# CodeWarrior™ Development Studio for Freescale™ 56800/E Digital Signal Controllers: MC56F8xxx/DSP5685x Family Targeting Manual

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# How to Contact Freescale

| | |
|---|---|
| Corporate Headquarters | Freescale Corporation<br>7700 West Parmer Lane<br>Austin, TX 78729<br>U.S.A. |
| World Wide Web | http://www.freescale.com/codewarrior |
| Technical Support | http://www.freescale.com/support |

# Table of Contents

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# Introduction

This manual explains how to use the CodeWarrior™ Integrated Development Environment (IDE) to develop code for the DSP56800E family of processors (MC56F8xxx and DSP5685x).

This chapter contains the following sections:

- CodeWarrior IDE on page 13
- Freescale 56800/E Digital Signal Controllers on page 14
- References on page 16

## CodeWarrior IDE

The CodeWarrior IDE consists of a project manager, a graphical user interface, compilers, linkers, a debugger, a source-code browser, and editing tools. You can edit, navigate, examine, compile, link, and debug code, within the one CodeWarrior environment. The CodeWarrior IDE lets you configure options for code generation, debugging, and navigation of your project.

Unlike command-line development tools, the CodeWarrior IDE organizes all files related to your project. You can see your project at a glance, so organization of your source-code files is easy. Navigation among those files is easy, too.

When you use the CodeWarrior IDE, there is no need for complicated build scripts of makefiles. To add files to your project or delete files from your project, you use your mouse and keyboard, instead of tediously editing a build script.

For any project, you can create and manage several configurations for use on different computer platforms. The platform on which you run the CodeWarrior IDE is called he host. From the host, you use the CodeWarrior IDE to develop code to target various platforms.

Note the two meanings of the term *target*:

- **Platform Target —** The operating system, processor, or microcontroller from or on which your code will execute.
- **Build Target** — The group of settings and files that determine what your code is, as well as control the process of compiling and linking.

The CodeWarrior IDE lets you specify multiple build targets. For example, a project can contain one build target for debugging and another build target optimized for a particular operating system (platform target). These build targets can share files, even though each build target uses its own settings. After you debug the program, the only actions necessary to generate a final version are selecting the project's optimized build target and using a single Make command.

The CodeWarrior IDE's extensible architecture uses plug-in compilers and linkers to target various operating systems and microprocessors. For example, the IDE uses a GNU tool adapter for internal calls to DSP56800E development tools.

Most features of the CodeWarrior IDE apply to several hosts, languages, and build targets. However, each build target has its own unique features. This manual explains the features unique to the CodeWarrior Development Studio for Freescale 56800/E Digital Signal Controllers.

For comprehensive information about the CodeWarrior IDE, see the *CodeWarrior IDE User's Guide*.

**NOTE** For the very latest information on features, fixes, and other matters, see the *CodeWarrior Release Notes*, on the CodeWarrior IDE CD.

# Freescale 56800/E Digital Signal Controllers

The Freescale 56800/E Digital Signal Controllers consist of two sub-families, which are named the DSP56F80x/DSP56F82x (DSP56800) and the MC56F8xxx/DSP5685x (DSP56800E). The DSP56800E is an enhanced version of the DSP56800.

The processors in the DSP56800 and DSP56800E sub-families are shown in Table 1.1 on page 15.

With this product the following Targeting Manuals are included:

- *Code Warrior Development Studio for Freescale 56800/E Digital Signal Controllers: DSP56F80x/DSP56F82x Family Targeting Manual*
- *Code Warrior Development Studio for Freescale 56800/E Digital Signal Controllers: MC56F8xxx/DSP5685x Family Targeting Manual*

**NOTE** Please refer to the Targeting Manual specific to your processor.

**Table 1.1 Supported DSP56800x Processors for CodeWarrior Development Studio for Freescale 56800/E Digital Signal Controllers**

| DSP56800 | DSP56800E |
|---|---|
| DSP56F801 (60 MHz) | DSP56852 |
| DSP56F801 (80 MHz) | DSP56853 |
| DSP56F802 | DSP56854 |
| DSP56F803 | DSP56855 |
| DSP56F805 | DSP56857 |
| DSP56F807 | DSP56858 |
| DSP56F826 | MC56F8013 |
| DSP56F827 | MC56F8014 |
| | MC56F8023 |
| | MC56F8025 |
| | MC56F8036 |
| | MC56F8037 |
| | MC56F8122 |
| | MC56F8123 |
| | MC56F8145 |
| | MC56F8146 |
| | MC56F8147 |
| | MC56F8155 |
| | MC56F8156 |
| | MC56F8157 |
| | MC56F8165 |
| | MC56F8166 |
| | MC56F8167 |
| | MC56F8322 |

**Table 1.1 Supported DSP56800x Processors for CodeWarrior Development Studio for Freescale 56800/E Digital Signal Controllers (*continued*)**

| DSP56800 | DSP56800E |
|---|---|
| | MC56F8323 |
| | MC56F8335 |
| | MC56F8345 |
| | MC56F8346 |
| | MC56F8356 |
| | MC56F8357 |
| | MC56F8365 |
| | MC56F8366 |
| | MC56F8367 |

# References

- Your CodeWarrior IDE includes these manuals:
  - *CodeWarrior™ IDE User's Guide*
  - *CodeWarrior™ Development Studio IDE 5.6 Windows® Automation Guide*
  - *CodeWarrior™ Development Studio for Freescale 56800/E Digital Signal Controllers: DSP56F80x/DSP56F82x Family Targeting Manual*
  - *CodeWarrior™ Development Studio for Freescale 56800/E Digital Signal Controllers: MC56F8xxx/DSP5685x Family Targeting Manual*
  - *CodeWarrior™ Builds Tools Reference for Freescale 56800/E Digital Signal Controllers*
  - *CodeWarrior™ Development Studio IDE 5.5 User's Guide Profiler Supplement*
  - *CodeWarrior™ Development Studio for Freescale™ DSP56800x Embedded Systems Assembler Manual*
  - *Codewarrior™ USB TAP Users Guide*
  - *Freescale™ 56800 Family IEEE - 754 Compliant Floating-Point Library User Manual*
  - *Freescale™ 56800E Family IEEE - 754 Compliant Floating-Point Library User Manual*

- *CodeWarrior™ Development Studio HTI Host Target Interface (for Once™/ JTAG Communication) User's Manual*
- *DSP56800 to DSP56800E Porting Guide,* Freescale Semiconductors, Inc.
- *56F807 to 56F8300/56F8100 Porting User Guide*, Freescale Semiconductors Inc.
- To learn more about the DSP56800E processor, refer to the Freescale manual, *DSP56800E Family Manual*.

To download electronic copies of these manuals or order printed versions, visit:

`http://www.freescale.com/`

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# Getting Started

This chapter explains the setup and installation for the CodeWarrior™ IDE, including hardware connections and communications protocols.

This chapter contains these sections:

- System Requirements on page 19
- Installing and Registering the CodeWarrior IDE on page 19
- Creating a Project

## System Requirements

Table 2.1 on page 19 lists system requirements for installing and using the CodeWarrior IDE for DSP56800E.

**Table 2.1 Requirements for the CodeWarrior IDE**

| Category | Requirement |
|---|---|
| Host Computer Hardware | PC or compatible host computer with 1.0-GHz Pentium®-compatible processor, 512 megabytes of RAM, and a CD-ROM drive |
| Operating System | Microsoft® Windows® 2000/XP |
| Hard Drive | 2.0 gigabytes of free space, plus space for user projects and source code |
| DSP56800E | 56800E EVM or custom 56800E development board, with JTAG header |

## Installing and Registering the CodeWarrior IDE

Follow these steps:

1. To install the CodeWarrior software:
   a. Insert the CodeWarrior CD into the CD-ROM drive — the welcome screen appears.

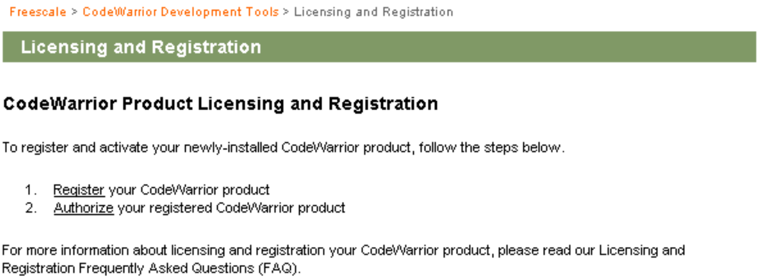
**NOTE** If the Auto Install is disabled, run the program `Launch.exe` in the root directory of the CD.

   b. Click **Launch CodeWarrior Setup** — the install wizard displays welcome page.
   c. Follow the wizard instructions, accepting all the default settings.
   d. At the prompt to check for updates, click the **Yes** button — the CodeWarrior updater opens.
2. To check for updates:

**NOTE** If the updater already has Internet connection settings, you may proceed directly to substep f.

   a. Click the **Settings** button — the **Updater Settings** dialog box appears.
   b. Click the **Load Settings** button — the updater loads settings from your Windows control panel.
   c. Modify the settings, as appropriate.
   d. If necessary, enter the proxy username and the password.
   e. Click the **Save** button — the **Updater Settings** dialog box disappears.
   f. In the updater screen, click the **Check for Updates** button.
   g. If updates are available, follow the on-screen instructions to download the updates to your computer.
   h. When you see the message, “Your version … is up to date”, click the **OK** button — the message box closes.
   i. Click the updater **Close** button — the installation resumes.
   j. At the prompt to restart the computer, select the **Yes** option button.
   k. Click the **Finish** button — the computer restarts, completing installation.
3. To register the CodeWarrior software:
   a. Select **Start> Programs>Freescale CodeWarrior>CW for DSC56800 R8.0>CodeWarrior IDE**.
   b. Select **Help** > **Register Product** — the Freescale registration page appears.

**Figure 2.1 Freescale Registration Page**


Freescale > CodeWarrior Development Tools > Licensing and Registration
Licensing and Registration

**CodeWarrior Product Licensing and Registration**

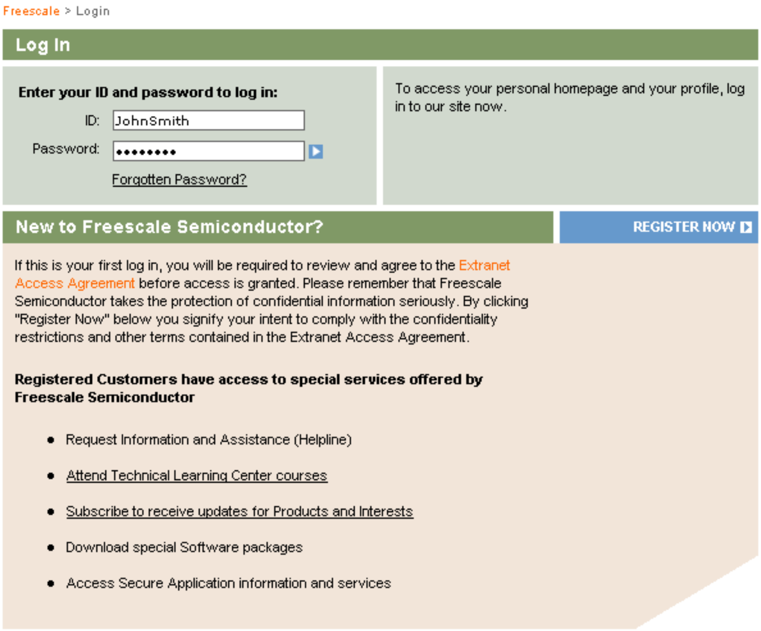
To register and activate your newly-installed CodeWarrior product, follow the steps below.

1. Register your CodeWarrior product
2. Authorize your registered CodeWarrior product

For more information about licensing and registration your CodeWarrior product, please read our Licensing and Registration Frequently Asked Questions (FAQ).

c. Click item number 1 — Register your CodeWarrior product.

d. Login or Register on the Freescale site.



**Enter your ID and password to log in:**

ID: JohnSmith

Password: ••••••••

Forgotten Password?

To access your personal homepage and your profile, log in to our site now.

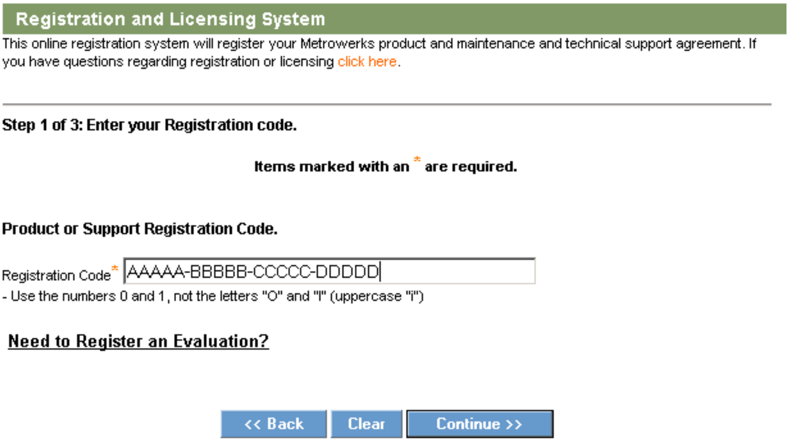
**New to Freescale Semiconductor?**

If this is your first log in, you will be required to review and agree to the Extranet Access Agreement before access is granted. Please remember that Freescale Semiconductor takes the protection of confidential information seriously. By clicking "Register Now" below you signify your intent to comply with the confidentiality restrictions and other terms contained in the Extranet Access Agreement.

**Registered Customers have access to special services offered by Freescale Semiconductor**

- Request Information and Assistance (Helpline)
- Attend Technical Learning Center courses
- Subscribe to receive updates for Products and Interests
- Download special Software packages
- Access Secure Application information and services

e. Enter your Registration Code and click the Continue button.


Registration and Licensing System

This online registration system will register your Metrowerks product and maintenance and technical support agreement. If you have questions regarding registration or licensing click here.

Step 1 of 3: Enter your Registration code.

Items marked with an * are required.

Product or Support Registration Code.

Registration Code* AAAAA-BBBBB-CCCCC-DDDDD

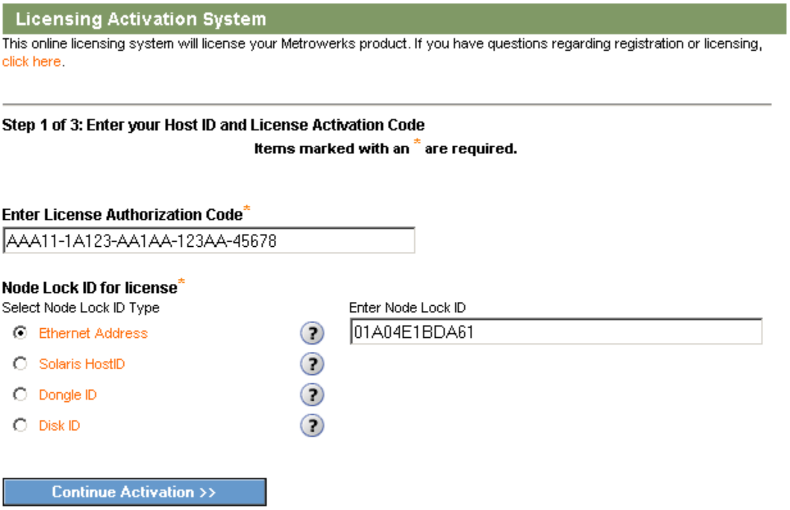
- Use the numbers 0 and 1, not the letters "O" and "I" (uppercase "i")

**NOTE** In the next screen you will be asked to confirm your Registration code by clicking Continue a second time. After registration is complete, you will receive an email with the activation code and directions on how to activate your product.

f. Click the Activation link in the email that you receive.

g. Login to the Freescale site.

h. Enter the License Authorization Code into the field.



**Licensing Activation System**

This online licensing system will license your Metrowerks product. If you have questions regarding registration or licensing, click here.

**Step 1 of 3: Enter your Host ID and License Activation Code**

**Items marked with an * are required.**

**Enter License Authorization Code***
AAA11-1A123-AA1AA-123AA-45678

**Node Lock ID for license***
Select Node Lock ID Type
● Ethernet Address
○ Solaris HostID
○ Dongle ID
○ Disk ID

Enter Node Lock ID
01A04E1BDA61

i. For the default selection: Ethernet Address — determine your ethernet address:

Launch a Command Prompt window

Enter `ipconfig /all`

Copy the Physical Address value of the first Ethernet adapter listed

Paste value into the "Node Lock ID for license" text box (remove spaces or dashes)

j. Click Continue Activation.

k. Click Continue to confirm the Host ID and License Authorization Code.

The website will display your license keys along with instructions on installing the license. Copy and paste these keys into the top of the "license.dat" file located at the root of your CodeWarrior installation directory. Your product should now be fully licensed and operational.

Table 2.2 on page 23 lists the directories created during full installation.

To test your system, follow the instructions of the next section to create a project.

**Table 2.2 Installation Directories, CodeWarrior IDE for DSP56800E**

| Directory | Contents |
|---|---|
| (CodeWarrior_Examples) | Target-specific projects and code. |
| (Helper Apps) | Applications such as cwspawn.exe and cvs.exe. |

**Table 2.2 Installation Directories, CodeWarrior IDE for DSP56800E (*continued*)**

| Directory | Contents |
|---|---|
| bin | The CodeWarrior IDE application and associated plug-in tools. |
| ccs | Command converter server executable files and related support files. |
| DSP56800x_EABI_Support | Default files for the DSP56800x stationery. |
| DSP56800x_EABI_Tools | Drivers to the CCS and command line tools, plus IDE default files for the DSP56800x stationery |
| Freescale_Documentation | Documentation specific to the Freescale DSP56800E series. |
| Help | Core IDE and target-specific help files. (Access help files through the Help menu or F1 key.) |
| License | Licensing information. |
| M56800E Support | Initialization files, Freescale Standard Library (MSL) and Runtime Library. |
| M56800x Support | Profiler libraries. |
| ProcessorExpert | Files for the Processor Expert. |
| Release_Notes | Release notes for the CodeWarrior IDE and each tool. |
| Stationery | Templates for creating DSP56800E projects. Each template pertains to a specific debugging protocol. |

# Creating a Project

To test software installation, create a sample project. Follow these steps:

1. Select **Start>Freescale CodeWarrior>CW for DSC56800 R8.0>CodeWarrior IDE**. The IDE starts; the main window appears.

To create a DSP56800x project use either the:

- DSP56800x new project wizard
- DSP56800x EABI stationery

To create a new project with the DSP56800x new project wizard, please see the sub-section “Creating a New Project with the DSP56800x New Project Wizard.”

To create a new project with the DSP56800x EABI stationery, please see the sub-section “Creating a New Project with the DSP56800x EABI Stationery.”

## Creating a New Project with the DSP56800x New Project Wizard

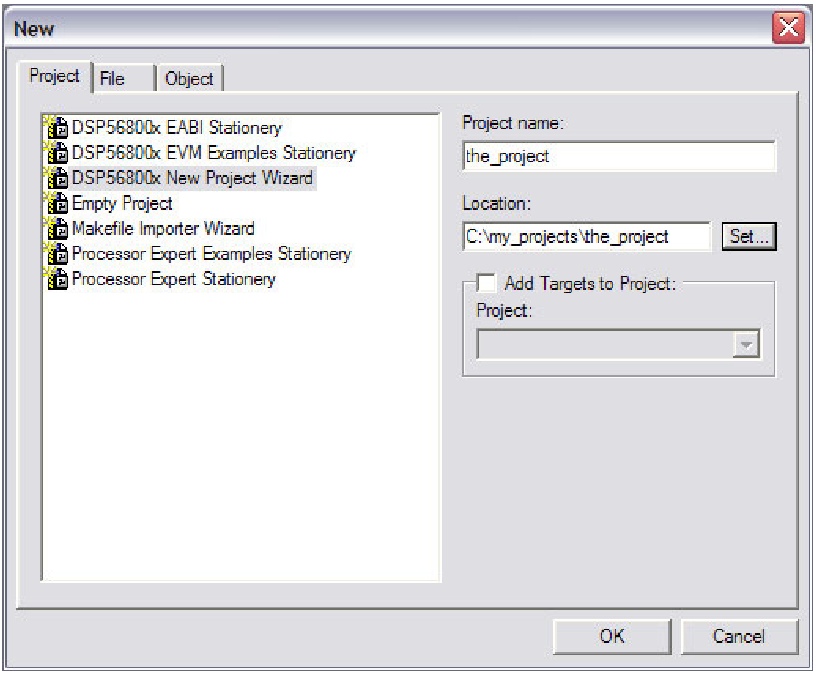
In this section of the tutorial, you work with the CodeWarrior IDE to create a project. with the DSP56800x New Project Wizard.

To create a project:

1. From the menu bar of the Freescale CodeWarrior window, select **File>New**.

   The **New** dialog box (Figure 2.2 on page 25) appears.

**Figure 2.2 New Dialog Box**



Project name: the_project

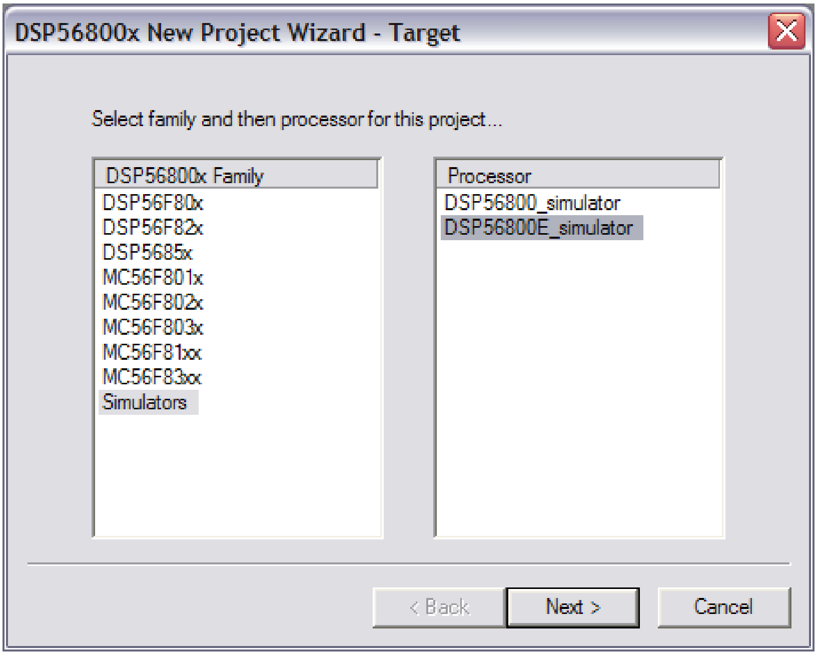
Location: C:\my_projects\the_project

New
Project
File
Object
DSP56800x EABI Stationery
DSP56800x EVM Examples Stationery
DSP56800x New Project Wizard
Empty Project
Makefile Importer Wizard
Processor Expert Examples Stationery
Processor Expert Stationery
Set...
☐ Add Targets to Project:
Project:
OK
Cancel

2. Select **DSP56800x New Project Wizard**.
3. In the **Project Name** text box, type the project name. For example, the_project.

4. In the **Location** text box, type the location where you want to save this project or choose the default location.
5. Click **OK**. The **DSP56800x New Project Wizard — Target** dialog box (Figure 2.3 on page 26) appears.

**Figure 2.3 DSP56800x New Project Wizard — Target Dialog Box**



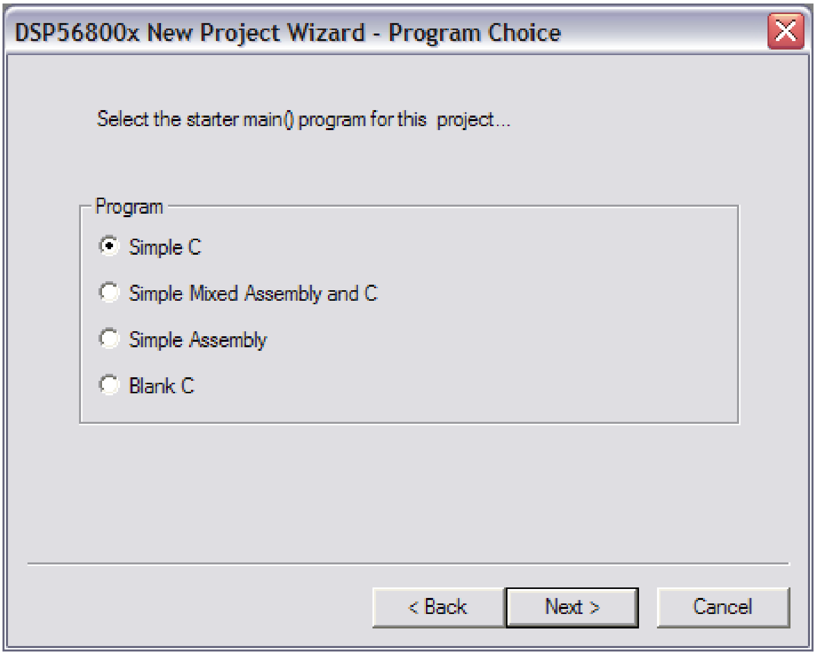
DSP56800x New Project Wizard - Target

Select family and then processor for this project...

| DSP56800x Family | Processor |
|---|---|
| DSP56F80x | DSP56800_simulator |
| DSP56F82x | DSP56800E_simulator |
| DSP5685x | |
| MC56F801x | |
| MC56F802x | |
| MC56F803x | |
| MC56F81xx | |
| MC56F83xx | |
| Simulators | |

6. Select the target board and processor
   a. Select the family, such as Simulators, from the **DSP56800x Family** list.
   b. Select the processor or simulator, such as DSP56800E_simulator, from the **Processor** list.
7. Click **Next**. The **DSP56800x New Project Wizard — Program Choice** dialog box (Figure 2.4 on page 27) appears.

**Figure 2.4 DSP56800x New Project Wizard — Program Choice Dialog Box**



DSP56800x New Project Wizard - Program Choice

Select the starter main() program for this project...

Program

● Simple C

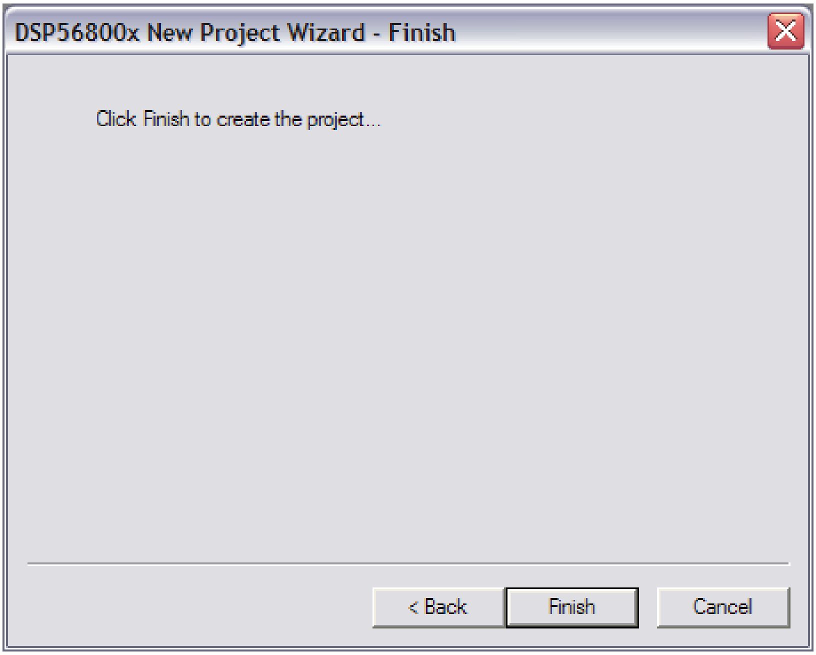
○ Simple Mixed Assembly and C

○ Simple Assembly

○ Blank C

8. Select the example main() program for this project, such as Simple C.
9. Click **Next**. The **DSP56800x New Project Wizard — Finish** dialog box (Figure 2.5 on page 28) appears.

**Figure 2.5 DSP56800x New Project Wizard — Finish Dialog Box**



DSP56800x New Project Wizard - Finish

Click Finish to create the project...

10. Click **Finish** to create the new project.

**NOTE** For more details of the DSP56800x new project wizard, please see Appendix B.

This completes project creation. You are ready to edit project contents, according to the optional steps below.

**NOTE** Stationery projects include source files that are placeholders for your own files. If a placeholder file has the same name as your file (such as `main.c`), you must replace the placeholder file with your source file.

11. (Optional) Remove files from the project.
    a. In the project window, select (highlight) the files.
    b. Press the **Delete** key (or right-click the filename, then select Remove from the context menu). A CodeWarrior dialog box appears. Select OK and the filenames disappear.
12. (Optional) Add source files to the project.

a. Method 1: From the main-window menu bar, select **Project>Add Files**. Then use the **Select files to add** dialog box to specify the files.

b. Method 2: Drag files from the desktop or Windows Explorer to the project window.

13. (Optional) Edit code in the source files.

a. Double-click the filename in the project window (or select the filename, then press the Enter key).

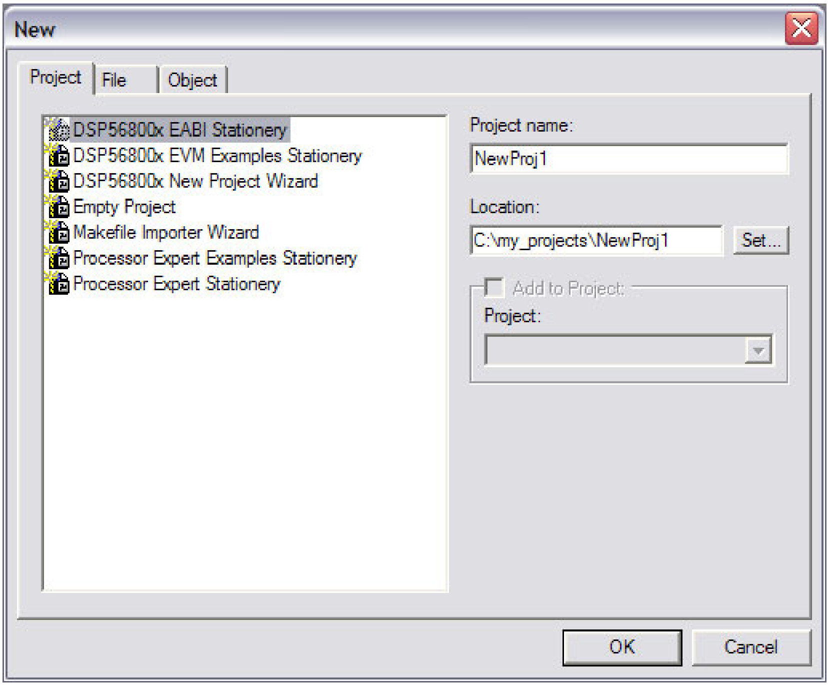
b. The IDE opens the file in the editor window; you are ready to edit file contents.

## Creating a New Project with the DSP56800x EABI Stationery

To create a sample project. Follow these steps:

1. From the menu bar, select **File>New**. The **New** window (Figure 2.6 on page 29) appears.

**Figure 2.6 New Window**



Project name: NewProj1

Location: C:\my_projects\NewProj1

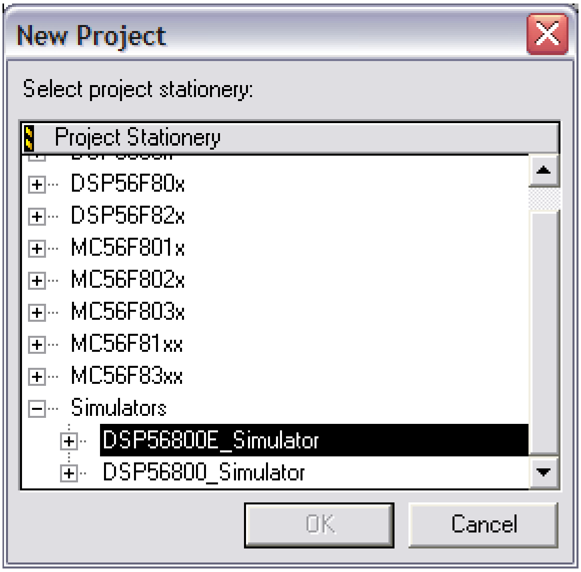
New
Project
File
Object
DSP56800x EABI Stationery
DSP56800x EVM Examples Stationery
DSP56800x New Project Wizard
Empty Project
Makefile Importer Wizard
Processor Expert Examples Stationery
Processor Expert Stationery
Set...
□ Add to Project:
Project:
OK
Cancel

2. Specify a new DSP56800E project named NewProj1.
   a. If necessary, click the Project tab to move the Project page to the front of the window.
   b. From the project list, select DSP56800x EABI Stationery.

**NOTE** Stationery is a set of project templates, including libraries and place-holders for source code. Using stationery is the quickest way to create a new project.

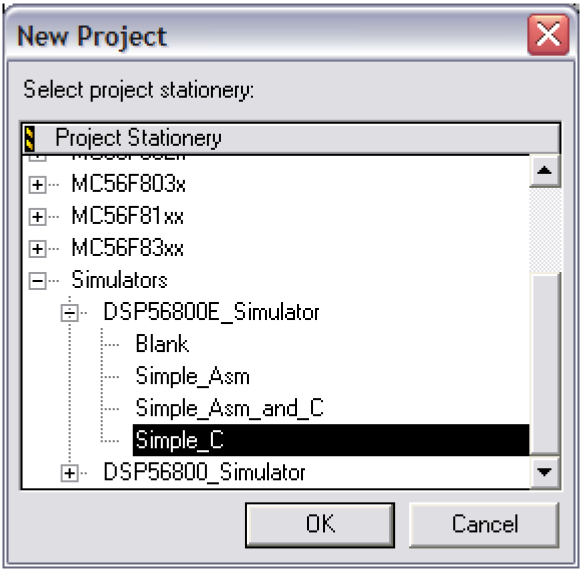
   c. In the Project name text box, type: `NewProj1`. (When you save this project, the IDE automatically will add the `.mcp` extension to its filename.)
3. In the **New** window, click the OK button. The **New Project** window (Figure 2.7 on page 30) appears, listing board-specific project stationery.

**Figure 2.7 New Project Window**



4. Select the simulator C stationery target.
   a. Click the expand control (+) for the DSP56800E Simulator. The tree expands to show stationery selections.
   b. Select Simple C. (Figure 2.8 on page 31 shows this selection.)

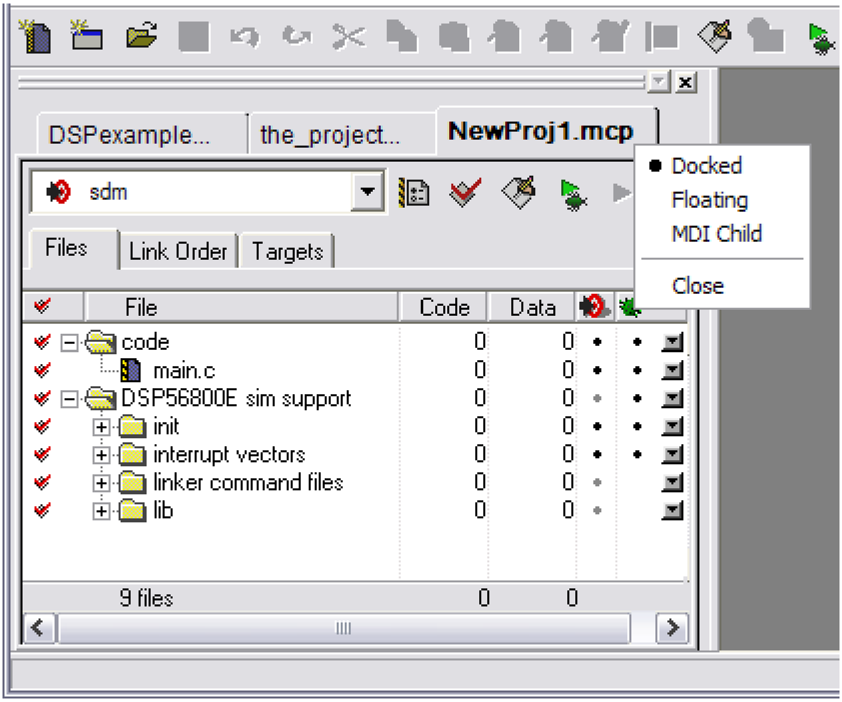
**Figure 2.8  Simulator Simple C Selection**



**NOTE** You should select a simulator target if your system is not connected to a development board. If you do have a development board, your target selection must correspond to the board’s processor.

c. Click the **OK** button. A project window opens, listing the folders for project NewProj1.mcp. Figure 2.9 on page 32 shows this project window docked in the IDE main window.

**Figure 2.9 Project Window (docked)**



| File | Code | Data |
|---|---|---|
| code | 0 | 0 |
| main.c | 0 | 0 |
| DSP56800E sim support | 0 | 0 |
| init | 0 | 0 |
| interrupt vectors | 0 | 0 |
| linker command files | 0 | 0 |
| lib | 0 | 0 |
| 9 files | 0 | 0 |

**NOTE** The IDE has the same functionality whether subordinate windows (such as the project window) are docked, floating, or child.
To undock the project window, right-click its title tab, then select Floating or Child from the context menu. To dock a floating window, right-click its title bar, then select Docked from the context menu.

5. This completes project creation. You are ready to edit project contents, according to the optional steps below.

**NOTE** Stationery projects include source files that are placeholders for your own files. If a placeholder file has the same name as your file (such as `main.c`), you must remove the placeholder file before adding your source file.

6. (Optional) Remove files from the project.

   a. In the project window, select (highlight) the files.

   b. Press the **Delete** key (or right-click the filename, then select Remove from the context menu). A CodeWarrior dialog box appears. Select OK and the filenames disappear.

7. (Optional) Add source files to the project.

   a. Method 1: From the main-window menu bar, select **Project>Add Files**. Then use the **Select files to add** dialog box to specify the files.

   b. Method 2: Drag files from the desktop or Windows Explorer to the project window.

8. (Optional) Edit code in the source files.

   a. Double-click the filename in the project window (or select the filename, then press the Enter key).

   b. The IDE opens the file in the editor window; you are ready to edit file contents.

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# Development Studio Overview

This chapter describes the CodeWarrior™ IDE and explains application development using the IDE. This chapter contains these sections:

- CodeWarrior IDE on page 35
- Development Process on page 36

If you are an experienced CodeWarrior IDE user, you will recognize the look and feel of the user interface. However, you must become familiar with the DSP56800E runtime software environment.

## CodeWarrior IDE

The CodeWarrior IDE lets you create software applications. It controls the project manager, the source-code editor, the class browser, the compiler, linker, and the debugger.

You use the project manager to organize all the files and settings related to your project. You can see your project at a glance and easily navigate among source-code files. The CodeWarrior IDE automatically manages build dependencies.

A project can have multiple build targets. A build target is a separate build (with its own settings) that uses some or all of the files in the project. For example, you can have both a debug version and a release version of your software as separate build targets within the same project.

The CodeWarrior IDE has an extensible architecture that uses plug-in compilers and linkers to target various operating systems and microprocessors. The CodeWarrior CD includes a C compiler for the DSP56800E family of processors. Other CodeWarrior software packages include C, C++, and Java compilers for Win32, Mac® OS, Linux, and other hardware and software combinations.

The IDE includes:

- **CodeWarrior Compiler for DSP56800E** — an ANSI-compliant C compiler, based on the same compiler architecture used in all CodeWarrior C compilers. Use this compiler with the CodeWarrior linker for DSP56800E to generate DSP56800E applications and libraries.

**NOTE** The CodeWarrior compiler for DSP56800E does not support C++.

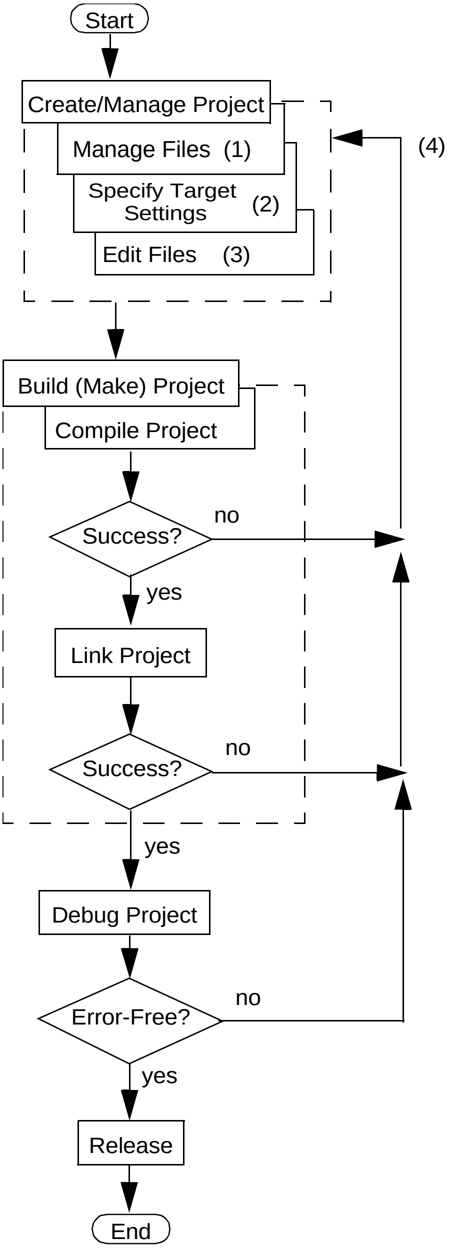
- **CodeWarrior Assembler for DSP56800E** — an assembler that features easy-to-use syntax. It assembles any project file that has a `.asm` filename extension. For further information, refer to the *Code Warrior Development Studio Freescale DSP56800x Embedded Systems Assembler Manual*.
- **CodeWarrior Linker for DSP56800E** — a linker that lets you generate either Executable and Linker Format (ELF) or S-record output files for your application.
- **CodeWarrior Debugger for DSP56800E** — a debugger that controls your program's execution, letting you see what happens internally as your program runs. Use this debugger to find problems in your program.

  The debugger can execute your program one statement at a time, suspending execution when control reaches a specified point. When the debugger stops a program, you can view the chain of function calls, examine and change the values of variables, inspect processor register contents, and see the contents of memory.
- **Metrowerks Standard Library (MSL)** — a set of ANSI-compliant, standard C libraries for use in developing DSP56800E applications. Access the library sources for use in your projects. A subset of those used for all platform targets, these libraries are customized and the runtime adapted for DSP56800E development.

# Development Process

The CodeWarrior IDE helps you manage your development work more effectively than you can with a traditional command-line environment. Figure 3.1 on page 37 depicts application development using the IDE.

**Figure 3.1** CodeWarrior IDE Application Development



Notes:

(1) Use any combination: stationery (template) files, library files, or your own source files.

(2) Compiler, linker, debugger settings; target specification; optimizations.

(3) Edit source and resource files.

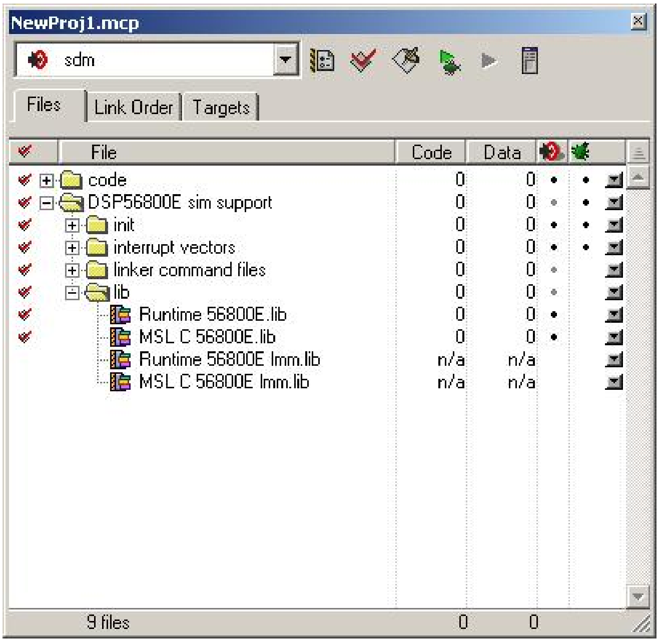
(4) Possible corrections: adding a file, changing settings, or editing a file.

# Project Files

A CodeWarrior project consists of source-code, library, and other files. The project window (Figure 3.2 on page 38) lists all files of a project, letting you:

- Add files,
- Remove files,
- Specify the link order,
- Assign files to build targets, and
- Direct the IDE to generate debug information for files.

**Figure 3.2  Project Window**



| ✓ | File | Code | Data | | | |
|---|---|---|---|---|---|---|
| ✓ | ⊞ code | 0 | 0 | • | • | |
| ✓ | ⊟ DSP56800E sim support | 0 | 0 | • | • | |
| ✓ | ⊞ init | 0 | 0 | • | • | |
| ✓ | ⊞ interrupt vectors | 0 | 0 | • | • | |
| ✓ | ⊞ linker command files | 0 | 0 | • | | |
| ✓ | ⊟ lib | 0 | 0 | • | | |
| ✓ | Runtime 56800E.lib | 0 | 0 | • | | |
| ✓ | MSL C 56800E.lib | 0 | 0 | • | | |
| | Runtime 56800E lmm.lib | n/a | n/a | | | |
| | MSL C 56800E lmm.lib | n/a | n/a | | | |
| | 9 files | 0 | 0 | | | |

**NOTE** Figure 3.2 on page 38 shows a floating project window. Alternatively, you can dock the project window in the IDE main window or make it a child window. You can have multiple project windows open at the same time; if the windows are docked, their tabs let you control which one is at the front of the main window.

The CodeWarrior IDE automatically handles the dependencies among project files, and stores compiler and linker settings for each build target. The IDE tracks which files have changed since your last build, recompiling only those files during your next project build.

A CodeWarrior project is analogous to a collection of makefiles, as the same project can contain multiple builds. Examples are a debug version and a release version of code, both part of the same project. As earlier text explained, *build targets* are such different builds within a single project.

## Editing Code

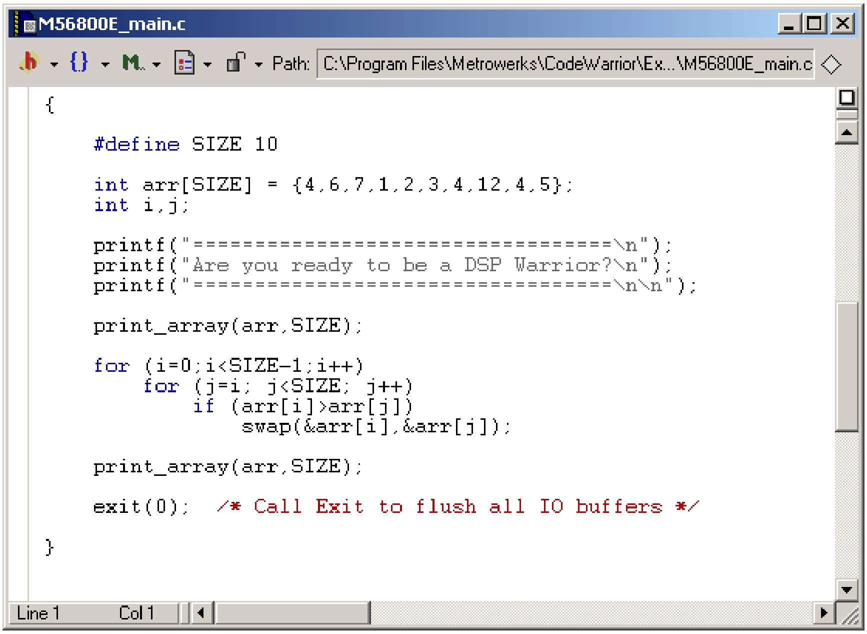
The CodeWarrior text editor handles text files in MS-DOS® , Windows®, UNIX, and Mac® OS formats.

To edit a source-code file (or any other editable project file), either:

- Double-click its filename in the project window, or
- Select (highlight) the filename, then drag the highlighted filename to the CodeWarrior main window.

The IDE opens the file in the editor window (Figure 3.3 on page 40). This window lets you switch between related files, locate particular functions, mark locations within a file, or go to a specific line of code.

**Figure 3.3  Editor Window**


M56800E_main.c
Path: C:\Program Files\Metrowerks\CodeWarrior\Ex...\M56800E_main.c
Line 1
Col 1

```
{
    #define SIZE 10

    int arr[SIZE] = {4,6,7,1,2,3,4,12,4,5};
    int i,j;

    printf("==================================\n");
    printf("Are you ready to be a DSP Warrior?\n");
    printf("==================================\n\n");

    print_array(arr,SIZE);

    for (i=0;i<SIZE-1;i++)
        for (j=i; j<SIZE; j++)
            if (arr[i]>arr[j])
                swap(&arr[i],&arr[j]);

    print_array(arr,SIZE);

    exit(0);  /* Call Exit to flush all IO buffers */
}
```

**NOTE** Figure 3.3 on page 40 shows a floating editor window. Alternatively, you can dock the editor window in the IDE main window or make it a child window.

## Building: Compiling and Linking

For the CodeWarrior IDE, *building* includes both compiling and linking. To start building, you select **Project>Make**, from the IDE main-window menu bar. The IDE compiler:

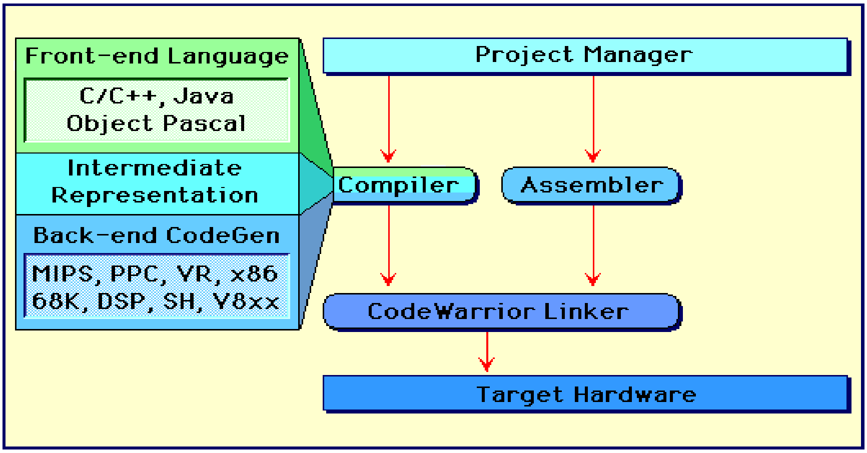
- Generates an object-code file from each source-code file of the build target, incorporating appropriate optimizations.
- Updates other files of the build target, as appropriate.
- In case of errors, issues appropriate error messages and halts.

**NOTE** It is possible to compile a single source file. To do so, highlight its filename in the project window, then select **Project > Compile**, from the main-window menu bar. Another useful option is compiling all modified files of the build target: select **Project>Bring Up to Date** from the main-window menu bar.

In UNIX and other command-line environments, the IDE stores object code in a binary (`.o` or `.obj`) file. On Windows targets, the IDE stores and manages object files internally in the data folder.

A proprietary compiler architecture at the heart of the CodeWarrior IDE handles multiple languages and platform targets. Front-end language compilers generate an intermediate representation (IR) of syntactically correct source code. This IR is memory-resident and language-independent. Back-end compilers generate code from the IR for specific platform targets. As Figure 3.4 on page 41 depicts, the CodeWarrior IDE manages this whole process.

**Figure 3.4 CodeWarrior Build System**



This architecture means that the CodeWarrior IDE uses the same front-end compiler to support multiple back-end platform targets. In some cases, the same back-end compiler can generate code from a variety of languages. User benefits of this architecture include:

- An advance in the C/C++ front-end compiler means an immediate advance in all code generation.
- Optimizations in the IR mean that any new code generator is highly optimized.
- Targeting a new processor does not require compiler-related changes in source code, simplifying porting.

Freescale builds all compilers as plug-in modules. The compiler and linker components are modular plug-ins. Freescale publishes this API, so that developers can create custom or proprietary tools. For more information, go to Freescale Support:

http://www.Freescale.com/MW/Support

When compilation succeeds, building moves on to linking. The IDE linker:

- Links the object files into one executable file. (You use the M56800E Target settings panel to name the executable file.)
- In case of errors, issues appropriate error messages and halts.

The IDE uses linker command files to control the linker, so you do not need to specify a list of object files. The Project Manager tracks all the object files automatically; it lets you specify the link order.

When linking succeeds, you are ready to test and debug your application.

# Debugging

To debug your application, select **Project>Debug** from the main-window menu bar. The debugger window opens, displaying your program code.

Run the application from within the debugger, to observe results. The debugger lets you set breakpoints, and check register, parameter, and other values at specific points of code execution.

When your code executes correctly, you are ready to add features, to release the application to testers, or to release the application to customers.

**NOTE** Another debugging feature of the CodeWarrior IDE is viewing preprocessor output. This helps you track down bugs cause by macro expansion or another subtlety of the preprocessor. To use this feature, specify the output filename in the project window, then select **Project>Preprocess** from the main-window menu bar. A new window opens to show the preprocessed file.

4

# Target Settings

Each build target in a CodeWarrior™ project has its own settings. This chapter explains the target settings panels for DSP56800E software development. The settings that you select affect the DSP56800E compiler, linker, assembler, and debugger.

This chapter contains the following sections:

- Target Settings Overview on page 43
- CodeWarrior IDE Target Settings Panels on page 47
- DSP56800E-Specific Target Settings Panels on page 48

## Target Settings Overview

The target settings control:

- Compiler options
- Linker options
- Assembler options
- Debugger options
- Error and warning messages

When you create a project using stationery, the build targets, which are part of the stationery, already include default target settings. You can use those default target settings (if the settings are appropriate), or you can change them.

**NOTE** Use the DSP56800E project stationery when you create a new project.

### Target Setting Panels

Table 4.1 on page 44 lists the target settings panels:

- Links identify the panels specific to DSP56800E projects. Click the link to go to the explanation of that panel.
- The Use column explains the purpose of generic IDE panels that also can apply to DSP56800E projects. For explanations of these panels, see the *IDE User Guide*.

### Table 4.1 Target Setting Panels

| Group | Panel Name | Use |
|---|---|---|
| Target | Target Settings on page 49 | |
| | Access Paths | Selects the paths that the IDE searches to find files of your project. Types include absolute and project-relative. |
| | Build Extras | Sets options for building a project, including using a third-party debugger. |
| | File Mappings | Associates a filename extension, such as .c, with a plug-in compiler. |
| | Source Trees | Defines project-specific source trees (root paths) for your project. |
| | M56800E Target on page 50 | |
| Language Settings | C/C++ Language (C Only) on page 51 | |
| | C/C++ Preprocessor on page 55 | |
| | C/C++ Warnings on page 57 | |
| | M56800E Assembler on page 62 | |
| Code Generation | ELF Disassembler on page 68 | |
| | M56800E Processor on page 64 | |
| | Global Optimizations | Configures how the compiler optimizes code. |
| Linker | M56800E Linker on page 71 | |

**Table 4.1 Target Setting Panels (*continued*)**

| Group | Panel Name | Use |
|---|---|---|
| Editor | Custom Keywords | Changes colors for different types of text. |
| Debugger | Debugger Settings | Specifies settings for the CodeWarrior debugger. |
| | Remote Debugging on page 76 | |
| | M56800E Target Settings (Debugging) | |
| | Remote Debug Options on page 82 | |

# Changing Target Settings

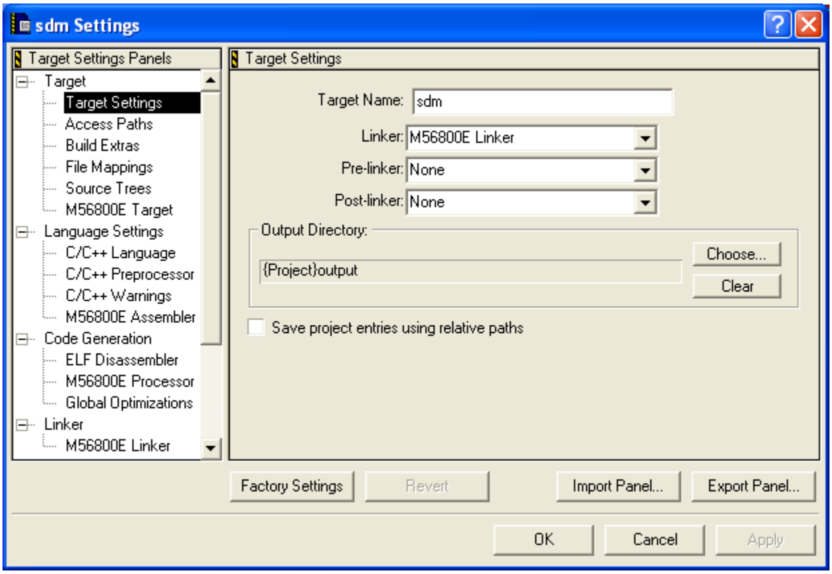
To change target settings:

1. Select **Edit > Target Name Settings.**

   *Target Name* is the name of the current build target in the CodeWarrior project.

   After you select this menu item, the CodeWarrior IDE displays the **Target Settings** window (Figure 4.1 on page 46).

**Figure 4.1 Target Settings Window**



Target Name: sdm

Linker: M56800E Linker

Pre-linker: None

Post-linker: None

Output Directory: {Project}output

□ Save project entries using relative paths

The left side of the **Target Settings** window contains a list of target settings panels that apply to the current build target.

2. To view the Target Settings panel:

   Click on the name of the **Target Settings** panel in the **Target Settings** panels list on the left side of the **Target Settings** window.

   The CodeWarrior IDE displays the target settings panel that you selected.

3. Change the settings in the panel.
4. Click OK.

# Exporting and Importing Panel Options to XML Files

The CodeWarrior IDE can export options for the current settings panel to an Extensible Markup Language (XML) file or import options for the current settings panel from a previously saved XML file.

### Exporting Panel Options to XML File

1. Click the Export Panel button.
2. Assign a name to the XML file and save the file in the desired location.

### Importing Panel Options from XML File

1. Click the Import Panel button.
2. Locate the XML file to where you saved the options for the current settings panel.
3. Open the file to import the options.

### Saving New Target Settings in Stationery

To create stationery files with new target settings:

1. Create your new project from an existing stationery.
2. Change the target settings in your new project for any or all of the build targets in the project.
3. Save the new project in the Stationery folder.

## Restoring Target Settings

After you change settings in an existing project, you can restore the previous settings by using any of the following methods:

- To restore the previous settings, click **Revert** at the bottom of the **Target Settings** window.
- To restore the settings to the factory defaults, click **Factory Settings** at the bottom of the window.

# CodeWarrior IDE Target Settings Panels

Table 4.2 on page 48 lists and explains the CodeWarrior IDE target settings panels that can apply to DSP56800E.

**Table 4.2 Code Warrior IDE Target Settings Panels**

| Target Settings Panels | Description |
|---|---|
| Access Paths | Use this panel to select the paths that the CodeWarrior IDE searches to find files in your project. You can add several kinds of paths including absolute and project-relative.<br>See *IDE User Guide*. |
| Build Extras | Use this panel to set options that affect the way the CodeWarrior IDE builds a project, including the use of a third-party debugger.<br>See *IDE User Guide*. |
| File Mappings | Use this panel to associate a file name extension, such as.c, with a plug-in compiler.<br>See *IDE User Guide*. |
| Source Trees | Use this panel to define project-specific source trees (root paths) for use in your projects.<br>See *IDE User Guide*. |
| Custom Keywords | Use this panel to change the colors that the CodeWarrior IDE uses for different types of text.<br>See *IDE User Guide*. |
| Global Optimizations | Use this panel to configure how the compiler optimizes the object code.<br>See *IDE User Guide*. |
| Debugger Settings | Use this panel to specify settings for the CodeWarrior debugger. |

# DSP56800E-Specific Target Settings Panels

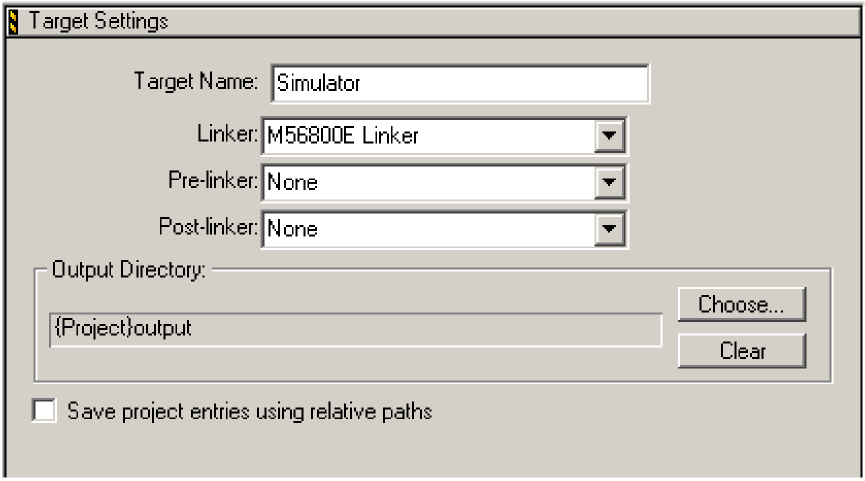
The rest of this chapter explains the target settings panels specific to DSP56800E development.

# Target Settings

Use the **Target Settings** panel (Figure 4.2 on page 49) to specify a linker. This selection also specifies your target. Table 4.3 on page 49 explains the elements of the Target Settings panel.

The Target Settings window changes its list of panels to reflect your linker choice. As your linker choice determines which other panels are appropriate, it should be your first settings action.

### Figure 4.2 Target Settings Panel



Target Name: Simulator

Linker: M56800E Linker

Pre-linker: None

Post-linker: None

Output Directory:

{Project}output

□ Save project entries using relative paths

### Table 4.3 Target Settings Panel Elements

| Element | Purpose | Comments |
|---|---|---|
| Target Name text box | Sets or changes the name of a build target. | For your development convenience, not the name of the final output file. (Use the M56800E Target panel to name the output file.) |
| Linker list box | Specifies the linker. | Select M56800E Linker. |
| Pre-linker list box | Specifies a pre-linker. | Select None.<br>(No pre-linker is available for the M56800E linker.) |

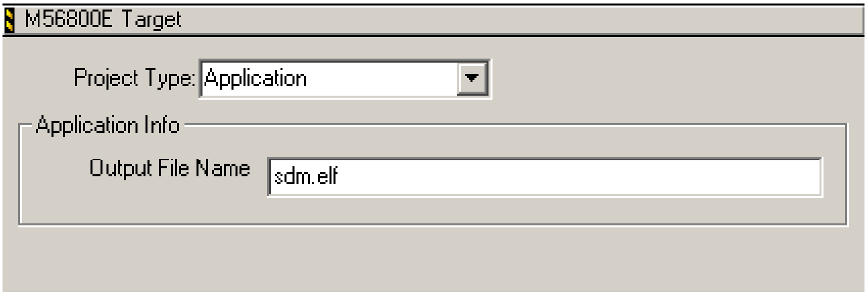
**Table 4.3 Target Settings Panel Elements (*continued*)**

| Element | Purpose | Comments |
|---|---|---|
| Post-linker list box | Specifies a post-linker. | Select None.<br>(No post-linker is available for the M56800E linker.) |
| Output Directory text box | Tells the IDE where to save the executable file. To specify a different output directory, click the **Choose** button, then use the access-path dialog box to specify a directory. (To delete such an alternate directory, click the **Clear** button.) | Default: the directory that contains the project file. |
| Save Project Entries Using Relative Paths checkbox | Controls whether multiple project files can have the same name:<br>• Clear — Each project entry must have a unique name.<br>• Checked — The IDE uses relative paths to save project entries; entry names need not be unique. | Default: Clear — project entries must have unique names. |

# M56800E Target

Use the **M56800E Target** panel (Figure 4.3 on page 50) to specify the project type and the name of the output file. Table 4.4 on page 51 explains the elements of this panel.

**Figure 4.3 M56800E Target Panel**



M56800E Target

Project Type: Application

Application Info

Output File Name sdm.elf

**Table 4.4  M56800E Target Panel Elements**

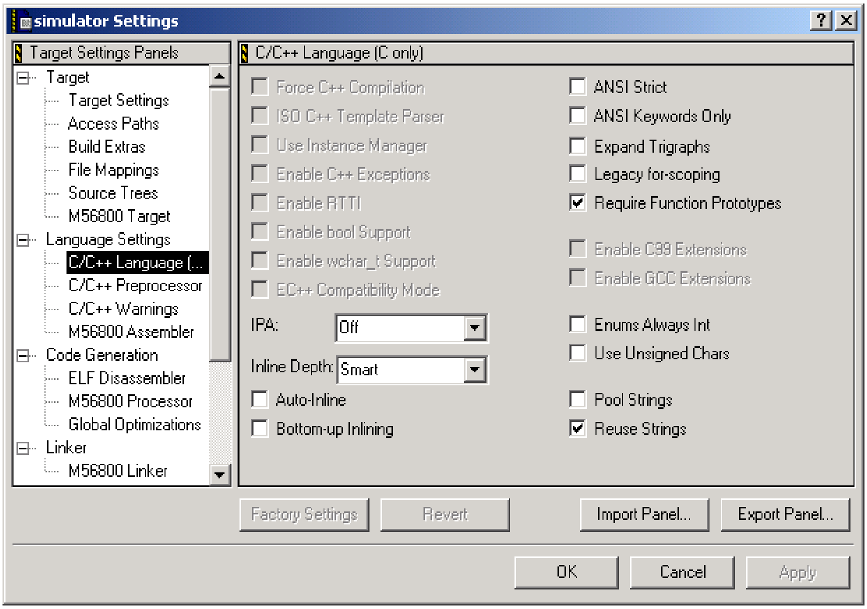
| Element | Purpose | Comments |
|---|---|---|
| Project Type list box | Specifies an **Application** or **Library** project. | Application is the usual selection. |
| Output File Name text box | Specifies the name of the output file. | End application filenames with the .elf extension; end library filenames with the .lib extension. |

**NOTE** Be sure to name libraries with the extension `.lib`. It is possible to use a different extension, but this requires a file-mapping entry in the **File Mappings** panel. For more information, see the *IDE User Guide*.

# C/C++ Language (C Only)

Use the **C/C++ Language (C Only)** panel (Figure 4.4 on page 52) to specify C language features. Table 4.5 on page 53 explains the elements of this panel that apply to the DSP56800E processor, which supports only the C language.

### Figure 4.4 C/C++ Language Panel (C Only)



C/C++ Language (C only)

- □ Force C++ Compilation
- □ ISO C++ Template Parser
- □ Use Instance Manager
- □ Enable C++ Exceptions
- □ Enable RTTI
- □ Enable bool Support
- □ Enable wchar_t Support
- □ EC++ Compatibility Mode
- IPA: Off
- Inline Depth: Smart
- □ Auto-Inline
- □ Bottom-up Inlining
- □ ANSI Strict
- □ ANSI Keywords Only
- □ Expand Trigraphs
- □ Legacy for-scoping
- ☑ Require Function Prototypes
- □ Enable C99 Extensions
- □ Enable GCC Extensions
- □ Enums Always Int
- □ Use Unsigned Chars
- □ Pool Strings
- ☑ Reuse Strings

**NOTE** Always disable the following options, which do not apply to the DSP56800E compiler: Legacy for-scoping and Pool Strings.

### Table 4.5 C/C++ Language (C Only) Panel Elements

| Element | Purpose | Comments |
|---|---|---|
| IPA list box | Specifies Interprocedural Analysis (IPA):<br>Off — IPA is disabled<br>File — inlining is deferred to the end of the file processing<br>Program — Inlining is deferred until all files within the program are processed. | When the **Program** option is selected the **Disable Deadstripping** option on the linker preference panel must be enabled. |
| Inline Depth list box | Together with the ANSI Keyword Only checkbox, specifies whether to inline functions:<br>Don't Inline — do not inline any<br>Smart — inline small functions to a depth of 2 to 4<br>1 to 8 — Always inline functions to the number's depth<br>Always inline — inline all functions, regardless of depth | If you call an inline function, the compiler inserts the function code, instead of issuing calling instructions. Inline functions execute faster, as there is no call. But overall code may be larger if function code is repeated in several places. |
| Auto-Inline checkbox | Checked — Compiler selects the functions to inline<br>Clear — Compiler does not select functions for inlining | To check whether automatic inlining is in effect, use the __option(auto_inline) command. |
| Bottom-up Inlining checkbox | Checked — For a chain of function calls, the compiler begins inlining with the last function.<br>Clear — Compiler does not do bottom-up inlining. | To check whether bottom-up inlining is in effect, use the __option(inline_bottom_up) command. |

**Table 4.5 C/C++ Language (C Only) Panel Elements (*continued*)**

| Element | Purpose | Comments |
|---|---|---|
| ANSI Strict checkbox | Checked — Disables CodeWarrior compiler extensions to C<br>Clear — Permits CodeWarrior compiler extensions to C | Extensions are C++-style comments, unnamed arguments in function definitions, # not an argument in macros, identifier after #endif, typecasted pointers as lvalues, converting pointers to same-size types, arrays of zero length in structures, and the D constant suffix.<br>To check whether ANSI strictness is in effect, use the __option(ANSI_strict) command. |
| ANSI Keywords Only checkbox | Checked — Does not permit additional keywords of CodeWarrior C.<br>Clear — Does permit additional keywords. | Additional keywords are asm (use the compiler built-in assembler) and inline (lets you declare a C function to be inline).<br>To check whether this keyword restriction is in effect, use the __option(only_std_keywords) command. |
| Expand Trigraphs checkbox | Checked — C Compiler ignores trigraph characters.<br>Clear — C Compiler does not allow trigraph characters, per strict ANSI/ ISO standards. | Many common character constants resemble trigraph sequences, especially on the Mac OS. This extension lets you use these constants without including escape characters.<br>NOTE: If this option is on, be careful about initializing strings or multi-character constants that include question marks.<br>To check whether this option is on. use the __option(trigraphs) command. |

**Table 4.5 C/C++ Language (C Only) Panel Elements (*continued*)**

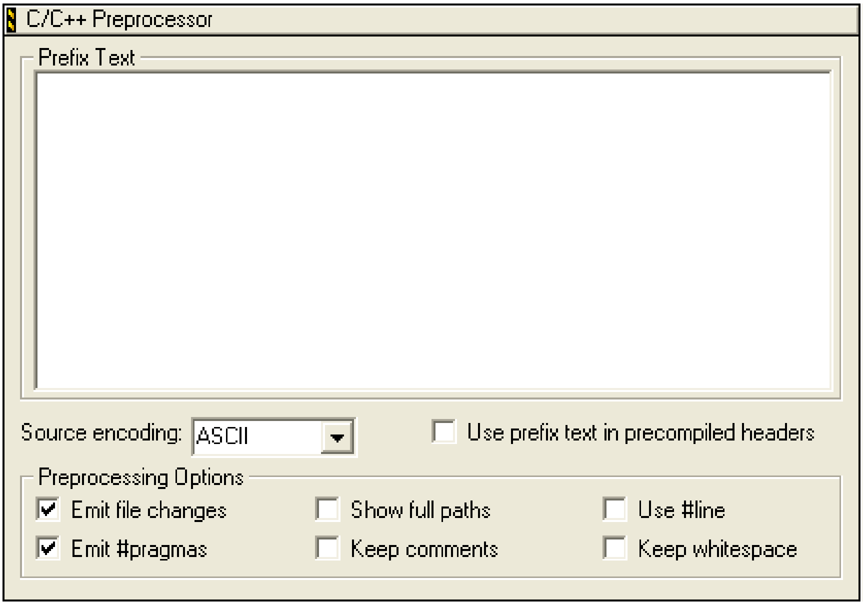
| Element | Purpose | Comments |
|---|---|---|
| Require Function Prototypes checkbox | Checked — Compiler does not allow functions that do not have prototypes.<br>Clear — Compiler allows functions without prototypes. | This option helps prevent errors from calling a function before its declaration or definition.<br>To check whether this option is in effect, use the __option(require_prototypes) command. |
| Enums Always Int checkbox | Checked — Restricts all enumerators to the size of a signed int.<br>Clear — Compiler converts unsigned int enumerators to signed int, then chooses an accommodating data type, char to long int. | To check whether this restriction is in effect, use the __option(enumalwaysint) command. |
| Use Unsigned Chars checkbox | Checked — Compiler treats a char declaration as an unsigned char declaration.<br>Clear — Compiler treats char and unsigned char declarations differently. | Some libraries were compiled without this option. Selecting this option may make your code incompatible with such libraries.<br>To check whether this option is in effect, use the __option(unsigned_char) command. |
| Reuse Strings checkbox | Checked — Compiler stores only one copy of identical string literals, saving memory space.<br>Clear — Compiler stores each string literal. | If you select this option, changing one of the strings affects them all. |

# C/C++ Preprocessor

The C/C++ Preprocessor (Figure 4.5 on page 56) panel controls how the preprocessor interprets source code. By modifying the settings on this panel, you can control how the preprocessor translates source code into preprocessed code.

More specifically, the C/C++ Preprocessor panel provides an editable text field that can be used to #define macros, set #pragmas, or #include prefix files.

**Figure 4.5 The C/C++ Preprocessor Panel**



C/C++ Preprocessor

Prefix Text

Source encoding: ASCII

□ Use prefix text in precompiled headers

Preprocessing Options

☑ Emit file changes
□ Show full paths
□ Use #line
☑ Emit #pragmas
□ Keep comments
□ Keep whitespace

Table 4.6 on page 56 provides information about the options in this panel.

**Table 4.6 C/C++ Language Preprocessor Elements**

| Element | Purpose | Comments |
|---|---|---|
| Source encoding | Allows you to specify the default encoding of source files. Multibyte and Unicode source text is supported. | To replicate the obsolete option “Multi-Byte Aware”, set this option to System or Autodetect. Additionally, options that affect the "preprocess" request appear in this panel. |
| Use prefix text in precompiled header | Controls whether a *.pch or *.pch++ file incorporates the prefix text into itself. | This option defaults to “off” to correspond with previous versions of the compiler that ignore the prefix file when building precompiled headers. If any #pragmas are imported from old C/C++ Language (C Only) Panel settings, this option is set to “on”. |

**Table 4.6 C/C++ Language Preprocessor Elements (*continued*)**

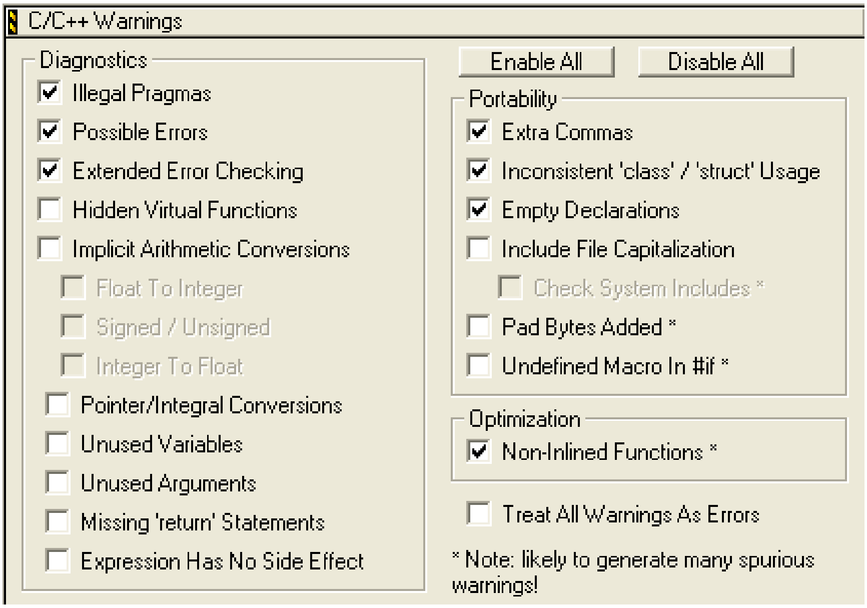
| Element | Purpose | Comments |
|---|---|---|
| Emit file changes | Controls whether notification of file changes (or #line changes) appear in the output. | |
| Emit #pragmas | Controls whether #pragmas encountered in the source text appear in the preprocessor output. | This option is essential for producing reproducible test cases for bug reports. |
| Show full paths | Controls whether file changes show the full path or the base filename of the file. | |
| Keep comments | Controls whether comments are emitted in the output. | |
| Use #line | Controls whether file changes appear in comments (as before) or in #line directives. | |
| Keep whitespace | Controls whether whitespace is stripped out or copied into the output. | This is useful for keeping the starting column aligned with the original source, though we attempt to preserve space within the line. This doesn't apply when macros are expanded. |

# C/C++ Warnings

Use the C/C++ Warnings panel (Figure 4.6 on page 58) to specify C language features for the DSP56800E. Table 4.7 on page 59 explains the elements of this panel.

**NOTE** The CodeWarrior compiler for DSP56800E does not support C++.

**Figure 4.6 C/C++ Warnings Panel**



Diagnostics

- ☑ Illegal Pragmas
- ☑ Possible Errors
- ☑ Extended Error Checking
- □ Hidden Virtual Functions
- □ Implicit Arithmetic Conversions
  - □ Float To Integer
  - □ Signed / Unsigned
  - □ Integer To Float
- □ Pointer/Integral Conversions
- □ Unused Variables
- □ Unused Arguments
- □ Missing 'return' Statements
- □ Expression Has No Side Effect

Portability

- ☑ Extra Commas
- ☑ Inconsistent 'class' / 'struct' Usage
- ☑ Empty Declarations
- □ Include File Capitalization
  - □ Check System Includes *
- □ Pad Bytes Added *
- □ Undefined Macro In #if *

Optimization

- ☑ Non-Inlined Functions *

□ Treat All Warnings As Errors

* Note: likely to generate many spurious warnings!

### Table 4.7 C/C++ Warnings Panel Elements

| Element | Purpose | Comments |
|---|---|---|
| Illegal Pragmas checkbox | Checked — Compiler issues warnings about invalid pragma statements.<br>Clear — Compiler does not issue such warnings. | According to this option, the invalid statement **#pragma near_data off** would prompt the compiler response **WARNING: near data is not a pragma**.<br>To check whether this option is in effect, use the __option(warn_illpragma) command. |
| Possible Errors checkbox | Checked — Compiler checks for common typing mistakes, such as == for =.<br>Clear — Compiler does not perform such checks. | If this option is in effect, any of these conditions triggers a warning: an assignment in a logical expression; an assignment in a while, if, or for expression; an equal comparison in a statement that contains a single expression; a semicolon immediately after a while, if, or for statement.<br>To check whether this option is in effect, use the __option(warn_possunwant) command. |
| Extended Error Checking checkbox | Checked — Compiler issues warnings in response to specific syntax problems.<br>Clear — Compiler does not perform such checks. | Syntax problems are: a non-void function without a return statement, an integer or floating-point value assigned to an enum type, or an empty return statement in a function not declared void.<br>To check whether this option is in effect, use the __option(extended_errorcheck) command. |
| Hidden Virtual Functions | Leave clear. | Does not apply to C. |

### Table 4.7 C/C++ Warnings Panel Elements (*continued*)

| Element | Purpose | Comments |
|---|---|---|
| Implicit Arithmetic Conversions checkbox | Checked — Compiler verifies that operation destinations are large enough to hold all possible results.<br>Clear — Compiler does not perform such checks. | If this option is in effect, the compiler would issue a warning in response to assigning a long value to a char variable.<br>To check whether this option is in effect, use the __option(warn_implicitconv) command. |
| Pointer/ Integral Conversions | Checked — Compiler checks for pointer/integral conversions.<br>Clear — Compiler does not perform such checks. | See #pragma warn_any_ptr_int_conv and #pragma warn_ptr_int_conv. |
| Unused Variables checkbox | Checked — Compiler checks for declared, but unused, variables.<br>Clear — Compiler does not perform such checks. | The pragma **unused** overrides this option.<br>To check whether this option is in effect, use the __option(warn_unusedvar) command. |
| Unused Arguments checkbox | Checked — Compiler checks for declared, but unused, arguments.<br>Clear — Compiler does not perform such checks. | The pragma unused overrides this option.<br>Another way to override this option is clearing the ANSI Strict checkbox of the C/C++ Language (C Only) panel, then not assigning a name to the unused argument.<br>To check whether this option is in effect, use the __option(warn_unusedarg) command. |
| Missing ‘return’ Statements | Checked — Compiler checks for missing ‘return’ statements.<br>Clear — Compiler does not perform such checks. | See #pragma warn_missingreturn. |

**Table 4.7 C/C++ Warnings Panel Elements (*continued*)**

| Element | Purpose | Comments |
|---|---|---|
| Expression Has No Side Effect | Checked — Compiler issues warning if expression has no side effect.<br>Clear — Compiler does not perform such checks. | See #pragma warn_no_side_effect |
| Extra Commas checkbox | Checked — Compiler checks for extra commas in enums.<br>Clear — Compiler does not perform such checks. | To check whether this option is in effect, use the __option(warn_extracomma) command. |
| Inconsistent Use of ‘class’ and ‘struct’ Keywords checkbox | Leave clear. | Does not apply to C. |
| Empty Declarations checkbox | Checked — Compiler issues warnings about declarations without variable names.<br>Clear — Compiler does not issue such warnings. | According to this option, the incomplete declaration **int ;** would prompt the compiler response **WARNING**.<br>To check whether this option is in effect, use the __option(warn_emptydecl) command. |
| Include File Capitalization | Checked — Compiler issues warning about include file capitalization.<br>Clear — Compiler does not perform such checks. | See #pragma warn_filenamecaps. |
| Pad Bytes Added | Checked — Compiler checks for pad bytes added.<br>Clear — Compiler does not perform such checks. | See #pragma warn_padding. |
| Undefined Macro In #if | Checked — Compiler checks for undefined macro in #if.<br>Clear — Compiler does not perform such checks. | See #pragma warn_undefmacro. |

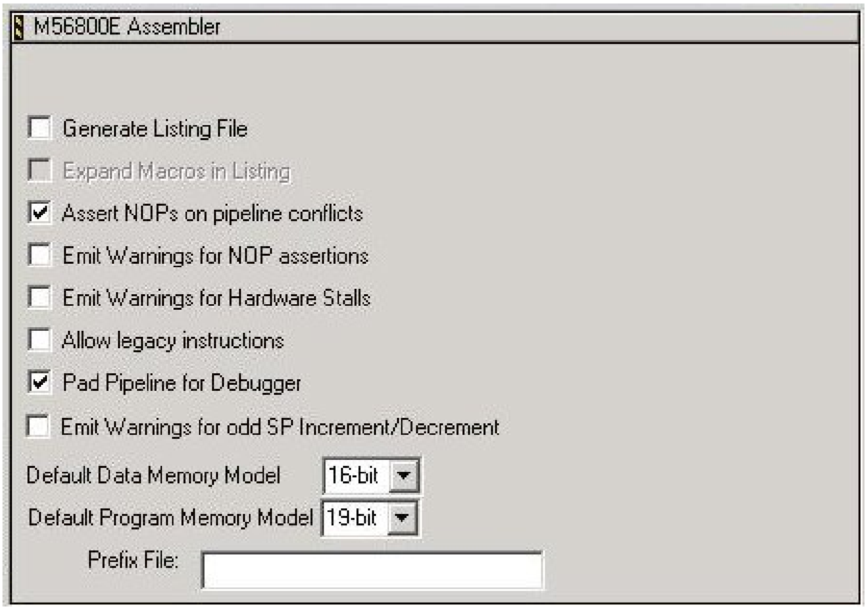
**Table 4.7 C/C++ Warnings Panel Elements (*continued*)**

| Element | Purpose | Comments |
|---|---|---|
| Non-Inlined Functions checkbox | Checked — Compiler issues a warning if unable to inline a function.<br>Clear — Compiler does not issue such warnings. | To check whether this option is in effect, use the __option(warn_notinlined) command. |
| Treat All Warnings As Errors checkbox | Checked — System displays warnings as error messages.<br>Clear — System keeps warnings and error messages distinct. | |

# M56800E Assembler

Use the M56800E Assembler panel (Figure 4.7 on page 62) to specify the format of the assembly source files and the code that the DSP56800E assembler generates. Table 4.8 on page 63 explains the elements of this panel.

**Figure 4.7 M56800E Assembler Panel**



M56800E Assembler

□ Generate Listing File
□ Expand Macros in Listing
☑ Assert NOPs on pipeline conflicts
□ Emit Warnings for NOP assertions
□ Emit Warnings for Hardware Stalls
□ Allow legacy instructions
☑ Pad Pipeline for Debugger
□ Emit Warnings for odd SP Increment/Decrement

Default Data Memory Model: 16-bit
Default Program Memory Model: 19-bit
Prefix File:

**Table 4.8 M56800E Assembler Panel Elements**

| Element | Purpose | Comments |
|---|---|---|
| Generate Listing File checkbox | Checked — Assembler generates a listing file during IDE assembly of source files.<br>Clear — Assembler does not generate a listing file. | A listing file contains the source file with line numbers, relocation information, and macro expansions. The filename extension is .lst. |
| Expand Macros in Listing checkbox | Checked — Assembler macros expand in the assembler listing.<br>Clear — Assembler macros do not expand. | This checkbox is available only if the Generate Listing File checkbox is checked. |
| Assert NOPs on pipeline conflicts checkbox | Checked — Assembler automatically resolves pipeline conflicts by inserting NOPs.<br>Clear — Assembler does not insert NOPs; it reports pipeline conflicts in error messages. | |
| Emit Warnings for NOP assertions checkbox | Checked — Assembler issues a warning any time it inserts a NOP to prevent a pipeline conflict.<br>Clear — Assembler does not issue such warnings. | This checkbox is available only if the Assert NOPs on pipeline conflicts checkbox is checked. |
| Emit Warnings for Hardware Stalls checkbox | Checked — Assembler warns when a hardware stall occurs upon execution.<br>Clear — Assembler does not issue such warnings. | This option helps optimize the cycle count. |
| Allow legacy instructions checkbox | Checked — Assembler permits legacy DSP56800 instruction syntax.<br>Clear — Assembler does not permit this legacy syntax. | Selecting this option sets the Default Data Memory Model and Default Program Memory Model values to 16 bits. |

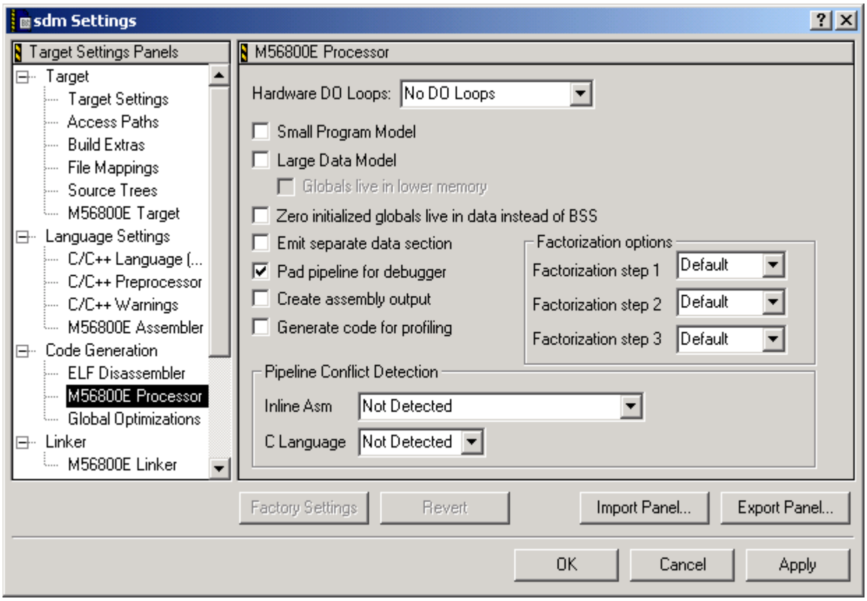
**Table 4.8 M56800E Assembler Panel Elements (*continued*)**

| Element | Purpose | Comments |
|---|---|---|
| Pad Pipeline for Debugger checkbox | Checked — Mandatory for using the debugger. Inserts NOPs after certain branch instructions to make breakpoints work reliably.<br>Clear — Does not insert such NOPs. | If you select this option, you should select the same option in the M56800E Processor Settings panel. Selecting this option increases code size by 5 percent. But not selecting this option risks nonrecovery after the debugger comes to breakpoint branch instructions. |
| Emit Warnings for odd SP Increment/ Decrement checkbox | Checked — Enables assembler warnings about instructions that could misalign the stack frame.<br>Clear — Does not enable such warnings. | |
| Default Data Memory Model list box | Specifies 16 or 24 bits as the default size. | Factory setting: 16 bits. |
| Default Program Memory Model list box | Specifies 16, 19, or 21 bits as the default size. | Factory setting: 19 bits. |
| Prefix File text box | Specifies a file to be included at the beginning of every assembly file of the project. | Lets you include common definitions without using an include directive in every file. |

# M56800E Processor

Use the M56800E Processor panel (Figure 4.8 on page 65) to specify the kind of code the compiler creates. This panel is available only if the current build target uses the M56800E Linker. Table 4.9 on page 65 explains the elements of this panel.

**Figure 4.8 M56800E Processor Panel**



M56800E Processor

Hardware DO Loops: No DO Loops

☐ Small Program Model

☐ Large Data Model

☐ Globals live in lower memory

☐ Zero initialized globals live in data instead of BSS

☐ Emit separate data section

☑ Pad pipeline for debugger

☐ Create assembly output

☐ Generate code for profiling

Factorization options

Factorization step 1: Default

Factorization step 2: Default

Factorization step 3: Default

Pipeline Conflict Detection

Inline Asm: Not Detected

C Language: Not Detected

**Table 4.9 M56800E Processor Panel Elements**

| Element | Purpose | Comments |
|---|---|---|
| Hardware DO Loops list box | Specifies the level of hardware DO loops:<br>• No DO Loops — Compiler does not generate any<br>• No Nested DO Loops — Compiler generates hardware DO loops, but does not nest them<br>• Nested DO Loops — Compiler generates hardware DO loops, nesting them two deep. | If hardware DO loops are enabled, debugging will be inconsistent about stepping into loops.<br>Test immediately after this table contains additional Do-loop information. |
| Small Program Model checkbox | Checked — Compiler generates a more efficient switch table, provided that code fits into the range 0x0—0xFFFF<br>Clear — Compiler generates an ordinary switch table. | Do not check this checkbox unless the entire program code fits into the 0x0—0xFFFF memory range. |

### Table 4.9 M56800E Processor Panel Elements (*continued*)

| Element | Purpose | Comments |
|---|---|---|
| Large Data Model checkbox | Checked — Extends DSP56800E addressing range by providing 24-bit address capability to instructions<br>Clear — Does not extend address range | 24-bit address modes allow access beyond the 64K-byte boundary of 16-bit addressing. |
| Globals live in lower memory checkbox | Checked — Compiler uses 24-bit addressing for pointer and stack operations, 16-bit addressing for access to global and static data.<br>Clear — Compiler uses 24-bit addressing for all data access. | This checkbox is available only if the Large Data Model checkbox is checked. |
| Pad pipeline for debugger checkbox | Checked — Mandatory for using the debugger. Inserts NOPs after certain branch instructions to make breakpoints work reliably.<br>Clear — Does not insert such NOPs. | If you select this option, you should select the same option in the M56800E Assembler panel. Selecting this option increases code size by 5 percent. But not selecting this option risks nonrecovery after the debugger comes to breakpoint branch instructions. |
| Emit separate character data section checkbox | Checked — Compiler breaks out all character data, placing it in appropriate data sections (.data.char, .bss.char, or .const.data.char).<br>Clear — Compiler does not break out this data. | See additional information immediately after this table. |
| Zero-initialized globals live in data instead of BSS checkbox | Checked — Globals initialized to zero reside in the .data section.<br>Clear — Globals initialized to zero reside in the .bss section. | |
| Create assembly output checkbox | Checked — Assembler generates assembly code for each C file.<br>Clear — Assembler does not generate assembly code for each C file. | The pragma #asmoutput overrides this option for individual files. |

**Table 4.9 M56800E Processor Panel Elements (*continued*)**

| Element | Purpose | Comments |
|---|---|---|
| Generate code for profiling | Checked — Compiler generates code for profiling.<br>Clear — Compiler does not generate code for profiling. | For more details about the profiler, see the “Profiler” on page 227. |
| Pipeline Conflict Detection Inline ASM list box | Specifies pipeline conflict detection during compiling of inline assembly source code:<br>• Not Detected — compiler does not check for conflicts<br>• Conflict Error — compiler issues error messages if it detects conflicts<br>• Conflict Error/Hardware Stall Warning — compiler issues error messages if it detects conflicts, warnings if it detects hardware stalls | For more information about pipeline conflicts, see the explanations of pragmas check_c_src_pipeline and check_inline_asm_pipeline. |
| Pipeline Conflict Detection C Language list box | Specifies pipeline conflict detection during compiling of C source code:<br>• Not Detected — compiler does not check for conflicts<br>• Conflict error — compiler issues error messages if it detects conflicts | For more information about pipeline conflicts, see the explanations of pragmas check_c_src_pipeline and check_inline_asm_pipeline. |

The compiler generates hardware DO loops for two situations:

1. Aggregate (array and structure) initializations, and for struct copy, under any of these conditions:
   - The aggregate is byte aligned, and the aggregate size is greater than four bytes.
   - The aggregate is word aligned, and the aggregate size is greater than four words.
   - The aggregate is long aligned, the aggregate size is greater than eight words, and the Global Optimizations panel specifies Optimize for Smaller Code Size.
   - The aggregate is long aligned, the aggregate size is greater than 32 words, and the Global Optimizations panel specifies Optimize for Faster Execution.

2. Counted loops in C, provided that the loop counter value is less than 65536, and that there are no jumps to subroutines inside the loop.

If you enable separate character data sections, the compiler puts character data (and structures containing character data) into these sections:

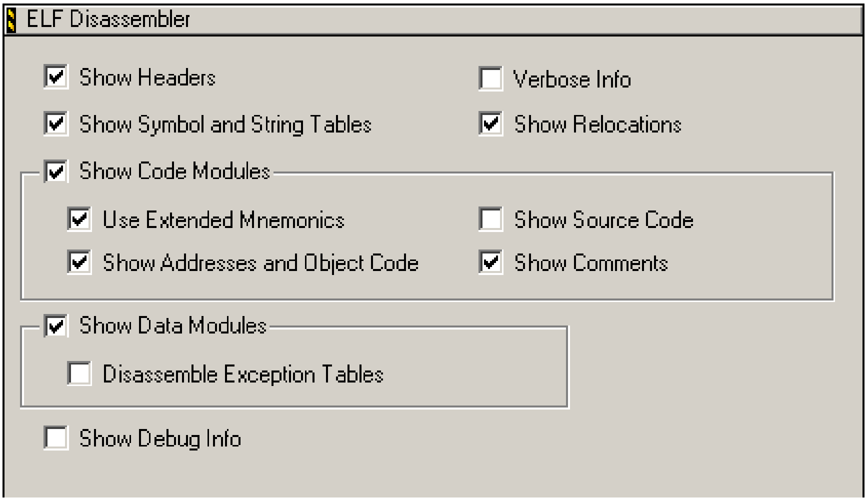
- .data.char — initialized static or global character data objects
- .bss.char — uninitialized static or global character data objects
- .const.data.char — const qualified character objects and static string data

You can locate these data sections in the lower half of the memory map, making sure that the data can be addressed.

# ELF Disassembler

Use the ELF Disassembler panel (Figure 4.9 on page 68) to specify the content and display format for disassembled object files. Table 4.10 on page 69 explains the elements of this panel. (To view a disassembled module, select **Project>Disassemble** from the main-window menu bar.)

**Figure 4.9 ELF Disassembler Panel**



ELF Disassembler

☑ Show Headers
□ Verbose Info
☑ Show Symbol and String Tables
☑ Show Relocations
☑ Show Code Modules
☑ Use Extended Mnemonics
□ Show Source Code
☑ Show Addresses and Object Code
☑ Show Comments
☑ Show Data Modules
□ Disassemble Exception Tables
□ Show Debug Info

**Table 4.10 ELF Disassembler Panel Elements**

| Element | Purpose | Comments |
|---|---|---|
| Show Headers checkbox | Checked — Disassembled output includes ELF header information.<br>Clear — Disassembled output does not include this information. | |
| Show Symbol and String Tables checkbox | Checked — Disassembled modules include symbol and string tables.<br>Clear — Disassembled modules do not include these tables. | |
| Verbose Info checkbox | Checked — ELF file includes additional information.<br>Clear — ELF file does not include additional information. | For the .symtab section, additional information includes numeric equivalents for some descriptive constants. For the .line and .debug sections, additional information includes an unstructured hex dump. |
| Show Relocations checkbox | Checked — Shows relocation information for corresponding text (.rela.text) or data (.rela.data) section.<br>Clear — Does not show relocation information. | |
| Show Code Modules checkbox | Checked — Disassembler outputs ELF code sections for the disassembled module. Enables subordinate checkboxes.<br>Clear — Disassembler does not output these sections. Disables subordinate checkboxes. | Subordinate checkboxes are Use Extended Mnemonics, Show Addresses and Object Code, Show Source Code, and Show Comments. |
| Use Extended Mnemonics checkbox | Checked — Disassembler lists extended mnemonics for each instruction of the disassembled module.<br>Clear — Disassembler does not list extended mnemonics. | This checkbox is available only if the Show Code Modules checkbox is checked. |

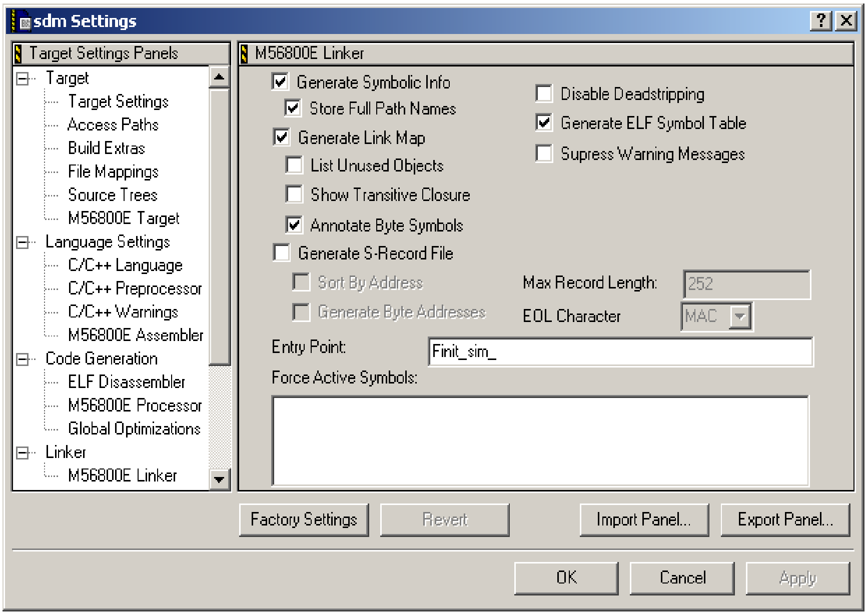
**Table 4.10 ELF Disassembler Panel Elements (*continued*)**

| Element | Purpose | Comments |
|---|---|---|
| Show Addresses and Object Code checkbox | Checked — Disassembler lists address and object code for the disassembled module.<br>Clear — Disassembler does not list this code. | This checkbox is available only if the Show Code Modules checkbox is checked. |
| Show Source Code checkbox | Checked — Disassembler lists source code for the current module.<br>Clear — Disassembler does not list source code. | Source code appears in mixed mode, with line-number information from the original C source file.<br>This checkbox is available only if the Show Code Modules checkbox is checked. |
| Show Comments checkbox | Checked — Disassembler comments appear in sections that have comment columns.<br>Clear — Disassembler does not produce comments. | This checkbox is available only if the Show Code Modules checkbox is checked. |
| Show Data Modules checkbox | Checked — Disassembler outputs ELF data sections, such as .data and .bss, for the disassembled module.<br>Clear — Disassembler does not output ELF data sections. | |
| Disassemble Exception Tables checkbox | **Leave clear.** | Does not apply to C. |
| Show Debug Info checkbox | Checked — Disassembler includes DWARF symbol information in output.<br>Clear — Disassembler does not include this information in output. | |

## M56800E Linker

Use the M56800E Linker panel (Figure 4.10 on page 71) to specify linker behavior of the linker. (This panel is only available if the current build target uses the M56800E Linker.) Table 4.11 on page 72 explains the elements of this panel.

**Figure 4.10 M56800E Linker Panel**



M56800E Linker

☑ Generate Symbolic Info

☑ Store Full Path Names

☑ Generate Link Map

□ List Unused Objects

□ Show Transitive Closure

☑ Annotate Byte Symbols

□ Generate S-Record File

□ Sort By Address

□ Generate Byte Addresses

□ Disable Deadstripping

☑ Generate ELF Symbol Table

□ Supress Warning Messages

Max Record Length: 252

EOL Character: MAC

Entry Point: Finit_sim_

Force Active Symbols:

### Table 4.11 M56800E Linker Panel Elements

| Element | Purpose | Comments |
|---|---|---|
| Generate Symbolic Info checkbox | Checked — Linker generates debugging information, within the linked ELF file.<br>Clear — Linker does not generate debugging information. | If you select Project>Debug from the main-window menu bar, the IDE automatically enables this option.<br>Clearing this checkbox prevents you from using the CodeWarrior debugger on your project; it also disables the subordinate Store Full Path Names checkbox. |
| Store Full Path Names checkbox | Checked — Linker includes full path names for source files. (Default)<br>Clear — Linker uses only file names. | This checkbox is available only if the Generate Symbolic Info checkbox is checked. |
| Generate Link Map checkbox | Checked — Linker generates a link map. Enables subordinate checkboxes List Unused Objects, Show Transitive Closure, and Annotate Byte Symbols.<br>Clear — Linker does not generate a link map. | A link map shows which file provided the definition of each object and function, the address of each object and function, a memory map of section locations, and values of linker-generated symbols. It also lists unused but unstripped symbols. |
| List Unused Objects checkbox | Checked — Linker includes unused objects in the link map.<br>Clear — Linker does not include unused objects in the link map. | This checkbox is available only if the Generate Link Map checkbox is checked. |
| Show Transitive Closure checkbox | Checked — Link map includes a list of all objects that main( ) references.<br>Clear — Link map does not include this list. | Text after this table includes an example list.<br>This checkbox is available only if the Generate Link Map checkbox is checked. |

**Table 4.11 M56800E Linker Panel Elements (*continued*)**

| Element | Purpose | Comments |
|---|---|---|
| Annotate Byte Symbols | Checked — Linker includes B annotation for byte data types (e.g., char) in the Linker Command File.<br>Clear — By default, the Linker does not include the B annotation in the Linker Command File. Everything without the B annotation is a word address. | For an example of the Linker Command File with and without the B annotation, see Listing 4.3 on page 75. |
| Disable Deadstripping checkbox | Checked — Prevents the linker from stripping unused code or data.<br>Clear — Lets the linker deadstrip. | |
| Generate ELF Symbol Table checkbox | Checked — Linker includes an ELF symbol table and relocation list in the ELF executable file.<br>Clear — Linker does not include these items in the ELF executable file. | |
| Suppress Warning Messages checkbox | Checked — Linker does not display warnings in the message window.<br>Clear — Linker displays warnings in the message window. | |
| Generate S-Record File checkbox | Checked — Linker generates an output file in S-record format. Activates subordinate checkboxes.<br>Clear — Linker does not generate an S-record file. | For the DSP56800E, this option outputs three S-record files: .s (both P and X memory contents), .p (P memory contents), and .x (X memory contents). The linker puts S-record files in the output folder (a sub-folder of the project folder.) |
| Sort By Address checkbox | Checked — Enables the compiler to use byte addresses to sort type S3 S-records that the linker generates.<br>Clear — Does not enable byte-address sorting. | This checkbox is available only if the Generate S-Record File checkbox is checked. |

### Table 4.11 M56800E Linker Panel Elements (*continued*)

| Element | Purpose | Comments |
|---|---|---|
| Generate Byte Addresses checkbox | Checked — Enables the linker to generate type S3 S-records in bytes.<br>Clear — Does not enable byte generation. | This checkbox is available only if the Generate S-Record File checkbox is checked. |
| Max Record Length text box | Specifies the maximum length of type S3 S-records that the linker generates, up to 256 bytes. | The CodeWarrior debugger handles 256-byte S-records. If you use different software to load your embedded application, this text box should specify that software's maximum length for S-records.<br>This checkbox is available only if the Generate S-Record File checkbox is checked. |
| EOL Character list box | Specifies the end-of-line character for the type S3 S-record file: MAC, DOS, or UNIX format. | This checkbox is available only if the Generate S-Record File checkbox is checked. |
| Entry Point text box | Specifies the program starting point — the first function the linker uses when the program runs. | Text after this table includes additional information about the entry point. |
| Force Active Symbols text box | Directs the linker to include symbols in the link, even if those symbols are not referenced. Makes symbols immune to deadstripping. | Separate multiple symbols with single spaces. |

Check the Show Transitive Closure checkbox to have the link map include the list of objects main( ) references. Consider the sample code of Listing 4.1 on page 74. If the Show Transitive Closure option is in effect and you compile this code, the linker generates a link map file that includes the list of Listing 4.2 on page 75.

### Listing 4.1 Sample Code for Show Transitive Closure

```
void foot( void ){  int a = 100; }
void pad( void ){ int b = 101; }

int main( void ){
  foot();
  pad();
  return 1;
}
```

### Listing 4.2 Link Map File: List of main( ) references

```
# Link map of Finit_sim_
  1] interrupt_vectors.text found in 56800E_vector.asm
   2] sim_intRoutine (notype,local) found in 56800E_vector.asm
   2] Finit_sim_ (func,global) found in 56800E_init.asm
    3] Fmain (func,global) found in M56800E_main.c
     4] Ffoot (func,global) found in M56800E_main.c
     4] Fpad (func,global) found in M56800E_main.c
    3] F__init_sections (func,global) found in Runtime 56800E.lib
initsections.o
     4] Fmemset (func,global) found in MSL C 56800E.lib mem.o
      5] F__fill_mem (func,global) found in MSL C 56800E.lib
mem_funcs.o
  1] Finit_sim_ (func,global) found in 56800E_init.asm
```

Use the Entry Point text box to specify the starting point for a program. The default function this text box names is in the startup code that sets up the DSP56800E environment before your code executes. This function and its corresponding startup code depend on your stationery selection.

For hardware-targeted stationery, the startup code is on the path:

`support\<`*`name of hardware, e.g., M56852E`*`>\startup`

For simulator-targeted stationery, the startup code is on the path:

`support\M56800E\init`

The startup code performs such additional tasks as clearing the hardware stack, creating an interrupt table, and getting the addresses for the stack start and exception handler. The final task for the startup code is calling your `main()` function.

Check the Annotate Byte Symbols checkbox to have the link map include the `B` annotation for byte addresses and no `B` annotation for word addresses (Listing 4.3 on page 75).

### Listing 4.3 Example of Annotate Byte Symbols

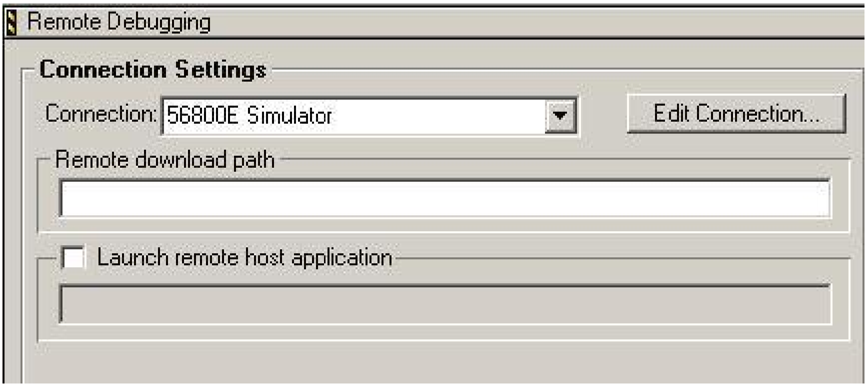
```
int myint;
char mychar;


B 0000049C 00000001 .bss Fmychar (main.c)
0000024F 00000001 .bss Fmyint (main.c)
```

## Remote Debugging

Use the Remote Debugging panel (Figure 4.11 on page 76, Figure 4.12 on page 76) to set parameters for communication between a DSP56800E board or Simulator and the CodeWarrior DSP56800E debugger. Table 4.12 on page 77 explains the elements of this panel.

**NOTE** Communications specifications also involve settings of the debugging M56800E Target panel (Figure 4.14 on page 79).

**Figure 4.11 Remote Debugging Panel (56800E Simulator)**



Remote Debugging

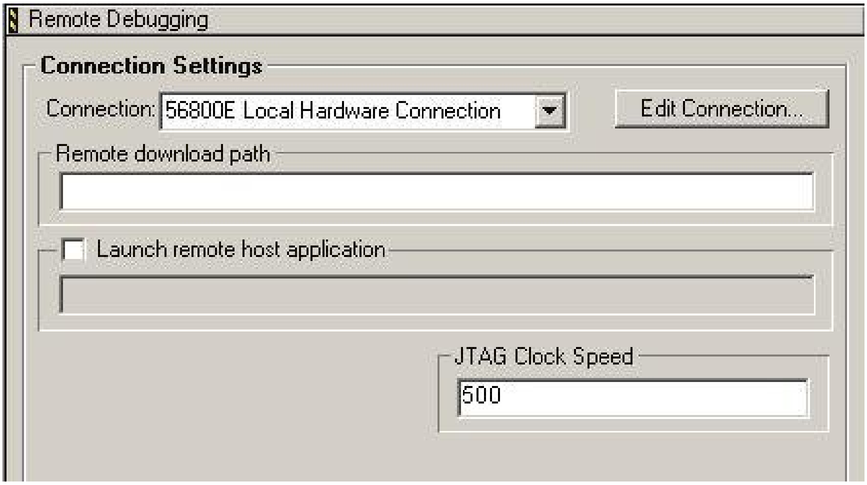
Connection Settings

Connection: 56800E Simulator

Remote download path

□ Launch remote host application

**Figure 4.12 Remote Debugging Panel (56800E Local Connection)**



Remote Debugging

Connection Settings

Connection: 56800E Local Hardware Connection

Remote download path

□ Launch remote host application

JTAG Clock Speed

500

**Table 4.12  Remote Debugging Panel Elements**

| Element | Purpose | Comments |
|---|---|---|
| Connection list box | Specifies the connection type:<br>• 56800E Simulator — appropriate for testing code on the simulator before downloading code to an actual board.<br>• 56800E Local Hardware Connection (CSS) — appropriate for using your computer's command converter server, connected to a DSP56800E board. | Selecting 56800E Simulator keeps the panel as Figure 4.11 on page 76 shows.<br>Selecting Local Hardware Connection adds the JTAG Clock Speed text box to the panel, as Figure 4.12 on page 76 shows. |
| Remote download path text box | | Not supported at this time. |
| Launch Remote Host Application checkbox | | Not supported at this time. |
| JTAG Clock Speed text box | Specifies the JTAG clock speed for local hardware connection. (Default is 500 kilohertz.) | This list box is available only if the Connection list box specifies Local Hardware Connection (CSS). The HTI will not work properly with a clock speed over 500 kHz. |

# M56800E Target (Debugging)

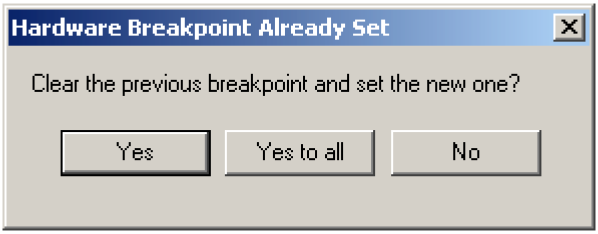
Use the debugging M56800E Target panel (Figure 4.14 on page 79) to set parameters for communication between a DSP56800E board or Simulator and the CodeWarrior DSP56800E debugger. Table 4.13 on page 79 explains the elements of this panel.

**NOTE** Communications specifications also involve settings of the Remote Debugging panel (Figure 4.11 on page 76, Figure 4.12 on page 76).

## Auto-clear previous breakpoint on new breakpoint request

This option is only available when you enable the **Breakpoint Mode (HW only)** option. When you also enable the **Auto-clear previous hardware breakpoint** and set a breakpoint, the original breakpoint is automatically cleared and the new breakpoint is immediately set. If you disable the **Auto-clear previous hardware breakpoint** option and attempt to set another breakpoint, you will be prompted with the following message:

**Figure 4.13 Hardware Breakpoint Already Set**



Hardware Breakpoint Already Set

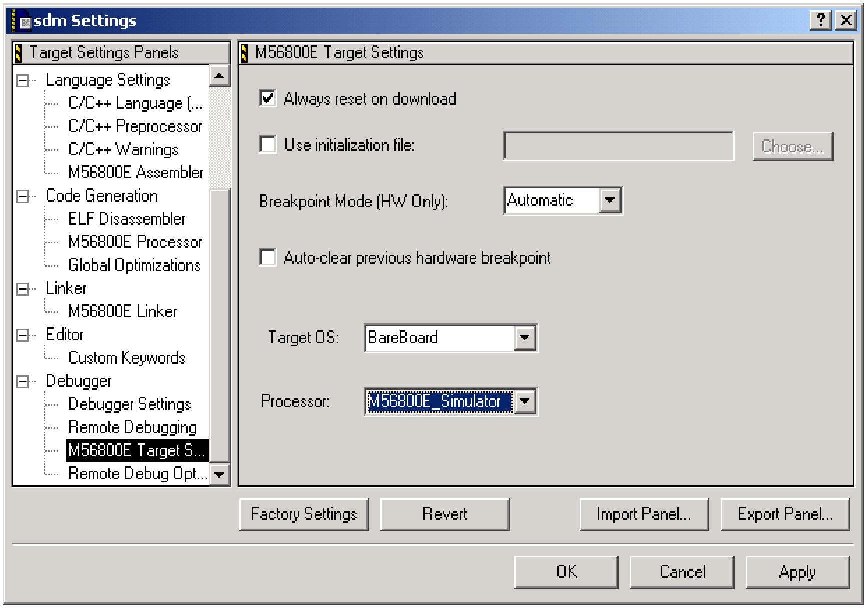
Clear the previous breakpoint and set the new one?

If you click the **Yes** button, the previous breakpoint is cleared and the new breakpoint is set.

If you click the **Yes to all** button, the **Auto-clear previous hardware breakpoint** option is enabled and the previously set breakpoint is cleared out without prompting for every subsequent occurrence.

If you click the **No** button, the previous breakpoint is kept and the new breakpoint request is ignored.

### Figure 4.14 Debugging M56800E Target Panel



☑ Always reset on download

□ Use initialization file:

Breakpoint Mode (HW Only): Automatic

□ Auto-clear previous hardware breakpoint

Target OS: BareBoard

Processor: M56800E_Simulator

### Table 4.13 Debugging M56800E Target Panel Elements

| Element | Purpose | Comments |
|---|---|---|
| Always reset on download checkbox | Checked — IDE issues a reset to the target board each time you connect to the board.<br>Clear — IDE does not issue a reset each time you connect to the target board. | |
| Use initialization file checkbox | Checked — After a reset, the IDE uses an optional hardware initialization file before downloading code.<br>Clear — IDE does not use a hardware initialization file. | The Use initialization file text box specifies the file.<br>Text immediately after this table gives more information about initialization files. |
| Use initialization file text box | Specifies the initialization file. | Applicable only if the Use initialization file checkbox is checked. |

**Table 4.13 Debugging M56800E Target Panel Elements (*continued*)**

| Element | Purpose | Comments |
|---|---|---|
| Breakpoint Mode checkbox | Specifies the breakpoint mode:<br>• Automatic — CodeWarrior software determines when to use software or hardware breakpoints.<br>• Software — CodeWarrior software always uses software breakpoints.<br>• Hardware — CodeWarrior software always uses the available hardware breakpoints. | Software breakpoints contain debug instructions that the debugger writes into your code. You cannot set such breakpoints in flash, as it is read-only.<br>Hardware breakpoints use the on-chip debugging capabilities of the DSP56800E. The number of available hardware breakpoints limits these capabilities.<br>Note, Breakpoint Mode (HW only) affects HW targets. |
| Auto-clear previous hardware breakpoint | Checked — Automatically clears the previous hardware breakpoint.<br>Clear — Does not automatically clear the previous hardware breakpoint. | |
| Target OS list box | Specifies the OS | Selects the OS plug-in. The **BareBoard** option does not use an OS plug-in. |
| Processor list box | Specifies the processor | Currently this selects the register layout. |

An initialization file consists of text instructions telling the debugger how to initialize the hardware after reset, but before downloading code. You can use initialization file commands to assign values to registers and memory locations, and to set up flash memory parameters.

The initialization files of your IDE are on the path:

```
{CodeWarrior path}\M56800E Support\initialization
```

The name of each initialization file includes the number of the corresponding processor, such as 568345. Each file with “_ext” enables the processor’s external memory. If the processor has Flash memory, the initialization file with “_flash” enables both Flash and external memory.

To set up an initialization file:

1. In the debugging M56800E Target panel, check the Use initialization file checkbox.
2. Specify the name of the initialization file, per either substep a or b:
   a. Type the name in the Use initialization file text box. If the name is not a full pathname, the debugger searches for the file in the project directory. If the file is not in this directory, the debugger searches on the path:

   ```
   {CodeWarrior path}\M56800E Support\initialization
   directory.
   ```

   b. Click the **Choose** button; the Choose file dialog box appears. Navigate to the appropriate file. When you select the file, the system puts its name in the Use initialization file text box.

Each text line of a command file begins with a command or the comment symbol #. The system ignores comment lines, as well as blank lines.

Table 4.14 on page 81 lists the supported commands and their arguments. For a more detailed description of the Flash Memory commands see "Flash Memory Commands."

### Table 4.14 Initialization File Commands and Arguments

| Command | Arguments | Description |
|---|---|---|
| `writepmem` | <addr> <value> | Writes a 16-bit value to the specified P: Memory location. |
| `writexmem` | <addr> <value> | Writes a 16-bit value to the specified X: Memory location. |
| `writereg` | <regName> <value> | Writes a 16-bit value to the specified register. |
| `set_hfmclkd` | <value> | Writes the flash memory's clock divider value to the hfmclkd register |
| `set_hfm_base` | <address> | Sets the address of hfm_base. This is the map location of the flash memory control registers in X: Memory. |
| `add_hfm_unit` | <startAddr><endAddr> <bank><numSectors> <pageSize><progMem> <boot><interleaved> | Adds a flash memory unit to the list and sets its parameter values. |

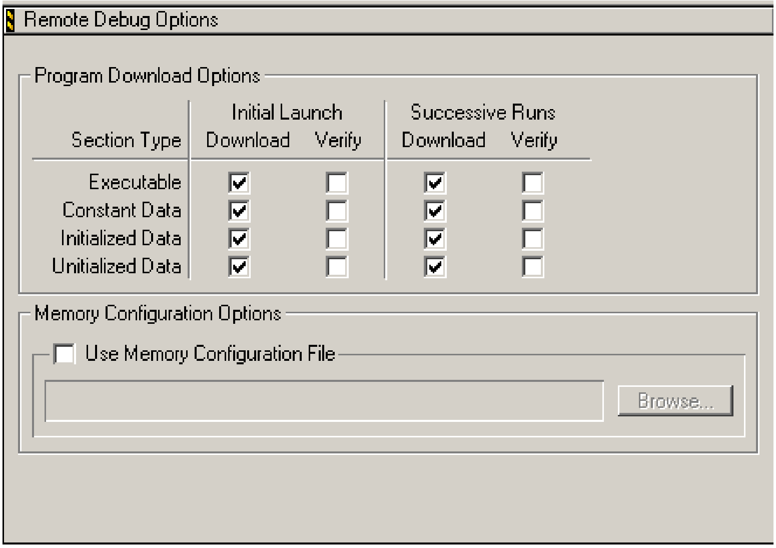
**Table 4.14 Initialization File Commands and Arguments (*continued*)**

| Command | Arguments | Description |
|---|---|---|
| set_hfm_programmer_base | <address> | Specifies the address where the onboard flash programmer will be loaded in P: Memory. |
| set_hfm_prog_buffer_base | <address> | Specifies where the data to be programmed will be loaded in X: Memory. |
| set_hfm_prog_buffer_size | <size> | Specifies the size of the buffer in X: Memory which will hold the data to be programmed. |
| `set_hfm_erase_mode` | <units \| pages \| all> | Sets the erase mode. |
| `set_hfm_verify_erase` | <1 \| 0> | Sets the flash memory erase verification mode. |
| `set_hfm_verify_program` | <1 \| 0> | Sets the flash program verification mode. |
| `unlock_flash_on_connect` | <1 \| 0> | Unlocks and erases flash memory immediately upon connection. |

# Remote Debug Options

Use the Remote Debug Options panel (Figure 4.15 on page 83) to specify different remote debug options.

**Figure 4.15  Remote Debug Options**



Remote Debug Options

Program Download Options

| | Initial Launch | | Successive Runs | |
|---|---|---|---|---|
| Section Type | Download | Verify | Download | Verify |
| Executable | ☑ | ☐ | ☑ | ☐ |
| Constant Data | ☑ | ☐ | ☑ | ☐ |
| Initialized Data | ☑ | ☐ | ☑ | ☐ |
| Unitialized Data | ☑ | ☐ | ☑ | ☐ |

Memory Configuration Options

☐ Use Memory Configuration File

### Table 4.15 Remote Debug Options Panel Elements

| Element | Purpose | Comments |
|---|---|---|
| Program Download Options area | Checked Download checkboxes specify the section types to be downloaded on initial launch and on successive runs.<br>Checked Verify checkboxes specify the section types to be verified (that is, read back to the linker). | Section types:<br>• Executable — program-code sections that have X flags in the linker command file.<br>• Constant Data — program-data sections that do not have X or W flags in the linker command file.<br>• Initialized Data — program-data sections with initial values. These sections have W flags, but not X flags, in the linker command file.<br>• Uninitialized Data — program-data sections without initial values. These sections have W flags, but not X flags, in the linker command file. |
| Use Memory Configuration File checkbox | | Not supported at this time. |

# 5

# Processor Expert Interface

Your CodeWarrior™ IDE features a Processor Expert™ plug-in interface, for rapid development of embedded applications. This chapter explains Processor Expert concepts, and Processor Expert additions to the CodeWarrior visual interface. This chapter includes a brief tutorial exercise.

This chapter contains these sections:

- Processor Expert Overview on page 85
- Processor Expert Windows on page 93
- Processor Expert Tutorial on page 106

## Processor Expert Overview

The Processor Expert Interface (PEI) is an integrated development environment for applications based on DSP56800/E (or many other) embedded microcontrollers. It reduces development time and cost for applications. Its code makes very efficient use of microcontroller and peripheral capabilities. Furthermore, it helps develop code that is highly portable.

Features include:

- **Embedded Beans™ components** — Each bean encapsulates a basic functionality of embedded systems, such as CPU core, CPU on-chip peripherals, and virtual devices. To create an application, you select, modify, and combine the appropriate beans.
  - The **Bean Selector** window lists all available beans, in an expandable tree structure. The Bean Selector describes each bean; some descriptions are extensive.
  - The **Bean Inspector** window lets you modify bean properties, methods, events, and comments.
- **Processor Expert page** — This additional page for the CodeWarrior project window lists project CPUs, beans, and modules, in a tree structure. Selecting or double-clicking items of the page opens or changes the contents of related Processor Expert windows.
- **Target CPU window** — This window depicts the target microprocessor as a simple package or a package with peripherals. As you move the cursor over this picture's

pins, the window shows pin numbers and signals. Additionally, you can have this window show a scrollable block diagram of the microprocessor.

- **CPU Structure window** — This window shows the relationships of all target-microprocessor elements, in an expandable-tree representation.
- **CPU Types Overview** — This reference window lists all CPUs that your Processor Expert version supports.
- **Memory Map** — This window shows the CPU address space, plus mapping for internal and external memory.
- **Resource Meter** — This window shows the resource allocation for the target microprocessor.
- **Peripheral Usage Inspector** — This window shows which bean allocates each on-chip peripheral.
- **Installed Beans Overview** — This reference window provides information about all installed beans in your Processor Expert version.
- **Driver generation** — The PEI suggests, connects, and generates driver code for embedded-system hardware, peripherals, and algorithms.
- **Top-Down Design** — A developer starts design by defining application behavior, rather than by focussing on how the microcontroller works.
- **Extensible beans library** — This library supports many microprocessors, peripherals, and virtual devices.
- **Beans wizard** — This external tool helps developers create their own custom beans.
- **Extensive help information** — You access this information either by selecting Help from the Program Expert menu, or by clicking the Help button of any Processor Expert window or dialog box.

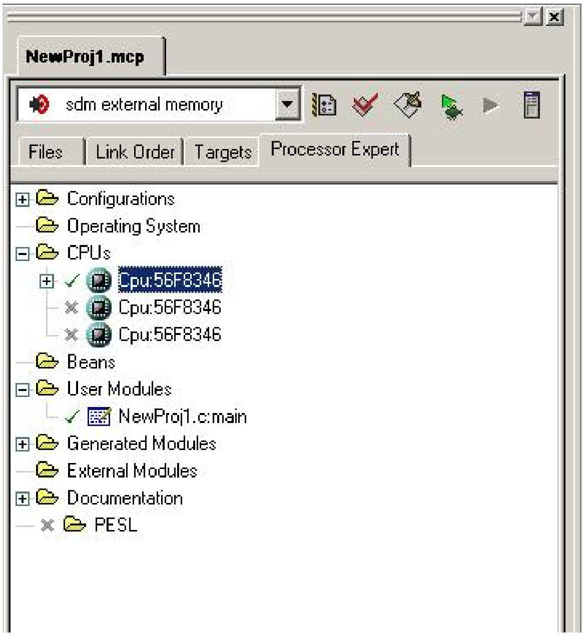
# Processor Expert Code Generation

The PEI manages your CPU and other hardware resources so that you can concentrate on virtual prototyping and design. Your steps for application development are:

1. Creating a CodeWarrior project, specifying the Processor Expert stationery appropriate for your target processor.
2. Configuring the appropriate CPU bean.
3. Selecting and configuring the appropriate function beans.
4. Starting code design (that is, building the application).

As you create the project, the project window opens in the IDE main window. This project window has a Processor Expert page (Figure 5.1 on page 87). The Processor Expert Target CPU window also appears at this time. So does the Processor Expert bean selector window, although it is behind the Target CPU window.

**Figure 5.1 Project Window: Processor Expert Page**



When you start code design, the PEI generates commented code from the bean settings. This code generation takes advantage of the Processor Expert CPU knowledge system and solution bank, which consists of hand-written, tested code optimized for efficiency.

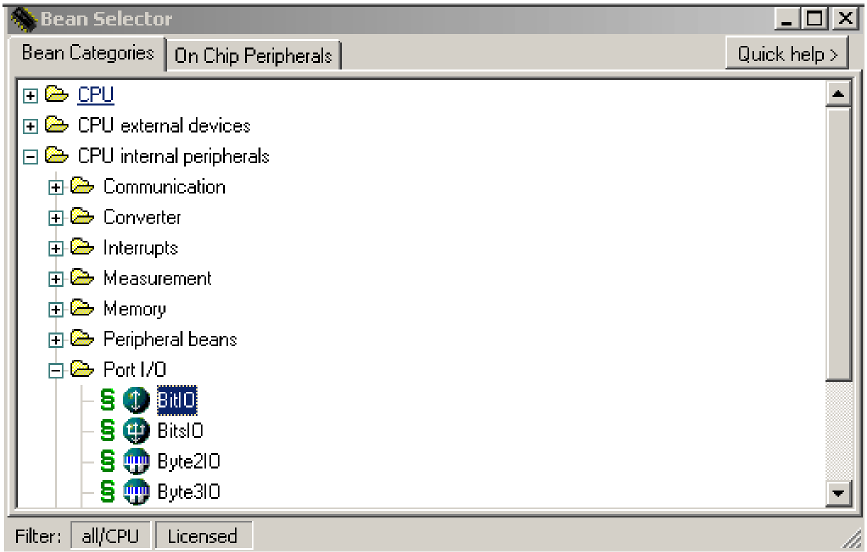
To add new functionalities, you select and configure additional beans, then restart code design. Another straightforward expansion of PEI code is combining other code that you already had produced with different tools.

# Processor Expert Beans

Beans encapsulate the most-required functionalities for embedded applications. Examples include port bit operations, interrupts, communication timers, and A/D converters.

The Bean Selector (Figure 5.2 on page 88) helps you find appropriate beans by category: processor, MCU external devices, MCU internal peripherals, or on-chip peripherals. To open the bean selector, select **Processor Expert** > **View** > **Bean Selector**, from the main-window menu bar.

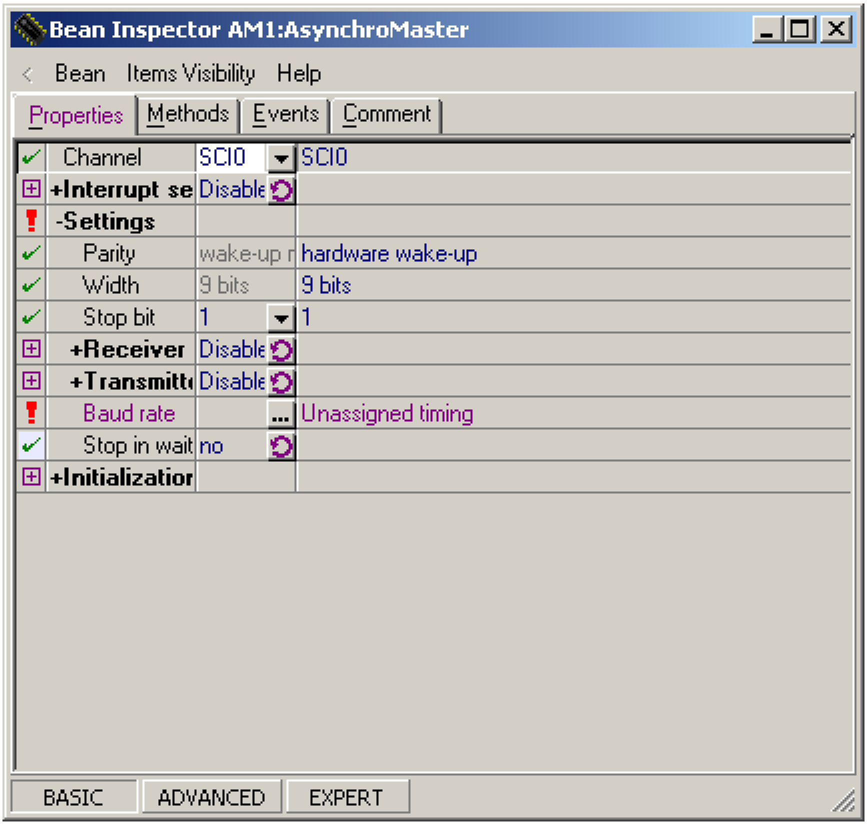
**Figure 5.2 Bean Selector**



The bean selector's tree structures list all available beans; double-clicking the name adds the bean to your project. Clicking the Quick Help button opens or closes an explanation pane that describes the highlighted bean.

Once you determine the appropriate beans, you use the Bean Inspector (Figure 5.3 on page 89) to fine tune each bean, making it optimal for your application.

**Figure 5.3  Bean Inspector**



| | | | |
|---|---|---|---|
| ✓ | Channel | SCI0 | SCI0 |
| ⊞ | +Interrupt se | Disable | |
| ! | -Settings | | |
| ✓ | Parity | wake-up r | hardware wake-up |
| ✓ | Width | 9 bits | 9 bits |
| ✓ | Stop bit | 1 | 1 |
| ⊞ | +Receiver | Disable | |
| ⊞ | +Transmitt | Disable | |
| ! | Baud rate | ... | Unassigned timing |
| ✓ | Stop in wait | no | |
| ⊞ | +Initializatior | | |

Using the Bean Inspector to set a bean's initialization properties automatically adds bean initialization code to CPU initialization code. You use the Bean Inspector to adjust bean properties, so that generated code is optimal for your application.

Beans greatly facilitate management of on-chip peripherals. When you choose a peripheral from bean properties, the PEI presents all possible candidates. But the PEI indicates which candidates already are allocated, and which are not compatible with current bean settings.

# Processor Expert Menu

Table 5.1 on page 90 explains the selections of the Processor Expert menu.

**Table 5.1  Processor Expert Menu Selections**

| Item | Subitem | Action |
|---|---|---|
| Open Processor Expert | none | Opens the PEI for the current project.<br>(Available only if the current project does not already involve the PEI.) |
| Code Design <Project> | none | Generates code, including drivers, for the current project. Access these files via the Generate Code folder, of the project-window Files page. |
| Undo Last Code Design | none | Deletes the most recently-generated code, returning project files to their state after the previous, error-free code generation. |
| View | Project Panel | Brings the Processor Expert page to the front of the CodeWarrior project window.<br>(Not available if the project window does not include a Processor Expert page.) |
|  | Bean Inspector | Opens the Bean Inspector window, which gives you access to bean properties. |
|  | Bean Selector | Opens the Beans Selector window, which you use to choose the most appropriate beans. |
|  | Target CPU Package | Opens the Target CPU Package window, which depicts the processor. As you move your cursor over the pins of this picture, text boxes show pin numbers and signal names. |
|  | Target CPU Block Diagram | Opens the Target CPU Package window, but portrays the processor as a large block diagram. Scroll bars let you view any part of the diagram. As you move your cursor over modules, floating text boxes identify pin numbers and signals. |
|  | Error Window | Opens the Error Window, which shows hints, warnings, and error messages. |

**Table 5.1 Processor Expert Menu Selections (*continued*)**

| Item | Subitem | Action |
|---|---|---|
| | Resource Meter | Opens the Resource Meter window, which shows usage and availability of processor resources. |
| View *(continued)* | Target CPU Structure | Opens the CPU Structure window, which uses an expandible tree structure to portray the processor. |
| | Peripherals Usage Inspector | Opens the Peripherals Usage Inspector window, which shows which bean allocates each peripheral. |
| | Peripheral Initialization Inspector | Opens the Peripherals Initialization Inspector window, which show the initialization value and value after reset for all peripheral register bits. |
| | Installed Beans Overview | Opens the Beans Overview window, which provides information about all beans in your project. |
| | CPU Types Overview | Opens the CPU Overview window, which lists supported processors in an expandable tree structure. |
| | CPU Parameters Overview | Opens the CPU Parameters window, which lists clock-speed ranges, number of pins, number of timers, and other reference information for the supported processors. |
| | Memory Map | Opens the Memory Map window, which depicts CPU address space, internal memory, and external memory. |
| Tools | <tool name> | Starts the specified compiler, linker or other tool. (You use the Tools Setup window to add tool names to this menu.) |
| | SHELL | Opens a command-line window. |
| | Tools Setup | Opens the Tools Setup window, which you use to add tools to this menu. |
| Help | Processor Expert Help | Opens the help start page. |

**Table 5.1 Processor Expert Menu Selections (*continued*)**

| Item | Subitem | Action |
|---|---|---|
| | Introduction | Opens the PEI help introduction. |
| | Benefits | Opens an explanation of PEI benefits. |
| | User Interface | Opens an explanation of the PEI environment. |
| | Tutorial | [None available for the DSP56800/E.] |
| | Quick Start | Opens PEI quick start instructions. |
| Help (continued) | Embedded Beans | Opens the first page of a description database of all beans. |
| | Embedded Beans Categories | Opens the first page of a description database of beans, organized by category. |
| | Supported CPUs, Compilers, and Debuggers | Opens the list of processors and tools that the PEI plug-in supports. |
| | PESL Library User Manual | Opens the Processor Expert System Library, for advanced developers. |
| | User Guide | Opens a .pdf guide that focuses on the DSP56800/E processor family. |
| | Search in PDF Documentation of the Target CPU | Opens documentation of the target processor, in a .pdf search window. |
| | Go to Processor Expert Home Page | Opens your default browser, taking you to the PEI home page. |
| | About Processor Expert | Opens a standard About dialog box for the PEI. |
| Update | Update Processor Exert Beans from Package | Opens the Open Update Package window. You can use this file-selection window to add updated or new beans (which you downloaded over the web) to your project. |

**Table 5.1 Processor Expert Menu Selections (*continued*)**

| Item | Subitem | Action |
|---|---|---|
| | Check Processor Expert Web for Updates | Checks for updates available over the web. If any are available, opens your default browser, so that you can download them. |
| Bring PE Windows to Front | none | Moves PEI windows to the front of your monitor screen. |
| Arrange PE Windows | none | Restores the default arrangement of all open PEI windows. |

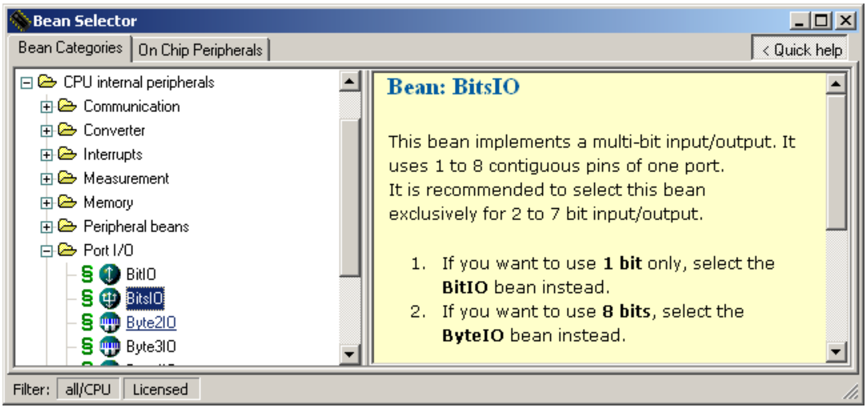
# Processor Expert Windows

This section illustrates important Processor Expert windows and dialog boxes.

## Bean Selector

The **Bean Selector** window (Figure 5.4 on page 93) explains which beans are available, helping you identify those most appropriate for your application project. To open this window, select **Processor Expert > View > Bean Selector**, from the main-window menu bar.

**Figure 5.4 Bean Selector Window**



**Bean: BitsIO**

This bean implements a multi-bit input/output. It uses 1 to 8 contiguous pins of one port.
It is recommended to select this bean exclusively for 2 to 7 bit input/output.

1. If you want to use **1 bit** only, select the **BitIO** bean instead.
2. If you want to use **8 bits**, select the **ByteIO** bean instead.

The **Bean Categories** page, at the left side of this window, lists the available beans in category order, in an expandable tree structure. Green string bean symbols identify beans that have available licenses. Grey string bean symbols identify beans that do not have available licenses.

The **On-Chip Peripherals** page lists beans available for specific peripherals, also in an expandable tree structure. Yellow folder symbols identify peripherals fully available. Light blue folder symbols identify partially used peripherals. Dark blue folder symbols identify fully used peripherals.

Bean names are black; bean template names are blue. Double-click a bean name to add it to your project.

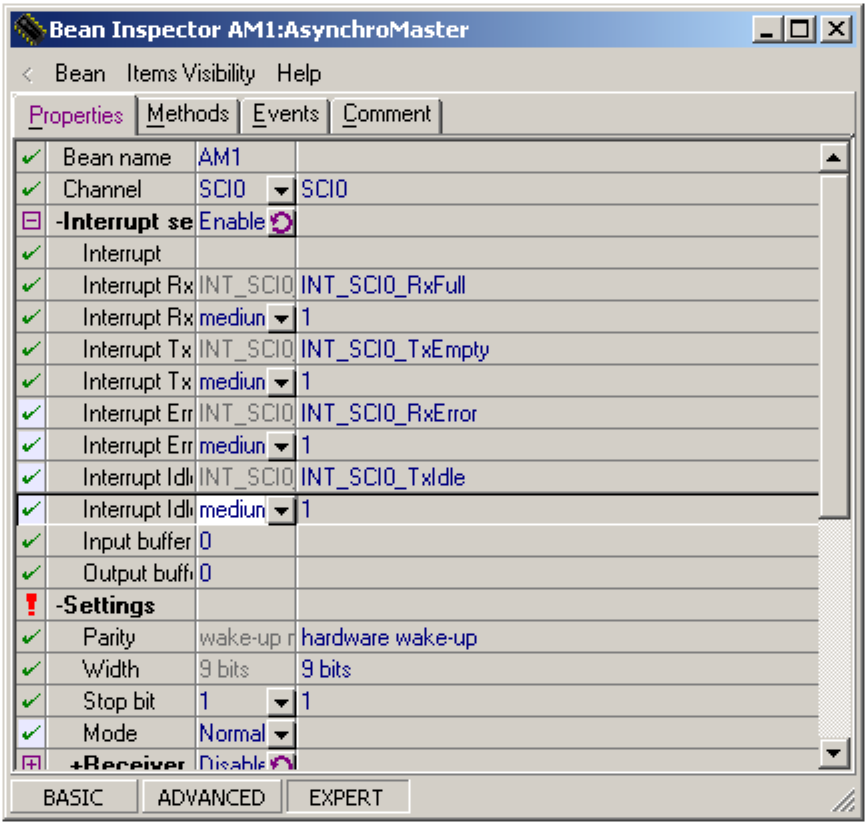
Click the Quick Help button to add the explanation pane to the right side of the window, as Figure 5.4 on page 93 shows. This pane describes the selected (highlighted) bean. Use the scroll bars to read descriptions that are long.

Click the two buttons at the bottom of the window to activate or deactivate filters. If the **all/CPU** filter is active, the window lists only the beans for the target CPU. If the license filter is active, the window lists only the beans for which licenses are available.

## Bean Inspector

The **Bean Inspector** window (Figure 5.5 on page 95) lets you modify bean properties and other settings. To open this window, select **Processor Expert > View > Bean Inspector**, from the main-window menu bar.

**Figure 5.5 Bean Inspector Window**



| | | | |
|---|---|---|---|
| ✓ | Bean name | AM1 | |
| ✓ | Channel | SCI0 | SCI0 |
| ⊟ | -Interrupt se | Enable | |
| ✓ | Interrupt | | |
| ✓ | Interrupt Rx | INT_SCI0 | INT_SCI0_RxFull |
| ✓ | Interrupt Rx | mediun | 1 |
| ✓ | Interrupt Tx | INT_SCI0 | INT_SCI0_TxEmpty |
| ✓ | Interrupt Tx | mediun | 1 |
| ✓ | Interrupt Err | INT_SCI0 | INT_SCI0_RxError |
| ✓ | Interrupt Err | mediun | 1 |
| ✓ | Interrupt Idl | INT_SCI0 | INT_SCI0_TxIdle |
| ✓ | Interrupt Idl | mediun | 1 |
| ✓ | Input buffer | 0 | |
| ✓ | Output buff | 0 | |
| ! | -Settings | | |
| ✓ | Parity | wake-up r | hardware wake-up |
| ✓ | Width | 9 bits | 9 bits |
| ✓ | Stop bit | 1 | 1 |
| ✓ | Mode | Normal | |
| ⊞ | +Receiver | Disable | |

This window shows information about the currently selected bean — that is, the highlighted bean name in the project-window Processor Expert page. The title of the Bean Inspector window includes the bean name.

The Bean Inspector consists of Properties, Methods, Events, and Comment pages. The first three pages have these columns:

- **Item names** — Items to be set. Double-click on group names to expand or collapse this list. For the Method or Event page, double-clicking on an item may open the file editor, at the corresponding code location.
- **Selected settings** — Possible settings for your application. To change any ON/OFF-type setting, click the circular-arrow button. Settings with multiple possible values have triangle symbols: click the triangle to open a context menu, then select the appropriate value. Timing settings have an ellipsis (...) button: click this button to open a setting dialog box.

- **Setting status** — Current settings or error statuses.

Use the comments page to write any notations or comments you wish.

**NOTE** If you have specified a target compiler, the Bean Inspector includes an additional Build options page for the CPU bean.
If your project includes external peripherals, the Bean Inspector includes an additional Used page. Clicking a circular-arrow button reserves a resource for connection to an external device. Clicking the same button again frees the resource.

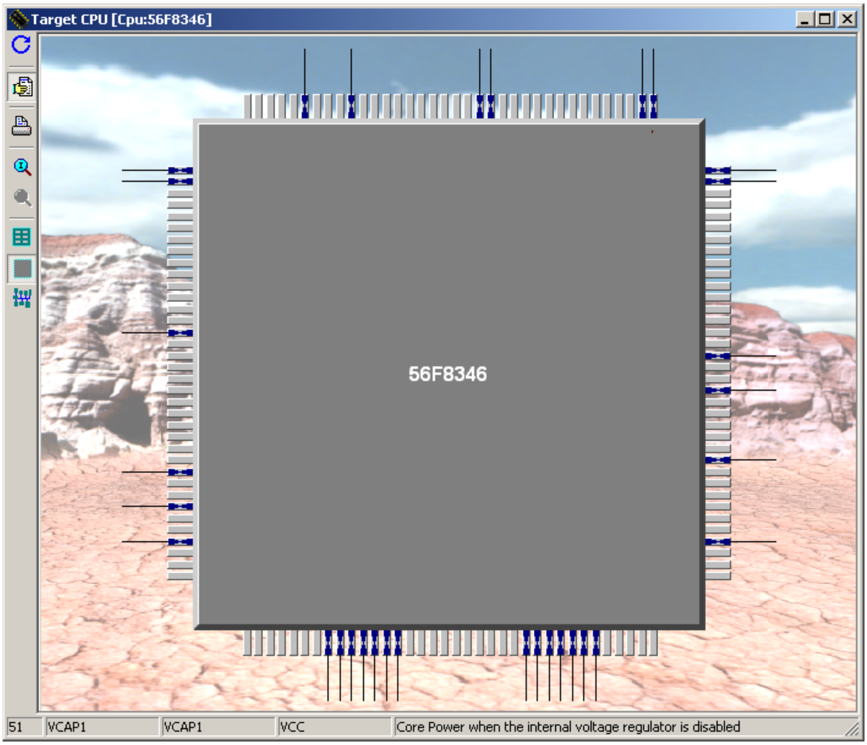
The Basic, Advanced, and Expert view mode buttons, at the bottom of the window, let you change the detail level of Bean Inspector information.

The Bean Inspector window has its own menu bar. Selections include restoring default settings, saving the selected bean as a template, changing the bean's icon, disconnecting from the CPU, and several kinds of help information.

## Target CPU Window

The **Target CPU** window (Figure 5.6 on page 97) depicts the target processor as a realistic CPU package, as a CPU package with peripherals, or as a block diagram. To open this window, select **Processor Expert > View > Target CPU Package**, from the main-window menu bar. (To have this window show the block diagram, you may select **Processor Expert > View > Target CPU Block Diagram**, from the main-window menu bar.)

**Figure 5.6 Target CPU Window: Package**

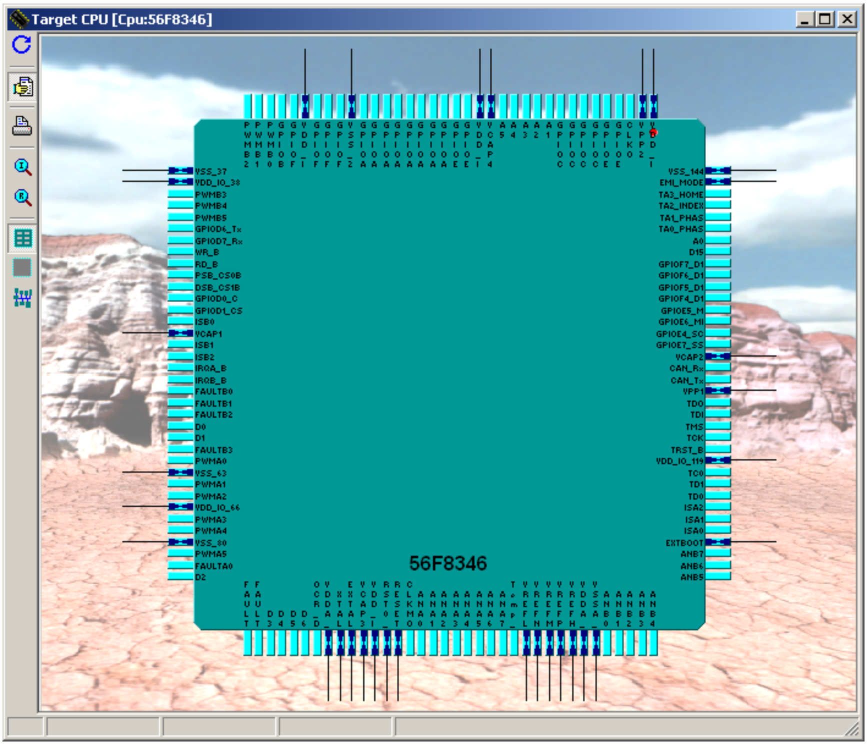


Core Power when the internal voltage regulator is disabled

Arrows on pins indicate input, output, or bidirectional signals. As you move your cursor over the processor pins, text boxes at the bottom of this window show the pin numbers and signal names.

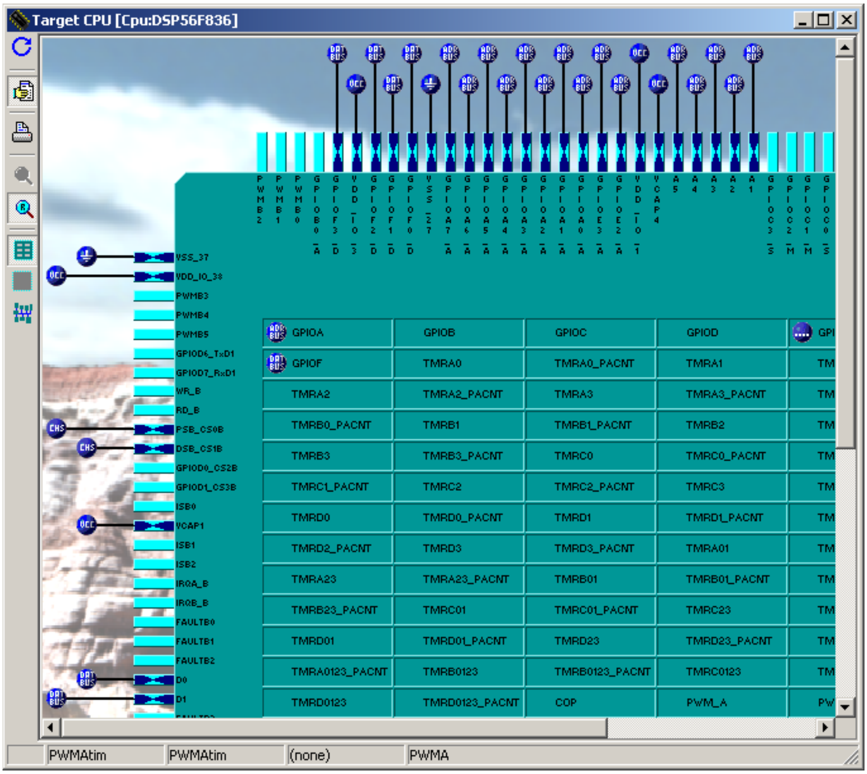
Use the control buttons at the left edge of this window to modify the depiction of the processor. One button, for example, changes the picture view the CPU package with peripherals. However, as Figure 5.7 on page 98 shows, it is not always possible for the picture of a sophisticated processor to display internal peripherals.

### Figure 5.7 Target CPU Window: Package and Peripherals



In such a case, you can click the **Always show internal peripheral devices** control button. Figure 5.8 on page 99 shows that this expands the picture size, as necessary, to allow the peripheral representations. This view also includes bean icons (blue circles) attached to the appropriate processor pins. Use the scroll bars to view other parts of the processor picture.

**Figure 5.8 Target CPU Window: Peripherals and Bean Icons**

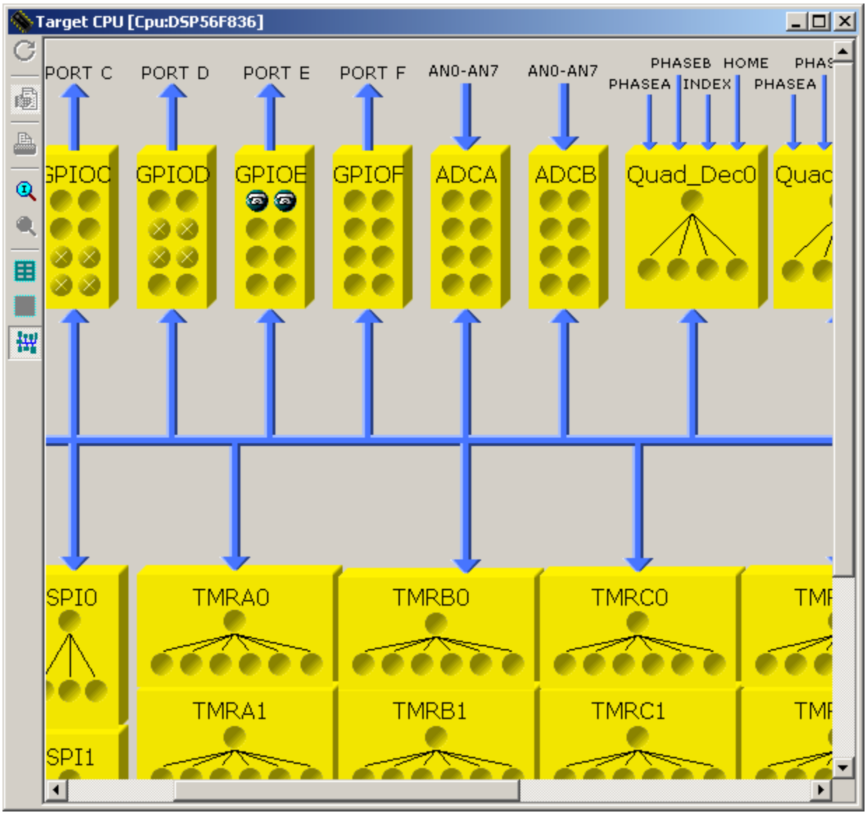


| | | | | |
|---|---|---|---|---|
| GPIOA | GPIOB | GPIOC | GPIOD | GPI |
| GPIOF | TMRA0 | TMRA0_PACNT | TMRA1 | TM |
| TMRA2 | TMRA2_PACNT | TMRA3 | TMRA3_PACNT | TM |
| TMRB0_PACNT | TMRB1 | TMRB1_PACNT | TMRB2 | TM |
| TMRB3 | TMRB3_PACNT | TMRC0 | TMRC0_PACNT | TM |
| TMRC1_PACNT | TMRC2 | TMRC2_PACNT | TMRC3 | TM |
| TMRD0 | TMRD0_PACNT | TMRD1 | TMRD1_PACNT | TM |
| TMRD2_PACNT | TMRD3 | TMRD3_PACNT | TMRA01 | TM |
| TMRA23 | TMRA23_PACNT | TMRB01 | TMRB01_PACNT | TM |
| TMRB23_PACNT | TMRC01 | TMRC01_PACNT | TMRC23 | TM |
| TMRD01 | TMRD01_PACNT | TMRD23 | TMRD23_PACNT | TM |
| TMRA0123_PACNT | TMRB0123 | TMRB0123_PACNT | TMRC0123 | TM |
| TMRD0123 | TMRD0123_PACNT | COP | PWM_A | PW |

PWMAtim | PWMAtim | (none) | PWMA

Click the Show CPU Block Diagram to change the picture to a block diagram, as Figure 5.9 on page 100 shows. Use the scroll bars to view other parts of the diagram. (You can bring up the block diagram as you open the Target CPU window, by selecting **Processor Expert > View > Target CPU Block Diagram**, from the main-window menu bar.)

**Figure 5.9 Target CPU Window: Block Diagram**


Target CPU [Cpu:DSP56F836]

Other control buttons at the left edge of the window let you:

- Show bean icons attached to processor pins.
- Rotate the CPU picture clockwise 90 degrees.
- Toggle default and user-defined names of pins and peripherals.
- Print the CPU picture.

**NOTE** As you move your cursor over bean icons, peripherals, and modules, text boxes or floating hints show information such as names, descriptions, and the allocating beans.

And note these additional mouse control actions for the Target CPU window:

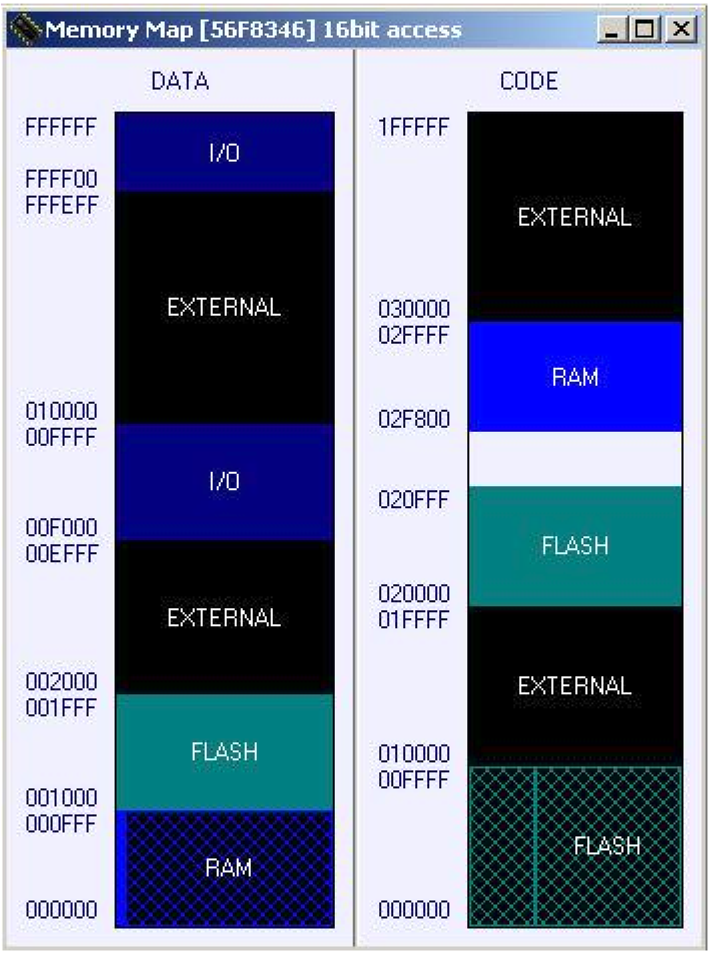
- Clicking a bean icon selects the bean in the project window’s Processor Expert page**.**

- Double-clicking a bean icon opens the Bean Inspector, displaying information for that bean.
- Right-clicking a bean icon, a pin, or a peripheral opens the corresponding context menu.
- Double-clicking an ellipsis (...) bean icon opens a context menu of all beans using parts of the peripheral. Selecting one bean from this menu opens the Bean Inspector.
- Right-clicking an ellipsis (...) bean icon opens a context menu of all beans using parts of the peripheral. Selecting one bean from this menu opens the bean context menu.

## Memory Map Window

The **Memory Map** window (Figure 5.10 on page 102) depicts CPU address space, and the map of internal and external memory. To open this window, select **Processor Expert > View** > **Memory Map**, from the main-window menu bar.

**Figure 5.10 Memory Map Window**



The color key for memory blocks is:

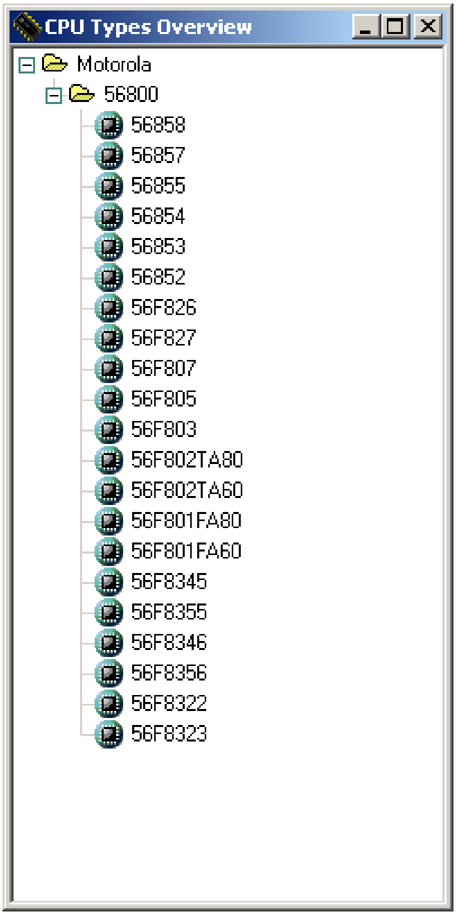
- White — Non-usable space
- Dark Blue — I/O space
- Medium Blue — RAM
- Light Blue — ROM
- Cyan — FLASH memory or EEPROM
- Black — External memory.

Pause your cursor over any block of the map to bring up a brief description.

## CPU Types Overview

The **CPU Types Overview** window (Figure 5.11 on page 103) lists supported processors, in an expandable tree structure. To open this window, select **Processor Expert > View > CPU Types Overview**, from the main-window menu bar.

**Figure 5.11 CPU Types Overview Window**



CPU Types Overview

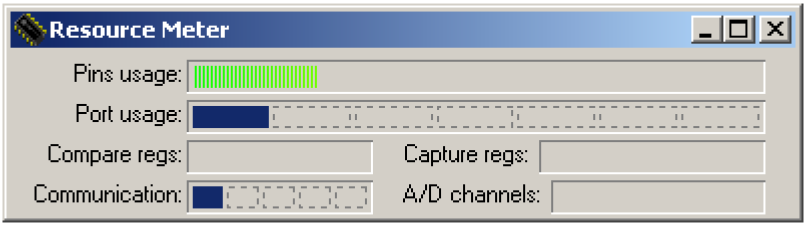
- Motorola
  - 56800
    - 56858
    - 56857
    - 56855
    - 56854
    - 56853
    - 56852
    - 56F826
    - 56F827
    - 56F807
    - 56F805
    - 56F803
    - 56F802TA80
    - 56F802TA60
    - 56F801FA80
    - 56F801FA60
    - 56F8345
    - 56F8355
    - 56F8346
    - 56F8356
    - 56F8322
    - 56F8323

Right-click the window to open a context menu that lets you add the selected CPU to the project, expand the tree structure, collapse the tree structure, or get help information.

# Resource Meter

The **Resource Meter** window (Figure 5.12 on page 104) shows the usage or availability of processor resources. To open this window, select **Processor Expert > View > Resource Meter**, from the main-window menu bar.

**Figure 5.12 Resource Meter Window**



Bars of this window indicate:

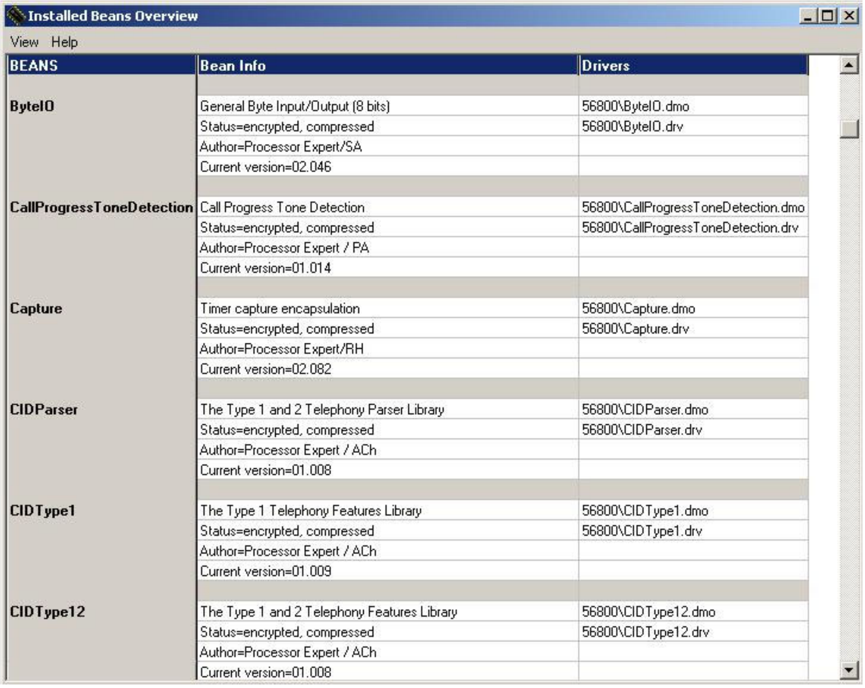
- The number of pins used
- The number of ports used
- Allocation of timer compare registers
- The number of timer capture registers used
- Allocation of serial communication channels
- Allocation of A/D converter channels.

Pausing your cursor over some fields of this window brings up details of specific resources.

# Installed Beans Overview

The **Installed Beans Overview** window (Figure 5.13 on page 105) shows reference information about the installed beans. To open this window, select **Processor Expert > View > Installed Beans Overview**, from the main-window menu bar.

**Figure 5.13 Installed Beans Overview Window**



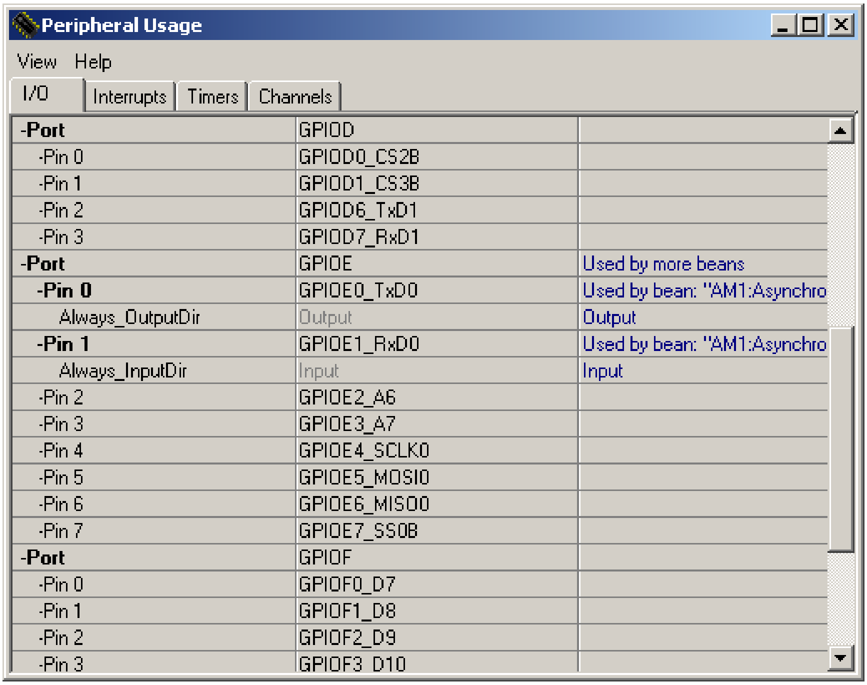
| BEANS | Bean Info | Drivers |
|---|---|---|
| ByteIO | General Byte Input/Output (8 bits) | 56800\ByteIO.dmo |
| | Status=encrypted, compressed | 56800\ByteIO.drv |
| | Author=Processor Expert/SA | |
| | Current version=02.046 | |
| CallProgressToneDetection | Call Progress Tone Detection | 56800\CallProgressToneDetection.dmo |
| | Status=encrypted, compressed | 56800\CallProgressToneDetection.drv |
| | Author=Processor Expert / PA | |
| | Current version=01.014 | |
| Capture | Timer capture encapsulation | 56800\Capture.dmo |
| | Status=encrypted, compressed | 56800\Capture.drv |
| | Author=Processor Expert/RH | |
| | Current version=02.082 | |
| CIDParser | The Type 1 and 2 Telephony Parser Library | 56800\CIDParser.dmo |
| | Status=encrypted, compressed | 56800\CIDParser.drv |
| | Author=Processor Expert / ACh | |
| | Current version=01.008 | |
| CIDType1 | The Type 1 Telephony Features Library | 56800\CIDType1.dmo |
| | Status=encrypted, compressed | 56800\CIDType1.drv |
| | Author=Processor Expert / ACh | |
| | Current version=01.009 | |
| CIDType12 | The Type 1 and 2 Telephony Features Library | 56800\CIDType12.dmo |
| | Status=encrypted, compressed | 56800\CIDType12.drv |
| | Author=Processor Expert / ACh | |
| | Current version=01.008 | |

This window's View menu lets you change the display contents, such as showing driver status and information, restricting the kinds of beans the display covers, and so on.

# Peripherals Usage Inspector

The **Peripherals Usage** window (Figure 5.14 on page 106) shows which bean allocates each peripheral. To open this window, select **Processor Expert > View > Peripherals Usage Inspector**, from the main-window menu bar.

**Figure 5.14 Peripherals Usage Window**



| | | |
|---|---|---|
| **-Port** | GPIOD | |
| -Pin 0 | GPIOD0_CS2B | |
| -Pin 1 | GPIOD1_CS3B | |
| -Pin 2 | GPIOD6_TxD1 | |
| -Pin 3 | GPIOD7_RxD1 | |
| **-Port** | GPIOE | Used by more beans |
| **-Pin 0** | GPIOE0_TxD0 | Used by bean: "AM1:Asynchro |
| Always_OutputDir | Output | Output |
| **-Pin 1** | GPIOE1_RxD0 | Used by bean: "AM1:Asynchro |
| Always_InputDir | Input | Input |
| -Pin 2 | GPIOE2_A6 | |
| -Pin 3 | GPIOE3_A7 | |
| -Pin 4 | GPIOE4_SCLK0 | |
| -Pin 5 | GPIOE5_MOSI0 | |
| -Pin 6 | GPIOE6_MISO0 | |
| -Pin 7 | GPIOE7_SS0B | |
| **-Port** | GPIOF | |
| -Pin 0 | GPIOF0_D7 | |
| -Pin 1 | GPIOF1_D8 | |
| -Pin 2 | GPIOF2_D9 | |
| -Pin 3 | GPIOF3_D10 | |

The pages of this window reflect the peripheral categories: I/O, interrupts, timers, and channels. The columns of each page list peripheral pins, signal names, and the allocating beans.

Pausing your cursor over various parts of this window brings up brief descriptions of items. This window's View menu lets you expand or collapse the display.

# Processor Expert Tutorial

This tutorial exercise generates code that flashes the LEDs of a DSP56858 development board. Follow these steps:

1. Create a project:
   a. Start the CodeWarrior IDE, if it is not started already.
   b. From the main-window menu bar, select **File** > **New**. The **New** window appears.
   c. In the Project page, select (highlight) **Processor Expert Examples Stationery**.

d. In the Project name text box, enter a name for the project, such as `LEDcontrol`.

e. Click the **OK** button. The **New Project** window replaces the **New** window.

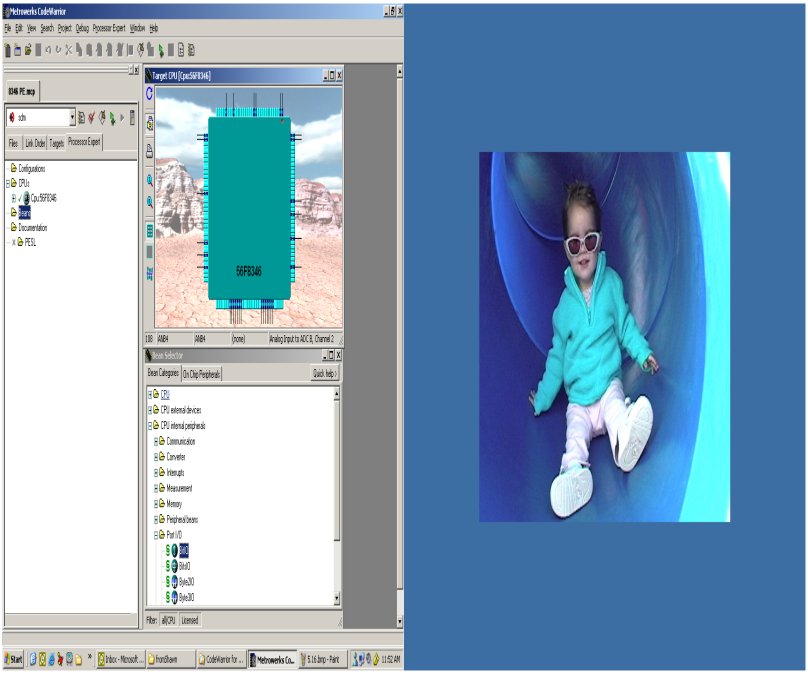
f. In the Project Stationery list, select **TestApplications** > **Tools** > **LED** > **56858**.

g. Click the **OK** button.

h. Click the **OK** button. The IDE:

- Opens the project window, docking it the left of the main window. This project window includes a Processor Expert page.
- Opens the **Target CPU** window, as Figure 5.15 on page 107 shows. This window shows the CPU package and peripherals view.
- Opens the **Bean Selector** window, behind the **Target CPU** window.

### Figure 5.15 Project, Target CPU Windows



2. Select the sdm external memory target.

   a. Click the project window’s Targets tab. The Targets page moves to the front of the window.

   b. Click the target icon of the **sdm external memory** entry. The black arrow symbol moves to this icon, confirming your selection.

3. Add six BitIO beans to the project.

   a. Click the project window's Processor Expert tab. The Processor Expert page moves to the front of the window.

   b. Make the **Bean Selector** window visible:

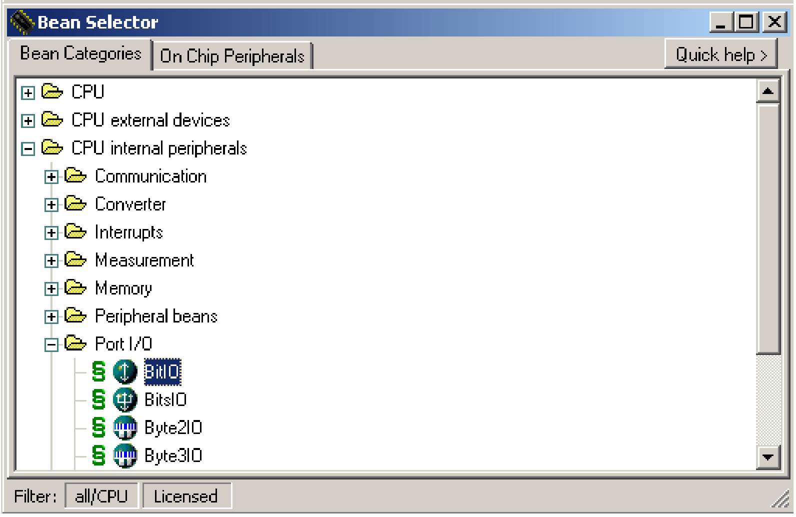
   - Minimize the **Target CPU** window.
   - Select **Processor Expert > View > Bean Selector**, from the main-window menu bar.

   c. In the Bean Categories page, expand the entry **MCU internal peripherals**.

   d. Expand the subentry **Port I/O**.

   e. Double-click the **BitIO** bean name six times. (Figure 5.16 on page 108 depicts this bean selection.) The IDE adds these beans to your project; new bean icons appear in the project window's Processor Expert page.

**Figure 5.16 Bean Selector: BitIO Selection**



**NOTE** If new bean icons do not appear in the Processor Expert page, the system still may have added them to the project. Close the project, then reopen it. When you bring the Processor Expert page to the front of the project window, the page should show the new bean icons.

4. Add two ExtInt beans to the project.

a. In the Bean Categories page of the Bean Selector window, expand the **Interrupts** subentry.

b. Double-click the **ExtInt** bean name two times. The IDE adds these beans to your project; new bean icons appear in the Processor Expert page.

c. You may close the **Bean Inspector** window.

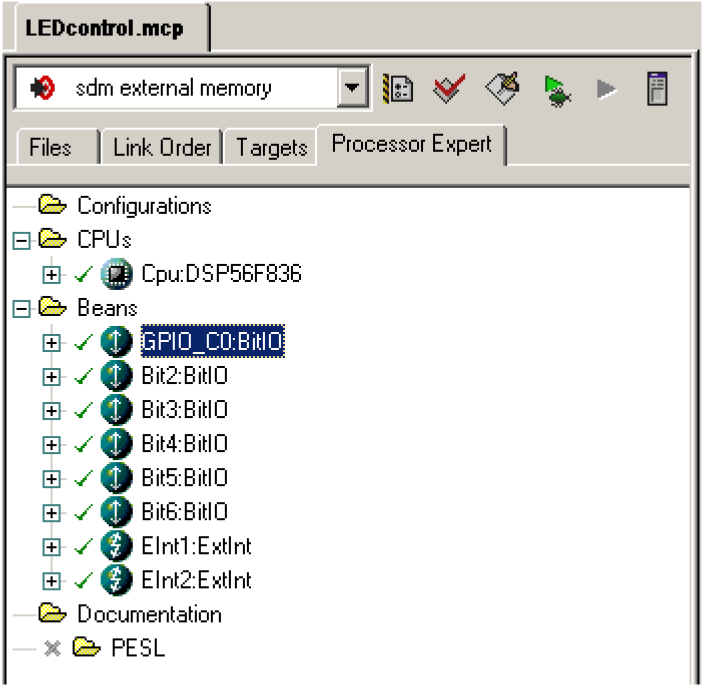
5. Rename the eight beans GPIO_C0 — GPIO_C3, GPIO_D6, GPIO_D7, IRQA, and IRQB.

a. In the project window's Processor Expert page, right-click the name of the first BitIO bean. A context menu appears.

b. Select **Rename Bean**. A change box appears around the bean name.

c. Type the new name `GPIO_C0`, then press the Enter key. The list shows the new name; as Figure 5.17 on page 109 shows, this name still ends with `BitIO`.

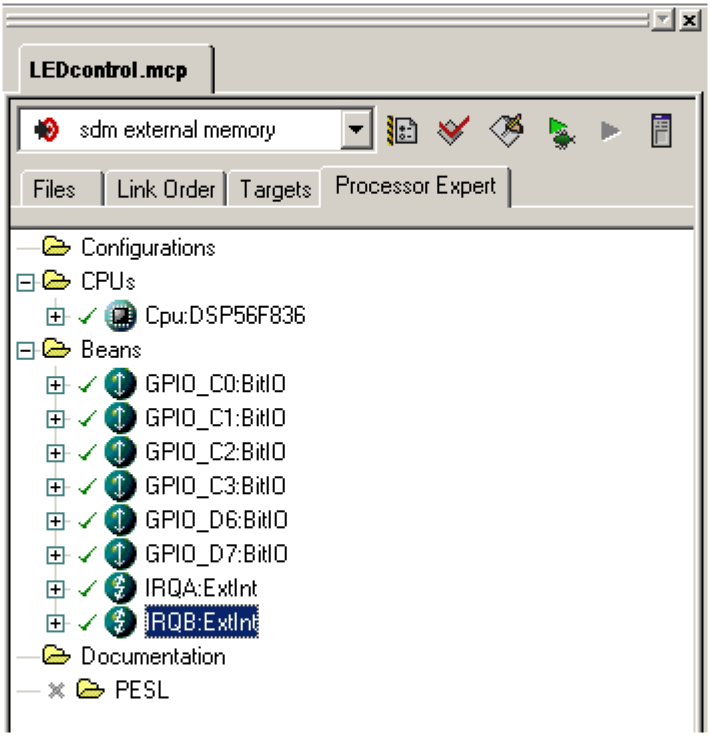
**Figure 5.17  New Bean Name**



d. Repeat substeps a, b, and c for each of the other BitIO beans, renaming them `GPIO_C1`, `GPIO_C2`, `GPIO_C3`, `GPIO_D6`, and `GPIO_D7`.

e. Repeat substeps a, b, and c for the two ExtInt beans, renaming them `IRQA` and `IRQB`. (Figure 5.18 on page 110 shows the Processor Expert page at this point.)

**Figure 5.18 New Bean Names**



6. Update pin associations for each bean.

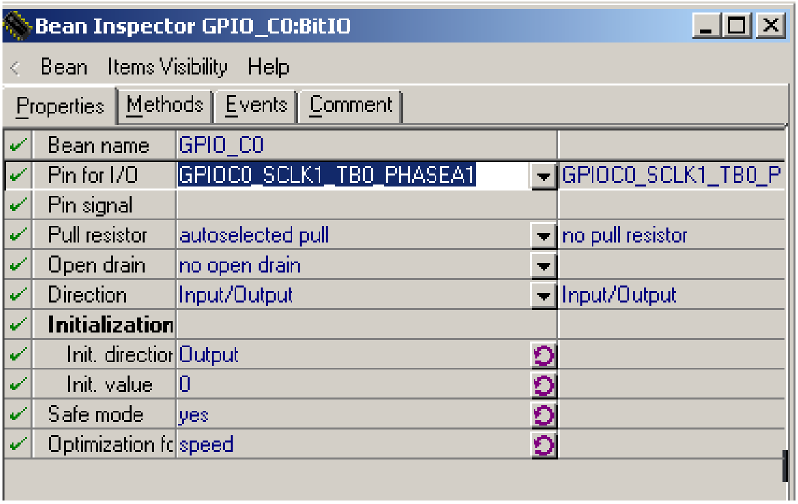
   a. In the Processor Expert page, double-click the bean name `GPIO_C0`. The **Bean Inspector** window opens, displaying information for this bean.

   b. Use standard window controls to make the middle column of the Properties page about 2 inches wide.

   c. In the **Pin for I/O** line, click the triangle symbol of the middle-column list box. The list box opens.

   d. Use this list box to select **GPIOC0_SCLK1_TB0_PHASEA1**. (Figure 5.19 on page 111 depicts this selection.)

**Figure 5.19  New Pin Association**



| | | | |
|---|---|---|---|
| ✓ | Bean name | GPIO_C0 | |
| ✓ | Pin for I/O | GPIOC0_SCLK1_TB0_PHASEA1 | GPIOC0_SCLK1_TB0_P |
| ✓ | Pin signal | | |
| ✓ | Pull resistor | autoselected pull | no pull resistor |
| ✓ | Open drain | no open drain | |
| ✓ | Direction | Input/Output | Input/Output |
| ✓ | **Initialization** | | |
| ✓ | Init. directior | Output | |
| ✓ | Init. value | 0 | |
| ✓ | Safe mode | yes | |
| ✓ | Optimization fc | speed | |

e. In the project window's Processor Expert page, select the bean name `GPIO_C1`. The Bean Inspector information changes accordingly.

f. Use the **Pin for I/O** middle-column list box to select **GPIOC1_MOSI1_TB1_PHASEB1**.

g. Repeat substeps e and f, for bean `GPIO_C2`, to change its associated pin to **GPIOC2_MISO1_TB2_INDEX1**.

h. Repeat substeps e and f, for bean `GPIO_C3`, to change its associated pin to **GPIOC3_SSA_B_TB3_HOME1**.

i. Repeat substeps e and f, for bean `GPIO_D6`, to change its associated pin to **GPIOD6_TxD1**.

j. Repeat substeps e and f, for bean `GPIO_D7`, to change its associated pin to **GPIOD7_RxD1**.

k. In the project window's Processor Expert page, select the bean name `IRQA`. The Bean Inspector information changes accordingly.

l. Use the **Pin** middle-column list box to select **IRQA_B**.

m. Repeat substeps k and l, for bean `IRQB`, to change its associated pin to **IRQB_B**.

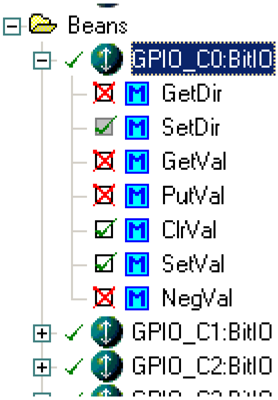
n. You may close the **Bean Inspector** window.

7. Enable BitIO SetDir, ClrVal, and SetVal functions.

a. In the Processor Expert page, click the plus-sign control for the `GPIO_C0` bean. The function list expands: red X symbols indicate disabled functions, green check symbols indicate enabled functions.

b. Double-click function symbols as necessary, so that only **SetDir**, **ClrVal**, and **SetVal** have green checks. (Figure 5.20 on page 112 shows this configuration.)

**Figure 5.20 GPIO_C3 Enabled Functions**



c. Click the `GPIO_C0` minus-sign control. The function list collapses.

d. Repeat substeps a, b, and c for beans `GPIO_C1`, `GPIO_C2`, `GPIO_C3`, `GPIO_D6`, and `GPIO_D7`.

8. Enable ExtInt OnInterrupt, GetVal functions.

a. In the Processor Expert page, click the plus-sign control for the `IRQA` bean. The function list expands.

b. Double-click function symbols as necessary, so that only **OnInterrupt** and **GetVal** have green check symbols.

c. Click the `IRQA` minus-sign control. The function list collapses.

d. Repeat substeps a, b, and c for bean `IRQB`.

9. Design (generate) project code.

a. From the main-window menu bar, select **Processor Expert > Code Design ‘LEDcontrol.mcp**.’ (This selection shows the actual name of your project.) The IDE and PEI generate several new files for your project.

b. You may close all windows except the project window.

10. Update file Events.c.

a. Click the project window’s Files tab. The Files page moves to the front of the window.

b. Expand the **User Modules** folder.

c. Double-click filename **Events.c**. An editor window opens, displaying this file's text. (Listing 5.1 on page 113, at the end of this tutorial, shows this file's contents.)

d. Find the line `IRQB_OnInterrupt()`.

e. Above this line, enter the new line **`extern short IRQB_On;`**.

f. Inside `IRQB_OnInterrupt()`, enter the new line `IRQB_On ^= 1;`.

g. Find the line `IRQA_OnInterrupt()`.

h. Above this line, enter the new line **`extern short IRQA_On;`**.

i. Inside `IRQA_OnInterrupt()`, enter the new line `IRQA_On ^= 1;`.

**NOTE** Listing 5.1 on page 113 shows these new lines as bold italics.

j. Save and close file Events.c.

11. Update file LEDcontrol.c.

a. In the project window's Files page, double-click filename **LEDcontrol.c** (or the actual .c filename of your project). An editor window opens, displaying this file's text.

b. Add custom code, to utilize the beans.

**NOTE** Listing 5.2 on page 116 shows custom entries as bold italics. Processor Expert software generated all other code of the file.

c. Save and close the file.

12. Build and debug the project.

a. From the main-window menu bar, select **Project** > **Make**. The IDE compiles and links your project, generating executable code.

b. Debug your project, as you would any other CodeWarrior project.

This completes the Processor Expert tutorial exercise. Downloading this code to a DSP56836E development board should make the board LEDs flash in a distinctive pattern.

### Listing 5.1 File Events.c

```
/*
** #################################################################
**
**     Filename  : Events.C
**
**     Project   : LEDcontrol
```

```
**
**     Processor : DSP56F836
**
**     Beantype  : Events
**
**     Version   : Driver 01.00
**
**     Compiler  : Metrowerks DSP C Compiler
**
**     Date/Time : 3/24/2003, 1:18 PM
**
**     Abstract  :
**
**         This is user's event module.
**         Put your event handler code here.
**
**     Settings  :
**
**
**     Contents  :
**
**         IRQB_OnInterrupt - void IRQB_OnInterrupt(void);
**         IRQA_OnInterrupt - void IRQA_OnInterrupt(void);
**
**
**     (c) Copyright UNIS, spol. s r.o. 1997-2002
**
**     UNIS, spol. s r.o.
**     Jundrovska 33
**     624 00 Brno
**     Czech Republic
**
**     http      : www.processorexpert.com
**     mail      : info@processorexpert.com
**
** #########################################################
*/
/* MODULE Events */

/*Including used modules for compilling procedure*/
#include "Cpu.h"
#include "Events.h"
#include "GPIO_C0.h"
#include "GPIO_C1.h"
#include "GPIO_C2.h"
#include "GPIO_C3.h"
#include "GPIO_D6.h"
#include "GPIO_D7.h"
```

```
#include "IRQA.h"
#include "IRQB.h"

/*Include shared modules, which are used for whole project*/
#include "PE_Types.h"
#include "PE_Error.h"
#include "PE_Const.h"
#include "IO_Map.h"

/*
** ==========================================================
**     Event       :  IRQB_OnInterrupt (module Events)
**
**     From bean   :  IRQB [ExtInt]
**     Description :
**         This event is called when the active signal edge/level
**         occurs.
**     Parameters  : None
**     Returns     : Nothing
** ==========================================================
*/
#pragma interrupt called
extern short IRQB_On;
void IRQB_OnInterrupt(void)
{
  IRQB_On ^=1;
  /* place your IRQB interrupt procedure body here */
}


/*
** ==========================================================
**     Event       :  IRQA_OnInterrupt (module Events)
**
**     From bean   :  IRQA [ExtInt]
**     Description :
**         This event is called when the active signal edge/level
**         occurs.
**     Parameters  : None
**     Returns     : Nothing
** ===================================================================
*/
#pragma interrupt called
extern short IRQA_On;
void IRQA_OnInterrupt(void)
{
  IRQA_On ^= 1;
  /* place your IRQA interrupt procedure body here */
}


/* END Events */

/*
** ########################################################
**
**     This file was created by UNIS Processor Expert 03.15 for
**     the Freescale DSP56x series of microcontrollers.
**
** ##########################################################
*/
```

**Listing 5.2  File LEDcontrol.c**

```
/*
** ###################################################################
**     Filename  : LEDcontrol.C
**
**     Project   : LEDcontrol
**
**     Processor : DSP56F836
**
**     Version   : Driver 01.00
**
**     Compiler  : Metrowerks DSP C Compiler
**
**     Date/Time : 3/24/2003, 1:18 PM
**
**     Abstract  :
**
**         Main module.
**         Here is to be placed user's code.
**
**     Settings  :
**
**
**     Contents  :
**
**         No public methods
**
**
**     (c) Copyright UNIS, spol. s r.o. 1997-2002
**
**     UNIS, spol. s r.o.
**     Jundrovska 33
**     624 00 Brno
**     Czech Republic
**
**     http      : www.processorexpert.com
**     mail      : info@processorexpert.com
**
** ###################################################################
*/
/* MODULE LEDcontrol */

/* Including used modules for compilling procedure */
#include "Cpu.h"
#include "Events.h"
#include "GPIO_C0.h"
#include "GPIO_C1.h"
#include "GPIO_C2.h"
#include "GPIO_C3.h"
#include "GPIO_D6.h"
#include "GPIO_D7.h"
#include "IRQA.h"
#include "IRQB.h"
/* Include shared modules, which are used for whole project */
#include "PE_Types.h"
#include "PE_Error.h"
#include "PE_Const.h"
#include "IO_Map.h"

/*
 * Application Description:
 *   LED program for the 56836 EVM.
 *
 *   Pattern: "Count" from 0 to 63, using LEDs to represent the bits of
the number.
 *
 *   Pressing the IRQA button flips LED order: commands that previously
went to LED1 go to LED6, and so forth.
 *   Pressing the IRQB button reverses the enabled/disabled LED states.
 *
 */

/* global used as bitfield, to remember currently active bits, used to
 * enable/disable all LEDs. */
long    num = 0;
short   IRQA_On,IRQB_On;

/* simple loop makes LED changes visible to the eye */
void wait(int);
voide wait(int count)
```

```
{
        int i;
        for (i=0; i<count; ++i);
}

/*set the given LED */
void setLED(int);
void setLED(int num)
{
        if (!IRQA_On)
        {
                num = 7-num;
        }
        if (!IRQB_On)
        {
                switch (num)
                {
                        case 1:  GPIO_C0_ClrVal(); break;
                        case 2:  GPIO_C1_ClrVal(); break:
                        case 3:  GPIO_C2_ClrVal(); break;
                        case 4:  GPIO_C3_ClrVal(); break;
                        case 5:  GPIO_D6_ClrVal(); break;
                        case 6:  GPIO_D7_ClrVal(); break;
                }
        }
        else
        {
                switch (num)
                {
                        case 1:  GPIO_C0_SetVal(); break;
                        case 2:  GPIO_C1_SetVal(); break;
                        case 3:  GPIO_C2_SetVal(); break;
                        case 4:  GPIO_C3_SetVal(); break;
                        case 5:  GPIO_D6_SetVal(); break;
                        case 6:  GPIO_D7_SetVal(); break;
                }
        }
}

/* clear the given LED */
void clrLED(int);
void clrLED(int num)
{
        if (!IRQA_On)
        {
                num = 7-num;
        }
        if (IRQB_On)
        {
                switch (num)
                {
                        case 1:  GPIO_C0_ClrVal(); break;
                        case 2:  GPIO_C1_ClrVal(); break;
                        case 3:  GPIO_C2_ClrVal(): break;
                        case 4:  GPIO_C3_ClrVal(); break;
                        case 5:  GPIO_D6_ClrVal(); break;
                        case 6:  GPIO_D7_ClrVal(); break;
                }
        }
        else
        {
                switch (num)
                {
                        case 1:  GPIO_C0_SetVal(); break;
                        case 2:  GPIO_C1_SetVal(); break;
                        case 3:  GPIO_C2_SetVal(); break;
                        case 4:  GPIO_C3_SetVal(); break;
                        case 5:  GPIO_D6_SetVal(); break;
                        case 6:  GPIO_D7_SetVal(); break;
                }
        }
}

#define CLEARLEDS    showNumberWithLEDs(0)
/* method to set each LED status to reflect the given number/bitfield
*/
void shwNumberWithLEDs(long);
void showNumberWithLEDs(long num)
{
        int i;
        for (i=0; i<6; ++i)
        {
                if ((num>>i) & 1
                        setLED(i+1);
                else
                        clrLED(i+1);
        }
}

/*  Pattern: "Count" from 0 to 63 in binary using LEDs to represent
bits of the current number. 1 = enabled LED, 0 = disabled LED. */
void pattern();
void pattern()
{
        long  i;
        int       j;
        for (i=0; i<=0b111111; ++i)
        {
                showNumberWithLEDs(i);
                wait(100000);
        }
}

void main(void)
{
  /*** Processor Expert internal initialization. DON'T REMOVE THIS
CODE!!! ***/
  PE_low_level_init();
  /*** End of Processor Expert internal initialization.            ***/

  /*Write your code here*/
#pragma  warn_possunwant off

  IRQA_On = IRQA_GetVal() ? 1 : 0;
  IRQB_On = IRQB_GetVal() ? 1 : 0;

  for(;;); {

        CLEARLEDS;
        pattern();

  }

#pragma  warn_possunwant reset
}

/* END LEDcontrol */
/*
** ####################################################################
/*
**     This file was created by UNIS Processor Expert 03.15 for
**     the Freescale DSP56x series of microcontrollers.
**
** ################################################################
*/
```

# 6

# C for DSP56800E

This chapter explains considerations for using C with the DSP56800E processor. Note that the DSP56800E processor does not support:

- The C++ language
- Standard C trigonometric and algebraic floating-point functions (such as sine, cosine, tangent, and square root)

Furthermore, C pointers allow access only to X memory.

**NOTE** The DSP56800E MSL implements a few trigonometric and algebraic functions, but these are mere examples that the DSP56800E does not support.

This chapter contains these sections:

## Number Formats

This section explains how the CodeWarrior compiler implements ordinal and floating-point number types for 56800E processors. For more information, read `limits.h` and `float.h`, under the M56800E Support folder.

Table 6.1 on page 122 shows the sizes and ranges of ordinal data types.

### Table 6.1 56800E Ordinal Types

| Type | Option Setting | Size (bits) | Range |
|---|---|---|---|
| char | **Use Unsigned Chars** is disabled in the C/C++ Language (C Only) settings panel | 8 | -128 to 127 |
| | **Use Unsigned Chars** is enabled | 8 | 0 to 255 |
| signed char | n/a | 8 | -128 to 127 |
| unsigned char | n/a | 8 | 0 to 255 |
| short | n/a | 16 | -32,768 to 32,767 |
| unsigned short | n/a | 16 | 0 to 65,535 |
| int | n/a | 16 | -32,768 to 32,767 |
| unsigned int | n/a | 16 | 0 to 65,535 |
| long | n/a | 32 | -2,147,483,648 to 2,147,483,647 |
| unsigned long | n/a | 32 | 0 to 4,294,967,295 |
| pointer | small data model (“Large Data Model” is disabled in the M56800E Processor settings panel) | 16 | 0 to 65,535 |
| | large data model (“Large Data Model” is enabled) | 24 | 0 to 16,777,215 |

Table 6.2 on page 123 shows the sizes and ranges of the floating-point types.

Table 6.2 M56800E Floating-Point Types

| Type | Size (bits) | Range |
|---|---|---|
| float | 32 | 1.17549e-38 to 3.40282e+38 |
| short double | 32 | 1.17549e-38 to 3.40282e+38 |
| double | 32 | 1.17549e-38 to 3.40282e+38 |
| long double | 32 | 1.17549e-38 to 3.40282e+38 |

# Calling Conventions and Stack Frames

The DSP56800E compiler stores data and call functions differently than the DSP56800 compiler does. Advantages of the DSP56800E method include: more registers for parameters and more efficient byte storage.

## Passing Values to Functions

The compiler uses registers A,B, R1, R2, R3, R4, Y0, and Y1 to pass parameter values to functions. Upon a function call, the compiler scans the parameter list from left to right, using registers for these values:

- The first two 8/16-bit integer values — Y0 and Y1.
- The first two 32-bit integer or float values — A and B.
- The first four pointer parameter values — R2, R3, R4, and R1 (in that order).
- The third and fourth 8/16-bit integer values — A and B (provided that the compiler does not use these registers for 32-bit parameter values).
- The third 8/16-bit integer value — B (provided that the compiler does not use this register for a 32-bit parameter value).

The compiler passes the remaining parameter values on the stack. The system increments the stack by the total amount of space required for memory parameters. This incrementing must be an even number of words, as the stack pointer (SP) must be continuously long-aligned. The system moves parameter values to the stack from left to right, beginning with the stack location closest to the SP. Because a long parameter must begin at an even address, the compiler introduces one-word gaps before long parameter values, as appropriate.

# Returning Values From Functions

The compiler returns function results in registers A, R0, R2, and Y0:

- 8-bit integer values — Y0.
- 16-bit integer values — Y0.
- 32-bit integer or float values — A.
- All pointer values — R2.
- Structure results — R0 contains a pointer to a temporary space allocated by the caller. (The pointer is a hidden parameter value.)

Additionally, the compiler:

- Reserves R5 for the stack frame pointer when a function makes a dynamic allocation. (This is the original stack pointer before allocations.) Otherwise, the compiler saves R5 across function calls.
- Saves registers C10 and D10 across function calls.
- Does not save registers C2 and D2 across function calls.

# Volatile and Non-Volatile Registers

Values in *non-volatile* registers can be saved across functions calls. Another term for such registers is *saved over a call* registers (SOCs).

Values in *volatile* registers cannot be saved across functions calls. Another term for such registers is *non-SOC* registers.

Table 6.3 on page 124 lists both the volatile and non-volatile registers.

**Table 6.3 Volatile and Non-Volatile Registers**

| Unit | Register | Size | Type | Comments |
|---|---|---|---|---|
| Arithmetic Logic Unit (ALU) | Y1 | 16 | Volatile (non-SOC) | |
| | Y0 | 16 | Volatile (non-SOC) | |
| | Y | 32 | Volatile (non-SOC) | |
| | X0 | 16 | Volatile (non-SOC) | |

**Table 6.3 Volatile and Non-Volatile Registers (*continued*)**

| Unit | Register | Size | Type | Comments |
|---|---|---|---|---|
| | A2 | 4 | Volatile (non-SOC) | |
| | A1 | 16 | Volatile (non-SOC) | |
| | A0 | 16 | Volatile (non-SOC) | |
| Arithmetic Logic Unit (ALU) (continued) | A10 | 32 | Volatile (non-SOC) | |
| | A | 36 | Volatile (non-SOC) | |
| | B2 | 4 | Volatile (non-SOC) | |
| | B1 | 16 | Volatile (non-SOC) | |
| | B0 | 16 | Volatile (non-SOC) | |
| | B10 | 32 | Volatile (non-SOC) | |
| | B | 36 | Volatile (non-SOC) | |
| | C2 | 4 | Volatile (non-SOC) | |
| | C1 | 16 | Non-Volatile (SOC) | |
| | C0 | 16 | Non-Volatile (SOC) | |
| | C10 | 32 | Non-Volatile (SOC) | |
| | C | 36 | Volatile (non-SOC) | Includes volatile register C2. |

**Table 6.3 Volatile and Non-Volatile Registers (*continued*)**

| Unit | Register | Size | Type | Comments |
|---|---|---|---|---|
| | D2 | 4 | Volatile (non-SOC) | |
| | D1 | 16 | Non-Volatile (SOC) | |
| | D0 | 16 | Non-Volatile (SOC) | |
| | D10 | 32 | Non-Volatile (SOC) | |
| | D | 36 | Volatile (non-SOC) | Includes volatile register D2. |
| Address Generation Unit (AGU) | R0 | 24 | Volatile (non-SOC) | |
| | R1 | 24 | Volatile (non-SOC) | |
| | R2 | 24 | Volatile (non-SOC) | |
| | R3 | 24 | Volatile (non-SOC) | |
| | R4 | 24 | Volatile (non-SOC) | |
| | R5 | 24 | Non-volatile (SOC) | If the compiler uses R5 as a pointer, it becomes a non-volatile register — its value can not be saved over called functions. |
| | N | 24 | Volatile (non-SOC) | |
| Address Generation Unit (AGU) (continued) | SP | 24 | Volatile (non-SOC) | |

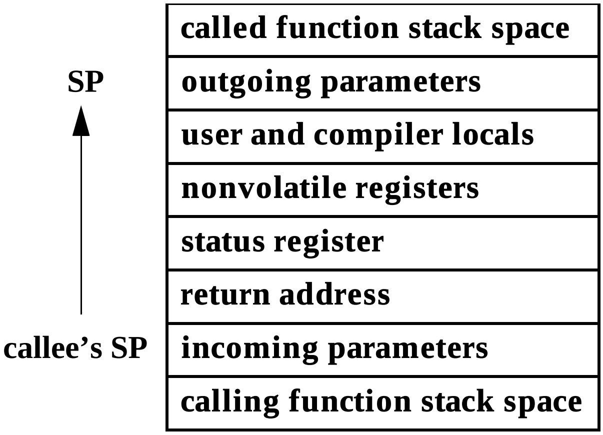
**Table 6.3 Volatile and Non-Volatile Registers (*continued*)**

| Unit | Register | Size | Type | Comments |
|---|---|---|---|---|
| | N3 | 16 | Volatile (non-SOC) | |
| | M01 | 16 | Volatile (non-SOC) | Certain registers must keep specific values for proper C execution — set this register to 0xFFFF. |
| Program Controller | PC | 21 | Volatile (non-SOC) | |
| | LA | 24 | Volatile (non-SOC) | |
| | LA2 | 24 | Volatile (non-SOC) | |
| | HWS | 24 | Volatile (non-SOC) | |
| | FIRA | 21 | Volatile (non-SOC) | |
| | FISR | 13 | Volatile (non-SOC) | |
| | OMR | 16 | Volatile (non-SOC) | Certain registers must keep specific values for proper C execution — in this register, set the CM bit. |
| | SR | 16 | Volatile (non-SOC) | |
| | LC | 16 | Volatile (non-SOC) | |
| | LC2 | 16 | Volatile (non-SOC) | |

# Stack Frame and Alignment

Figure 6.1 on page 128. depicts generation of the stack frame. The stack grows upward, so pushing data onto the stack increments the stack pointer’s address value.

**Figure 6.1 Stack Frame**



The stack pointer (SP) is a 24-bit register, always treated as a word pointer. During a function execution, the stable position for the SP is at the top of the user and compiler locals. The SP increases during the call if the stack is used for passed parameters.

The software stack supports structured programming techniques, such as parameter passing to subroutines and local variables. These techniques are available for both assembly-language and high-level-language programming. It is possible to support passed parameters and local variables for a subroutine at the same time within the stack frame.

The compiler stores local data by size. It stores smaller data closest to the SP, exploiting SP addressing modes that have small offsets. This means that the compiler packs all bytes two per word near the stack pointer. It packs the block of words next, then blocks of longs. Aggregates (structs and arrays) are farthest from the stack pointer, not sorted by size.

**NOTE** When a function makes a dynamic allocation, the compiler reserves R5 as a stack frame pointer. (This is the stack pointer before allocations.)

The compiler always must operate with the stack pointer long aligned. This means that:

- The start-up code in the runtime first initializes the stack pointer to an odd value.
- At all times after that, the stack pointer must point to an odd word address.
- The compiler never generates an instruction that adds or subtracts an odd value from the stack pointer.

- The compiler never generates a MOVE.W or MOVEU.W instruction that uses the X:(SP)+ or X:(SP)- addressing mode.

# User Stack Allocation

The 56800E compilers build frames for hierarchies of function calls using the stack pointer register (SP) to locate the next available free X memory location in which to locate a function call's frame information. There is usually no explicit frame pointer register. Normally, the size of a frame is fixed at compile time. The total amount of stack space required for incoming arguments, local variables, function return information, register save locations (including those in pragma interrupt functions) is calculated and the stack frame is allocated at the beginning of a function call.

Sometimes, you may need to modify the SP at runtime to allocate temporary local storage using inline assembly calls. This invalidates all the stack frame offsets from the SP used to access local variables, arguments on the stack, etc. With the User Stack Allocation feature, you can use inline assembly instructions (with some restrictions) to modify the SP while maintaining accurate local variable, compiler temps, and argument offsets, i.e., these variables can still be accessed since the compiler knows you have modified the stack pointer.

The User Stack Allocation feature is enabled with the `#pragma check_inline_sp_effects [on|off|reset]` pragma setting. The pragma may be set on individual functions. By default the pragma is off at the beginning of compilation of each file in a project.

The User Stack Allocation feature allows you to simply add inline assembly modification of the SP anywhere in the function. The restrictions are straight-forward:

1. The SP must be modified by the same amount on all paths leading to a control flow merge point.
2. The SP must be modified by a literal constant amount. That is, address modes such as "(SP)+N" and direct writes to SP are not handled.
3. The SP must remain properly aligned.
4. You must not overwrite the compiler's stack allocation by decreasing the SP into the compiler allocated stack space.

Point 1 above is required when you think about an if-then-else type statement. If one branch of a decision point modifies the SP one way and the other branch modifies SP another way, then the value of the SP is run-time dependent, and the compiler is unable to determine where stack-based variables are located at run-time. To prevent this from happening, the User Stack Allocation feature traverses the control flow graph, recording the inline assembly SP modifications through all program paths. It then checks all control flow merge points to make sure that the SP has been modified consistently in each branch converging on the merge point. If not, a warning is emitted citing the inconsistency.

Once the compiler determined that inline SP modifications are consistent in the control flow graph, the SP's offsets used to reference local variables, function arguments, or temps are fixed up with knowledge of inline assembly modifications of the SP. Note, you may freely allocate local stack storage:

1. As long as it is equally modified along all branches leading to a control flow merge point.
2. The SP is properly aligned. The SP must be modified by an amount the compiler can determine at compile time.

A single new pragma is defined. `#pragma check_inline_sp_effects [on|off|reset]` will generate a warning if the user specifies an inline assembly instruction which modifies the SP by a run-time dependent amount. If the pragma is not specified, then stack offsets used to access stack-based variables will be incorrect. It is the user's responsibility to enable `#pragma check_inline_sp_effects`, if they desire to modify the SP with inline assembly and access local stack-based variables. Note this pragma has no effect in function level assembly functions or separate assembly only source files (`.asm` files).

In general, inline assembly may be used to create arbitrary flow graphs and not all can be detected by the compiler.

For example:

```
REP #3
ADDA #2,SP
```

This example would modify the SP by three, but the compiler would only see a modification of one. Other cases such as these might be created by the user using inline jumps or branches. These are dangerous constructs and are not detected by the compiler.

In cases where the SP is modified by a run-time dependent amount, a warning is issued.

### Listing 6.1 Example 1 – Legal modification of SP Using Inline Assembly

```
#define EnterCritical() { asm(adda #2,SP);\
                        asm(move.l  SR,X:(SP)+); \
                        asm(bfset #0x0300,SR); \
                        asm(nop); \
                        asm(nop);}

#define ExitCritical()  { asm(deca.l SP);\
                          asm(move.l x:(SP)-,SR); \
                          asm(nop);\
                        asm(nop);}

#pragma check_inline_sp_effects on
```

```
int func()
{
         int a=1, b=1, c;

         EnterCritical();

         c = a+b;

         ExitCritical();

}
```

This case will work because there are no control flow merge points. SP is modified consistently along all paths from the beginning to the end of the function and is properly aligned.

**Listing 6.2 Example 2 – Illegal Modification of SP using Inline Assembly**

```
#define EnterCritical() { asm(adda #2,SP);\
                        asm(move.l  SR,X:(SP)+); \
                        asm(bfset #0x0300,SR); \
                        asm(nop); \
                        asm(nop);}

#define ExitCritical()  { asm(deca.l SP);\
                          asm(move.l x:(SP)-,SR); \
                          asm(nop);\
                        asm(nop);}

#pragma check_inline_sp_effects on

int func()
{
          int a=1, b=1, c;

          if (a)
{
                 EnterCritical();

                 c = a+b;

          }
          else {
                 c = b++;
          }

          ExitCritical();
          return (b+c);
}
```

This example will generate the following warning because the SP entering the ‘ExitCritical’ macro is different depending on which branch is taken in the if. Therefore, accesses to variables `a`, `b`, or `c` may not be correct.

```
Warning : Inconsistent inline assembly modification of SP in this
function.
M56800E_main.c line 29    ExitCritical();
```

### Listing 6.3 Example 3 – Modification of SP by a Run-time Dependent Amount

```
#define EnterCritical() { asm(adda R0,SP);\
                          asm(move,l  SR,X:(SP)+); \
                          asm(bfset   #0x0300,SR); \
                          asm(nop); \
                          asm(nop);}

#define ExitCritical()  { asm(deca.l SP);\
                          asm(move.l X:(SP)-,SR); \
                          asm(nop);\
                          asm(nop);}

#pragma check_inline_sp_effects on
int func()
{
          int a=1, b=1, c;

          if (a)
          {
                  EnterCritical();

                  c = a+b;

          }
          else {
                  EnterCritical();
                  c = b++;
          }
          return (b+c);
}
```

This example will generate the following warning:

```
Warning : Cannot determine SP modification value at compile time
M56800E_main.c line 20     EnterCritical();
```

This example is not legal since the SP is modified by run-time dependent amount.

If all inline assembly modifications to the SP along all branches are equal approaching the exit of a function, it is not necessary to explicitly deallocate the increased stack space. The compiler “cleans up” the extra inline assembly stack allocation automatically at the end of the function.

**Listing 6.4 Example 4 – Automatic Deallocation of Inline Assembly Stack Allocation**

```
#pragma check_inline_sp_effects on
int func()
{
           int a=1, b=1, c;

           if (a)
           {
                     EnterCritical();

                     c = a+b;

           }
           else {
                     EnterCritical();
                     c = b++;
           }



           return (b+c);
}
```

This example does not need to call the ‘ExitCritical’ macro because the compiler will automatically clean up the extra inline assembly stack allocation.

# Data Alignment Requirements

The data alignment rules for DSP56800E stack and global memory are:

- Bytes — byte boundaries.

  Exception: bytes passed on the stack are always word-aligned, residing in the lower bytes.

- Words — word boundaries.
- Longs, floats, and doubles — double-word boundaries:
  - Least significant word is always on an even word address.
  - Most significant word is always on an odd word address.
  - Long accesses through pointers in AGU registers (for example, R0 through R5 or N) point to the least significant word. That is, the address is even.
  - Long accesses through pointers using SP point to the most significant word. That is, the address in SP is odd.
- Structures — word boundaries (not byte boundaries).

**NOTE** A structure containing only bytes still is word aligned.

- Structures — double-word boundaries if they contain 32-bit elements, or if an inner structure itself is double-word aligned.
- Arrays — the size of one array element.

# Word and Byte Pointers

The alignment requirements explained above determine how the compiler uses DSP56800E byte and word pointers to implement C pointer types. The compiler uses:

- Word pointers for all structures
- The SP to access the stack resident data of all types:
  - Bytes
  - Shorts
  - Longs
  - Floats
  - Doubles
  - Any pointer variables
- Word pointers to access:
  - Shorts
  - Longs
  - Any pointer variables

- Byte pointers for:
  - Single global or static byte variable, if accessed through a pointer using X:(Rn)
  - Global or static array of byte variables

    The compiler does not use pointers to access scalar global or static byte variables directly by their addresses. Instead, it uses an instruction with a .BP suffix:

    ```
    MOVE[U].BP   X:xxxx,<dest>
    MOVE.BP      <src>,X:xxxx
    ```

## Reordering Data for Optimal Usage

The compiler changes data order, for optimal usage. The data reordering follows these guidelines:

- Reordering is mandatory if local variables are allocated on the stack.
- The compiler does not reorder data for parameter values passed in memory (instead of being passed in registers).
- The compiler does not reorder data when locating fields within a structure.

# Variables in Program Memory

This feature allows the programmer full flexibility in deciding the placement of variables in memory. Variables can be now declared as part of the program memory, using a very simple and intuitive syntax. For example:

`__pmem int c; // 'c'` is an integer that will be stored in program memory.

This feature is very useful when data memory is tight, because some or all of the data can be moved to program memory. It can be handled exactly the same way as normal data. This is almost completely transparent to the programmer, with a few exceptions that will be presented in the next paragraphs.

The CPU architecture only allows post increment addressing of words (16-bit data) in program memory. While the compiler circumvents this restriction and allows full access to all data types in program memory, the performance is decreased. If placement of some variables in program memory is needed, and at the same time the execution speed is important, here are some pointers that can be used to organize the code:

- Try to keep all variables that are used in a loop (the loop counter included) in data memory. This condition becomes more important as the loop nesting level increases.
- If possible, place only int (16-bit) data in program memory. Data types with different dimensions are accessed via sequences of code rather than single instructions. 16-bit data is fastest, followed by 32-bit data and 8-bit data.

- Data in program memory can be loaded and stored in a limited number of DALU registers. Because of this, a number of register save/restore sequences can appear if there are not enough available DALU registers. This could be a problem with computational intensive code because the operations do not take place only in registers anymore, and the execution of the code will be slower. This can be avoided by using as many variables in data memory as possible.

## Declaring Program Memory Variables

A program memory variable is declared using the `__pmem` qualifier. Here are some examples:

```
typedef struct // simple structure declaration
{
   int i;
   char *p;
   long l;
} test;

__pmem int ip1 = 5; // initialized int in program memory
__pmem int ip2; // uninitialized int in program memory
int *__pmem ppx1; // pointer in program memory to int in data memory
__pmem int * __pmem ppp1; // pointer in program memory to int in
program memory
__pmem int parr[ 100 ]; // array in program memory
__pmem test sp; // structure in program memory
__pmem int aap[ 2 ][ 2 ]; // two dimensional array in program memory
__pmem int *pxp1; // pointer in data memory to int in program memory
```

## Using Variables in Program Memory

Variables in program memory can be used almost exactly like variables in data memory. The exceptions are presented below:

- the `__pmem` qualifier can't be used in a structure declaration because a structure can have all its members either in program memory or in data memory, but not in both memory spaces. The compiler will issue an error message in this case. For example:

```
typedef struct // simple structure declaration
{
   int i;
   char __pmem *p; // error, __pmem not allowed here
   long l;
} test;
```

- the compiler will signal an error when an implicit conversion between a pointer to data in data memory and a pointer to data in program memory is attempted. For example, using the previous definitions, the compiler gives an error for this assignment:

```
pxp1 = ppx1;
```

Explicit conversions are allowed, but they should be used with care. An explicit conversion for the previous assignment that is accepted by the compiler is given below:

```
pxp1 = ( __pmem int * )ppx1;
```

Another consequence of this restriction is that an important part of the MSL functions that have at least an argument that is a pointer will not work with variables in program memory. For example:

```
char *c1; // pointer in data memory to char in data memory
char __pmem *c2; // pointer in data memory to char in program
memoryvstrcat( c1, c2 ); // error, the second argument can't be
converted to 'const char *'
```

If variable argument lists are used, this problem is generally hidden. The program is compiled with no errors from the compiler, but it doesn't work as expected. The most common example is the `printf` function:

```
char *c1 = "xmem";          // pointer in data memory to char in data
memory
char __pmem *c2 = "pmem"; // pointer in data memory to char in program
memory

printf( "%s\n", c1 );       // works as expected
printf( "%s\n", c2 );       // doesn't work as expected
```

Here, the type of the arguments is lost because `printf` uses a variable argument list. Thus the compiler can not signal a type mismatch and the program will compile without errors, but it won't work as expected, because `printf` assumes that all the data is stored in data memory.

## Linking with Variables in Program Memory

The compiler creates special sections in the output file for variables in program memory. This is a description of all data in program memory sections:

- .data.pmem (initialized program memory data)
- .const.data.pmem (constant program memory data)
- bss.pmem (uninitialized program memory data).

The following sections are also generated if you choose to generate separate sections for char data:

- .data.char.pmem  (initialized program memory chars)
- .const.data.char.pmem (constant program memory chars)
- .bss.char.pmem (uninitialized program memory chars)

These sections are used in the linker command file just like normal sections. A typical linker command file for a program that uses data in program memory looks like this:

```
MEMORY
{
    .p_RAM              (RWX) : ORIGIN = 0x0082,   LENGTH = 0xFF3E
    .p_reserved_regs    (RWX) : ORIGIN = 0xFFC0,   LENGTH = 0x003F
    .p_RAM2             (RWX) : ORIGIN = 0xFFFF,   LENGTH = 0x0000
    .x_RAM              (RW)  : ORIGIN = 0x0001,   LENGTH = 0x7FFE   #
SDM xRAM limit is 0x7FFF
}

SECTIONS
{
    .application_code :
    {v        # .text sections

        * (.text)
        * (rtlib.text)
        * (fp_engine.text)
        * (user.text)
        * (.data.pmem)            # program memory initalized data
        * (.const.data.pmem)      # program memory constant data
        * (.bss.pmem)             # program memory uninitialized data
    } > .p_RAM
    .data :
    {
        # .data sections

        * (.const.data.char)  # used if "Emit Separate Char Data
Section" enabled
        * (.const.data)v        * (fp_state.data)
        * (rtlib.data)
        * (.data.char)        # used if "Emit Separate Char Data
Section" enabled
        * (.data)

        # .bss sections

        * (rtlib.bss.lo)
        * (rtlib.bss)
        . = ALIGN(1);
        _START_BSS = .;
        * (.bss.char)         # used if "Emit Separate Char Data
Section" enabled
        * (.bss)
        _END_BSS   = .;

        # setup the heap address

        . = ALIGN(4);
        _HEAP_ADDR = .;
        _HEAP_SIZE = 0x100;
        _HEAP_END = _HEAP_ADDR + _HEAP_SIZE;
        . = _HEAP_END;

        # setup the stack address

        _min_stack_size = 0x200;
        _stack_addr = _HEAP_END;
        _stack_end  = _stack_addr + _min_stack_size;
        . = _stack_end;

        # export heap and stack runtime to libraries

        F_heap_addr   = _HEAP_ADDR;
        F_heap_end    = _HEAP_END;
        F_Lstack_addr = _HEAP_END;
        F_start_bss   = _START_BSS;
        F_end_bss     = _END_BSS;
    } > .x_RAM
}
```

# Code and Data Storage

The DSP56800E processor has a dual Harvard architecture with separate `CODE` (P: memory) and `DATA` (X: memory) memory spaces. Table 6.4 on page 140. shows the sizes and ranges of these spaces, as well as the range of character data within X memory, for both the small and large memory models. (You may need to use the **ELF Linker and Command Language** or **M56800E Linker** settings panel to specify how the project-defined sections map to real memory.)

**Table 6.4 Code and Data Memory Ranges**

| Section | Small Model |  | Large Model |  |
|---|---|---|---|---|
|  | Size | Range<br>(Word Address) | Size | Range<br>(Word Address) |
| CODE<br>(P: memory) | 128 KB | 0 - 0xFFFF | 1 MB | 0 - 0x7FFFF |
| DATA<br>(X: memory) | 128 KB | 0 - 0xFFFF | 32 MB | 0 - 0xFFFFFF |
| DATA<br>(X: memory)<br>character data | 64 KB | 0 - 0x7FFF | 16 MB | 0 - 0x7FFFFF |

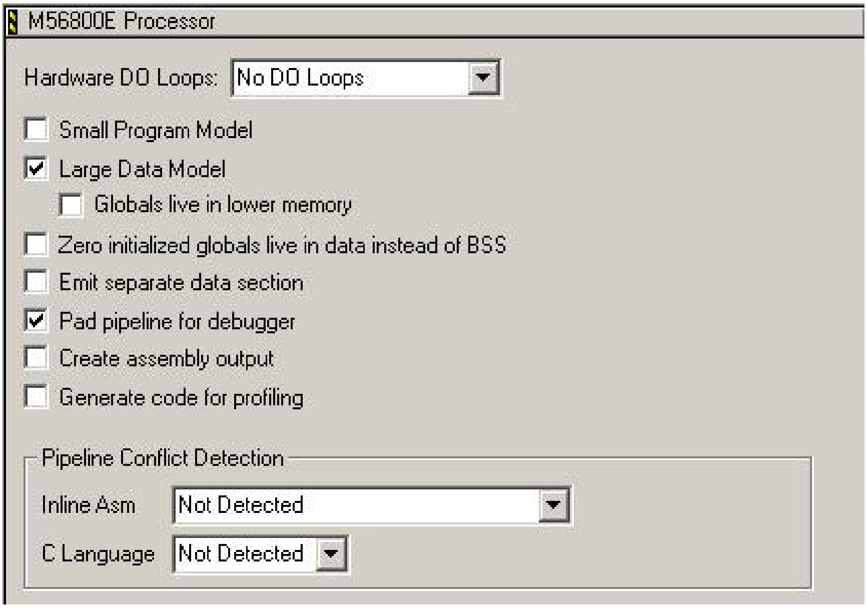
A peculiarity of the DSP56800E architecture is byte addresses for character (1-byte) data, but word addresses for data of all other types. To calculate a byte address, multiply the word address by 2. An address cannot exceed the maximum physical address, so placing character data in the upper half of memory makes the data unaddressable. (Address registers have a fixed width.)

For example, in the small memory model (maximum data address: 64 KB), placing character data at 0x8001 requires an access address of 0x10002. But this access address does not fit into 16-bit storage, as the small data memory model requires. Under your control, the compiler increases flexibility by placing all character data into specially-named sections as described in “Emit separate character data section checkbox.” You can locate these sections in the lower half of the memory map, making sure that the data can be addressed.

# Large Data Model Support

The DSP56800E extends the DSP56800 data addressing range, by providing 24-bit address capability to some instructions. 24-bit address modes allow user accesses beyond the 64K-word boundary of 16-bit addressing. To control large data memory model support, use the M56800E Processor panel (Figure 6.2 on page 141). See "M56800E Processor" on page 64 for explanations of this panel's elements.

**Figure 6.2 M56800E Processor Panel: Large Data Model**



M56800E Processor

Hardware DO Loops: No DO Loops

□ Small Program Model
☑ Large Data Model
□ Globals live in lower memory
□ Zero initialized globals live in data instead of BSS
□ Emit separate data section
☑ Pad pipeline for debugger
□ Create assembly output
□ Generate code for profiling

Pipeline Conflict Detection

Inline Asm: Not Detected
C Language: Not Detected

*Extended data* is data located beyond the 16-bit address boundary — as if it exists in extended (upper) memory. Memory located below the 64K boundary is *lower memory*.

The compiler default arrangement is using 16-bit addresses for all data accesses. This means that absolute addresses (X:xxxx addressing mode) are limited to 16 bits. Direct addressing or pointer registers load or store 16-bit addresses. Indexed addressing indexes are 16-bit quantities. The compiler treats data pointers as 16-bit pointers that you may store in single words of memory.

If the large data memory model is enabled, the compiler accesses all data by 24-bit addressing modes. It treats data pointers as 24-bit quantities that you may store in two words of memory. Absolute addressing occurs as 24-bit absolute addresses. Thus, you may access the entire 24-bit data memory, locating data objects anywhere.

You do not need to change C source code to take advantage of the large data memory model.

Examples in DSP56800E assembly code of extended data addressing are:

# Extended Data Addressing Example

Consider the code of Listing 6.5 on page 142:

### Listing 6.5 Addressing Extended Data

```
move.w x:0x123456,A1    ; move int using 24 bit absolute address
tst.l   x:(R0-0x123456) ; test a global long for zero using 24-bit
                                ; pointer indexed addressing
move.l r0,x:(R0)+       ; r0 stored as 24-bit quantity
cmpa r0,r1              ; compare pointer registers as 24 bit
                            ; quantities
```

The large data memory model is convenient because you can place data objects anywhere in the 24-bit data memory map. But the model is inefficient because extended data addressing requires more program memory and additional execution cycles.

However, all global and static data of many target applications easily fit within the 64 K word memory boundary. With this in mind, you can check the **Globals live in lower memory** checkbox of the M56800E Processor settings panel. This tells the compiler to access global and static data with 16-bit addresses, but to use 24-bit addressing for all pointer and stack operations. This arrangement combines the flexibility of the large data memory model with the efficiency of the small data model’s access to globals and statics.

**NOTE** If you check the Globals live in lower memory checkbox, be sure to store data in lower memory.

# Accessing Data Objects Examples

Table 6.5 on page 143 and Table 6.6 on page 143 show appropriate ways to access a global integer and a global pointer variable. The first two columns of each table list states of two checkboxes, **Large Data Model** and **Globals live in lower memory**. Both checkboxes are in the M56800E Processor settings panel. Note that the first enables the second.

Table 6.5 on page 143 lists ways to access a global integer stored at address X:0x1234.

```
int g1;
```

### Table 6.5 Accessing a Global Integer

| Large Data Model checkbox | Globals live in lower memory checkbox | Instruction | Comments |
|---|---|---|---|
| Clear | Clear | move.w X:0x1234,y0 | Default values |
| Checked | Clear | move.w X:0x001234,y 0 | |
| Clear | Checked | Combination not allowed | |
| Checked | Checked | move.w X:0x1234,y0 | Global accesses use 16-bit addressing |

Table 6.6 on page 143 lists ways to load a global pointer variable, at X:0x4567, into an address register.

```
int * gp1;
```

### Table 6.6 Loading a Global Pointer Variable

| Large Data Model checkbox | Globals live in lower memory checkbox | Instruction | Comments |
|---|---|---|---|
| Clear | Clear | move.w X:0x4567,r0 | Default 16-bit addressing, 16-bit pointer value |
| Checked | Clear | move.l X:0x004567,r0 | 24-bit addressing, pointer value is 24-bit |
| Clear | Checked | Combination not allowed | |
| Checked | Checked | move.l X:0x4567,r0 | 16-bit addressing, pointer value is 24-bit |

## External Library Compatibility

If you enable the large data model when the compiler builds your main application, external libraries written in C also must be built with the large data model enabled. The linker enforces this requirement, catching global objects located out of range for particular instructions.

A more serious compatibility problem involves pointer parameters. Applications built with the large data memory model may pass pointer parameter values in two words of the stack. But libraries built using the small memory model may expect pointer arguments to occupy a single word of memory. This incompatibility will cause runtime stack corruption.

You may or may not build external libraries or modules written in assembly with extended addressing modes. The linker does not enforce any compatibility rules on assembly language modules or libraries.

The compiler encodes the memory model into the object file. The linker verifies that all objects linked into an executable have compatible memory models. The ELF header’s e_flags field includes the bit fields that contain the encoded data memory model attributes of the object file:

```
#define EF_M56800E_LDMM 0x00000001 /* Large data memory model
     flag */
```

Additionally, C language objects are identified by an ELF header flag.

```
#define EF_M56800E_C 0x00000002 /* Object file generated from
     C source */
```

# Optimizing Code

Register coloring is an optimization specific to DSP56800E development. The compiler assigns two (or more) register variables to the same register, if the code does not use the variables at the same time. The code of Listing 6.6 on page 144 does not use variables `i` and `j` at the same time, so the compiler could store them in the same register:

**Listing 6.6 Register Coloring Example**

```
short i;
int j;

for (i=0; i<100; i++) { MyFunc(i); }
for (j=0; j<100; j++) { MyFunc(j); }
```

However, if the code included the expression `MyFunc (i+j)`, the variables would be in use at the same time. The compiler would store the two variables in different registers.

For DSP56800E development, you can instruct the compiler to:

1. **Store all local variables on the stack.** — (That is, do *not* perform register coloring.) The compiler loads and stores local variables when you read them and write to them. You may prefer this behavior during debugging, because it guarantees meaningful values for all variables, from initialization through the end of the function. To have the compiler behave this way, specify **Optimizations Off**, in the **Global Optimizations** settings panel.
2. **Place as many local variables as possible in registers.** — (That is, *do* perform register coloring.) To have the compiler behave this way, specify optimization Level 1 or higher, in the **Global Optimizations** settings panel.

**NOTE** **Optimizations Off** is best for code that you will debug after compilation. Other optimization levels include register coloring. If you compile code with an optimization level greater than 0 and then debug the code, register coloring could produce unexpected results.

Variables declared `volatile` (or those that have the address taken) are not kept in registers and may be useful in the presence of interrupts.

3. **Run Peephole Optimization.** — The compiler eliminates some compare instructions and improves branch sequences. Peephole optimizations are small and local optimizations that eliminate some compare instructions and improve branch sequences. To have the compiler behave this way, specify optimization Levels 1 through 4, in the **Global Optimizations** settings panel.

# Deadstripping and Link Order

The M56800E Linker deadstrips unused code and data only from files compiled by the CodeWarrior C compiler. The linker never deadstrips assembler relocatable files or C object files built by other compilers.

Libraries built with the CodeWarrior C compiler contribute only the used objects to the linked program. If a library has assembly files or files built with other C compilers, the only files that contribute to the linked program are those that have at least one referenced object. If you enable deadstripping, the linker completely ignores files without any referenced objects.

The Link Order page of the project window specifies the order (top to bottom) in which the DSP56800E linker processes C source files, assembly source files, and archive (.a and .lib) files. If both a source-code file and a library file define a symbol, the linker uses the definition of the file that appears first, in the link order. To change the link order, drag the appropriate filename to a different place, in this page’s list.

# Working with Peripheral Module Registers

This section highlights the issues and recommends programming style for using bit fields to access memory mapped I/O. Memory mapped I/O is a way of accessing devices that are not on the system. A part of the normal address space is mapped to I/O ports. A read/write to that memory location triggers an access to the I/O device, though to the program it seems like a normal memory access. Even if one byte is written to in the space allocated to a peripheral register, the whole register is written to. So the other byte of the peripheral register will not retain its data. This may happen because the compiler generates optimal bit-field instructions with a read(byte)-mask-writeback(byte) code sequence.

## Compiler Generates Bit Instructions

The compiler generates BFSET for |= , BFCLR for &=, and BFCHG for ^= operators.

Listing 6.7 on page 146 shows a C source example and the generated sample code.

### Listing 6.7 C Source Example

```
int i;
int *ip;

void main(void)
{
     i &= ~1;


/* generated codes
P: 00000082:  8054022D0001     bfclr   #1,X:0x00022d
*/

     (*(ip))^= 1;

/* generated codes
P:00000085: F87C022C           moveu.w  X:0x00022c,R0
P:00000087: 84400001           bfchg     #1,X:(R0)
*/

     *((int*)(0x1234))|=1;

/* generated codes
P:00000089: E4081234           move.l    #4660,R0
P:0000008B: 82400001           bfset     #1,X:(R0)
*/

}
```

```
/* generated codes
P:0000008D: E708               rts
*/
```

Note, the following example:

```
#define word int

union {
  word Word;
  struct {
    word SBK  :1;
    word RWU  :1;
    word RE   :1;
    word TE   :1;
    word REIE :1;
    word RFIE :1;
    word TIIE :1;
    word TEIE :1;
    word PT   :1;
    word PE   :1;
    word POL  :1;
    word WAKE :1;
    word M    :1;
    word RSRC :1;
    word SWAI :1;
    word LOOP :1;
  } Bits;
} SCICR;

/* Code:*/
     SCICR.Bits.TE = 1;            /* SCICR content is 0x0800 */
     SCICR.Bits.PE = 1;            /* SCICR content is 0x0002 ??? */
```

## Explanation of Undesired Behavior

If "SCICR" is mapped to a peripheral register, the code that is used to access the register is not portable and might be unsafe, like in DSP56800E at present.

Bit field behavior in C is almost all implementation defined. So generating the following code is legal:

```
     SCICR.Bits.TE = 1;            /* SCICR content is 0x0800 */
```

```
/* generated codes
P:00000082:874802c       moveu.w      #SCICR,R0
P:00000084:F0E0000       move.b       X:(R0),A
P:00000086:8350008       bfset        #8,A1
P:00000088:9800          move.b       A1,X:(R0)
*/

     SCICR.Bits.PE = 1;            /* SCICR content is 0x0002 ??? */

/* generated codes
P:00000089:F0E00001      move.b       X:(R0+1),A
P:0000008B:83500002      bfset        #2,A1
P:0000008D:9804          move.b       A1,X:(R0+1)
*/
```

However, since the writes (at P:0x88 and at P:0x8D) are byte instructions and only 16 bits can be written to the SCICR register, the other bytes look as if they are filled with zeros before the SCICR is overwritten.

The use of byte accesses is due to a compiler optimization that tries to generate the smallest possible memory access.

## Recommended Programming Style

The use of a union of a member that can hold the whole register (the "Word" member above) and a struct that can access the bits of the register (the "Bits" member above) is a good idea.

What is recommended is to read the whole memory mapped register (using the "Word" union member) into a local instance of the union, do the bit-manipulation on the local, and then write the result as a whole word into the memory mapped register. So the C code would look something like:

```
#define word int

union SCICR_union{
  word Word;
  struct {
    word SBK  :1;
    word RWU  :1;
    word RE   :1;
    word TE   :1;
    word REIE :1;
    word RFIE :1;
    word TIIE :1;
    word TEIE :1;
    word PT   :1;
    word PE   :1;
    word POL  :1;
    word WAKE :1;
    word M    :1;
    word RSRC :1;
    word SWAI :1;
    word LOOP :1;
  } Bits;
} SCICR;


/* Code: */

 union SCICR_union localSCICR;
 localSCICR.Word = SCICR.Word;

/* generated codes
P:00000083:F07C022C    move.w      X:#SCICR,A
P:00000085:907F        move.w      A1, X: (SP-1)
*/

 localSCICR.Bits.TE = 1;

/* generated codes
P:00000086:8AB4FFFF    adda        #-1,SP,R0
P:00000088:F0E00000    move.b      X:(R0),A
P:0000008A:83500008    bfset       #8,A1
P:0000008C:9800        move.b      A1,X: (R0)
*/

 localSCICR.Bits.PE = 1;

/* generated codes
P:0000008D:F0E00001    move.b      X: (R0+1),A
P:0000008F:83500002    bfset       #2,A1
P:00000091:9804        move.b      A1,x: (R0+1)
*/

 SCICR.Word = localSCICR.Word;

*/ generated codes
P:00000092:B67F022C    move.w      X:(SP-1),X:#SCICR
*/
```

# Generating MAC Instruction Set

The compiler generates the `imac.l` instruction if the C code performs multiplication on two long operands which are casted to short type; and the product is added to a long type. For example, the following code:

```
short a;
short b;
long c;
.....
long d = c+((long)a*(long)b);
.....
```

generates the following assembly:

```
move.w X:0x000000,Y0 ; Fa
move.w X:0x000000,B ; Fb
move.l X:0x000000,A ; Fc
imac.l B1,Y0,A
```

7

# High-Speed Simultaneous Transfer

High-Speed Simultaneous Transfer (HSST) facilitates data transfer between low-level targets (hardware or simulator) and host-side client applications. The data transfer occurs without stopping the core.

The host-side client must be an IDE plug-in or a script run through the command-line debugger.

When the customer links their application to the target side hsst lib, the debugger detects that the customer wants to use hsst and automatically enables hsst communications.

**NOTE** To use HSST, you must launch the target side application through the debugger.

## Host-Side Client Interface

This section describes the API calls for using High-Speed Simultaneous Transfer (HSST) from your host-side client application.

At the end of this section, an example of a HSST host-side program is given (Listing 7.1 on page 157).

### hsst_open

A host-side client application uses this function to open a communication channel with the low-level target. Opening a channel that has already been opened will result in the same channel ID being returned.

#### Prototype

```
HRESULT hsst_open (
     const char* channel_name,
     size_t *cid );
```

### Parameters

`channel_name`

Specifies the communication channel name.

`cid`

Specifies the channel ID associated with the communication channel.

### Returns

`S_OK` if the call succeeds or `S_FALSE` if the call fails.

## hsst_close

A host-side client application uses this function to close a communication channel with the low-level target.

### Prototype

```
HRESULT hsst_close ( size_t channel_id ) ;
```

### Parameters

`channel_id`

Specifies the channel ID of the communication channel to close.

### Returns

`S_OK` if the call succeeds or `S_FALSE` if the call fails.

## hsst_read

A host-side client application uses this function to read data sent by the target application without stopping the core.

### Prototype

```
HRESULT hsst_read  (
     void *data,
     size_t size,
     size_t nmemb,
     size_t channel_id,
     size_t *read );
```

### Parameters

`data`

Specifies the data buffer into which data is read.

`size`

Specifies the size of the individual data elements to read.

`nmemb`

Specifies the number of data elements to read.

`channel_id`

Specifies the channel ID of the communication channel from which to read.

`read`

Contains the number of data elements read.

### Returns

`S_OK` if the call succeeds or `S_FALSE` if the call fails.

## hsst_write

A host-side client application uses this function to write data that the target application can read without stopping the core.

### Prototype

```
HRESULT hsst_write (
     void *data,
     size_t size,
     size_t nmemb,
     size_t channel_id,
     size_t *written );
```

### Parameters

`data`

Specifies the data buffer that holds the data to write.

`size`

Specifies the size of the individual data elements to write.

`nmemb`

Specifies the number of data elements to write.

`channel_id`

Specifies the channel ID of the communication channel to write to.

`written`

Contains the number of data elements written.

### Returns

`S_OK` if the call succeeds or `S_FALSE` if the call fails.

## hsst_size

A host-side client application uses this function to determine the size of unread data (in bytes) in the communication channel.

### Prototype

```
HRESULT hsst_size  (
     size_t channel_id,
     size_t *unread );
```

### Parameters

`channel_id`

Specifies the channel ID of the applicable communication channel.

`unread`

Contains the size of unread data in the communication channel.

### Returns

`S_OK` if the call succeeds or `S_FALSE` if the call fails.

## hsst_block_mode

A host-side client application uses this function to set a communication channel in blocking mode. All calls to read from the specified channel block indefinitely until the requested amount of data is available. By default, a channel starts in the blocking mode.

### Prototype

```
HRESULT hsst_block_mode ( size_t channel_id );
```

### Parameters

`channel_id`

Specifies the channel ID of the communication channel to set in blocking mode.

### Returns

`S_OK` if the call succeeds or `S_FALSE` if the call fails.

## hsst_noblock_mode

A host-side client application uses this function to set a communication channel in non-blocking mode. Calls to read from the specified channel do not block for data availability.

### Prototype

```
HRESULT hsst_noblock_mode ( size_t channel_id );
```

### Parameters

`channel_id`

Specifies the channel ID of the communication channel to set in non-blocking mode.

### Returns

`S_OK` if the call succeeds or `S_FALSE` if the call fails.

## hsst_attach_listener

Use this function to attach a host-side client application as a listener to a specified communication channel. The client application receives a notification whenever data is available to read from the specified channel.

HSST notifies the client application that data is available to read from the specified channel. The client must implement this function:

```
void NotifiableHSSTClient:: Update (size_t descriptor, size_t
     size, size_t nmemb);
```

HSST calls the `Notifiable HSST Client:: Update` function when data is available to read.

### Prototype

```
HRESULT hsst_attach_listener (
    size_t cid,
    NotifiableHSSTClient *subscriber );
```

### Parameters

`cid`

Specifies the channel ID of the communication channel to listen to.

`subscriber`

Specifies the address of the variable of class `Notifiable HSST Client`.

### Returns

`S_OK` if the call succeeds or `S_FALSE` if the call fails.

## hsst_detach_listener

Use this function to detach a host-side client application that you previously attached as a listener to the specified communication channel.

### Prototype

```
HRESULT hsst_detach_listener ( size_t cid );
```

### Parameters

`cid`

Specifies the channel ID of the communication channel from which to detach a previously specified listener.

### Returns

`S_OK` if the call succeeds or `S_FALSE` if the call fails.

## hsst_set_log_dir

A host-side client application uses this function to set a log directory for the specified communication channel.

This function allows the host-side client application to use data logged from a previous High-Speed Simultaneous Transfer (HSST) session rather than reading directly from the board.

After the initial call to `hsst_set_log_dir`, the CodeWarrior software examines the specified directory for logged data associated with the relevant channel instead of communicating with the board to get the data. After all the data has been read from the file, all future reads are read from the board.

To stop reading logged data, the host-side client application calls `hsst_set_log_dir` with `NULL` as its argument. This call only affects host-side reading.

### Prototype

```
HRESULT hsst_set_log_dir (
     size_t cid,
     const char* log_directory );
```

### Parameters

`cid`

Specifies the channel ID of the communication channel from which to log data.

`log_directory`

Specifies the path to the directory in which to store temporary log files.

### Returns

`S_OK` if the call succeeds or `S_FALSE` if the call fails.

## HSST Host Program Example

In Listing 7.1 on page 157 the host is the IDE plugin (DLL) to the interface with the HSST target (DSP56800E) project. This establishes data transfer between the host (your computer) and the target (the DSP56800E board).

**NOTE** Before launching the program, the IDE plugin needs to be created and placed in the folder: `CodeWarrior\bin\Plugins\Com`.

**Listing 7.1 Sample HSST Host Program**

```
#include "CodeWarriorCommands.h"
#include "HSSTInterface.h"
#include <cstdio>
#include <cstdlib>

unsigned __stdcall HSSTClientMain ( void *pArguments );

#define buf_size  1000                                          /* Data
size */
```

```
/* Assigning name for Plugin and Menu Title */
extern const CWPluginID kToolbarTestPluginID =      "HSST_host_sample";
extern const wchar_t* MenuTitle = L"HSST_host_sample";


unsigned __stdcall HSSTClientMain ( void *pArguments )
{
         IMWHSST_Client *pHSST = (IMWHSST_Client *)pArguments;

         long data[buf_size];
         size_t channel_1, channel_2, read_items, written_items;


         * Opening channel 1 and 2 from HOST side */
         HRESULT hr_1 = pHSST->hsst_open ( "channel_1",
           &channel_1 );
         HRESULT hr_2 = pHSST->hsst_open ( "channel_2",
           &channel_2 );


         /* HOST reading data from channel 1 */
     pHSST->hsst_read ( data, sizeof(long), buf_size, channel_1,
       &read_items );

     /* HOST writing data to channel 2 */
     pHSST->hsst_write( data, sizeof(long), buf_size, channel_2,
       &written_items );

     return 0;
}
```

# Target Library Interface

This section describes the API calls for using High-Speed Simultaneous Transfer (HSST) from your target application.

At the end of this section, an example of a HSST target program is given (Listing 7.2 on page 165).

## HSST_open

A target application uses this function to open a bidirectional communication channel with the host. The default setting is for the function to open an output channel in buffered mode. Opening a channel that has already been opened will result in the same channel ID being returned.

### Prototype

```
HSST_STREAM*  HSST_open  ( const char *stream );
```

### Parameters

`stream`

Passes the communication channel name.

### Returns

The stream associated with the opened channel.

## HSST_close

A target application uses this function to close a communication channel with the host.

### Prototype

```
int    HSST_close ( HSST_STREAM *stream );
```

### Parameters

`stream`

Passes a pointer to the communication channel.

### Returns

`0` if the call was successful or `-1` if the call was unsuccessful.

## HSST_setvbuf

A target application can use this function to perform the following actions:

- Set an open channel opened in write mode to use buffered mode

**NOTE** This can greatly improve performance.

- Resize the buffer in an existing buffered channel opened in write mode
- Provide an external buffer for an existing channel opened in write mode
- Reset buffering to unbuffered mode

You can use this function only after you successfully open the channel.

The contents of a buffer (either internal or external) at any time are indeterminate.

## Prototype

```
int    HSST_setvbuf (
     HSST_STREAM *rs,
     unsigned char *buf,
     int mode,
     size_t size );
```

## Parameters

`rs`

Specifies a pointer to the communication channel.

`buf`

Passes a pointer to an external buffer.

`mode`

Passes the buffering mode as either buffered (specified as `HSSTFBUF`) or unbuffered (specified as `HSSTNBUF`).

`size`

Passes the size of the buffer.

## Returns

`0` if the call was successful or `-1` if the call was unsuccessful.

**NOTE** You must flush the buffers before exiting the program to ensure that all the data that has been written is sent to the host. For more details, see HSST_flush on page 162.

## HSST_write

A target application uses this function to write data for the host-side client application to read.

### Prototype

```
size_t   HSST_write (
     void *data,
     size_t size,
     size_t nmemb,
     HSST_STREAM *stream );
```

### Parameters

`data`

Passes a pointer to the data buffer holding the data to write.

`size`

Passes the size of the individual data elements to write.

`nmemb`

Passes the number of data elements to write.

`stream`

Passes a pointer to the communication channel.

### Returns

The number of data elements written.

## HSST_read

A target application uses this function to read data sent by the host.

### Prototype

```
size_t   HSST_read  (
     void *data,
     size_t size,
     size_t nmemb,
     HSST_STREAM *stream );
```

### Parameters

`data`

Passes a pointer to the data buffer into which to read the data.

`size`

Passes the size of the individual data elements to read.

`nmemb`

Passes the number of data elements to read.

`stream`

Passes a pointer to the communication channel.

### Returns

The number of data elements read.

## HSST_flush

A target application uses this function to flush out data buffered in a buffered output channel.

### Prototype

```
int HSST_flush ( HSST_STREAM *stream );
```

### Parameters

`stream`

Passes a pointer to the communication channel. The High-Speed Simultaneous Transfer (HSST) feature flushes all open buffered communication channels if this parameter is null.

### Returns

`0` if the call was successful or `-1` if the call was unsuccessful.

## HSST_size

A target application uses this function to determine the size of unread data (in bytes) for the specified communication channel.

### Prototype

```
size_t HSST_size ( HSST_STREAM *stream );
```

### Parameters

`stream`

Passes a pointer to the communication channel.

### Returns

The number of bytes of unread data.

## HSST_raw_read

A target application uses this function to read raw data from a communication channel (without any automatic conversion for endianness while communicating).

### Prototype

```
size_t    HSST_raw_read  (
     void *ptr,
     size_t length,
     HSST_STREAM *rs );
```

### Parameters

`ptr`

Specifies the pointer that points to the buffer into which data is read.

`length`

Specifies the size of the buffer in bytes.

`rs`

Specifies a pointer to the communication channel.

### Returns

The number of bytes of raw data read.

**NOTE** This function is useful for sending data structures (e.g., C-type structures).

## HSST_raw_write

A target application uses this function to write raw data to a communication channel (without any automatic conversion for endianness while communicating).

### Prototype

```
size_t    HSST_raw_write (
     void *ptr,
     size_t length,
     HSST_STREAM *rs );
```

### Parameters

`ptr`

Specifies the pointer that points to the buffer that holds the data to write.

`length`

Specifies the size of the buffer in bytes.

`rs`

Specifies a pointer to the communication channel.

### Returns

The number of data elements written.

**NOTE** This function is useful for sending data structures (e.g., C-type structures).

## HSST_set_log_dir

A target application uses this function to set the host-side directory for storing temporary log files. Old logs that existed prior to the call to `HSST_set_log_dir()` are overwritten. Logging stops when the channel is closed or when `HSST_set_log_dir()` is called with a null argument. These logs can be used by the host-side function `HSST_set_log_dir`.

### Prototype

```
int    HSST_set_log_dir (
     HSST_STREAM *stream,
     char *dir_name );
```

### Parameters

`stream`

Passes a pointer to the communication channel.

`dir_name`

Passes a pointer to the path to the directory in which to store temporary log files.

### Returns

`0` if the call was successful or `-1` if the call was unsuccessful.

## HSST Target Program Example

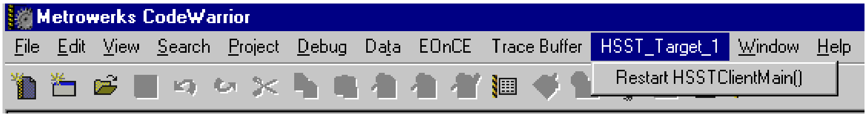
In Listing 7.2 on page 165 the HSST target program runs in parallel with the host plugin. The target communicates with the host-side (your computer).

**NOTE** To restart the program after execution, click on **Restart HSST** as shown in Figure 7.1 on page 166.

**Listing 7.2 Sample HSST Target Program**

```
#include <stdio.h>
#include <stdlib.h>
#include "HSST.h"


#define buf_size  1000     /* Data size */

long i, test_buffer[buf_size];

int main ( )
{
    HSST_STREAM *channel_1, *channel_2;
    int written_items=0;
    int read_items=0;

    for ( i = 0; i < buf_size; ++ i )
    {
         test_buffer[i] = i;
    }


    /* Opening channel 1 and 2 from TARGET side */
    channel_1 = HSST_open ( "channel_1" );
    channel_2 = HSST_open ( "channel_2" );
    /* TARGET writing data to channel 1 */
    written_items = HSST_write(test_buffer, sizeof(long),
        buf_size, channel_1);

    /* TARGET reading data from channel 2 */
    read_items = HSST_read(test_buffer, sizeof(long), buf_size,
        channel_2);

    return 0;
}
```

**Figure 7.1 Restart HSST**


Metrowerks CodeWarrior
File Edit View Search Project Debug Data EOnCE Trace Buffer HSST_Target_1 Window Help
Restart HSSTClientMain()

**NOTE** For an HSST example, see the HSST example in this path: `{CodeWarrior path}(CodeWarrior_Examples)\DSP56800E_hsst_client-to-client`

# 8

# Data Visualization

Data visualization lets you graph variables, registers, regions of memory, and HSST data streams as they change over time.

The Data Visualization tools can plot memory data, register data, global variable data, and HSST data.

- Starting Data Visualization on page 167
- Data Target Dialog Boxes on page 168
- Graph Window Properties on page 172

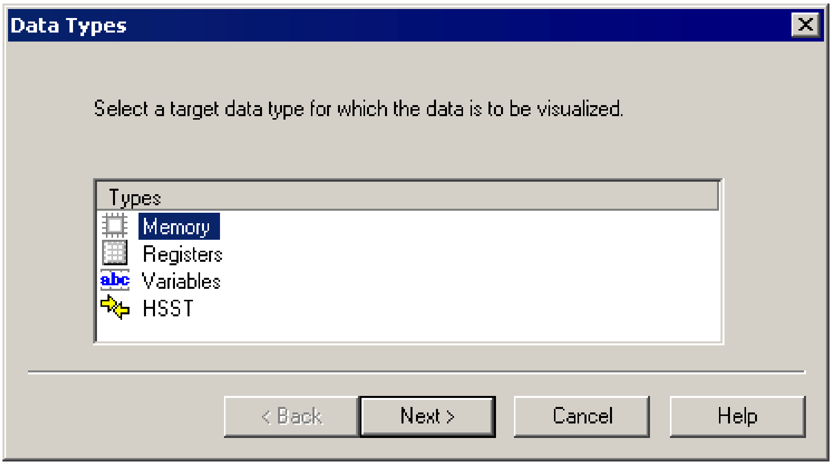
## Starting Data Visualization

To start the Data Visualization tool:

1. Start a debug session
2. Select Data Visualization > Configurator.

   The Data Types window (Figure 8.1 on page 167) appears. Select a data target type and click the Next button.

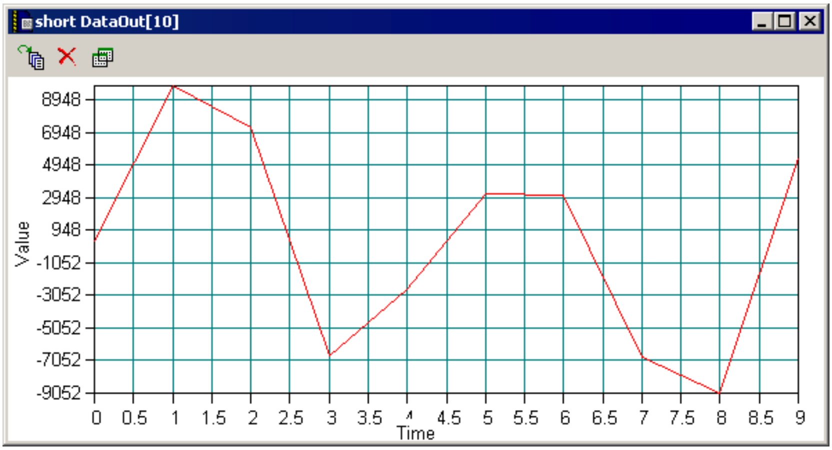
**Figure 8.1 Data Types Window**



Select a target data type for which the data is to be visualized.

3. Configure the data target dialog box and filter dialog box.
4. Run your program to display the data (Figure 8.2 on page 168).

**Figure 8.2 Graph Window**



# Data Target Dialog Boxes

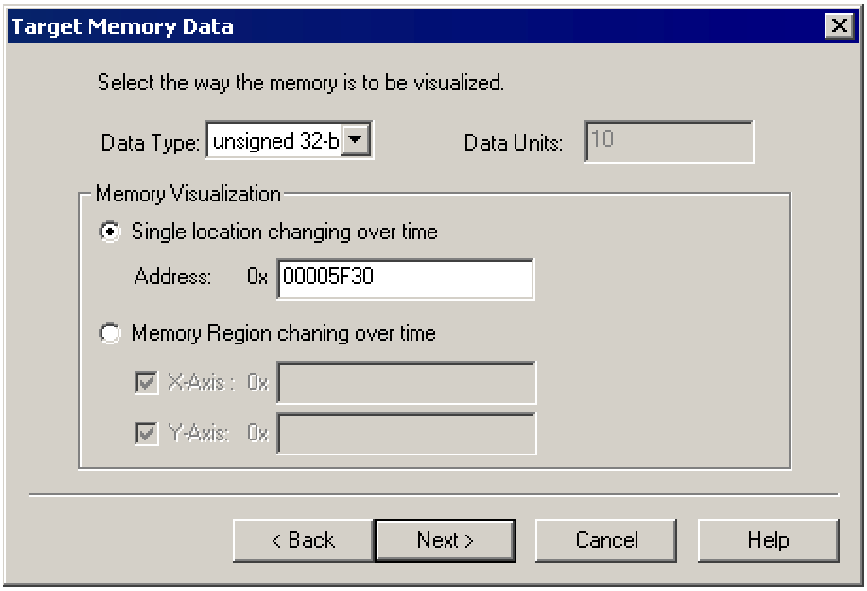
There are four possible data targets. Each target has its own configuration dialog.

- Memory on page 168
- Registers on page 170
- Variables on page 170
- HSST on page 171

## Memory

The Target Memory dialog box lets you graph memory contents in real-time.

Figure 8.3 Target Memory Dialog Box



Select the way the memory is to be visualized.

Data Type: unsigned 32-b

Data Units: 10

Memory Visualization

● Single location changing over time

Address: 0x 00005F30

○ Memory Region chaning over time

☑ X-Axis : 0x

☑ Y-Axis: 0x

## Data Type

The Data Type list box lets you select the type of data to be plotted.

## Data Unit

The Data Units text field lets you enter a value for number of data units to be plotted. This option is only available when you select Memory Region Changing Over Time.

## Single Location Changing Over Time

The Single Location Changing Over Time option lets you graph the value of a single memory address. Enter this memory address in the Address text field.

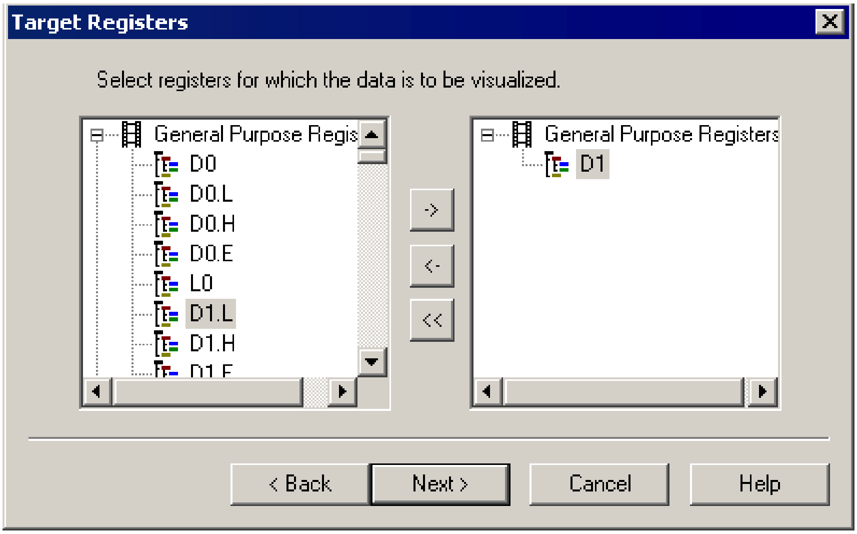
## Memory Region Changing Over Time

The Memory Region Changing Over Time options lets you graph the values of a memory region. Enter the memory addresses for the region in the X-Axis and Y-Axis text fields.

# Registers

The Target Registers dialog box lets you graph the value of registers in real-time.

**Figure 8.4 Target Registers Dialog Box**



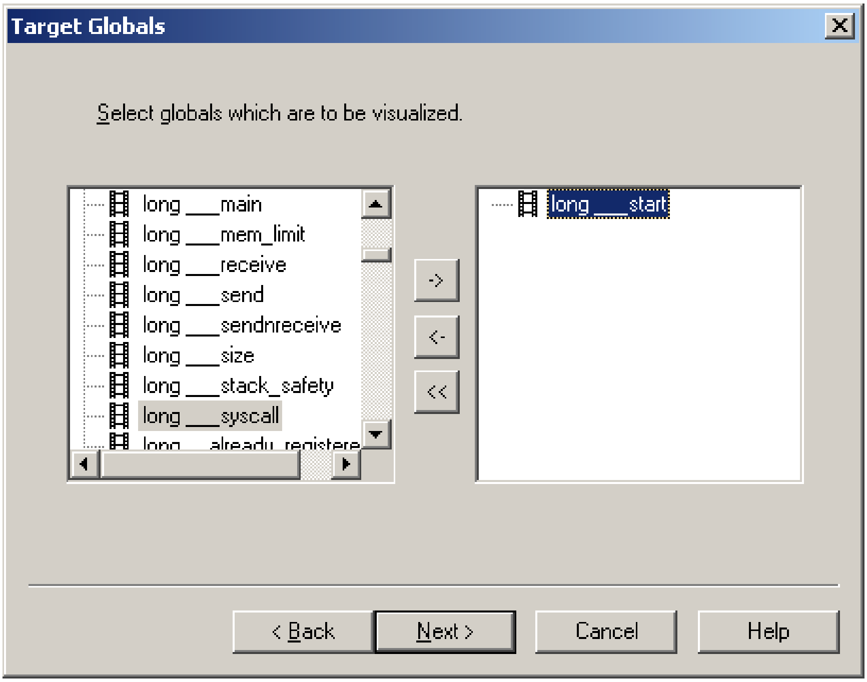
Select registers for which the data is to be visualized.

Select registers from the left column, and click the -> button to add them to the list of registers to be plotted.

# Variables

The Target Globals dialog box lets you graph the value of global variables in real-time. (See Figure 8.5 on page 171.)

**Figure 8.5 Target Globals Dialog Box**



Select globals which are to be visualized.

```
long __main
long __mem_limit
long __receive
long __send
long __sendnreceive
long __size
long __stack_safety
long __syscall
long __already_registere
```

```
long __start
```

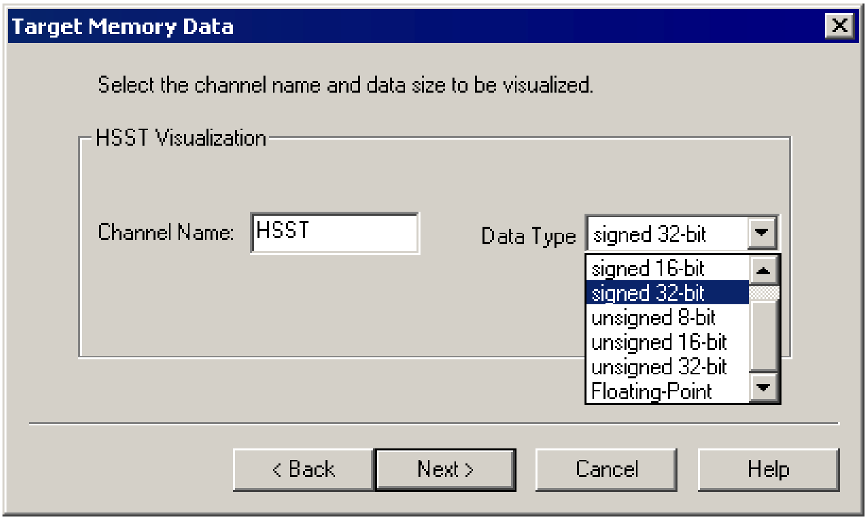
Select global variables from the left column, and click the -> button to add them to the list of variables to be plotted.

# HSST

The Target HSST dialog box lets you graph the value of an HSST stream in real-time. (See Figure 8.6 on page 172.)

**NOTE** To plot HSST data, the data visualization tool needs its own HSST channel. Make sure your program opens a separate channel exclusively for the data visualization window. This will avoid impacting data transmissions on other channels.

**Figure 8.6  Target HSST Dialog Box**



Target Memory Data

Select the channel name and data size to be visualized.

HSST Visualization

Channel Name: HSST

Data Type: signed 32-bit

## Channel Name

The Channel Name text field lets you specify the name of the HSST stream to be plotted.

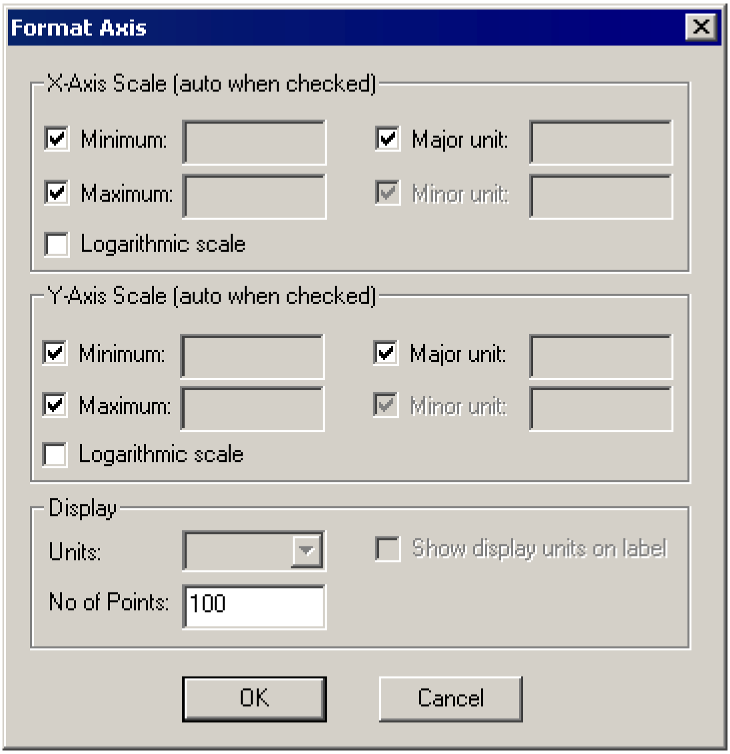
## Data Type

The Data Type list box lets you select the type of data to be plotted.

# Graph Window Properties

To change the look of the graph window, click the graph properties button to open the Format Axis dialog box.

**Figure 8.7 Format Axis Dialog Box**



X-Axis Scale (auto when checked)

☑ Minimum:

☑ Maximum:

☑ Major unit:

☑ Minor unit:

□ Logarithmic scale

Y-Axis Scale (auto when checked)

☑ Minimum:

☑ Maximum:

☑ Major unit:

☑ Minor unit:

□ Logarithmic scale

Display

Units:

□ Show display units on label

No of Points: 100

## Scaling

The default scaling settings of the data visualization tools automatically scale the graph window to fit the existing data points.

To override the automatic scaling, uncheck a scaling checkbox to enable the text field and enter your own value.

To scale either axis logarithmically, enable the Logarithmic Scale option of the corresponding axis.

## Display

The Display settings let you change the maximum number of data points that are plotted on the graph.

**NOTE** For a data visualization example that uses HSST, see the data visualization example in this path:
`{CodeWarrior path}(CodeWarrior_Examples)\hsst_Data_Visualization`

# 9

# Debugging for DSP56800E

This chapter, which explains the generic features of the CodeWarrior™ debugger, consists of these sections:

## Using Remote Connections

Remote connections are settings that describe how the CodeWarrior IDE should connect to and control program execution on target boards or systems, such as the debugger protocol, connection type, and connection parameters the IDE should use when it connects to the target system. This section shows you how to access remote connections in the CodeWarrior IDE, and describes the various debugger protocols and connection types the IDE supports.

**NOTE** We have included several types of remote connections in the default CodeWarrior installation. You can modify these default remote connections to suit your particular needs.

**NOTE** When you import a Makefile into the CodeWarrior IDE to create a CodeWarrior project, the IDE asks you to specify the type of debugger interface (remote connection) you want to use. To debug the generated CodeWarrior project, you must properly configure the remote connection you selected when you created the project.

# Accessing Remote Connections

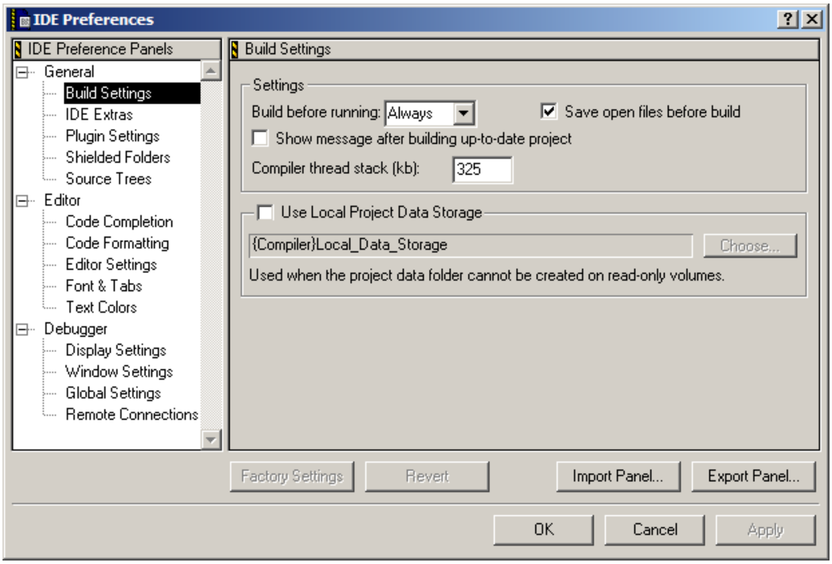
You access remote connections in the CodeWarrior **IDE Preferences** window. Remote connections listed in the preferences window are available for use in all CodeWarrior projects and build targets.

To access remote connections:

1. From the CodeWarrior menu bar, select **Edit > Preferences**.

   The **IDE Preferences** window (Figure 9.1 on page 176) appears.

**Figure 9.1 IDE Preferences Window**



Build before running: Always

☑ Save open files before build

□ Show message after building up-to-date project

Compiler thread stack (kb): 325

□ Use Local Project Data Storage

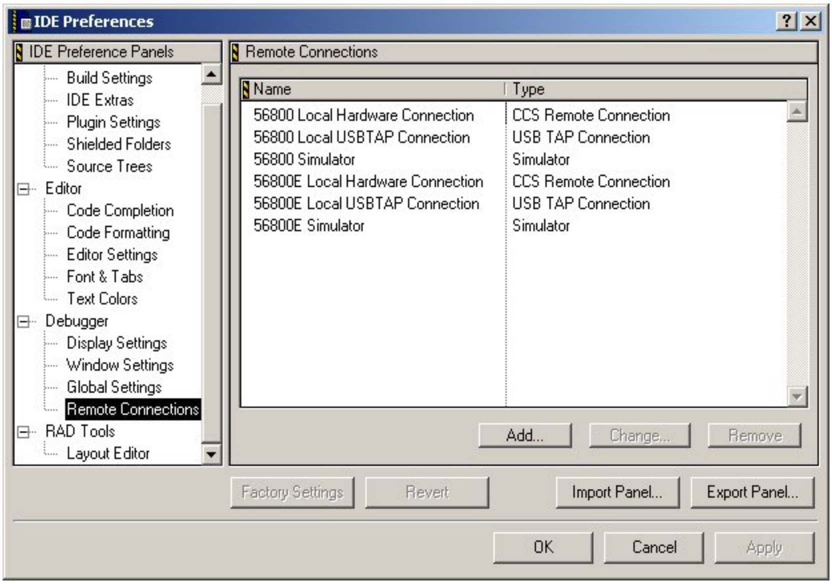
{Compiler}Local_Data_Storage

Used when the project data folder cannot be created on read-only volumes.

2. In the **IDE Preference Panels** list, select **Remote Connections**.

   The **Remote Connections** preference panel (Figure 9.2 on page 177) appears**.**

**Figure 9.2 Remote Connections Preference Panel**



| Name | Type |
|---|---|
| 56800 Local Hardware Connection | CCS Remote Connection |
| 56800 Local USBTAP Connection | USB TAP Connection |
| 56800 Simulator | Simulator |
| 56800E Local Hardware Connection | CCS Remote Connection |
| 56800E Local USBTAP Connection | USB TAP Connection |
| 56800E Simulator | Simulator |

**NOTE** The specific remote connections that appear in the Remote Connections list differ between CodeWarrior products and hosts.

The **Remote Connections** preference panel lists all of the remote connections of which the CodeWarrior IDE is aware. You use this preference panel to add your own remote connections, remove remote connections, and configure existing remote connections to suit your needs.

To add a new remote connection, click **Add**.

To configure an existing remote connection, select it and click **Change**.

To remove an existing remote connection, select it and click **Remove**.

**NOTE** To specify a remote connection for a particular build target in a CodeWarrior project, you select the remote connection from the **Connection** list box in the **Remote Debugging** target settings panel. For an overview of the **Remote Debugging** settings panel, see the *CodeWarrior IDE User’s Guide*.

# Understanding Remote Connections

Every remote connection specifies a debugger protocol and a connection type.

A *debugger protocol* is the protocol the IDE uses to debug the target system. This setting generally relates specifically to the particular device you use to physically connect to the target system.

A *connection type* is the type of connection (such as CCS, USBTAP, or Simulator) the CodeWarrior IDE uses to communicate with and control the target system.

Table 9.1 on page 178 describes each of the supported debugger protocols.

**Table 9.1 Debugger Protocols**

| Debugger Protocol | Description |
|---|---|
| CCS 56800E Protocol Plugin | Select to use a CCS hardware target system. |
| 56800E Simulator | Select to use the Simulator on the host computer. |

Each of these protocols supports one or more types of connections (CCS, USBTAP, and Simulator). “Editing Remote Connections” on page 178 describes each supported connection type and how to configure them.

# Editing Remote Connections

Based on the specified debugger protocol and connection type, the IDE makes different settings available to you. For example, if you specify a Serial connection type, the IDE presents settings for baud rate, stop bits, flow control, and so on. Table 9.2 on page 178 describes the supported connection types for each debugger protocol.

**Table 9.2 Supported Connection Types**

| Debugger Protocol | Supported Connection Types |
|---|---|
| CCS 56800E Protocol Plugin | CCS Remote Connection on page 179, USBTAP on page 181 |
| 56800E Simulator | on page 183Simulator on page 183 |

To configure a remote connection to correspond to your particular setup, you must edit the connection settings. You access the settings with the **Edit Connection** dialog box. You can view this dialog box in one of these ways:

- In the **Remote Connections** IDE preference panel, select a connection from the list, and click **Edit**. The **Edit Connection** dialog box appears.
- In the **Remote Connections** IDE preference panel, click **Add** to create a new remote connection. The **New Connection** dialog box appears.

- In the **Remote Debugging** target settings panel, select a connection from the **Connection** list box, then click the **Edit Connection** button. The **Edit Connection** dialog box appears.

This section describes the settings for each connection type:

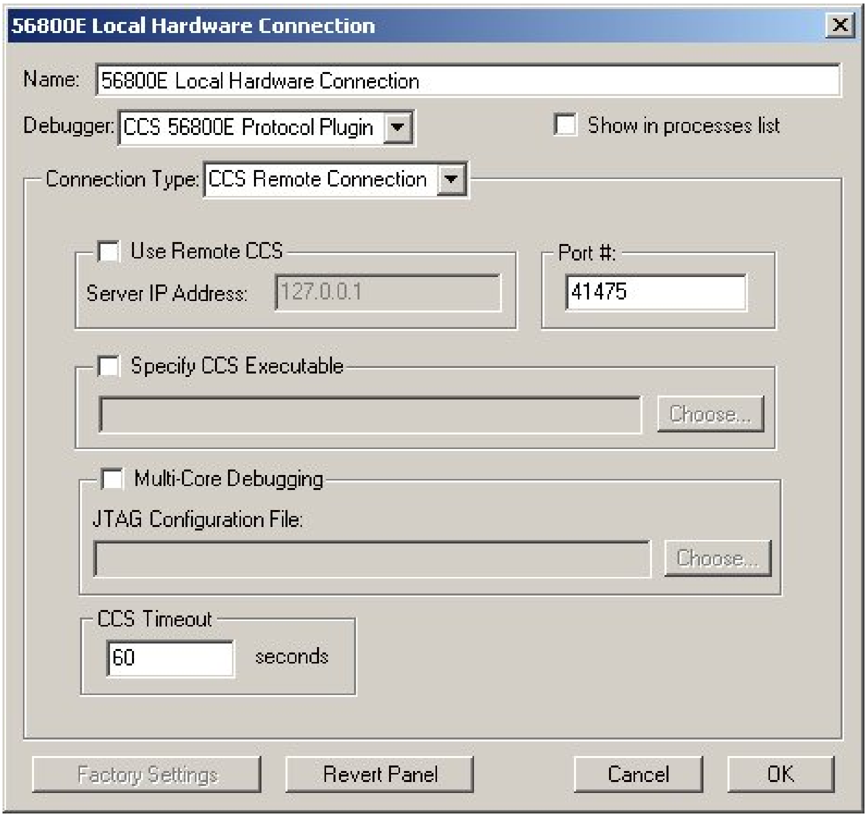
- CCS Remote Connection on page 179
- USBTAP on page 181
- Simulator on page 183

## CCS Remote Connection

Use this connection type to configure how the IDE uses the Command Converter Server (CCS) protocol to connect with the target system. This connection type is available only when the **CCS 56800E Protocol Plugin** debugger protocol is selected.

Figure 9.3 on page 180 shows the settings that are available to you when you select **CCS Remote Connection** from the **Connection Type** list box in the **Edit Connection** dialog box.

**Figure 9.3  CCS Remote Connection Settings**



56800E Local Hardware Connection

Name: 56800E Local Hardware Connection

Debugger: CCS 56800E Protocol Plugin

□ Show in processes list

Connection Type: CCS Remote Connection

□ Use Remote CCS

Server IP Address: 127.0.0.1

Port #: 41475

□ Specify CCS Executable

□ Multi-Core Debugging

JTAG Configuration File:

CCS Timeout: 60 seconds

Table 9.3 on page 180 describes the options in this dialog box.

**Table 9.3  CCS Remote Connection Options**

| Option | Description |
|---|---|
| Name | Enter the name you want to use to refer to this remote connection within the CodeWarrior IDE. |
| Debugger | Select **CCS 56800E Protocol Plugin**. |
| Connection Type | Select **CCS Remote Connection**. |
| Use Remote CCS | Check to debug code on a target system when the system already has CCS running and connected. |

Table 9.3  CCS Remote Connection Options (*continued*)

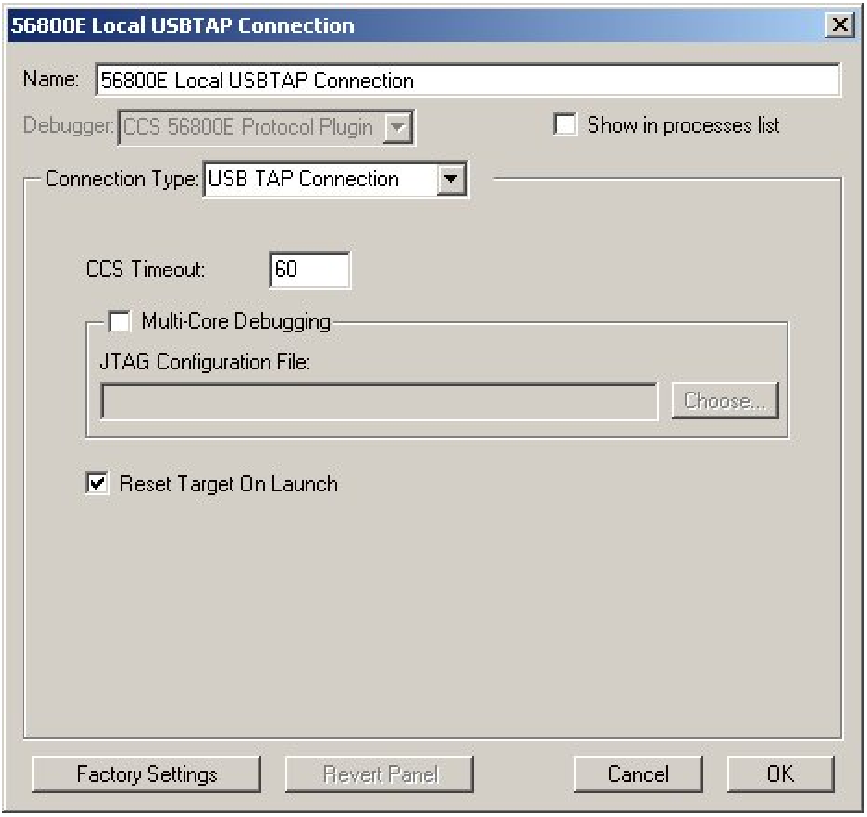
| Option | Description |
|---|---|
| Server IP Address | Enter the Internet Protocol (IP) address assigned to the target system. |
| Port # | Enter the port number on the target system to which the IDE should connect for CCS operations. The default port number for CCS hardware connections is 41475. Enter 41476 for the CCS Simulator. |
| Specify CCS Executable | Check to use another CCS executable file rather than the default CCS executable file:<br>`CWInstall\ccs\bin\ccs.exe` |
| Multi-Core Debugging | Check to debug code on a target system with multiple cores where you need to specify the JTAG chain for debugging. Click **Choose** to specify the JTAG initialization file. A JTAG initialization file contains the names and order of the boards / cores you want to debug.<br>Note: this option has no effect for the 56800E Digital Signal Controller. |
| CCS Timeout | Enter the duration (in seconds) after which the CCS should attempt to reconnect to the target system if a connection attempt fails. |

## USBTAP

Use this connection type to configure how the IDE uses CodeWarrior USB TAP device to connect with the target system. This connection type is available only when the **CCS 56800E Protocol Plugin** debugger protocol is selected.

Figure 9.4 on page 182 shows the settings that are available to you when you select **USBTAP** from the **Connection Type** list box in the **Edit Connection** dialog box.

### Figure 9.4 USBTAP Connection Settings



56800E Local USBTAP Connection

Name: 56800E Local USBTAP Connection

Debugger: CCS 56800E Protocol Plugin

□ Show in processes list

Connection Type: USB TAP Connection

CCS Timeout: 60

□ Multi-Core Debugging

JTAG Configuration File:

☑ Reset Target On Launch

Table 9.4 on page 182 describes the options in this dialog box.

### Table 9.4 UBTAP Options

| Option | Description |
|---|---|
| Name | Enter the name you want to use to refer to this remote connection within the CodeWarrior IDE. |
| Debugger | Select **CCS 56800E Protocol Plugin**. |
| Connection Type | Select **USBTAP Connection**. |

**Table 9.4 UBTAP Options (*continued*)**

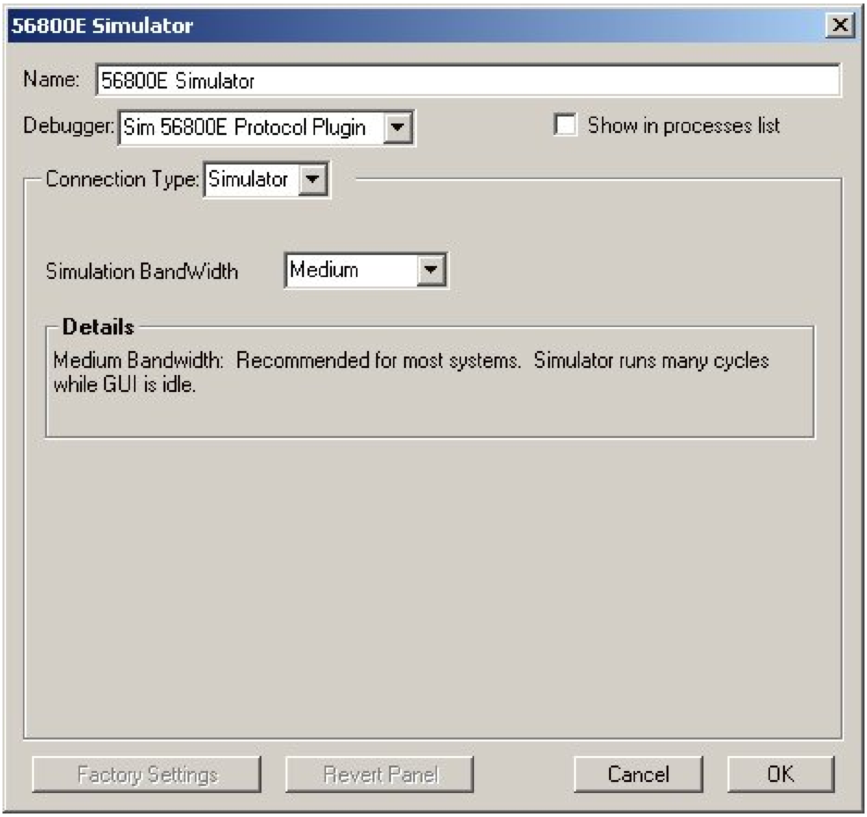
| Option | Description |
|---|---|
| CCS Timeout | Enter the maximum number of seconds the debugger should wait for a response from CCS. By default, the debugger waits up to 10 seconds for responses. |
| Multi-Core Debugging | Check to debug code on a target system with multiple cores where you need to specify the JTAG chain for debugging. Click **Choose** to specify the JTAG initialization file. A JTAG initialization file contains the names and order of the boards / cores you want to debug.<br>Note: this option has no effect for the 56800E Digital Signal Controller. |
| Reset Target on Launch | Check to have the debugger send a reset signal to the target system when you start debugging.<br>Clear to prevent the debugger from resetting the target device when you start debugging. |

## Simulator

Use this connection type to configure the behavior of the simulator. This connection type is available only when the **56800E Simulator Protocol Plugin** debugger protocol is selected.

Figure 9.5 on page 184 shows the setting that are available to you when you select **Simulator** from the **Connection Type** list box in the **Edit Connection** dialog box.

**Figure 9.5 Simulator Connection Settings**



Name: 56800E Simulator

Debugger: Sim 56800E Protocol Plugin

□ Show in processes list

Connection Type: Simulator

Simulation BandWidth Medium

**Details**

Medium Bandwidth: Recommended for most systems. Simulator runs many cycles while GUI is idle.

Table 9.5 on page 184 describes the options in this dialog box.

**Table 9.5 Simulator Options**

| Option | Description |
|---|---|
| Name | Enter the name you want to use to refer to this remote connection within the CodeWarrior IDE. |
| Debugger | Select **SIM 56800E Protocol Plugin**. |
| Connection Type | Select **Simulator**. |
| Simulation Bandwidth | Select the simulator bandwidth (**low**, **medium**, or **high**). |

# Target Settings for Debugging

**Table 9.6 Target Settings for Debugging**

| Option | Description |
|---|---|
| Name | Enter the name you want to use to refer to this remote connection within the CodeWarrior IDE. |
| Debugger | Select **CCS 56800E Protocol Plugin**. |
| Connection Type | Select **USBTAP**. |
| Use default serial number | Check if you only have one USB TAP device connected to the host computer.<br>Clear if you have more than one USB TAP device connected to the host computer. When this checkbox is checked, the **USB TAP Serial Number** text box is available. |
| USB TAP Serial Number | If you have more than one USB TAP connected to the host computer, enter the serial number of the USB TAP you want to use for debugging.<br>**Note:** The USB TAP serial number is located on a label on the bottom of the device. |
| CCS Timeout | Enter the maximum number of seconds the debugger should wait for a response from CCS. By default, the debugger waits up to 10 seconds for responses. |
| Interface Clock Frequency | Select the clock frequency for the Ethernet TAP device. We recommended you set this to **4 MHz**. |
| Mem Read Delay | Enter the number of additional processor cycles (in the range: 0 through 65024) the debugger should insert as a delay for completion of memory read operations. By default, the debugger delays for 350 cycles. |
| Mem Write Delay | Enter the number of additional processor cycles (in the range: 0 through 65024) the debugger should insert as a delay for completion of memory write operations. By default, the debugger does not delay. |
| Reset Target on Launch | Check to have the debugger send a reset signal to the target system when you start debugging.<br>Clear to prevent the debugger from resetting the target device when you start debugging. |

**Table 9.6 Target Settings for Debugging (*continued*)**

| Option | Description |
|---|---|
| Force Shell Download | Check to have the debugger start the Ethernet TAP shell when you start debugging.<br>Clear to prevent the debugger from starting the Ethernet TAP shell when you start debugging. |
| Do not use fast download | Check to have the debugger use a standard (slow) procedure to write to memory on the target system.<br>Clear to have the debugger use an optimized (fast) download procedure to write to memory on the target system. |
| Enable Logging | Check to have the IDE display a log of all debugger transactions during the debug session. If this checkbox is checked, a protocol logging window appears when you connect the debugger to the target system.<br>**Note:** If you set the `AMCTAP_LOG_FILE` environment variable, the IDE directs log messages to the specified file. |

This section explains how to control the debugger by modifying the appropriate settings panels.

To properly debug DSP56800E software, you must set certain preferences in the **Target Settings** window. The **M56800E Target** panel is specific to DSP56800E development. The remaining settings panels are generic to all build targets.

Other settings panels can affect debugging. Table 9.7 on page 186 lists these panels.

**Table 9.7 Setting Panels that Affect Debugging**

| This panel… | Affects… | Refer to… |
|---|---|---|
| M56800E Linker | symbolics, linker warnings | “Deadstripping and Link Order” on page 145 |
| M56800E Processor | optimizations | “Optimizing Code” on page 144 |
| Debugger Settings | Debugging options | |

**Table 9.7 Setting Panels that Affect Debugging (*continued*)**

| This panel… | Affects… | Refer to… |
|---|---|---|
| Remote Debugging | Debugging communication protocol | "Remote Debugging" on page 76 |
| Remote Debug Options | Debugging options | "Remote Debug Options" on page 82 |

The **M56800E Target** panel is unique to DSP56800E debugging. The available options in this panel depend on the DSP56800E hardware you are using and are described in detail in the section on "Remote Debug Options" on page 82.

# Command Converter Server

The command converter server (CCS) handles communication between the CodeWarrior debugger and the target board. An icon in the status bar indicates the CCS is running. The CCS is automatically launched by your project when you start a CCS debug session if you are debugging a target board using a local machine. However, when debugging a target board connected to a remote machine, see "Setting Up a Remote Connection."

**NOTE** Projects are set to debug locally by default. The protocol the debugger uses to communicate with the target board, for example, PCI, is determined by how you installed the CodeWarrior software. To modify the protocol, make changes in the **Freescale Command Converter Server** window ().

## Essential Target Settings for Command Converter Server

Before you can download programs to a target board for debugging, you must specify the target settings for the command converter server:

- Local Settings

  If you specify that the CodeWarrior IDE start the command converter server locally, the command converter server uses the connection port (for example, LPT1) that you specified when you installed CodeWarrior Development Studio for Freescale 56800/E Digital Signal Controllers.

- Remote Settings

If you specify that the CodeWarrior IDE start the command converter server on a remote machine, specify the IP address of the remote machine on your network (as described in “Setting Up a Remote Connection.”)

- Default Settings

  By default, the command converter server listens on port 41475. You can specify a different port number for the debugger to connect to if needed (as described in “Setting Up a Remote Connection.”) This is necessary if the CCS is configured to a port other than 41475.

After you have specified the correct settings for the command converter server (or verified that the default settings are correct), you can download programs to a target board for debugging.

The CodeWarrior IDE starts the command converter server at the appropriate time if you are debugging on a local target.

Before debugging on a board connected to a remote machine, ensure the following:

- The command converter server is running on the remote host machine.
- Nobody is debugging the board connected to the remote host machine.

# Changing the Command Converter Server Protocol to Parallel Port

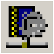
If you specified the wrong parallel port for the command converter server when you installed CodeWarrior Development Studio for Freescale 56800/E Digital Signal Controllers, you can change the port.

Change the parallel port:

1. Click the command converter server icon.

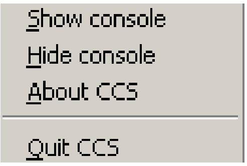
   While the command converter server is running, locate the command converter server icon on the status bar. Right-click on the command converter server icon (Figure 9.6 on page 188):

**Figure 9.6 Command Converter Server Icon**



A menu appears (Figure 9.7 on page 189):

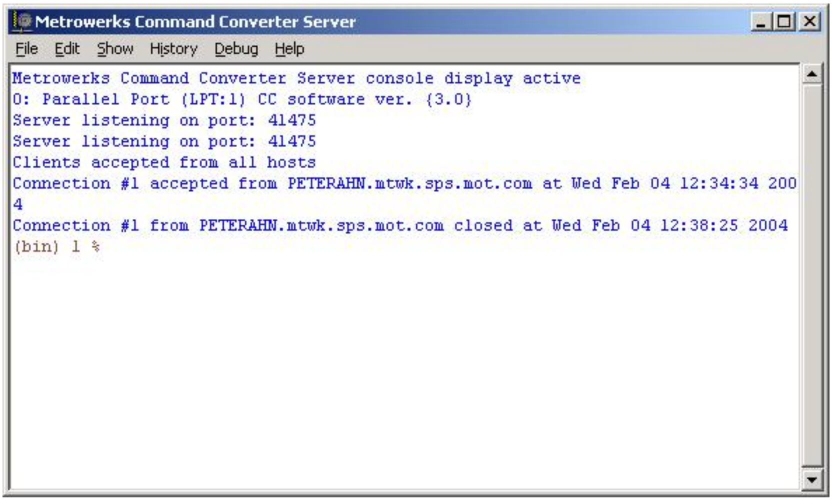
**Figure 9.7 Command Converter Server Menu**



2. Select Show console from the menu.

   The **Freescale Command Converter Server** window appears ().

**Figure 9.8 Command Converter Server Window**


Metrowerks Command Converter Server
File Edit Show History Debug Help

```
Metrowerks Command Converter Server console display active
0: Parallel Port (LPT:1) CC software ver. {3.0}
Server listening on port: 41475
Server listening on port: 41475
Clients accepted from all hosts
Connection #1 accepted from PETERAHN.mtwk.sps.mot.com at Wed Feb 04 12:34:34 200
4
Connection #1 from PETERAHN.mtwk.sps.mot.com closed at Wed Feb 04 12:38:25 2004
(bin) 1 %
```

3. On the console command line, type the following command:

   ```
   delete all
   ```

4. Press Enter.
5. Type the following command, substituting the number of the parallel port to use (for example, 1 for LPT1):

   ```
   config cc parallel:1
   ```

6. Press Enter.
7. Type the following command to save the configuration:

   ```
   config save
   ```

8. Press Enter.

# Changing the Command Converter Server Protocol to HTI

To change the command converter server to an HTI Connection:

1. While the command converter server is running, right-click on the command converter server icon shown in Figure 9.6 on page 188 or double click on it.
2. From the menu shown in Figure 9.7 on page 189, select Show Console.
3. At the console command line in the Freescale Command Converter Server window, type the following command:

   ```
   delete all
   ```

4. Press Enter.
5. Type the following command:

   ```
   config cc: address
   ```

   (substituting for **`address`** the name of the IP address of your CodeWarrior HTI)

**NOTE** If the software rejects this command, your CodeWarrior HTI may be an earlier version. Try instead the command: `config cc nhti:address`, or the command: `config cc Panther:address`, substituting for **`address`** the IP address of the HTI.

6. Press Enter.
7. Type the following command to save the configuration:

   ```
   config save
   ```

8. Press Enter.

# Changing the Command Converter Server Protocol to PCI

To change the command converter server to a PCI Connection:

1. While the command converter server is running, right-click on the command converter server icon shown in Figure 9.6 on page 188 or double click on it.
2. From the menu shown in Figure 9.7 on page 189, select Show Console.
3. At the console command line in the Freescale Command Converter Server window, type the following command:

   ```
   delete all
   ```

4. Press Enter.

5. Type the following command:

   ```
   config cc pci
   ```

6. Press Enter.
7. Type the following command to save the configuration:

   ```
   config save
   ```

8. Press Enter.

# Setting Up a Remote Connection

A remote connection is a type of connection to use for debugging along with any preferences that connection may need. To change the preferences for a remote connection or to create a new remote connection:

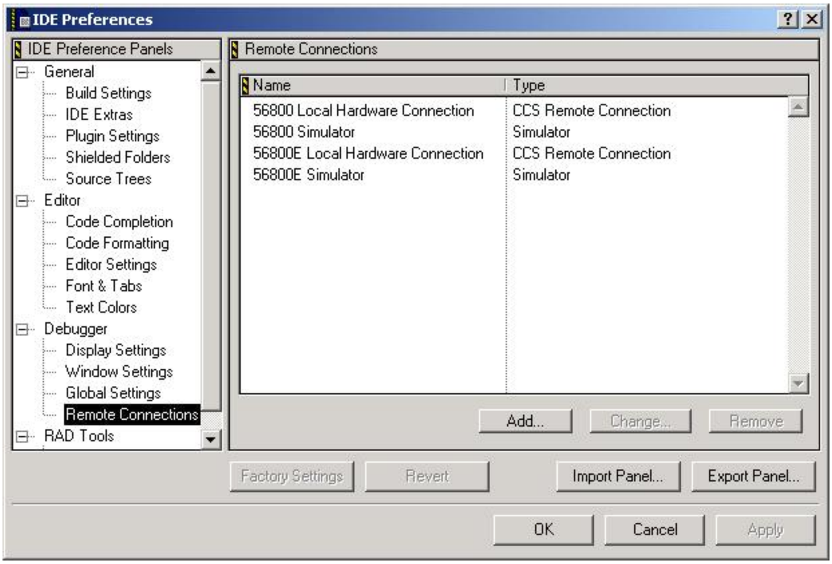
1. On the main menu, select Edit > Preferences.

   The IDE Preferences Window appears.

2. Click Remote Connections in the left column.

   The **Remote Connections** panel shown in Figure 9.9 on page 191 appears.

**Figure 9.9 Remote Connections Panel**



| Name | Type |
|---|---|
| 56800 Local Hardware Connection | CCS Remote Connection |
| 56800 Simulator | Simulator |
| 56800E Local Hardware Connection | CCS Remote Connection |
| 56800E Simulator | Simulator |

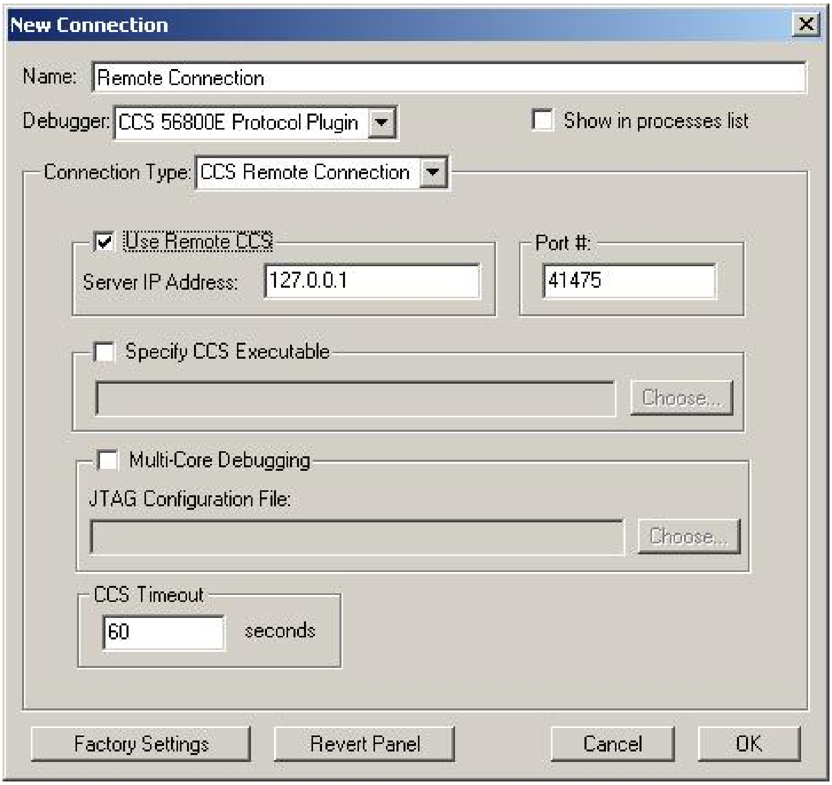
## To Add a New Remote Connection

To add a new remote connection:

1. Click the Add button.

   The **New Connection** window appears as shown in Figure 9.10 on page 192.

**Figure 9.10 New Connection Window**



New Connection

Name: Remote Connection

Debugger: CCS 56800E Protocol Plugin

□ Show in processes list

Connection Type: CCS Remote Connection

☑ Use Remote CCS

Server IP Address: 127.0.0.1

Port #: 41475

□ Specify CCS Executable

□ Multi-Core Debugging

JTAG Configuration File:

CCS Timeout

60 seconds

2. In the Name edit box, type in the connection name.
3. Check Use Remote CCS checkbox.

   Select this checkbox to specify that the CodeWarrior IDE is connected to a remote command converter server. Otherwise, the IDE starts the command converter server locally
4. Enter the Server IP address or host machine name.

   Use this text box to specify the IP address where the command converter server resides when running the command converter server from a location on the network.

5. Enter the Port # to which the command converter server listens or use the default port, which is 41475.
6. Click the OK button.

## To Change an Existing Remote Connection

To change an existing remote connection:

Double click on the connection name that you want to change, or click once on the connection name and click the **Change** button (shown in Figure 9.9 on page 191 in grey).

## To Remove an Existing Remote Connection

To remove an existing remote connection:

Click once on the connection name and click the **Remove** button (shown in Figure 9.9 on page 191 in grey).

## Debugging a Remote Target Board

For debugging a target board connected to a remote machine with Code Warrior IDE installed, perform the following steps:

1. Connect the target board to the remote machine.
2. Launch the command converter server (CCS) on the remote machine with the local settings configuration using instructions described in the section "Essential Target Settings for Command Converter Server" on page 187.
3. In the Target Settings>Remote Debugging panel for your project, make sure the proper remote connection is selected.
4. Launch the debugger.

# Launching and Operating the Debugger

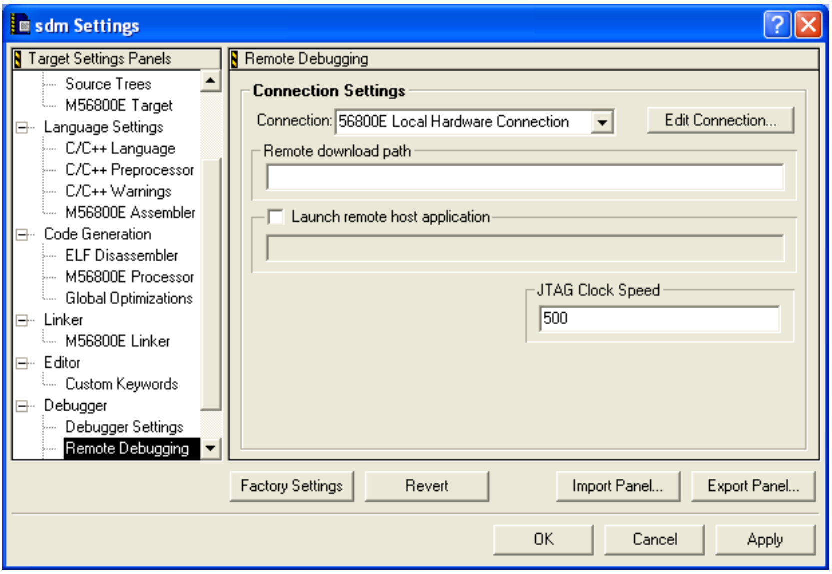
**NOTE** CodeWarrior IDE automatically enables the debugger and sets debugger-related settings within the project.

1. Set debugger preferences.

   Select **Edit >sdm Settings from** the menu bar of the Freescale CodeWarrior window.

   The IDE displays the **Remote Debugging** window.

**Figure 9.11 Remote Debugging Panel**



Remote Debugging

Connection Settings

Connection: 56800E Local Hardware Connection

Remote download path

☐ Launch remote host application

JTAG Clock Speed: 500

2. Select the Connection.

   For example, select **56800E Local Hardware Connection (CCS).**

3. Click OK button.

4. Debug the project.

   Use either of the following options:

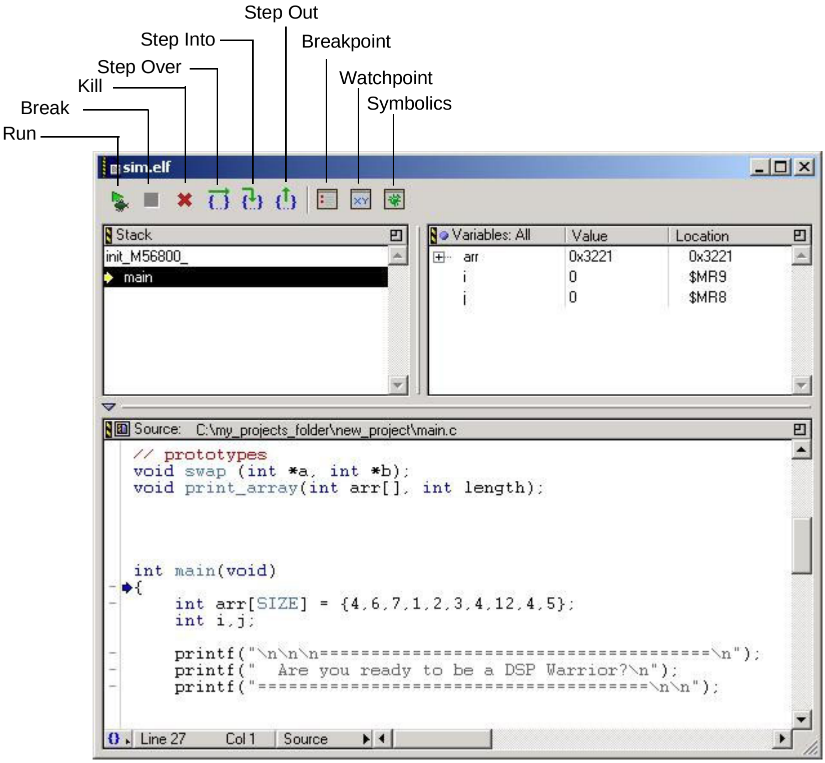
   - From the Freescale CodeWarrior window, select **Project > Debug**.
   - Click the **Debug** button in the project window.

This command resets the board (if **Always reset on download** is checked in the Debugger's **M56800E Target** panel shown in Figure 4.14 on page 79) and the download process begins.

When the download to the board is complete, the IDE displays the **Program** window (**sdm.elf** in sample) shown in Figure 9.12 on page 195.

**NOTE** Source code is shown only for files that are in the project folder or that have been added to the project in the project manager, and for which the IDE has created debug information. You must navigate the file system in order to locate sources that are outside the project folder and not in the project manager, such as library source files.

### Figure 9.12 Program Window



Stack

init_M56800_
main

| Variables: All | Value | Location |
|---|---|---|
| arr | 0x3221 | 0x3221 |
| i | 0 | $MR9 |
| j | 0 | $MR8 |

Source: C:\my_projects_folder\new_project\main.c

```
// prototypes
void swap (int *a, int *b);
void print_array(int arr[], int length);


int main(void)
{
    int arr[SIZE] = {4,6,7,1,2,3,4,12,4,5};
    int i,j;

    printf("\n\n\n======================================\n");
    printf("  Are you ready to be a DSP Warrior?\n");
    printf("======================================\n\n");
```

Line 27 Col 1 Source

5. Navigate through your code.

   The **Program** window has three panes:

   - Stack pane

     The **Stack** pane shows the function calling stack.

   - Variables pane

     The **Variables** pane displays local variables.

   - Source pane

     The **Source** pane displays source or assembly code.

   The toolbar at the top of the window has buttons that allows you access to the execution commands in the **Debug** menu.

# Setting Breakpoints and Watchpoints

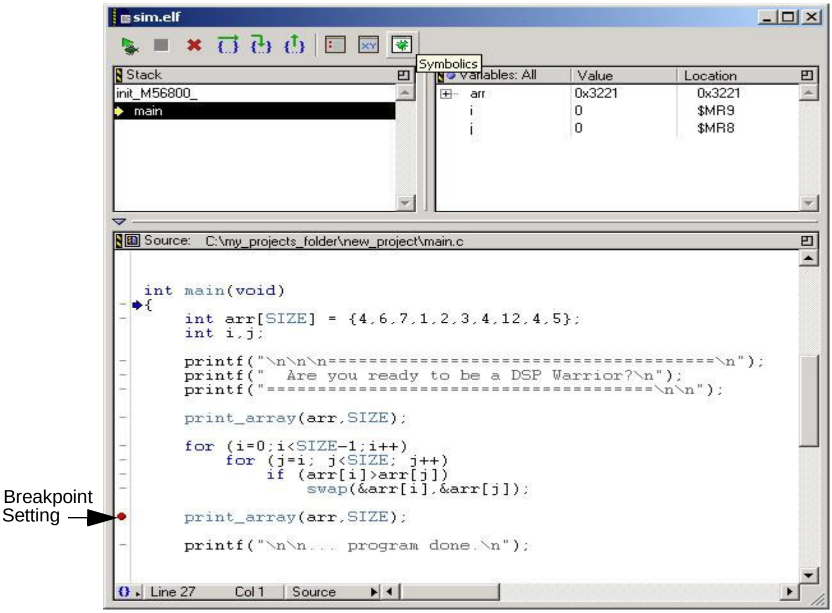
1. Locate the code line.

   Scroll through the code in the **Source** pane of the **Program** window until you come across the `main()` function.

2. Select the code line.

   Click the gray dash in the far left-hand column of the window, next to the first line of code in the `main()` function. A red dot appears (Figure 9.13 on page 196), confirming you have set your breakpoint.

**Figure 9.13 Breakpoint in the Program Window**



Stack:

- init_M56800_
- main

| Variables: All | Value | Location |
|---|---|---|
| arr | 0x3221 | 0x3221 |
| i | 0 | $MR9 |
| j | 0 | $MR8 |

```
int main(void)
{
    int arr[SIZE] = {4,6,7,1,2,3,4,12,4,5};
    int i,j;

    printf("\n\n\n======================================\n");
    printf("  Are you ready to be a DSP Warrior?\n");
    printf("======================================\n\n");

    print_array(arr,SIZE);

    for (i=0;i<SIZE-1;i++)
        for (j=i; j<SIZE; j++)
            if (arr[i]>arr[j])
                swap(&arr[i],&arr[j]);

    print_array(arr,SIZE);

    printf("\n\n... program done.\n");
```

**NOTE** To remove the breakpoint, click the red dot. The red dot disappears.

For more details on how to set breakpoints and use watchpoints, see the *CodeWarrior IDE User's Guide*.

**NOTE** For the DSP56800E only one watchpoint is available. This watchpoint is only available on hardware targets.

# Viewing and Editing Register Values

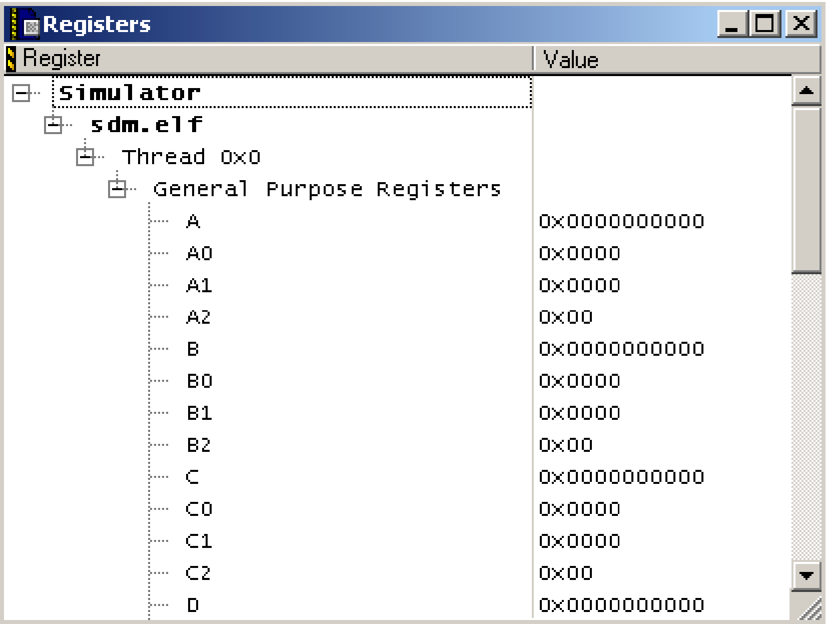
Registers are platform-specific. Different chip architectures have different registers.

1. **Access the Registers** window.

   From the menu bar of the Freescale CodeWarrior window, select **View** > **Registers**.

   Expand the **General Purpose Registers** tree control to view the registers as in Figure 9.14 on page 197, or double-click on **General Purpose Registers** to view the registers as in Figure 9.15 on page 198.

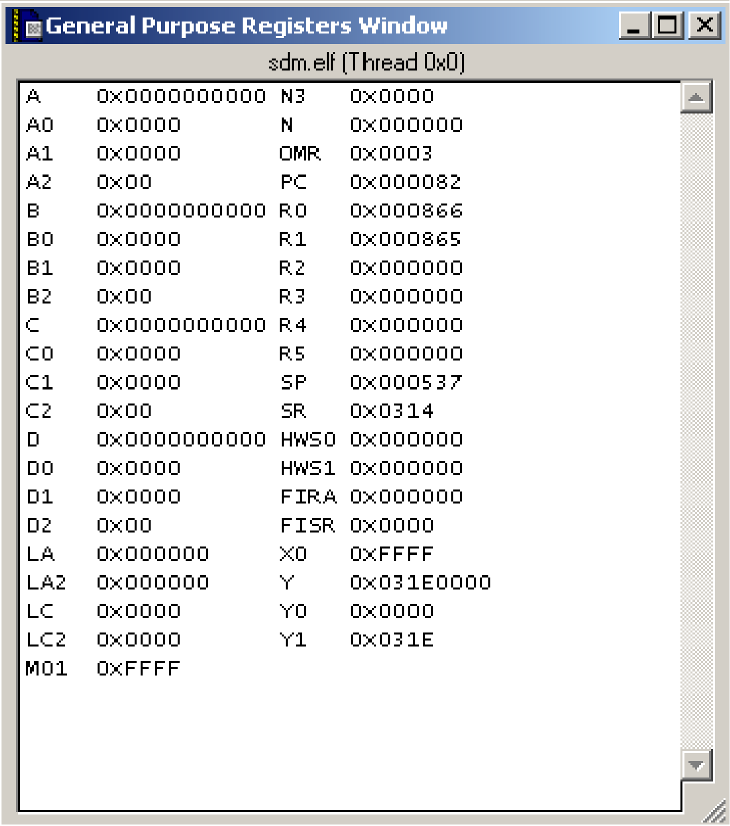
**Figure 9.14 General Purpose Registers for DSP56800E**



Registers

| Register | Value |
|---|---|
| Simulator | |
| sdm.elf | |
| Thread 0x0 | |
| General Purpose Registers | |
| A | 0x0000000000 |
| A0 | 0x0000 |
| A1 | 0x0000 |
| A2 | 0x00 |
| B | 0x0000000000 |
| B0 | 0x0000 |
| B1 | 0x0000 |
| B2 | 0x00 |
| C | 0x0000000000 |
| C0 | 0x0000 |
| C1 | 0x0000 |
| C2 | 0x00 |
| D | 0x0000000000 |

**Figure 9.15 General Purpose Registers Window**



sdm.elf (Thread 0x0)

```
A     0x0000000000 N3    0x0000
A0    0x0000       N     0x000000
A1    0x0000       OMR   0x0003
A2    0x00         PC    0x000082
B     0x0000000000 R0    0x000866
B0    0x0000       R1    0x000865
B1    0x0000       R2    0x000000
B2    0x00         R3    0x000000
C     0x0000000000 R4    0x000000
C0    0x0000       R5    0x000000
C1    0x0000       SP    0x000537
C2    0x00         SR    0x0314
D     0x0000000000 HWS0  0x000000
D0    0x0000       HWS1  0x000000
D1    0x0000       FIRA  0x000000
D2    0x00         FISR  0x0000
LA    0x000000     X0    0XFFFF
LA2   0x000000     Y     0x031E0000
LC    0x0000       Y0    0x0000
LC2   0x0000       Y1    0x031E
M01   0XFFFF
```

2. Edit register values.

   To edit values in the register window, double-click a register value. Change the value as you wish.

3. Exit the window.

   The modified register values are saved.

**NOTE** To view peripheral registers, select the appropriate processor form the processor list box in the M56800E Target Settings Panel.

# Viewing X: Memory

You can view X memory space values as hexadecimal values with ASCII equivalents. You can edit these values at debug time.

**NOTE** On targets that have Flash ROM, you cannot edit those values in the memory window that reside in Flash memory.

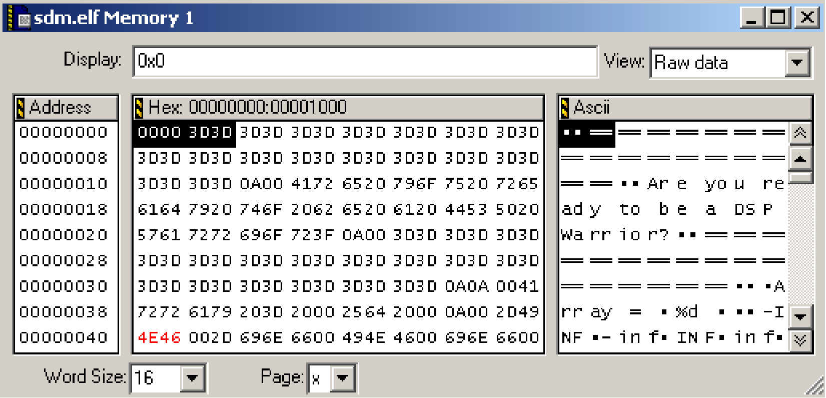
1. Locate a particular address in program memory.

   From the menu bar of the Freescale CodeWarrior window, select **Data** > **View Memory**.

**NOTE** The **Source** pane in the **Program** window needs to be the active one in order for the **Data** > **View Memory** to be activated.

The **Memory** window appears (Figure 9.16 on page 199).

**Figure 9.16 View X:Memory Window**



Display: 0x0

View: Raw data

```
Address    Hex: 00000000:00001000                       Ascii
00000000   0000 3D3D 3D3D 3D3D 3D3D 3D3D 3D3D 3D3D      •• == == == == == == ==
00000008   3D3D 3D3D 3D3D 3D3D 3D3D 3D3D 3D3D 3D3D      == == == == == == == ==
00000010   3D3D 3D3D 0A00 4172 6520 796F 7520 7265      == == •• Ar e  yo u  re
00000018   6164 7920 746F 2062 6520 6120 4453 5020      ad y  to  b e  a  DS P
00000020   5761 7272 696F 723F 0A00 3D3D 3D3D 3D3D      Wa rr io r? •• == == ==
00000028   3D3D 3D3D 3D3D 3D3D 3D3D 3D3D 3D3D 3D3D      == == == == == == == ==
00000030   3D3D 3D3D 3D3D 3D3D 3D3D 3D3D 0A0A 0041      == == == == == == •• •A
00000038   7272 6179 203D 2000 2564 2000 0A00 2D49      rr ay  =  • %d  • •• -I
00000040   4E46 002D 696E 6600 494E 4600 696E 6600      NF •- in f• IN F• in f•
```

Word Size: 16

Page: x

2. Select type of memory.

   Locate the **Page** list box at the bottom of the **View Memory** window. Select **X** for X Memory.

3. Enter memory address.

   Type the memory address in the **Display** field located at the top of the **Memory** window.

   To enter a hexadecimal address, use standard C hex notation, for example, 0x0.

**NOTE** You also can enter the symbolic name whose value you want to view by typing its name in the **Display** field of the **Memory** window.

**NOTE** The other view options (Disassembly, Source and Mixed) do not apply when viewing X memory.

## Viewing P: Memory

You can view P memory space and edit the opcode hexadecimal values at debug time.

**NOTE** On targets that have Flash ROM, you cannot edit those values in the memory window that reside in Flash memory.

1. Locate a particular address in program memory.

   To view program memory, from the menu bar of the Freescale CodeWarrior window, select **Data > View Memory**.

   The **Memory** window appears (Figure 9.16 on page 199).

2. Select type of memory.

   Locate the **Page** list box at the bottom of the **View Memory** window. Select **P** for P Memory.

3. Enter memory address.

   Type the memory address in the **Display** field located at the top of the **Memory** window.

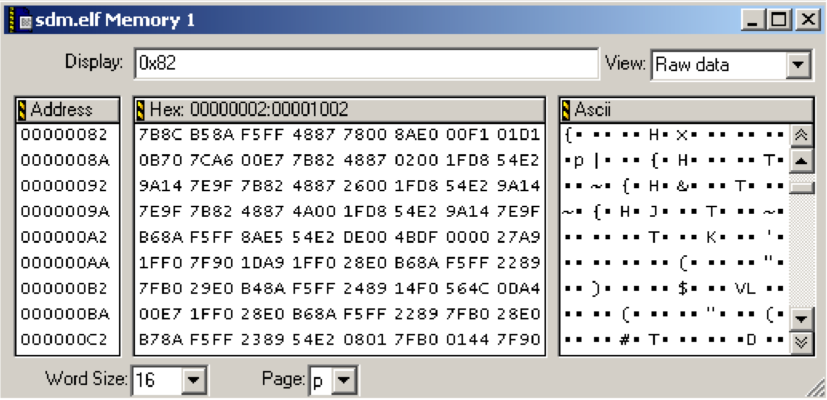
   To enter a hexadecimal address, use standard C hex notation, for example: `0x82`.

4. Select how you want to view P memory.

   Using the **View** list box, you have the option to view P Memory in four different ways.

   - **Raw Data** (Figure 9.17 on page 201).

### Figure 9.17 View P:Memory (Raw Data) Window



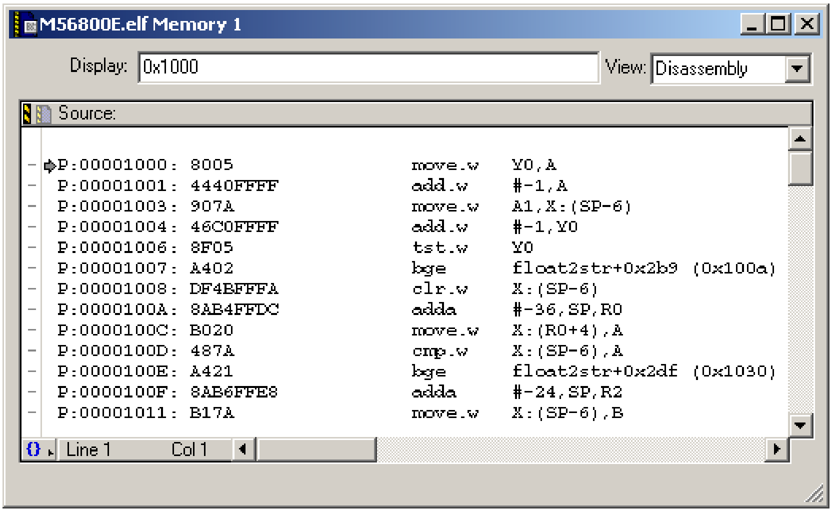
Display: 0x82   View: Raw data

```
Address    Hex: 00000002:00001002                    Ascii
00000082   7B8C B58A F5FF 4887 7800 8AE0 00F1 01D1   {▪ ▪▪ ▪▪ H▪ x▪ ▪▪ ▪▪ ▪▪
0000008A   0B70 7CA6 00E7 7B82 4887 0200 1FD8 54E2   ▪p |▪ ▪▪ {▪ H▪ ▪▪ ▪▪ T▪
00000092   9A14 7E9F 7B82 4887 2600 1FD8 54E2 9A14   ▪▪ ~▪ {▪ H▪ &▪ ▪▪ T▪ ▪▪
0000009A   7E9F 7B82 4887 4A00 1FD8 54E2 9A14 7E9F   ~▪ {▪ H▪ J▪ ▪▪ T▪ ▪▪ ~▪
000000A2   B68A F5FF 8AE5 54E2 DE00 4BDF 0000 27A9   ▪▪ ▪▪ ▪▪ T▪ ▪▪ K▪ ▪▪ '▪
000000AA   1FF0 7F90 1DA9 1FF0 28E0 B68A F5FF 2289   ▪▪ ▪▪ ▪▪ ▪▪ (▪ ▪▪ ▪▪ "▪
000000B2   7FB0 29E0 B48A F5FF 2489 14F0 564C 0DA4   ▪▪ )▪ ▪▪ ▪▪ $▪ ▪▪ VL ▪▪
000000BA   00E7 1FF0 28E0 B68A F5FF 2289 7FB0 28E0   ▪▪ ▪▪ (▪ ▪▪ ▪▪ "▪ ▪▪ (▪
000000C2   B78A F5FF 2389 54E2 0801 7FB0 0144 7F90   ▪▪ ▪▪ #▪ T▪ ▪▪ ▪▪ ▪D ▪▪
```

Word Size: 16   Page: p

- **Disassembly** (Figure 9.18 on page 201).

### Figure 9.18 View P:Memory (Disassembly) Window



Display: 0x1000   View: Disassembly

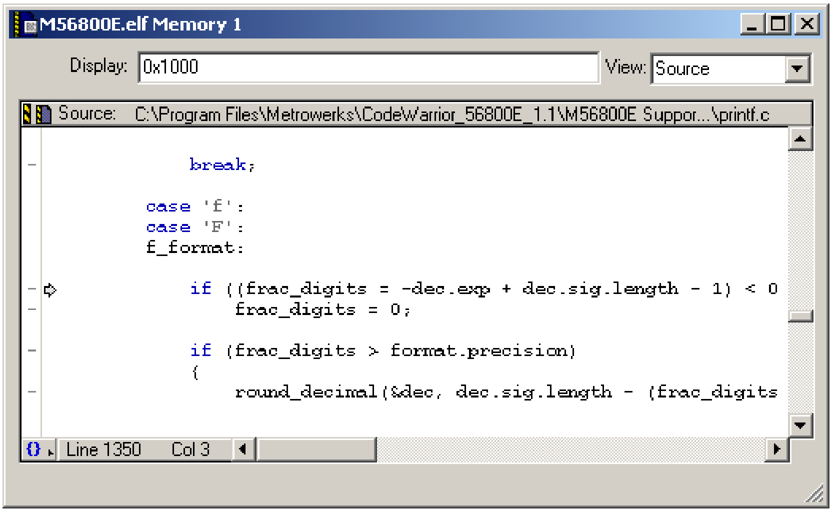
Source:

```
-  P:00001000:  8005           move.w   Y0,A
-  P:00001001:  4440FFFF       add.w    #-1,A
-  P:00001003:  907A           move.w   A1,X:(SP-6)
-  P:00001004:  46C0FFFF       add.w    #-1,Y0
-  P:00001006:  8F05           tst.w    Y0
-  P:00001007:  A402           bge      float2str+0x2b9 (0x100a)
-  P:00001008:  DF4BFFFA       clr.w    X:(SP-6)
-  P:0000100A:  8AB4FFDC       adda     #-36,SP,R0
-  P:0000100C:  B020           move.w   X:(R0+4),A
-  P:0000100D:  487A           cmp.w    X:(SP-6),A
-  P:0000100E:  A421           bge      float2str+0x2df (0x1030)
-  P:0000100F:  8AB6FFE8       adda     #-24,SP,R2
-  P:00001011:  B17A           move.w   X:(SP-6),B
```

Line 1   Col 1

- **Source** (Figure 9.19 on page 202).

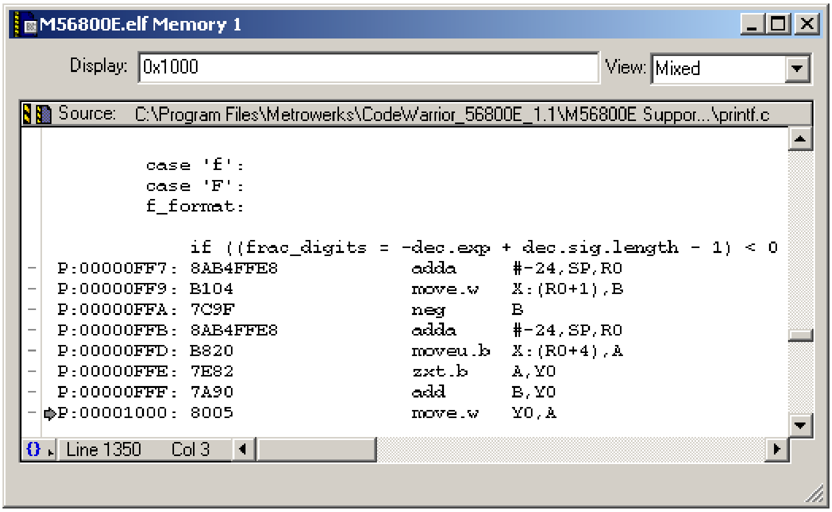
### Figure 9.19 View P:Memory (Source) Window


M56800E.elf Memory 1
Display: 0x1000
View: Source
Source: C:\Program Files\Metrowerks\CodeWarrior_56800E_1.1\M56800E Suppor...\printf.c
Line 1350 Col 3

```
                break;

        case 'f':
        case 'F':
        f_format:

            if ((frac_digits = -dec.exp + dec.sig.length - 1) < 0
                frac_digits = 0;

            if (frac_digits > format.precision)
            {
                round_decimal(&dec, dec.sig.length - (frac_digits
```

- **Mixed** (Figure 9.20 on page 202).

### Figure 9.20 View P:Memory (Mixed) Window

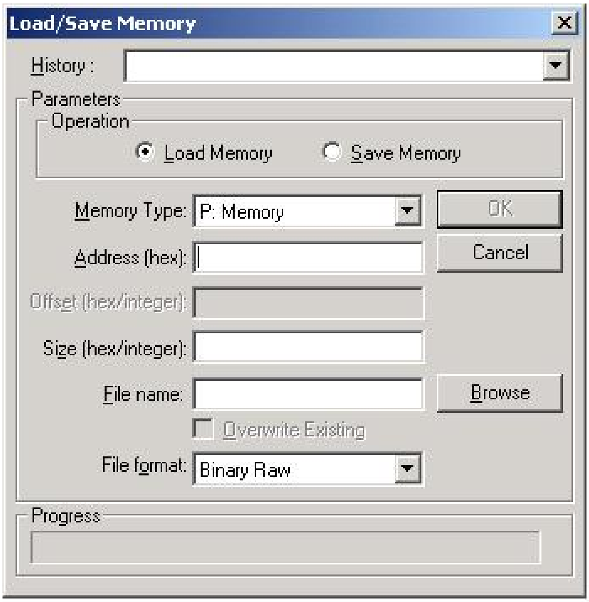

M56800E.elf Memory 1
Display: 0x1000
View: Mixed
Source: C:\Program Files\Metrowerks\CodeWarrior_56800E_1.1\M56800E Suppor...\printf.c
Line 1350 Col 3

```
        case 'f':
        case 'F':
        f_format:

            if ((frac_digits = -dec.exp + dec.sig.length - 1) < 0
P:00000FF7: 8AB4FFE8           adda     #-24,SP,R0
P:00000FF9: B104               move.w   X:(R0+1),B
P:00000FFA: 7C9F               neg      B
P:00000FFB: 8AB4FFE8           adda     #-24,SP,R0
P:00000FFD: B820               moveu.b  X:(R0+4),A
P:00000FFE: 7E82               zxt.b    A,Y0
P:00000FFF: 7A90               add      B,Y0
P:00001000: 8005               move.w   Y0,A
```

# Load/Save Memory

From the menu bar of the Freescale CodeWarrior window, select **Debug > 56800E > Load/Save Memory** to display the **Load/Save Memory** dialog box (Figure 9.21 on page 203).

**Figure 9.21 Load/Save Memory Dialog Box**



● Load Memory ○ Save Memory

Memory Type: P: Memory

☐ Overwrite Existing

File format: Binary Raw

Use this dialog box to load and save memory at a specified location and size with a user-specified file. You can associate a key binding with this dialog box for quick access. Press the **Tab** key to cycle through the dialog box displays, which lets you quickly make changes without using the mouse.

## History Combo Box

The **History** combo box displays a list of recent loads and saves. If this is the first time you load or save, the **History** combo box is empty. If you load/save more than once, the combo box fills with the memory address of the start of the load or save and the size of the fill, to a maximum of ten sessions.

If you enter information for an item that already exists in the history list, that item moves up to the top of the list. If you perform another operation, that item appears first.

**NOTE** By default, the **History** combo box displays the most recent settings on subsequent viewings.

## Radio Buttons

The **Load/Save Memory** dialog box has two radio buttons:

- Load Memory
- Save Memory

The default is **Load Memory**.

## Memory Type Combo Box

The memory types that appear in the **Memory Type** Combo box are:

- P: Memory (Program Memory)
- X: Memory (Data Memory)

## Address Text Field

Specify the address where you want to write the memory. If you want your entry to be interpreted as hex, prefix it with `0x`; otherwise, it is interpreted as decimal.

## Size Text Field

Specify the number of words to write to the target. If you want your entry to be interpreted as hex, prefix it with `0x`; otherwise, it is interpreted as decimal.

## Dialog Box Controls

### Cancel, Esc, and OK

In Load and Save operations, all controls are disabled except **Cancel** for the duration of the load or save. The status field is updated with the current progress of the operation. Clicking **Cancel** halts the operation, and re-enables the controls on the dialog box. Clicking **Cancel** again closes the dialog box. Pressing the **Esc** key is same as clicking the **Cancel** button.

With the **Load Memory** radio button selected, clicking **OK** loads the memory from the specified file and writes it to memory until the end of the file or the size specified is reached. If the file does not exist, an error message appears.

With the **Save Memory** radio button selected, clicking **OK** reads the memory from the target piece by piece and writes it to the specified file. The status field is updated with the current progress of the operation.

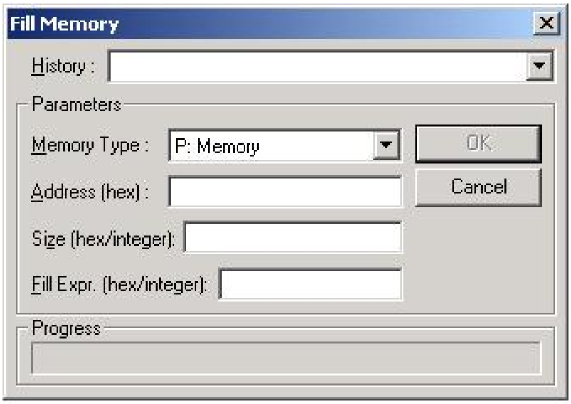
### Browse Button

Clicking the **Browse** button displays OPENFILENAME or SAVEFILENAME, depending on whether you selected the **Load Memory** or **Save Memory** radio button.

## Fill Memory

From the menu bar of the Freescale CodeWarrior window, select **Debug > 56800E > Fill Memory** to display the **Fill Memory** dialog box (Figure 9.22 on page 205).

**Figure 9.22 Fill Memory Dialog Box**



Use this dialog box to fill memory at a specified location and size with user- specified raw memory data. You can associate a key binding with this dialog box for quick access. Press the **Tab** key to cycle through the dialog box display, which lets you quickly make changes without using the mouse.

**NOTE** Fill Memory does not support Flash Memory.

## History Combo Box

The **History** combo box displays a list of recent fill operations. If this is the first time you perform a fill operation, the **History** combo box is empty. If you do more than one fill, then the combo box populates with the memory address of that fill, to a maximum of ten sessions.

If you enter information for an item that already exists in the history list, that item moves up to the top of the list. If you do another fill, then this item is the first one that appears.

**NOTE** By default, the **History** combo box displays the most recent settings on subsequent viewings.

## Memory Type Combo Box

The memory types that can appear in the **Memory Type** Combo box are:

- P:Memory (Program Memory)
- X:Memory (Data Memory)

## Address Text Field

Specify the address where you want to write the memory. If you want it to be interpreted as hex, prefix it with `0x`; otherwise, it is interpreted as decimal.

## Size Text Field

Specify the number of words to write to the target. If you want it to be interpreted as hex, prefix your entry with `0x`; otherwise, it is interpreted as decimal.

## Fill Expression Text Field

Fill writes a set of characters to a location specified by the address field on the target, repeatedly copying the characters until the user-supplied fill size has been reached. **Size** is the total words written, not the number of times to write the string.

### Interpretation of the Fill Expression

The fill string is interpreted differently depending on how it is entered in the Fill String field. Any words prefixed with `0x` is interpreted as hex bytes. Thus, `0xBE 0xEF` would actually write `0xBEEF` on the target. Optionally, the string could have been set to `0xBEEF` and this would do the same thing. Integers are interpreted so that the equivalent signed integer is written to the target.

### ASCII Strings

ASCII strings can be quoted to have literal interpretation of spaces inside the quotes. Otherwise, spaces in the string are ignored. Note that if the ASCII strings are not quoted and they are numbers, it is possible to create illegal numbers. If the number is illegal, an error message is displayed.

## Dialog Box Controls

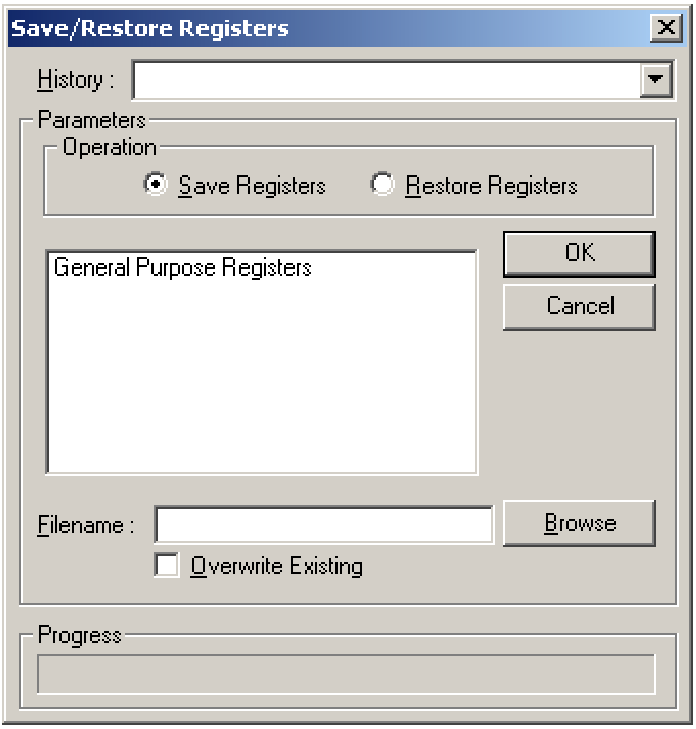
### OK, Cancel, and Esc

Clicking **OK** writes the memory piece by piece until the target memory is filled in. The **Status** field is updated with the current progress of the operation. When this is in progress, the entire dialog box grays out except the **Cancel** button, so the user cannot change any information. Clicking the **Cancel** button halts the fill operation, and re-enables the controls on the dialog box. Clicking the **Cancel** button again closes the dialog box. Pressing the **Esc** key is same as pressing the **Cancel** button.

# Save/Restore Registers

From the menu bar of the Freescale CodeWarrior window, select **Debug > 56800E > Save/Restore Registers** to display the **Save/Restore Registers** dialog box (Figure 9.23 on page 208).

**Figure 9.23  Save/Restore Registers Dialog Box**



Use this dialog box to save and restore register groups to and from a user-specified file.

## History Combo Box

The **History** combo box displays a list of recent saves and restores. If this is the first time you have saved or restored, the **History** combo box is empty. If you saved or restored before, the combo box remembers your last ten sessions. The most recent session will appear at the top of the list.

## Radio Buttons

The **Save/Restore Registers** dialog box has two radio buttons:

- Save Registers
- Restore Registers

The default is **Save Registers**.

### Register Group List

This list is only available when you have selected **Save Registers**. If you have selected **Restore Registers**, the items in the list are greyed out. Select the register group that you wish to save.

## Dialog Box Controls

### Cancel, Esc, and OK

In Save and Restore operations, all controls are disabled except **Cancel** for the duration of the load or save. The status field is updated with the current progress of the operation. Clicking **Cancel** halts the operation, and re-enables the controls on the dialog box. Clicking **Cancel** again closes the dialog box. Pressing the **Esc** key is same as clicking the **Cancel** button.

With the **Restore Registers** radio button selected, clicking **OK** restores the registers from the specified file and writes it to the registers until the end of the file or the size specified is reached. If the file does not exist, an error message appears.

With the **Save Register** radio button selected, clicking **OK** reads the registers from the target piece by piece and writes it to the specified file. The status field is updated with the current progress of the operation.

### Browse Button

Clicking the **Browse** button displays OPENFILENAME or SAVEFILENAME, depending on whether you selected the **Restore Registers** or **Save Registers** radio button.

# EOnCE Debugger Features

The following EOnCE Debugger features are discussed in this section:

- Set Hardware Breakpoint Panel on page 210
- Special Counters on page 210
- Trace Buffer on page 212
- Set Trigger Panel on page 215

**NOTE** These features are only available when debugging with a hardware target.

For more information on the debugging capabilities of the EOnCE, see the EOnCE chapter of your processor’s user manual.

## Set Hardware Breakpoint Panel

The **Set Hardware BreakPoint** panel (Figure 9.24 on page 210) lets you set a trigger to do one of the following: halt the processor, cause an interrupt, or start or stop trace buffer capture.

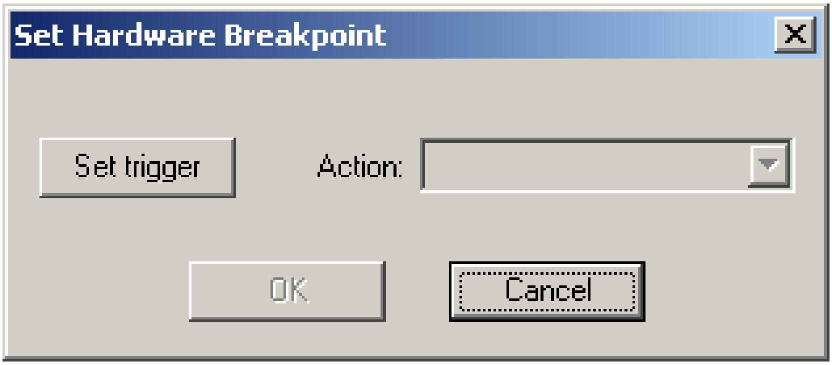
To open this panel:

1. From the menu bar, select DSP56800E > Set Breakpoint Trigger(s).

To clear triggers set with this panel:

1. From the menu bar, select DSP56800E > Clear Triggers.

**Figure 9.24 Set Hardware Breakpoint Panel**



The **Set Hardware BreakPoint** panel options are:

- Set trigger

Select this button to open the **Set Trigger** panel (Figure 9.28 on page 216). For more information on using this panel, see “Set Trigger Panel.”

- Action

This pull down list lets you select the resulting action caused by the trigger.

- – Halt core

  Stops the processor.

- – Interrupt

  Causes an interrupt and uses the vector for the EOnCE hardware breakpoint (unit 0).

## Special Counters

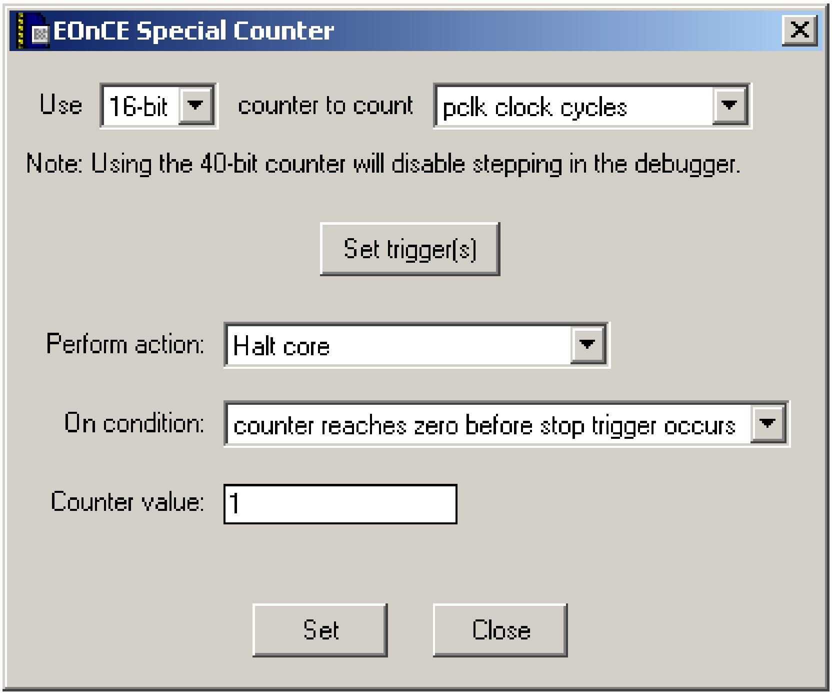
This feature lets you use the special counting function of the EOnCE unit.

To open the EOnCE Special Counter panel (Figure 9.25 on page 211):

1. From the menu bar, select DSP56800E > Special Counter.

   This panel is non-modal and will update itself whenever the processor stops.

**Figure 9.25 EOnCE Special Counter Panel**



EOnCE Special Counter

Use 16-bit counter to count pclk clock cycles

Note: Using the 40-bit counter will disable stepping in the debugger.

Perform action: Halt core

On condition: counter reaches zero before stop trigger occurs

Counter value: 1

The **EOnCE Special Counter** panel options are:

- Counter size

  This pull down list gives you the option to use a 16 or 40-bit counter.

**NOTE** Using the 40-bit counter will disable stepping in the debugger.

- Counter function

  This pull down list allows you to choose which counting function to use.

- Set trigger(s)

  Pushing this button opens the **Set Trigger** panel. For more information on using this panel, see "Set Trigger Panel.".

- **Perform action**

  This pull down list lets you select the action that occurs when the correct conditions are met, as set in the **Set Trigger** panel and the **On condition** pull down list.

- **On condition**

  This pull down list lets you set the order in which a trigger and counter reaching zero must occur to perform the action specified in **Perform action**.

- **Counter value**

  This edit box should be preloaded with a non-zero counter value when setting the counter. The counter will proceed backward until a stop condition occurs. The edit box will contain the value of the counter and will be updated whenever the processor stops.

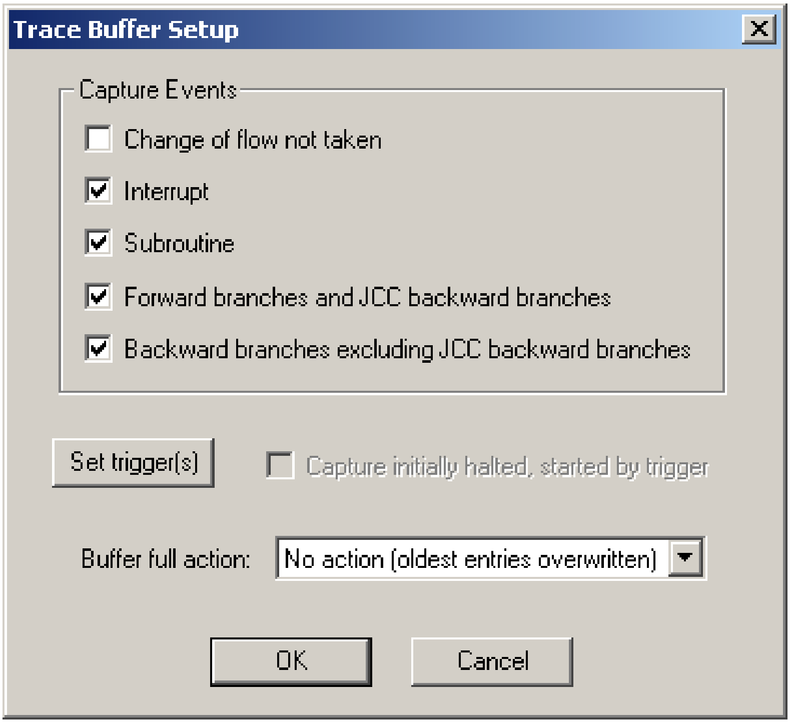
# Trace Buffer

The trace buffer lets you view the target addresses of change-of-flow instructions that the program executes. The trace buffer is configured with the **Trace Buffer Setup** panel (Figure 9.26 on page 213).

To open this panel:

1. From the IDE menu bar, select DSP56800E > Setup Trace Buffer.

**Figure 9.26  Trace Buffer Setup Panel**



Trace Buffer Setup

Capture Events

☐ Change of flow not taken

☑ Interrupt

☑ Subroutine

☑ Forward branches and JCC backward branches

☑ Backward branches excluding JCC backward branches

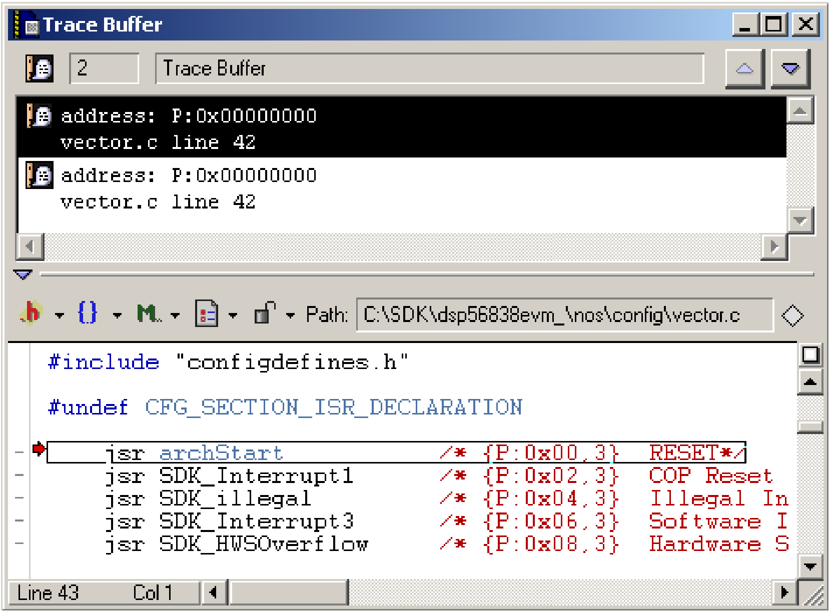
☐ Capture initially halted, started by trigger

Buffer full action: No action (oldest entries overwritten)

To view the contents of the trace buffer (Figure 9.27 on page 214):

1. From the IDE menu bar, select DSP56800E > Dump Trace Buffer.

**Figure 9.27 Contents of Trace Buffer**



Trace Buffer

2 Trace Buffer

```
address: P:0x00000000
vector.c line 42
address: P:0x00000000
vector.c line 42
```

Path: C:\SDK\dsp56838evm_\nos\config\vector.c

```
#include "configdefines.h"

#undef CFG_SECTION_ISR_DECLARATION

      jsr archStart          /* {P:0x00,3}   RESET*/
      jsr SDK_Interrupt1     /* {P:0x02,3}   COP Reset
      jsr SDK_illegal        /* {P:0x04,3}   Illegal In
      jsr SDK_Interrupt3     /* {P:0x06,3}   Software I
      jsr SDK_HWSOverflow    /* {P:0x08,3}   Hardware S
```

Line 43 Col 1

To clear triggers set with the **Trace Buffer Setup** panel (Figure 9.26 on page 213):

1. From the menu bar, select DSP56800E > Clear Triggers.

   The **Trace Buffer Setup** panel options are:

   - **Capture Events**

     Select this set of checkboxes to specify which instructions get captured by the trace buffer.

     – Change of flow not taken

       Select this checkbox to capture target addresses of conditional branches and jumps that are not taken.

     – Interrupt

       Select this checkbox to capture addresses of interrupt vector fetches and target addresses of RTI instructions.

     – Subroutine

       Select this checkbox to capture target addresses of JSR, BSR, and RTS instructions.

– Forward branches and JCC Backward branches

  Select this checkbox to capture target addresses of the following taken instructions:

```
BCC forward branch
BRSET forward branch
BRCLR forward branch
JCC forward and backward branches
```

– **Backward branches excluding JCC backward branches**

  Select this checkbox to capture target addresses of the following taken instructions:

```
BCC backward branch
BRSET backward branch
BRCLR backward branch
```

- Set trigger(s)

  Select this button to open the **Set Trigger** panel (Figure 9.28 on page 216). For more information on using this panel, see "Set Trigger Panel.". The resulting trigger halts trace buffer capture.

- **Capture initially halted, started by trigger**

  When this option is checked, the trace buffer starts off halted.

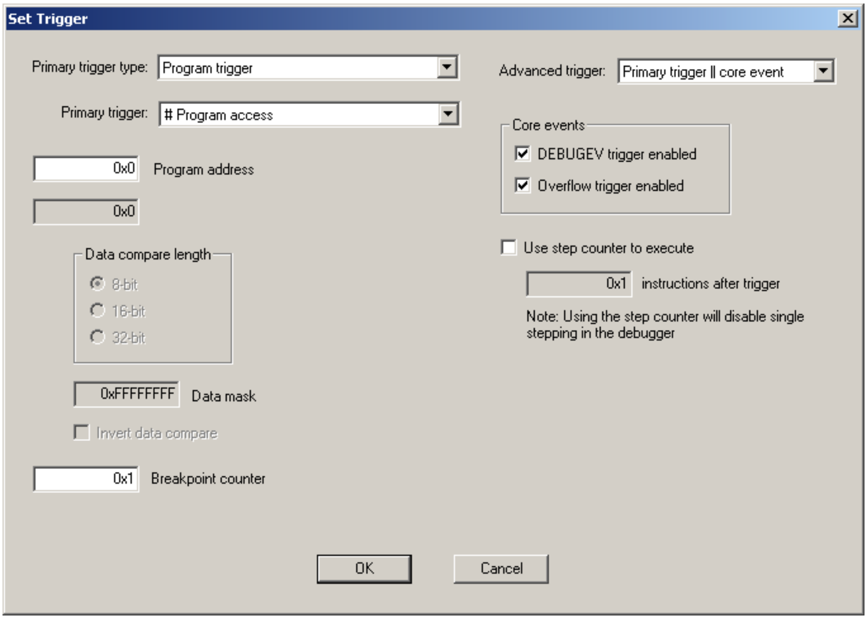
- **Buffer full action**

  This pull down list lets you select the resulting action caused by the trace buffer filling.

# Set Trigger Panel

The **Set Trigger** panel (Figure 9.28 on page 216) lets you set triggers for all the EOnCE functions. It can be accessed from the panels used to configure those functions. The options available change depending on the function being configured.

**Figure 9.28  Set Trigger Panel**



Set Trigger

Primary trigger type: Program trigger

Primary trigger: # Program access

0x0 Program address

0x0

Data compare length

● 8-bit
○ 16-bit
○ 32-bit

0xFFFFFFFF Data mask

□ Invert data compare

0x1 Breakpoint counter

Advanced trigger: Primary trigger || core event

Core events

☑ DEBUGEV trigger enabled
☑ Overflow trigger enabled

□ Use step counter to execute

0x1 instructions after trigger

Note: Using the step counter will disable single stepping in the debugger

The **Set Trigger** panel options are:

- **Primary trigger type**

  This pull down list contains the general categories of triggers that can be set.

- **Primary trigger**

  This pull down list contains the specific forms of the triggers that can be set. This list changes depending on the selection made in the **Primary trigger type** option. The # symbol contained in some of the triggers' descriptions specifies that the sub-trigger that it precedes must occur the number of times specified in the **Breakpoint counter** option to cause a trigger. The - > symbol specifies that the first sub-trigger must occur, then the second sub-trigger must occur to cause a trigger.

- Value options

  There are two edit boxes used to specify addresses and data values. The descriptions next to the boxes change according to the selection in **Primary trigger type** and **Primary trigger**. According to these options, only one value may be available.

- **Data compare length**

  When the data trigger (address and data) compare trigger is selected, this set of radio buttons becomes available. These options allow you to specify the length of data being compared at that address.

- **Data mask**

  When a data compare trigger is selected, this edit box becomes available. This value specifies which bits of the data value are compared.

- **Invert data compare**

  When a data compare trigger is selected, this checkbox becomes available. When checked, the comparison result of the data value is inverted (logical NOT).

- **Breakpoint counter**

  This edit box specifies the number of times a sub-trigger preceded by a # (see above) must occur to cause a trigger.

- **Advanced trigger**

  This pull down list contains options for combining triggers. The types of triggers that can be combined are triggers set in this panel and core events.

- **Core events**

  This set of checkboxes specify which core events are allowed to enter the breakpoint logic and cause a trigger.

  - **DEBUGEV trigger enabled**

    When this checkbox is selected, the **DEBUGEV** instruction causes a core event.

  - **Overflow trigger enabled**

    When this checkbox is selected, overflow and saturation conditions in the processor cause core events.

- **Use step counter to execute**

  When this checkbox is selected, the processor steps through additional instructions after a trigger is signalled. The number of instructions to be stepped is specified in the edit box that is enabled when this checkbox is checked.

# Using the DSP56800E Simulator

The CodeWarrior Development Studio for Freescale 56800/E Digital Signal Controllers includes the Freescale DSP56800E Simulator. This software lets you run and debug code on a simulated DSP56800E architecture without installing any additional hardware.

The simulator simulates the DSP56800E processor, not the peripherals. In order to use the simulator, you must select a connection that uses the simulator as your debugging protocol from the **Remote Debugging** panel.

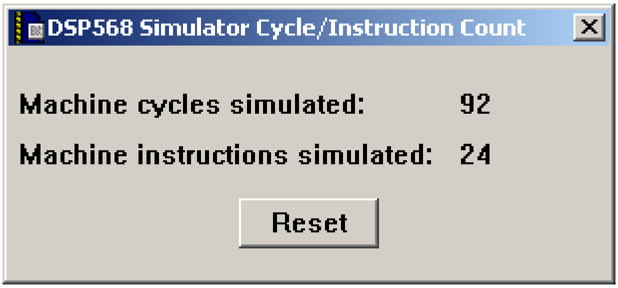
**NOTE** The simulator also enables the DSP56800E menu for retrieving the machine cycle count and machine instruction count when debugging.

**NOTE** The data memory of the 56800E simulator is read-only from X:0xFF80 to X:0xFFFF.

# Cycle/Instruction Count

From the menu bar of the Freescale CodeWarrior window, select **56800E > Display Cycle/Instruction count**. The following window appears (Figure 9.29 on page 218):

**Figure 9.29 Simulator Cycle/Instruction Count**



Machine cycles simulated: 92

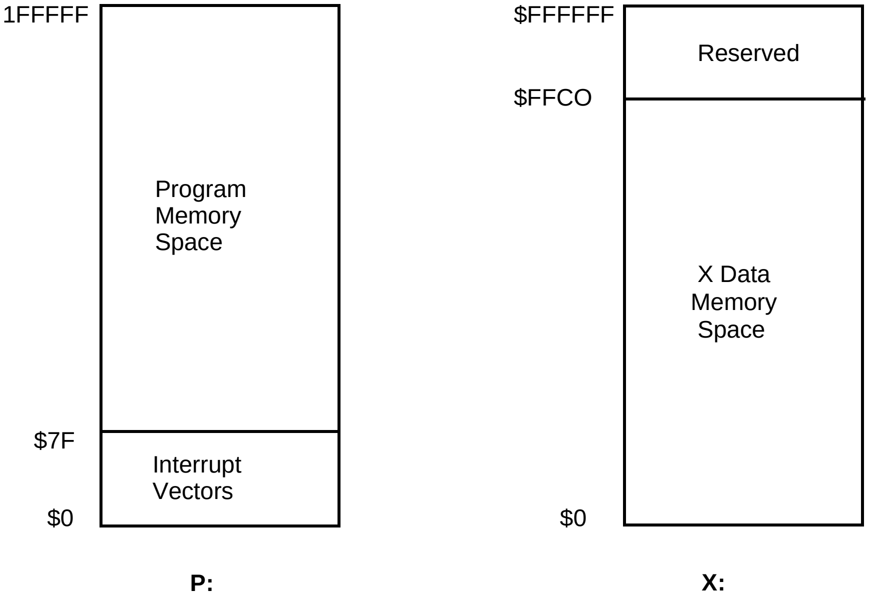
Machine instructions simulated: 24

**NOTE** Cycle counting is not accurate while single stepping through source code in the debugger. It is only accurate while running. Thus, the cycle counter is more of a profiling tool than an interactive tool.

Press the **Reset** button to zero out the current machine-cycle and machine-instruction readings.

## Memory Map

**Figure 9.30 Simulator Memory Map**

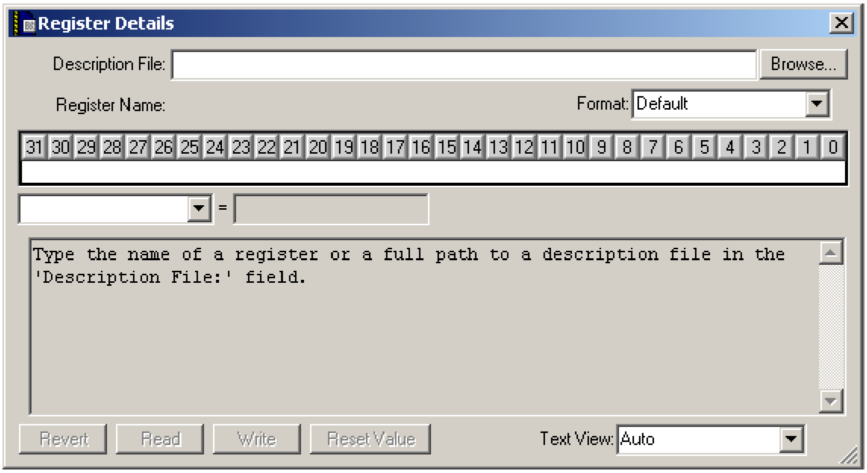


**NOTE** Figure 9.30 on page 219 is the memory map configuration for the simulator. Therefore, the simulator does not simulate each DSP568xx device’s specific memory map, but assumes the memory map of the DSP56824.

# Register Details Window

From the menu bar of the Freescale CodeWarrior window, select **View** > **Register Details** or in the Registers window (Figure 9.14 on page 197) double-click on the register. The **Register Details** window appears (Figure 9.31 on page 220).

**Figure 9.31 Register Details Window**



```
Type the name of a register or a full path to a description file in the
'Description File:' field.
```

In the **Register Details** window, type the name of the register (e.g., OMR, SR, IPR, etc.) in the **Description File** field. The applicable register and its values appears.

By default, the CodeWarrior IDE looks in the following path when searching for register description files.

\CodeWarrior\bin\Plugins\support\Registers\M56800E\GPR

Register description files must end with the `.xml` extension. Alternatively, you can use the **Browse** button to locate the register description files.

Using the **Format** list box in the **Register Details** window, you can change the format in which the CodeWarrior IDE displays the registers.

Using the **Text View** list box in the **Register Details** window, you can change the text information the CodeWarrior IDE displays.

# Loading a .elf File without a Project

You can load and debug a `.elf` file without an associated project. To load a `.elf` file for debugging without an associated project:

1. Launch the CodeWarrior IDE.
2. Choose **File > Open** and specify the file to load in the standard dialog box that appears.

   Alternatively, you can drag and drop a `.elf` file onto the IDE.

3. You may have to add additional access paths in the Access Path preference panel in order to see all of the source code.
4. Choose **Project > Debug** to begin debugging the application.

**NOTE** When you debug a `.elf` file without a project, the IDE sets the **Build before running** setting on the Build Settings panel of the IDE Preference panels to Never. Consequently, if you open another project to debug after debugging a `.elf` file, you must change the **Build before running** setting before you can build the project.

The project that the CodeWarrior tools uses to create a new project for the given `.elf` file is `56800E_Default_Project.xml`, which is in the directory located in the path:

```
CodeWarrior\bin\plugins\support
```

You can create your own version of this file to use as a default setting when opening a `.elf` file:

1. Create a new project with the default setting you want.
2. Export the project to xml format.
3. Rename the xml format of the project to 56800E_Default_Project.xml and place it in the support directory.

**NOTE** Back up or rename the original version of the default xml project before overwriting it with your own customized version.

# Using the Command Window

In addition to using the regular CodeWarrior IDE debugger windows, you also can debug using Tcl scripts or the Command Window.

For more information on Tcl scripts and the Command Window, please see the *CodeWarrior Development Studio IDE 5.6 Windows® Automation Guide*.

# System-Level Connect

The CodeWarrior DSP56800E debugger lets you connect to a loaded target board and view system registers and memory. A system-level connect does not let you view symbolic information during a connection.

**NOTE** The following procedure explains how to connect in the context of developing and debugging code on a target board. However, you can select the **Debug >**

**Connect** command anytime you have a project window open, even if you have not yet downloaded a file to your target board.

To perform a system-level connect:

1. Select the Project window for the program you downloaded.
2. From the menu bar, select Debug > Connect.

   The debugger connects to the board. You can now examine registers and the contents of memory on the board.

# Debugging in the Flash Memory

The debugger is capable of programming flash memory. The programming occurs at launch, during download. The flash programming option is turned on and the parameters are set in the initialization file. This file is specified in the **Debugger>M56800E Target** preference panel. A list of flash memory commands is given in the next section.

The stationery provides an example of how to specify a default initialization file, how to write a linker command file for flash memory, and how to copy initialized data from ROM to RAM using provided library functions.

**NOTE** If you use the phase locked loop (PLL) to change the system speed and you are using software or automatic breakpoints, you will need to enable the alternate flash download sequence, as described by the “target_code_sets_hfmclkd” command in the following section.

## Flash Memory Commands

The following is a list of flash memory commands that can be included in your initialization file.

For more information on flash memory commmands and initialization of the flash, see “M56800E Target (Debugging).”

### set_hfmclkd <value>

This command writes the `value` which represents the clock divider for the flash memory to the hfmclkd register.

The value for the `set_hfmclkd` command depends on the frequency of the clock. If you are using a supported EVM, this value should not be changed from the value provided in the default initialization file. However, if you are using an unsupported board and the clock frequency is different from that of the supported EVM, a new value must be calculated as described in the user's manual of the particular processor that you are using.

**NOTE** The `set_hfmclkd`, `set_hfm_base`, and at least one `add_hfm_unit` command must exist to enable flash programming. All other flash memory commands are optional.

## set_hfm_base <address>

This command sets the address of `hfm_base`, which is where the flash control registers are mapped in X: memory.

**NOTE** The `set_hfm_base` and `add_hfm_unit` commands should not be changed for a particular processor. Their values will always be the same.

## set_hfm_config_base <address>

This command sets the address of `hfm_config_base`, which is where the flash security values are written in program flash memory. If this command is present, the debugger used the address to mimic part of the hardware reset behavior by copying the protection values from the configuration field to the appropriate flash control registers.

## add_hfm_unit <startAddr> <endAddr> <bank> <numSectors> <pageSize> <progMem> <boot> <interleaved>

This command adds a flash unit to the list and sets its parameters.

**NOTE** The `set_hfm_base` and `add_hfm_unit` commands should not be changed for a particular processor. Their values will always be the same.

### set_hfm_erase_mode   units | pages | all

This command sets the erase mode as `units`, `pages` or `all`. If you set this to `units`, the units that are programmed are mass erased. If set this to `pages`, the pages that are programmed are erased. If you set this to `all`, all units are mass erased including those that have not been programmed. If you omit this command, the erase mode defaults to the unit mode.

### set_hfm_verify_erase   1 | 0

If you set this to `1`, the debugger verifies that the flash memory has been erased, and alerts you if the erase failed. If this command is omitted, the flash erase is not verified.

### set_hfm_verify_program   1 | 0

If you set this to `1`, the debugger verifies that the flash has been programmed correctly, and alerts you if the programming failed. If you omit this command, flash programming is not verified.

### target_code_sets_hfmclkd   1 | 0

If you set this to `1`, the debugger uses an alternate launch sequence. First, the flash memory is loaded. Next, the processor is reset to clear the hfmclkd register to allow the correct divider to be set for the new system speed (as set by the PLL). Finally, if needed, the RAM is loaded.

When this option is enabled, the hfmclkd register needs to be loaded in the startup code. For more details on setting the hfmclkd register, see the chapter “Flash Memory” in the *MC56F8300 Peripheral User Manual*. For a demo of the proper use of this feature, see the example code.

## Flash Lock/Unlock

The **Flash Lock** and **Flash Unlock** commands let you control the Flash security state.

The **Flash Lock** command enables the Flash security state. In this state, you can not read the memory or the registers.

The **Flash Unlock** command disables the Flash security. This results in all the Flash memory being erased.

**NOTE** The **Flash Lock** and **Flash Unlock** commands can only be enabled if the debugger session is not running.

To use the **Flash Lock** or **Flash Unlock** command:

1. Kill any open debugger sessions.
2. Select a DSP56800E project with a Flash target.

**NOTE** A Flash target is a target using an initialization file containing Flash commands.

3. Select a Flash target.
4. Select either **Debug** > **56800E** > **Flash Lock** or **Debug** > **56800E** > **Flash Unlock** command.

# Notes for Debugging on Hardware

Below are some tips and some things to be aware of when debugging on a hardware target:

- Ensure your Flash data size fits into Flash memory.

  The linker command file specifies where data is written to. There is no bounds checking for Flash programming.

- The standard library I/O function such as `printf` uses large amount of memory and may not fit into flash targets.
- Use the Flash stationery when creating a new project intended for ROM.

  The default stationery contains the Flash configuration file and debugger settings required to use the Flash programmer.

- There is only one hardware breakpoint available, which is shared by IDE breakpoints (when the Breakpoint Mode is set to hardware in the **M56800E Target** panel), watchpoints, and EOnCE triggers. Only one of these may be set at a time.
- When a hardware breakpoint trigger is set to react to an instruction fetch (IDE hardware breakpoint or EOnCE trigger) be aware that the hardware will react to the fetch whether or not the fetched instruction is executed. For example, if a hardware breakpoint is set just after a loop, the processor will stop with the execution point inside the loop. This is because the target instruction will be fetched while the program is in the loop due to the large pipeline. A branch will occur to facilitate the loop; however, the processor will stop because the target instruction has already been fetched.

- The M56800E cannot single step over certain two and three-word uninterrupted sequences. However, the debugger compensates using software breakpoints and the trace buffer to allow single stepping in these situations. But, if these techniques cannot be used (e.g., debugging in ROM or the trace buffer in use) single stepping over these sequences results in the processor executing each instruction in the sequence before stopping. The execution will be correct. Just be aware of this "slide" in these situations.
- Debugging an application involves single-stepping through code. But if you don't modify interrupts that are part of normal code execution, the debugger could jump to interrupt-handler code, instead of stepping to the next instruction. By default, The CodeWarrior debugger for DSC automatically masks all interrupt levels when the user single steps over an instruction or a function and unmasks them afterwards. Therefore, the user is advised to be aware of the temporary interrupt mask enable values in Status Register (SR) when stepping over an inline assembly instruction that copies the value of SR to another location.

10

# Profiler

The profiler is a run-time feature that collects information about your program. It records the minimum, maximum, and total number of clock cycles spent in each function. The profiler allows you to evaluate your code and determine which functions require optimization.

When profiling is enabled, the compiler adds code to call the entry functions in the profiler library. These profiler library functions do all of the data collection. The profiler library, with the help of the debugger create a binary output file, which is opened and displayed by the CodeWarrior IDE.

**NOTE** For more information on the profiler library and its usage, see the *CodeWarrior Development Studio IDE 5.5 User's Guide Profiler Supplement*.

To enable your project for profiling:

1. Add the following path to your list of user paths in the Access Paths settings panel:

   ```
   {Compiler}M56800x Support\profiler
   ```

2. Add the following line to the file that contains the function main():

   ```
   #include "Profiler.h"
   ```

3. Add the profiler library file to your project. Select the library that matches your target from this path:

   ```
   {CodeWarrior path}M56800x Support\profiler\lib
   ```

4. Add the following function calls to main():

   ```
   ProfilerInit()
   ProfilerClear()
   ProfilerSetStatus()
   ProfilerDump()
   ProfilerTerm()
   ```

   For more details of these functions, see the *CodeWarrior Development Studio IDE 5.5 User's Guide Profiler Supplement*.

5. It may be necessary to increase the heap size to accommodate the profiler data collection.  This can be set in the linker command file by changing the value of __heap_size.

6. Enable profiling by setting the **Generate code for profiling** option in the **M56800E Processor** settings panel or by using the profile on | off pragma to select individual functions to profile.

**NOTE** For a profiler example, see the profiler example in this path: `{CodeWarrior path}(CodeWarrior_Examples)\SimpleProfiler`

# 11

# Inline Assembly Language and Intrinsics

The CodeWarrior™ compiler supports inline assembly language and intrinsic functions. This chapter explains the IDE implementation of Freescale assembly language, with regard to DSP56800E development. It also explains the relevant intrinsic functions.

This chapter contains these sections:

## Inline Assembly Language

This section explains how to use inline assembly language. It contains these sections:

### Inline Assembly Overview

To specify assembly-language interpretation for a block of code in your file, use the `asm` keyword and standard DSP56800E instruction mnemonics.

**NOTE** To make sure that the C compiler recognizes the `asm` keyword, you must clear the **ANSI Keywords Only** checkbox of the **C/C++ Language (C Only)** settings panel.
Differences in calling conventions mean that you cannot re-use DSP56800 assembly code in the DSP56800E compiler.

Listing 11.1 on page 230 shows how to use the `asm` keyword with braces, to specify that an *entire function* is in assembly language.

**Listing 11.1 Function-Level Syntax**

```
asm <function header>
{
        <assembly instructions>
}
```

The function header can be any valid C function header; the local declarations are any valid C local declarations.

Listing 11.2 on page 230 shows how to use the `asm` keyword with braces, to specify that a block of statements or a single statement is in assembly language.

**Listing 11.2 Statement-Level Syntax**

```
asm { inline assembly statement
      inline assembly statement
        . . .
}

asm {inline assembly statement}
```

The inline assembly statement is any valid assembly-language statement.

Listing 11.3 on page 230 shows how to use the `asm` keyword with parentheses, to specify that a single statement is in assembly language. Note that a semicolon must follow the close parenthesis.

**Listing 11.3 Alternate Single-Statement Syntax**

```
asm (inline assembly statement);
```

**NOTE** If you apply the `asm` keyword to one statement or a block of statements *within a function*, you must *not* define local variables within any of the inline-assembly statements.

## Assembly Language Quick Guide

Keep these rules in mind as you write assembly language functions:

1. Each statement must be a *label* or a *function*.
2. A *label* can be any identifier not already declared as a local variable.
3. All *labels* must follow the syntax:

   `[LocalLabel:]`

   Listing 11.4 on page 231 illustrates the use of labels.

### Listing 11.4 Labels in M56800E Assembly

```
x1:   add  x0,y1,a
x2:
      add  x0,y1,a
x3    add  x0,y1,a   //ERROR, MISSING COLON
```

4. All *instructions* must follow the syntax:

   `( (`*`instruction`*`) [`*`operands`*`] )`

5. Each statement must end with a new line
6. Assembly language directives, instructions, and registers are not case-sensitive. The following two statements are the same:

   ```
   add   x0,y0
   ADD   X0,Y0
   ```

7. Comments must have the form of C or C++ comments; they must not begin with the ; or # characters. on page 231Listing 11.5 on page 231 shows the valid syntax for comments.

### Listing 11.5 Valid Comment Syntax

```
    move.w     x:(r3),y0      #  ERROR
    add.w      x0,y0          // OK
    move.w     r2,x:(sp)      ; ERROR
    adda     r0,r1,n        /* OK */
```

8. To optimize a block of inline assembly source code, use the inline assembly directive `.optimize_iasm on` before the code block. Then use the directive `.optimize_iasm off` at the end of the block. (Omitting `.optimize_iasm off` means that optimizations continue to the end of the function.)

# Calling Assembly Language Functions from C Code

You can call assembly language functions from C just as you would call any standard C function, using standard C syntax.

## Calling Inline Assembly Language Functions

Listing 11.6 on page 232 demonstrates how to create an inline assembly language function in a C source file. This example adds two 16-bit integers and returns the result.

Notice that you are passing two 16-bit addresses to the `add_int` function. You pick up those addresses in R2 and R3, passing the sum back in Y0.

**Listing 11.6  Sample Code - Creating an Inline Assembly Language Function**

```
asm int add_int( int * i, int * j )
{
  move.w    x:(r2),y0
  move.w    x:(r3),x0
  add   x0,y0
  // int result returned in y0
  rts
}
```

Listing 11.7 on page 232 shows the C calling statement for this inline-assembly-language function.

**Listing 11.7  Sample Code - Calling an Inline Assembly Language Function**

```
  int x = 4, y = 2;

  y = add_int( &x, &y ); /* Returns 6 */
```

## Calling Pure Assembly Language Functions

If you want C code to call assembly language files, you must specify a `SECTION` mapping for your code, for appropriate linking. You must also specify a memory space location. Usually, this means that the `ORG` directive specifies code to program memory (P) space.

In the definition of an assembly language function, the `GLOBAL` directive must specify the current-section symbols that need to be accessible by other sections.

Listing 11.8 on page 233 is an example of a complete assembly language function. This function writes two 16-bit integers to program memory. A separate function is required for writing to P: memory, because C pointer variables allow access only to X: data memory.

The first parameter is a short value and the second parameter is the 16-bit address.

### Listing 11.8 Sample Code - Creating an Assembly Language Function

```
                          ;"my_asm.asm"
  SECTION user            ;map to user defined section in CODE
  ORG P:                  ;put the following program in P
                          ;memory

  GLOBAL  Fpmemwrite      ;This symbol is defined within the
                          ;current section and should be
                          ;accessible by all sections
Fpmemwrite:
  MOVE   Y1,R0            ;Set up pointer to address
  NOP                     ;Pipeline delay for R0
  MOVE   Y0,P:(R0)+       ;Write 16-bit value to address
                          ;pointed to by R0 in P: memory and
                          ;post-increment R0
  rts                     ;return to calling function

  ENDSEC                  ;End of section
  END                     ;End of source program
```

Listing 11.9 on page 233 shows the C calling statement for this assembly language function.

### Listing 11.9 Sample Code - Calling an Assembly Language Function from C

```
void pmemwrite( short, short );/* Write a value into P: memory */

void main( void )
{
  // ...other code

  // Write the value given in the first parameter to the address
  // of the second parameter in P: memory
  pmemwrite( (short)0xE9C8, (short)0x0010 );

  // other code...
}
```

## Calling Functions from Assembly Language

Assembly language programs can call functions written in either C or assembly language.

- From within assembly language instructions, you can call C functions. For example, if the C function definition is:

  ```
      void foot( void ) {
          /* Do something */
     }
  ```

  Your assembly language calling statement is:

  ```
  jsr  Ffoot
  ```

- From within assembly language instructions, you can call assembly language functions. For example, if `pmemwrite` is an assembly language function, the assembly language calling statement is:

  ```
  jsr  Fpmemwrite
  ```

# Intrinsic Functions

This section explains CodeWarrior intrinsic functions. It consists of these sections:

- Implementation on page 234
- Fractional Arithmetic on page 235
- Intrinsic Functions for Math Support on page 236
- Modulo Addressing Intrinsic Functions on page 267

## Implementation

The CodeWarrior IDE for DSP56800E has intrinsic functions to generate inline-assembly-language instructions. These intrinsic functions are a CodeWarrior extension to ANSI C.

Use intrinsic functions to target specific processor instructions. For example:

- Intrinsic functions let you pass in data for specific optimized computations. For example, ANSI C data-representation rules may make certain calculations inefficient, forcing the program to jump to runtime math routines. Such calculations would be coded more efficiently as assembly language instructions and intrinsic functions.
- Intrinsic functions can control small tasks, such as enabling saturation. One method is using inline assembly language syntax, specifying the operation in an `asm` block,

every time that the operation is required. But intrinsic functions let you merely set the appropriate bit of the operating mode register.

The IDE implements intrinsic functions as inline C functions in file `intrinsics_56800E.h`, in the MSL directory tree. These inline functions contain mostly inline assembly language code. An example is the `abs_s` intrinsic, defined as:

### Listing 11.10 Example Code - Definition of Intrinsic Function: abs_s

```
#define    abs_s(a) __abs_s(a)
           /* ABS_S */
inline Word16 __abs_s(register Word16 svar1)
{
/*
 *   Defn: Absolute value of a 16-bit integer or fractional value
 *        returning a 16-bit result.
 *        Returns $7fff for an input of $8000
 *
 *   DSP56800E instruction syntax:  abs FFF
 *             Allowed src regs:  FFF
 *             Allowed dst regs:  (same)
 *
 *   Assumptions: OMR's SA bit was set to 1 at least 3 cycles
 *   before this code.
 */
   asm(abs svar1);
   return svar1;
}
```

# Fractional Arithmetic

Many of the intrinsic functions use fractional arithmetic with *implied fractional values*. An implied fractional value is a symbol declared as an integer type, but calculated as a fractional type. Data in a memory location or register can be interpreted as fractional or integer, depending on program needs.

All intrinsic functions that generate multiply or divide instructions perform fractional arithmetic on implied fractional values. (These intrinsic functions are DIV, MPY, MAC, MPYR, and MACR) The relationship between a 16-bit integer and a fractional value is:

Fractional Value = Integer Value / ($2^{15}$)

The relationship between a 32-bit integer and a fractional value is similar:

Fractional Value = Long Integer Value / ($2^{31}$)

Table 11.1 on page 236 on page 236 shows how 16- and 32-bit values can be interpreted as either fractional or integer values.

**Table 11.1 Interpretation of 16- and 32-bit Values**

| Type | Hex | Integer Value | Fixed-point Value |
|---|---|---|---|
| short int | 0x2000 | 8192 | 0.25 |
| short int | 0xE000 | -8192 | -0.25 |
| long int | 0x20000000 | 536870912 | 0.25 |
| long int | 0xE0000000 | -536870912 | -0.25 |

**NOTE** Intrinsic functions us these macros:

Word16. — A macro for signed short.

Word32. — A macro for signed long.

## Intrinsic Functions for Math Support

Table 11.2 on page 237 lists the math intrinsic functions. See section “Modulo Addressing Intrinsic Functions.” for explanations of the remaining intrinsic functions.

For the latest information about intrinsic functions, refer to file `intrinsics_56800E.h`.

**Table 11.2 Intrinsic Functions for DSP56800E**

| Category | Function | Category (cont.) | Function (cont.) |
|---|---|---|---|
| Absolute/ Negate on page 239 | abs_s on page 239 | Multiplication/ MAC on page 250 | mac_r on page 250 |
| | negate on page 239 | | msu_r on page 251 |
| | L_abs on page 240 | | mult on page 252 |
| | L_negate on page 240 | | mult_r on page 252 |
| Addition/ Subtraction on page 241 | add on page 241 | | L_mac on page 253 |
| | sub on page 241 | | L_msu on page 253 |
| | L_add on page 242 | | L_mult on page 254 |
| | L_sub on page 243 | | L_mult_ls on page 255 |

**Table 11.2 Intrinsic Functions for DSP56800E (*continued*)**

| Category | Function | Category (cont.) | Function (cont.) |
|---|---|---|---|
| Control on page 243 | stop on page 243 | Normalization on page 255 | ffs_s on page 255 |
| | wait on page 244 | | norm_s on page 256 |
| | turn_off_conv_rndg on page 244 | | ffs_l on page 256 |
| | turn_off_sat on page 245 | | norm_l on page 257 |
| | turn_on_conv_rndg on page 245 | Rounding on page 258 | round on page 258 |
| | turn_on_sat on page 245 | Shifting on page 258 | shl on page 259 |
| Deposit/ Extract on page 245 | extract_h on page 246 | | shlftNs on page 260 |
| | extract_l on page 246 | | shlfts on page 260 |
| | L_deposit_h on page 247 | | shr on page 261 |
| | L_deposit_l on page 247 | | shr_r on page 262 |
| Division on page 247 | div_s on page 248 | | shrtNs on page 263 |
| | div_s4q on page 248 | | L_shl on page 263 |
| | div_ls on page 249 | | L_shlftNs on page 264 |
| | div_ls4q on page 249 | | L_shlfts on page 265 |
| | | | L_shr on page 265 |
| | | | L_shr_r on page 266 |
| | | | L_shrtNs on page 267 |

# Absolute/Negate

The intrinsic functions of the absolute-value/negate group are:

- abs_s on page 239
- negate on page 239
- L_abs on page 240
- L_negate on page 240

## abs_s

Absolute value of a 16-bit integer or fractional value returning a 16-bit result. Returns 0x7FFF for an input of 0x8000.

### Assumptions

OMR’s SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

### Prototype

```
Word16 abs_s(Word16 svar1)
```

### Example

```
int result, s1 = 0xE000;  /*  - 0.25    */
result = abs_s(s1);
// Expected value of result: 0x2000 = 0.25
```

## negate

Negates a 16-bit integer or fractional value returning a 16-bit result. Returns 0x7FFF for an input of 0x8000.

### Assumptions

OMR’s SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

### Prototype

```
Word16 negate(Word16 svar1)
```

### Example

```
int result, s1 = 0xE000;  /*  - 0.25    */

result = negate(s1);

// Expected value of result: 0x2000 = 0.25
```

## L_abs

Absolute value of a 32-bit integer or fractional value returning a 32-bit result. Returns 0x7FFFFFFF for an input of 0x80000000.

### Assumptions

OMR's SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

### Prototype

```
Word32 L_abs(Word32 lvar1)
```

### Example

```
long result, l = 0xE0000000;  /*  - 0.25    */

result = L_abs(s1);

// Expected value of result: 0x20000000 = 0.25
```

## L_negate

Negates a 32-bit integer or fractional value returning a 32-bit result. Returns 0x7FFFFFFF for an input of 0x80000000.

### Assumptions

OMR's SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

### Prototype

```
Word32 L_negate(Word32 lvar1)
```

### Example

```
long result, l = 0xE0000000;  /*  - 0.25    */
```

```
result = L_negate(s1);
// Expected value of result: 0x20000000 = 0.25
```

## Addition/Subtraction

The intrinsic functions of the addition/subtraction group are:

- add on page 241
- sub on page 241
- L_add on page 242
- L_sub on page 243

## add

Addition of two 16-bit integer or fractional values, returning a 16-bit result.

### Assumptions

OMR's SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

### Prototype

```
Word16 add(Word16 src_dst, Word16 src2)
```

### Example

```
short s1 = 0x4000;   /* 0.5  */
short s2 = 0x2000;   /* 0.25 */
short result;

result = add(s1,s2);
// Expected value of result: 0x6000 = 0.75
```

## sub

Subtraction of two 16-bit integer or fractional values, returning a 16-bit result.

### Assumptions

OMR’s SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

### Prototype

```
Word16 sub(Word16 src_dst, Word16 src2)
```

### Example

```
short s1 = 0x4000;   /* 0.5   */
short s2 = 0xE000;   /* -0.25 */
short result;

result = sub(s1,s2);
// Expected value of result: 0x6000 = 0.75
```

## L_add

Addition of two 32-bit integer or fractional values, returning a 32-bit result.

### Assumptions

OMR’s SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

### Prototype

```
Word32 L_add(Word32 src_dst, Word32 src2)
```

### Example

```
long la = 0x40000000;   /* 0.5  */
long lb = 0x20000000;   /* 0.25 */
long result;

result = L_add(la,lb);
// Expected value of result: 0x60000000 = 0.75
```

## L_sub

Subtraction of two 32-bit integer or fractional values, returning a 32-bit result.

### Assumptions

OMR’s SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

### Prototype

```
Word32 L_sub(Word32 src_dst, Word32 src2)
```

### Example

```
long la = 0x40000000;   /* 0.5   */
long lb = 0xE0000000;   /* -0.25 */
long result;

result = L_sub(la,lb);
// Expected value of result: 0x60000000 = 0.75
```

## Control

The intrinsic functions of the control group are:

- stop on page 243
- wait on page 244
- turn_off_conv_rndg on page 244
- turn_off_sat on page 245
- turn_on_conv_rndg on page 245
- turn_on_sat on page 245

## stop

Generates a STOP instruction which places the processor in the low power STOP mode.

### Prototype

```
void  stop(void)
```

### Usage

```
stop();
```

## wait

Generates a WAIT instruction which places the processor in the low power WAIT mode.

### Prototype

```
void  wait(void)
```

### Usage

```
wait();
```

## turn_off_conv_rndg

Generates a sequence for disabling convergent rounding by setting the R bit in the OMR register and waiting for the enabling to take effect.

**NOTE**

**NOTE** If convergent rounding is disabled, the assembler performs 2’s complement rounding.

### Prototype

```
void  turn_off_conv_rndg(void)
```

### Usage

```
turn_off_conv_rndg();
```

## turn_off_sat

Generates a sequence for disabling automatic saturation in the MAC Output Limiter by clearing the SA bit in the OMR register and waiting for the disabling to take effect.

### Prototype

```
void  turn_off_sat(void)
```

### Usage

```
turn_off_sat();
```

## turn_on_conv_rndg

Generates a sequence for enabling convergent rounding by clearing the R  bit in the OMR register and waiting for the enabling to take effect.

### Prototype

```
void  turn_on_conv_rndg(void)
```

### Usage

```
turn_on_conv_rndg();
```

## turn_on_sat

Generates a sequence for enabling automatic saturation in the MAC Output Limiter by setting the SA bit in the OMR register and waiting for the enabling to take effect.

### Prototype

```
void  turn_on_sat(void)
```

### Usage

```
turn_on_sat();
```

# Deposit/Extract

The intrinsic functions of the deposit/extract group are:

## extract_h

Extracts the 16 MSBs of a 32-bit integer or fractional value. Returns a 16-bit value. Does not perform saturation. When an accumulator is the destination, zeroes out the LSP portion. Corresponds to *truncation* when applied to fractional values.

### Prototype

```
Word16 extract_h(Word32 lsrc)
```

### Example

```
long l = 0x87654321;
short result;

result = extract_h(l);
// Expected value of result: 0x8765
```

## extract_l

Extracts the 16 LSBs of a 32-bit integer or fractional value. Returns a 16-bit value. Does not perform saturation. When an accumulator is the destination, zeroes out the LSP portion.

### Prototype

```
Word16 extract_l(Word32 lsrc)
```

### Example

```
long l = 0x87654321;
short result;

result = extract_l(l);
```

```
// Expected value of result: 0x4321
```

## L_deposit_h

Deposits the 16-bit integer or fractional value into the upper 16 bits of a 32-bit value, and zeroes out the lower 16 bits of a 32-bit value.

### Prototype

```
Word32 L_deposit_h(Word16 ssrc)
```

### Example

```
short s1 = 0x3FFF;
long result;

result = L_deposit_h(s1);
// Expected value of result: 0x3fff0000
```

## L_deposit_l

Deposits the 16-bit integer or fractional value into the lower 16 bits of a 32- bit value, and sign extends the upper 16 bits of a 32-bit value.

### Prototype

```
Word32 L_deposit_l(Word16 ssrc)
```

### Example

```
short s1 = 0x7FFF;
long result;

result = L_deposit_l(s1);
// Expected value of result: 0x00007FFF
```

## Division

The intrinsic functions of the division group are:

## div_s

Single quadrant division, that is, both operands are of positive 16-bit fractional values, returning a 16-bit result. If both operands are equal, returns 0x7FFF (occurs naturally).

**NOTE** Does not check for division overflow or division by zero.

### Prototype

```
Word16 div_s(Word16 s_numerator, Word16 s_denominator)
```

### Example

```
short s1=0x2000; /*  0.25 */
short s2=0x4000; /*  0.5  */
short result;

result = div_s(s1,s2);
// Expected value of result: 0.25/0.5 = 0.5 = 0x4000
```

## div_s4q

Four quadrant division of two 16-bit fractional values, returning a 16-bit result.

**NOTE** Does not check for division overflow or division by zero.

### Prototype

```
Word16 div_s4q(Word16 s_numerator, Word16 s_denominator)
```

### Example

```
short s1=0xE000;/*  -0.25 */
short s2=0xC000;/*  -0.5  */
short result;

result = div_s4q(s1,s2);
// Expected value of result: -0.25/-0.5 = 0.5 = 0x4000
```

## div_ls

Single quadrant division, that is, both operands are positive two 16-bit fractional values, returning a 16-bit result. If both operands are equal, returns 0x7FFF (occurs naturally).

**NOTE** Does not check for division overflow or division by zero.

### Prototype

```
Word16 div_ls(Word32 l_numerator, Word16 s_denominator)
```

### Example

```
long  l =0x20000000;/*  0.25 */
short s2=0x4000;/*  0.5  */
short result;

result = div_ls(l,s2);
// Expected value of result: 0.25/0.5 = 0.5 = 0x4000
```

## div_ls4q

Four quadrant division of a 32-bit fractional dividend and a 16-bit fractional divisor, returning a 16-bit result.

**NOTE** Does not check for division overflow or division by zero.

### Prototype

```
Word16 div_ls4q(Word32 l_numerator, Word16 s_denominator)
```

### Example

```
long  l =0xE0000000;/*  -0.25 */
short s2=0xC000;/*  -0.5  */
short result;

result = div_ls4q(s1,s2);
// Expected value of result: -0.25/-0.5 = 0.5 = 0x4000
```

## Multiplication/MAC

The intrinsic functions of the multiplication/MAC group are:

- mac_r on page 250
- msu_r on page 251
- mult on page 252
- mult_r on page 252
- L_mac on page 253
- L_msu on page 253
- L_mult on page 254
- L_mult_ls on page 255

## mac_r

Multiply two 16-bit fractional values and add to 32-bit fractional value. Round into a 16-bit result, saturating if necessary. When an accumulator is the destination, zeroes out the LSP portion.

### Assumptions

OMR’s SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

OMR’s R bit was set to 1 at least 3 cycles before this code, that is, 2’s complement rounding, not convergent rounding.

### Prototype

```
Word16 mac_r(Word32 laccum, Word16 sinp1, Word16 sinp2)
```

### Example

```
short s1 = 0xC000;/* - 0.5 */
short s2 = 0x4000;/*   0.5 */
short result;
long Acc = 0x0000FFFF;

result = mac_r(Acc,s1,s2);
// Expected value of result: 0xE001
```

## msu_r

Multiply two 16-bit fractional values and subtract this product from a 32-bit fractional value. Round into a 16-bit result, saturating if necessary.  When an accumulator is the destination, zeroes out the LSP portion.

### Assumptions

OMR’s SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

OMR’s R bit was set to 1 at least 3 cycles before this code, that is, 2’s complement rounding, not convergent rounding.

### Prototype

```
Word16 msu_r(Word32 laccum, Word16 sinp1, Word16 sinp2)
```

### Example

```
short s1 = 0xC000;/* - 0.5 */
short s2 = 0x4000;/*   0.5 */
short result;
long Acc = 0x20000000;

result = msu_r(Acc,s1,s2);
// Expected value of result: 0x4000
```

## mult

Multiply two 16-bit fractional values and truncate into a 16-bit fractional result. Saturates only for the case of 0x8000 x 0x8000. When an accumulator is the destination, zeroes out the LSP portion.

### Assumptions

OMR’s SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

### Prototype

```
Word16 mult(Word16 sinp1, Word16 sinp2)
```

### Example

```
short s1 = 0x2000;/*  0.25 */
short s2 = 0x2000;/*  0.25 */
short result;

result = mult(s1,s2);
// Expected value of result: 0.625 = 0x0800
```

## mult_r

Multiply two 16-bit fractional values, round into a 16-bit fractional result.  Saturates only for the case of 0x8000 x 0x8000. When an accumulator is the destination, zeroes out the LSP portion.

### Assumptions

OMR’s SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

OMR’s R bit was set to 1 at least 3 cycles before this code, that is, 2’s complement rounding, not convergent rounding.

### Prototype

```
Word16 mult_r(Word16 sinp1, Word16 sinp2)
```

### Example

```
short s1 = 0x2000;/*   0.25 */
short s2 = 0x2000;/*   0.25 */
short result;

result = mult_r(s1,s2);
// Expected value of result: 0.0625 = 0x0800
```

## L_mac

Multiply two 16-bit fractional values and add to 32-bit fractional value, generating a 32-bit result, saturating if necessary.

### Assumptions

OMR’s SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

### Prototype

```
Word32 L_mac(Word32 laccum, Word16 sinp1, Word16 sinp2)
```

### Example

```
short s1 = 0xC000;/* - 0.5 */
short s2 = 0x4000;/*   0.5 */
long result, Acc = 0x20000000;/*  0.25 */

result = L_mac(Acc,s1,s2);
// Expected value of result: 0
```

## L_msu

Multiply two 16-bit fractional values and subtract this product from a 32-bit fractional value, saturating if necessary. Generates a 32-bit result.

### Assumptions

OMR’s SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

### Prototype

```
Word32 L_msu(Word32 laccum, Word16 sinp1, Word16 sinp2)
```

### Example

```
short s1 = 0xC000;/* - 0.5 */
short s2 = 0xC000;/* - 0.5 */
long result, Acc = 0;

result = L_msu(Acc,s1,s2);
// Expected value of result: 0.25
```

## L_mult

Multiply two 16-bit fractional values generating a signed 32-bit fractional result. Saturates only for the case of 0x8000 x 0x8000.

### Assumptions

OMR’s SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

### Prototype

```
Word32 L_mult(Word16 sinp1, Word16 sinp2)
```

### Example

```
short s1 = 0x2000;/*  0.25 */
short s2 = 0x2000;/*  0.25 */
long result;

result = L_mult(s1,s2);
// Expected value of result: 0.0625 = 0x08000000
```

## L_mult_ls

Multiply one 32-bit and one-16-bit fractional value, generating a signed 32-bit fractional result. Saturates only for the case of 0x80000000 x 0x8000.

### Assumptions

OMR's SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

### Prototype

```
Word32 L_mult_ls(Word32 linp1, Word16 sinp2)
```

### Example

```
long l1 = 0x20000000;/* 0.25 */
short s2 = 0x2000;/* 0.25 */
long result;

result = L_mult(l1,s2);
// Expected value of result: 0.625 = 0x08000000
```

# Normalization

The intrinsic functions of the normalization group are:

- ffs_s on page 255
- norm_s on page 256
- ffs_l on page 256
- norm_l on page 257

## ffs_s

Computes the number of left shifts required to normalize a 16-bit value, returning a 16-bit result (finds 1st sign bit). Returns a shift count of 31 for an input of 0x0000.

**NOTE** Does not actually normalize the value! Also see the intrinsic norm_s on page 256 which handles the case where the input == 0x0000 differently.

### Prototype

```
Word16 ffs_s(Word16 ssrc)
```

### Example

```
short s1 = 0x2000;/* .25 */
short result;

result = ffs_s(s1);
// Expected value of result: 1
```

## norm_s

Computes the number of left shifts required to normalize a 16-bit value, returning a 16-bit result. Returns a shift count of 0 for an input of 0x0000.

**NOTE** Does not actually normalize the value! This operation is *not* optimal on the DSP56800E because of the case of returning 0 for an input of 0x0000. See the intrinsic ffs_s on page 255 which is more optimal but generates a different value for the case where the input == 0x0000.

### Prototype

```
Word16 norm_s(Word16 ssrc)
```

### Example

```
short s1 = 0x2000;/* .25 */
short result;

result = norm_s(s1);
// Expected value of result: 1
```

## ffs_l

Computes the number of left shifts required to normalize a 32-bit value, returning a 16-bit result (finds 1st sign bit). Returns a shift count of 31 for an input of 0x00000000.

**NOTE** Does not actually normalize the value! Also, see the intrinsic norm_l on page 257 which handles the case where the input == 0x00000000 differently.

### Prototype

```
Word16 ffs_l(Word32 lsrc)
```

### Example

```
long ll = 0x20000000;/* .25 */
short result;

result = ffs_l(ll);
// Expected value of result: 1
```

## norm_l

Computes the number of left shifts required to normalize a 32-bit value, returning a 16-bit result. Returns a shift count of 0 for an input of 0x00000000.

**NOTE** Does not actually normalize the value! This operation is *not* optimal on the DSP56800E because of the case of returning 0 for an input of 0x00000000. See the intrinsic ffs_l on page 256 which is more optimal but generates a different value for the case where the input == 0x00000000.

### Prototype

```
Word16 norm_l(Word32 lsrc)
```

### Example

```
long ll = 0x20000000;/* .25 */
short result;

result = norm_l(ll);
// Expected value of result: 1
```

# Rounding

The intrinsic function of the rounding group is:

- round on page 258

## round

Rounds a 32-bit fractional value into a 16-bit result. When an accumulator is the destination, zeroes out the LSP portion.

### Assumptions

OMR's R bit was set to 1 at least 3 cycles before this code, that is, 2's complement rounding, not convergent rounding.

OMR's SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

### Prototype

```
Word16 round(Word32 lvar1)
```

### Example

```
long l = 0x12348002;/*if low 16 bits = 0xFFFF > 0x8000 then
add 1 */
short result;

result = round(l);
// Expected value of result: 0x1235
```

# Shifting

The intrinsic functions of the shifting group are:

- shl on page 259
- shlftNs on page 260
- shlfts on page 260
- shr on page 261
- shr_r on page 262
- shrtNs on page 263

- L_shl on page 263
- L_shlftNs on page 264
- L_shlfts on page 265
- L_shr on page 265
- L_shr_r on page 266
- L_shrtNs on page 267

## shl

Arithmetic shift of 16-bit value by a specified shift amount. If the shift count is positive, a left shift is performed. Otherwise, a right shift is performed. Saturation may occur during a left shift. When an accumulator is the destination, zeroes out the LSP portion.

**NOTE** This operation is not optimal on the DSP56800E because of the saturation requirements and the bidirectional capability. See the intrinsic shlftNs on page 260 or shlfts on page 260 which are more optimal.

### Assumptions

OMR’s SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

### Prototype

```
Word16 shl(Word16 sval2shft, Word16 s_shftamount)
```

### Example

```
short result;
short s1 = 0x1234;
short s2 = 1;

result = shl(s1,s2);
// Expected value of result: 0x2468
```

## shlftNs

Arithmetic shift of 16-bit value by a specified shift amount. If the shift count is positive, a left shift is performed. Otherwise, a right shift is performed. Saturation does not occur during a left shift. When an accumulator is the destination, zeroes out the LSP portion.

**NOTE** Ignores upper N-5 bits of s_shftamount except the sign bit (MSB).

If s_shftamount is positive and the value in the lower 5 bits of s_shftamount is greater than 15, the result is 0.

If s_shftamount is negative and the absolute value in the lower 5 bits of s_shftamount is greater than 15, the result is 0 if sval2shft is positive, and 0xFFFF if sval2shft is negative.

### Prototype

```
Word16 shlftNs(Word16 sval2shft, Word16 s_shftamount)
```

### Example

```
short result;
short s1 = 0x1234;
short s2 = 1;

result = shlftNs(s1,s2);
// Expected value of result: 0x2468
```

## shlfts

Arithmetic left shift of 16-bit value by a specified shift amount. Saturation does occur during a left shift if required. When an accumulator is the destination, zeroes out the LSP portion.

**NOTE** This is not a bidirectional shift.

### Assumptions

Assumed s_shftamount is positive.

OMR’s SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

### Prototype

```
Word16 shlfts(Word16 sval2shft, Word16 s_shftamount)
```

### Example

```
short result;
short s1 = 0x1234;
short s2 = 3;

result = shlfts(s1,s2);
// Expected value of result: 0x91a0
```

## shr

Arithmetic shift of 16-bit value by a specified shift amount. If the shift count is positive, a right shift is performed. Otherwise, a left shift is performed. Saturation may occur during a left shift. When an accumulator is the destination, zeroes out the LSP portion.

**NOTE** This operation is not optimal on the DSP56800E because of the saturation requirements and the bidirectional capability. See the intrinsic shrtNs on page 263 which is more optimal.

### Assumptions

OMR’s SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

### Prototype

```
Word16 shr(Word16 sval2shft, Word16 s_shftamount)
```

### Example

```
short result;
short s1 = 0x2468;
short s2= 1;

result = shr(s1,s2);
// Expected value of result: 0x1234
```

## shr_r

Arithmetic shift of 16-bit value by a specified shift amount. If the shift count is positive, a right shift is performed. Otherwise, a left shift is performed. If a right shift is performed, then rounding performed on result. Saturation may occur during a left shift. When an accumulator is the destination, zeroes out the LSP portion.

**NOTE** This operation is not optimal on the DSP56800E because of the saturation requirements and the bidirectional capability. See the intrinsic shrtNs on page 263 which is more optimal.

### Assumptions

OMR's SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

### Prototype

```
Word16 shr_r(Word16 s_val2shft, Word16 s_shftamount)
```

### Example

```
short result;
short s1 = 0x2468;
short s2= 1;

result = shr(s1,s2);
// Expected value of result: 0x1234
```

## shrtNs

Arithmetic shift of 16-bit value by a specified shift amount. If the shift count is positive, a right shift is performed. Otherwise, a left shift is performed. Saturation does not occur during a left shift. When an accumulator is the destination, zeroes out the LSP portion.

**NOTE** Ignores upper N-5 bits of s_shftamount except the sign bit (MSB).

If s_shftamount is positive and the value in the lower 5 bits of s_shftamount is greater than 15, the result is 0 if sval2shft is positive, and 0xFFFF is sval2shft is negative.

If s_shftamount is negative and the absolute value in the lower 5 bits of s_shftamount is greater than 15, the result is 0.

### Prototype

```
Word16 shrtNs(Word16 sval2shft, Word16 s_shftamount)
```

### Example

```
short result;
short s1 = 0x2468;
short s2= 1;

result = shrtNs(s1,s2);
// Expected value of result: 0x1234
```

## L_shl

Arithmetic shift of 32-bit value by a specified shift amount. If the shift count is positive, a left shift is performed. Otherwise, a right shift is performed. Saturation may occur during a left shift. When an accumulator is the destination, zeroes out the LSP portion.

**NOTE** This operation is not optimal on the DSP56800E because of the saturation requirements and the bidirectional capability. See the intrinsic L_shlftNs on page 264 or L_shlfts on page 265 which are more optimal.

### Assumptions

OMR’s SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

### Prototype

```
Word32 L_shl(Word32 lval2shft, Word16 s_shftamount)
```

### Example

```
long result, l = 0x12345678;
short s2 = 1;

result = L_shl(l,s2);
// Expected value of result: 0x2468ACF0
```

## L_shlftNs

Arithmetic shift of 32-bit value by a specified shift amount. If the shift count is positive, a left shift is performed. Otherwise, a right shift is performed. Saturation does not occur during a left shift.

**NOTE** Ignores upper N-5 bits of s_shftamount except the sign bit (MSB).

### Prototype

```
Word32 L_shlftNs(Word32 lval2shft, Word16 s_shftamount)
```

### Example

```
long result, l = 0x12345678;
short s2= 1;

result = L_shlftNs(l,s2);
// Expected value of result: 0x2468ACF0
```

## L_shlfts

Arithmetic left shift of 32-bit value by a specified shift amount. Saturation does occur during a left shift if required.

**NOTE** This is not a bidirectional shift.

### Assumptions

Assumed s_shftamount is positive.

OMR’s SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

### Prototype

```
Word32 L_shlfts(Word32 lval2shft, Word16 s_shftamount)
```

### Example

```
long result, l = 0x12345678;
short s1 = 3;

result = shlfts(l, s1);
// Expected value of result: 0x91A259E0
```

## L_shr

Arithmetic shift of 32-bit value by a specified shift amount. If the shift count is positive, a right shift is performed. Otherwise, a left shift is performed. Saturation may occur during a left shift. When an accumulator is the destination, zeroes out the LSP portion.

**NOTE** This operation is not optimal on the DSP56800E because of the saturation requirements and the bidirectional capability. See the intrinsic L_shrtNs on page 267 which is more optimal.

### Assumptions

OMR’s SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

### Prototype

```
Word32 L_shr(Word32 lval2shft, Word16 s_shftamount)
```

### Example

```
long result, l = 0x24680000;
short s2= 1;

result = L_shrtNs(l,s2);
// Expected value of result: 0x12340000
```

## L_shr_r

Arithmetic shift of 32-bit value by a specified shift amount. If the shift count is positive, a right shift is performed. Otherwise, a left shift is performed. If a right shift is performed, then rounding performed on result. Saturation may occur during a left shift.

### Assumptions

OMR's SA bit was set to 1 at least 3 cycles before this code, that is, saturation on data ALU results enabled.

### Prototype

```
Word32 L_shr_r(Word32 lval2shft, Word16 s_shftamount)
```

### Example

```
long l1 = 0x41111111;
short s2 = 1;
long result;

result = L_shr_r(l1,s2);
// Expected value of result: 0x20888889
```

## L_shrtNs

Arithmetic shift of 32-bit value by a specified shift amount.If the shift count is positive, a right shift is performed. Otherwise, a left shift is performed. Saturation does not occur during a left shift.

**NOTE** Ignores upper N-5 bits of s_shftamount except the sign bit (MSB).

### Prototype

```
Word32 L_shrtNs(Word32 lval2shft, Word16 s_shftamount)
```

### Example

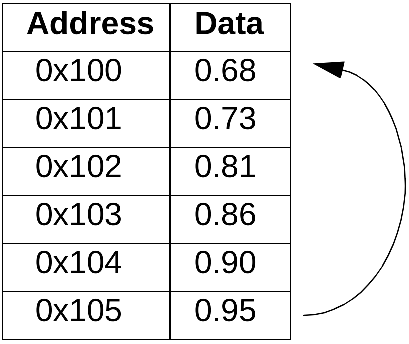
```
long result, l = 0x24680000;
short s2= 1;

result = L_shrtNs(l,s2);
// Expected value of result: 0x12340000
```

# Modulo Addressing Intrinsic Functions

A modulo buffer is a buffer in which the data pointer loops back to the beginning of the buffer once the pointer address value exceeds a specified limit.

Figure 11.1 on page 268 depicts a modulo buffer with the limit six. Increasing the pointer address value to 0x106 makes it point to the same data it would point to if its address value were 0x100.

**Figure 11.1 Example of a Modulo Buffer**



| Address | Data |
|---|---|
| 0x100 | 0.68 |
| 0x101 | 0.73 |
| 0x102 | 0.81 |
| 0x103 | 0.86 |
| 0x104 | 0.90 |
| 0x105 | 0.95 |

The CodeWarrior C compiler for DSP56800E uses intrinsic functions to create and manipulate modulo buffers. Normally, a modulo operation, such as the % operator, requires a runtime function call to the arithmetic library. For normally timed critical DSP loops, this binary operation imposes a large execution-time overhead.

The CodeWarrior implementation, however, replaces the runtime call with an efficient implementation of circular-address modification, either by using hardware resources or by manipulating the address mathematically.

Processors such as the DSP56800E have on-chip hardware support for modulo buffers. Modulo control registers work with the DSP pointer update addressing modes to access a range of addresses instead of a continuous, linear address space. But hardware support imposes strict requirements on buffer address alignment, pointer register resources, and limited modulo addressing instructions. For example, R0 and R1 are the only registers available for modulo buffers.

Accordingly, the CodeWarrior C compiler uses a well-defined set of instrinsic APIs to implement modulo buffers.

## Modulo Addressing Intrinsic Functions

The intrinsic functions for modulo addressing are:

- __mod_init on page 269
- __mod_initint16 on page 269
- __mod_start on page 270
- __mod_access on page 270
- __mod_update on page 271
- __mod_stop on page 271
- __mod_getint16 on page 271
- __mod_setint16 on page 272

- __mod_error on page 272

## __mod_init

Initialize a modulo buffer pointer with arbitrary data using the address specified by the <addr_expr>. This function expects a byte address. <addr_expr> is an arbitrary C expression which normally evaluates the address at the beginning of the modulo buffer, although it may be any legal buffer address. The <mod_desc> evaluates to a compile time constant of either 0 or 1, represented by the modulo pointers R0 or R1, respectively. The <mod_sz> is a compile time integer constant representing the size of the modulo buffer in bytes. The <data_sz> is a compile time integer constant representing the size of data being stored in the buffer in bytes. <data_sz> is usually derived from the sizeof() operator.

The __mod_init function may be called independently for each modulo pointer register.

If __mod_error has not been previously called, no record of __mod_init errors are saved.

If __mod_error has been previously called, __mod_init may set one of the error condition in the static memory location defined by __mod_error. (See __mod_error description for a complete list of error conditions).

### Prototype

```
void __mod_init (
int <mod_desc>,
void * <addr_expr>,
int <mod_sz>,
int <data_sz>  );
```

### Example

Initialize a modulo buffer pointer with a buffer size of 3 and where each element is a structure:

```
__mod_init(0, (void *)&struct_buf[0], 3, sizeof(struct 
mystruct) );
```

## __mod_initint16

Initialize modulo buffer pointer with integer data. The __mod_initint16 function behaves similarly to the __mod_init function, except that word addresses are used to initialize the modulo pointer register.

### Prototype

```
void __mod_initint16(
int <mod_desc>,
int * <addr_expr>,
int <mod_sz> );
```

### Example

Initialize an integer modulo buffer pointer with a buffer size of 10.

```
__mod_initint16(0, &int_buf[9], 10);
```

## __mod_start

Write the modulo control register. The __mod_start function simply writes the modulo control register (M01) for each modulo pointer register which has been previously initialized. The values written to M01 depends on the size of the modulo buffer and which pointers have been initialized.

### Prototype

```
void __mod_start( void );
```

## __mod_access

Retrieve the modulo pointer. The __mod_access function returns the modulo pointer value specified by <mod_desc> in the R2 register, as per calling conventions. The value returned is a byte address. The data in the modulo buffer may be read or written by a cast and dereference of the resulting pointer.

### Prototype

```
void  *__mod_access( int <mod_desc>);
```

### Example

Assign a value to the modulo buffer at the current pointer.

```
*((char *)__mod_access(0)) = (char)i;
```

## __mod_update

Update the modulo pointer. The __mod_update function updates the modulo pointer by the number of data type units specified in <amount>. <amount> may be negative. Of course, the pointer will wrap to the beginning of the modulo buffer if the pointer is advanced beyond the modulo boundaries. <amount> must be a compile time constant.

### Prototype

```
void  __mod_update( int <mod_desc>, int <amount>);
```

### Example

Advance the modulo pointer by 2 units.

```
__mod_update(0, 2);
```

## __mod_stop

Reset modulo addressing to linear addressing. This function writes the modulo control register with a value which restore linear addressing to the R0 and R1 pointer registers.

### Prototype

```
void  __mod_stop( int <mod_desc );
```

## __mod_getint16

Retrieve a 16-bit signed value from the modulo buffer and update the modulo pointer.This function returns an integer value from the location pointed to by the modulo pointer. The function then updates the modulo pointer by <amount> integer units (<amount>*2 bytes). <amount> must be a compile time constant.

### Prototype

```
int __mod_getint16( int <mod_desc>, int <amount> );
```

### Example

Retrieve an integer value from a modulo buffer and update the modulo buffer pointer by one word.

```
int y;
y = __mod_getint16(0, 1);
```

## __mod_setint16

Write a 16-bit signed integer to the modulo buffer and update the pointer. This function evaluates <int_expr> and copies the value to the location pointed to by the modulo pointer. The modulo pointer is then updated by <amount>. <amount> must be a compile time constant.

### Prototype

```
int __mod_setint16( int <mod_desc>, int <int_expr>, int
     <amount> );
```

### Example

Write the modulo buffer with a value derived from an expression, do not update modulo pointer.

```
__mod_setint16( 0, getrandomint(), 0 );
```

## __mod_error

Set up a modulo error variable. This function registers a static integer address to hold the error results from any of the modulo buffer API calls. The function returns 0 if it is successful, 1 otherwise. The argument must be the address of a static, global integer variable. This variable holds the result of calling each of the previously defined API functions. This allows the user to monitor the status of the error variable and take action if the error variable is non-zero. Typically, the user would use __mod_error during development and remove it once debugging is complete. __mod_error generates no code, although the error variable may occupy a word of memory. A non-zero value in the error variable indicates a misuse of the one of the API functions. Once the error variable is set it is reset when __mod_stop is called. The error variable contains the error number of the last error. A successful call to an API function will not reset the error variable; only __mod_stop will reset the error variable.

### Prototype

```
int __mod_error( int * <static_object_addr>);
```

### Example

Register the error number variable

```
static int myerrno;


assert( __mod_error(&myerrno) == 0 ) ;
```

## Modulo Buffer Examples

Listing 11.11 on page 273 and Listing 11.12 on page 274.are two modulo buffer examples.

**Listing 11.11 Modulo Buffer Example 1**

```
#pragma define_section DATA_INT_MODULO ".data_int_modulo"


/* Place the buffer object in a unique section so the it can be aligned
properly in the linker control file. */

#pragma section DATA_INT_MODULO begin
int int_buf[10];
#pragma section DATA_INT_MODULO end


                                                     /* Convenient
defines for modulo descriptors */

#define M0 0
#define M1 1

int main ( void )
{
                                                     int i;

/*   Modulo buffer will be initialized. R0 will be the modulo pointer
register. The buffer size is 10 units. The unit size is ‘sizeof(int)’.
*/

  __mod_init(M0, (void *)&int_buf[0], 10, sizeof(int));

/* Write the modulo control register */

  __mod_start();

/* Write int_buf[0] through int_buf[9]. R0 initially points at
int_buf[0] and wraps when the pointer value exceeds int_buf[9]. The
pointer is updated by 1 unit each time through the loop */

                                                     for ( i=0;
i<100; i++ )
                                                     {

                                                     *((int
*)__mod_access(M0)) = i;
                                                     __mod_update(M0,
1);

                                                     }

/* Reset modulo control register to linear addressing mode */
                                                     __mod_stop();

}
```

**Listing 11.12 Modulo Buffer Example 2**

```
/* Set up a static location to save error codes */
if ( ! __mod_error(&err_codes)) {
                                                     printf
("__mod_error set up failed\n");
}

/* Initialize a modulo buffer pointer, pointing to an array of 10 ints.
*/

__mod_initint16(M0, &int_buf[9], 10);

/* Check for success of previous call */

                                                     if ( err_code ) {
printf ( "__mod_initint16 failed\n" ) };

                                                     __mod_start();


/* Write modulo buffer with the result of the expression "i".
Decrement the buffer pointer for each execution of the loop.
The modulo buffer wraps from index 0 to 9 through the entire execution
of the loop. */

                                                     for ( i=100;
i>0; i-- ) {
```

```
__mod_setint16(M0, i, -1);
                                                        }
                                                        __mod_stop();
```

## Points to Remember

As you use modulo buffer intrinsic functions, keep these points in mind:

1. You must align modulo buffers properly, per the constraints that the *M56800E User's Manual* explains. There is no run-time validation of alignment. Using the modulo buffer API on unaligned buffers will cause erratic, unpredictable behavior during data accesses.
2. Calling `__mod_start()` to write to the modulo control register effectively changes the hardware's global-address-generation state. This change of state affects all user function calls, run-time supporting function calls, standard library calls, and interrupts.
3. You must account for any side-effects of enabling modulo addressing. Such a side-effect is that R0 and R1update in a modulo way.
4. If you need just one modulo pointer is required, use the R0 address register. Enabling the R1 address register for modulo use also enables the R0 address register for modulo use. This is true even if `__mod_init()` or `__mod_initint16()` have not explicitly initialized R0.
5. A successful API call does not clear the error code from the error variable. Only function `__mod_stop` clears the error code.

## Modulo Addressing Error Codes

If you want to register a static variable for error-code storage, use `__mod_error()`. In case of an error occur, this static variable will contain one of the values Table 11.3 on page 275 explains. Table 11.4 on page 276. lists the error codes possible for each modulo addressing intrinsic function.

**Table 11.3 Modulo Addressing Error Codes**

| Code | Meaning |
|---|---|
| 11 | <mod_desc> parameter must be zero or one. |
| 12 | R0 modulo pointer is already initialized. An extraneous call to `__mod_init` or `__mod_initint16` to initialize R0 has been made. |

### Table 11.3 Modulo Addressing Error Codes (*continued*)

| Code | Meaning |
|---|---|
| 13 | R1 modulo pointer is already initialized. An extraneous call to `__mod_init` or `__mod_initint16` to initialize R1 has been made. |
| 14 | Modulo buffer size must be a compile time constant. |
| 15 | Modulo buffer size must be greater than one. |
| 16 | Modulo buffer size is too big. |
| 17 | Modulo buffer size for R0 and R1 must be the same. |
| 18 | Modulo buffer data types for R0 and R1 must be the same. |
| 19 | Modulo buffer has not been initialized. |
| 20 | Modulo buffer has not been started. |
| 21 | Parameter is not a compile time constant. |
| 22 | Attempt to use word pointer functions with byte pointer initialization. `__mod_getint16` and `__mod_setint16` were called but `__mod_init` was used for initialization. `__mod_initint16` is required for pointer initialization. |
| 23 | Modulo increment value exceeds modulo buffer size. |
| 24 | Attempted use of R1 as a modulo pointer without initializing R0 for modulo use. |

### Table 11.4 Possible Error Codes

| Function | Possible Error Code |
|---|---|
| `__mod_init` | 11, 12, 13, 14, 15, 16, 17, 18, 21 |
| `__mod_stop` | none |
| `__mod_getint16` | 11, 14, 20, 22, 24 |
| `__mod_setint16` | 11, 14, 20, 22, 24 |
| `__mod_start` | none |
| `__mod_access` | 11, 19, 20, 24 |

**Table 11.4 Possible Error Codes (*continued*)**

| Function | Possible Error Code |
|---|---|
| `__mod_update` | 11, 14, 20, 23, 24 |
| `__mod_initint16` | 11, 12, 13, 14, 15, 16, 17 |

# 12

# ELF Linker

The CodeWarrior™ Executable and Linking Format (ELF) Linker makes a program file out of the object files of your project. The linker also allows you to manipulate code in different ways. You can define variables during linking, control the link order to the granularity of a single function, change the alignment, and even compress code and data segments so that they occupy less space in the output file.

All of these functions are accessed through commands in the linker command file (LCF). The linker command file has its own language complete with keywords, directives, and expressions, that are used to create the specifications for your output code. The syntax and structure of the linker command file is similar to that of a programming language.

This chapter contains the following sections:

- Structure of Linker Command Files on page 279
- Linker Command File Syntax on page 282
- Linker Command File Keyword Listing on page 291

## Structure of Linker Command Files

Linker command files contain three main segments:

- Memory Segment on page 279
- Closure Blocks on page 280
- Sections Segment on page 281

A command file must contain a memory segment and a sections segment. Closure segments are optional.

### Memory Segment

In the memory segment, available memory is divided into segments. The memory segment format looks like Listing 12.1 on page 279.

**Listing 12.1 Sample MEMORY Segment**

```
MEMORY {
    segment_1 (RWX): ORIGIN = 0x8000, LENGTH = 0x1000
    segment_2 (RWX): ORIGIN = AFTER(segment_1), LENGTH = 0
    data       (RW)  : ORIGIN = 0x2000, LENGTH = 0x0000
    #segment_name (RW)  : ORIGIN = memory address, LENGTH = segment
    #length
    #and so on...
   }
```

The first memory segment definition (`segment_1`) can be broken down as follows:

- the (`RWX`) portion of the segment definition pertains to the ELF access permission of the segment. The (RWX) flags imply **r**ead, **w**rite, and e**x**ecute access.
- `ORIGIN` represents the start address of the memory segment (in this case `0x8000`).
- `LENGTH` represents the size of the memory segment (in this case `0x1000`).

Memory segments with RWX attributes are placed into P: memory while RW attributes are placed into X: memory.

If you cannot predict how much space a segment will occupy, you can use the function `AFTER` and `LENGTH = 0` (unlimited length) to fill in the unknown values.

# Closure Blocks

The linker is very good at deadstripping unused code and data. Sometimes, however, symbols need to be kept in the output file even if they are never directly referenced. Interrupt handlers, for example, are usually linked at special addresses, without any explicit jumps to transfer control to these places.

Closure blocks provide a way to make symbols immune from deadstripping. The closure is transitive, meaning that symbols referenced by the symbol being closed are also forced into closure, as are any symbols referenced by those symbols, and so on.

**NOTE** The closure blocks need to be in place before the SECTIONS definition in the linker command file.

The two types of closure blocks available are:

- Symbol-level

  Use `FORCE_ACTIVE` to include a symbol into the link that would not be otherwise included. An example is shown in Listing 12.2 on page 280.

### Listing 12.2 Sample Symbol-level Closure Block

```
FORCE_ACTIVE {break_handler, interrupt_handler, my_function}
```

- Section-level

Use KEEP_SECTION when you want to keep a section (usually a user-defined section) in the link. Listing 12.3 on page 281 shows an example.

#### Listing 12.3 Sample Section-level Closure Block

```
KEEP_SECTION {.interrupt1, .interrupt2}
```

A variant is REF_INCLUDE. It keeps a section in the link, but only if the file where it is coming from is referenced. This is very useful to include version numbers. Listing 12.4 on page 281 shows an example of this.

#### Listing 12.4 Sample Section-level Closure Block With File Dependency

```
REF_INCLUDE {.version}
```

## Sections Segment

Inside the sections segment, you define the contents of your memory segments, and define any global symbols to be used in the output file.

The format of a typical sections block looks like Listing 12.5 on page 281.

**NOTE** As shown in Listing 12.5 on page 281, the .bss section always needs to be put at the end of a segment or in a standalone segment, because it is not a loadable section.

#### Listing 12.5 Sample SECTIONS Segment

```
SECTIONS {
   .section_name : #the section name is for your reference
   {               #the section name must begin with a '.'
     filename.c   (.text) #put the .text section from filename.c
     filename2.c (.text) #then the .text section from filename2.c
     filename.c   (.data)
     filename2.c (.data)
     filename.c   (.bss)
     filename2.c (.bss)
      . = ALIGN (0x10);  #align next section on 16-byte boundary.
   } > segment_1     #this means "map these contents to segment_1"

   .next_section_name:
   {
      more content descriptions
   } > segment_x       # end of .next_section_name definition
   }                      # end of the sections block
```

# Linker Command File Syntax

This section explains some practical ways in which to use the commands of the linker command file to perform common tasks.

## Alignment

To align data on a specific word-boundary, use the ALIGN on page 293 and ALIGNALL on page 293 commands to bump the location counter to the preferred boundary. For example, the following fragment uses `ALIGN` to bump the location counter to the next 16-byte boundary. An example is given in Listing 12.6 on page 282.

**Listing 12.6  Sample ALIGN Command Usage**

```
file.c (.text)
. = ALIGN (0x10);
file.c (.data)    # aligned on a word boundary.
```

You can also align data on a specific word-boundary with `ALIGNALL`, as shown in Listing 12.7 on page 282.

**Listing 12.7  Sample ALIGNALL Command Usage**

```
file.c (.text)
ALIGNALL (0x10);  #everything past this point aligned on word boundary
file.c (.data)
```

## Arithmetic Operations

Standard C arithmetic and logical operations may be used to define and use symbols in the linker command file. Table 12.1 on page 283 shows the order of precedence for each operator. All operators are left-associative.

### Table 12.1 Arithmetic Operators

| Precedence | Operators |
|---|---|
| highest (1) | `- ~ !` |
| 2 | `* / %` |
| 3 | `+ -` |
| 4 | `>> <<` |
| 5 | `== != > < <= >=` |
| 6 | `&` |
| 7 | `\|` |
| 8 | `&&` |
| 9 | `\|\|` |

**NOTE** The shift operator shifts two-bits for each shift operation. The divide operator performs division and rounding.

# Comments

Comments may be added by using the pound character (#) or C++ style double-slashes (//). C-style comments are not accepted by the LCF parser. Listing 12.8 on page 283 shows examples of valid comments.

### Listing 12.8 Sample Comments

```
#  This is a one-line comment
* (.text) // This is a partial-line comment
```

# Deadstrip Prevention

The M56800E linker removes unused code and data from the output file. This process is called deadstripping. To prevent the linker from deadstripping unreferenced code and data, use the FORCE_ACTIVE on page 294, KEEP_SECTION on page 295, and REF_INCLUDE on page 297 directives to preserve them in the output file.

# Variables, Expressions, and Integral Types

This section explains variables, expressions, and integral types.

## Variables and Symbols

All symbol names within a Linker Command File (LCF) start with the underscore character (_), followed by letters, digits, or underscore characters. Listing 12.9 on page 284 shows examples of valid lines for a command file:

**Listing 12.9 Valid Command File Lines**

```
_dec_num = 99999999;
_hex_num_ = 0x9011276;
```

Variables that are defined within a `SECTIONS` section can only be used within a `SECTIONS` section in a linker command file.

## Global Variables

Global variables are accessed in a linker command file with an ‘F’ prepended to the symbol name. This is because the compiler adds an ‘F’ prefix to externally defined symbols.

Listing 12.10 on page 284 shows an example of using a global variable in a linker command file. This example sets the global variable `_foot`, declared in C with the `extern` keyword, to the location of the address location current counter.

**Listing 12.10 Using a Global Variable in the LCF**

```
F_foot = .;
```

If you use a global symbol in an LCF, as in Listing 12.10 on page 284, you can access it from C program sources as shown in Listing 12.11 on page 284.

**Listing 12.11 Accessing a Global Symbol From C Program Sources**

```
extern unsigned long _foot;
void main( void ) {
  unsigned long i;
  // ...
  i = _foot;   // _foot value determined in LCF
  // ...
}
```

## Expressions and Assignments

You can create symbols and assign addresses to those symbols by using the standard assignment operator. An assignment may only be used at the start of an expression, and a semicolon is required at the end of an assignment statement. An example of standard assignment operator usage is shown in Listing 12.12 on page 285.

### Listing 12.12 Standard Assignment Operator Usage

```
_symbolicname = some_expression;                      # Legal
_sym1 + _sym2 = _sym3;          # ILLEGAL!
```

When an expression is evaluated and assigned to a variable, it is given either an absolute or a relocatable type. An absolute expression type is one in which the symbol contains the value that it will have in the output file. A relocatable expression is one in which the value is expressed as a fixed offset from the base of a section.

## Integral Types

The syntax for linker command file expressions is very similar to the syntax of the C programming language. All integer types are `long` or `unsigned long`.

Octal integers (commonly know as base eight integers) are specified with a leading zero, followed by numeral in the range of zero through seven. Listing 12.13 on page 285 shows valid octal patterns that you can put into your linker command file.

### Listing 12.13 Sample Octal Patterns

```
_octal_number  = 012;
_octal_number2 = 03245;
```

Decimal integers are specified as a non-zero numeral, followed by numerals in the range of zero through nine. To create a negative integer, use the minus sign (-) in front of the number. Listing 12.14 on page 285 shows examples of valid decimal integers that you can write into your linker command file.

### Listing 12.14 Sample Decimal Integers

```
_dec_num       = 9999;
_decimalNumber = -1234;
```

Hexadecimal (base sixteen) integers are specified as `0x` or `0X` (a zero with an X), followed by numerals in the range of zero through nine, and/or characters `A` through `F`. Examples of valid hexadecimal integers that you can put in your linker command file appear in Listing 12.15 on page 286.

**Listing 12.15 Sample Hex Integers**

```
_somenumber         = 0x0F21;
_fudgefactorspace = 0XF00D;
_hexonyou           = 0xcafe;
```

**NOTE** When assigning a value to a pointer variable, the value is in byte units despite that in the linked map (.xMAP file), the variable value appears in word units.

## File Selection

When defining the contents of a `SECTION` block, specify the source files that are contributing to their sections.

In a large project, the list can become very long. For this reason, you have to use the asterisk (*) keyword. The * keyword represents the filenames of every file in your project. Note that since you have already added the `.text` sections from the `main.c`, `file2.c`, and `file3.c files`, the * keyword does not include the `.text` sections from those files again.

## Function Selection

The OBJECT on page 297 keyword allows precise control over how functions are placed within a section. For example, if the functions `pad` and `foot are` to be placed before anything else in a section, use the code as shown in the example in Listing 12.16 on page 286.

**Listing 12.16 Sample Function Selection Using OBJECT Keyword**

```
SECTIONS {
  .program_section :
    {
      OBJECT (Fpad, main.c)
      OBJECT (Ffoot, main.c)
      * (.text)
     } > ROOT
  }
```

**NOTE** If an object is written once using the `OBJECT` function selection keyword, the same object will not be written again if you use the '`*`' file selection keyword.

## ROM to RAM Copying

In embedded programming, it is common to copy a portion of a program resident in ROM into RAM at runtime. For example, program variables cannot be accessed until they are copied to RAM.

To indicate data or code that is meant to be copied from ROM to RAM, the data or code is assigned two addresses. One address is its resident location in ROM (where it is downloaded). The other is its intended location in RAM (where it is later copied in C code).

Use the `MEMORY` segment to specify the intended RAM location, and the `AT(address)` parameter to specify the resident ROM address.

For example, you have a program and you want to copy all your initialized data into RAM at runtime. Listing 12.17 on page 287 shows the LCF you use to set up for writing data to ROM.

### Listing 12.17 LCF to Setup for ROM to RAM Copy

```
MEMORY {
  .text  (RWX) : ORIGIN = 0x8000, LENGTH = 0x0        # code (p:)
  .data  (RW)  : ORIGIN = 0x3000, LENGTH = 0x0        # data (x:)->
RAM
}

SECTIONS{

    .main_application :
  {
     # .text sections

     *(.text)
     *(.rtlib.text)
     *(.fp_engine.txt)
     *(user.text)
  } > .text

   __ROM_Address = 0x2000
   .data : AT(__ROM_Address)   # ROM Address definition
  {
     # .data sections
     F__Begin_Data = .;        # Start location for RAM (0x3000)
     *(.data)                  # Write data to the section (ROM)
     *(fp_state.data);
     *(rtlib.data);
     F__End_Data = .;          # Get end location for RAM

     # .bss sections
     * (rtlib.bss.lo)
     * (.bss)
     F__ROM_Address = __ROM_Address

} > .data
}
```

To make the runtime copy from ROM to RAM, you need to know where the data starts in ROM (`__ROM_Address`) and the size of the block in ROM you want to copy to RAM. In the following example (Listing 12.18 on page 288), copy all variables in the data section from ROM to RAM in C code.

### Listing 12.18 ROM to RAM Copy From C After Writing Data Flash

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

int GlobalFlash = 6;

// From linker command file
extern __Begin_Data, __ROMAddress, __End_Data;

void main( void )
{
   unsigned short a = 0, b = 0, c = 0;
   unsigned long dataLen  = 0x0;
   unsigned short __myArray[] = { 0xdead, 0xbeef, 0xcafe };

   // Calculate the data length of the X: memory written to Flash
   dataLen = (unsigned long)&__End_Data -
   unsigned long)&__Begin_Data;

   // Block move from ROM to RAM
   memcpy( (unsigned long *)&__Begin_Data,
  (const unsigned long *)&__ROMAddress,dataLen );

   a = GlobalFlash;

   return;
 }
```

# Utilizing Program Flash and Data RAM for Constant Data in C

There are many advantages and one disadvantage if constant data in C is flashed to program flash memory (pROM) and copied to data flash memory (xRAM) at startup, with the usual pROM-to-xRAM initialization.

The advantages are:

- constant data is defined and addressed conventionally via C language
- pROM flash space is used for constant data (pROM is usually larger than xROM)
- the pROM flash is now freed up or available

The disadvantage is that the xRAM is consumed for constant data at run-time.

If you wish to store constant data in program flash memory and have it handled by the pROM-to-xRAM startup process, a simple change is necessary to the pROM-to-xRAM LCF. Simply, place the constant data references into the data_in_p_flash_ROM section after the __xRAM_data_start variable like the other data references and remove the "data in xROM" section. Please see Listing 12.19 on page 289.

### Listing 12.19 Using the Typical pROM-to-xRAM LCF

```
.data_in_p_flash_ROM : AT(__pROM_data_start)
{
   __xRAM_data_start = .;

   * (.const.data.char) # move constant data references here
   * (.const.char)

   * (.data.char)
   * (.data)

   etc.
```

# Utilizing Program Flash for User-Defined Constant Section in Assembler

There are many advantages and one disadvantage in writing specific data to pROM with linker commands and accessing this data in assembly,

The advantages are:

- pROM flash space is used for user-specified constant data (pROM is usually larger than xROM), where the constant data is defined and addressed by assembly language

- part of the pROM flash is now freed up or available

The disadvantage is that data is not defined or accessed conventionally via C language; data is specifically flashed to pROM via the linker command file and fetched from pROM with assembly.

If you want to keep specific constant data in pROM and access it from there, you can use the linker commands to explicitly store the data in pROM and then later access the data in pROM with assembly.

The next two sections describe putting data in the pROM flash at build and run-time.

## Putting Data in pROM Flash at Build-time

The linker commands have specific instructions which set values in the binary image at the build time (Listing 12.20 on page 290). For example, WRITEH inserts two bytes of data at the current address of a section. These commands are placed in the LCF, which tells the linker at build time to place data in P or X memory. Optionally, you can also set the current location prior to the write command to ensure a specific location address for easier reference later. The location within the section is not important.

For more information, please see the LCF section in this document.

**Listing 12.20 LCF write example using MC56F832x for build-time**

```
.executing_code :
{
   # .text sections

   . = 0x00A4; # optionally set the location -- we use 0x00A4 in this
   case
   WRITEH(0xABCD); # now set some value here; location within the
   section is not important
   * (.text)
   * (interrupt_routines.text)
   * (rtlib.text)
   * (fp_engine.text)
   * (user.text)

   etc

   } > .p_flash_ROM
```

Putting Data in pROM Flash at Run-time

The assembly example in Listing 12.21 on page 291 fetches the pROM-flashed value at run-time in Listing 12.20 on page 290.

**Listing 12.21 LCF write example using MC56F832x for run-time**

```
move.l #$00A4, r1 ; move the pROM address into r3
move.w p:(r3)+, x0 ; fetch data from pROM at address r1 into x0
```

## Stack and Heap

To reserve space for the stack and heap, arithmetic operations are performed to set the values of the symbols used by the runtime.

The Linker Command File (LCF) performs all the necessary stack and heap initialization. When Stationery is used to create a new project, the appropriate LCFs are added to the new project.

See any Stationery-generated LCFs for examples of how stack and heap are initialized.

## Writing Data Directly to Memory

You can write data directly to memory using the `WRITEx` command in the linker command file. The `WRITEB` command writes a byte, the `WRITEH` command writes two bytes, and the `WRITEW` command writes four bytes. You insert the data at the section’s current address.

**Listing 12.22 Embedding Data Directly Into Output**

```
.example_data_section :
{
   WRITEB 0x48;  //  'H'
   WRITEB 0x69;  //  'i'
   WRITEB 0x21;  //  '!'
}
```

# Linker Command File Keyword Listing

This section explains the keywords available for use when creating CodeWarrior Development Studio for Freescale 56800/E Digital Signal Controllers application objects with the linker command file. Valid linker command file functions, keywords, directives, and commands are:

## . (location counter)

The period character (.) always maintains the current position of the output location. Since the period always refers to a location in a SECTIONS on page 297 block, it can not be used outside a section definition.

A period may appear anywhere a symbol is allowed. Assigning a value to period that is greater than its current value causes the location counter to move, but the location counter can never be decremented.

This effect can be used to create empty space in an output section. In the example below, the location counter is moved to a position that is 0x1000 words past the symbol FSTART_.

### Example

```
.data :
{
     *(.data)
     *(.bss)
     FSTART_ = .;
     . = FSTART_ + 0x1000;
     __end = .;
} > DATA
```

## ADDR

The ADDR function returns the address of the named section or memory segment.

### Prototype

ADDR (*sectionName* | *segmentName* | *symbol*)

In the example below, ADDR is used to assign the address of ROOT to the symbol __rootbasecode.

### Example

```
MEMORY{
    ROOT  (RWX) : ORIGIN = 0x8000, LENGTH = 0
}
```

```
SECTIONS{
  .code :
  {
  __rootbasecode = ADDR(ROOT);
     *(.text);
  } > ROOT
}
```

**NOTE** In order to use segmentName with this command, the segmentName must start with the period character even though segmentNames are not required to start with the period character by the linker, as is the case with sectionName.

## ALIGN

The `ALIGN` function returns the value of the location counter aligned on a boundary specified by the value of `alignValue`. The `alignValue` must be a power of two.

### Prototype

```
ALIGN(alignValue)
```

Note that `ALIGN` does not update the location counter; it only performs arithmetic. To update the location counter, use an assignment such as:

### Example

```
. = ALIGN(0x10);     #update location counter to 16
                     #byte alignment
```

## ALIGNALL

`ALIGNALL` is the command version of the `ALIGN` function. It forces the minimum alignment for all the objects in the current segment to the value of `alignValue`. The `alignValue` must be a power of two.

### Prototype

```
ALIGNALL(alignValue);
```

Unlike its counterpart ALIGN on page 293, `ALIGNALL` is an actual command. It updates the location counter as each object is written to the output.

### Example

```
.code :
{
  ALIGNALL(16);  // Align code on 16 byte boundary
  *     (.init)
  *     (.text)

  ALIGNALL(16);  //align data on 16 byte boundary
  *     (.rodata)
} > .text
```

## FORCE_ACTIVE

The `FORCE_ACTIVE` directive allows you to specify symbols that you do not want the linker to deadstrip. You must specify the symbol(s) you want to keep before you use the SECTIONS on page 297 keyword.

### Prototype

```
FORCE_ACTIVE{ symbol[, symbol] }
```

## INCLUDE

The `INCLUDE` command let you include a binary file in the output file.

### Prototype

```
INCLUDE filename
```

## KEEP_SECTION

The `KEEP_SECTION` directive allows you to specify sections that you do not want the linker to deadstrip. You must specify the section(s) you want to keep before you use the SECTIONS on page 297 keyword.

### Prototype

```
KEEP_SECTION{ sectionType[, sectionType] }
```

## MEMORY

The `MEMORY` directive allows you to describe the location and size of memory segment blocks in the target. This directive specifies the linker the memory areas to avoid, and the memory areas into which it links the code and date.

The linker command file may only contain one `MEMORY` directive. However, within the confines of the `MEMORY` directive, you may define as many memory segments as you wish.

### Prototype

```
MEMORY { memory_spec }
```

The `memory_spec` is:

*segmentName* (*accessFlags*) : ORIGIN = *address*, LENGTH = *length*, [COMPRESS] [> *fileName*]

`segmentName` can include alphanumeric characters and underscore '_' characters.

`accessFlags` are passed into the output ELF file (`Phdr.p_flags`). The `accessFlags` can be:

- R-read
- W-write
- X-executable (for P: memory placement)

`ORIGIN address` is one of the following:

**Table 12.2 Origin Address**

| | |
|---|---|
| a memory address | Specify a hex address, such as 0x8000. |
| an AFTER command | Use the AFTER(name [,name]) command to tell the linker to place the memory segment after the specified segment. In the example below, overlay1 and overlay2 are placed after the code segment. When multiple memory segments are specified as parameters for AFTER, the highest memory address is used. |

### Example

```
memory{
code      (RWX)   : ORIGIN = 0x8000,      LENGTH = 0
overlay1  (RWX)   : ORIGIN = AFTER(code), LENGTH = 0
overlay2  (RWX)   : ORIGIN = AFTER(code), LENGTH = 0
data      (RW)    : ORIGIN = 0x1000,      LENGTH = 0
}
```

`ORIGIN is the assigned address.`

`LENGTH` is one of the following:

**Table 12.3 Length**

| | |
|---|---|
| a value greater than zero | If you try to put more code and data into a memory segment than your specified length allows, the linker stops with an error. |
| autolength by specifying zero | When the length is 0, the linker lets you put as much code and data into a memory segment as you want. |

**NOTE** There is no overflow checking with autolength. The linker can produce an unexpected result if you use the autolength feature without leaving enough free memory space to contain the memory segment. For this reason, when you use autolength, use the `AFTER` keyword to specify origin addresses.

`> fileName` is an option to write the segment to a binary file on disk instead of an ELF program header. The binary file is put in the same folder as the ELF output file. This option has two variants:

**Table 12.4  Option Choices**

| | |
|---|---|
| `>fileName` | Writes the segment to a new file. |
| `>>fileName` | Appends the segment to an existing file. |

## OBJECT

The `OBJECT` keyword allows control over the order in which functions are placed in the output file.

### Prototype

```
OBJECT (function, sourcefile.c)
```

It is important to note that if you write an object to the output file using the `OBJECT` keyword, the same object will not be written again by either the `GROUP` keyword or the '*' wildcard.

## REF_INCLUDE

The `REF_INCLUDE` directive allows you to specify sections that you do not want the linker to deadstrip, but only if they satisfy a certain condition: the file that contains the section must be referenced. This is useful if you want to include version information from your source file components. You must specify the section(s) you want to keep before you use the SECTIONS on page 297 keyword.

### Prototype

```
REF_INCLUDE{ sectionType [, sectionType]}
```

## SECTIONS

A basic `SECTIONS` directive has the following form:

### Prototype

```
SECTIONS { <section_spec> }
```

`section_spec` is one of the following:

- *sectionName*: [AT (*loadAddress*)] {contents}  > *segmentName*
- *sectionName*: [AT (*loadAddress*]] {contents} >> *segmentName*

`sectionName` is the section name for the output section. It must start with a period character. For example, "`.mysection`".

`AT (loadAddress)` is an optional parameter that specifies the address of the section. The default (if not specified) is to make the load address the same as the relocation address.

`contents` are made up of statements. These statements can:

- Assign a value to a symbol.
- Describe the placement of an output section, including which input sections are placed into it.

`segmentName` is the predefined memory segment into which you want to put the contents of the section. The two variants are:

**Table 12.5  Option Choices**

| | |
|---|---|
| `>segmentName` | Places the section contents at the beginning of the memory segment segmentName. |
| `>>segmentName` | Appends the section contents to the memory segment segmentName. |

### Example

```
SECTIONS {
  .text : {
            F_textSegmentStart = .;
            footpad.c (.text)
            . = ALIGN (0x10);
            padfoot.c (.text)
            F_textSegmentEnd = .;
  } > TEXT
  .data : { *(.data) } > DATA
  .bss  : { *(.bss) > BSS
            *(COMMON)
  }
}
```

## SIZEOF

The `SIZEOF` function returns the size of the given segment or section. The return value is the size in bytes.

### Prototype

`SIZEOF(`*`sectionName`* `|` *`segmentName`* `|` *`symbol`*`)`

**NOTE** In order to use segmentName with this command, the segmentName must start with the period character even though segmentNames are not required to start with the period character by the linker, as is the case with sectionName.

## SIZEOFW

The `SIZEOFW` function returns the size of the given segment or section. The return value is the size in words.

### Prototype

`SIZEOFW(`*`sectionName`* `|` *`segmentName`* `|` *`symbol`*`)`

**NOTE** In order to use segmentName with this command, the segmentName must start with the period character even though segmentNames are not required to start with the period character by the linker, as is the case with sectionName.

## WRITEB

The WRITEB command inserts a byte of data at the current address of a section.

### Prototype

```
WRITEB (expression);
```

`expression` is any expression that returns a value `0x00` to `0xFF`.

## WRITEH

The WRITEH command inserts two bytes of data at the current address of a section.

### Prototype

```
WRITEH (expression);
```

`expression` is any expression that returns a value `0x0000` to `0xFFFF`.

## WRITEW

The WRITEW command inserts 4 bytes of data at the current address of a section.

### Prototype

```
WRITEW (expression);
```

`expression` is any expression that returns a value `0x00000000` to `0xFFFFFFFF`.

# 13

# Command-Line Tools

This chapter contains the following sections:

## Usage

To call the command-line tools, use the following format:

**Table 13.1 Format**

| Tools | File Names | Format |
|---|---|---|
| Compiler | mwcc56800e.exe | compiler-options [linker-options] file-list |
| Linker | mwld56800e.exe | linker-options file-list |
| Assembler | mwasm56800e.exe | assembler-options file-list |

The compiler automatically calls the linker by default and any options from the linker is passed on by the compiler to the assembler. However, you may choose to only compile with the `–c` flag. In this case, the assembler will only assemble and will not call the linker.

Also, available are environment variables. These are used to provide path information for includes or libraries, and to specify which libraries are to be included. You can specify the variables listed in Table 13.2 on page 302.

**Table 13.2 Environment Variables**

| Tool | Library | Description |
|---|---|---|
| Compiler | MWC56800EIncludes | Similar to Access Paths panel; separate paths with ‘;’ and prefix a path with ‘+’ to specify a recursive path |
| Linker | MW56800ELibraries<br>MW56800ELibraryFiles | Similar to MWC56800EIncludes<br>List of library names to link with project; separate with ‘;’ |
| Assembler | MWAsm56800EIncludes | (similar to MWC56800EIncludes) |

These are the target-specific variables, and will only work with the DSP56800E tools. The generic variables **MWCIncludes**, **MWLibraries**, **MWLibraryFiles**, and **MWAsmIncludes** apply to all target tools on your system (such as Windows). If you only have the DSP56800E tools installed, then you may use the generic variables if you prefer.

# Response File

In addition to specifying commands in the argument list, you may also specify a “response file”. A response file’s filename begins with an ‘@’ (for example, @file), and the contents of the response file are commands to be inserted into the argument list. The response file supports standard UNIX-style comments. For example, the response file @file, contain the following:

```
# Response file @file
-o out.elf          # change output file name to ‘out.elf’
-g                  # generate debugging symbols
```

The above response file can used in a command such as:

**mwcc56800e** @file main.c

It would be the same as using the following command:

**mwcc56800e** –o out.elf –g main.c

# Sample Build Script

This following is a sample of a DOS batch (BAT) file. The sample demonstrates:

- Setting of the environmental variables.
- Using the compiler to compile and link a set of files.

```
      REM *** set GUI compiler path ***
      set COMPILER={path to compiler}

      REM *** set includes path ***
      set MWCIncludes=+%COMPILER%\M56800E Support
      set MWLibraries=+%COMPILER%\M56800E Support
      set MWLibraryFiles=Runtime 56800E.Lib;MSL C 56800E.lib

      REM *** add CLT directory to PATH ***
      set
PATH=%PATH%;%COMPILER%\DSP56800E_EABI_Tools\Command_Line_Tools\

      REM *** compile options and files ***
      set COPTIONS=-O3
      set CFILELIST=file1.c file2.c
      set LOPTIONS=-m FSTART_ -o output.elf -g
      set LCF=linker.cmd

      REM *** compile, assemble and link ***
      mwcc56800e %COPTIONS% %CFILELIST%
      mwasm56800e %AFILELIST%
      mwld56800e %LOPTIONS% %LFILELIST% %LCF%
```

# Arguments

## General Command-Line Options

```
----------------------------------------------------------------------
General Command-Line Options

   All the options are passed to the linker unless otherwise noted.

   Please see '-help usage' for details about the meaning of this help.
----------------------------------------------------------------------
  -help [keyword[,...]]      # global; for this tool;
                             #   display help
```

```
     usage                  #    show usage information
     [no]spaces             #    insert blank lines between options in
                            #      printout
     all                    #    show all standard options
     [no]normal             #    show only standard options
     [no]obsolete           #    show obsolete options
     [no]ignored            #    show ignored options
     [no]deprecated         #    show deprecated options
     [no]meaningless       #    show options meaningless for this
target
     [no]compatible         #    show compatibility options
    opt[ion]=name        #    show help for a given option; for
'name',
                            #      maximum length 63 chars
    search=keyword      #    show help for an option whose name or
help
                        #      contains 'keyword' (case-sensitive);
for
                        #      'keyword', maximum length 63 chars
   group=keyword        #    show help for groups whose names contain
                        #     'keyword' (case-sensitive); for
'keyword'
                            #       maximum length 63 chars
   tool=keyword[,...]   #    categorize groups of options by tool;
                            #      default
    all                 #     show all options available in this tool
    this                #     show options executed by this tool
                            #        default
      other|skipped       #      show options passed to another tool
      both                #      show options used in all tools
                            #
                            #
  -version                  # global; for this tool;
                          #   show version, configuration, and build
date
  -timing                   # global; collect timing statistics
  -progress                 # global; show progress and version
  -v[erbose]                # global; verbose information; cumulative;
                            #   implies -progress
  -search                as # global; search access paths for source
files
                         #   specified on the command line; may
specify
                         #   object code and libraries as well; this
                         #   option provides the IDE's 'access paths'
                            #   functionality
  -[no]wraplines            # global; word wrap messages; default
  -maxerrors max      # specify maximum number of errors to print,
zero
                            #   means no maximum; default is 0
  -maxwarnings max    # specify maximum number of warnings to print,
                            #   zero means no maximum; default is 0
  -msgstyle keyword        # global; set error/warning message style
     mpw                    #    use MPW message style
     std                    #    use standard message style; default
     gcc                    #    use GCC-like message style
     IDE                    #    use CW IDE-like message style
     parseable          #    use context-free machine-parseable
message
                            #      style
                            #
  -[no]stderr         # global; use separate stderr and stdout
streams;
                          #   if using -nostderr, stderr goes to
stdout
```

## Compiler

```
----------------------------------------------------------------
Preprocessing, Precompiling, and Input File Control Options
----------------------------------------------------------------
  -c                          # global; compile only, do not link
  -[no]codegen                # global; generate object code
  -[no]convertpaths      # global; interpret #include filepaths
specified
                       #   for a foreign operating system; i.e.,
                       #   <sys/stat.h> or <:sys:stat.h>; when
enabled,
                     #   '/' and ':' will separate directories and
                     #   cannot be used in filenames (note: this is
                     #   not a problem on Win32, since these
                     #   characters are already disallowed in
                     #   filenames; it is safe to leave the option
                            #   'on'); default
  -cwd keyword       # specify #include searching semantics:  before
                     #   searching any access paths, the path
                     #   specified by this option will be searched
     proj            #    begin search in current working directory;
                            #      default
     source          #    begin search in directory of source file
     explicit        #    no implicit directory; only search '-I' or
                            #      '-ir' paths
     include         #    begin search in directory of referencing
```

```
                            #      file
                            #
  -D+ | -d[efine     # cased; define symbol 'name' to 'value' if
    name[=value]     #   specified, else '1'
  -[no]defaults      # global; passed to linker;
                            #   same as '-[no]stdinc'; default
  -dis[assemble]            # global; passed to all tools;
                            #   disassemble files to stdout
  -E                        # global; cased; preprocess source files
  -EP                       # global; cased; preprocess and strip out
#line
                            #   directives
  -ext extension     # global; specify extension for generated object
                     #   files; with a leading period ('.'), appends
                     #   extension; without, replaces source file's
                     #   extension; for 'extension', maximum length 14
                            #   chars; default is none
  -gccinc[ludes]     # global; adopt GCC #include semantics:  add '-I'
                     #   paths to system list if '-I-' is not
                            #   specified, and search directory of
                     #   referencing file first for #includes (same as
                            #   '-cwd include')
  -i- | -I-          # global; change target for '-I' access paths to
                     #   the system list; implies '-cwd explicit';
                     #   while compiling, user paths then system paths
                     #   are searched when using '#include "..."'; only
                     #   system paths are searched with '#include
                            #   <...>'
  -I+ | -i p         # global; cased; append access path to current
                     #   #include list(see '-gccincludes' and '-I-')
  -ir path              # global; append a recursive access path to
                        #   current #include list
  -[no]keepobj[ects]    # global; keep object files generated after
                        #   invoking linker; if disabled, intermediate
                       #   object files are temporary and deleted
after
                       #   link stage; objects are always kept when
                            #   compiling
  -M                        # global; cased; scan source files for
                           #   dependencies and emit Makefile, do not
                            #   generate object code
  -MM                  # global; cased; like -M, but do not list
system
                            #   include files
  -MD                  # global; cased; like -M, but write dependency
                       #   map to a file and generate object code
  -MMD                # global; cased; like -MD, but do not list
system
```

```
                            #   include files
  -make                # global; scan source files for dependencies
and
                            #   emit Makefile, do not generate object
code  -nofail          # continue working after errors in earlier
files
  -nolink                   # global; compile only, do not link
  -noprecompile             # do not precompile any files based on the
                            #   filename extension
  -nosyspath           # global; treat #include <...> like #include
                       #   "..."; always search both user and system
                            #   path lists
  -o file|dir         # specify output filename or directory for
object
                      #   file(s) or text output, or output filename
                            #   for linker if called
  -P                  # global; cased; preprocess and send output to
                            #   file; do not generate code
  -precompile file|di  # generate precompiled header from source;
write
                       #   header to 'file' if specified, or put
header
                       #   in 'dir'; if argument is "", write header
to
                       #   source-specified location; if neither is
                       #   defined, header filename is derived from
                       #   source filename; note: the driver can tell
                       #   whether to precompile a file based on its
                       #   extension; '-precompile file source' then
is
                            #   the same as '-c -o file source'
  -preprocess               # global; preprocess source files
  -prefix file        # prefix text file or precompiled header onto
all
                            #   source files
  -S                        # global; cased; passed to all tools;
                            #   disassemble and send output to file
  -[no]stdinc              # global; use standard system include paths
                            #   (specified by the environment variable
                        #   %MWCIncludes%); added after all system '-
I'
                            #   paths; default
  -U+ | -u[ndefine] name    # cased; undefine symbol 'name'

----------------------------------------------------------------------
Front-End C/C++ Language Options
----------------------------------------------------------------------
  -ansi keyword       # specify ANSI conformance options, overriding
```

```
                            #   the given settings
     off                #    same as '-stdkeywords off', '-enum min',
and
                            #      '-strict off'; default
     on|relaxed         #    same as '-stdkeywords on', '-enum min', and
                            #      '-strict on'
     strict             #    same as '-stdkeywords on', '-enum int', and
                            #      '-strict on'
                            #
  -ARM on|off           # check code for ARM (Annotated C++ Reference
                            #   Manual) conformance; default is off
  -bool on|off          # enable C++ 'bool' type, 'true' and 'false'
                            #    constants; default is off
  -char keyword         # set sign of 'char'
     signed                 #    chars are signed; default
     unsigned               #    chars are unsigned
                            #
  -Cpp_exceptions on|off    # passed to linker;
                      #    enable or disable C++ exceptions; default
is
                            #    on
  -dialect | -lang keyword  # passed to linker;
                            #   specify source language
     c                      #    treat source as C always
     c++                    #    treat source as C++ always
     ec++                #    generate warnings for use of C++ features
                            #    outside Embedded C++ subset (implies
                            #    'dialect cplus')
                            #      ‘dialect cplus’)
  -enum keyword             # specify word size for enumeration types
     min                    #   use minimum sized enums; default
     int                    #   use int-sized enums
                            #
  -inline keyword[,...]     # specify inline options
     on|smart           #    turn on inlining for 'inline' functions;
                            #      default
     none|off               #    turn off inlining
     auto                   #    auto-inline small functions (without
                            #      'inline' explicitly specified)
     noauto                 #    do not auto-inline; default
     all                    #    turn on aggressive inlining: same as
                            #      '-inline on, auto'
     deferred           #    defer inlining until end of compilation
                        #      unit; this allows inlining of functions
in
                            #    both directions
     level=n            #    cased; inline functions up to 'n' levels
                        #      deep; level 0 is the same as '-inline
```

```
on';
                            #      for 'n', range 0 - 8
                            #
  -iso_templates on|off    # enable ISO C++ template parser (note:
this
                            #   requires a different MSL C++ library);
                            #   default is off
  -[no]mapcr                # reverse mapping of '\n' and '\r' so that
                           #   '\n'==13 and '\r'==10 (for Macintosh
MPW
                            #   compatability)
  -msext keyword            # [dis]allow Microsoft VC++ extensions
     on                     #    enable extensions: redefining macros,
                         #      allowing XXX::yyy syntax when
declaring
                            #      method yyy of class XXX,
                            #      allowing extra commas,
                            #      ignoring casts to the same type,
                         #      treating function types with
equivalent
                      #      parameter lists but different return
types
                            #      as equal,
                       #      allowing pointer-to-integer conversions,
                            #      and various syntactical differences
    off                     #    disable extensions; default on non-
x86
                            #      targets
                            #
  -[no]multibyte[aware]     # enable multi-byte character encodings
for
                            #   source text, comments, and strings
  -once                  # prevent header files from being processed
more
                            #  than once
  -pragma                   # define a pragma for the compiler such as
                            #  "#pragma ..."
  -r[equireprotos]          # require prototypes
  -relax_pointers           # relax pointer type-checking rules
  -RTTI on|off            # select run-time typing information (for
C++);
                            #   default is on
  -som                    # enable Apple's Direct-to-SOM
implementation
  -som_env_check            # enables automatic SOM environment and
new
                            #   allocation checking; implies -som
  -stdkeywords on|off      # allow only standard keywords; default is
```

```
off
  -str[ings] keyword[,...]  # specify string constant options
     [no]reuse           #    reuse strings; equivalent strings are
the
                            #      same object; default
     [no]pool               #    pool strings into a single data
object
     [no]readonly           #    make all string constants read-only
                            #
  -strict on|off         # specify ANSI strictness checking; default
is
                            #   off
  -trigraphs on|off   # enable recognition of trigraphs; default is
off
  -wchar_t on|off      # enable wchar_t as a built-in C++ type;
default
                            #   is on

----------------------------------------------------------------------
Optimizer Options

   Note that all options besides '-opt
off|on|all|space|speed|level=...' are
   for backwards compatibility; other optimization options may be
superceded
   by use of '-opt level=xxx'.
----------------------------------------------------------------------
  -O                        # same as '-O2'
  -O+keyword[,...]       # cased; control optimization; you may
combine
                            #   options as in '-O4,p'
     0                      #    same as '-opt off'
     1                      #    same as '-opt level=1'
     2                      #    same as '-opt level=2'
     3                      #    same as '-opt level=3'
     4                      #    same as '-opt level=4'
     p                      #    same as '-opt speed'
     s                      #    same as '-opt space'
                            #
  -opt keyword[,...]        # specify optimization options
     off|none               #    suppress all optimizations; default
     on                     #    same as '-opt level=2'
     all|full               #    same as '-opt speed, level=4'
     [no]space              #    optimize for space
     [no]speed              #    optimize for speed
     l[evel]=num            #    set optimization level:
                            #      level 0: no optimizations
                            #
                            #      level 1: global register
allocation,
                            #      peephole, dead code elimination
                            #
                            #      level 2: adds common subexpression
                            #      elimination and copy propagation
                            #
                            #      level 3: adds loop transformations,
                        #      strength reduction, loop-invariant code
                            #      motion
                            #
                            #      level 4: adds repeated common
                            #      subexpression elimination and
                            #      loop-invariant code motion
                        #      ; for 'num', range 0 - 4; default is 0
     [no]cse                #    common subexpression elimination
       [no]commonsubs       #
     [no]deadcode           #    removal of dead code
     [no]deadstore          #    removal of dead assignments
     [no]lifetimes          #    computation of variable lifetimes
     [no]loop[invariants]   #    removal of loop invariants
     [no]prop[agation]  #   propagation of constant and copy
assignments
     [no]strength       #   strength reduction; reducing
multiplication
                            #      by an index variable into addition
     [no]dead               #    same as '-opt [no]deadcode' and '-opt
                            #      [no]deadstore'
     display|dump           #    display complete list of active
                            #      optimizations
                            #

----------------------------------------------------------------------
DSP M56800E CodeGen Options
----------------------------------------------------------------------
  -DO keyword               # for this tool;
                            #   specify hardware DO loops
     off                    #    no hardware DO loops; default
     nonested               #    hardware DO loops but no nested ones
     nested                 #    nested hardware DO loops
                            #
  -padpipe                  # for this tool;
                            #   pad pipeline for debugger
  -ldata | -largedata       # for this tool;
                            #  data space not limited to 64K
  -globalsInLowerMemory     # for this tool;
                      #   globals live in lower memory; implies '-
large
```

```
                            #   data model'
  -sprog | -smallprog       # for this tool;
                            #   program space limited to 64K

----------------------------------------------------------------------
Debugging Control Options
----------------------------------------------------------------------
  -g                   # global; cased; generate debugging
information;
                            #   same as '-sym full'
  -sym keyword[,...]        # global; specify debugging options
     off                    #    do not generate debugging
information;
                            #      default
     on                     #    turn on debugging information
     full[path]             #    store full paths to source files
                            #
----------------------------------------------------------------------
C/C++ Warning Options
----------------------------------------------------------------------
  -w[arn[ings]]             # global; for this tool;
    keyword[,...]           #   warning options
     off                    #    passed to all tools;
                            #      turn off all warnings
     on                     #    passed to all tools;
                            #      turn on most warnings
     [no]cmdline            #    passed to all tools;
                            #      command-line driver/parser warnings
     [no]err[or] |          #    passed to all tools;
       [no]iserr[or]        #      treat warnings as errors
     all                  #    turn on all warnings, require
prototypes
     [no]pragmas |          #    illegal #pragmas
       [no]illpragmas       #
     [no]empty[decl]        #    empty declarations
     [no]possible |         #    possible unwanted effects
       [no]unwanted         #
     [no]unusedarg          #    unused arguments
     [no]unusedvar          #    unused variables
     [no]unused             #    same as -w
[no]unusedarg,[no]unusedvar
     [no]extracomma |       #    extra commas
       [no]comma            #
     [no]pedantic |         #    pedantic error checking
       [no]extended         #
     [no]hidevirtual |      #    hidden virtual functions
       [no]hidden[virtual]  #
     [no]implicit[conv]     #    implicit arithmetic conversions
     [no]notinlined         #    'inline' functions not inlined
     [no]largeargs         #    passing large arguments to
unprototyped
                            #      functions
     [no]structclass      #    inconsistent use of 'class' and
'struct'
     [no]padding            #    padding added between struct members
     [no]notused         #    result of non-void-returning function
not
                            #      used
     [no]unusedexpr       #    use of expressions as statements
without
                            #      side effects
     [no]ptrintconv     #    conversions from pointers to integers,
and
                            #      vice versa
     display|dump           #    display list of active warnings
                            #
```

## Linker

```
----------------------------------------------------------------------
Command-Line Linker Options
```

```
  -dis[assemble]           # global; disassemble object code and do
not
                            #   link; implies '-nostdlib'
  -L+ | -l path      # global; cased; add library search path; default
                      #   is to search current working directory and
                      #   then system directories (see '-defaults');
                      #   search paths have global scope over the
                      #   command line and are searched in the order
                      #   given
  -lr path            # global; like '-l', but add recursive library
                      #   search path
  -l+file             # cased; add a library by searching access paths
                      #   for file named lib<file>.<ext> where <ext>
is
                      #   a typical library extension; added before
                      #   system libraries (see '-defaults')
  -[no]defaults               # global; same as -[no]stdlib; default
  -nofail                     # continue importing or disassembling
after
                            #   errors in earlier files
  -[no]stdlib               # global; use system library access paths
                      #   (specified by %MWLibraries%) and add system
                            #   libraries (specified by
%MWLibraryFiles%);
                            #   default
  -S                  # global; cased; disassemble and send output to
                            #   file; do not link; implies '-nostdlib'

----------------------------------------------------------------------
ELF Linker Options
----------------------------------------------------------------------
  -[no]dead[strip]      # enable dead-stripping of unused code;
default
  -force_active        # specify a list of symbols as undefined;
useful
    symbol[,...]            #   to force linking of static libraries
                            #
  -keep[local] on|off    # keep local symbols (such as relocations and
                       #   output segment names) generated during
link;
                            #   default is on
  -m[ain] symbol       # set main entry point for application or
shared
                       #   library; use '-main ""' to specify no entry
                      #   point; for 'symbol', maximum length 63
chars;
                            #   default is 'FSTART_'
  -map [keyword[,...]]      # generate link map file
     closure                #    calculate symbol closures
     unused                 #    list unused symbols
                            #
  -sortbyaddr             # sort S-records by address; implies '-srec'
  -srec                     # generate an S-record file; ignored when
                            #   generating static libraries
  -sreceol keyword       # set end-of-line separator for S-record
file;
                            #   implies '-srec'
     mac                    #    Macintosh ('\r')
     dos                    #    DOS ('\r\n'); default
     unix                   #    Unix ('\n')
                            #
  -sreclength length        # specify length of S-records (should be a
                            #   multiple of 4); implies '-srec'; for
                            #   'length', range 8 - 252; default is 64
  -usebyteaddr             # use byte address in S-record file;
implies
                            #   '-srec'
  -o file                   # specify output filename
```

```
----------------------------------------------------------------------
DSP M56800E Project Options
----------------------------------------------------------------------
  -application              # global; generate an application; default
  -library                  # global; generate a static library

----------------------------------------------------------------------
DSP M56800E CodeGen Options
----------------------------------------------------------------------
  -ldata | -largedata       # data space not limited to 64K

----------------------------------------------------------------------
Linker C/C++ Support Options


----------------------------------------------------------------------
  -Cpp_exceptions on|off # enable or disable C++ exceptions; default
is on
  -dialect | -lang keyword  # specify source language
     c                 #    treat source as C++ unless its extension
is
                            #      '.c', '.h', or '.pch'; default
     c++                    #    treat source as C++ always
                            #

----------------------------------------------------------------------
Debugging Control Options


----------------------------------------------------------------------
  -g                   # global; cased; generate debugging
information;
                            #   same as '-sym full'
  -sym keyword[,...]        # global; specify debugging options
     off                    #    do not generate debugging
information;
                            #      default
     on                     #    turn on debugging information
     full[path]             #    store full paths to source files
                            #

----------------------------------------------------------------------
Warning Options
----------------------------------------------------------------------
  -w[arn[ings]]             # global; warning options
    keyword[,...]           #
     off                    #    turn off all warnings
     on                     #    turn on all warnings
     [no]cmdline            #    command-line parser warnings
     [no]err[or] |          #    treat warnings as errors
       [no]iserr[or]        #
     display|dump           #    display list of active warnings
                            #

----------------------------------------------------------------------
ELF Disassembler Options
----------------------------------------------------------------------
  -show keyword[,...]       # specify disassembly options
     only|none              #    as in '-show none' or, e.g.,
                            #      '-show only,code,data'
     all                    #    show everything; default
     [no]code | [no]text  #   show disassembly of code sections;
default
     [no]comments         #   show comment field in code; implies '-
show
                            #      code'; default
     [no]extended          #    show extended mnemonics; implies '-
show
                            #      code'; default
     [no]data            #    show data; with '-show verbose', show
hex
                            #      dumps of sections; default
     [no]debug | [no]sym    #    show symbolics information; default
     [no]exceptions     #  show exception tables; implies '-show
data';
                            #      default
     [no]headers            #    show ELF headers; default
     [no]hex                #    show addresses and opcodes in code
                        #    disassembly; implies '-show code';
default
     [no]names              #    show symbol table; default
     [no]relocs             #    show resolved relocations in code and
                            #      relocation tables; default
     [no]source         #    show source in disassembly; implies '-
show
                        #    code'; with '-show verbose', displays
                        #      entire source file in output, else
shows
                        #      only four lines around each function;
                            #      default
     [no]xtables            #    show exception tables; default
     [no]verbose        #  show verbose information, including hex
dump
                            #      of program segments in
applications;
```

```
                            #      default
                            #
```

## Assembler

```
----------------------------------------------------------------------
Assembler Control Options
----------------------------------------------------------------------
  -[no]case                 # identifiers are case-sensitive; default
  -[no]debug                # generate debug information
  -[no]macro_expand         # expand macro in listin output
  -[no]assert_nop     # add nop to resolve pipeline dependency;
default
  -[no]warn_nop             # emit warning when there is a pipeline
                            #   dependency
  -[no]warn_stall        # emit warning when there is a hardware stall
  -[no]legacy               # allow legacy DSP56800 instructions(imply
                            #   data/prog 16)
  -[no]debug_workaround      # Pad nop workaround debuggin issue in
some
                            #   implementation; default
  -data keyword             # data memory compatibility
     16                     #    16 bit; default
     24                     #    24 bit
                            #
  -prog keyword             # program memory compatibility
     16                     #    16 bit; default
     19                     #    19 bit
     21                     #    21 bit
                               #
```

# 14

# Libraries and Runtime Code

You can use a variety of libraries with the CodeWarrior™ IDE. The libraries include ANSI-standard libraries for C, runtime libraries, and other codes. This chapter explains how to use these libraries for DSP56800E development.

With respect to the Metrowerks Standard Library (MSL) for C, this chapter is an extension of the *MSL C Reference*. Consult that manual for general details on the standard libraries and their functions.

This chapter contains the following sections:

## MSL for DSP56800E

This section explains the Metrowerks Standard Library (MSL) that has been modified for use with DSP56800E.

### Using MSL for DSP56800E

CodeWarrior Development Studio for Freescale 56800/E Digital Signal Controllers includes a version of the Metrowerks Standard Library (MSL). MSL is a complete C library for use in embedded projects. All of the sources necessary to build MSL are included in CodeWarrior Development Studio for Freescale 56800/E Digital Signal Controllers, along with the project files for different configurations of MSL. If you already have a version of the CodeWarrior IDE installed on your computer, the CodeWarrior installer adds the new files needed for building versions of MSL for DSP56800E.

The project directory for the DSP56800E MSL is:

```
CodeWarrior\M56800E Support\msl\MSL_C\DSP_56800E\projects\MSL C
56800E.mcp
```

Do not modify any of the source files included with MSL. If you need to make changes based on your memory configuration, make changes to the runtime libraries.

Ensure that you include one or more of the header files located in the following directory:

```
CodeWarrior\M56800E Support\msl\MSL_C\DSP_56800E\inc
```

When you add the relative-to-compiler path to your project, the appropriate MSL and runtime files will be found by your project. If you create your project from Stationery, the new project will have the proper support access path.

# Console and File I/O

DSP56800E Support provides standard C calls for I/O functionality with full ANSI/ISO standard I/O support with host machine console and file I/O for debugging sessions (Host I/O) through the JTAG port or HSST in addition to such standard C calls such as memory functions malloc() and free().

A minimal "thin" printf via "console_write" and "fflush_console" is provided in addition to standard I/O.

See the *MSL C Reference* manual (Metrowerks Standard Library).

## Library Configurations

There are Large Data Model and Small Data Model versions of all libraries. (Small Program Model default is off for all library and Stationery targets.)

Metrowerks Standard Library (MSL) provides standard C library support.

The Runtime libraries provide the target-specific low-level functions below the high-level MSL functions. There are two types of Runtime libraries:

- JTAG-based Host I/O
- HSST-based Host I/O.

  For each project requiring standard C library support, a matched pair of MSL and Runtime libraries are required (SDM or LDM pairs).

  The HSST library is added to HSST client-to-client DSP56800E targets. For more information see "High-Speed Simultaneous Transfer" on page 151.

**NOTE** DSP56800E stationery creates new projects with LDM and SDM targets and the appropriate libraries.

Below is a list of the DSP56800E libraries:

- Metrowerks Standard Libraries (MSL)
  - `MSL C 56800E.lib`

    Standard C library support for Small Data Model.
  - `MSL C 56800E lmm.lib`

Standard C library support for Large Data Model.

- Runtime Libraries
  - `runtime 56800E.lib`

    Low-level functions for MSL support for Small Data Model with Host I/O via JTAG port.
  - `runtime 56800E lmm.lib`

    Low-level functions for MSL support for Large Data Model with Host I/O via JTAG port.
  - `runtime_hsst_56800E.lib`

    Low-level functions for MSL support for Small Data Model with Host I/O via HSST.
  - `runtime_hsst_56800E_lmm.lib`

    Low-level functions for MSL support for Large Data Model with Host I/O via HSST.
- HSST Libraries

  There are debug and release targets for SDM and LDM. The release targets have maximum optimization settings and debug info turned off. For more information see “High-Speed Simultaneous Transfer” on page 151.
  - `hsst_56800E.lib`

    DSP 56800E HSST client functions for Small Data Model.
  - `hsst_56800E_lmm.lib`

    DSP56800E HSST client functions for Large Data Model.

## Host File Location

Files are created with `fopen` on the host machine as shown in Table 14.1 on page 321.

**Table 14.1 Host File Creation Location**

| fopen Filename Parameter | Host Creation Location |
|---|---|
| filename with no path | target project file folder |
| full path | location of full path |

# Allocating Stacks and Heaps for the DSP56800E

Stationery linker command files (LCF) define heap, stack, and bss locations. LCFs are specific to each target board. When you use M56800E stationery to create a new project, CodeWarrior automatically adds the LCF to the new project.

See “ELF Linker,” for general LCF information. See each specific target LCF in Stationery for specific LCF information.

See Table 14.2 on page 322 for the variables defined in each Stationery LCF.

**Table 14.2 LCF Variables and Address**

| Variables | Address |
|---|---|
| _stack_addr | the start address of the stack |
| _heap_size | the size of the heap |
| _heap_addr | the start address of the heap |
| _heap_end | the end address of the heap |
| _bss_start | start address of memory reserved for uninitialized variables |
| _bss_end | end address of bss |

To change the locations of these default values, modify the linker command file in your DSP56800E project.

**NOTE** Ensure that the stack and heap memories reside in data memory.

## Definitions

### Stack

The stack is a last-in-first-out (LIFO) data structure. Items are pushed on the stack and popped off the stack. The most recently added item is on top of the stack. Previously added items are under the top, the oldest item at the bottom. The "top" of the stack may be in low memory or high memory, depending on stack design and use. M56800E uses a 16-bit-wide stack.

### Heap

Heap is an area of memory reserved for temporary dynamic memory allocation and access. MSL uses this space to provide heap operations such as malloc. M56800E does not have an operating system (OS), but MSL effectively synthesizes some OS services such as heap operations.

### BSS

BSS is the memory space reserved for uninitialized data. The compiler will put all uninitialized data here. If the **Zero initialized globals live in data** instead of BSS checkbox in the M56800E Processor Panel is checked, the globals that are initialized to zero reside in the `.data` section instead of the `.bss` section. The stationery init code zeroes this area at startup. See the M56852 init (startup) code in this chapter for general information and the stationery init code files for specific target implementation details.

**NOTE** Instead of accessing the original Stationery files themselves (in the Stationery folder), create a new project using Stationery which will make copies of the specific target board files such as the LCF.

## Runtime Initialization

The default init function is the bootstrap or glue code that sets up the DSP56800E environment before your code executes. This function is in the init file for each board-specific stationery project. The routines defined in the init file performs other tasks such as clearing the hardware stack, creating an interrupt table, and retrieving the stack start and exception handler addresses.

The final task performed by the init function is to call the `main()` function.

The starting point for a program is set in the **Entry Point** field in the **M56800E Linker on page 71** settings panel.

The project for the DSP56800E runtime is:

```
CodeWarrior\M56800E Support\runtime_56800E\projects\Runtime 56800E.mcp
```

### Table 14.3  Library Names and Locations

| Library Name | Location |
|---|---|
| Large Memory Model<br>`Runtime 56800E lmm.lib` | CodeWarrior\M56800E Support\runtime_56800E\lib |
| Small Memory Model<br>`Runtime 56800E.Lib` | CodeWarrior\M56800E Support\runtime_56800E\lib |

When creating a project from R1.1 or later Stationery, the associated init code is specific to the DSP56800E board. See the startup folder in the new project folder for the init code.

### Listing 14.1  Sample Initialization File (DSP56852EVM)

```
#

; -------------------------------------------------------
;
;       56852_init.asm
;       sample
        description:  main entry point to C code.
;                 setup runtime for C and call main
;
; -------------------------------------------------------


;===============================
; OMR mode bits
;===============================
NL_MODE                 EQU              $8000
CM_MODE                 EQU              $0100
XP_MODE                 EQU              $0080
R_MODE                  EQU              $0020
SA_MODE                 EQU              $0010
```

```


        section rtlib

        XREF F_stack_addr
        org p:


        GLOBAL Finit_M56852_
        SUBROUTINE "Finit_M56852_",Finit_M56852_,Finit_M56852END-
Finit_M56852_

Finit_M56852_:

;
; setup the OMr with the values required by C
;
       bfset   #NL_MODE,omr     ; ensure NL=1  (enables nsted DO
loops)
        nop
        nop
   bfclr   #(CM_MODE|XP_MODE|R_MODE|SA_MODE),omr ; ensure CM=0
(optional for C)
                   ; ensure XP=0 to enable harvard architecture
                   ; ensure R=0  (required for C)
                   ; ensure SA=0 (required for C)

; Setup the m01 register for linear addressing
        move.w  #-1,x0
        moveu.w x0,m01        ; Set the m register to linear
addressing

        moveu.w hws,la        ; Clear the hardware stack
        moveu.w hws,la
        nop
        nop


CALLMAIN:                           ; Initialize compiler environment


;Initialize the Stack
        move.l #>>F_Lstack_addr,r0
        bftsth #$0001,r0
        bcc noinc
        adda #1,r0
noinc:
        tfra    r0,sp                ; set stack pointer too
        move.w  #0,r1
        nop
        move.w  r1,x:(sp)
        adda    #1,sp

  jsr                   F__init_sections

; Call main()
```

```
        move.w  #0,y0               ; Pass parameters to main()
        move.w  #0,R2
        move.w  #0,R3

        jsr            Fmain        ; Call the Users program
;
;  The fflush calls where removed because they added code
;  growth in cases where the user is not using any debugger IO.
;  Users should now make these calls at the end of main if they use
debugger IO
;
;       move.w  #0,r2
;       jsr     Ffflush             ; Flush File IO
;       jsr     Ffflush_console     ; Flush Console IO

;       end of program; halt CPU
        debughlt
        rts
Finit_M56852END:

       endsec
```

# EOnCE Library

The EOnCE (Enhanced On Chip Emulator) library provides functions, which allows your program to control the EOnCE. The library lets you set and clear triggers for breakpoints, watchpoints, program traces, and counters. With several option enumerations, the library greatly simplifies using the EOnCE from within the core, and thus eliminates the need for a DSP56800E User Manual. The library and the debugger are coordinated so that the debugger does not overwrite a trigger set by the library, and vice versa.

To use the EOnCE library, you must include it in your project. The name of the file is `eonce 56800E lmm.lib` and it is located at:

`CodeWarrior\M56800ESupport\eonce\lib`

The **Large Data Model** option must be enabled in the **M56800E Processor** preference panel. Any source file that contains code that calls any of the EOnCE Library functions must `#include eonceLib.h`. This header file is located at:

`CodeWarrior\M56800E Support\eonce\include`

The library functions are listed below:

- _eonce_Initialize on page 327
- _eonce_SetTrigger on page 328
- _eonce_SetCounterTrigger on page 329

- _eonce_ClearTrigger on page 330
- _eonce_GetCounters on page 331
- _eonce_GetCounterStatus on page 331
- _eonce_SetupTraceBuffer on page 332
- _eonce_GetTraceBuffer on page 332
- _eonce_ClearTraceBuffer on page 333
- _eonce_StartTraceBuffer on page 334
- _eonce_HaltTraceBuffer on page 334
- _eonce_EnableDEBUGEV on page 334
- _eonce_EnableLimitTrigger on page 335

The sub-section “Definitions” on page 336 defines:

- Return Codes on page 336
- Normal Trigger Modes on page 337
- Counter Trigger Modes on page 338
- Data Selection Modes on page 340
- on page 340Counter Function Modes on page 340
- Normal Unit Action Options on page 341
- Counter Unit Action Options on page 341
- Accumulating Trigger Options on page 342
- Miscellaneous Trigger Options on page 343
- Trace Buffer Capture Options on page 343
- Trace Buffer Full Options on page 344
- Miscellaneous Trace Buffer Option on page 345

## _eonce_Initialize

Initializes the library by setting the necessary variables.

### Prototype

```
void _eonce_Initialize( unsigned long baseAddr, unsigned int
     units )
```

### Parameters

`baseAddrunsigned long`

Specifies the location in X: memory where the EOnCE registers are located.

`unitsunsigned int`

Specifies the number of EOnCE breakpoint units available.

### Remarks

This function must be called before any other library function is called. Its parameters are dependent on the processor being used. Instead of calling this function directly, one of the defined macros can be called in its place. These include **_eonce_Initialize56838E()**, **_eonce_Initialize56852E()**, and **_eonce_Initialize56858E()**. These macros call **_eonce_Initialize** with the correct parameters for the 56838, 56852, and 56858, respectively.

### Returns

Nothing.

## _eonce_SetTrigger

Sets a trigger condition used to halt the processor, cause an interrupt, or start and stop the trace buffer. This function does not set triggers for special counting functions.

### Prototype

```
int _eonce_SetTrigger( unsigned int unit, unsigned long
     options, unsigned long value1, unsigned long value2,
     unsigned long mask, unsigned int counter )
```

### Parameters

`unitunsigned int`

Specifies which breakpoint unit to use.

`optionsunsigned long`

Describes the behavior of the trigger. For more information on the identifiers for this parameter, please see the sub-section “Definitions” on page 322.

`value1unsigned long`

Specifies the address or data value to compare as defined by the options parameter.

`value2unsigned long`

Specifies the address or data value to compare as defined by the options parameter.

`maskunsigned long`

Specifies which bits of value2 to compare.

`counterunsigned int`

Specifies the number of successful comparison matches to count before completing trigger sequence as defined by the options parameter

### Remarks

This function sets all triggers, except those used to define the special counting function behavior. Carefully read the list of defined identifiers that can be OR'ed into the options parameter.

### Returns

Error code as defined in the sub-section “Definitions.”

## _eonce_SetCounterTrigger

Sets a trigger condition used for special counting functions.

### Prototype

```
int _eonce_SetCounterTrigger( unsigned int unit, unsigned
      long options, unsigned long value1, unsigned long value2,
      unsigned long mask, unsigned int counter, unsigned long
      counter2 )
```

### Parameters

`unitunsigned int`

Specifies which breakpoint unit to use.

`optionsunsigned long`

Describes the behavior of the trigger. For more information on the identifiers for this parameter, please see the sub-section “Definitions” on page 322.

`value1unsigned long`

Specifies the address or data value to compare as defined by the options parameter.

`value2unsigned long`

Specifies the address or data value to compare as defined by the options parameter.

`maskunsigned long`

Specifies which bit of value2 to compare.

`counterunsigned int`

Specifies the value used to pre-load the counter, which proceeds backward when `EXTEND_COUNTER` is OR'ed into the options parameter. `counter` contains the least significant 16-bits.

`counter2unsigned long`

Specifies the value used to pre-load the counter, which proceeds backward. When `EXTEND_COUNTER` is OR'ed into the options parameter. `counter2` contains the most significant 24-bits. However, when `EXTEND_COUNTER` is not OR'ed `counter2` should be set to `0`.

### Remarks

This function is used to set special counting function triggers. The special counting options are defined in the sub-section "Definitions." Carefully read the list of defined identifiers that can be OR'ed into the options parameter.

### Returns

Error code as defined in the sub-section "Definitions."

## _eonce_ClearTrigger

Clears a previously set trigger.

### Prototype

```
int _eonce_ClearTrigger( unsigned int unit )
```

### Parameters

`unitunsigned int`

Specifies which breakpoint unit to use.

### Remarks

This function clears a trigger set with the **_eonce_SetTrigger** or **_eonce_SetCounterTrigger** functions.

### Returns

Error code as defined in the sub-section "Definitions."

## _eonce_GetCounters

Retrieves the values in the two counter registers.

### Prototype

```
int _eonce_GetCounters( unsigned int unit, unsigned int
     *counter, unsigned long *counter2 )
```

### Parameters

`unitunsigned int`

Specifies which breakpoint unit to use.

`counterunsigned int *`

Holds the value of the counter, or the least significant 16-bits, if the counter has been extended to 40-bits.

`counter2unsigned long *`

Holds the most significant 24-bits if the counter has been extended to 40-bits. This parameter must be a valid pointer even if the counter has not been extended.

### Remarks

This function retrieves the value of the counter of the specified breakpoint unit. This function is most useful when using the special counting function of the breakpoint, but can also be used to retrieve the trigger occurrence counter.

### Returns

Error code as defined in the sub-section “Definitions.”

## _eonce_GetCounterStatus

Retrieves the status of the breakpoint counter.

### Prototype

```
int _eonce_GetCounters( char *counterIsZero, char
     *counterIsStopped)
```

### Parameters

`counterIsZero char *`

Returns a 1 if the breakpoint counter has reached zero.

`counterIsStopped char *`

Returns a 1 if the breakpoint counter has been stopped by a Counter Stop Trigger.

### Remarks

This function returns the state of the breakpoint counter when using the special counting function.

### Returns

Error code as defined in the sub-section “Definitions.”

## _eonce_SetupTraceBuffer

Configures the behavior of the trace buffer.

### Prototype

```
int _eonce_SetupTraceBuffer( unsigned int options )
```

### Parameters

`optionsunsigned int`

Describes the behavior of the trace buffer. Please see the section Definitions for more information on the identifiers for this parameter.

### Remarks

Sets the behavior of the trace buffer. Triggers can also be set to start and stop trace buffer capture using the **_eonce_SetTrigger** function.

### Returns

Error code as defined in the sub-section “Definitions.”

## _eonce_GetTraceBuffer

Retrieves the contents of the trace buffer.

### Prototype

```
int _eonce_GetTraceBuffer( unsigned int *count, unsigned long
     *buffer )
```

### Parameters

`countunsigned int *`

Passes in the size of the buffer; if 0 is passed in, the contents of the trace buffer are not retrieved, instead the number of entries in the trace buffer are returned in count.

`bufferunsigned long *`

Points to an array in which the contents of the trace buffer are returned starting with the oldest entry.

### Remarks

This function retrieves the addresses contained in the trace buffer. The addresses represent the program execution point when certain change-of-flow events occur. The trace buffer behavior, including capture events, can be configured using **_eonce_SetupTraceBuffer**.

### Returns

Error code as defined in the sub-section “Definitions.”

## _eonce_ClearTraceBuffer

Clears the contents of the trace buffer.

### Prototype

```
int _eonce_ClearTraceBuffer( )
```

### Parameters

None.

### Remarks

This function clears the trace buffer and is useful when you want a fresh set of data. It is necessary to resume capturing when the trace buffer is full and configured to stop capturing.

### Returns

Error code as defined in the sub-section “Definitions.”

## _eonce_StartTraceBuffer

Resumes trace buffer capturing.

### Prototype

```
int _eonce_StartTraceBuffer( )
```

### Parameters

None.

### Remarks

This function causes the trace buffer to immediately start capturing.

### Returns

Error code as defined in the sub-section “Definitions.”

## _eonce_HaltTraceBuffer

Halts trace buffer capturing.

### Prototype

```
int _eonce_HaltTraceBuffer( )
```

### Parameters

None.

### Remarks

Causes the trace buffer to immediately stop capturing.

### Returns

Error code as defined in the sub-section “Definitions.”

## _eonce_EnableDEBUGEV

Allows or disallows a DEBUGEV instruction to cause a core event in breakpoint unit 0.

### Prototype

```
int _eonce_EnableDEBUGEV( char enable )
```

### Parameters

`enablechar`

If a non-zero value, allows the DEBUGEV instruction to cause a core event. If a zero value, prevents the DEBUGEV instruction from causing a core event.

### Remarks

This function configures the behavior for the DEBUGEV instructions. For a core event to occur, breakpoint unit 0 must be activated by setting a trigger using the **_eonce_SetTrigger** or **_eonce_SetCounterTrigger** functions.

### Returns

Error code as defined in the sub-section "Definitions."

## _eonce_EnableLimitTrigger

Allows or disallows a limit trigger to cause a core event in breakpoint unit 0.

### Prototype

```
int _eonce_EnableLimitTrigger( char enable )
```

### Parameters

`enablechar`

If a non-zero value, allows this instruction to cause a core event. If a zero value, prevents this instruction from causing a core event.

### Remarks

This function configures the behavior for overflow and saturation conditions in the processor core. For a core event to occur, breakpoint unit 0 must be activated by setting a trigger using the **_eonce_SetTrigger** or **_eonce_SetCounterTrigger** functions.

### Returns

Error code as defined in the sub-section "Definitions."

# Definitions

This sub-section defines:

# Return Codes

Every function except **_eonce_Initialize** returns one of the error codes in Table 14.4 on page 336.

**Table 14.4 Error Codes**

| Error Code | Description |
|---|---|
| EONCE_ERR_NONE | No error. |
| EONCE_ERR_NOT_INITIALIZED | The **_eonce_Initialize** function has not been called before the current function. |
| EONCE_ERR_UNIT_OUT_OF_RANGE | The unit parameter is greater than or equal to the number of units specified in **_eonce_Initialize.** |
| EONCE_ERR_LOCKED_OUT | The core cannot access the EOnCE registers because the debugger has locked out the core. This occurs when a trigger has been set using the EOnCE GUI panels or through an IDE breakpoint or watchpoint. |

## Normal Trigger Modes

One of the defined identifiers listed in Listing 14.2 on page 337 must be OR'ed into the options parameter of the **_eonce_SetTrigger** function. A key for the defined identifiers listed in Listing 14.2 on page 337 is given in Table 14.5 on page 338 on page 337.

### Listing 14.2 Normal Trigger Modes

```
B1PA_N
B1PR_N
B1PW_N
B2PF_N
B1XA_OR_B2PF_N
B1XA_N_OR_B2PF
B1PF_OR_B2PF_N
B1PA_OR_B2PF_N
B1PA_N_OR_B2PF
B1PF_OR_N_B2PF
B1PA_OR_N_B2PF
B1XR_AND_N_B2DR
B1XW_AND_N_B2DW
B1XA_AND_N_B2DRW
B1PF_N_THEN_B2PF
B2PF_THEN_B1PF_N
B1PA_N_THEN_B2PF
B1PA_THEN_B2PF_N
B2PF_N_THEN_B1PA
B2PF_THEN_B1PA_N
B1XA_N_THEN_B2PF
B1XA_THEN_B2PF_N
B2PF_N_THEN_B1XA
B2PF_THEN_B1XA_N
B1XW_N_THEN_B2PF
B1XW_THEN_B2PF_N
B2PF_N_THEN_B1XW
B2PF_THEN_B1XW_N
B1XR_N_THEN_B2PF
B1XR_THEN_B2PF_N
B2PF_N_THEN_B1XR
B2PF_THEN_B1XR_N
B1PF_STB_B2PF_HTB
B1PA_STB_B2PF_HTB
B2PF_STB_B1PA_HTB
Defined Identifier Key for Normal Trigger Modes
```

**Table 14.5 Defined Identifier Key: Normal Trigger Modes**

| Identifier Fragments | Description |
|---|---|
| B1 | breakpoint 1; value set in value1 |
| B2 | breakpoint 2; value set in value2 |
| P | p-memory address; this is followed by a type of access |
| X | x-memory address; this is followed by a type of access |
| D | value being read from or written to x-memory |
| A | memory access |
| R | memory read |
| W | memory write |
| F | memory fetch; only follows a P |
| OR | links two sub-triggers by a logical or |
| AND | links two sub-triggers by a logical and |
| THEN | creates a sequence; first sub-trigger must occur, then second sub-trigger must occur to complete the trigger |
| N | the sub-trigger it follows must occur N times as set in the count parameter; if N follows an operation, then the combination of the sub-triggers must occur N times; (count - 1) will be written to the BCNTR register |
| STB | sub-trigger starts the trace buffer |
| HTB | sub-trigger halts the trace buffer |

## Counter Trigger Modes

The following triggers generate a Counter Stop Trigger. The exceptions are the modes that generate both start and stop triggers.

The defined identifiers listed in Listing 14.3 on page 339 must be OR'ed into the options parameter of the **_eonce_SetCounterTrigger** function. A key for the defined identifiers listed in Listing 14.3 on page 339 is given in Table 14.6 on page 339

### Listing 14.3 Counter Trigger Modes

```
B1PA
B1PR
B1PW
B2PF
B1XA_OR_B2PF
B1PF_OR_B2PF
B1PA_OR_B2PF
```

```
B1XR_AND_B2DR
B1XW_AND_B2DW
B1XA_AND_B2DRW
B1PF_THEN_B2PF
B1PA_THEN_B2PF
B2PF_THEN_B1PA
B1XA_THEN_B2PF
B2PF_THEN_B1XA
B1XW_THEN_B2PF
B2PF_THEN_B1XW
B1XR_THEN_B2PF
B2PF_THEN_B1XR
B1PF_SC_B2PF_HC
B1PA_SC_B2PF_HC
B2PF_SC_B1PA_HC
```

### Table 14.6 Defined Identifier Key: Counter Trigger Modes

| Identifier Fragments | Description |
|---|---|
| B1 | breakpoint 1; value set in value1 |
| B2 | breakpoint 2; value set in value2 |
| P | p-memory address; this is followed by a type of access |
| X | x-memory address; this is followed by a type of access. |
| D | value being read from or written to x-memory |
| A | memory access |
| R | memory read |
| W | memory write |
| F | memory fetch; only follows a P |

**Table 14.6 Defined Identifier Key: Counter Trigger Modes (*continued*)**

| Identifier Fragments | Description |
|---|---|
| OR | links two sub-triggers by a logical or |
| AND | links two sub-triggers by a logical and |
| THEN | creates a sequence; first sub-trigger must occur, then second sub-trigger must occur to complete the trigger |
| SC | sub-trigger starts the counter |
| HC | sub-trigger halts the counter |

## Data Selection Modes

If the trigger mode being set includes a data value compare (contains B2D from the list Normal Trigger Modes or Counter Trigger Modes), then one of the defined identifiers in Table 14.7 on page 340 must be OR'ed into the options parameter of the **_eonce_SetTrigger** or **_eonce_SetCounterTrigger** function. If not, then do not OR in any of these identifiers.

**Table 14.7 Data Selection Modes**

| Defined Identifiers | Description |
|---|---|
| B2D_BYTE | makes a comparison when the data being moved is of byte-length |
| B2D_WORD | makes a comparison when the data being moved is of word-length |
| B2D_LONG | makes a comparison when the data being moved is of long-length |

## Counter Function Modes

One of the defined identifiers in Table 14.8 on page 340 must be OR'ed into the options parameter of the **_eonce_SetCounterTrigger** function.

**Table 14.8 Counter Function Modes**

| Defined Identifiers | Description |
|---|---|
| PCLK_CLOCK_CYCLES | count pclk cycles |
| CLK_CLOCK_CYCLES | count clk cycles |

Table 14.8 Counter Function Modes (*continued*)

| Defined Identifiers | Description |
|---|---|
| INSTRUCTIONS_EXECUTED | count instructions executed |
| TRACE_BUFFER_WRITES | count writes to the trace buffer |
| COUNTER_START_TRIGGERS | count Counter Start Triggers |
| PCLK_CLOCK_CYCLES | count pclk cycles |

## Normal Unit Action Options

This list of options describes the action taken when a non-counter trigger is generated. One of the defined identifiers in Table 14.9 on page 341 must be OR'ed into the options parameter of the **_eonce_SetTrigger** function.

Table 14.9 Normal Unit Actions Options Mode

| Defined Identifiers | Description |
|---|---|
| UNIT_ACTION | enters debug mode is unit 0, else passes signal on to next unit |
| INTERRUPT_CORE | interrupts to vector set for this unit |
| HALT_TRACE_BUFFER | trace buffer capture is halted |
| START_TRACE_BUFFER | trace buffer capture is started |
| UNIT_ACTION | enters debug mode is unit 0, else passes signal on to next unit |

## Counter Unit Action Options

This list of options describes the action taken when a counter trigger is generated. One of the defined identifiers in Table 14.10 on page 342 must be OR'ed into the options parameter of the **_eonce_SetCounterTrigger** function. Identifiers that include ZERO_BEFORE_TRIGGER only perform the action when the counter counts down to zero before the Counter Stop Trigger occurs. Identifiers that include TRIGGER_BEFORE_ZERO only perform the action when the Counter Stop Trigger occurs before the counter counts down to zero.

**Table 14.10  Counter Unit Actions Options Mode**

| Defined Identifiers | Description |
|---|---|
| NO_ACTION | counter status bits still get set |
| UNIT_ACTION_ZERO_BEFORE_TRIGGER | enters debug mode is unit 0, else passes signal on to next unit |
| INTERRUPT_CORE_ZERO_BEFORE_TRIGGER | interrupts to vector set for this unit |
| UNIT_ACTION_TRIGGER_BEFORE_ZERO | enters debug mode is unit 0, else passes signal on to next unit |
| INTERRUPT_CORE_TRIGGER_BEFORE_ZERO | interrupts to vector set for this unit |

## Accumulating Trigger Options

One of the defined identifiers in Table 14.11 on page 342 must be OR'ed into the options parameter of the **_eonce_SetTrigger** function when breakpoint unit 0 is being configured.

**Table 14.11  Accumulating Trigger Options Mode with Breakpoint Unit 0**

| Defined Identifiers | Description |
|---|---|
| PREV_UNIT_OR_THIS_TRIGGER_OR_CORE_EVENT | a trigger is generated if the previous breakpoint unit passes in a trigger signal or this breakpoint unit creates a trigger signal or if a core event occurs |
| PREV_UNIT_THEN_THIS_TRIGGER_OR_CORE_EVENT | a trigger is generated if the previous breakpoint unit passes in a trigger signal followed by either this breakpoint unit creating a trigger signal or a core event occurring |
| THIS_TRIGGER_THEN_CORE_EVENT | a trigger is generated if this breakpoint unit creates a trigger signal followed by a core event occurring |
| PREV_UNIT_THEN_THIS_TRIGGER_THEN_CORE_EVENT | a trigger is generated if the previous breakpoint unit passes in a trigger signal followed by this breakpoint unit creating a trigger signal followed by a core event occurring |

One of the defined identifiers in Table 14.12 on page 343 must be OR'ed into the options parameter of the **_eonce_SetTrigger** function when a breakpoint unit other than unit 0 is being configured.

**Table 14.12 Accumulating Trigger Options Mode, Non-0 Breakpoint Unit**

| Defined Identifiers | Description |
|---|---|
| PREV_UNIT_OR_THIS_TRIGGER | a trigger is generated if the previous breakpoint unit passes in a trigger signal or this breakpoint unit creates a trigger signal |
| PREV_UNIT_THEN_THIS_TRIGGER | a trigger is generated if the previous breakpoint unit passes in a trigger signal followed by this breakpoint unit creating a trigger signal |

## Miscellaneous Trigger Options

The defined identifiers in Table 14.13 on page 343 are optional.

**Table 14.13 Miscellaneous Trigger Options**

| Defined Identifiers | Description |
|---|---|
| INVERT_B2_COMPARE | the signal from breakpoint 2 is inverted before entering the combination logic; this can be OR'ed into the options parameter of the **_eonce_SetTrigger** or **_eonce_SetCounterTrigger** function |
| EXTEND_COUNTER | the counter, when using the special counting function, is extended to 40-bits by using the OSCNTR as the most significant 24-bits; this can be OR'ed into the options parameter of the **_eonce_SetCounterTrigger** function when configuring breakpoint unit 0; WARNING: It is not recommended that this option be used if the processor will enter debug mode (breakpoint, console or file I/O) before the counter is read, because the OSCNTR is needed for stepping and would corrupt the counter |

## Trace Buffer Capture Options

The options in Table 14.14 on page 344 determine which kind of changes-of-flow will be captured. OR in as many of the following defined identifiers into the options parameter of the **_eonce_SetupTraceBuffer** function.

**Table 14.14 Trace Buffer Capture Options**

| Defined Identifiers | Description |
|---|---|
| CAPTURE_CHANGE_OF_FLOW_NOT_TAKEN | saves target addresses of conditional branches and jumps that are not taken to the trace buffer |
| CAPTURE_CHANGE_OF_FLOW_INTERRUPT | saves addresses of interrupt vector fetches and target addresses of RTI instructions to the trace buffer |
| CAPTURE_CHANGE_OF_FLOW_SUBROUTINE | saves the target addresses of JSR, BSR, and RTS instructions to the trace buffer |
| CAPTURE_CHANGE_OF_FLOW_0 | saves the target addresses of the following taken instructions to the trace buffer:<br>BCC forward branch<br>BRSET forward branch<br>BRCLR forward branch<br>JCC forward and backward branches |
| CAPTURE_CHANGE_OF_FLOW_1 | saves the target addresses of the following taken instructions to the trace buffer:<br>BCC backward branch<br>BRSET backward branch<br>BRCLR backward branch |

## Trace Buffer Full Options

The options in Table 14.15 on page 344 describe what action to take when the trace buffer is full. One of the following defined identifiers must be OR’ed into the options parameter of the **_eonce_SetupTraceBuffer** function.

**Table 14.15 Trace Buffer Full Options**

| Defined Identifiers | Description |
|---|---|
| TB_FULL_NO_ACTION | capture continues, overwriting previous entries |
| TB_FULL_HALT_CAPTURE | capture is halted |

Table 14.15 Trace Buffer Full Options (*continued*)

| Defined Identifiers | Description |
|---|---|
| TB_FULL_DEBUG | processor enters debug mode |
| TB_FULL_INTERRUPT | processor interrupts to vector specified as Trace Buffer Interrupt |

## Miscellaneous Trace Buffer Option

The TRACE_BUFFER_HALTED option may be OR'ed into the options parameter of the **_eonce_SetupTraceBuffer** function. This option puts the trace buffer in a halted state when leaving **_eonce_SetupTraceBuffer** function. This is most useful when setting a trigger, by calling **_eonce_SetTrigger**, to start the trace buffer when a specific condition is met.

# A

# Porting Issues

This appendix explains issues relating to successfully porting code to the most current version of the CodeWarrior Development Studio for Freescale 56800/E Digital Signal Controllers.

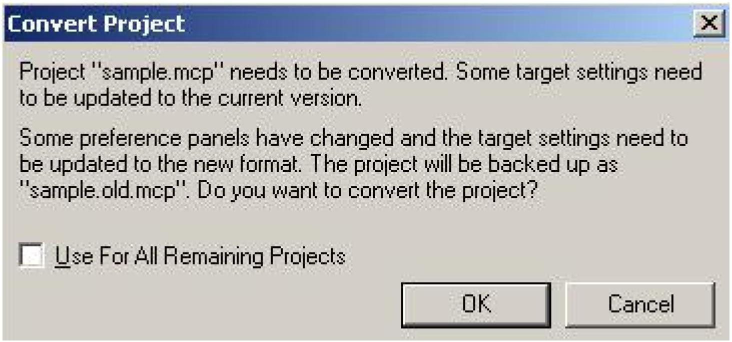
This appendix contains the following sections:

- Converting the DSP56800E Projects from Previous Versions on page 347
- Removing "illegal object_c on pragma directive" Warning on page 348

## Converting the DSP56800E Projects from Previous Versions

When you open older projects in the CodeWarrior IDE, the IDE automatically prompts you to convert your existing project (Figure A.1 on page 347). Your old project will be backed up if you need to access that project file at a later time. The CodeWarrior IDE cannot open older projects if you do not convert them.

**Figure A.1 Project Conversion Dialog**



Convert Project

Project "sample.mcp" needs to be converted. Some target settings need to be updated to the current version.

Some preference panels have changed and the target settings need to be updated to the new format. The project will be backed up as "sample.old.mcp". Do you want to convert the project?

□ Use For All Remaining Projects

# Removing "illegal object_c on pragma directive" Warning

If after porting a project to DSP56800E 7.x, you get a warning that says `illegal object_c on pragma directive`, you need to remove it. To remove this warning:

1. Open the project preference and go to the C/C++ Preprocessor.
2. Remove the line `#pragma objective_con` from the prefix text field.

B

# DSP56800x New Project Wizard

This appendix explains the high-level design of the new project wizard.

## Overview

The DSP56800x New Project Wizard supports the DSP56800x processors listed in Table B.1 on page 349.

Table B.1 Supported DSP56800x Processors for the New Project Wizard

| DSP56800 | DSP56800E |
|---|---|
| DSP56F801 (60 MHz) | DSP56852 |
| DSP56F801 (80 MHz) | DSP56853 |
| DSP56F802 | DSP56854 |
| DSP56F803 | DSP56855 |
| DSP56F805 | DSP56857 |
| DSP56F807 | DSP56858 |
| DSP56F826 | MC56F8013 |
| DSP56F827 | MC56F8014 |
| | MC56F8023 |
| | MC56F8025 |
| | MC56F8036 |
| | MC56F8037 |
| | MC56F8122 |
| | MC56F8123 |

Table B.1 Supported DSP56800x Processors for the New Project Wizard (*continued*)

| DSP56800 | DSP56800E |
|---|---|
| | MC56F8145 |
| | MC56F8146 |
| | MC56F8147 |
| | MC56F8155 |
| | MC56F8156 |
| | MC56F8157 |
| | MC56F8165 |
| | MC56F8166 |
| | MC56F8167 |
| | MC56F8322 |
| | MC56F8323 |
| | MC56F8335 |
| | MC56F8345 |
| | MC56F8346 |
| | MC56F8356 |
| | MC56F8357 |
| | MC56F8365 |
| | MC56F8366 |
| | MC56F8367 |

Wizard rules for the DSP56800x New Project Wizard are described in the following sub-sections:

- Page Rules on page 351
- Resulting Target Rules on page 352
- on page 353Rule Notes on page 353

Click on the following link for details about the DSP56800x New Project Wizard Graphical User Interface:

- DSP56800x New Project Wizard Graphical User Interface on page 354

# Page Rules

The page rules governing the wizard page flow for the simulator and the different processors are shown in the Table B.2 on page 351, Table B.3 on page 351, Table B.4 on page 352, and Table B.5 on page 352.

**Table B.2 Page Rules for the Simulator, DSP56F801 (60 and 80 MHz), DSP56F802, MC56F801x, MC56F802x, MC56F803x, MC56F812x, and MC56F832x**

| Target Selection Page | Next Page | Next Page |
|---|---|---|
| any simulator | Program Choice Page | Finish Page |
| DSP56F801 60 MHz | | |
| DSP56F801 80 MHz | | |
| DSP56F802 | | |
| MC56F801x | | |
| MC56F802x | | |
| MC56F803x | | |
| MC56F812x | | |
| MC56F832x | | |

**Table B.3 Page Rules for the DSP56F803, DSP56F805, DSP56F807, DSP56F826, and DSP56F827**

| Target Selection Page | Next Page | Next Page | Next Page |
|---|---|---|---|
| DSP56F803 | Program Choice Page | External/Internal Memory Page | Finish Page |
| DSP56F805 | | | |
| DSP56F807 | | | |
| DSP56F826 | | | |
| DSP56F827 | | | |

**Table B.4 Page Rules for the DSP56852, DSP56853, DSP56854, DSP56855, DSP56857, and DSP56858**

| Target Selection Page | Next Page | Next Page |
|---|---|---|
| DSP56852 | Program Choice Page | Finish Page |
| DSP56853 | | |
| DSP56854 | | |
| DSP56855 | | |
| DSP56857 | | |
| DSP56858 | | |

**Table B.5 Page Rules for the MC56F814x, MC56F815x, MC56F816x, MC56F833x, MC56F834x, MC56F835x, and MC56F836x**

| Target Selection Page | Next Page | Next Page | Next Page if Processor Expert Not Selected | Next Page |
|---|---|---|---|---|
| MC56F814x | Program Choice Page | Data Memory Model Page | External/Internal Memory Page | Finish Page |
| MC56F815x | | | | |
| MC56F816x | | | | |
| MC56F833x | | | | |
| MC56F834x | | | | |
| MC56F835x | | | | |
| MC56F836x | | | | |

# Resulting Target Rules

The rules governing possible final project configurations are shown in Table B.6 on page 353.

**Table B.6 Resulting Target Rules**

| Target | Possible Targets |
|---|---|
| 56800 Simulator | Target with Non-HostIO Library and Target with Host IO Library |
| 56800E Simulator | Small Data Model and Large Data Model |
| DSP5680x | External Memory and/or Internal Memory with pROM-to-xRAM Copy |
| DSP5682x | External Memory and/or Internal Memory with pROM-to-xRAM Copy |
| DSP5685x | (Small Data Model and Small Data Model with HSST) or (Large Data Model and Large Data Model with HSST) |
| MC56F801x<br>MC56F802x<br>MC56F803x | Small Data Model Internal Memory with pROM-to-xRAM Copy |
| MC56F812x<br>MC56F832x | Small Data Model or Large Data Model Internal Memory with pROM-to xRAM Copy |
| MC56F814x<br>MC56F815x<br>MC56F816x<br>MC56F833x<br>MC56F834x<br>MC56F835x<br>MC56F836x | (Small Data Memory External and/or Small Data Memory Internal with pROM-to-xRAM Copy) or (Large Data Memory External and/or Large Data Memory Internal with pROM-to-xRAM Copy) |

# Rule Notes

Additional notes for the DSP56800x New Project Wizard rules are:

- The DSP56800x New Project Wizard uses the DSP56800x EABI Stationery for all projects. Anything that is in the DSP56800x EABI
Stationery will be in the wizard-created projects depending on the wizard choices.
- The DSP56800x EABI Stationery has all possible targets, streamlined and tuned with the DSP56800x New Project Wizard in mind.

- The DSP56800x New Project Wizard creates the entire simulator project with all the available targets in context of “Stationery as documentation and example.”

# DSP56800x New Project Wizard Graphical User Interface

This section describe the DSP56800x New Project Wizard graphical user interface.

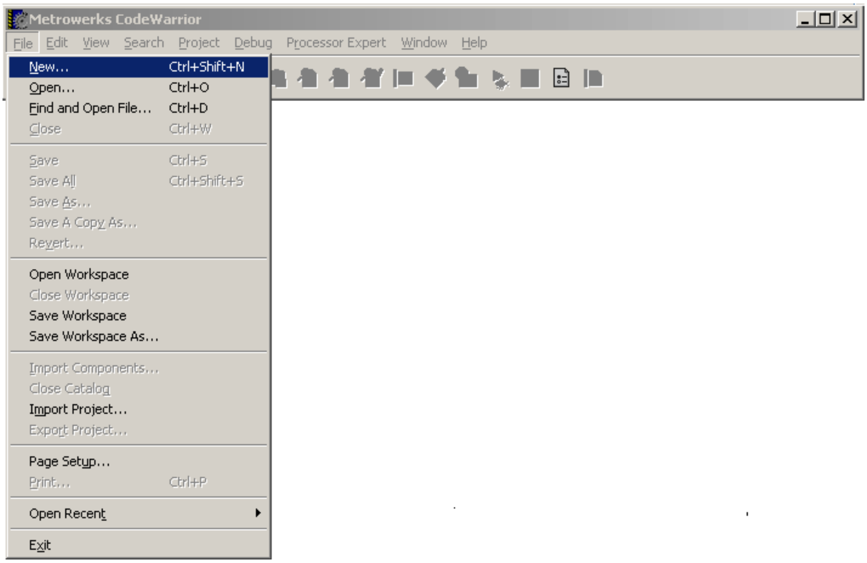
The subsections in this section are:

- Invoking the New Project Wizard on page 354
- New Project Dialog Box on page 355
- Target Pages on page 356
- Program Choice Page on page 365
- Data Memory Model Page on page 366
- External/Internal Memory Page on page 367
- Finish Page on page 368

## Invoking the New Project Wizard

To invoke the New Project dialog box, from the Freescale CodeWarrior menu bar, select **File>New** (Figure B.1 on page 355).

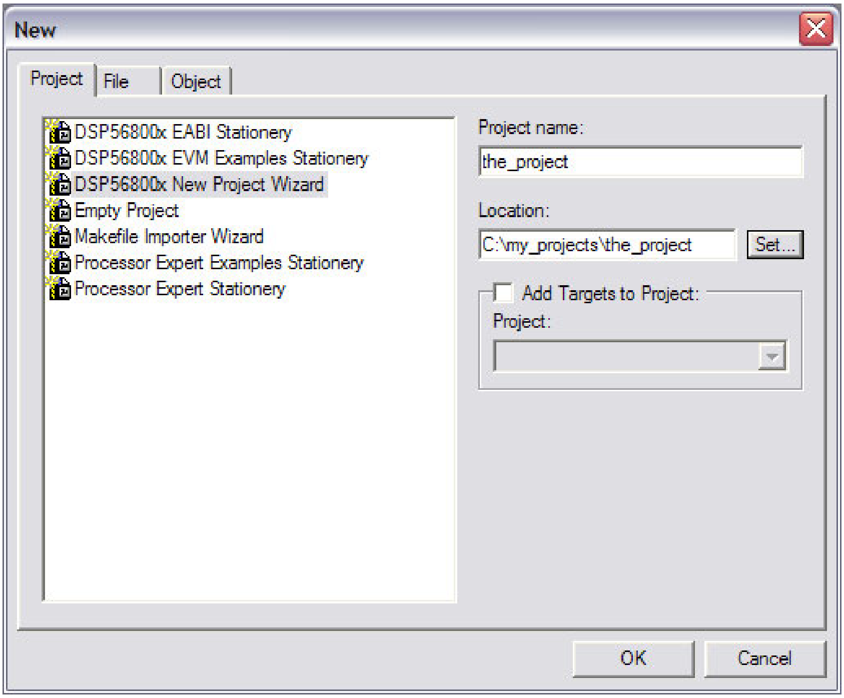
**Figure B.1 Invoking the DSP56800x New Project Wizard**



# New Project Dialog Box

After selecting **File>New** from the Freescale CodeWarrior menu bar, the New project Dialog Box (Figure B.2 on page 356) appears. In the list of stationeries, you can select either the “DSP56800x New Project Wizard” or any of the other regular stationery.

**Figure B.2 New Project Dialog Box**



- DSP56800x EABI Stationery
- DSP56800x EVM Examples Stationery
- DSP56800x New Project Wizard
- Empty Project
- Makefile Importer Wizard
- Processor Expert Examples Stationery
- Processor Expert Stationery

Project name: the_project

Location: C:\my_projects\the_project

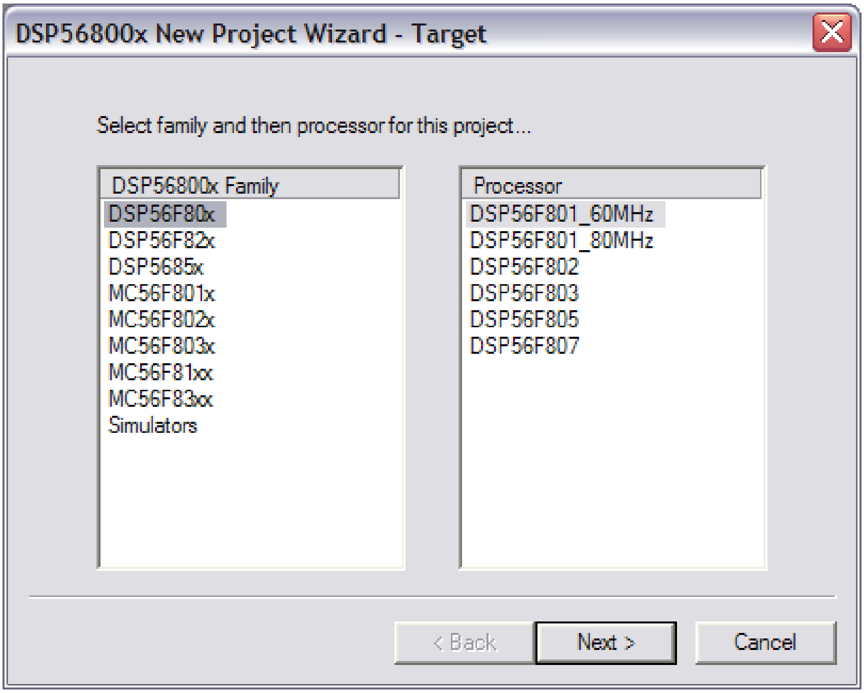
□ Add Targets to Project:

Project:

# Target Pages

When invoked, the New Project Wizard first shows a dynamically created list of supported target families and processors or simulators. Each DSP56800x family is associated with a subset of supported processors and a simulator (Figure B.3 on page 357, Figure B.4 on page 358, Figure B.5 on page 359, Figure B.6 on page 360, Figure B.7 on page 361, Figure B.8 on page 362, Figure B.9 on page 363, Figure B.10 on page 364, and Figure B.11 on page 365).

**Figure B.3 DSP56800x New Project Wizard Target Dialog Box (DSP56F80x)**

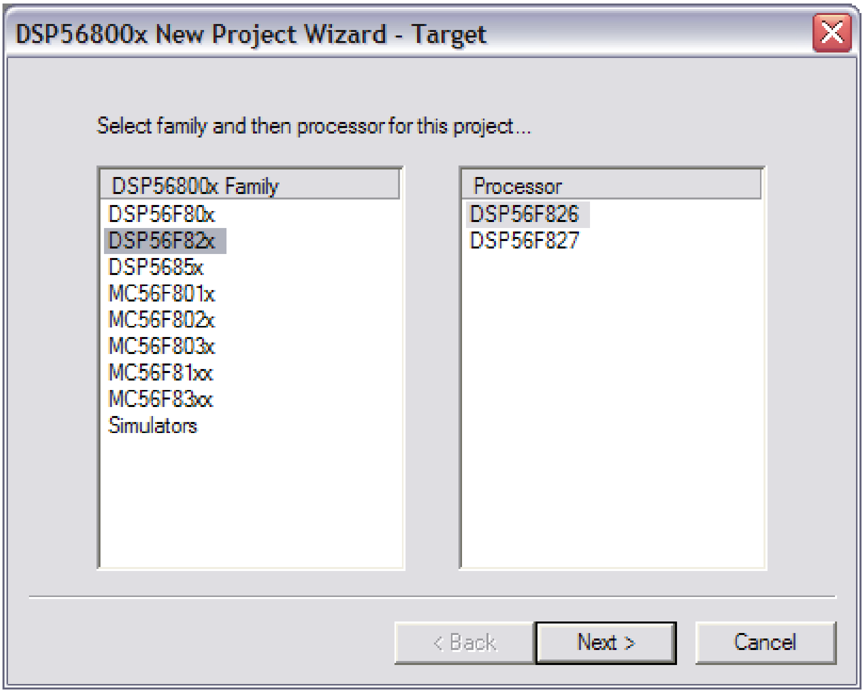


DSP56800x New Project Wizard - Target

Select family and then processor for this project...

| DSP56800x Family | Processor |
|---|---|
| DSP56F80x | DSP56F801_60MHz |
| DSP56F82x | DSP56F801_80MHz |
| DSP5685x | DSP56F802 |
| MC56F801x | DSP56F803 |
| MC56F802x | DSP56F805 |
| MC56F803x | DSP56F807 |
| MC56F81xx | |
| MC56F83xx | |
| Simulators | |

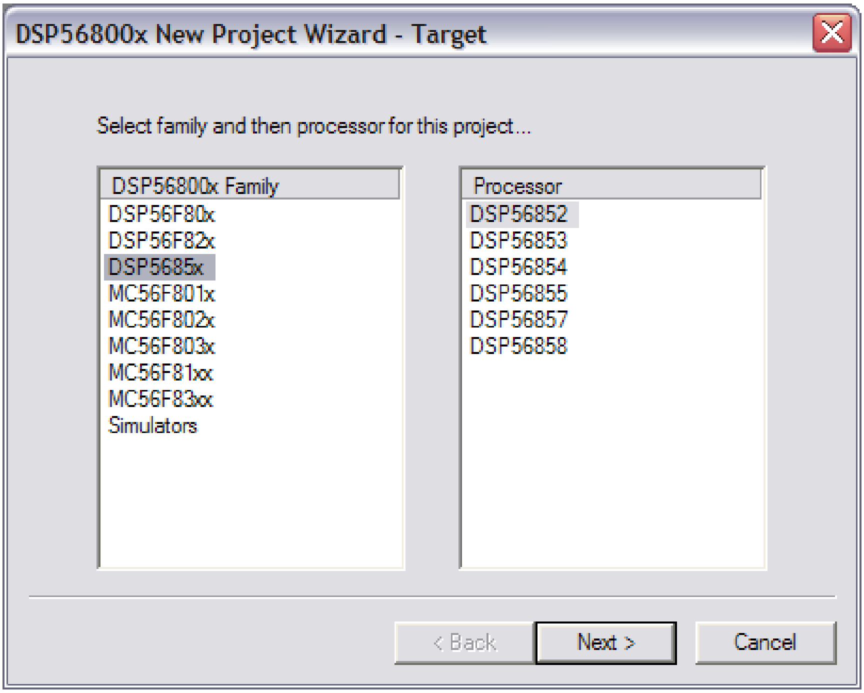
**Figure B.4 DSP56800x New Project Wizard Target Dialog Box (DSP56F82x)**



Select family and then processor for this project...

| DSP56800x Family | Processor |
|---|---|
| DSP56F80x | DSP56F826 |
| DSP56F82x | DSP56F827 |
| DSP5685x | |
| MC56F801x | |
| MC56F802x | |
| MC56F803x | |
| MC56F81xx | |
| MC56F83xx | |
| Simulators | |

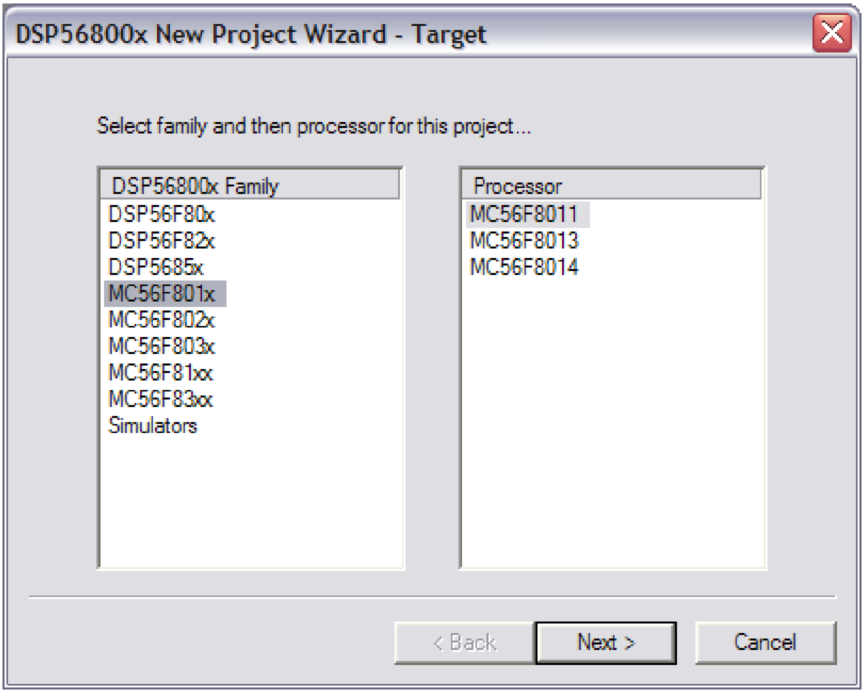
**Figure B.5 DSP56800x New Project Wizard Target Dialog Box (DSP5685x)**



Select family and then processor for this project...

| DSP56800x Family | Processor |
|---|---|
| DSP56F80x | DSP56852 |
| DSP56F82x | DSP56853 |
| DSP5685x | DSP56854 |
| MC56F801x | DSP56855 |
| MC56F802x | DSP56857 |
| MC56F803x | DSP56858 |
| MC56F81xx | |
| MC56F83xx | |
| Simulators | |

**Figure B.6 DSP56800x New Project Wizard Target Dialog Box (MC56F801x)**



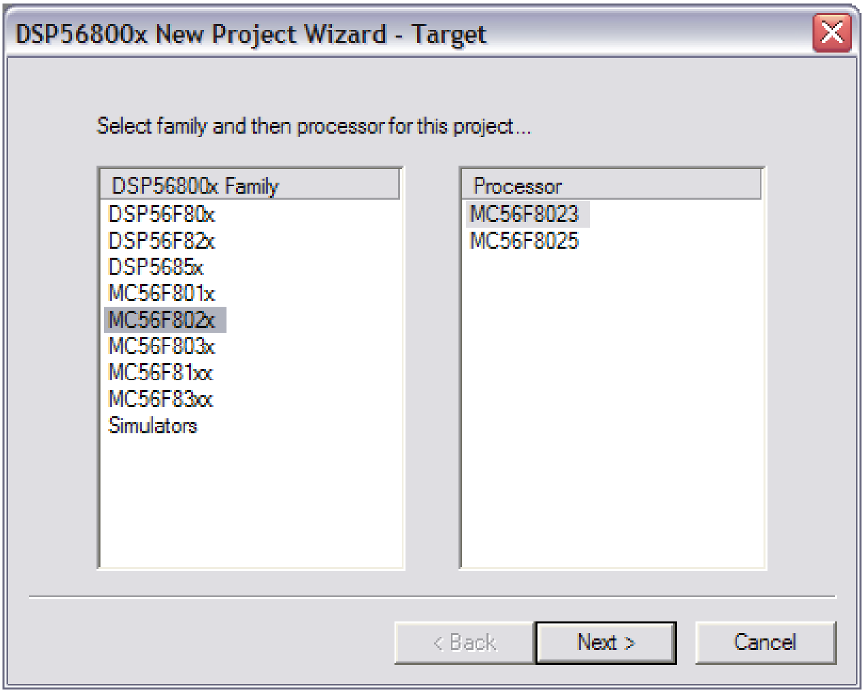
DSP56800x New Project Wizard - Target

Select family and then processor for this project...

DSP56800x Family
DSP56F80x
DSP56F82x
DSP5685x
MC56F801x
MC56F802x
MC56F803x
MC56F81xx
MC56F83xx
Simulators

Processor
MC56F8011
MC56F8013
MC56F8014

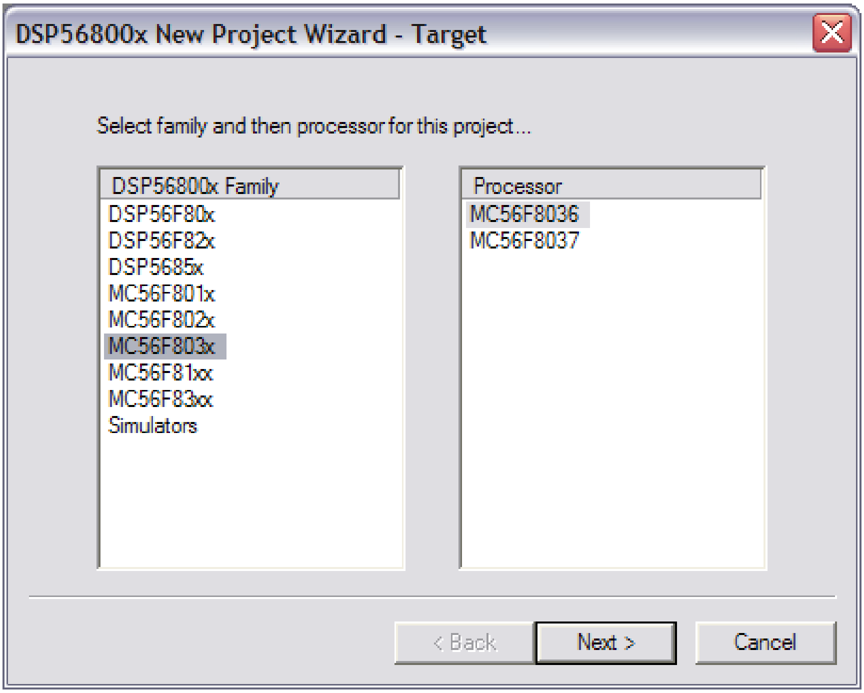
**Figure B.7 DSP56800x New Project Wizard Target Dialog Box (MC56F802x)**



DSP56800x New Project Wizard - Target

Select family and then processor for this project...

**Figure B.8  DSP56800x New Project Wizard Target Dialog Box (MC56F803x)**

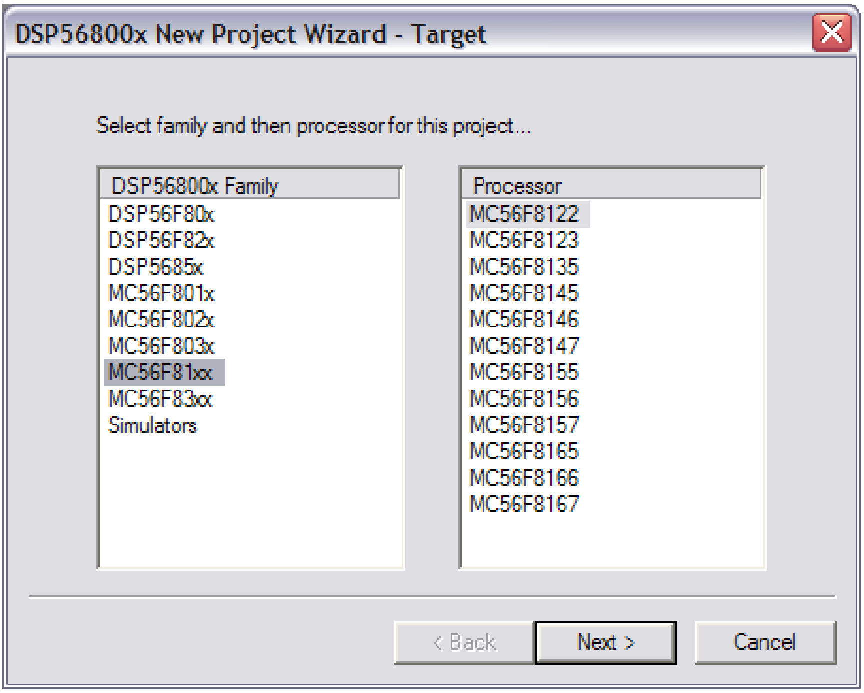


DSP56800x New Project Wizard - Target

Select family and then processor for this project...

| DSP56800x Family | Processor |
|---|---|
| DSP56F80x | MC56F8036 |
| DSP56F82x | MC56F8037 |
| DSP5685x | |
| MC56F801x | |
| MC56F802x | |
| MC56F803x | |
| MC56F81xx | |
| MC56F83xx | |
| Simulators | |

**Figure B.9 DSP56800x New Project Wizard Target Dialog Box (MC56F81xx)**

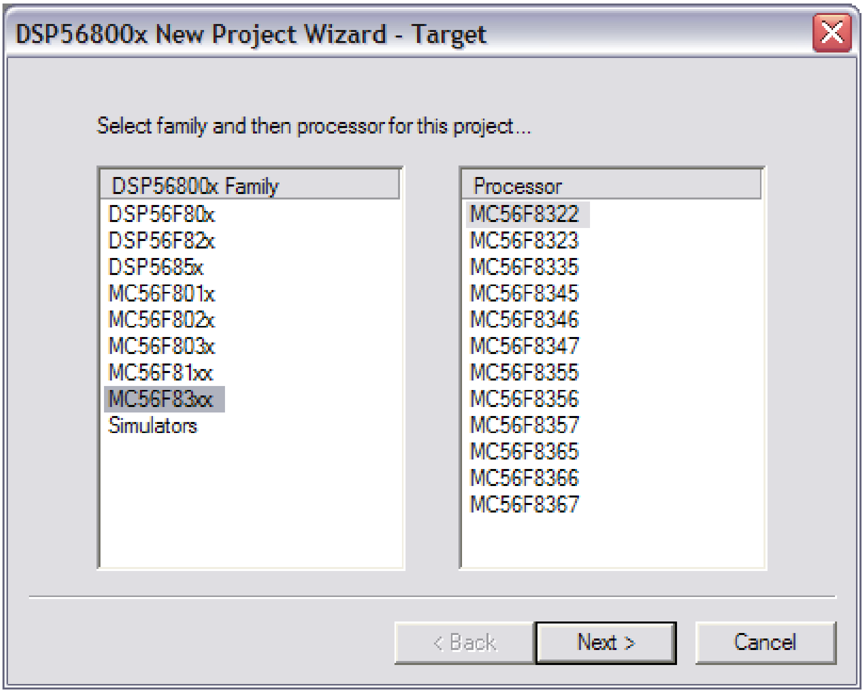


DSP56800x New Project Wizard - Target

Select family and then processor for this project...

| DSP56800x Family | Processor |
|---|---|
| DSP56F80x | MC56F8122 |
| DSP56F82x | MC56F8123 |
| DSP5685x | MC56F8135 |
| MC56F801x | MC56F8145 |
| MC56F802x | MC56F8146 |
| MC56F803x | MC56F8147 |
| MC56F81xx | MC56F8155 |
| MC56F83xx | MC56F8156 |
| Simulators | MC56F8157 |
| | MC56F8165 |
| | MC56F8166 |
| | MC56F8167 |

**Figure B.10 DSP56800x New Project Wizard Target Dialog Box (MC56F8xxx)**

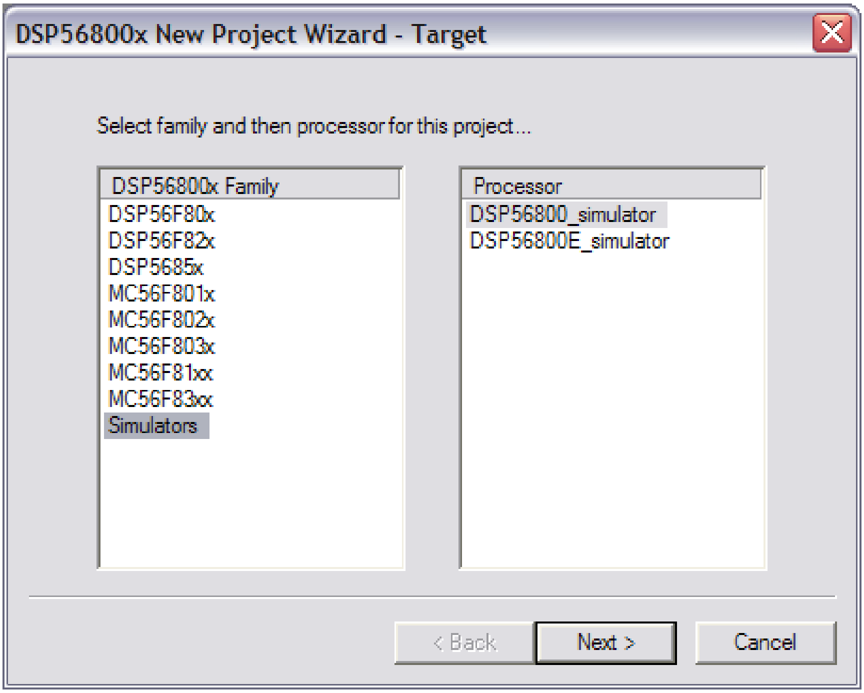


DSP56800x New Project Wizard - Target

Select family and then processor for this project...

| DSP56800x Family | Processor |
|---|---|
| DSP56F80x | MC56F8322 |
| DSP56F82x | MC56F8323 |
| DSP5685x | MC56F8335 |
| MC56F801x | MC56F8345 |
| MC56F802x | MC56F8346 |
| MC56F803x | MC56F8347 |
| MC56F81xx | MC56F8355 |
| MC56F83xx | MC56F8356 |
| Simulators | MC56F8357 |
| | MC56F8365 |
| | MC56F8366 |
| | MC56F8367 |

**Figure B.11 DSP56800x New Project Wizard Target Dialog Box (Simulators)**



DSP56800x New Project Wizard - Target

Select family and then processor for this project...

| DSP56800x Family |
|---|
| DSP56F80x |
| DSP56F82x |
| DSP5685x |
| MC56F801x |
| MC56F802x |
| MC56F803x |
| MC56F81xx |
| MC56F83xx |
| Simulators |

| Processor |
|---|
| DSP56800_simulator |
| DSP56800E_simulator |

One target family and one target processor or simulator must be selected before continuing to the next wizard page.

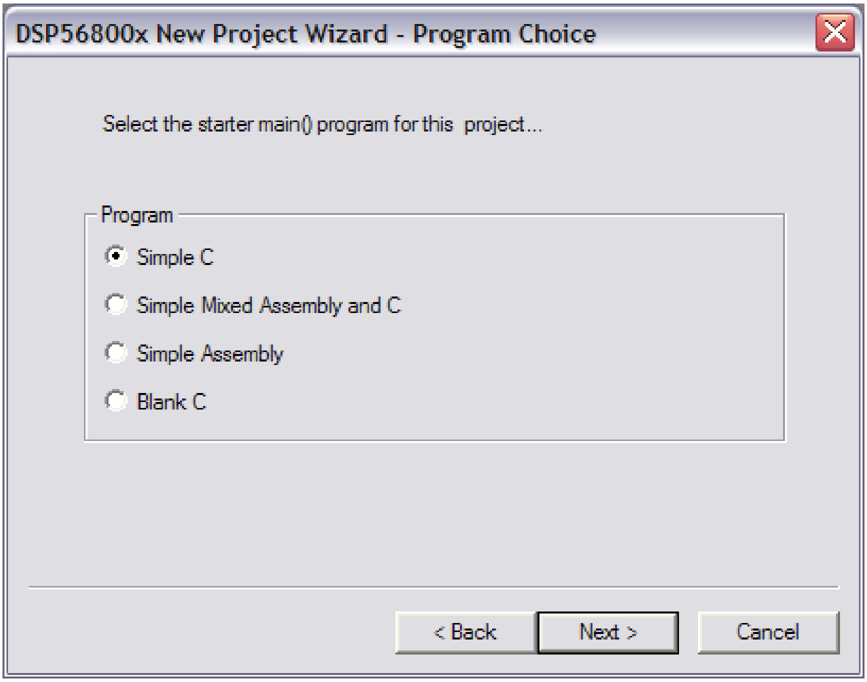
**NOTE** Depending on which processor you select, different screens will appear according to the “Page Rules” on page 351.

If you choose the simulator, then the DSP56800x New Project Wizard - Program Choice page appears (see “Program Choice Page” on page 365. )

## Program Choice Page

If you chose either of the simulators, then Figure B.12 on page 366 appears and you can now choose what sort of main() program to include in the project.

**Figure B.12 DSP56800x New Project Wizard - Program Choice**



DSP56800x New Project Wizard - Program Choice

Select the starter main() program for this project...

Program

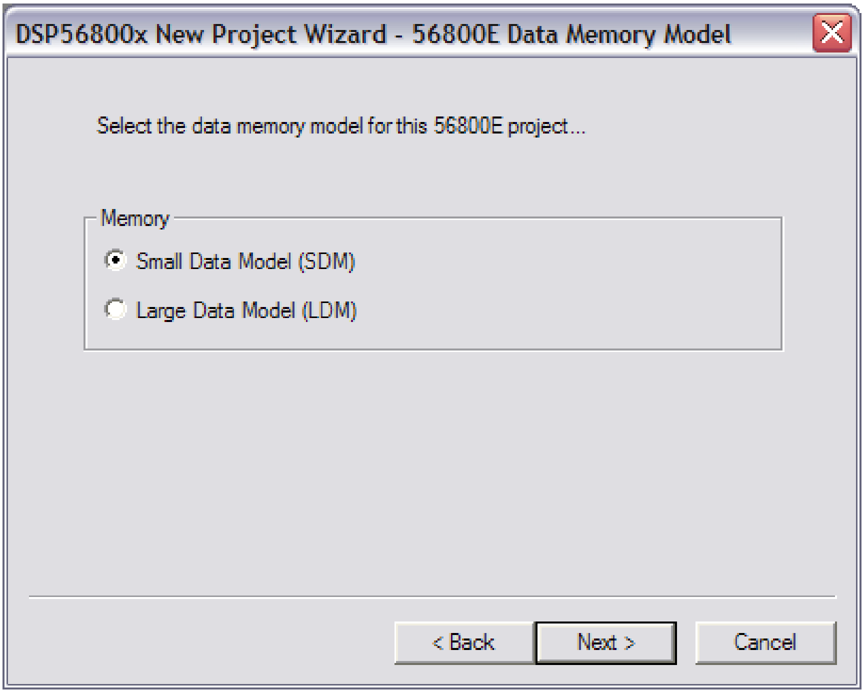
- ● Simple C
- ○ Simple Mixed Assembly and C
- ○ Simple Assembly
- ○ Blank C

When you click **Next**, the Wizard jumps to the appropriate page determined by the “Page Rules” on page 351.

# Data Memory Model Page

If you select a DSP56800E processor (56F83xx or 5685x family), then the Data Memory Model page appears (Figure B.13 on page 367) and you must select either the Small Data Model (SDM) or Large Data Model (LDM).

**Figure B.13 DSP56800x New Project Wizard - 56800E Data Memory Model Page**



DSP56800x New Project Wizard - 56800E Data Memory Model

Select the data memory model for this 56800E project...

Memory

● Small Data Model (SDM)

○ Large Data Model (LDM)

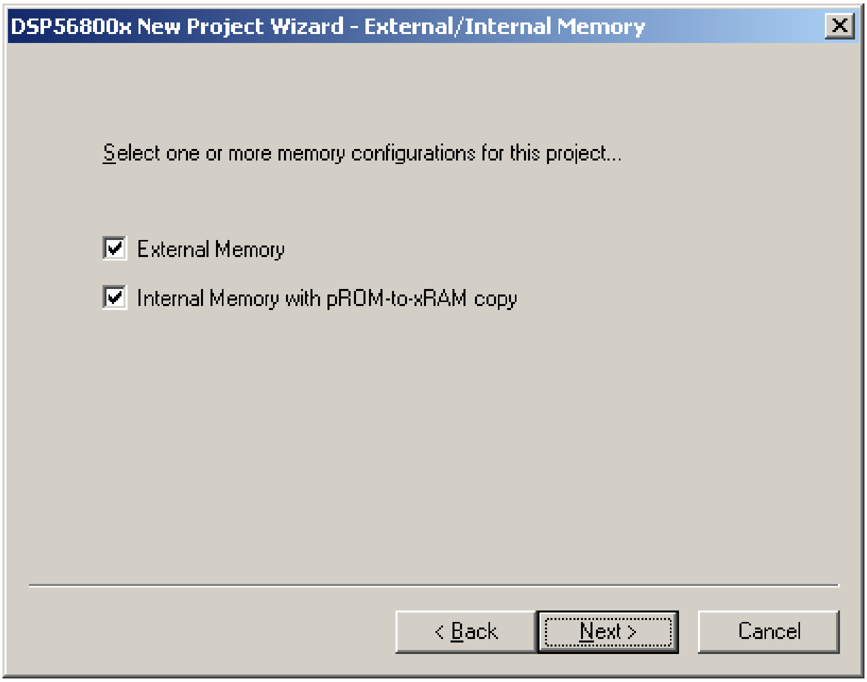
When you click **Next**, the Wizard jumps to the appropriate page determined by the "Page Rules" on page 351.

# External/Internal Memory Page

Depending on the processor that you select, the External/Internal Memory page may appear (Figure B.14 on page 368) and you must select either external or internal memory.

**NOTE** Multiple memory targets can be checked.

**Figure B.14 DSP56800x New Project Wizard - External/Internal Memory Page**



Select one or more memory configurations for this project...

☑ External Memory

☑ Internal Memory with pROM-to-xRAM copy

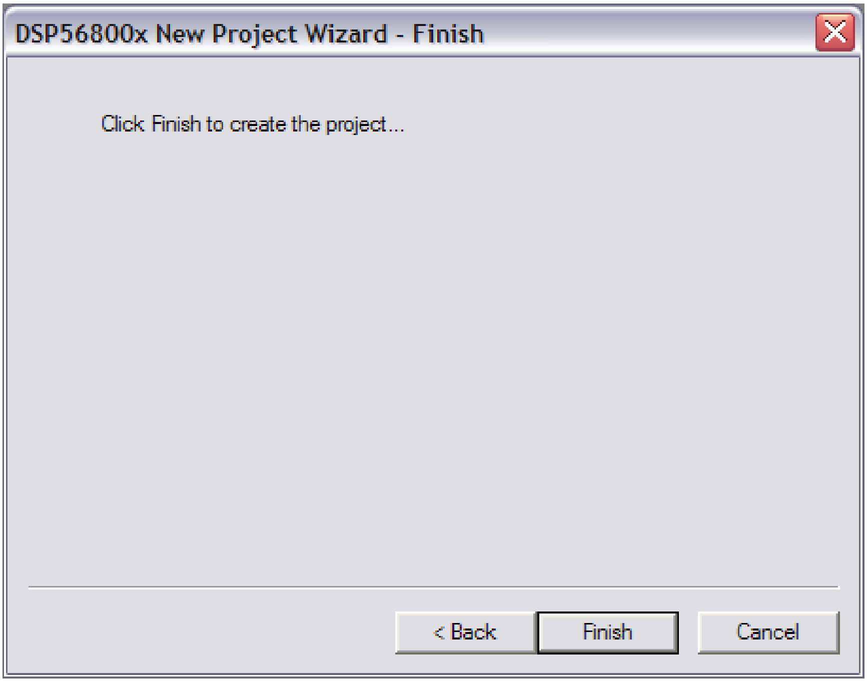
When you click **Next**, the Wizard jumps to the appropriate page determined by the "Page Rules" on page 351.

## Finish Page

When you click the **Finish** button on the Finish Page (Figure B.15 on page 369), the project creation process start.

**NOTE** All target choices end on this page.

**Figure B.15 DSP56800x New Project Wizard - Finish Page**



DSP56800x New Project Wizard - Finish

Click Finish to create the project...

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