Freescale Semiconductor, Inc.

CodeWarrior™ Development Studio

Assembler Reference

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metrowerks

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Freescale Semiconductor, Inc.

How to Contact Metrowerks

Corporate Headquarters	Metrowerks Corporation 7700 West Parmer Lane Austin, TX 78729 U.S.A.
World Wide Web	`http://www.metrowerks.com`
Sales	Voice: 800-377-5416 Fax: 512-996-4910 Email: sales@metrowerks.com
Technical Support	Voice: 800-377-5416 Email: support@metrowerks.com

Contents

1

Introduction

This manual describes the assembly language syntax and the CodeWarrior IDE settings for the processor-specific assemblers provided by CodeWarrior.

This chapter includes the following topics:

- Read the Release Notes!
- What's in This Book
- Conventions Used in This Manual
- Where to Learn More

Read the Release Notes!

The release notes contain important information about new features, bug fixes, and incompatibilities and reside in the following directory:

```
{CodeWarrior directory}\Release_Notes
```

What's in This Book

CodeWarrior provides several assemblers, depending on the processor for which you are developing code. This manual describes the syntax for assembly language statements, including macros and directives, used by the CodeWarrior assemblers.

NOTE	Refer to the *Targeting* manual for your target processor and *C Compilers Reference* for information on the inline assembler provided by the CodeWarrior C/C++ compiler.

The basic syntax of assembly language statements is identical among the processor-specific assemblers (which this manual describes). However, the instruction mnemonics and register names for each processor differ.

This manual assumes you are familiar with assembly language and the processor for which you are developing code.

Unless otherwise stated, all the information in this manual applies to all the assemblers.

NOTE When this manual states that information applies to *the assembler*, the information refers to all the assemblers unless otherwise stated.

Chapter Descriptions

Table 1.1 describes each chapter.

Table 1.1 Chapter descriptions

Chapter Title	Description
Introduction	This chapter, which describes this manual.
Assembly Language Syntax	Describes the main syntax of assembly language statements.
Using Directives	Describes the assembler directives.
Using Macros	Describes how to define and invoke macros.
Common Assembler Settings	Describes the assembler settings that are common among the assemblers

Code Examples

The code examples in the general chapters of this manual (Table 1.1 on page 6) are for x86 processors. Any processor-specific chapters included in this manual contain corresponding examples wherever the code differs for the processor discussed in that chapter. Each processor-specific example also is cross-referenced to the corresponding example in the general chapters.

Conventions Used in This Manual

This manual includes syntax statements that describe how to use assembly language statements. Table 1.2 describes how to interpret the syntax.

Table 1.2 Understanding Syntax Examples

Syntax	Description
literal	Include the item in your statement as shown.
metasymbol	Replace the symbol with an appropriate value.
a | b | c	The text after the syntax example describes what the appropriate values are. Use one of the items in the group: either a, b, or c. Do not type the | character because it is not part of the statement being defined.
[a]	Include the item, which is optional, when needed. The text after the syntax example describes when to include it. Do not type the square brackets ([]) because they are not part of the statement being defined.
a ::= b | c	Substitute one or more items on the right side of the `::=` symbol for the item on the left side as indicated by the syntax on the right side. In the example, `a` is defined as either `b` or `c`.

Where to Learn More

Each assembler uses the standard assembly language mnemonics and register names defined by the manufacturer of the applicable processor. For information on related documentation, see the processor-specific chapters of this manual.

- PowerPC Assembler: *The PowerPC Architecture*, IBM Inc.

The *PowerPC Assembler* supports all instructions for the Freescale MPC8xx, Freescale MPC505, little-endian code. It generates only 32-bit code.

2

Assembly Language Syntax

This chapter describes the syntax of assembly language statements and includes the following topics:

- Assembly Language Statements Description
- Assembly Language Statement Syntax
- Symbols
- Constants
- Expressions
- Comments
- Data Alignment

Assembly Language Statements Description

Three types of assembly language statements exist:

- Instruction statement
- Macro statement
- Directive statement

The type of the assembly language statement differs depending on whether the operation performed by the statement is a machine instruction, a macro call, or an assembler directive.

Instruction, directive, and macro names are case insensitive. For example, `MOV`, `Mov`, and `mov` all name the same instruction.

When creating assembly language statements, you must be aware of the following information:

- The maximum length of a statement or an expanded macro is 1000 characters.
- A statement must reside on a single line. However, you can concatenate two or more lines by typing a backslash (\) character at the end of the line.
- Each line of the source file can contain only one statement unless the assembler is running in GNU mode, which allows multiple statements to reside on one line, separated by semicolons.

Refer to the processor-specific chapters of this manual for information on where to find machine instructions for a particular chip. For more information on assembler directives, refer to “Using Directives”. For more information on macros, refer to “Using Macros”.

Assembly Language Statement Syntax

Listing 2.1 shows the syntax of an assembly language statement.

Listing 2.1 Statement syntax

```
statement ::= [ symbol ] operation [ operand ] [ ,operand ]... [ comment ]

operation ::= machine_instruction | assembler_directive | macro_call

operand ::= symbol | constant | expression | register_name
```

Table 2.1 provides information related to the syntax shown in Listing 2.1.

Table 2.1 Syntax-related information

Syntax Element	Description
symbol	A *symbol* is a combination of characters that represents a value. For more information, see “Symbols” on page 11.
machine_instruction	A machine instruction for your target processor. For information on where to find machine instructions for a particular processor, see the processor-specific chapters of this manual.
assembler_directive	Assembler directives are special instructions that tell the assembler how to process other assembly language statements. For example, certain assembler directives tell the assembler where the beginning and end of a macro is. For more information on assembler directives, see “Using Directives”.

Table 2.1 Syntax-related information

Syntax Element	Description
macro_call	A call to a previously specified macro. For information on macro-related assembler directives, see “Macro Directives”. For more information on macros, see “Using Macros”.
constant	A defined value such as a string of characters or a numeric value. For more information, see “Constants” on page 16.
expression	A mathematical expression. For more information, see “Expressions” on page 19.
register_name	The name of a register; these names are processor-specific. For information on related processor-specific documentation, see the processor-specific chapters of this manual.
comment	A *comment* is text that the assembler ignores. You can use comments to document your code. For more information, see “Comments” on page 21.

Symbols

A *symbol* is a group of characters that represents a value, such as an address, numeric constant, string constant, or character constant. The length of a symbol name is unlimited.

The syntax of a symbol follows:

symbol `::=` *label* | *equate*

NOTE For the complete syntax of an assembly language statement, see Listing 2.1 on page 10.

In general, a symbol has file-wide scope. *File-wide scope* means that you can access the symbol anywhere within the file where you defined the symbol and only within that file. However, symbols sometimes have a different scope. For more information, see “Local labels” on page 13.

This section discusses the following topics:

- Labels

- Equates
- Case-sensitive identifiers

Labels

A *label* is a symbol that represents an address. The assembler provides local labels and non-local labels. Whether a label is local or non-local determines its scope.

The syntax of a label follows:

label `::=` *local_label* `[ : ]` | *non-local_label* `[ : ]`

By default, a label ends with a colon (:) and can begin in any column. However, if you are porting existing code that does not follow this convention, clear the **Labels must end with ':'** checkbox on the Assembler settings panel. After you clear the checkbox, a label must either begin in column 1 or end with a colon (:).

NOTE For more information, see “Common Assembler Settings”.

This section contains the following topics:

- Non-local labels
- Local labels
- Relocatable labels

Non-local labels

A non-local label is a symbol that represents an address and has file-wide scope.

The first character of a non-local label must be one of the following:

- A letter (a-z or A-Z)
- A period (.)
- A question mark (?)
- An underscore (_)

The subsequent characters of a non-local label can be either a character from the preceding list or one of the following:

- A numeral between zero and nine (0-9)
- A dollar sign ($)

Local labels

A local label is a symbol that represents an address and has local scope. *Local scope* means that the scope of the label extends forward and backward within the file until the point where the assembler encounters a non-local label.

The first character of a local label must be an at-sign (@). The subsequent characters of a local label must be one of the following:

- A letter (a-z or A-Z)
- A numeral between zero and nine (0-9)
- An underscore (_)
- A question mark (?)
- A dollar sign ($)
- A period (.)

NOTE You cannot export local labels. In addition, local labels do not appear in debugging tables.

Within an expanded macro, the scope of local labels works differently:

- The scope of local labels defined in macros does not extend outside the macro.
- A non-local label in an expanded macro does not end the scope of locals in the unexpanded source.

Listing 2.2 shows the scope of local labels in macros.

Listing 2.2 The scope of local labels in a macro

```
MAKEPOS    .MACRO
     cmp      eax, 1
     jne      @SKIP
     neg      eax
@SKIP:  ;Scope of this label is within the macro
    .ENDM
START:
     mov      eax, COUNT
     cmp      eax, 1
     jne      @SKIP
     MAKEPOS
@SKIP:    ;Scope of this label is START to END
          ;excluding lines arising from
          ;macro expansion
```

```
      add    eax, 1
END:  ret
```

In Listing 2.2, the `@SKIP` label defined in the macro does not conflict with the `@SKIP` label defined in the main body of code.

Relocatable labels

The assembler assumes a flat 32-bit memory space. You can specify the relocation of a 32-bit label with the expressions shown in Table 2.2.

NOTE Some expressions are not allowed in all assemblers.

Table 2.2 Relocatable label expressions

This...	Represents this
label	The offset from the address of the label to the base of its section, relocated by the section base address. It also is the PC-relative target of a branch or call. It is a 32-bit address.
label`@l`	The low 16-bits of the relocated address of the symbol.
label`@h`	The high 16-bits of the relocated address of the symbol. You can OR this with *label*`@l` to produce the full 32-bit relocated address.
label`@ha`	The adjusted high 16-bits of the relocated address of the symbol. You can add this to *label*`@l` to produce the full 32-bit relocated address.
label`@sdax`	For labels in a small data section, the offset from the base of the small data section to the label. This syntax is not allowed for labels in other sections.
label`@got`	For chips with a global offset table, the offset from the base of the global offset table to the 32-bit entry for label.

Equates

An *equate* is a symbol that represents any value. You can create an equate with a `.equ` or `.set` directive.

NOTE For more information, see “equ” and “set”.

This section contains the following topics:

- Equate names
- Forward Equates

Equate names

The first character of an must be one of the following:

- A letter (a-z or A-Z)
- A period (.)
- A question mark (?)
- An underscore (_)

The subsequent characters of an equate can be either a character from the preceding list or one of the following:

- A numeral between zero and nine (0-9)
- A dollar sign ($)

Forward Equates

The assembler allows *forward equates*. This means that you can refer to an equate in a file before it is defined. When an assembler encounters an expression it cannot resolve because the expression references a symbol whose value is not known, the assembler retains the expression and marks it as unresolved. After the assembler reads the entire file, it reevaluates unresolved expressions and, if necessary, repeatedly reevaluates them until it resolves them all or it cannot resolve them any further. If the assembler cannot resolve an expression, it raises an error.

However, the assembler must be able to immediately resolve any expression whose value affects the location counter.

NOTE Note that if the assembler can make a reasonable assumption about the location counter, the expression is allowed. For example, in a forward branch instruction for a 68K processor, you can specify a default assumption of 8, 16, or 32 bits.

Thus, the code in Listing 2.3 is valid.

Listing 2.3 Valid forward equate

```
.data
.long  alloc_size
alloc_size     .set   rec_size + 4
; a valid forward equate on next line
rec_size       .set   table_start-table_end
.text;...
table_start:
; ...
table_end:
```

However, the code in Listing 2.4 is not valid. The assembler cannot immediately resolve the expression in the `.space` directive. Consequently, the effect on the location counter is unknown.

Listing 2.4 Invalid forward equate

```
;invalid forward equate on next line
rec_size    .set   table_start-table_end
            .space rec_size
            .text; ...
table_start:
; ...
table_end:
```

Case-sensitive identifiers

The **Case-sensitive identifiers** checkbox on the Assembler settings panel lets you choose whether symbols are case-sensitive.

If you click the checkbox, symbols are case sensitive, so `SYM1`, `sym1`, and `Sym1` are three different symbols, for example.

If you clear the checkbox, symbols are *not* case-sensitive, so `SYM1`, `sym1`, and `Sym1` are the same symbol, for example. By default, this option is on.

Constants

The assembler recognizes three kinds of constants:

- Integer Constants

- Floating-Point Constants
- Character Constants

Integer Constants

Table 2.3 lists the preferred notation for integer constants.

Table 2.3 Preferred integer constant notation

For numbers of this type...	Use...
Decimal	A string of decimal digits, such as `12345678`.
Hexadecimal	A dollar sign (`$`) followed by a string of hexadecimal digits, such as `$deadbeef`.
Binary	A percent sign (`%`) followed by a string of binary digits, such as `%01010001`.

To help you port existing code, the assembler also supports the notation in Table 2.4.

Table 2.4 Alternate integer constant notation

For numbers of this type...	Use...
Hexadecimal	`0x` followed by a string of hexadecimal digits, such as `0xdeadbeef`.
Hexadecimal	`0` followed by a string of hexadecimal digits, such as `0deadbeef`, and ending with an `h`, such as `0deadbeefh`.
Decimal	A string of decimal digits followed by `d`, such as `12345678d`.
`Binary`	A string of binary digits followed by a `b`, such as `01010001b`.

NOTE The assembler stores and manipulates integer constants using 32-bit signed arithmetic.

Floating-Point Constants

You can specify floating point constants in either hexadecimal or decimal format. A floating point constant in decimal format must contain either a decimal point or an exponent, e.g. `1E-10` or `1.0`.

You can use floating point constants only in data generation directives like `.float` and `.double`, or in floating point instructions. You cannot use them in expressions.

Character Constants

Enclose a character constant in single quotes unless the character constant includes a single quote. In that case, enclose the character constant in double quotes.

NOTE A character constant cannot include both single and double quotes.

The maximum width of a character constant is 4 characters, depending on the context. For example, the following items are character constants:

- `'A'`
- `'ABC'`
- `'TEXT'`

A character constant can contain any of the escape sequences shown in Table 2.5.

Table 2.5 Escape sequences

Sequence	Description
\b	Backspace
\n	Line feed (ASCII character 10)
\r	Return (ASCII character 13)
\t	Tab
\"	Double quote
\\	Backslash
\nnn	Octal value of \nnn

A character constant is zero-extended to 32 bits during computation. You can use a character constant anywhere you can use an integer constant.

Expressions

The assembler evaluates expressions using 32-bit signed arithmetic and does not check for arithmetic overflow.

Since there is no common set of operators in the existing assemblers for different processors, the assembler uses an expression syntax similar to the one for the C language. Expressions use the C language arithmetic rules for such things as parentheses and associativity, and they use the same operators.

NOTE To refer to the program counter in an expression, use a period (.), dollar sign ($), or asterisk (*).

The assembler supports the binary operators listed in Table 2.6.

Table 2.6 Binary operators

Operator	Description
+	add
-	subtract
*	multiply
/	divide
%	modulo
||	logical OR
&&	logical AND
|	bitwise OR
&	bitwise AND
^	bitwise XOR
<<	shift left
>>	shift right (zeros are shifted into high order bits)
==	equal to
!=	not equal to
<=	less than or equal to
>=	greater than or equal to

Table 2.6 Binary operators

Operator	Description
<	less than
>	greater than

The assembler supports the unary operators listed in Table 2.7.

Table 2.7 Unary operators

Operator	Description
+	unary plus
-	unary minus
~	unary bitwise complement

The assembler also supports the operations listed in Table 2.8.

Table 2.8 Alternate operators

Operator	Description
<>	not equal to
%	modulo
|	logical OR
||	logical XOR

The operators have the following precedence, with the highest priority first:

1. unary + - ~
2. * / %
3. binary + -
4. << >>
5. < <= > >=
6. == !=
7. &

8. ^
9. |
10. &&
11. ||

Comments

Comments are text that the assembler ignores. You can use them to document your code.

There are several ways you can specify comments:

- Type a semicolon (;) followed by your text entry.
  - **In GNU Mode** - The semicolon indicates multiple assembly instructions on one line.
  - **Not in GNU Mode** - The semicolon is interpreted as a comment.
- Use the following types of C-style comments, which can start in any column:

```
/* This is a comment. */
// This is a comment.
```

- Type an asterisk (*) as the first character of the line followed by your comment.

NOTE	The asterisk (*) must be the first character of the line for it to specify a comment. The asterisk has other meanings when it occurs elsewhere in a line.

- Clear the **Allow space in operand field** checkbox on the Assembler settings panel. In this case, the assembler ignores any text between a space character in the operand field and the end of the line. Therefore, after you type a space in the operand field, you can type a comment on the remainder of the line.
- Begin a comment with a pound sign (#), which can start in any column:

```
# This is a comment.
```

NOTE	The assembler distinguishes between a comment that begins with a pound sign (#) and a preprocessor directive that begins with a pound sign.

The three immediately preceding comment methods are helpful for porting existing code.

Data Alignment

By default, the assembler aligns all data on a natural boundary for the data size and for the target processor family. You can turn off alignment with the `alignment` argument to the `.option` directive, described in “option.”

The assembler does not align data automatically in the `.debug` section. For more information on the `.debug` section, see “Debugging Directives.”

3

Using Directives

This chapter describes the directives that are available for the assembler.

NOTE	Some directives are not available for every assembler.

By default, most directives must begin with a period (.). However if you clear the **Directives begin with '.'** checkbox of the Assembler settings panel, you can omit the period.

NOTE	You can specify several preprocessor directives using the C/C++ preprocessor format.

This chapter discusses the following topics:

- Macro Directives
- Conditional Preprocessor Directives
- Section Control Directives
- Scope Control Directives
- Symbol Definition Directives
- Data Declaration Directives
- Assembler Control Directives
- Debugging Directives

Macro Directives

The following directives let you create macros:

- `macro`
- `endm`
- `mexit`
- #define

For more information on macros, see “Using Macros”.

macro

label `.macro [` *parameter* `] [ ,`*parameter* `] ...`

Begins the definition of a macro named *label*, with the specified parameters.

endm

`.endm`

Ends a macro definition.

mexit

`.mexit`

Causes the assembler to stop macro processing before the `.endm` statement is reached and resume execution with the statement following the macro call.

#define

`#define` *name* `[ (`*parms*`) ]` *assembly_statement* `[ ; ] [ \ ]`
assembly_statement `[ ; ] [ \ ]`
assembly_statement
parms `::=` *parameter* `[ ,`*parameter* `]...`

Defines a macro named *name* with the specified parameters. You can extend *assembly_statement* by typing a backslash (\) and continuing the statement on the next physical line. You also can specify multiple assembly statements in the macro by typing a semicolon (;) followed by a backslash (\) and typing a new assembly statement on the next physical line. The assembler must be in GNU mode for multiple statements to reside on one line of code (refer to “Comments.”).

NOTE For more information, see “Defining a macro with the #define directive”.

Conditional Preprocessor Directives

Conditional directives create a conditional assembly block. If you wrap some code with `ifdef` and `endif` you can control whether that code is included in compilation. This is useful for making several different builds that are slightly different.

You must use conditional directives together to form a complete block. The assembler also contains several variations of `.if` to make it easier to make blocks that test strings for equality, test whether a symbol is defined, and so on.

NOTE You can specify several of the conditional preprocessor directives using the C/C++ preprocessor format:

```
#if
#ifdef
#ifndef
#else
#elif
#endif
```

These directives function identically whether preceded by a pound sign (#) or a period with two exceptions. You cannot use the pound sign form of the directive in a macro. The period (.) form of the `#elif` directive is `.elseif`.

This section discusses the following topics:

- `if`
- `ifdef`
- `ifndef`
- `ifc`
- `ifnc`
- `endif`
- `elseif`
- `else`
- `Other conditional preprocessor directives`

if

`.if` *bool-expr*

Specifies the beginning of a conditional assembly block, where *bool-expr* is a Boolean expression. If *bool-expr* is true, the assembler processes the statements associated with

the .if directive. If *bool-expr* is false, the assembler skips the statements associated with the .if directive.

Each .if directive must have a matching .endif directive.

NOTE	A Boolean expression is a special type of arithmetic expression. The assembler interprets a Boolean expression that evaluates to zero as false and a Boolean expression that evaluates to a nonzero result as true. For more information on expressions, see “Expressions”.

ifdef

```
#ifdef symbol
```

Specifies the beginning of a conditional assembly block and tests whether symbol is already defined. If *symbol* was defined previously, the assembler processes the statements associated with the .ifdef directive. If *symbol* is not yet defined, the assembler skips the statements associated with the .ifdef directive.

Each .ifdef directive must have a matching .endif directive.

ifndef

```
.ifndef symbol
```

Specifies the beginning of a conditional assembly block and tests whether *symbol* is not yet defined. If *symbol* is *not* yet defined, the assembler processes the statements associated with the .ifndef directive. If *symbol* is already defined, the assembler skips the statements associated with the .ifndef directive.

Each .ifndef directive must have a matching .endif directive.

ifc

```
.ifc string1, string2
```

Specifies the beginning of a conditional assembly block and tests whether *string1* and *string2* are equal. The comparison is case-sensitive. If the strings are equal, the assembler processes the statements associated with the .ifc directive. If the strings are *not* equal, the assembler skips the statements associated with the .ifc directive.

Each .ifc directive must have a matching .endif directive.

ifnc

`.ifnc` *string1, string2*

Specifies the beginning of a conditional assembly block and tests whether *string1* and *string2* are *not* equal. The comparison is case-sensitive. If the strings are *not* equal, the assembler processes the statements associated with the `.ifnc` directive. If the strings are equal, the assembler skips the statements associated with the `.ifnc` directive.

Each `.ifnc` directive must have a matching `.endif` directive.

endif

`.endif`

Specifies the end of a conditional assembly block. Each type of `.if` directive must have a matching `.endif` directive.

elseif

`.elseif` *bool-expr*

You can use the `.elseif` directive to create a series of directives that together comprise a logical multilevel *if-then-else* statement, the syntax of which follows:

`.if` *bool-expr statement-group*

`[ .elseif` *bool-expr statement-group* `]...`

`[ .else` *statement-group* `]`

`.endif`

In the preceding syntax statement, *bool-expr* is any Boolean expression and *statement-group* is any group of assembly language statements.

Expanding the syntax as follows helps to explain the flow of the statement:

```
.if bool-expr-1
statement-group-1
.elseif bool-expr-2
statement-group-2
.elseif bool-expr-3
statement-group-3
.elseif bool-expr-4
statement-group-4
.else
statement-group-5
.en
dif
```

In the preceding syntax statement, if *bool-expr-1* is true, the assembler executes *statement-group-1* (the first group of conditional assembly language statements) and goes to the `.endif` directive. If *bool-expr-1* is false, the assembler skips *statement-group-1* and tests *bool-expr-2* in the first `.elseif` directive.

If *bool-expr-2* is true, the assembler executes *statement-group-2* and goes to the `.endif` directive. If *bool-expr-2* is false, the assembler skips *statement-group-2* and tests *bool-expr-3* in the second `.elseif` directive.

The assembler continues evaluating the Boolean expressions in succeeding `.elseif` directives until it comes to a Boolean expression that evaluates to true. If none of the `.elseif` directives have a Boolean expression that evaluates to true, the assembler processes the statements associated with the `.else` directive, if there is one.

else

```
.else
```

Marks the beginning of a conditional assembly block to execute if the Boolean expressions for an `.if` directive and its associated `.elseif` directives are false.

NOTE Using an `.else` directive is optional.

Other conditional preprocessor directives

For compatibility with other assemblers, the assembler also supports the following directives:

`.ifeq` (if equal)

```
.ifeq string1, string2
```

Specifies the beginning of a conditional block, and tests whether *string1* and *string2* are equal to each other.

- If the strings are equal to each other, the assembler processes the statements associated with this directive.
- If the strings are not equal to each other, the assembler skips over all associated statements.

`.ifne` (if not equal)

Specifies the beginning of a conditional block, and tests whether *string1* is not equal to zero.

- If the string is not equal to zero, the assembler processes the statements associated with this directive.
- If the string is equal to zero, the assembler skips over all associated statements.

`.iflt` (if less than)

Specifies the beginning of a conditional block, and tests whether *string1* is less than zero.

- If the string is is less than zero, the assembler processes the statements associated with this directive.
- If the string is not less than zero, the assembler skips over all associated statements.

`.ifle` (if less than or equal)

Specifies the beginning of a conditional block, and tests whether *string1* is less than or equal to *string2*.

- If *string1* is less than or equal to *string2*, the assembler processes the statements associated with this directive.

- If *string1* is not less than or equal to *string2*, the assembler skips over all associated statements.

`.ifgt` (if greater than)

Specifies the beginning of a conditional block, and tests whether *string1* is greater than *string2*.

- If *string1* is less greater than *string2*, the assembler processes the statements associated with this directive.
- If *string1* is not greater than *string2*, the assembler skips over all associated statements.

`.ifge` (if greater than or equal)

Specifies the beginning of a conditional block, and tests whether *string1* is greater than or equal to *string2*.

- If *string1* is greater than or equal to *string2*, the assembler processes the statements associated with this directive.
- If *string1* is not greater than or equal to *string2*, the assembler skips over all associated statements.

Section Control Directives

The following directives identify the different sections of an assembly file:

- `text`
- `data`
- `rodata`
- `bss`
- `sdata`
- `sdata2`
- `sbss`
- `debug`
- `previous`
- `offset`
- `section`

text

```
.text
```

Specifies an executable code section. This must be in front of the actual code in a file.

data

```
.data
```

Specifies an initialized read-write data section.

rodata

```
.rodata
```

Specifies an initialized read-only data section.

bss

```
.bss
```

Specifies an uninitialized read-write data section.

sdata

```
.sdata
```

Specifies a small data section as initialized and read-write.

sdata2

```
.sdata2
```

Specifies a small data section as initialized and read-only.

sbss

```
.sbss
```

Specifies a small data section as uninitialized and read-write.

debug

```
.debug
```

Specifies a debug section. If you enable the debugger, the assembler automatically generates some debug information for your project. However, you use special directives in the debug section that provide the debugger with more detailed information. For more information on the debug directives, see "Debugging Directives" on page 43.

previous

```
.previous
```

Reverts to the previous section. This switch toggles between the current section and the previous section.

offset

```
.offset [expression]
```

Defines a record. The optional parameter *expression* specifies the initial location counter. The record definition extends until the start of the next section.

Within a record, you can use only the following directives:

Table 3.1 Directives within a record

`.equ`	`.set`	`.textequ`
`.align`	`.org`	`.space`
`.byte`	`.short`	`.long`
`.space`	`.ascii`	`.asciz`
`.float`	`.double`	

The data declaration directives (like `.byte` and `.short`) update the location counter but do not allocate any storage.

Listing 3.1 shows a sample record definition.

Listing 3.1 A record definition with the offset directive

```
            .offset
top:        .short   0
left:       .short   0
bottom:     .short   0
right:      .short   0
```

```
rectSize    .equ      *
```

section

For the ELF (Executable and Linkable Format) object file format, the `.section` directive has the following syntax:

```
.section name [ ,alignment ] [ ,type ] [ ,flags ]
```

Defines a section in an object file. Use this directive to create arbitrary relocatable sections, including sections to be loaded at an absolute address.

Table 3.2 describes the syntax elements for the ELF `.section` directive.

Table 3.2 Syntax descriptions for ELF .section directive

Syntax Element	Description
name	The name of the section.
alignment	Specifies the alignment boundary of the section.
type	Numeric value for the ELF section type, per Table 3.3 on page 33. The default *type* value is SHT_PROGBITS.
flags	Numeric value for the ELF section flags, per Table 3.4 on page 35. The default *flags* value is SHF_ALLOC+SHF_WRITE.

The following example specifies a section named `vector` with an alignment of 4 bytes:

```
.section vector,4
```

Table 3.3 defines the ELF section types.

Table 3.3 ELF section types

Type	Name	Description
0	NULL	Indicates that the section header is inactive.
1	PROGBITS	Indicates that the section contains information defined by the program.

Table 3.3 ELF section types

Type	Name	Description
2	SYMTAB	Indicates that the section contains a symbol table.
3	STRTAB	Indicates that the section contains a string table.
4	RELA	Indicates that the section contains relocation entries with explicit addends.
5	HASH	Indicates that the section contains a symbol hash table.
6	DYNAMIC	Indicates that the section contains information used for dynamic linking.
7	NOTE	Indicates that the section contains information that marks the file, often for compatibility purposes between programs.
8	NOBITS	Indicates that the section occupies no space in the object file.
9	REL	Indicates that the section contains relocation entries without explicit addends.
10	SHLIB	Indicates that the section has unspecified semantics and, therefore, does not conform to the Application Binary Interface (ABI) standard.
11	DYNSYM	Indicates that the section contains a minimal set of symbols used for dynamic linking.

Table 3.4 defines the ELF section flags.

Table 3.4 ELF section flags

Flag	Name	Description
0x00000001	WRITE	Indicates that the section contains data that is writable during execution.
0x00000002	ALLOC	Indicates that the section occupies memory during execution.
0x00000004	EXECINSTR	Indicates that the section contains executable machine instructions.
0xF0000000	MASKPROC	Indicates that the bits specified in this mask are reserved for processor-specific purposes.

Scope Control Directives

The assembler provides the following directives that let you import and export labels:

- `global`
- `extern`
- `public`

For more information on labels, see “Labels”.

NOTE You cannot import or export equates or local labels.

global

`.global` *label* `[` , *label* `]`...

Instructs the assembler to export the specified labels, that is, make them available to other files.

Use the `.extern` or `.public` directive to reference the labels in another file.

extern

`.extern` *label* `[` , *label* `]`...

Instructs the assembler to import the specified labels, that is, to find the label definitions in another file.

Use the `.global` or `.public` directive to export the labels from another file.

public

`.public` *label* `[` *,label* `]`…

Declares that the specified labels are public. If the labels are already defined in the same file, the assembler exports them, that is, makes them available to other files. If the equates are *not* already defined, the assembler imports them, that is, finds the label definitions in another file.

Symbol Definition Directives

You can use the following directives to create equates:

- `set`
- equal sign (=)
- `equ`
- `textequ`

set

equate `.set` *expression*

Temporarily assigns the value *expression* to *equate*. You can change the value of *equate* after defining it.

equal sign (=)

equate `=` *expression*

Temporarily assigns the value *expression* to *equate*. You can change the value of *equate* after defining it.

NOTE This directive is equivalent to `.set` and is available only for compatibility with assemblers provided by other companies.

equ

equate `.equ` *expression*

Permanently assigns the value *expression* to *equate*. You cannot change the value of *equate* after defining it.

textequ

equate `.textequ "`*string*`"`

Substitutes *equate* with the text you specify in *string*. You can use this directive, which helps to port existing code, to give new names to machine instructions, directives, and operands.

Whenever you use *equate*, the assembler replaces it with *string* before performing any other processing on that source line. Listing 3.2 shows examples of `.textequ` statements.

Listing 3.2 texteq examples

```
dc.b    .textequ    ".byte"
endc    .textequ    ".endif"
```

Data Declaration Directives

The assembler provides the following types of directives that initialize data:

- Integer Directives
- String Directives
- Floating-Point Directives

Integer Directives

The following directives initialize blocks of integer data:

- `byte`
- `short`
- `long`
- `space`
- `fill`

byte

[*label*] .byte *expression* [,*expression*]...

Declares an initialized block of bytes with the name *label*. The assembler allocates one byte for each *expression*. Each *expression* must fit in a byte.

short

[*label*] .short *expression* [,*expression*]...

Declares an initialized block of 16-bit short integers with the name *label*. The assembler allocates 16 bits for each *expression*. Each *expression* must fit in 16 bits.

long

[*label*] .long *expression* [,*expression*]...

Declares an initialized block of 32-bit short integers with the name *label*. The assembler allocates 32 bits for each *expression*. Each *expression* must fit in 32 bits.

space

[*label*] .space *expression*

Declares a block of zero-initialized bytes with the name *label*. The assembler allocates a block *expression* bytes long and initializes each byte to zero.

fill

[*label*] .fill *expression*

Declares a block of zero-initialized bytes with the name *label*. The assembler allocates a block *expression* bytes long and initializes each byte to zero.

String Directives

The following directives initialize blocks of character data:

- ascii
- asciz

A string can contain any of the escape sequences shown in Table 3.5.

Table 3.5 Escape sequences

Sequence	Description
\b	Backspace
\n	Line feed (ASCII character 10)
\r	Return (ASCII character 13)
\t	Tab
\"	Double quote
\\	Backslash
\nnn	Octal value of \nnn

ascii

```
[ label ]   .ascii "string"
```

Declares a block of storage for the string *string* with the name *label*. The assembler allocates a byte for each character in *string*.

asciz

```
[ label ]   .asciz "string"
```

Declares a zero-terminated block of storage for the string *string* with the name *label*. The assembler allocates a byte for each character in *string*. The assembler then allocates an extra byte at the end and initializes the byte to zero.

Floating-Point Directives

The following directives initialize blocks of floating-point data:

- `float`
- `double`

float

```
[ label ] .float   value [ ,value ]...
```

Declares an initialized block of 32-bit floating-point numbers with the name *label*. The assembler allocates 32 bits for each value *value*. Each value must fit in the specified size.

double

```
[ label ] .double value [ ,value ]…
```

Declares an initialized block of 64-bit floating-point numbers with the name *label*. The assembler allocates 64 bits for each value *value*. Each value must fit in the specified size.

Assembler Control Directives

These directives let you control how the assembler emits code:

- `align`
- `endian`
- `error`
- `include`
- `pragma`
- `org`
- `option`

align

```
.align expression
```

Aligns the location counter to the next multiple of the *expression*. The *expression* must be a power of 2, such as 2, 4, 8, 16, or 32.

endian

```
.endian big | little
```

Specifies the byte ordering for the target processor.

NOTE	You can use this directive only for processors that allow you to change the byte ordering.

error

```
.error "error"
```

Prints *error* to the Errors & Warnings window in the CodeWarrior IDE.

include

`.include` *filename*

Causes the assembler to switch input to *filename*. The assembler takes input from the specified file. When the assembler reaches the end of the file, it begins taking input from the assembly statement line that follows the `.include` directive.

The file specified by *filename* can contain an `.include` directive for another file.

pragma

`.pragma` *pragma-type setting*

Tells the assembler to assemble the code using a particular pragma setting.

org

`.org` *expression*

Changes the location counter to the value of *expression, the value of which is relative to the base of the current section*. The addresses of the subsequent assembly statements begin at the new location counter value. The value of *expression* must be greater than the current value of the location counter.

The following code snipet is presented as an example.

```
.text
.org 0x1000
Foo:
...
blr
```

The label `Foo` reflects the value of `.text` + `0x1000`. The runtime value of `Foo` depends upon where the section defined by `.text`, is placed by the linker. For example, if `Foo` is placed at 0x10000000, its final value is 0x10000000.

NOTE	You must use the CodeWarrior IDE and Linker to place code at an absolute address.

option

`.option` *keyword setting*

Sets the assembler options as described in Table 3.6. Specifying *reset* sets the option to its previous setting. Using *reset* a second time resets the option to the setting before the current setting.

Table 3.6 Option keywords

Keyword	Description
alignment off | on | reset	Controls whether data is aligned on natural boundary. This does not correspond to any option in the Assembler settings panel.
branchsize 8 | 16 | 32	Specifies the size of forward branch displacement. This keyword applies only to the x86 and 68K assemblers. This does not correspond any option in the Assembler settings panel.
case off | on | reset	Specifies whether identifiers are case sensitive. If this option is on, identifiers are case sensitive. If this option is off, identifiers are not case sensitive. This corresponds to the **Case-sensitive identifiers** checkbox of the Assembler settings panel, described in “Case-sensitive identifiers”.
colon off | on | reset	Specifies whether labels must end with a colon (:). If this option is on, you must specify each label with a colon at the end. If this option is off, you can omit the colon from the end of label names that start in the first column. (This option corresponds to the **Labels must end with ':'** checkbox of the Assembler settings panel, described in “Labels must end with :”.)
`no_at_macros off | on`	If this option is on, the assembler does not allow macros that use $AT. If this option is off, the assembler produces a warning if a macro uses $AT. This option keyword string applies only to the MIPS Assembler.
period off | on | reset	Specifies whether the assembler requires a period (.) in directive names. If this option is on, each directive must start with a period. If this option is off, you can omit the period in front of a directive. This corresponds to the **Directives begin with '.'** checkbox of the Assembler settings panel, described in “Directives begin with .”.

Table 3.6 Option keywords

Keyword	Description
reorder off | on | reset	Specifies whether the assembler inserts a NOP (no operation) instruction after jumps and branches. If this option is on, the assembler inserts a NOP instruction. If this option is off, the assembler does not insert a NOP instruction, and you can substitute an instruction of your choice after jumps and branches. This option keyword string applies only to the MIPS Assembler.
space off | on | reset	Specifies whether the assembler allows a space in an operand field. If this option is on, operand fields can contain spaces. If this option is off, a space in the operand field signals the start of a comment. (This option corresponds to the **Allow space in operand field** checkbox of the Assembler settings panel, described in "Allow space in operand field".)

Debugging Directives

When you enable the debugger, the assembler automatically generates some debug information for your project. However, you can use the following directives in the debug section to provide the debugger with more detailed information:

- `file`
- `function`
- `line`
- `size`
- `type`

NOTE The preceding directives are allowed *only* in the `.debug` and `.text` sections of an assembly file.

For the debugging directives to work, you must enable debugging for the particular file that contains them (in the Project window).

file

`.file "`*filename*`"`

Specifies the name of the file containing the source code. This directive enables generated assembly code to be correlated with the source code.

You must supply the .function and .line statements as well as the .file directive if you plan on writing your own DWARF code. The following is an example of how to use the .file directive when writing your own DWARF code.

```
.file “MyFile.c”
.text
.function “MyFunction”,start,end-start
start:
.line 1
lwz r3, 0(r3)
.line 2
blr
end:
```

NOTE The `.file` directive must precede the other debugging directives in the assembly language file.

function

`.function "`*func*`",` *label*`,` *length*

Specifies that the subroutine *func* begins at *label* and is *length* bytes long. This directive generates file debugging data.

line

`.line` *number*

Specifies the absolute line number in the current source file that generated the subsequent code or data. The first line in the file is numbered `1`.

size

`.size` *symbol*`,` *expression*

Specifies that *symbol* is *expression* bytes long.

type

`.type` *symbol*`,` *type*

Specifies that *symbol* is of type *type*, where type can be either `@function` (a function) or `@object` (a variable).

4

Using Macros

This chapter describes how to define and use macros. You can use the same macro language regardless of your target processor.

This chapter includes the following topics:

- Defining Macros
- Invoking Macros

Defining Macros

This section, which describes how to define macros, includes the following topics:

- Macro Definition Syntax
- Using Macro Arguments
- Using Local Labels in a Macro
- Creating Unique Labels and Equates
- Referring to the Number of Arguments

Macro Definition Syntax

A *macro definition* is one or more assembly statements that define:

- the name of a macro
- the format of the macro call
- the assembly statements to process when you invoke the macro

You can use the following methods to define a macro:

- Defining a macro with the .macro directive
- Defining a macro with the #define directive

Defining a macro with the .macro directive

One way to define a macro is to use the `.macro` directive. Listing 4.1 shows the syntax of a macro definition using the `.macro` directive.

Listing 4.1 Macro definition syntax using the .macro directive

```
name: .macro  [ parameter ] [ ,parameter ] ...
macro_body
.endm
```

The `.macro` directive indicates the first line of a macro definition. Every macro definition must end with the `.endm` directive.

Table 4.1 describes the syntax elements shown in Listing 4.1.

Table 4.1 Macro syntax descriptions for .macro directive

Syntax Element	Description
name	A label used to invoke the macro.
parameter	Operands that are passed to the macro and used in the macro body.
macro_body	One or more assembly language statements that are substituted for a macro call when you invoke the macro.

You can specify a conditional assembly block within a macro. Based on the result of the tested condition, you can use the `.mexit` directive to stop macro execution before the assembler reaches the `.endm` directive.

Listing 4.2 shows a macro that uses the `.mexit` directive.

Listing 4.2 Conditional macro using the .mexit directive

```
#define a macro
addto .macro dest,val
      .if val==0
no-op
.mexit # execution goes to the statement
       # immediately after the .endm directive
.elseif val==1
# use compact instruction
```

```
inc dest
.mexit # execution goes to the statement
       # immediately after the .endm directive
.endif
# if val is not equal to either 0 or 1,
# add dest and val
add dest,val
# end macro definition
.endm
```

Listing 4.3 shows assembly language code that calls the `addto` macro shown in Listing 4.2.

Listing 4.3 Assembly code that calls the addto macro

```
# specify an executable code section
.text
xor   eax,eax
# call the addto macro
addto eax,0
addto eax,1
addto eax,2
addto eax,3
```

Listing 4.4 shows the expanded `addto` macro calls shown in Listing 4.3 on page 49.

Listing 4.4 Expanded addto macro calls

```
xor  eax,eax
nop
inc  eax
add  eax,2
add  eax,3
```

Defining a macro with the #define directive

Another way to define a macro is to use the `#define` directive. Listing 4.5 shows the syntax of a macro definition using the `#define` directive.

Listing 4.5 Macro definition syntax using the #define directive

```
#define name [ (parms) ] assembly_statement [ ; ] [ \ ]
```

assembly_statement [;] [\ ]
assembly_statement

parms ::= *parameter* [,*parameter*]...

NOTE If you specify parameters for a macro, you must enclose the parameters in parentheses.

Table 4.2 describes the syntax elements shown in Listing 4.5.

Table 4.2 Macro syntax descriptions for #define directive

Syntax Element	Description
name	A label used to invoke the macro.
parameter	Operands that are passed to the macro.
assembly_statement	An assembly language statement that is substituted for a macro call when you invoke the macro. You can extend the assembly language statement beyond the length of one physical line by typing a backslash (\) at the end of a line and continuing the statement on the subsequent line. You also can specify multiple assembly statements in the macro by typing a semicolon (;) followed by a backslash (\) and typing a new assembly statement on the next physical line.

Using Macro Arguments

You can refer to parameters directly by name. Listing 4.6 shows the `setup` macro, which moves an integer into a register and branches to the label `_final_setup`.

Listing 4.6 The setup macro

```
setup:      .macro name
             mov    eax, name
             call   _final_setup
            .endm
```

Listing 4.7 shows one way to invoke the `setup` macro.

Listing 4.7 Calling setup

```
#define VECT 0
setup  VECT
```

Listing 4.8 shows how the assembler expands the `setup` macro after the preceding call.

Listing 4.8 Expanded setup

```
move    eax, VECT
call    _final_setup
```

When you refer to named macro parameters in the macro body, you can precede or follow the macro parameter with `&&`. This lets you embed the parameter in a string. For example, Listing 4.9 shows the `smallnum` macro, which creates a small float by appending the string `E-20` to the macro argument.

Listing 4.9 The smallnum macro

```
smallnum:    .macro    mantissa
             .float    mantissa&&E-20
             .endm
```

Listing 4.10 shows one way to invoke the `smallnum` macro.

Listing 4.10 Invoking smallnum

```
smallnum  10
```

Listing 4.11 shows how the assembler expands the smallnum macro after the preceding call.

Listing 4.11 Expanding smallnum

```
        .float      10E-20
```

Using Local Labels in a Macro

When you use a local label (a label that begins with @) in a macro, the scope of the label is limited to the expansion of the macro. For more information, see "Local labels".

Creating Unique Labels and Equates

You can generate unique labels and equates within a macro with the following characters: `\@`. Each time you invoke the macro, the assembler generates a unique symbol of the form `??`*nnnn*, such as `??0001` or `??0002`.

You refer to unique labels and equates (those that use \@) in your code with the same methods used for regular labels and equates. The assembler replaces the \@ sequence with a unique numeric string and increments the value of the string each time you invoke the macro.

Listing 4.12 shows a macro that uses unique labels and equates.

Listing 4.12 Unique label macro

```
my_macro:  .macro
           foo\@ = my_count
my_count   .set my_count + 1
           add  ebx, foo\@
           jmp  label\@
           add  eax, ebx
label\@:
           nop
           .endm
```

Listing 4.13 shows a call to the `my_macro` macro twice (with `my_count` initialized to 0).

Listing 4.13 Invoking my_macro

```
my_count   .set 0
           my_macro
           my_macro
```

Listing 4.14 shows the expanded `my_macro` code after the calls in Listing 4.13 on page 52.

Listing 4.14 Expanded my_macro calls

```
foo??0000    =      my_count
my_count     .set   my_count + 1
             add    ebx, foo??0000
             jmp    label??0000
             add    eax, ebx
label??0000
             nop
foo??0001    =      my_count
my_count     .set   my_count + 1
             add    ebx, foo??0001
             jmp    label??0001
             add    eax, ebx
label??0001
             nop
```

Referring to the Number of Arguments

To refer to the number of non-null arguments passed to a macro, use the special symbol `narg`. You can use it only during macro expansion.

Invoking Macros

To invoke a macro, use its name in your assembler listing.

When invoking a macro, you must separate parameters with commas. To pass a parameter that includes a comma, enclose the parameter in angle brackets.

For example, Listing 4.15 shows a macro named pattern, which repeats a pattern of bytes passed to it the number of times specified in the macro call.

Listing 4.15 The pattern macro

```
pattern:     .macro times,bytes
                 .rept times
                 .byte bytes
                 .endr
```

```
        .endm
```

Listing 4.16 shows a statement that calls `pattern`, passing a parameter that includes a comma.

Listing 4.16 Calling a macro with an argument that contains commas

```
        .data

halfgrey:   pattern 4,<0xAA,0x55>
```

The call in Listing 4.16 generates the same data as the code shown in Listing 4.17.

Listing 4.17 Alternate way to generate a repeating pattern of bytes

```
halfgrey:   .byte 0xAA,0x55,0xAA,0x55,0xAA,0x55,0xAA,0x55
```

5

Common Assembler Settings

This chapter describes the settings on the Assembler target settings panel that are common to all the assemblers.

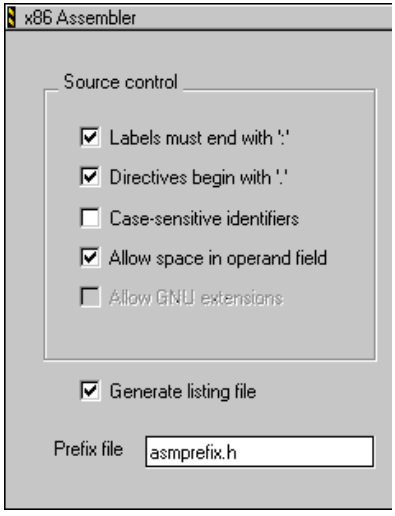
Displaying Assembler Target Settings Panel

To modify the settings for an assembler:

1. Select **Edit > Project Settings**.
2. In the resulting dialog box, select the name of the assembler to see its settings panel.

   Figure 5.1 shows the settings on the Assembler target settings panel that are common to all the assemblers. For information on settings that may be specific to your assembler, see the processor-specific chapters of this manual.

Figure 5.1 Common assembler settings



Common Assembler Settings Descriptions

The following common assembler settings exist:

- Labels must end with :
- Directives begin with .
- Case-sensitive identifiers
- Allow space in operand field
- Generate listing file
- Prefix file

Labels must end with :

You can use the **Labels must end with ':'** checkbox to specify whether labels must end with a colon (:). If you select this checkbox, a label must end with a colon (:) and can begin in any column. If you clear this checkbox, a symbol is a label if it starts in column 1 *or* if it ends with a colon (:).

By default, the **Labels must end with ':'** checkbox is selected. This checkbox corresponds to the `colon` parameter of the `.option` directive, described in “option”.

NOTE	The **Labels must end with ':'** checkbox is especially useful when porting existing code that has symbols that do not end with a colon (:).

For more information, see “Labels”.

Directives begin with .

You can use the **Directives begin with '.'** checkbox to specify whether a period (.) must precede each directive name. If you select this checkbox, a period (.) must precede each directive. If you clear this checkbox, you can omit the period. For more information, see “Using Directives”.

By default, the **Directives begin with '.'** checkbox is selected. This checkbox corresponds to the `period` parameter of the `.option` directive, described in “option”.

Case-sensitive identifiers

You can use the **Case-sensitive identifiers** checkbox to specify whether symbols are case-sensitive. If you select this checkbox, symbols are case sensitive. For example, in this case, `SYM1`, `sym1`, and `Sym1` are three different symbols.

If you clear this checkbox, symbols are *not* case-sensitive. Therefore, in this case, `SYM1`, `sym1`, and `Sym1` are the same symbol. For more information, see “Symbols.”

NOTE	Instruction, directive, and macro names are always case insensitive.

By default, the **Case-sensitive identifiers** checkbox is selected. This checkbox corresponds to the `case` parameter of the `.option` directive, described in “option”.

Allow space in operand field

You can use the **Allow space in operand field** checkbox to specify whether a comment can start with a space in the operand field. If you select this checkbox, the assembler allows spaces in the operand field. If you clear this checkbox, the assembler ignores any text between a space character in the operand field and the end of the line

(which makes that text a comment). For more information, see “Comments”. By default, the **Allow space in operand field** checkbox is selected. This checkbox corresponds to the `space` parameter of the `.option` directive, described in “option”.

Generate listing file

You can use the **Generate listing file** checkbox to create a text file that you can use to compare your source code with the machine code that the assembler produced. If you select this checkbox, the assembler creates a listing file using the source name and the following suffix:

```
.list
```

For example, for the file `test.asm`, the assembler assigns the following name to the listing file:

```
test.asm.list
```

If you clear the **Generate listing file** checkbox, the assembler does not create a listing file. By default, the **Generate listing file** checkbox is cleared.

Prefix file

You can use the **Prefix file** field to specify a file that the assembler processes before every assembly file in your project. The effect of using a prefix file is similar to putting the same `.include` directive at the beginning of every assembly file. By default, no prefix file is specified.

6

PowerPC-Specific Information

The CodeWarrior PowerPC assembler supports all instructions for the PowerPC processor.

This chapter provides information specific to the PowerPC processor. For example, this chapter discusses features and examples that differ from the information provided in the other chapters of this manual.

This chapter includes the following topics:

- Related Documentation
- PowerPC-Specific Examples

Related Documentation

PowerPC Microprocessor Family: The Programming Environments for 32-Bit Microprocessors (published by Freescale, Inc.) is helpful for writing PowerPC assembly language code.

PowerPC-Specific Examples

This section contains examples shown in previous chapters that differ for the PowerPC assembler. Table 6.1 lists the PowerPC-specific examples and the corresponding examples shown in previous chapters.

Table 6.1 Corresponding example table

Original Example	PowerPC-Specific Example
Listing 2.2	Listing 6.1 on page 60
Listing 4.2	Listing 6.2 on page 60

Table 6.1 Corresponding example table

Original Example	PowerPC-Specific Example
Listing 4.3	Listing 6.3 on page 61
Listing 4.4	Listing 6.4 on page 61
Listing 4.6	Listing 6.5 on page 61
Listing 4.8	Listing 6.7 on page 62
Listing 4.12	Listing 6.8 on page 62
Listing 4.14	Listing 6.10 on page 63

Listing 6.1 shows the scope of local labels in macros.

Listing 6.1 PowerPC example: the scope of local labels in a macro

```
MAKEPOS:  .MACRO
     cmpdi    r3, 1
     bne      @SKIP
     neg      r3,r3
@SKIP:  ;Scope of this label is within the macro
    .ENDM
START:
     lis      r2, COUNT@h    ; COUNT is defined elsewhere
     ori      r2,r2,COUNT@l
     cmpdi    r3, 1
     bne      @SKIP
     MAKEPOS
@SKIP:    ;Scope of this label is START to END
          ;excluding lines arising from
          ;macro expansion
      add    r2,r2,1
END:
```

Listing 6.2 shows a macro that uses the `.mexit` directive.

Listing 6.2 PowerPC example: conditional macro using the .mexit directive

```
; define a macro
addto:  .macro   val,dest
        .if val==0
       nop
       .mexit ; execution goes to the statement
```

```
                ; immediately after the .endm directive
        .elseif val==1
         addi dest,dest,1
         .mexit ; execution goes to the statement
                ; immediately after the .endm directive
         .endif
; if val is not equal to either 0 or 1,
; add dest and val
addi dest,dest,val
; end macro definition
.endm
```

Listing 6.3 shows assembly language code that calls the `addto` macro shown in Listing 6.2.

Listing 6.3 PowerPC example: assembly code that calls the addto macro

```
; specify an executable code section
    .text
    xor   r3,r3,r2
; call the addto macro
    addto r3,0
    addto r3,1
    addto r3,2
    addto r3,3
```

Listing 6.4 shows the listing file for the macro calls shown in Listing 6.3.

Listing 6.4 PowerPC example: Listing file contents for addto macro calls

```
.text
    nop
    addi    r3,r3,1
    addi    r3,r3,2
    addi    r3,r3,3
```

Listing 6.5 shows the `setup` macro, which moves an integer into a register and branches to the label `_final_setup`.

Listing 6.5 PowerPC example: the setup macro

```
setup:       .macro name
             lis   r3, name@h
```

```
            ori    r3, name@l
            b     _final_setup
            .endm
```

Listing 6.6 shows one way to invoke the `setup` macro. (Listing 6.6 shows the same call as Listing 4.7.)

Listing 6.6 PowerPC example: calling setup

```
            #define VECT 0
            setup  VECT
```

Listing 6.7 shows how the assembler expands the `setup` macro after a particular call.

Listing 6.7 PowerPC example: expanded setup

```
            lis     r3,VECT
            b       _final_setup
```

Listing 6.8 shows a macro that uses unique labels.

Listing 6.8 PowerPC example: unique label macro

```
my_macro:  .macro
           foo\@ = my_count
my_count   .set my_count + 1
           addi r3,r3,foo\@
           b    label\@
           add  r4,r4,r3
label\@:
           nop
           .endm
```

Listing 6.9 shows a call to the `my_macro` macro twice (with `my_count` initialized to 0). (Listing 6.9 shows the same calls as Listing 4.13.)

Listing 6.9 PowerPC example: invoking my_macro

```
mycount   .set 0
          my_macro
          my_macro
```

Listing 6.10 shows the assembler output for the unique label macro.

Listing 6.10 PowerPC example: expanded my_macro calls

```
foo??0000    =      my_count
my_count     .set   my_count + 1
             addi   r3,r3,foo??0000
             b      label??f0000
             add    r4,r4,r3
label??0000
             nop
foo??0001    =      my_count
my_count     .set   my_count + 1
             addi   r3,r3,foo??0001
             b      label??0001
             add    r4,r4,r3
label??0001
             nop
```

Index

R

S

T

U