ptrdiff_t	Signed integral type of the result of subtracting two pointers.
size_t	Unsigned integral type of the result of the sizeof operator.
wchar_t	Integral type whose range of values can represent distinct codes for all members of the largest extended character set specified among the supported locales.

Input/Output <stdio.h>

The `<stdio.h>` header declares input and output functions.

Macro

EOF	Expands to a negative integral constant. Returned by functions to indicate end of file.

Functions

Formatted Input/Output

int printf(char *format, ...);	Writes formatted data to stdout.
int scanf(char *format, ...);	Reads formatted data from stdin.
int sprintf(char *s, char *format, ...);	Writes formatted data to string.
int sscanf(char *s, char *format, ...);	Reads formatted data from string.
int vprintf(char *format, va_list arg);	Writes formatted data to stdout.
int vsprintf(char *s, char *format, va_list arg);	Writes formatted data to a string.

Character Input/Output

int getchar(void);	Reads a character from stdin.
char *gets(char *s);	Reads a line from stdin.
int putchar(int c);	Writes a character to stdout.
int puts(char *s);	Writes a line to stdout.

General Utilities <stdlib.h>

The `<stdlib.h>` header declares several types, functions of general utility, and macros.

Types

div_t	Structure type that is the type of the value returned by the div function.
ldiv_t	Structure type that is the type of the value returned by the ldiv function.
size_t	Unsigned integral type of the result of the sizeof operator.
wchar_t	Integral type whose range of values can represent distinct codes for all members of the largest extended character set specified among the supported locales.

Macros

EDOM	Expands to distinct nonzero integral constant expressions.
ERANGE	Expands to distinct nonzero integral constant expressions.
EXIT_SUCCESS	Expands to integral expression that indicates successful termination status.
EXIT_FAILURE	Expands to integral expression that indicates unsuccessful termination status.
HUGE_VAL	Expands to a positive double expression, not necessarily represented as a float.
NULL	Expands to a null pointer constant.
RAND_MAX	Expands to an integral constant expression, the value of which is the maximum value returned by the rand function.

Functions

The general utilities are listed and briefly described in the following sections:

- “String Conversion” on page 348
- “Pseudorandom Sequence Generation” on page 348
- “Memory Management” on page 349
- “Searching and Sorting Utilities” on page 349
- “Integer Arithmetic” on page 349
- “Miscellaneous” on page 349

String Conversion

The `atof`, `atoi`, and `atol` functions do not affect the value of the errno macro on an error. If the result cannot be represented, the behavior is undefined.

double atof(char *nptr);	Converts string to double.
int atoi(char *nptr);	Converts string to int.
long int atol(char *nptr);	Converts string to long.
double strtod(char *nptr, char **endptr);	Converts string pointed to by nptr to a double.
long int strtol(char *nptr, char **endptr, int base);	Converts string to a long decimal integer that is equal to a number with the specified radix.

Pseudorandom Sequence Generation

int rand(void)	Gets a pseudorandom number.
void srand(unsigned int seed);	Initializes pseudorandom series.

Memory Management

The order and contiguity of storage allocated by successive calls to the `calloc`, `malloc`, and `realloc` functions are unspecified. The pointer returned if the allocation succeeds is suitably aligned so that it can be assigned to a pointer to any type of object and then used to access such an object in the space allocated (until the space is explicitly freed or reallocated).

void *calloc(size_t nmemb, size_t size);	Allocates storage for array.
void free(void *ptr);	Frees a block allocated with calloc, malloc, or realloc.
void *malloc(size_t size);	Allocates a block.
void *realloc(void *ptr, size_t size);	Reallocates a block.

Searching and Sorting Utilities

void *bsearch(void *key, void *base, size_t nmemb, size_t size, int (*compar)(void *, void *));	Performs binary search.
void qsort(void *base, size_t nmemb, size_t size, int (*compar)(void *, void *));	Performs a quick sort.

Integer Arithmetic

int abs(int j);	Finds absolute value of integer value.
div_t div(int numer, int denom);	Computes integer quotient and remainder.
long int labs(long int j);	Finds absolute value of long integer value.
ldiv_t ldiv(long int numer, long int denom);	Computes long quotient and remainder.

Miscellaneous

void abort(void)	Abnormal program termination.

String Handling <string.h>

The `<string.h>` header declares several functions useful for manipulating character arrays and other objects treated as character arrays. Various methods are used for determining the lengths of arrays, but in all cases a char* or void* argument points to the initial (lowest addressed) character of the array. If an array is written beyond the end of an object, the behavior is undefined.

Type

size_t	Unsigned integral type of the result of the sizeof operator.

Macro

NULL	Expands to a null pointer constant.

Functions

The string-handling functions are listed and briefly described in the following sections:

- "Copying" on page 350
- "Concatenation" on page 350
- "Comparison" on page 350
- "Search" on page 351
- "Miscellaneous" on page 351

Copying

void *memcpy(void *s1, void *s2, size_t n);	Copies a specified number of characters from one buffer to another.
void *memmove(void *s1, void *s2, size_t n);	Moves a specified number of characters from one buffer to another.
char *strcpy(char *s1, char *s2);	Copies one string to another.
char *strncpy(char *s1, char *s2, size_t n);	Copies n characters of one string to another.

Concatenation

char *strcat(char *s1, char *s2);	Appends a string.
char *strncat(char *s1, char *s2, size_t n);	Appends n characters of string.

Comparison

The sign of the value returned by the comparison functions is determined by the sign of the difference between the values of the first pair of characters that differ in the objects being compared.

int memcmp(void *s1, void *s2, size_t n);	Compares the first n characters.
int strcmp(char *s1, char *s2);	Compares two strings.
int strncmp(char *s1, char *s2, size_t n);	Compares n characters of two strings.

Search

void *memchr(void *s, int c, size_t n);	Returns a pointer to the first occurrence, within a specified number of characters, of a given character in the buffer.
char *strchr(char *s, int c);	Finds first occurrence of a given character in string.
size_t strcspn(char *s1, char *s2);	Finds first occurrence of a character from a given character in string.
char *strpbrk(char *s1, char *s2);	Finds first occurrence of a character from one string to another.
char *strrchr(char *s, int c);	Finds last occurrence of a given character in string.
size_t strspn(char *s1, char *s2);	Finds first substring from a given character set in string.
char *strstr(char *s1, char *s2);	Finds first occurrence of a given string in another string.
char *strtok(char *s1, char *s2);	Finds next token in string.

Miscellaneous

void *memset(void *s, int c, size_t n);	Uses a given character to initialize a specified number of bytes in the buffer.
size_t strlen(char *s);	Finds length of string.

STANDARD FUNCTIONS

The following functions are standard functions:

abort	abs	acos	asin	atan
atan2	atof	atoi	atol	bsearch
calloc	ceil	cos	cosh	div
exp	fabs	floor	fmod	free
frexp	getchar	gets	isalnum	isalpha
iscntrl	isdigit	isgraph	islower	isprint
ispunct	isspace	isupper	isxdigit	labs
ldexp	ldiv	log	log10	longjmp
malloc	memchr	memcmp	memcpy	memmove
memset	modf	pow	printf	putchar

puts	qsort	rand	realloc	scanf
setjmp	sin	sinh	sprintf	sqrt
srand	sscanf	strcat	strchr	strcmp
strcpy	strcspn	strlen	strncat	strncmp
strncpy	strpbrk	strrchr	strspn	strstr
strtod	strtok	strtol	tan	tanh
tolower	toupper	va_arg	va_end	va_start
vprintf	vsprintf			

abort

Causes an abnormal termination of the program.

Synopsis

```
#include <stdlib.h>
void abort(void);
```

TIP: The `abort` function is usually called by the `assert` macro. If you use `asserts` in your application, you might want to permanently place a breakpoint in `abort()` to simplify debugging when `asserts` fail.

abs

Computes the absolute value of an integer `j`. If the result cannot be represented, the behavior is undefined.

Synopsis

```
#include <stdlib.h>
int abs(int j);
```

Returns

The absolute value.

Example

```
int I=-5632;
int j;
j=abs(I);
```

acos

Computes the principal value of the arc cosine of `x`. A domain error occurs for arguments not in the range [-1,+1].

Synopsis

```
#include <math.h>
double acos(double x);
```

Returns

The arc cosine in the range [0, pi].

Example

```
double y=0.5635;
double x;
x=acos(y)
```

asin

Computes the principal value of the arc sine of `x`. A domain error occurs for arguments not in the range [-1,+1].

Synopsis

```
#include <math.h>
double asin(double x);
```

Returns

The arc sine in the range [-pi/2,+pi/2].

Example

```
double y=.1234;
double x;
x = asin(y);
```

atan

Computes the principal value of the arc tangent of *x*.

Synopsis

```
#include <math.h>
double atan(double x);
```

Returns

The arc tangent in the range (-pi/2, +pi/2).

Example

```
double y=.1234;
double x;
x=atan(y);
```

atan2

Computes the principal value of the arc tangent of *y*/*x*, using the signs of both arguments to determine the quadrant of the return value. A domain error occurs if both arguments are zero.

Synopsis

```
#include <math.h>
double atan2(double y, double x);
```

Returns

The arc tangent of *y*/*x*, in the range [-pi, +pi].

Example

```
double y=.1234;
double x=.4321;
double z;
z=atan2(y,x);
```

atof

Converts the string pointed to by nptr to double representation. Except for the behavior on error, `atof` is equivalent to `strtod (nptr, (char **)NULL)`.

Synopsis

```
#include <stdlib.h>
double atof(char *nptr);
```

Returns

The converted value.

Example

```
char str []="1.234";
double x;
x= atof(str);
```

atoi

Converts the string pointed to by nptr to int representation. Except for the behavior on error, it is equivalent to `(int)strtol(nptr, (char **)NULL, 10)`.

Synopsis

```
#include <stdlib.h>
int atoi(char *nptr);
```

Returns

The converted value.

Example

```
char str []="50";
int x;
x=atoi(str);
```

atol

Converts the string pointed to by nptr to `long int` representation. Except for the behavior on error, it is equivalent to `strtol(nptr, (char **)NULL, 10)`.

Synopsis

```
#include <stdlib.h>
long int atol(char *nptr);
```

Returns

The converted value.

Example

```
char str[]="1234567";
long int x;
x=atol(str);
```

bsearch

Searches an array of nmemb objects, the initial member of which is pointed to by base, for a member that matches the object pointed to by key. The size of each object is specified by size.

The array has been previously sorted in ascending order according to a comparison function pointed to by `compar`, which is called with two arguments that point to the objects being compared. The `compar` function returns an integer less than, equal to, or greater than zero if the first argument is considered to be respectively less than, equal to, or greater than the second.

Synopsis

```
#include <stdlib.h>
void *bsearch(void *key, void *base,
            size_t nmemb, size_t size,
            int (*compar)(void *, void *));
```

Returns

A pointer to the matching member of the array or a null pointer, if no match is found.

Example

```
#include <stdlib.h>
int list[]={2,5,8,9};
int k=8;

int compare (void * x, void * y);
int main(void)
{
      int *result;
      result = bsearch(&k, list, 4, sizeof(int), compare);
}

int compare (void * x, void * y)
{
      int a = *(int *) x;
      int b = *(int *) y;
      if (a < b) return -1;
      if (a == b)return 0;
      return 1;
}
```

The `compare` function prototype is, as shown in the preceding example:

```
int compare (void * x, void * y);
```

calloc

Allocates space for an array of nmemb objects, each of whose size is `size`. The space is initialized to all bits zero.

Synopsis

```
#include <stdlib.h>
void *calloc(size_t nmemb, size_t size);
```

Returns

A pointer to the start (lowest byte address) of the allocated space. If the space cannot be allocated, or if nmemb or `size` is zero, the `calloc` function returns a null pointer.

Example

```
char *buf;
buf = (char*)calloc(40, sizeof(char));
if (buf != NULL)
     /*success*/
else
     /*fail*/
```

ceil

Computes the smallest integer not less than x.

Synopsis

```
#include <math.h>
double ceil(double x);
```

Returns

The smallest integer not less than x, expressed as a `double`.

Example

```
double y=1.45;
double x;
x=ceil(y);
```

cos

Computes the cosine of x (measured in radians). A large magnitude argument can yield a result with little or no significance.

Synopsis

```
#include <math.h>
double cos(double x);
```

Returns

The cosine value.

Example

```
double y=.1234;
double x;
x=cos(y)
```

cosh

Computes the hyperbolic cosine of x. A range error occurs if the magnitude of x is too large.

Synopsis

```
#include <math.h>
double cosh(double x);
```

Returns

The hyperbolic cosine value.

Example

```
double y=.1234;
double x
x=cosh(y);
```

div

Computes the quotient and remainder of the division of the numerator `numer` by the denominator `denom`. If the division is inexact, the sign of the quotient is that of the mathematical quotient, and the magnitude of the quotient is the largest integer less than the magnitude of the mathematical quotient.

Synopsis

```
#include <stdlib.h>
div_t div(int numer, int denom);
```

Returns

A structure of type div_t, comprising both the quotient and the remainder. The structure contains the following members, in either order:

```
int quot;       /* quotient */
int rem;        /* remainder */
```

Example

```
int x=25;
int y=3;
div_t t;
```

```
int q;
int r;
t=div (x,y);
q=t.quot;
r=t.rem;
```

exp

Computes the exponential function of x. A range error occurs if the magnitude of x is too large.

Synopsis

```
#include <math.h>
double exp(double x);
```

Returns

The exponential value.

Example

```
double y=.1234;
double x;
x=exp(y)
```

fabs

Computes the absolute value of a floating-point number x.

Synopsis

```
#include <math.h>
double fabs(double x);
```

Returns

The absolute value of x.

Example

```
double y=6.23;
double x;
x=fabs(y);
```

floor

Computes the largest integer not greater than x.

Synopsis

```
#include <math.h>
double floor(double x);
```

Returns

The largest integer not greater than x, expressed as a `double`.

Example

```
double y=6.23;
double x;
x=floor(y);
```

fmod

Computes the floating-point remainder of `x/y`. If the quotient of `x/y` cannot be represented, the behavior is undefined.

Synopsis

```
#include <math.h>
double fmod(double x, double y);
```

Returns

The value of x if y is zero. Otherwise, it returns the value f, which has the same sign as x, such that x - i * y + f for some integer i, where the magnitude of f is less than the magnitude of y.

Example

```
double y=7.23;
double x=2.31;
double z;
z=fmod(y,x);
```

free

Causes the space pointed to by ptr to be deallocated, that is, made available for further allocation. If ptr is a null pointer, no action occurs. Otherwise, if the argument does not match a pointer earlier returned by the `calloc`, `malloc`, or `realloc` function, or if the space has been deallocated by a call to `free` or `realloc`, the behavior is undefined. If freed space is referenced, the behavior is undefined.

Synopsis

```
#include <stdlib.h>
void free(void *ptr);
```

Example

```
char *buf;
buf=(char*) calloc(40, sizeof(char));
free(buf);
```

frexp

Breaks a floating-point number into a normalized fraction and an integral power of 2. It stores the integer in the `int` object pointed to by `exp`.

Synopsis

```
#include <math.h>*
double frexp(double value, int *exp);
```

Returns

The value x, such that x is a `double` with magnitude in the interval [1/2, 1] or zero, and value equals x times 2 raised to the power *exp. If value is zero, both parts of the result are zero.

Example

```
double y, x=16.4;
int n;
y=frexp(x,&n);
```

getchar

Waits for the next character to appear at the serial port and return its value.

Synopsis

```
#include <stdio.h>
int getchar(void);
```

Returns

The next character from the input stream pointed to by stdin. If the stream is at end-of-file, the end-of-file indicator for the stream is set and `getchar` returns EOF. If a read error occurs, the error indicator for the stream is set, and `getchar` returns EOF.

Example

```
int i;
i=getchar();
```

NOTE: The UART needs to be initialized using the Zilog `init_uart()` function. See "init_uart" on page 167.

gets

Reads characters from a UART into the array pointed to by `s`, until end-of-file is encountered or a new-line character is read. The new-line character is discarded and a null character is written immediately after the last character read into the array.

Synopsis

```
#include <stdio.h>
char *gets(char *s);
```

Returns

The value of `s` if successful. If a read error occurs during the operation, the array contents are indeterminate, and a null pointer is returned.

Example

```
char *r;
char buf [80];
r=gets(buf);
if (r==NULL)
     /*No input*/
```

NOTE: The UART needs to be initialized using the Zilog `init_uart()` function. See "init_uart" on page 167.

isalnum

Tests for any character for which `isalpha` or `isdigit` is true.

Synopsis

```
include <ctype.h>
int isalnum(int c);
```

Example

```
int r;
char c='a';
r=isalnum(c)
```

isalpha

Tests for any character for which `isupper` or `islower` is true.

Synopsis

```
#include <ctype.h>
int isalpha(int c);
```

Example

```
int r;
char c='a';
r=isalpha(c)
```

iscntrl

Tests for any control character.

Synopsis

```
#include <ctype.h>
int iscntrl(int c);
```

Example

```
int r;
char c=NULL;
r=iscntrl(c);
```

isdigit

Tests for any decimal digit.

Synopsis

```
#include <ctype.h>
int isdigit(int c);
```

Example

```
int r;
char c='4';
r=isdigit(c);
```

isgraph

Tests for any printing character except space (' ').

Synopsis

```
#include <ctype.h>
int isgraph(int c);
```

Example

```
int r;
char c='';
r=isgraph(c);
```

islower

Tests for any lowercase letter 'a' to 'z'.

Synopsis

```
#include <ctype.h>
int islower(int c);
```

Example

```
int r;
char c='a';
r=islower(c);
```

isprint

Tests for any printing character including space (' ').

Synopsis

```
#include <ctype.h>
int isprint(int c);
```

Example

```
int r;
char c='1';
r=isprint(c);
```

ispunct

Tests for any printing character except space (' ') or a character for which `isalnum` is true.

Synopsis

```
#include <ctype.h>
int ispunct(int c);
```

Example

```
int r;
char c='a';
r=ispunct(c);
```

isspace

Tests for the following white-space characters: space (' '), form feed ('\f'), new line ('\n'), carriage return ('\r'), horizontal tab ('\t'), or vertical tab ('\v').

Synopsis

```
#include <ctype.h>
int isspace(int c);
```

Example

```
int r;
char c='';
r=isspace(c);
```

isupper

Tests for any uppercase letter 'A' to 'Z'.

Synopsis

```
#include <ctype.h>
int isupper(int c);
```

Example

```
int r;
char c='a';
r=isupper(c);
```

isxdigit

Tests for any hexadecimal digit '0' to '9' and 'A' to 'F'.

Synopsis

```
#include <ctype.h>
int isxdigit(int c);
```

Example

```
int r;
char c='f';
r=isxdigit(c)
```

labs

Computes the absolute value of a long j.

Synopsis

```
#include <stdlib.h>
long labs(long j);
```

Example

```
long i=-193250;
long j
j=labs(i);
```

ldexp

Multiplies a floating-point number by an integral power of 2. A range error can occur.

Synopsis

```
#include <math.h>
double ldexp(double x, int exp);
```

Returns

The value of x times 2 raised to the power of exp.

Example

```
double x=1.235
int exp=2;
double y;
y=ldexp(x,exp);
```

ldiv

Computes the quotient and remainder of the division of the numerator `numer` by the denominator `denom`. If the division is inexact, the sign of the quotient is that of the mathematical quotient, and the magnitude of the quotient is the largest integer less than the magnitude of the mathematical quotient.

Synopsis

```
#include <stdlib.h>
ldiv_t ldiv(long numer, long denom);
```

Example

```
long x=25000;
long y=300;
div_t t;
int q;
int r;
t=ldiv(x,y);
q=t.quot;
r=t.rem;
```

log

Computes the natural logarithm of x. A domain error occurs if the argument is negative. A range error occurs if the argument is zero.

Synopsis

```
#include <math.h>
double log(double x);
```

Returns

The natural logarithm.

Example

```
double x=2.56;
double y;
y=log(x);
```

log10

Computes the base-ten logarithm of x. A domain error occurs if the argument is negative. A range error occurs if the argument is zero.

Synopsis

```
#include <math.h>
double log10(double x);
```

Returns

The base-ten logarithm.

Example

```
double x=2.56;
double y;
y=log10(x);
```

longjmp

Restores the environment saved by the most recent call to `setjmp` in the same invocation of the program, with the corresponding jmp_buf argument. If there has been no such call, or if the function containing the call to `setjmp` has executed a `return` statement in the interim, the behavior is undefined.

All accessible objects have values as of the time `longjmp` was called, except that the values of objects of automatic storage class that do not have `volatile` type and have been changed between the `setjmp` and `longjmp` call are indeterminate.

As it bypasses the usual function call and returns mechanisms, the `longjmp` function executes correctly in contexts of interrupts, signals, and any of their associated functions. However, if the `longjmp` function is invoked from a nested signal handler (that is, from a function invoked as a result of a signal raised during the handling of another signal), the behavior is undefined.

Synopsis

```
#include <setjmp.h>
void longjmp(jmp_buf env, int val);
```

Returns

After `longjmp` is completed, program execution continues as if the corresponding call to `setjmp` had just returned the value specified by `val`. The `longjmp` function cannot cause `setjmp` to return the value 0; if val is 0, `setjmp` returns the value 1.

Example

```
int i;
jmp_buf (env)
i=setjmp(env)
longjmp(env,i);
```

malloc

Allocates space for an object whose size is specified by `size`.

NOTE: The existing implementation of `malloc()` depends on the heap area being located from the bottom of the heap (referred to by the symbol __heapbot) to the top of the stack (SP). Care must be taken to avoid holes in this memory range. Otherwise, the `malloc()` function might not be able to allocate a valid memory object.

Synopsis

```
#include <stdlib.h>
void *malloc(size_t size);
```

Returns

A pointer to the start (lowest byte address) of the allocated space. If the space cannot be allocated, or if size is zero, the `malloc` function returns a null pointer.

Example

```
char *buf;
buf=(char *) malloc(40*sizeof(char));
if(buf !=NULL)
      /*success*/
else
      /*fail*/
```

memchr

Locates the first occurrence of c (converted to an `unsigned char`) in the initial n characters of the object pointed to by s.

Synopsis

```
#include <string.h>
void *memchr(void *s, int c, size_t n);
```

Returns

A pointer to the located character or a null pointer if the character does not occur in the object.

Example

```
char *p1;
char str[]="COMPASS";
c='p';
p1=memchr(str,c,sizeof(char));
```

memcmp

Compares the first n characters of the object pointed to by s2 to the object pointed to by s1.

Synopsis

```
#include <string.h>
int memcmp(void *s1, void *s2, size_t n);
```

Returns

An integer greater than, equal to, or less than zero, according as the object pointed to by s1 is greater than, equal to, or less than the object pointed to by s2.

Example

```
char s1[]="COMPASS";
char s2[]="IDE";
int res;
res=memcmp(s1, s2, sizeof (char));
```

memcpy

Copies n characters from the object pointed to by s2 into the object pointed to by s1. If the two regions overlap, the behavior is undefined.

Synopsis

```
#include <string.h>
void *memcpy(void *s1, void *s2, size_t n);
```

Returns

The value of s1.

Example

```
char s1[10];
char s2[10] = "COMPASS";
memcpy(s1, s2, 8);
```

memmove

Moves n characters from the object pointed to by s2 into the object pointed to by s1. Copying between objects that overlap takes place correctly.

Synopsis

```
#include <string.h>
void *memmove(void *s1, void *s2, size_t n);
```

Returns

The value of s1.

Example

```
char s1[10];
char s2[]="COMPASS";
memmove(s1, s2, 8*sizeof(char));
```

memset

Copies the value of c (converted to an `unsigned char`) into each of the first n characters of the object pointed to by s.

Synopsis

```
#include <string.h>
void *memset(void *s, int c, size_t n);
```

Returns

The value of s.

Example

```
char str[20];
char c='a';
memset(str, c, 10*sizeof(char));
```

modf

Breaks the argument value into integral and fractional parts, each of which has the same sign as the argument. It stores the integral part as a `double` in the object pointed to by iptr.

Synopsis

```
#include <math.h>
double modf(double value, double *iptr);
```

Returns

The signed fractional part of value.

Example

```
double x=1.235;
double f;
double I;
i=modf(x, &f);
```

pow

Computes the x raised to the power of y. A domain error occurs if x is zero and y is less than or equal to zero, or if x is negative and y is not an integer. A range error can occur.

Synopsis

```
#include <math.h>
double pow(double x, double y);
```

Returns

The value of x raised to the power y.

Example

```
double x=2.0;
double y=3.0;
double=res;
res=pow(x,y);
```

printf

Writes output to the stream pointed to by stdout, under control of the string pointed to by format that specifies how subsequent arguments are converted for output.

A format string contains two types of objects: plain characters, which are copied unchanged to stdout, and conversion specifications, each of which fetch zero or more subsequent arguments. The results are undefined if there are insufficient arguments for the format. If the format is exhausted while arguments remain, the excess arguments are evaluated but otherwise ignored. The `printf` function returns when the end of the format string is encountered.

Each conversion specification is introduced by the character %. After the %, the following appear in sequence:

- Zero or more flags that modify the meaning of the conversion specification.
- An optional decimal integer specifying a minimum field width. If the converted value has fewer characters than the field width, it is padded on the left (or right, if the left

adjustment flag, described later, has been given) to the field width. The padding is with spaces unless the field width integer starts with a zero, in which case the padding is with zeros.

- An optional precision that gives the minimum number of digits to appear for the d, i, o, u, x, and X conversions, the number of digits to appear after the decimal point for e, E, and f conversions, the maximum number of significant digits for the g and G conversions, or the maximum number of characters to be written from a string in s conversion. The precision takes the form of a period (.) followed by an optional decimal integer; if the integer is omitted, it is treated as zero. The amount of padding specified by the precision overrides that specified by the field width.
- An optional h specifies that a following d, i, o, u, x, or X conversion character applies to a short_int or unsigned_short_int argument (the argument has been promoted according to the integral promotions, and its value is converted to short_int or unsigned_short_int before printing). An optional l (ell) specifies that a following d, i, o, u, x or X conversion character applies to a long_int or unsigned_long_int argument. An optional L specifies that a following e, E, f, g, or G conversion character applies to a long_double argument. If an h, l, or L appears with any other conversion character, it is ignored.
- A character that specifies the type of conversion to be applied.
- A field width or precision, or both, can be indicated by an asterisk * instead of a digit string. In this case, an int argument supplies the files width or precision. The arguments specifying field width or precision displays before the argument (if any) to be converted. A negative field width argument is taken as a - flag followed by a positive field width. A negative precision argument is taken as if it were missing.

NOTE: For more specific information on the flag characters and conversion characters for the `printf` function, see "printf Flag Characters" on page 374 and "printf Conversion Characters" on page 374.

Synopsis

```
#include <stdio.h>
int printf(char *format, ...);
```

Returns

The number of characters transmitted or a negative value if an output error occurred.

Example

```
int i=10;
printf("This is %d",i);
```

By default, Zilog compilers parse `printf` and `sprintf` format strings and generate calls to lower level support routines instead of generating calls to `printf` and `sprintf`. For more information, see the description of the `-genprintf` option in “Generate Printfs Inline” on page 70.

NOTE: The UART needs to be initialized using the Zilog `init_uart()` function. See “init_uart” on page 167.

printf Flag Characters

-	The result of the conversion is left-justified within the field.
+	The result of a signed conversion always begins with a plus or a minus sign.
space	If the first character of a signed conversion is not a sign, a space is added before the result. If the space and + flags both appear, the space flag is ignored
#	The result is to be converted to an "alternate form". For c, d, i, s, and u conversions, the flag has no effect. For o conversion, it increases the precision to force the first digit of the result to be a zero. For x (or X) conversion, a nonzero result always contains a decimal point, even if no digits follow the point (normally, a decimal point appears in the result of these conversions only if a digit follows it). For g and G conversions, trailing zeros are not removed from the result, as they normally are.

printf Conversion Characters

d,i,o,u,x,X	The int argument is converted to signed decimal (d or i), unsigned octal (o), unsigned decimal (u), or unsigned hexadecimal notation (x or X); the letters abcdef are used for x conversion and the letters ABCDEF for X conversion. The precision specifies the minimum number of digits to appear; if the value being converted can be represented in fewer digits, it is expanded with leading zeros. The default precision is 1. The result of converting a zero value with a precision of zero is no characters.
f	The double argument is converted to decimal notation in the style [-]ddd.ddd, where the number of digits after the decimal point is equal to the precision specification. If the precision is missing, it is taken as 6; if the precision is explicitly zero, no decimal point appears. If a decimal point appears, at least one digit appears before it. The value is rounded to the appropriate number of digits.
e,E	The double argument is converted in the style [-]d.ddde+dd, where there is one digit before the decimal point and the number of digits after it is equal to the precision; when the precision is missing, six digits are produced; if the precision is zero, no decimal point appears. The value is rounded to the appropriate number of digits. The E conversion character produces a number with E instead of e introducing the exponent. The exponent always contains at least two digits. However, if the magnitude to be converted is greater than or equal to lE+100, additional exponent digits are written as necessary.

g,G	The double argument is converted in style f or e (or in style E in the case of a G conversion character), with the precision specifying the number of significant digits. The style used depends on the value converted; style e is used only if the exponent resulting from the conversion is less than -4 or greater than the precision. Trailing zeros are removed from the result; a decimal point appears only if it is followed by a digit.
c	The int argument is converted to an unsigned char, and the resulting character is written.
s	The argument is taken to be a (const char *) pointer to a string. Characters from the string are written up to, but not including, the terminating null character, or until the number of characters indicated by the precision are written. If the precision is missing it is taken to be arbitrarily large, so all characters before the first null character are written.
p	The argument is taken to be a (const void) pointer to an object. The value of the pointer is converted to a sequence of hex digits.
n	The argument is taken to be an (int) pointer to an integer into which is written the number of characters written to the output stream so far by this call to `printf`. No argument is converted.
%	A % is written. No argument is converted.

In no case does a nonexistent or small field width cause truncation of a field. If the result of a conversion is wider than the field width, the field is expanded to contain the conversion result.

putchar

Writes a character to the serial port.

Synopsis

```
#include <stdio.h>
int putchar(int c);
```

Returns

The character written. If a write error occurs, `putchar` returns EOF.

Example

```
int i;
charc='a';
i=putchar(c);
```

NOTE: The UART needs to be initialized using the Zilog `init_uart()` function. See "init_uart" on page 167.

puts

Writes the string pointed to by s to the serial port and appends a new-line character to the output. The terminating null character is not written.

Synopsis

```
#include <stdio.h>
int puts(char *s);
```

Returns

EOF if an error occurs; otherwise, it is a nonnegative value.

Example

```
int i;
char strp[]="COMPASS";
i=puts(str);
```

NOTE: The UART needs to be initialized using the Zilog `init_uart()` function. See "init_uart" on page 167.

qsort

Sorts an array of nmemb objects, the initial member of which is pointed to by any base. The size of each object is specified by size.

The array is sorted in ascending order according to a comparison function pointed to by `compar`, which is called with two arguments that point to the objects being compared. The `compar` function returns an integer less than, equal to, or greater than zero if the first argument is considered to be respectively less than, equal to, or greater than the second.

If two members in the array compare as equal, their order in the sorted array is unspecified.

Synopsis

```
#include <stdlib.h>
void qsort(void *base, size_t nmemb, size_t size,
      int (*compar)(void *, void *));
```

Example

```
int lst[]={5,8,2,9};
int compare (void * x, void * y);
qsort (lst, sizeof(int), 4, compare);

int compare (void * x, void * y)
{
      int a = *(int *) x;
```

```
        int b = *(int *) y;
        if (a < b) return -1;
        if (a == b)return 0;
        return 1;
}
```

The `compare` function prototype is, as shown in the preceding example:

```
int compare (void * x, void * y);
```

rand

Computes a sequence of pseudorandom integers in the range 0 to RAND_MAX.

Synopsis

```
#include <stdlib.h>
int rand(void)
```

Returns

A pseudorandom integer.

Example

```
int i;
srand(1001);
i=rand();
```

realloc

Changes the size of the object pointed to by ptr to the size specified by size. The contents of the object are unchanged up to the lesser of the new and old sizes. If ptr is a null pointer, the `realloc` function behaves like the `malloc` function for the specified size. Otherwise, if ptr does not match a pointer earlier returned by the `calloc`, `malloc`, or `realloc` function, or if the space has been deallocated by a call to the `free` or `realloc` function, the behavior is undefined. If the space cannot be allocated, the `realloc` function returns a null pointer and the object pointed to by ptr is unchanged. If size is zero, the `realloc` function returns a null pointer and, if ptr is not a null pointer, the object it points to is freed.

Synopsis

```
#include <stdlib.h>
void *realloc(void *ptr, size_t size);
```

Returns

Returns a pointer to the start (lowest byte address) of the possibly moved object.

Example

```
char *buf;
buf=(char *) malloc(40*sizeof(char));
buf=(char *) realloc(buf, 80*sizeof(char));
if(buf !=NULL)
      /*success*/
else
      /*fail*/
```

scanf

Reads input from the stream pointed to by stdin, under control of the string pointed to by format that specifies the admissible input sequences and how they are to be converted for assignment, using subsequent arguments as pointers to the object to receive the converted input. If there are insufficient arguments for the format, the behavior is undefined. If the format is exhausted while arguments remain, the excess arguments are evaluated but otherwise ignored.

The format is composed of zero or more directives from the following list:

- one or more white-space characters
- an ordinary character (not %)
- a conversion specification

Each conversion specification is introduced by the character %. After the %, the following appear in sequence:

- An optional assignment-suppressing character *.
- An optional decimal integer that specifies the maximum field width.
- An optional h, l or L indicating the size of the receiving object. The conversion characters d, l, n, o, and x can be preceded by h to indicate that the corresponding argument is a pointer to short_int rather than a pointer to int, or by l to indicate that it is a pointer to long_int. Similarly, the conversion character u can be preceded by h to indicate that the corresponding argument is a pointer to unsigned_short_int rather than a pointer to unsigned_int, or by l to indicate that it is a pointer to unsigned_long_int. Finally, the conversion character e, f, and g can be preceded by l to indicate that the corresponding argument is a pointer to double rather than a pointer to float, or by L to indicate a pointer to long_double. If an h, l, or L appears with any other conversion character, it is ignored.
- A character that specifies the type of conversion to be applied. The valid conversion characters are described in the following paragraphs.

The `scanf` function executes each directive of the format in turn. If a directive fails, as detailed below, the `scanf` function returns. Failures are described as input failures (due to the unavailability of input characters), or matching failures (due to inappropriate input).

A directive composed of white space is executed by reading input up to the first non-white-space character (which remains unread), or until no more characters can be read. A white-space directive fails if no white-space character can be found.

A directive that is an ordinary character is executed by reading the next character of the stream. If the character differs from the one comprising the directive, the directive fails, and the character remains unread.

A directive that is a conversion specification defines a set of matching input sequences, as described below for each character. A conversion specification is executed in the following steps:

- Input white-space characters (as specified by the `isspace` function) are skipped, unless the specification includes a '[', 'c,' or 'n' character.
- An input item is read from the stream, unless the specification includes an n character. An input item is defined as the longest sequence of input characters (up to any specified maximum field width) which is an initial subsequence of a matching sequence. The first character, if any, after the input item remains unread. If the length of the input item is zero, the execution of the directive fails: this condition is a matching failure, unless an error prevented input from the stream, in which case it is an input failure.
- Except in the case of a % character, the input item (or, in the case of a `%n` directive, the count of input characters) is converted to a type appropriate to the conversion character. If the input item is not a matching sequence, the execution of the directive fails: this condition is a matching failure. Unless assignment suppression was indicated by a *, the result of the conversion is placed in the object pointed to by the first argument following the format argument that has not already received a conversion result. If this object does not have an appropriate type, or if the result of the conversion cannot be represented in the space provided, the behavior is undefined.

NOTE: See "scanf Conversion Characters" for valid input information.

Synopsis

```
#include <stdio.h>
int scanf(char *format, ...);
```

Returns

The value of the macro EOF if an input failure occurs before any conversion. Otherwise, the `scanf` function returns the number of input items assigned, which can be fewer than provided for, or even zero, in the event of an early conflict between an input character and the format.

Examples

```
int i
scanf("%d", &i);
```

The following example reads in two values. `var1` is an `unsigned char` with two decimal digits, and `var2` is a `float` with three decimal place precision.

```
scanf("%2d,%f",&var1,&var2);
```

scanf Conversion Characters

d	Matches an optionally signed decimal integer, whose format is the same as expected for the subject sequence of the strtol function with the value 10 for the base argument. The corresponding argument is a pointer to integer.
i	Matches an optionally signed integer, whose format is the same as expected for the subject sequence of the strtol function with the value 0 for the base argument. The corresponding argument is a pointer to integer.
o	Matches an optionally signed octal integer, whose format is the same as expected for the subject sequence of the strtol function with the value 8 for the base argument. The corresponding argument is a pointer to integer.
u	Matches an unsigned decimal integer, whose format is the same as expected for the subject sequence of the strtol function with the value 10 for the base argument. The corresponding argument is a pointer to unsigned integer.
x	Matches an optionally signed hexadecimal integer, whose format is the same as expected for the subject sequence of the strtol function with the value of 16 for the base argument. The corresponding argument is a pointer to integer.
e,f,g	Matches an optionally signed floating-point number, whose format is the same as expected for the subject string of the strtod function. The corresponding argument is a pointer to floating.
s	Matches a sequence of non-white-space characters. The corresponding argument is a pointer to the initial character of an array large enough to accept the sequence and a terminating null character, which is added automatically.
[	Matches a sequence of expected characters (the scanset). The corresponding argument is a pointer to the initial character of an array large enough to accept the sequence and a terminating null character, which is added automatically. The conversion character includes all subsequent characters is the format string, up to and including the matching right bracket ( ]). The characters between the brackets (the scanlist) comprise the scanset, unless the character after the left bracket is a circumflex (^), in which case the scanset contains all characters that do not appear in the scanlist between the circumflex and the right bracket. As a special case, if the conversion character begins with [] or [^], the right bracket character is in the scanlist and next right bracket character is the matching right bracket that ends the specification. If a - character is in the scanlist and is neither the first nor the last character, the behavior is indeterminate.

c	Matches a sequence of characters of the number specified by the field width (1 if no field width is present in the directive). The corresponding argument is a pointer to the initial character of an array large enough to accept the sequence. No null character is added.
p	Matches a hexadecimal number. The corresponding argument is a pointer to a pointer to void.
n	No input is consumed. The corresponding argument is a pointer to integer into which is to be written the number of characters read from the input stream so far by this call to the scanf function. Execution of a %n directive does not increment the assignment count returned at the completion of execution of the `scanf` function.
%	Matches a single %; no conversion or assignment occurs.

If a conversion specification is invalid, the behavior is undefined.

The conversion characters `e`, `g`, and `x` can be capitalized. However, the use of upper case is ignored.

If end-of-file is encountered during input, conversion is terminated. If end-of-file occurs before any characters matching the current directive have been read (other than leading white space, where permitted), execution of the current directive terminates with an input failure; otherwise, unless execution of the current directive is terminated with a matching failure, execution of the following directive (if any) is terminated with an input failure.

If conversion terminates on a conflicting input character, the offending input character is left unread in the input stream. Trailing white space (including new-line characters) is left unread unless matched by a directive. The success of literal matches and suppressed assignments is not directly determinable other than using the `%n` directive.

setjmp

Saves its calling environment in its jmp_buf argument, for later use by the `longjmp` function.

Synopsis

```
#include<setjmp.h>
int setjmp(jmp_buf env);
```

Returns

If the return is from a direct invocation, the `setjmp` function returns the value zero. If the return is from a call to the `longjmp` function, the `setjmp` function returns a nonzero value.

Example

```
int i;
jmp_buf(env);
i=setjmp(env);
longjmp(env, i);
```

sin

Computes the sine of x (measured in radians). A large magnitude argument can yield a result with little or no significance.

Synopsis

```
#include <math.h>
double sin(double x);
```

Returns

The sine value.

Example

```
double x=1.24;
double y;
y=sin[x];
```

sinh

Computes the hyperbolic sine of x. A range error occurs if the magnitude of x is too large.

Synopsis

```
#include <math.h>
double sinh(double x);
```

Returns

The hyperbolic sine value.

Example

```
double x=1.24;
double y;
y=sinh(x);
```

sprintf

The `sprintf` function is equivalent to `printf`, except that the argument s specifies an array into which the generated output is to be written, rather than to a stream. A null character is written at the end of the characters written; it is not counted as part of the returned sum.

Synopsis

```
#include <stdio.h>
int sprintf(char *s, char *format, ...);
```

Returns

The number of characters written in the array, not counting the terminating null character.

Example

```
int d=51;
char buf [40];
sprint(buf,"COMPASS/%d",d);
```

sqrt

Computes the nonnegative square root of x. A domain error occurs if the argument is negative.

Synopsis

```
#include <math.h>
double sqrt(double x);
```

Returns

The value of the square root.

Example

```
double x=25.0;
double y;
y=sqrt(x);
```

srand

Uses the argument as a seed for a new sequence of pseudorandom numbers to be returned by subsequent calls to `rand`. If `srand` is then called with the same seed value, the sequence of pseudorandom numbers is repeated. If `rand` is called before any calls to `srand` have been made, the same sequence is generated as when `srand` is first called with a seed value of 1.

Synopsis

```
#include <stdlib.h>
void srand(unsigned int seed);
```

Example

```
int i;
srand(1001);
i=rand();
```

sscanf

Reads formatted data from a string.

Synopsis

```
#include <stdio.h>
int sscanf(char *s, char *format, ...);
```

Returns

The value of the macro EOF if an input failure occurs before any conversion. Otherwise, the `sscanf` function returns the number of input items assigned, which can be fewer than provided for, or even zero, in the event of an early conflict between an input character and the format.

Example

```
char buf [80];
int i;
sscanf(buf,"&d",&i);
```

strcat

Appends a copy of the string pointed to by s2 (including the terminating null character) to the end of the string pointed to by s1. The initial character of s2 overwrites the null character at the end of s1.

Synopsis

```
#include <string.h>
char *strcat(char *s1, char *s2);
```

Returns

The value of s1.

Example

```
char *ptr;
char s1[80]="Production";
char s2[]="Languages";
ptr=strcat(s1,s2);
```

strchr

Locates the first occurrence of c (converted to a `char`) in the string pointed to by s. The terminating null character is considered to be part of the string.

Synopsis

```
#include <string.h>
char *strchr(char *s, int c);
```

Returns

A pointer to the located character, or a null pointer if the character does not occur in the string.

Example

```
char *ptr;
char str[]="COMPASS";
ptr=strchr(str,'p');
```

strcmp

Compares the string pointed to by s1 to the string pointed to by s2.

Synopsis

```
#include <string.h>
int strcmp(char *s1, char *s2);
```

Returns

An integer greater than, equal to, or less than zero, according as the string pointed to by s1 is greater than, equal to, or less than the string pointed to by s2.

Example

```
char s1[]="Production";
char s2[]="Programming";
int res;
res=strcmp(s1,s2);
```

strcpy

Copies the string pointed to by s2 (including the terminating null character) into the array pointed to by s1. If copying takes place between objects that overlap, the behavior is undefined.

Synopsis

```
#include <string.h>
char *strcpy(char *s1, char *s2);
```

Returns

The value of s1.

Example

```
char s1[80], *s2;
s2=strcpy(s1,"Production");
```

strcspn

Computes the length of the initial segment of the string pointed to by s1 that consists entirely of characters not from the string pointed to by s2. The terminating null character is not considered part of s2.

Synopsis

```
#include <string.h>
size_t strcspn(char *s1, char *s2);
```

Returns

The length of the segment.

Example

```
int pos;
char s1[]="xyzabc";
char s2[]="abc";
pos=strcspn(s1,s2);
```

strlen

Computes the length of the string pointed to by s.

Synopsis

```
#include <string.h>
size_t strlen(char *s);
```

Returns

The number of characters that precede the terminating null character.

Example

```
char s1[]="COMPASS";
int i;
i=strlen(s1);
```

strncat

Appends no more than n characters of the string pointed to by s2 (not including the terminating null character) to the end of the string pointed to by s1. The initial character of s2 overwrites the null character at the end of s1. A terminating null character is always appended to the result.

Synopsis

```
#include <string.h>
char *strncat(char *s1, char *s2, size_t n);
```

Returns

The value of s1.

Example

```
char *ptr;
char strl[80]="Production";
char str2[]="Languages";
ptr=strncat(str1,str2,4);
```

strncmp

Compares no more than n characters from the string pointed to by s1 to the string pointed to by s2.

Synopsis

```
#include <string.h>
int strncmp(char *s1, char *s2, size_t n);
```

Returns

An integer greater than, equal to, or less than zero, according as the string pointed to by s1 is greater than, equal to, or less than the string pointed to by s2.

Example

```
char s1[]="Production";
char s2[]="Programming";
int res;
res=strncmp(s1,s2,3);
```

strncpy

Copies not more than n characters from the string pointed to by s2 to the array pointed to by s1. If copying takes place between objects that overlap, the behavior is undefined.

If the string pointed to by s2 is shorter than n characters, null characters are appended to the copy in the array pointed to by s1, until n characters in all have been written.

Synopsis

```
#include <string.h>
char *strncpy(char *s1, char *s2, size_t n);
```

Returns

The value of s1.

Example

```
char *ptr;
char s1[40]="Production";
char s2[]="Languages";
ptr=strncpy(s1,s2,4);
```

strpbrk

Locates the first occurrence in the string pointed to by s1 of any character from the string pointed to by s2.

Synopsis

```
#include <string.h>
char *strpbrk(char *s1, char *s2);
```

Returns

A pointer to the character, or a null pointer if no character from s2 occurs in s1.

Example

```
char *ptr;
char s1[]="COMPASS";
char s2[]="PASS";
ptr=strpbrk(s1,s2);
```

strrchr

Locates the last occurrence of c (converted to a `char`) in the string pointed to by s. The terminating null character is considered to be part of the string.

Synopsis

```
#include <string.h>
char *strrchr(char *s, int c);
```

Returns

A pointer to the character, or a null pointer if c does not occur in the string.

Example

```
char *ptr;
char s1[]="COMPASS";
ptr=strrchr(s1,'p');
```

strspn

Finds the first substring from a given character set in a string.

Synopsis

```
#include <string.h>
size_t strspn(char *s1, char *s2);
```

Returns

The length of the segment.

Example

```
char s1[]="cabbage";
char s2[]="abc";
size_t res;
res=strspn(s1,s2);
```

strstr

Locates the first occurrence of the string pointed to by s2 in the string pointed to by s1.

Synopsis

```
#include <string.h>
char *strstr(char *s1, char *s2);
```

Returns

A pointer to the located string or a null pointer if the string is not found.

Example

```
char *ptr;
char s1[]="Production Languages";
char s2[]="Lang";
ptr=strstr(s1,s2);
```

strtod

Converts the string pointed to by nptr to `double` representation. The function recognizes an optional leading sequence of white-space characters (as specified by the `isspace` function), then an optional plus or minus sign, then a sequence of digits optionally containing a decimal point, then an optional letter e or E followed by an optionally signed integer, then an optional floating suffix. If an inappropriate character occurs before the first digit following the e or E, the exponent is taken to be zero.

The first inappropriate character ends the conversion. If endptr is not a null pointer, a pointer to that character is stored in the object endptr points to; if an inappropriate character occurs before any digit, the value of nptr is stored.

The sequence of characters from the first digit or the decimal point (whichever occurs first) to the character before the first inappropriate character is interpreted as a floating constant according to the rules of this section, except that if neither an exponent part or a decimal point appears, a decimal point is assumed to follow the last digit in the string. If a minus sign appears immediately before the first digit, the value resulting from the conversion is negated.

Synopsis

```
#include <stdlib.h>
double strtod(char *nptr, char **endptr);
```

Returns

The converted value, or zero if an inappropriate character occurs before any digit. If the correct value would cause overflow, plus or minus HUGE_VAL is returned (according to the sign of the value), and the macro `errno` acquires the value ERANGE. If the correct value causes underflow, zero is returned and the macro `errno` acquires the value ERANGE.

Example

```
char *ptr;
char s[]="0.1456";
```

```
double res;
res=strtod(s,&ptr);
```

strtok

A sequence of calls to the `strtok` function breaks the string pointed to by s1 into a sequence of tokens, each of which is delimited by a character from the string pointed to by s2. The first call in the sequence has s1 as its first argument, and is followed by calls with a null pointer as their first argument. The separator string pointed to by s2 can be different from call to call.

The first call in the sequence searches s1 for the first character that is not contained in the current separator string s2. If no such character is found, there are no tokens in s1, and the `strtok` function returns a null pointer. If such a character is found, it is the start of the first token.

The `strtok` function then searches from there for a character that is contained in the current separator string. If no such character is found, the current token extends to the end of the string pointed to by s1, and subsequent searches for a token fail. If such a character is found, it is overwritten by a null character, which terminates the current token. The `strtok` function saves a pointer to the following character, from which the next search for a token starts.

Each subsequent call, with a null pointer as the value of the first argument, starts searching from the saved pointer and behaves as described in the preceding paragraphs.

Synopsis

```
#include <string.h>
char *strtok(char *s1, char *s2);
```

Returns

A pointer to the first character of a token or a null pointer if there is no token.

Example

```
#include <string.h>
static char str[] = "?a???b, , ,#c";
char *t;
t = strtok(str,"?"); /* t points to the token "a" */
t = strtok(NULL,","); /* t points to the token   "??b " */
t = strtok(NULL,"#,"); /* t points to the token "c" */
t = strtok(NULL,"?"); /* t is a null pointer */
```

strtol

Converts the string pointed to by nptr to long int representation. The function recognizes an optional leading sequence of white-space characters (as specified by the isspace function), then an optional plus or minus sign, then a sequence of digits and letters, then an optional integer suffix.

The first inappropriate character ends the conversion. If endptr is not a null pointer, a pointer to that character is stored in the object endptr points to; if an inappropriate character occurs before the first digit or recognized letter, the value of nptr is stored.

If the value of base is 0, the sequence of characters from the first digit to the character before the first inappropriate character is interpreted as an integer constant according to the rules of this section. If a minus sign appears immediately before the first digit, the value resulting from the conversion is negated.

If the value of base is between 2 and 36, it is used as the base for conversion. Letters from a (or A) through z (or Z) are ascribed the values 10 to 35; a letter whose value is greater than or equal to the value of base ends the conversion. Leading zeros after the optional sign are ignored, and leading 0x or 0X is ignored if the value of base is 16. If a minus sign appears immediately before the first digit or letter, the value resulting from the conversion is negated.

Synopsis

```
#include <stdlib.h>
long strtol(char *nptr, char **endptr, int base);
```

Returns

The converted value, or zero if an inappropriate character occurs before the first digit or recognized letter. If the correct value would cause overflow, LONG_MAX or LONG_MIN is returned (according to the sign of the value), and the macro `errno` acquires the value ERANGE.

Example

```
char *ptr;
char s[]="12345";
long res;
res=strtol(s,&ptr,10);
```

tan

The tangent of x (measured in radians). A large magnitude argument can yield a result with little or no significance.

Synopsis

```
#include <math.h>
double tan(double x);
```

Returns

The tangent value.

Example

```
double x=2.22;
double y;
y=tan(x);
```

tanh

Computes the hyperbolic tangent of x.

Synopsis

```
#include <math.h>
double tanh(double x);
```

Returns

The hyperbolic tangent of x.

Example

```
double x=2.22;
double y;
y=tanh(x);
```

tolower

Converts an uppercase letter to the corresponding lowercase letter.

Synopsis

```
#include <ctype.h>
int tolower(int c);
```

Returns

If the argument is an uppercase letter, the `tolower` function returns the corresponding lowercase letter, if any; otherwise, the argument is returned unchanged.

Example

```
char c='A';
int i;
i=tolower(c);
```

toupper

Converts a lowercase letter to the corresponding uppercase letter.

Synopsis

```
#include <ctype.h>
int toupper(int c);
```

Returns

If the argument is a lowercase letter, the `toupper` function returns the corresponding uppercase letter, if any; otherwise, the argument is returned unchanged.

Example

```
char c='a';
int i;
i=toupper(c);
```

va_arg

Expands to an expression that has the type and value of the next argument in the call. The parameter `ap` is the same as the va_list ap initialized by `va_start`. Each invocation of `va_arg` modifies `ap` so that successive arguments are returned in turn. The parameter type is a type name such that the type of a pointer to an object that has the specified type can be obtained simply by fixing a * to type. If type disagrees with the type of the actual next argument (as promoted, according to the default argument conversions, into `int`, unsigned int, or double), the behavior is undefined.

Synopsis

```
#include <stdarg.h>
type va_arg(va_list ap, type);
```

Returns

The first invocation of the `va_arg` macro after that of the `va_start` macro returns the value of the argument after that specified by parmN. Successive invocations return the values of the remaining arguments in succession.

Example

The function f1 gathers into an array a list of arguments that are pointers to strings (but not more than MAXARGS arguments), then passes the array as a single argument to function f2. The number of pointers is specified by the first argument to f1.

```
#include <stdarg.h>
extern void f2(int n, char *array[]);
#define MAXARGS 31
void f1(int n_ptrs,...) {
      va_list ap;
      char *array[MAXARGS];
      int ptr_no = 0;
      if (n_ptrs > MAXARGS)
            n_ptrs = MAXARGS;
      va_start(ap, n_ptrs);
      while (ptr_no < n_ptrs)
            array[ptr_no++] = va_arg(ap, char *);
      va_end(ap);
      f2(n_ptrs, array);
}
```

Each call to f1 has in scope the definition of the function of a declaration such as `void f1(int, ...);`

va_end

Facilitates a normal return from the function whose variable argument list was referenced by the expansion of `va_start` that initialized the `va_list ap`. The `va_end` function can modify `ap` so that it is no longer usable (without an intervening invocation of `va_start`). If the `va_end` function is not invoked before the return, the behavior is undefined.

Synopsis

```
#include <stdarg.h>
void va_end(va_list ap);
```

Example

The function f1 gathers into an array a list of arguments that are pointers to strings (but not more than MAXARGS arguments), then passes the array as a single argument to function f2. The number of pointers is specified by the first argument to f1.

```
#include <stdarg.h>
extern void f2(int n, char *array[]);
#define MAXARGS 31
void f1(int n_ptrs,...) {
      va_list ap;
      char *array[MAXARGS];
      int ptr_no = 0;
      if (n_ptrs > MAXARGS)
            n_ptrs = MAXARGS;
      va_start(ap, n_ptrs);
      while (ptr_no < n_ptrs)
            array[ptr_no++] = va_arg(ap, char *);
      va_end(ap);
      f2(n_ptrs, array);
}
```

Each call to f1 has in scope the definition of the function of a declaration such as `void f1(int, ...);`

va_start

Is executed before any access to the unnamed arguments.

The parameter `ap` points to an object that has type `va_list`. The parameter `parmN` is the identifier of the rightmost parameter in the variable parameter list in the function definition (the one just before the , ...). The `va_start` macro initializes `ap` for subsequent use by `va_arg` and `va_end`.

Synopsis

```
#include <stdarg.h>
void va_start(va_list ap, parmN);
```

Example

The function f1 gathers into an array a list of arguments that are pointers to strings (but not more than MAXARGS arguments), then passes the array as a single argument to function f2. The number of pointers is specified by the first argument to f1.

```
#include <stdarg.h>
extern void f2(int n, char *array[]);
#define MAXARGS 31
void f1(int n_ptrs,...) {
      va_list ap;
      char *array[MAXARGS];
      int ptr_no = 0;
      if (n_ptrs > MAXARGS)
            n_ptrs = MAXARGS;
      va_start(ap, n_ptrs);
      while (ptr_no < n_ptrs)
```

```
            array[ptr_no++] = va_arg(ap, char *);
      va_end(ap);
      f2(n_ptrs, array);
}
```

Each call to f1 has in scope the definition of the function of a declaration such as `void f1(int, ...);`

vprintf

Equivalent to `printf`, with the variable argument list replaced by arg, which has been initialized by the `va_start` macro (and possibly subsequent `va_arg` calls). The `vprintf` function does not invoke the `va_end` function.

Synopsis

```
#include <stdarg.h>
#include <stdio.h>
int vprintf(char *format, va_list arg);
```

Returns

The number of characters transmitted or a negative value if an output error occurred.

Example

```
va_list va;
/* initialize the variable argument va here */
vprintf("%d %d %d",va)
```

vsprintf

Equivalent to `sprintf`, with the variable argument list replaced by arg, which has been initialized by the `va_start` macro (and possibly subsequent `va_arg` calls). The `vsprintf` function does not invoke the va_end function.

Synopsis

```
#include <stdarg.h>
#include <stdio.h>
int vsprintf(char *s, char *format, va_list arg);
```

Returns

The number of characters written in the array, not counting the terminating null character.

Example

```
va_list va;
char buf[80];
```

```
/*initialize the variable argument va here*/
vsprint("%d %d %d",va);
```

Running ZDS II from the Command Line

You can run ZDS II from the command line. ZDS II generates a make file (*project*`_Debug.mak` or *project*`_Release.mak`, depending on the project configuration) every time you build or rebuild a project. For a project named `test.zdsproj` set up in the Debug configuration, ZDS II generates a make file named `test_Debug.mak` in the project directory. You can use this make file to run your project from the command line.

The following sections describe how to run ZDS II from the command line:

- "Building a Project from the Command Line" on page 399
- "Running the Assembler from the Command Line" on page 400
- "Running the Compiler from the Command Line" on page 400
- "Running the Linker from the Command Line" on page 401
- "Assembler Command Line Options" on page 402
- "Compiler Command Line Options" on page 404
- "Librarian Command Line Options" on page 407
- "Linker Command Line Options" on page 407

BUILDING A PROJECT FROM THE COMMAND LINE

To build a project from the command line, use the following procedure:

1. To see the current path, type the following in a DOS window:

   ```
   PATH
   ```

2. To set up the ZDS II bin directory (for example, `C:\PROGRA~1\ZiLOG\ZDSII_Z8Encore!_4.11.0\bin`) in the path, type the following:

   ```
   SET PATH=%PATH%;C:\Program
   Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\bin
   ```

   The make utility is available in this directory.

3. Type `PATH` again to see the new path.
4. Open the project using the IDE.

5. Export the make file for the project using the Export Makefile command in the Project menu.
6. Open a DOS window and change to the intermediate files directory.
7. Build the project using the make utility on the command line in a DOS window.

   To build a project by compiling only the changed files, use the following command:

   ```
   make -f sampleproject_Debug.mak
   ```

   To rebuild the entire project, use the following command:

   ```
   make rebuildall -f sampleproject_Debug.mak
   ```

RUNNING THE ASSEMBLER FROM THE COMMAND LINE

To run the assembler from the command line:

1. To see the current path, type the following in a DOS window:

   ```
   PATH
   ```

2. To set up the ZDS II bin directory (for example, `C:\PROGRA~1\ZiLOG\ZDSII_Z8Encore!_4.11.0\bin`) in the path, type the following:

   ```
   C:\>SET PATH=%PATH%;C:\Program
   Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\bin
   ```

   The make utility is available in this directory.

3. Type `PATH` again to see the new path.
4. Open the make file in a text editor.
5. Copy the options in the ASFLAGS section.
6. In a Command Prompt window, type the path to the assembler, the options from the ASFLAGS section (on a single line and without backslashes), and your assembly file. For example:

   ```
   ez8asm -include:"..\include" -cpu:Z8F6423 test.asm
   ```

RUNNING THE COMPILER FROM THE COMMAND LINE

To run the compiler from the command line:

1. To see the current path, type the following in a DOS window:

   ```
   PATH
   ```

2. To set up the ZDS II bin directory (for example, `C:\PROGRA~1\ZiLOG\ZDSII_Z8Encore!_4.11.0\bin`) in the path, type the following:

   ```
   SET PATH=%PATH%;C:\Program
   Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\bin
   ```

   The make utility is available in this directory.
3. Type `PATH` again to see the new path.
4. Open the make file in a text editor.
5. Copy the options in the CFLAGS section.
6. In a Command Prompt window, type the path to the compiler, the options from the CFLAGS section (on a single line and without backslashes), and your C file. For example:

```
ez8cc -cpu:Z8F6423 -define _Z8F6423 -asmsw:"-cpu:Z8F6423" test.c
```

NOTE: If you use DOS, use double quotation marks for the `-stdinc` and `-usrinc` commands for the C-Compiler. For example:

```
-stdinc:"C:\ez8\include"
```

If you use cygwin, use single quotation marks on both sides of a pair of braces for the `-stdinc` and `-usrinc` commands for the C-Compiler. For example:

```
-stdinc:'{C:\ez8\include}'
```

RUNNING THE LINKER FROM THE COMMAND LINE

To run the linker from the command line:

1. To see the current path, type the following in a DOS window:

   ```
   PATH
   ```

2. To set up the ZDS II bin directory (for example, `C:\PROGRA~1\ZiLOG\ZDSII_Z8Encore!_4.11.0\bin`) in the path, type the following:

   ```
   SET PATH=%PATH%;C:\Program
   Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\bin
   ```

   The make utility is available in this directory.
3. Type `PATH` again to see the new path.
4. Open the make file in a text editor.

5. In a Command Prompt window, type the path to the linker and your linker file. For example:

```
ez8link @"C:\Program
Files\ZiLOG\ZDSII_Z8Encore!_4.11.0\samples\F083A\F083A_ledBlink
\src\ledblink_Debug.linkcmd"
```

ASSEMBLER COMMAND LINE OPTIONS

The following table describes the assembler command line options.

NOTE: If you use DOS, use double quotation marks for the `-stdinc` and `-usrinc` commands for the C compiler. For example:

```
-stdinc:"C:\ez8\include"
```

If you use cygwin, use single quotation marks on both sides of a pair of braces for the `-stdinc` and `-usrinc` commands for the C compiler. For example:

```
-stdinc:'{C:\ez8\include}'
```

Table 8. Assembler Command Line Options

Option Name	Description
`-cpu:`*name*	Sets the CPU.
`-debug`	Generates debug information for the symbolic debugger. The default setting is `-nodebug`.
`-define:`*name*[=*value*]	Defines a symbol and sets it to the constant value. For example: `-define:DEBUG=0` This option is equivalent to the C #define statement. The alternate syntax, `-define:`*myvar*, is the same as `-define:`*myvar*`=1`.
`-genobj`	Generates an object file with the `.obj` extension. This is the default setting.
`-help`	Displays the assembler help screen.
`-igcase`	Suppresses case sensitivity of user-defined symbols. When this option is used, the assembler converts all symbols to uppercase. The default setting is `-noigcase`.
`-include:`*path*	Allows the insertion of source code from another file into the current source file during assembly.
`-list`	Generates an output listing with the `.lst` extension. This is the default setting.
`-listmac`	Expands macros in the output listing. This is the default setting.
`-listoff`	Does not generate any output in list file until a directive in assembly file sets the listing as on.
`-metrics`	Keeps track of how often an instruction is used. This is a static rather than a dynamic measure of instruction frequency.
`-name`	Displays the name of the source file being assembled.

Table 8. Assembler Command Line Options (Continued)

Option Name	Description
`-nodebug`	Does not create a debug information file for the symbolic debugger. This is the default setting.
`-nogenobj`	Does not generate an object file with the `.obj` extension. The default setting is `genobj`.
`-noigcase`	Enables case sensitivity of user-defined symbols. This is the default.
`-nolist`	Does not create a list file. The default setting is `list`.
`-nolistmac`	Does not expand macros in the output listing. The default setting is `listmac`.
`-noquiet`	Displays title and other information. This is the default.
`-nosdiopt`	Does not perform span-dependent optimizations. All size optimizable instructions use the largest instruction size. The default is `sdiopt`.
`-nowarns`	Suppresses the generation of warning messages to the screen and listing file. A warning count is still maintained. The default is to generate warning messages.
`-pagelength:`*n*	Sets the new page length for the list file. The page length must immediately follow the = (with no space between). The default is `56`. For example: `-pagelength=60`
`-pagewidth:`*n*	Sets the new page width for the list file. The page width must immediately follow the = (with no space between). The default and minimum page width is 80. The maximum page width is `132`. For example: `-pagewidth=132`
`-quiet`	Suppresses title information that is normally displayed to the screen. Errors and warnings are still displayed. The default setting is to display title information.
`-relist:`*mapfile*	Generates an absolute listing by making use of information contained in a linker map file. This results in a listing that matches linker-generated output. *mapfile* is the name of the map file created by the linker. For example: `-relist:product.map`
`-sdiopt`	Performs jump optimizations. Translates any relative jumps to absolute jumps if the target is out of range. This is the default setting.
`-version`	Prints the version number of the assembler.
`-warns`	Allows the generation of warning messages to the screen and listing file. This is the default.

COMPILER COMMAND LINE OPTIONS

The following table describes the compiler command line options.

NOTE: If you use DOS, use double quotation marks for the `-stdinc` and `-usrinc` commands for the C compiler. For example:

```
-stdinc:"C:\ez8\include"
```

If you use cygwin, use single quotation marks on both sides of a pair of braces for the `-stdinc` and `-usrinc` commands for the C compiler. For example:

```
-stdinc:'{C:\ez8\include}'
```

Table 9. Compiler Command Line Options

Option Name	Description
`-asm`	Assembles compiler-generated assembly file. This switch results in the generation of an object module. The assembly file is deleted if no assemble errors are detected and the `keepasm` switch is not given. The default is `asm`.
`-asmsw:"`*sw*`"`	Passes *sw* to the assembler when assembling the compiler-generated assembly file.
`-bfpack:[tight | normal | compatible]`	Selects the bit-field packing algorithm. The `tight` setting produces the most compact packing, which is the default. The `normal` setting allocates space in the structure that corresponds exactly to the declared type of each bit-field. The `compatible` setting produces a packing that is compatible with the less efficient algorithm that was used before ZDS II release 4.11.0. If you have an older project that uses both C and assembly code to access bit-fields, you probably need to use `-bfpack:compatible`.
`-const:[ram|rom]`	Selects where const variables are placed. The default is to place const variables in ram. This is a depreciated option; use the `rom` keyword instead of const to place const data in rom.
`-cpu:`*cpu*	Sets the CPU.
`-debug`	Generates debug information for the symbolic debugger. This is the default.
`-define:`*def*	Defines a symbol and sets it to the constant value. For example: `-define:`*myvar*`=0` The alternate syntax, `-define:`*myvar*, is the same as `-define:`*myvar*`=1`.
`-fastcall`	Pass parameters in registers.
`-fplib`	Links with the floating-point emulation library.
`-genprintf`	The format string is parsed at compile time, and direct inline calls to the lower level helper functions are generated. The default is `genprintf`.
`-help`	Displays the compiler help screen.
`-jmpopt`	Turns on application of branch optimizations.
`-keepasm`	Keeps the compiler-generated assembly file.
`-keeplst`	Keeps the assembly listing file (`.lst`).

Table 9. Compiler Command Line Options (Continued)

Option Name	Description
`-list`	Generates a `.lis` source listing file.
`-listinc`	Displays included files in the compiler listing file.
`-model:`*model*	Selects the memory model. Select `S` for the small memory model or `L` for the large memory model. The default is `L`.
`-noasm`	Does not assemble the compiler-generated assembly file.
`-nodebug`	Does not generate symbol debug information.
`-nofastcall`	Pass parameters in memory.
`-nofplib`	Does not link with floating-point emulation library.
`-nogenprint`	A call to `printf()` or `sprintf()` parses the format string at run time to generate the required output.
`-nojmpopt`	Turns off application of branch optimizations.
`-nokeepasm`	Deletes the compiler-generated assembly file. This is the default.
`-nokeeplst`	Does not keep the assembly listing file (`.lst`). This is the default.
`-nolist`	Does not produce a source listing. All errors are identified on the console. This is the default.
`-nolistinc`	Does not show include files in the compiler listing file. This is the default.
`-nooptlink`	Sets the call frame as dynamic. This is the default.
`-nopromote`	Turns off ANSI promotion. The `-nopromote` option is deprecated.
`-noquiet`	Displays the title information. This is the default.
`-noreduceopt`	Perform all the optimizations. This is the default. **Note:** Debugging is allowed when this option is selected. With `-noredeuceopt` and `-debug`, the program can still be debugged, but it might be limited for some cases
`-noregvar`	Turns off the use of register variables.
`-optlink`	Sets the call frame as static.
`-promote`	Turns on ANSI promotion. This is the default.
`-quiet`	Suppresses title information that is normally displayed to the screen. Errors and warnings are still displayed.
`-reduceopt`	Reduces optimization for easier debugging. The default is `noreduceopt`. **Note:** Debugging is allowed when this option is not selected. With `-noredeuceopt` and `-debug`, the program can still be debugged, but it might be limited for some cases.
`-regvar[:`*val*`]`	Specifies the number of registers used for variables. The default is 8 registers.

Table 9. Compiler Command Line Options (Continued)

Option Name	Description
`-stdinc:"`*path*`"`	Sets the path for the standard include files. This defines the location of include files using the `#include <`*file*`.h>` syntax. Multiple paths are separated by semicolons. For example: `-stdinc:"c:\rtl;c:\myinc"` In this example, the compiler looks for the include file in 1. the project directory 2. the `c:\rtl` directory 3. the `c:\myinc` directory 4. the default directory If the file is not found after searching the entire path, the compiler flags an error. The default standard includes are located in the following directories: *<ZDS Installation Directory>*`\include\zilog` where *<ZDS Installation Directory>* is the directory in which Zilog Developer Studio was installed. By default, this is `C:\Program Files\ZiLOG\ZDSII_Z8Encore!_`*<version>*, where *<version>* might be `4.11.0` or `5.0.0`. Omitting this switch tells the compiler to search only the current and default directories.
`-usrinc:"`*path*`"`	Sets the search path for user include files. This defines the location of include files using the `#include "`*file*`.h"` syntax. Multiple paths are separated by semicolons. For example: `-usrinc:"c:\rtl;c:\myinc"` In this example, the compiler looks for the include file in 1. the project directory 2. the `c:\rtl` directory 3. the `c:\myinc` directory 4. the directory of the file from where the file is included 5. the directories listed under the `-stdinc` command 6. the default directory If the file is not found after searching the entire path, the compiler flags an error. Omitting this switch tells the compiler to search only the current directory.
`-version`	Prints the version number of the compiler.

LIBRARIAN COMMAND LINE OPTIONS

The following table describes the librarian command line options.

Table 10. Librarian Command Line Options

Option Name	Description
`@file`	Takes options from a file. (This option can be used only on the command line, not inside a file.)
`-help`	Displays the librarian help screen.
`Libfile=`	Specifies the library to create, modify, or extract from. This must precede any commands to modify or read from a library.
`List`	Instructs the librarian to list the contents of the library. **Note:** The command is `list`, or `LIST`, not `-list`.
`-noquiet`	Displays the title information.
`-nowarn`	Suppresses warning messages.
`+objectfile`	Instructs the librarian to add objectfile to the library. (If object file is already there, generates a message and ignores the command.)
`-+objectfile`	Instructs the librarian to remove objectfile from the library if necessary, then to add the new version.
`-objectfile`	Instructs the librarian to mark objectfile for removal from the library. (Removal does not actually occur until a rebuild command.)
`*objectfile`	Instructs the librarian to extract objectfile from the library.
`-quiet`	Suppresses title information that is normally displayed to the screen. Errors and warnings are still displayed. The default setting is to display title information.
`Rebuild`	Instructs the librarian to rebuild the library, removing any object files marked for removal and otherwise compacting the library.
`-version`	Displays the version number of the librarian.
`-warn`	Displays warnings.

LINKER COMMAND LINE OPTIONS

See “Using the Linker/Locator” on page 275 for the structure of the command file.

Using the Command Processor

The Command Processor allows you to use commands or script files to automate the execution of a significant portion of the integrated development environment (IDE). This section covers the following topics:

- "Sample Command Script File" on page 412
- "Supported Script File Commands" on page 413
- "Running the Flash Loader from the Command Processor" on page 434

You can run commands in one of the following ways:

- Using the Command Processor toolbar in the IDE.

  Commands entered into the Command Processor toolbar are executed after you press the Enter (or Return) key or click the Run Command button. The toolbar is described in "Command Processor Toolbar" on page 22.

- Using the `batch` command to run a command script file from the Command Processor toolbar.

  For example:

  ```
  batch "c:\path\to\command\file\runall.cmd"
  batch "commands.txt"
  ```

- Passing a command script file to the IDE when it is started.

  You need to precede the script file with an at symbol (`@`) when passing the command file to the IDE on the command line. For example:

  ```
  zds2ide @c:\path\to\command\file\runall.cmd
  zds2ide @commands.txt
  ```

Processed commands are echoed, and associated results are displayed in the Command Output window in the IDE and, if logging is enabled (see "log" on page 421), in the log file as well.

Commands are not case sensitive.

In directory or path-based parameters, you can use `\`, `\\`, or `/` as separators as long as you use the same separator throughout a single parameter. For example, the following examples are legal:

```
cd "..\path\to\change\to"
cd "..\\path\\to\\change\\to"
cd "../path/to/change/to"
```

The following examples are illegal:

```
cd "..\path/to\change/to"
cd "..\\path\to\change\to"
```

The following table lists ZDS II menu commands and dialog box options that have corresponding script file commands.

Table 11. Script File Commands

ZDS II Menus	ZDS II Commands	Dialog Box Options	Script File Commands	Location
File	New Project		new project	page 422
	Open Project		open project	page 423
	Exit		exit	page 420
Edit	Manage Breakpoints	 Go to Code Enable All Disable All Remove Remove All	list bp cancel bp cancel all	page 421 page 415 page 414
Project	Add Files		add file	page 413
	Project Settings (General page)	CPU Family CPU Show Warnings Generate Debug Information Ignore Case of Symbols (only available for Assembly Only projects) Intermediate Files Directory	 option general cpu option general warn option general debug option general igcase option general outputdir	page 426
	Project Settings (Assembler page)	Includes Defines Generate Listing Files (.lst) Expand Macros Page Width Page Length Jump Optimization	option assembler include option assembler define option assembler list option assembler listmac option assembler pagewidth option assembler pagelen option assembler sdiopt	page 424
	Project Settings (Code Generation page)	Safest Small and Debuggable Smallest Possible User Defined Limit Optimizations for Easier Debugging Memory Model Frames Parameter Passing	option compiler codegen option compiler codegen option compiler codegen option compiler codegen option compiler reduceopt option compiler model option compiler optlink option compiler fastcall	page 425

Table 11. Script File Commands (Continued)

ZDS II Menus	ZDS II Commands	Dialog Box Options	Script File Commands	Location
	Project Settings (Listing Files page)	Generate C Listing Files (.lis) With Include Files Generate Assembly Source Code Generate Assembly Listing Files (.lst)	option compiler list option compiler listinc option compiler keepasm option compiler keeplst	page 425
	Project Settings (Preprocessor page)	Preprocessor Definitions Standard Include Path User Include Path	option compiler define option compiler stdinc option compiler usrinc	page 425
	Project Settings (Advanced page)	Use Register Variables Generate Printfs Inline Bit-Field Packing	option compiler regvar option compiler genprintf option compiler bfpack	page 425
	Project Settings (Deprecated page)	Place Const Variables in ROM Disable ANSI Promotions	option compiler const option compiler promote	page 425
	Project Settings (Librarian page)	Output File Name	option librarian outfile	page 427
	Project Settings (ZSL page)	Include Zilog Standard Library (Peripheral Support) Ports Uarts	option middleware usezsl option middleware zslports option middleware zsluarts	page 429
	Project Settings (Commands page)	Always Generate from Settings Additional Directives Edit (Additional Linker Directives dialog box) Use Existing	option linker createnew option linker useadddirective option linker directives option linker linkctlfile	page 427
	Project Settings (Objects and Libraries page) (only available for Static Library projects)	Additional Object/Library Modules Standard Included in Project Use Standard Startup Linker Commands C Runtime Library Floating Point Library Zilog Standard Library (Peripheral Support)	option linker objlibmods option linker startuptype option linker startuptype option linker startuplnkcmds option linker usecrun option linker fplib option middleware usezsl	page 427 page 429

Table 11. Script File Commands (Continued)

ZDS II Menus	ZDS II Commands	Dialog Box Options	Script File Commands	Location
	Project Settings (Address Spaces page)	ROM RData EData NVDS (only available for Z8 Encore! XP 4K and 16K devices) Use PRAM checkbox Use PRAM field (PRAM is only available for the Z8 Encore! XP F1680 series)	option linker rom option linker rdata option linker edata option linker nvds option linker praminuse option linker pram	page 427
	Project Settings (Warnings page)	Treat All Warnings as Fatal Treat Undefined Symbols as Fatal Warn on Segment Overlap	option linker warnisfatal option linker undefisfatal option linker warnoverlap	page 427
	Project Settings (Output page)	Output File Name Generate Map File Sort Symbols By Show Absolute Addresses in Assembly Executable Formats Fill Unused Hex File Bytes with 0xFF Maximum Bytes per Hex File Line	option linker of option linker map option linker sort option linker relist option linker exeform option linker padhex option linker maxhexlen	page 427
	Project Settings (Debugger page)	Use Page Erase Before Flashing Target Setup Add Copy Delete Debug Tool Setup	 target set target options target create target copy debugtool set debugtool set	 page 433 page 433 page 432 page 431 page 417 page 417
	Export Makefile		makfile makefile	page 422 page 422
Build	Build		build	page 414
	Rebuild All		rebuild	page 430
	Stop Build		stop	page 431
	Set Active Configuration		set config	page 430
	Manage Configurations		set config delete config	page 430
Debug	Stop Debugging		quit	page 429

Table 11. Script File Commands (Continued)

ZDS II Menus	ZDS II Commands	Dialog Box Options	Script File Commands	Location
	Reset		reset	page 430
	Go		go	page 421
	Break		stop	page 431
	Step Into		stepin	page 431
	Step Over		step	page 431
	Step Out		stepout	page 431
Tools	Flash Loader			page 434
	Calculate File Checksum		checksum	page 415
	Show CRC		crc	page 415

SAMPLE COMMAND SCRIPT FILE

A script file is a text-based file that contains a collection of commands. The file can be created with any editor that can save or export files in a text-based format. Each command must be listed on its own line. Anything following a semicolon (`;`) is considered a comment.

The following is a sample command script file:

```
; change to correct default directory
cd "m:\Z8Encore\test\focustests"
open project "focus1.zdsproj"
log "focus1.log" ; Create log file
log on ; Enable logging
rebuild
reset
bp done
go
wait 2000 ; Wait 2 seconds
print "pc = %x" reg PC
log off ; Disable logging
quit ; Exit debug mode
close project
wait 2000
open project "focus2.zdsproj"
reset
bp done
go
wait 2000 ; Wait 2 seconds
```

```
log "focus2.log" ; Open log file
log on ; Enable logging
print "pc = %x" reg PC
log off ; Disable logging
quit
exit; Exit debug mode
```

This script consecutively opens two projects, sets a breakpoint at label `done`, runs to the breakpoint, and logs the value of the PC register. After the second project is complete, the script exits the IDE. The first project is also rebuilt.

SUPPORTED SCRIPT FILE COMMANDS

The Command Processor supports the following script file commands:

add file	delete config	savemem
batch	examine (?) for Expressions	set config
bp	examine (?) for Variables	step
build	exit	stepin
cancel all	fillmem	stepout
cancel bp	go	stop
cd	list bp	target copy
checksum	loadmem	target create
crc	log	target get
debugtool copy	makfile or makefile	target help
debugtool create	new project	target list
debugtool get	open project	target options
debugtool help	option	target save
debugtool list	print	target set
debugtool save	pwd	target setup
debugtool set	quit	wait
debugtool setup	rebuild	wait bp
defines	reset	

In the following syntax descriptions, items enclosed in angle brackets (< >) need to be replaced with actual values, items enclosed in square brackets ([ ]) are optional, double quotes (") indicate where double quotes must exist, and all other text needs to be included as is.

add file

The `add file` command adds the given file to the currently open project. If the full path is not supplied, the current working directory is used. The following is the syntax of the `add file` command:

`add file` "<[*path*\]<*filename*>"

For example:

```
add file "c:\project1\main.c"
```

batch

The `batch` command runs a script file through the Command Processor. If the full path is not supplied, the current working directory is used. The following is the syntax of the `batch` command:

`batch` [`wait`] "<[*path*\]<*filename*>"

`<wait>`	blocks other executing batch files until the invoked batch file is completed—useful when nesting batch files

For example:

```
BATCH "commands.txt"
batch wait "d:\batch\do_it.cmd"
```

bp

The `bp` command sets a breakpoint at a given label in the active file. The syntax can take one of the following forms:

`bp line` <*line number*>

sets/removes a breakpoint on the given line of the active file.

`bp` <*symbol*>

sets a breakpoint at the given symbol. This version of the `bp` command can only be used during a debug session.

For example:

```
bp main
bp line 20
```

build

The build command builds the currently open project based on the currently selected project build configuration. This command blocks the execution of other commands until the build process is complete. The following is the syntax of the `build` command:

```
build
```

cancel all

The `cancel all` command clears all breakpoints in the active file. The following is the syntax of the `cancel all` command:

```
cancel all
```

cancel bp

The `cancel bp` command clears the breakpoint at the bp list index. Use the `list bp` command to retrieve the index of a particular breakpoint. The following is the syntax of the `cancel bp` command:

`cancel bp` <*index*>

For example:

```
cancel bp 3
```

cd

The `cd` command changes the working directory to *dir*. The following is the syntax of the `cd` command:

`cd` "<*dir*>"

For example:

```
cd "c:\temp"
cd "../another_dir"
```

checksum

The `checksum` command calculates the checksum of a hex file. The following is the syntax of the `checksum` command:

`checksum` "<*filename*>"

For example, if you use the following command:

```
checksum "ledblink.hex"
```

The file checksum for the example is:

```
0xCEA3
```

crc

The `CRC` command performs a cyclic redundancy check (CRC). The syntax can take one of two forms:

- `crc`

  calculates the CRC for the whole Flash memory.

- `crc STARTADDRESS="<`*`address`*`>" ENDADDRESS="<`*`endaddress`*`>"`

  calculates the CRC for 4K-increment blocks. `STARTADDRESS` must be on a 4K boundary; if the address is not on a 4K boundary, ZDS II produces an error message. `ENDADDRESS` must be a 4K increment; if the end address is not a 4K increment, it is rounded up to a 4K increment.

For example:

```
crc STARTADDRESS="1000" ENDADDRESS="1FFF"
```

debugtool copy

The `debugtool copy` command creates a copy of an existing debug tool with the given new name. The syntax can take one of two forms:

- `debugtool copy NAME="<`*`new debug tool name`*`>"`

  creates a copy of the active debug tool named the value given for `NAME`.
- `debugtool copy NAME="<`*`new debug tool name`*`>" SOURCE="<`*`existing debug tool name`*`>"`

  creates a copy of the `SOURCE` debug tool named the value given for `NAME`.

For example:

```
debugtool copy NAME="Sim3" SOURCE="eZ80190"
```

debugtool create

The `debugtool create` command creates a new debug tool with the given name and using the given communication type: `usb`, `tcpip`, `ethernet`, or `simulator`. The following is the syntax of the `debugtool create` command:

`debugtool create NAME="`<*debug tool name*>`" COMMTYPE="`<*comm type*>`"`

For example:

```
debugtool create NAME="emulator2" COMMTYPE="ethernet"
```

debugtool get

The `debugtool get` command displays the current value for the given data item for the active debug tool. Use the `debugtool setup` command to view available data items and current values. The following is the syntax of the `debugtool get` command:

`debugtool get "`<*data item*>`"`

For example:

```
debugtool get "ipAddress"
```

debugtool help

The `debugtool help` command displays all debugtool commands. The following is the syntax of the `debugtool help` command:

```
debugtool help
```

debugtool list

The `debugtool list` command lists all available debug tools. The syntax can take one of two forms:

- `debugtool list`

  displays the names of all available debug tools.

- `debugtool list COMMTYPE="<type>"`

  displays the names of all available debug tools using the given communications type: `usb`, `tcpip`, `ethernet`, or `simulator`.

For example:

```
debugtool list COMMTYPE="ethernet"
```

debugtool save

The `debugtool save` command saves a debug tool configuration to disk. The syntax can take one of two forms:

- `debugtool save`

  saves the active debug tool.

- `debugtool save NAME ="<Debug Tool Name>"`

  saves the given debug tool.

For example:

```
debugtool save NAME="USBSmartCable"
```

debugtool set

The `debugtool set` command sets the given data item to the given data value for the active debug tool or activates a particular debug tool. The syntax can take one of two forms:

- `debugtool set "<data item>" "<new value>"`

  sets *data item* to *new value* for the active debug tool. Use `debugtool setup` to view available data items and current values.

  For example:

  ```
  debugtool set "ipAddress" "123.456.7.89"
  ```

- `debugtool set "<debug tool name>"`

  activates the debug tool with the given name. Use `debugtool list` to view available debug tools.

debugtool setup

The `debugtool setup` command displays the current configuration of the active debug tool. The following is the syntax of the `debugtool setup` command:

```
debugtool setup
```

defines

The `defines` command provides a mechanism to add to, remove from, or replace define strings in the compiler preprocessor defines and assembler defines options. This command provides a more flexible method to modify the defines options than the `option` command, which requires that the entire defines string be set with each use. Each `defines` parameter is a string containing a *single* define symbol, such as `"TRACE"` or `"_SIMULATE=1"`. The `defines` command can take one of three forms:

- `defines <compiler|assembler> add "<new define>"`

  adds the given define to the compiler or assembler defines, as indicated by the first parameter.
- `defines <compiler|assembler> replace "<new define>" "<old define>"`

  replaces <*old define*> with <*new define*> for the compiler or assembler defines, as indicated by the first parameter. If <*old define*> is not found, no change is made.
- `defines <compiler|assembler> remove "<define to be removed>"`

  removes the given define from the compiler or assembler defines, as indicated by the first parameter.

For example:

```
defines compiler add "_TRACE"
defines assembler add "_TRACE=1"
defines assembler replace "_TRACE" "_NOTRACE"
defines assembler replace "_TRACE=1" "_TRACE=0"
defines compiler remove "_NOTRACE"
```

delete config

The `delete config` command deletes the given existing project build configuration. The following is the syntax of the `delete config` command:

`delete config` "<*config_name*>"

If <*config_name*> is active, the first remaining build configuration, if any, is made active. If <*config_name*> does not exist, no action is taken.

For example:

```
delete config "MyDebug"
```

examine (?) for Expressions

The examine command evaluates the given expression and displays the result. It accepts any legal expression made up of constants, program variables, and C operators. The examine command takes the following form:

```
? [<data_type>] [<radix>] <expr> [:<count>]
```

<data_type> can consist of one of the following types:

```
short
int[eger]
long
ascii
asciz
```

<radix> can consist of one of the following types:

```
dec[imal]
hex[adecimal]
oct[al]
bin[ary]
```

Omitting a *<data_type>* or *<radix>* results in using the `$data_type` or `$radix` pseudo-variable, respectively.

[:*<count>*] represents the number of items to display.

The following are examples:

```
? x
```

shows the value of x using `$data_type` and `$radix`.

```
? ascii STR
```

shows the ASCII string representation of STR.

```
? 0x1000
```

shows the value of 0x1000 in the `$data_type` and `$radix`.

```
? *0x1000
```

shows the byte at address 0x1000.

```
? *0x1000 :25
```

shows 25 bytes at address 0x1000.

```
? L0
```

shows the value of register D0:0 using `$data_type` and `$radix`.

```
? asciz D0:0
```

shows the null-terminated string pointed to by the contents of register D0:0.

examine (?) for Variables

The examine command displays the values of variables. This command works for values of any type, including arrays and structures. The following is the syntax:

`?` *<expression>*

The following are examples:

To see the value of z, enter

```
?z
```

To see the nth value of array x, enter

```
? x[n]
```

To see all values of array x, enter

```
?x
```

To see the nth through the n+5th values of array x, enter

```
?x[n]:5
```

If x is an array of pointers to strings, enter

```
? asciz *x[n]
```

NOTE: When displaying a structure's value, the examine command also displays the names of each of the structure's elements.

exit

The `exit` command exits the IDE. The following is the syntax of the `exit` command:

```
exit
```

fillmem

The `fillmem` command fills a block of a specified memory space with the specified value. The functionality is similar to the Fill Memory command available from the context menu in the Memory window (see “Filling Memory” on page 317). The following is the syntax of the `fillmem` command:

```
fillmem SPACE="<displayed spacename>" FILLVALUE="<hexcadecimal value>"
   [STARTADDRESS="<hexadecimal address>"] [ENDADDRESS="<hexadecimal address>"]
```

If `STARTADDRESS` and `ENDADDRESS` are not specified, all the memory contents of a specified space are filled.

For example:

```
fillmem SPACE="ROM" VALUE="AA"
fillmem SPACE="ROM" VALUE="AA" STARTADDRESS="1000" ENDADDRESS="2FFF"
```

go

The `go` command executes the program code from the current program counter until a breakpoint or, optionally, a symbol is encountered. This command starts a debug session if one has not been started. The `go` command can take one of the following forms:

- `go`

  Resumes execution from the current location.

- `go` <*symbol*>

  Resumes execution from the current location and stops at the address associated with the given symbol, assuming the given symbol is valid and available. If the symbol is not found, the command has no effect. This version of the `go` command can only be used during a debug session.

The following are examples:

```
go
go myfunc
```

list bp

The `list bp` command displays a list of all of the current breakpoints of the active file. The following is the syntax of the `list bp` command:

```
list bp
```

loadmem

The `loadmem` command loads the data of an Intel hex file, a binary file, or a text file to a specified memory space at a specified address. The functionality is similar to the Load from File command available from the context menu in the Memory window (see “Loading from a File” on page 319). The following is the syntax of the `loadmem` command:

```
loadmem SPACE="<displayed spacename>" FORMAT=<HEX | BIN |TEXT> "<[PATH\]name>"
   [STARTADDRESS="<hexadecimal address>"]
```

If `STARTADDRESS` is not specified, the data is loaded at the memory lower address.

For example:

```
loadmem SPACE="RDATA" FORMAT=BIN "c:\temp\file.bin" STARTADDRESS="20"
loadmem SPACE="ROM" FORMAT=HEX "c:\temp\file.hex"
loadmem SPACE="ROM" FORMAT=TEXT "c:\temp\file.txt" STARTADDRESS="1000"
```

log

The `log` command manages the IDE’s logging feature. The `log` command can take one of three forms:

- `log "<[`*`path`*`\]`*`filename`*`>" [APPEND]` sets the file name for the script file. If `APPEND` is not provided, an existing log file with the same name is truncated when the log is next activated.

- `log on`

  activates the logging of data.
- `log off`

  deactivates the logging of data.

For example:

```
log "buildall.log"
log on
log off
```

makfile or makefile

The `makfile` and `makefile` commands export a make file for the current project. The syntax can take one of two forms:

- `makfile "<[path\]file name>"`
- `makefile "<[path\]file name>"`

If *path* is not provided, the current working directory is used.

For example:

```
makfile "myproject.mak"
makefile "c:\projects\test.mak"
```

new project

The `new project` command creates a new project designated by *project_name*, *target*, and the type supplied. If the full path is not supplied, the current working directory is used. By default, existing projects with the same name are replaced. Use `NOREPLACE` to prevent the overwriting of existing projects. The syntax can take one of the following forms:

- `new project "<[path\]name>" "<target>" "<exe|lib>" ["<cpu>"] [NOREPLACE]`

```
new project "<[path\]name>" "<target>" "<project type>"
"<exe|lib>" "<cpu>" [NOREPLACE]
```

where

- <*name*> is the path and name of the new project. If the path is not provided, the current working directory is assumed. Any file extension can be used, but none is required. If not provided, the default extension of `.zdsproj` is used.
- <*target*> *must* match that of the IDE (that is, the Z8 Encore! IDE can only create Z8 Encore! based projects).

- `<exe|lib>` The type parameter must be either `exe` (Executable) or `lib` (Static Library).
- ["<*cpu*>"] is the name of the CPU to configure for the new project.
- "<*project type*>" can be `"Standard"` or `"Assembly Only"`. `Standard` is the default.
- `NOREPLACE` Optional parameter to use to prevent the overwriting of existing projects

For example:

```
new project "test1.zdsproj" "Z8Encore" "exe"
new project "test1.zdsproj" "Z8Encore" "exe" NOREPLACE
```

open project

The `open project` command opens the project designated by *project_name*. If the full path is not supplied, the current working directory is used. The command fails if the specified project does not exist. The following is the syntax of the `open project` command:

`open project` "<*project_name*>"

For example:

```
open project "test1.zdsproj"
open project "c:\projects\test1.zdsproj"
```

option

The `option` command manipulates project settings for the active build configuration of the currently open project. Each call to `option` applies to a single tool but can set multiple options for the given tool. The following is the syntax for the `option` command:

`option` <*tool_name*> *expr1 expr2 . . . exprN*,

where

expr is (<*option name*> = <*option value*>)

For example:

```
option general debug = TRUE
option compiler debug = TRUE keeplst = TRUE
option debugger readmem = TRUE
option linker igcase = "FALSE"

option linker rom = 0000-FFFF
option general cpu=z8f64
```

NOTE: Many of these script file options are also available from the command line. For more details, see “Running ZDS II from the Command Line” on page 399.

The following table lists some command line examples and the corresponding script file commands.

Table 12. Command Line Examples

Script File Command Examples	Corresponding Command Line Examples
`option compiler keepasm = TRUE`	`eZ8cc -keepasm`
`option compiler keepasm = FALSE`	`eZ8cc -nokeepasm`
`option compiler const = RAM`	`eZ8cc -const:RAM`
`option general debug = TRUE`	`eZ8asm -debug`
`option linker igcase = "FALSE"`	`eZ8link -NOigcase`
`option librarian warn = FALSE`	`eZ8lib -nowarn`

The following script file options are available:

- "Assembler Options" on page 424
- "Compiler Options" on page 425
- "Debugger Options" on page 426
- "General Options" on page 426
- "Librarian Options" on page 427
- "Linker Options" on page 427
- "ZSL Options" on page 429

Assembler Options

Table 13. Assembler Options

Option Name	Description or Corresponding Option in Project Settings Dialog Box	Acceptable Values
`define`	Assembler page, Defines field	string (separate multiple defines with semicolons)
`include`	Assembler page, Includes field	string (separate multiple paths with semicolons)
`list`	Assembler page, Generate Assembler Listing Files (.lst) check box	TRUE, FALSE
`listmac`	Assembler page, Expand Macros check box	TRUE, FALSE
`pagelen`	Assembler page, Page Length field	integer

Table 13. Assembler Options (Continued)

Option Name	Description or Corresponding Option in Project Settings Dialog Box	Acceptable Values
`pagewidth`	Assembler page, Page Width field	integer
`quiet`	Toggles quiet assemble.	TRUE, FALSE
`sdiopt`	Assembler page, Jump Optimization check box Toggles Jump Optimization.	TRUE, FALSE

Compiler Options

Table 14. Compiler Options

Option Name	Description or Corresponding Option in Project Settings Dialog Box	Acceptable Values
`bfpack`	Advanced page, Bit-Field Packing field	“tight”, “compatible”
`codegen`	Code Generation page; Safest, Small and Debuggable, Smallest Possible, and User Defined buttons	“safest”, “smalldebug”, “smallest”, “userdefined”
`const`	Deprecated page, Place Const Variables in ROM Selects where const variables are placed. For example: `option compiler const=RAM`	'ROM', 'RAM'
`define`	Preprocessor page, Preprocessor Definitions field	string (separate multiple defines with semicolons)
`fastcall`	Code Generation page, Parameter Passing drop-down list box Select “true” for register parameter passing or “false” for memory parameter passing.	“true”, “false”
`genprintf`	Advanced page, Generate Printfs Inline check box	TRUE, FALSE
`keepasm`	Listing Files page, Generate Assembly Source Code check box	
`keeplst`	Listing Files page, Generate Assembly Listing Files (.lst) check box	TRUE, FALSE
`list`	Listing Files page, Generate C Listing Files (.lis) check box	TRUE, FALSE
`listinc`	Listing Files page, With Include Files check box Only applies if `list` option is currently true.	TRUE, FALSE

Table 14. Compiler Options (Continued)

Option Name	Description or Corresponding Option in Project Settings Dialog Box	Acceptable Values
`model`	Code Generation page, Model Selects the memory model. Select `S` for a small memory model, which is the most efficient model. Select `L` for a large memory model, which is less efficient than the small model. The default is `L`.	'L', 'Large', 'S', 'Small'
`optlink`	Code Generation page, Frames Uses a static frame for local variables and function arguments. This switch is required if the supplied run-time library is used. Although this switch is not required in other cases, it results in smaller, faster executables by minimizing use of the stack.	TRUE (for static frames), FALSE (for dynamic frames)
`optspeed`	Toggles optimizing for speed.	TRUE (optimize for speed), FALSE (optimize for size)
`promote`	Deprecated page, Disable ANSI Promotions check box **NOTE:** This option is deprecated.	TRUE, FALSE (FALSE disables the ANSI promotions)
`reduceopt`	Code Generation page, Limit Optimizations for Easier Debugging check box	TRUE, FALSE
`regvar`	Advanced page, Use Register Variables	'off', 'normal', 'aggressive'
`stdinc`	Preprocessor page, Standard Include Path field	string (separate multiple paths with semicolons)
`usrinc`	Preprocessor page, User Include Path field	string (separate multiple paths with semicolons)

Debugger Options

For debugger options, use the `target help` and `debugtool help` commands.

General Options

Table 15. General Options

Option Name	Corresponding Option in Project Settings Dialog Box	Acceptable Values
`cpu`	General page, CPU drop-down field Sets the CPU.	string (valid CPU name)

Table 15. General Options (Continued)

Option Name	Corresponding Option in Project Settings Dialog Box	Acceptable Values
`debug`	General page, Generate Debug Information check box	TRUE, FALSE
`igcase`	General page, Ignore Case of Symbols check box	TRUE, FALSE
`outputdir`	General page, Intermediate Files Directory field Sets the output directory.	string (path)
`warn`	General page, Show Warnings check box	TRUE, FALSE

Librarian Options

Table 16. Librarian Options

Option Name	Corresponding Option in Project Settings Dialog Box	Acceptable Values
`outfile`	Librarian page, Output File Name field Sets the output file name for the built library.	string (library file name with option path)

Linker Options

Table 17. Linker Options

Option Name	Description or Corresponding Option in Project Settings Dialog Box	Acceptable Values
`createnew`	Commands page, Always Generate from Settings button	TRUE, FALSE
`directives`	Additional Linker Directives dialog box Contains the text for additional directives. This is ignored if `useadddirective` is `false`.	string
`edata`	Address Spaces page, EData field Sets the size range for the EDATA memory space.	string (min–max, for example, “0000–FFFF”
`exeform`	Output page, Executable Formats area Sets the resulting executable format.	string: “IEEE 695” or "Intel Hex32"
`fplib`	Objects and Libraries page, Floating Point Library drop-down list box	string (“real”, “dummy”, or “none”)
`linkctlfile`	Sets the linker command file (path and) name. The value is only used when `createnew` is set to `1`.	string
`map`	Output page, Generate Map File check box Toggles map file generation.	TRUE, FALSE
`maxhexlen`	Output page, Maximum Bytes per Hex File Line check box	16, 32, 64, or 128

Table 17. Linker Options (Continued)

Option Name	Description or Corresponding Option in Project Settings Dialog Box	Acceptable Values
`nvds`	Address Spaces page, NVDS field Sets the size range for the NVDS memory space.	string (min–max, for example, "00–FF")
`objlibmods`	Objects and Libraries page, Additional Object/Library Modules field Sets the object/library modules to be linked into the result file.	string (separate multiple modules names with commas)
`of`	Output page, Output File Name field Sets the output file (path and) name.	string (path and file name, excluding file extension)
`padhex`	Output page, Fill Unused Hex File Bytes with 0xFF check box	TRUE, FALSE
`pram`	Address Spaces page, Use PRAM field	string (min–max, for example, "00–FF")
`praminuse`	Address Spaces page, Use PRAM check box Valid for the Z8 Encore! XP F1680 Series devices only	true, false
`rdata`	Address Spaces page, RData field	string (min–max, for example, "00–FF")
`relist`	Output page, Show Absolute Addresses in Assembly Listings check box	TRUE, FALSE
`rom`	Address Spaces page, ROM field Sets the size range for the ROM memory space.	string (min–max, for example, "00–FF")
`sort`	Output page, Sort Symbols By buttons	string
`startuplnkcmds`	Objects and Libraries page, Use Standard Startup Linker Commands check box	string ("standard" or "included")
`startuptype`	Objects and Libraries page, C Startup Module area	string ("standard" or "included")
`useadddirectives`	Commands page, Additional Directives check box	TRUE, FALSE
`usecrun`	Objects and Libraries page, C Runtime Library check box Toggles the inclusion of the C run-time library.	TRUE, FALSE
`undefisfatal`	Warnings page, Treat Undefined Symbols as Fatal check box	TRUE, FALSE
`warnisfatal`	Warnings page, Treat All Warnings as Fatal check box	TRUE, FALSE
`warnoverlap`	Warnings page, Warn on Segment Overlap check box	TRUE, FALSE

ZSL Options

For ZSL options, the *tool_name* is `middleware`. For example:

```
option middleware usezsl = TRUE
```

Table 18. ZSL Options

Option Name	Corresponding Option in Project Settings Dialog Box	Acceptable Values
`usezsl`	ZSL page, Include Zilog Standard Library (Peripheral Support) check box or Objects and Libraries page, Zilog Standard Library (Peripheral Support) check box	TRUE, FALSE
`zslports`	ZSL page, Ports area	comma-delimited string (“Port A,Port D”)
`zsluarts`	ZSL page, Uarts area	comma-delimited string (“UART0,UART1”)

print

The `print` command writes formatted data to the Command Output window and the log (if the log is enabled). Each expression is evaluated, and the value is inserted into the *format_string*, which is equivalent to that supported by a C language `printf`. The following is the syntax of the `print` command:

`print` "<*format_string*>" *expression1 expression2 ... expressionN*

For example:

```
PRINT "the pc is %x" REG PC
print "pc: %x, sp: %x" REG PC REG SP
```

pwd

The `pwd` command retrieves the current working directory. The following is the syntax of the `pwd` command:

```
pwd
```

quit

The `quit` command exits the current debug session. The following is the syntax of the `quit` command:

```
quit
```

rebuild

The `rebuild` command rebuilds the currently open project. This command blocks the execution of other commands until the build process is complete. The following is the syntax of the `rebuild` command:

```
rebuild
```

reset

The `reset` command resets execution of program code to the beginning of the program. This command starts a debug session if one has not been started. The following is the syntax of the `reset` command:

```
reset
```

By default, the `reset` command resets the PC to symbol 'main'. If you deselect the Reset to Symbol 'main' (Where Applicable) check box on the Debugger tab of the Options dialog box (see “Options—Debugger Tab” on page 126), the PC resets to the first line of the program.

savemem

The `savemem` command saves the memory content of the specified range into an Intel hex file, a binary file, or a text file. The functionality is similar to the Save to File command available from the context menu in the Memory window (see “Saving to a File” on page 318). The following is the syntax of the `savemem` command:

```
savemem SPACE="<displayed spacename>" FORMAT=<HEX | BIN |TEXT> "<[PATH\]name>"
   [STARTADDRESS="<hexadecimal address>"] [ENDADDRESS="<hexadecimal address>"]
```

If `STARTADDRESS` and `ENDADDRESS` are not specified, all the memory contents of a specified space are saved.

For example:

```
savemem SPACE="RDATA" FORMAT=BIN "c:\temp\file.bin" STARTADDRESS="20" ENDADDRESS="100"
savemem SPACE="ROM" FORMAT=HEX "c:\temp\file.hex"
savemem SPACE="ROM" FORMAT=TEXT "c:\temp\file.txt" STARTADDRESS="1000" ENDADDRESS="2FFF"
```

set config

The `set config` command activates an existing build configuration for or creates a new build configuration in the currently loaded project. The following is the syntax of the `set config` command:

`set config` "*config_name*" ["*copy_from_config_name*"]

The `set config` command does the following:

- Activates *config_name* if it exists.

- Creates a new configuration named *config_name* if it does not yet exist. When complete, the new configuration is made active. When creating a new configuration, the Command Processor copies the initial settings from the *copy_from_config_name* parameter, if provided. If not provided, the active build configuration is used as the copy source. If *config_name* exists, the *copy_from_config_name* parameter is ignored.

NOTE: The active/selected configuration is used with commands like `option tool name="value"` and `build`.

step

The `step` command performs a single step (stepover) from the current location of the program counter. If the count is not provided, a single step is performed. This command starts a debug session if one has not been started. The following is the syntax of the `step` command:

```
step
```

stepin

The `stepin` command steps into the function at the PC. If there is no function at the current PC, this command is equivalent to `step`. This command starts a debug session if one has not been started. The following is the syntax of the `stepin` command:

```
stepin
```

stepout

The `stepout` command steps out of the function. This command starts a debug session if one has not been started. The following is the syntax of the `stepout` command:

```
stepout
```

stop

The `stop` command stops the execution of program code. The following is the syntax of the `stop` command:

```
stop
```

target copy

The `target copy` command creates a copy of the existing target with a given name with the given new name. The syntax can take one of two forms:

- `target copy NAME="<new target name>"`

  creates a copy of the active target named the value given for `NAME`.

- `target copy NAME="<new target name>" SOURCE="<existing target name>"`

creates a copy of the `SOURCE` target named the value given for `NAME`.

For example:

```
target copy NAME="mytarget" SOURCE="Sim3"
```

target create

The `target create` command creates a new target with the given name and using the given CPU. The following is the syntax of the `target create` command:

`target create NAME="`*<target name>*`" CPU="`*<cpu name>*`"`

For example:

```
target create NAME="mytarget" CPU="eZ80190"
```

target get

The `target get` command displays the current value for the given data item for the active target. The following is the syntax of the `target get` command:

`target get "`*<data item>*`"`

Use the `target setup` command to view available data items and current values.

For example:

```
target get "cpu"
```

target help

The `target help` command displays all target commands. The following is the syntax of the `target help` command:

```
target help
```

target list

The `target list` command lists all available targets. The syntax can take one of three forms:

- `target list`

  displays the names of all available targets (restricted to the currently configured CPU family).
- `target list CPU="`*<cpu name>*`"`

  displays the names of all available targets associated with the given CPU name.
- `target list FAMILY="`*<family name>*`"`

  displays the names of all available targets associated with the given CPU family name.

For example:

```
target list FAMILY="eZ80"
```

target options

NOTE: See a target in the following directory for a list of categories and options:

ZILOGINSTALL`\ZDSII`*_product_version*`\targets`

<ZDS Installation Directory>`\targets`

where *<ZDS Installation Directory>* is the directory in which Zilog Developer Studio was installed. By default, this would be `C:\Program Files\ZiLOG\ZDSII_eZ80Acclaim!_<version>`, where *<version>* might be `4.11.0` or `5.0.0`.

To set a target value, use one of the following syntaxes:

```
target options CATEGORY="<Category>" OPTION="<Option>" "<token name>"="<value to set>"
target options CATEGORY="<Category>" "<token name>"="<value to set>"
target options "<token name>"="<value to set>"
```

To select a target, use the following syntax:

```
target options NAME ="<Target Name>"
```

target save

The `target save` command saves a target. To save the selected target, use the following syntax:

```
target save
```

To save a specified target, use the following syntax:

```
target save NAME="<Target Name>"
```

For example:

```
target save Name="Sim3"
```

target set

The `target set` command sets the given data item to the given data value for the active target or activates a particular target. The syntax can take one of two forms:

- `target set "<data item>" "<new value>"`

  Sets data item to new value for the active debug tool. Use `target setup` to view available data items and current values.

  For example:

  ```
  target set "frequency" "20000000"
  ```

- `target set "<target name>"`

  Activates the target with the given name. Use `target list` to view available targets.

target setup

The `target setup` command displays the current configuration. The following is the syntax of the `target setup` command:

```
target setup
```

wait

The `wait` command instructs the Command Processor to wait the specified milliseconds before executing the next command. The following is the syntax of the `wait` command:

`wait` <*milliseconds*>

For example:

```
wait 5000
```

wait bp

The `wait bp` command instructs the Command Processor to wait until the debugger stops executing. The optional *max_milliseconds* parameter provides a method to limit the amount of time a wait takes (that is, wait until the debugger stops or *max_milliseconds* passes). The following is the syntax of the `wait bp` command:

`wait bp` [*max_milliseconds*]

For example:

```
wait bp
wait bp 2000
```

RUNNING THE FLASH LOADER FROM THE COMMAND PROCESSOR

You can run the Flash Loader from the Command field. Command Processor keywords have been added to allow for easy scripting of the Flash loading process. Each of the parameters is persistent, which allows for the repetition of the Flash and verification processes with a minimum amount of repeated key strokes.

Use the following procedure to run the Flash Loader:

1. Create a project or open a project with a Z8 Encore! microcontroller selected in the CPU Family and CPU fields of the General page of the Project Settings dialog box (see “General Page” on page 56).
2. Select **USBSmartCable** as your debug tool (see “Debug Tool” on page 100) and click **Setup** to select the appropriate serial number.

3. In the Command field (in the Command Processor toolbar), type in one of the command sequences in the following sections to use the Flash Loader:
   – “Displaying Flash Help” on page 435
   – “Setting Up Flash Options” on page 435
   – “Executing Flash Commands” on page 435
   – “Examples” on page 436

Displaying Flash Help

Flash Setup	Displays the Flash setup in the Command Output window
Flash Help	Displays the Flash command format in the Command Output window

Setting Up Flash Options

Flash Options "<File Name>"	File to be flashed
Flash Options OFFSET = "<address>"	Offset address in hex file
Flash Options INTMEM	Set to internal memory
Flash Options NEBF	Do not erase before flash
Flash Options EBF	Erase before flash
Flash Options NISN	Do not include serial number
Flash Options ISN	Include a serial number
Flash Options NPBF	Do not page-erase Flash memory; use mass erase
Flash Options PBF	Page-erase Flash memory
Flash Options SERIALADDRESS = "<address>"	Serial number address
Flash Options SERIALNUMBER = "<Number in Hex>"	Initial serial number value
Flash Options SERIALSIZE = <1-8>	Number of bytes in serial number
Flash Options INCREMENT = "<Decimal value>"	Increment value for serial number

Executing Flash Commands

Flash READSERIAL	Read the serial number
Flash READSERIAL REPEAT	Read the serial number and repeat
Flash BURNSERIAL	Program the serial number
Flash BURNSERIAL REPEAT	Program the serial number and repeat
Flash ERASE	Erase Flash memory
Flash ERASE REPEAT	Erase Flash memory and repeat

Flash BURN	Program Flash memory
Flash BURN REPEAT	Program Flash memory and repeat
Flash BURNVERIFY	Program and verify Flash memory
Flash BURNVERIFY REPEAT	Program and verify Flash memory and repeat
Flash VERIFY	Verify Flash memory
Flash VERIFY REPEAT	Verify Flash memory and repeat

Caution The Flash Loader dialog box and the Command Processor interface use the same parameters. If an option is not specified with the Command Processor interface, the current setting in the Flash Loader dialog box is used. If a setting is changed in the Command Processor interface, the Flash Loader dialog box settings are changed.

Examples

The following are valid examples:

```
FLASH Options INTMEM
FLASH Options "c:\testing\test.hex"
FLASH BURN REPEAT
```

or

```
flash options intmem
flash options "c:\testing\test.hex"
flash burn repeat
```

The file `test.hex` is loaded into internal Flash memory. After the flashing is completed, you are prompted to program an additional unit.

```
FLASH VERIFY
```

The file `test.hex` is verified against internal Flash memory.

```
FLASH SETUP
```

The current Flash Loader parameters settings are displayed in the Command Output window.

```
FLASH HELP
```

The current Flash Loader command options are displayed in the Command Output window.

```
Flash Options PBF
```

Page erase is enabled instead of mass erase for internal and external Flash programming.

Compatibility Issues

The following sections describe assembler and compiler compatibility:

- "Assembler Compatibility Issues" on page 437
- "Compiler Compatibility Issues" on page 440

ASSEMBLER COMPATIBILITY ISSUES

The following table shows the equivalences between Z8 Encore! directives and those of other assemblers that are also supported by the Z8 Encore! assembler. ZMASM directives that are compatible with Z8 Encore! directives are also listed. The Z8 Encore! assembler directives in the left column are the preferred directives, but the assembler also accepts any of the directives in the right column.

Table 19. Z8 Encore! Directive Compatibility

Z8 Encore! Assembler	Compatible With
`ALIGN`	`.align`
`ASCII`	`.ascii`
`ASCIZ`	`.asciz`
`ASECT`	`.ASECT`
`ASG`	`.ASG`
`ASSUME`	`.ASSUME`
`BES`	`.bes`
`BREAK`	`.$BREAK,.$break`
`BSS`	`.bss`
`CHIP`	`chip, .cpu`
`CONTINUE`	`.$CONTINUE, .$continue`
`DATA`	`.data`
`DB`	`.byte, .ascii, DEFB, FCB, STRING, .STRING, byte, .asciz`
`DD`	`.double`
`DEFINE`	`.define`
`DF`	`.float`
`DL`	`.long, long`
`DR`	`<none>`

Table 19. Z8 Encore! Directive Compatibility (Continued)

Z8 Encore! Assembler	Compatible With
DS	.block
DW	.word, word, .int
DW24	.word24, .trio, .DW24
ELIF	.ELIF, .ELSEIF, ELSEIF, .$ELSEIF, .$elseif
ELSE	.ELSE, .$ELSE, .$else
END	.end
ENDIF	.endif, .ENDIF, ENDC, .$ENDIF, .$endif
ENDMAC	.endm, ENDMACRO, .ENDMACRO, .ENDMAC, ENDM, .ENDM, MACEND, .MACEND
ENDSTRUCT	.ENDSTRUCT
ERROR	.emsg
EQU	.equ, .EQU, EQUAL, .equal
EVAL	.EVAL
FCALL	.FCALL
FILE	.file
FRAME	.FRAME
GREG	GREGISTER
IF	.if, .IF, IFN, IFNZ, COND, IFTRUE, IFNFALSE, .$IF, .$if, .IFTRUE
INCLUDE	.include, .copy
LIST	.list <on> or <off>, .LIST
MACCNTR	<none>
MACEXIT	<none>
MACLIST	<none>
MACNOTE	.mmsg
MACRO	.macro, .MACRO
MLIST	<none>
MNOLIST	<none>
NEWBLOCK	.NEWBLOCK
NEWPAGE	.page [<len>] [<width>], PAGE

Table 19. Z8 Encore! Directive Compatibility (Continued)

Z8 Encore! Assembler	Compatible With
NIF	IFZ, IFE, IFFALSE, IFNTRUE, .IFNTRUE
NOLIST	.NOLIST
NOSAME	IFDIFF, IFNSAME
ORG	.org, ORIGIN
PE	V
P0	NV
POPSEG	<none>
PRINT	<none>
PT	<none>
PUSHSEG	<none>
REPEAT	.$REPEAT, .$repeat
SAME	IFNDIFF, IFSAME
SBLOCK	.SBLOCK
SCOPE	<none>
SEGMENT	.section, SECTION
STRUCT	.STRUCT
TAG	.TAG
TEXT	.text
TITLE	.title
UNTIL	.$UNTIL, .until
VAR	.VAR, SET, .SET
VECTOR	<none>
WARNING	.wmsg, MESSAGE
WEND	.$WEND, .$wend
WHILE	.$WHILE, .$while
XDEF	.global, GLOBAL, .GLOBAL, .public, .def, public
XREF	EXTERN, EXTERNAL, .extern, .ref
ZIGNORE	<none>

Table 19. Z8 Encore! Directive Compatibility (Continued)

Z8 Encore! Assembler	Compatible With
ZSECT	.sect
ZUSECT	.USECT

COMPILER COMPATIBILITY ISSUES

NOTE: Use of the #pragmas documented in this section should not be necessary in ZDS II release 4.10 and later. Zilog does not recommend their use, especially in new projects because it is extremely difficult to validate that they continue to work correctly as the compiler is updated and in all circumstances. They continue to be supported as they have been in older releases and will be accepted by the compiler.

Compiler options can be set in the Project Settings dialog box (on the C pages) or by using the `#pragma` directives described in this section.

If the `#pragma` directive is inserted in your code, it overrides the selections you made in the Project Settings dialog box.

#pragma alias

Enables alias checking. The compiler assumes that program variables can be aliased. This pragma is the default.

#pragma noalias

Disables alias checking. Before using this pragma, be sure that the program does not use aliases, either directly or indirectly. An alias occurs when two variables can reference the same memory location. The following example illustrates an alias:

```
func()
{
   int x,*p;
   p = &x;   /* both “x” and “*p” refer to same location */
  .
  .
  .
}
```

If both *p and x are used below the assignment, then malignant aliases exist and the NOALIAS switch must not be used. Otherwise, alias is benign, and the NOALIAS switch can be used.

#pragma cpu <cpu name>

Defines the target processor to the compiler.

#pragma globalcopy

Enables global copy propagation.

#pragma noglobalcopy

Disables global copy propagation.

#pragma globalcse

Enables global common elimination unless local common subexpressions are disabled.

#pragma noglobalcse

Disables global copy subexpression elimination

#pragma globaldeadvar

Enables global dead variable removal.

#pragma noglobaldeadvar

Disables global dead variable removal.

#pragma globalfold

Enables global constant folding.

#pragma noglobalfold

Disables global constant folding.

#pragma intrinsics: <state>

Defines whether the compiler-defined intrinsic functions are to be expanded to inline code.

NOTE: The intrinsic property is only available for compiler-defined intrinsic functions; user-defined intrinsics are not supported.

<*state*> can be ON or OFF. This pragma, with <*state*> ON, is the default.

#pragma nointrinsics

Disables the INTRINSICS switch.

#pragma nobss

Does not put uninitialized static data in bss segment, instead it puts it in data segment and initializes it at link time.

#pragma jumpopt

Enables jump optimizations.

#pragma nojumpopt

Disables jump optimizations.

#pragma localcopy

Enables local copy propagation.

#pragma nolocalcopy

Disables local copy propagation.

#pragma localcse

Enables local common subexpression elimination.

#pragma nolocalcse

Disables local and global common subexpression elimination.

#pragma localfold

Enables local constant folding.

#pragma nolocalfold

Disables local constant folding.

#pragma localopt

Enables all local optimizations.

#pragma nolocalopt

Disables all local optimizations.

#pragma noopt

Disables all optimizations.

#pragma optlink

Enables optimized linkage calling conventions.

#pragma nooptlink

Disables optimized linkage calling conventions.

#pragma optsize

Optimizes code to minimize size.

#pragma optspeed

Optimizes code to minimize execution time.

#pragma peephole

Enables peephole optimizations.

#pragma nopeephole

Disables peephole optimizations.

#pragma promote

Enables ANSI integer promotions.

#pragma nopromote

Disables ANSI integer promotions.

#pragma sdiopt

Performs span-dependent instruction optimization. This optimization results in branches generated by the compiler taking the shortest form possible. This pragma is the default.

#pragma nosdiopt

Disables span-dependent instruction optimizations.

#pragma stkck

Performs stack checking.

#pragma nostkck

Does not perform stack checking.

#pragma strict

Checks for conformance to the ANSI standard and its obsolescent features. These include old-style parameter type declarations, empty formal parameter lists, and calling functions with no prototype in scope. When any of these features are used a warning is flagged. The compiler requires this switch for proper code generation because it makes use of a static frame.

#pragma nostrict

Does not flag warnings for obsolete features.

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