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CONTENTS

PREFACE

Purpose ........................................................................................................... xiii
Intended Audience ................................................................................. xiii
Manual Contents .................................................................................. xiv
What’s New in this Manual ................................................................. xiv
Technical or Customer Support ....................................................... xiv
Supported Processors ........................................................................... xv
Product Information ............................................................................... xvi
  Analog Devices Web Site ............................................................... xvi
  VisualDSP++ Online Documentation ............................................. xvi
  Technical Library CD ................................................................. xvii
  EngineerZone .............................................................................. xviii
  Social Networking Web Sites ...................................................... xviii
Notation Conventions ........................................................................... xviii

ASSEMBLER

Assembler Guide .................................................................................... 1-2
  Assembler Overview ........................................................................ 1-3
  Writing Assembly Programs ........................................................ 1-3
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Content</td>
<td>1-6</td>
</tr>
<tr>
<td>Assembly Instructions</td>
<td>1-6</td>
</tr>
<tr>
<td>Assembler Directives</td>
<td>1-6</td>
</tr>
<tr>
<td>Preprocessor Commands</td>
<td>1-7</td>
</tr>
<tr>
<td>Program Structure</td>
<td>1-7</td>
</tr>
<tr>
<td>Code File Structure for SHARC Processors</td>
<td>1-10</td>
</tr>
<tr>
<td>LDF for SHARC Processors</td>
<td>1-11</td>
</tr>
<tr>
<td>Code File Structure for TigerSHARC Processors</td>
<td>1-13</td>
</tr>
<tr>
<td>LDF for TigerSHARC Processors</td>
<td>1-14</td>
</tr>
<tr>
<td>Code File Structure for Blackfin Processors</td>
<td>1-17</td>
</tr>
<tr>
<td>LDF for Blackfin Processors</td>
<td>1-18</td>
</tr>
<tr>
<td>Program Interfacing Requirements</td>
<td>1-20</td>
</tr>
<tr>
<td>Using Assembler Support for C Structs</td>
<td>1-21</td>
</tr>
<tr>
<td>Preprocessing a Program</td>
<td>1-24</td>
</tr>
<tr>
<td>Using Assembler Feature Macros</td>
<td>1-25</td>
</tr>
<tr>
<td>-D__VISUALDSPVERSION__ Predefined Macro</td>
<td>1-35</td>
</tr>
<tr>
<td>Generating Make Dependencies</td>
<td>1-37</td>
</tr>
<tr>
<td>Reading a Listing File</td>
<td>1-38</td>
</tr>
<tr>
<td>Enabling Statistical Profiling for Assembly Functions</td>
<td>1-38</td>
</tr>
<tr>
<td>Assembler Syntax Reference</td>
<td>1-41</td>
</tr>
<tr>
<td>Assembler Keywords and Symbols</td>
<td>1-42</td>
</tr>
<tr>
<td>Assembler Expressions</td>
<td>1-54</td>
</tr>
<tr>
<td>Assembler Operators</td>
<td>1-55</td>
</tr>
<tr>
<td>Numeric Formats</td>
<td>1-60</td>
</tr>
</tbody>
</table>
Contents

.GLOBAL, Make a Symbol Available Globally .................... 1-92
.IMPORT, Provide Structure Layout Information ............... 1-94
.INC/BINARY, Include Contents of a File ....................... 1-96
.LEFTMARGIN, Set the Margin Width of a Listing File ...... 1-97
.LIST/.NOLIST, Listing Source Lines and Opcodes .......... 1-98
.LIST_DATA/.NOLIST_DATA, Listing Data Opcodes .......... 1-99
.LIST_DATFILE/.NOLIST_DATFILE, List Data Init Files .... 1-100
.LIST_DEFTAB, Set the Default Tab Width for Listings ... 1-100
.LIST_LOCTAB, Set the Local Tab Width for Listings ..... 1-102
.LIST_WRAPDATA/.NOLIST_WRAPDATA ....................... 1-103
.LONG, Defines and Initializes 4-Byte Data Objects ....... 1-104
.MESSAGE, Alter the Severity of an Assembler Message .. 1-105
.NEWPAGE, Insert a Page Break in a Listing File .......... 1-109
.NOCOMPRESS, Terminate Compression ....................... 1-110
.PAGELENGTH, Set the Page Length of a Listing File .... 1-111
.PAGEWIDTH, Set the Page Width of a Listing File ....... 1-112
.PORT, Legacy Directive ......................................... 1-114
.PRECISION, Select Floating-Point Precision ............... 1-115
.PREVIOUS, Revert to the Previously Defined Section ... 1-117
.PRIORITY, Allow Prioritized Symbol Mapping in Linker 1-118
  Linker Operation ............................................. 1-119
.REFERENCE, Provide Better Info in an X-REF File ....... 1-121
.RETAIN_NAME, Stop Linker from Eliminating Symbol .... 1-121
.ROUND_, Select Floating-Point Rounding .................... 1-122
.SECTION, Declare a Memory Section .......................... 1-125
  Common .SECTION Attributes .................................. 1-125
  DOUBLE* Qualifiers .............................................. 1-126
  TigerSHARC-Specific Qualifiers ............................... 1-127
  SHARC-Specific Qualifiers ..................................... 1-127
  Initialization Section Qualifiers ............................. 1-129
 .SEGMENT and .ENDSEG, Legacy Directives ................. 1-131
 .SEPARATE_MEM_SEGMENTS ...................................... 1-131
 .SET, Set a Symbolic Alias ...................................... 1-132
 .SHORT, Defines and initializes 2-byte data objects ...... 1-132
 .STRUCT, Create a Struct Variable ............................ 1-133
 .TYPE, Change Default Symbol Type ............................ 1-137
 .VAR, Declare a Data Variable or Buffer .................... 1-138
   .VAR and ASCII String Initialization Support .......... 1-141
   .WEAK, Support Weak Symbol Definition and Reference 1-143
 Assembler Command-Line Reference ........................... 1-144
 Running the Assembler .......................................... 1-145
 Assembler Command-Line Switch Descriptions ............... 1-147
   -align-branch-lines ........................................... 1-151
   -anomaly-detect {id1[,id2...]|all|none} .................... 1-152
   -anomaly-warn {id1[,id2]|all|none} ........................ 1-152
   -anomaly-workaround {id1[,id2...]|all|none} ............. 1-153
   -char-size-8 .................................................... 1-154
   -char-size-32 ................................................... 1-154
Contents

- char-size-any .................................................................  1-154
- default-branch-np .........................................................  1-155
- default-branch-p ...........................................................  1-155
- Dmacro[=definition] .....................................................  1-155
- double-size-32 ...............................................................  1-156
- double-size-64 ...............................................................  1-156
- double-size-any .............................................................  1-156
- expand-symbolic-links ...................................................  1-157
- expand-windows-shortcuts .............................................  1-157
- file-attr attr[=val] ..........................................................  1-157
- flags-compiler ...............................................................  1-157
    User-Specified Defines Options .................................  1-158
    Include Options .........................................................  1-158
- flags-pp -opt1 [-opt2...] ...............................................  1-159
- g ...................................................................................  1-159
    WARNING ea1121: Missing End Labels .....................  1-160
- h[elp] ............................................................................  1-161
- i ....................................................................................  1-161
- l filename ......................................................................  1-162
- li filename .....................................................................  1-163
- M .................................................................................  1-163
- MM ..............................................................................  1-163
- Mo filename ..................................................................  1-164
- Mt filename ..................................................................  1-164
Contents

- **micaswarn** ........................................................................................................... 1-164
- **no-source-dependency** ...................................................................................... 1-164
- **no-anomaly-detect {id1[,id2...]|all|none}** ....................................................... 1-165
- **no-anomaly-workaround {id1[,id2...]|all|none}** .............................................. 1-165
- **no-expand-symbolic-links** .................................................................................. 1-166
- **no-expand-windows-shortcuts** ........................................................................... 1-166
- **no-temp-data-file** ............................................................................................... 1-166
- **normal-word-code or -nwc** ............................................................................... 1-167
- o filename ............................................................................................................... 1-167
- **pp** ....................................................................................................................... 1-167
- **proc processor** .................................................................................................. 1-168
- **save-temps** ........................................................................................................ 1-168
- **short-word-code or -swc** ................................................................................... 1-169
- **si-revision version** ............................................................................................... 1-169
- sp .............................................................................................................................. 1-170
- **stallcheck** .......................................................................................................... 1-170
- **swc-exclude name1[,name2]** .............................................................................. 1-170
- v[erbose] ................................................................................................................. 1-170
- **version** ................................................................................................................. 1-171
- **w** ........................................................................................................................ 1-171
- **Werror number[,number]** ................................................................................... 1-171
- **Winfo number[,number]** .................................................................................... 1-171
- **Wno-info** .............................................................................................................. 1-171
- **Wnumber[,number]** ............................................................................................. 1-171
Contents

-Wsuppress number[,number] ................................. 1-172
-Wwarn number[,number] ................................. 1-172
-Wwarn-error .................................................... 1-172
Specifying Assembler Options in VisualDSP++ .......... 1-173

PREPROCESSOR

Preprocessor Guide ............................................. 2-2
Writing Preprocessor Commands ............................ 2-3
Header Files and #include Command .................... 2-4
  System Header Files ........................................ 2-5
  User Header Files ......................................... 2-5
Sequence of Tokens ......................................... 2-5
Include Path Search ......................................... 2-6
Writing Macros ............................................... 2-7
  Macro Definition and Usage Guidelines ................. 2-8
Examples of Multi-Line Code Macros with Arguments .. 2-12
Debugging Macros ........................................... 2-13
Using Predefined Preprocessor Macros ................. 2-14
  -D__VISUALDSPVERSION____ Predefined Macro .... 2-16
Specifying Preprocessor Options ......................... 2-16
Preprocessor Command Reference ......................... 2-17
Preprocessor Commands and Operators ................. 2-18
  #define .................................................. 2-19
  Variable-Length Argument Definitions ............... 2-20
  #elif ..................................................... 2-22
<table>
<thead>
<tr>
<th>Preprocessor Command-Line Reference</th>
<th>2-39</th>
</tr>
</thead>
<tbody>
<tr>
<td>Running the Preprocessor</td>
<td>2-39</td>
</tr>
<tr>
<td>Preprocessor Command-Line Switches</td>
<td>2-40</td>
</tr>
<tr>
<td>-cpedef</td>
<td>2-42</td>
</tr>
<tr>
<td>-cs!</td>
<td>2-43</td>
</tr>
<tr>
<td>-cs/*</td>
<td>2-43</td>
</tr>
<tr>
<td>-cs//</td>
<td>2-44</td>
</tr>
<tr>
<td>-cs{</td>
<td>2-44</td>
</tr>
<tr>
<td>-csall</td>
<td>2-44</td>
</tr>
<tr>
<td>-Dmacro[=def]</td>
<td>2-44</td>
</tr>
</tbody>
</table>
Contents

-\texttt{-h} [elp] ................................................................. 2-44
-\texttt{-i} ................................................................. 2-45
-\texttt{-I} ................................................................. 2-45
-\texttt{-I-} ................................................................. 2-46
-\texttt{-M} ................................................................. 2-46
-\texttt{-MM} ............................................................... 2-47
-\texttt{-Mo} filename ................................................. 2-47
-\texttt{-Mt} filename ................................................... 2-47
-\texttt{-o} filename ..................................................... 2-48
-\texttt{-stringize} ....................................................... 2-48
-\texttt{-tokenize-dot} ............................................... 2-48
-\texttt{-Uname} ............................................................ 2-48
-\texttt{-v[erbose]} ...................................................... 2-49
-\texttt{-version} ......................................................... 2-49
-\texttt{-w} ................................................................. 2-49
-\texttt{-Wnumber} ....................................................... 2-49
-\texttt{-warn} ............................................................. 2-49

INDEX
PREFACE

Thank you for purchasing Analog Devices, Inc. development software for digital signal processing (DSP) applications.

Purpose

The *VisualDSP++ 5.0 Assembler and Preprocessor Manual* contains information about the assembler and preprocessor utilities for the following Analog Devices, Inc. processor families—Blackfin® (ADSP-BFxxx), SHARC® (ADSP-21xxx), and TigerSHARC® (ADSP-TSxxx) processors.

The manual describes how to write assembly programs for these processors and provides reference information about related development software. It also provides information on new and legacy syntax for assembler and preprocessor directives and comments, as well as command-line switches.

Intended Audience

The primary audience for this manual is a programmer who is familiar with Analog Devices processors. This manual assumes that the audience has a working knowledge of the appropriate processor architecture and instruction set. Programmers who are unfamiliar with Analog Devices processors can use this manual, but should supplement it with other texts (such as the appropriate hardware reference and programming reference manuals) that describe your target architecture.
Manual Contents

The manual consists of:

- Chapter 1, “Assembler”
  Provides an overview of the process of writing and building assembly programs. It also provides information about assembler switches, expressions, keywords, and directives.

- Chapter 2, “Preprocessor”
  Provides procedures for using preprocessor commands within assembly source files as well as the preprocessor’s command-line interface options and command sets.

What’s New in this Manual

This revision of the VisualDSP++ 5.0 Assembler and Preprocessor Manual documents assembler and preprocessor functionality that is new to VisualDSP++® 5.0 and updates (up to update 8), including support for new SHARC processors.

In addition, modifications and corrections based on errata reports against the previous revision of the manual have been made.

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• E-mail processor questions to
  processor.support@analog.com (World wide support)
  processor.europe@analog.com (Europe support)
  processor.china@analog.com (China support)

• Phone questions to 1-800-ANALOGD

• Contact your Analog Devices, Inc. local sales office or authorized
  distributor

• Send questions by mail to:
  Analog Devices, Inc.
  One Technology Way
  P.O. Box 9106
  Norwood, MA 02062-9106
  USA

**Supported Processors**

The assembler and preprocessor of VisualDSP++ 5.0 supports the following Analog Devices, Inc. processors.

• Blackfin (ADSP-BFxxx)
• SHARC (ADSP-21xxx)
• TigerSHARC (ADSP-TSxxx)

The majority of the information in this manual applies to all processors. For a complete list of processors supported by VisualDSP++ 5.0, refer to the online Help.
Product Information

Product Information

Product information can be obtained from the Analog Devices Web site, VisualDSP++ online Help system, and a technical library CD.

Analog Devices Web Site


To access a complete technical library for each processor family, go to http://www.analog.com/processors/technical_library. The manuals selection opens a list of current manuals related to the product as well as a link to the previous revisions of the manuals. When locating your manual title, note a possible errata check mark next to the title that leads to the current correction report against the manual.

Also note, MyAnalog.com is a free feature of the Analog Devices Web site that allows customization of a Web page to display only the latest information about products you are interested in. You can choose to receive weekly e-mail notifications containing updates to the Web pages that meet your interests, including documentation errata against all manuals. MyAnalog.com provides access to books, application notes, data sheets, code examples, and more.

Visit MyAnalog.com to sign up. If you are a registered user, just log on. Your user name is your e-mail address.

VisualDSP++ Online Documentation

Online documentation comprises the VisualDSP++ Help system, software tools manuals, hardware tools manuals, processor manuals, Dinkum Abridged C++ library, and FLEXnet License Tools documentation. You
can search easily across the entire VisualDSP++ documentation set for any topic of interest.

For easy printing, supplementary Portable Documentation Format (.pdf) files for all manuals are provided on the VisualDSP++ installation CD.

Each documentation file type is described as follows.

<table>
<thead>
<tr>
<th>File</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>.chm</td>
<td>Help system files and manuals in Microsoft help format</td>
</tr>
<tr>
<td>.htm or</td>
<td>Dinkum Abridged C++ library and FLEXnet license tools software</td>
</tr>
<tr>
<td>.html</td>
<td>documentation. Viewing and printing the .html files requires a browser, such as Internet Explorer 6.0 (or higher).</td>
</tr>
<tr>
<td>.pdf</td>
<td>VisualDSP++ and processor manuals in PDF format. Viewing and printing the .pdf files requires a PDF reader, such as Adobe Acrobat Reader (4.0 or higher).</td>
</tr>
</tbody>
</table>

**Technical Library CD**

The technical library CD contains seminar materials, product highlights, a selection guide, and documentation files of processor manuals, VisualDSP++ software manuals, and hardware tools manuals for the following processor families: Blackfin, SHARC, TigerSHARC, ADSP-218x, and ADSP-219x.

To order the technical library CD, go to [http://www.analog.com processors/technical_library](http://www.analog.com/proces-sors/technical_library), navigate to the manuals page for your processor, click the request CD check mark, and fill out the order form.

Data sheets, which can be downloaded from the Analog Devices Web site, change rapidly, and therefore are not included on the technical library CD. Technical manuals change periodically. Check the Web site for the latest manual revisions and associated documentation errata.
Notation Conventions

EngineerZone

EngineerZone is a technical support forum from Analog Devices. It allows you direct access to ADI technical support engineers. You can search FAQs and technical information to get quick answers to your embedded processing and DSP design questions.

Use EngineerZone to connect with other DSP developers who face similar design challenges. You can also use this open forum to share knowledge and collaborate with the ADI support team and your peers. Visit http://ez.analog.com to sign up.

Social Networking Web Sites

You can now follow Analog Devices processor development on Twitter and LinkedIn. To access:

- Twitter: http://twitter.com/ADIsharc and http://twitter.com/blackfin
- LinkedIn: Network with the LinkedIn group, Analog Devices SHARC or Analog Devices Blackfin: http://www.linkedin.com

Notation Conventions

Text conventions used in this manual are identified and described as follows.

Additional conventions, which apply only to specific chapters, may appear throughout this document.
### Example Descriptions

<table>
<thead>
<tr>
<th>Example</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Close command (File menu)</td>
<td>Titles in bold style reference sections indicate the location of an item within the VisualDSP++ environment’s menu system (for example, the Close command appears on the File menu).</td>
</tr>
<tr>
<td>{this</td>
<td>that}</td>
</tr>
<tr>
<td>[this</td>
<td>that]</td>
</tr>
<tr>
<td>[this,...]</td>
<td>Optional item lists in syntax descriptions appear within brackets delimited by commas and terminated with an ellipse; read the example as an optional comma-separated list of this.</td>
</tr>
<tr>
<td>.SECTION</td>
<td>Commands, directives, keywords, and feature names are in text with letter gothic font.</td>
</tr>
<tr>
<td>filename</td>
<td>Non-keyword placeholders appear in text with italic style format.</td>
</tr>
</tbody>
</table>

### Notes

- **Note**: For correct operation, ...
  - A Note provides supplementary information on a related topic. In the online version of this book, the word **Note** appears instead of this symbol.

### Caution

- **Caution**: Incorrect device operation may result if ...
  - A Caution identifies conditions or inappropriate usage of the product that could lead to undesirable results or product damage. In the online version of this book, the word **Caution** appears instead of this symbol.

### Warning

- **Warning**: Injury to device users may result if ...
  - A Warning identifies conditions or inappropriate usage of the product that could lead to conditions that are potentially hazardous for devices users. In the online version of this book, the word **Warning** appears instead of this symbol.
Notation Conventions
1 ASSEMBLER

This chapter provides information on how to use the assembler to develop and assemble programs for SHARC (ADSP-21xxx), TigerSHARC (ADSP-TSxxx), and Blackfin (ADSP-BFxxx) processors.

The chapter contains the following sections:

- **“Assembler Guide” on page 1-2**
  Describes how to develop new programs using the processor’s assembly language

- **“Assembler Syntax Reference” on page 1-41**
  Provides the assembler rules and conventions of syntax used to define symbols (identifiers), expressions, and to describe different numeric and comment formats

- **“Assembler Command-Line Reference” on page 1-144**
  Provides reference information on the assembler’s switches and conventions

⚠️ The code examples in this manual have been compiled using VisualDSP++ 5.0 The examples compiled with other versions of VisualDSP++ may result in build errors or different output although the highlighted algorithms stand and should continue to stand in future releases of VisualDSP++.
In VisualDSP++ 5.0, you can run the assembler drivers for each processor family from the VisualDSP++ integrated debugging and development environment (IDDE) or from an operating system command line. The assembler processes assembly source, data, and header files to produce an object file. Assembler operations depend on two types of controls: assembler directives and assembler switches.

VisualDSP++ 5.0 supports the following assembler drivers.

- easm21k.exe (for SHARC processors)
- easmts.exe (for TigerSHARC processors)
- easmblkfn.exe (for Blackfin processors)

This section describes how to develop new programs in the Analog Devices processor assembly language. It provides information on how to assemble your programs from the operating system’s command line.

Software developers using the assembler should be familiar with these topics:

- “Writing Assembly Programs” on page 1-3
- “Using Assembler Support for C Structs” on page 1-21
- “Preprocessing a Program” on page 1-24
- “Using Assembler Feature Macros” on page 1-25
- “Generating Make Dependencies” on page 1-37
- “Reading a Listing File” on page 1-38
For information about a processor’s architecture, including the instruction set used when writing assembly programs, refer to the *Hardware Reference* and the *Programming Reference* for the appropriate processor.

**Assembler Overview**

The assembler processes data from assembly source (.asm), data (.dat), and header (.h) files to generate object files in executable and linkable format (ELF), an industry-standard format for binary object files. The object file has a .doj extension.

In addition to the object file, the assembler can produce a listing file (.lst) that shows the correspondence between the binary code and the source.

Assembler switches are specified from the VisualDSP++ IDDE or from the command line used to invoke the assembler. These switches allow you to control the assembly process of source, data, and header files. Use these switches to enable and configure assembly features, such as search paths, output file names, and macro preprocessing. For more information, see “Assembler Command-Line Reference” on page 1-144.

You can also set assembler options via the *Assemble* page of the *Project Options* dialog box in VisualDSP++. For more information, see “Specifying Assembler Options in VisualDSP++” on page 1-173.

**Writing Assembly Programs**

Assembler directives are coded in assembly source files. The directives allow you to define variables, set up hardware features, and identify pro-
gram sections for placement within processor memory. The assembler uses directives for guidance as it translates a source program into object code.

Write assembly language programs using the VisualDSP++ editor or any editor that produces text files. Do not use a word processor that embeds special control codes in the text. Use an .asm extension to source file names to identify them as assembly source files.

Figure 1-1 shows a graphical overview of the assembly process. The figure shows the preprocessor processing the assembly source (.asm) and header (.h) files.
Assemble your source files from the VisualDSP++ environment or using any mechanism, such as a batch file or makefile, that supports invoking an appropriate assembler driver with a specified command-line command. By default, the assembler processes an intermediate file to produce a binary object file (.doj) and an optional listing file (.lst).

Object files produced by the processor assembler may be used as input to the linker and archiver. You can archive the output of an assembly process into a library file (.dlb), which can then be linked with other objects into an executable. Use the linker to combine separately assembled object files and objects from library files to produce an executable file. For more information about the linker and archiver, refer to the VisualDSP++ 5.0 Linker and Utilities Manual.

A binary object file (.doj) and an optional listing (.lst) file are final results of the successful assembly.

The assembler listing file is a text file read for information on the results of the assembly process. The listing file also provides information about the imported C data structures. The listing file tells which imports were used within the program, followed by a more detailed section. (See the .IMPORT directive on page 1-94.) The file shows the name, total size, and layout with offset for the members. The information appears at the end of the listing. You must specify the -l switch (on page 1-162) to produce a listing file.

The assembly source file may contain preprocessor commands, such as #include, that cause the preprocessor to include header files (.h) into the source program. The preprocessor’s only output, an intermediate source file (.is), is the assembler’s primary input. In normal operation, the preprocessor output is a temporary file that is deleted during the assembly process.
Program Content

Assembly source file statements include assembly instructions, assembler directives, and preprocessor commands.

Assembly Instructions

Instructions adhere to the processor’s instruction set syntax, which is documented in the processor’s Programming Reference. Each instruction line must be terminated by a semicolon (;). On TigerSHARC processors, each instruction line (which can contain up to 4 instructions) is terminated by an additional semicolon (;;). Figure 1-2 on page 1-8 shows an example assembly source file.

To mark the location of an instruction, place an address label at the beginning of an instruction line or on the preceding line. End the label with a colon (:) before beginning the instruction. Your program can then refer to this memory location using the label instead of an address. The assembler places no restriction on the number of characters in a label.

Labels are case sensitive. The assembler treats “outer” and “Outer” as unique labels. For example (in Blackfin processors),

outer: [11] = R0;
Outer: R1 = 0X1234;
JUMP outer; // jumps back 2 instructions

Assembler Directives

Assembler directives begin with a period (.) and end with a semicolon (;). The assembler does not differentiate between directives in lowercase or uppercase.

This manual prints directives in uppercase to distinguish them from other assembly statements.
Example (Blackfin processors):

```
.SECTION data1;
.BYTE2 sqrt_coeff[2] = 0x5D1D, 0xA9ED;
```

For a complete description of the assembler’s directive set, see “Assembler Directives” on page 1-71.

**Preprocessor Commands**

Preprocessor commands begin with a pound sign (#) and end with a carriage return. The pound sign must be the first non-white space character on the line containing the command. If the command is longer than one line, use a backslash (\) and a carriage return to continue the command onto the next line.

Do not put any characters between the backslash and the carriage return. Unlike assembler directives, preprocessor commands are case sensitive and must be lowercase. For example,

```
#include "string.h"
#define MAXIMUM 100
```

For more information, see “Writing Preprocessor Commands” on page 2-3. For a list of the preprocessor commands, see “Preprocessor Command-Line Reference” on page 2-39.

**Program Structure**

An assembly source file defines code (instructions) and data. It also organizes the instructions and data to allow the use of the linker description file (.ldf) to describe how code and data are mapped into the memory on your target processor. The way you structure your code and data into memory should follow the memory architecture of the target processor.
Use the .SECTION directive to organize the code and data in assembly source files. The .SECTION directive defines a grouping of instructions and data that occupies contiguous memory addresses in the processor. The name given in a .SECTION directive corresponds to an input section name in the linker description file.

Table 1-1, Table 1-2, and Table 1-3 show suggested input section names for data and code that can be used in your assembly source for various processors. Using these predefined names in your sources makes it easier to take advantage of the default .ldf file included in your DSP system. However, you may also define your own sections. For information on .ldf files, refer to the VisualDSP++ 5.0 Linker and Utilities Manual.

### Table 1-1. Suggested Input Section Names for a SHARC .ldf File

<table>
<thead>
<tr>
<th>.SECTION Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>seg_pmco</td>
<td>A section in program memory that holds code</td>
</tr>
<tr>
<td>seg_dmda</td>
<td>A section in data memory that holds data</td>
</tr>
<tr>
<td>seg_pmda</td>
<td>A section in program memory that holds data</td>
</tr>
<tr>
<td>seg_rth</td>
<td>A section in program memory that holds system initialization code and interrupt service routines</td>
</tr>
<tr>
<td>seg_swco</td>
<td>A section in short word memory that holds instructions encoded for execution from short word memory. <strong>Note:</strong> Applies to the ADSP-2146x processors only.</td>
</tr>
</tbody>
</table>

### Table 1-2. Suggested Input Section Names for a TigerSHARC .ldf File

<table>
<thead>
<tr>
<th>.SECTION Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>data1</td>
<td>A section that holds data in memory block M1</td>
</tr>
<tr>
<td>data2</td>
<td>A section that holds data in memory block M2 (specified with the PM memory qualifier)</td>
</tr>
<tr>
<td>program</td>
<td>A section that holds code</td>
</tr>
</tbody>
</table>
Use sections in a program to group elements to meet hardware constraints. For example, the ADSP-BF535 processor has a separate program and data memory in Level 1 memory only. Level 2 memory and external memory are not separated into instruction and data memory.

To group the code that resides in off-chip memory, declare a section for that code and place that section in the selected memory with the linker.

The example assembly program defines three sections. Each section begins with a \texttt{.SECTION} directive and ends with the occurrence of the next \texttt{.SECTION} directive or end-of-file.

Table 1-4 lists the sections in the source program:

### Table 1-4. Sections in Source Programs

<table>
<thead>
<tr>
<th>Section</th>
<th>Blackfin</th>
<th>SHARC</th>
<th>TigerSHARC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data Section</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variables and buffers are declared and can be initialized</td>
<td>data1</td>
<td>seg_dmda</td>
<td>data1</td>
</tr>
<tr>
<td></td>
<td>constdata</td>
<td></td>
<td>data2</td>
</tr>
<tr>
<td><strong>Program Section</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data, instructions, and possibly other types of statements are in this section, including statements that are needed for conditional assembly</td>
<td>seg_rth</td>
<td>seg_pmco</td>
<td>program</td>
</tr>
<tr>
<td></td>
<td>program</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1-2, Figure 1-3 on page 1-13, and Figure 1-4 on page 1-17 describe assembly code file structure for each processor family. They show how a program divides into sections that match the memory segmentation...
of a DSP system. Notice that an assembly source may contain preprocessor commands (such as \#include to include other files in source code), \#ifdef (for conditional assembly), or \#define (to define macros). The \texttt{SECTIONS{}} commands define the .SECTION placements in the system’s physical memory as defined by the linker’s \texttt{MEMORY{}} command. Assembler directives, such as .VAR (or .BYTE for Blackfin processors), appear within sections to declare and initialize variables.

\section*{Code File Structure for SHARC Processors}

\smallskip

\textbf{Figure 1-2} describes assembly code file structure for SHARC processors.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig1-2.png}
\caption{Assembly Code File Structure for SHARC Processors}
\end{figure}

\smallskip

1-10 VisualDSP++ 5.0 Assembler and Preprocessor Manual
Looking at Figure 1-2, notice that the .PRECISION and .ROUND_ZERO
directives inform the assembler to store floating-point data with 40-bit
precision and to round a floating-point value to a closer-to-zero value if it
does not fit in the 40-bit format.

LDF for SHARC Processors

Listing 1-1 shows a sample user-defined .ldf file for SHARC processors.
Looking at the file's SECTIONS{} command, notice that the INPUT_SECTION
commands map to the names of memory sections (such as program, data1,
data2, ctor, heaptab, and so on) used in the example assembly sample
program.

Listing 1-1. LDF Example for SHARC Processors

ARCHITECTURE(ADSP-21062)
SEARCH_DIR( $ADI_DSP\21k\lib )
$LIBRARIES = lib060.dlb, libc.dlb;
$OBJECTS = $COMMAND_LINE_OBJECTS, 060_hdr.doj;

MEMORY {
  seg_rth {TYPE(PM RAM) START(0x20000) END(0x20fff) WIDTH(48))
  seg_init{TYPE(PM RAM) START(0x21000) END(0x2100f) WIDTH(48))
  seg_pmco{TYPE(PM RAM) START(0x21010) END(0x210ff) WIDTH(48))
  seg_pmda{TYPE(DM RAM) START(0x28000) END(0x28fff) WIDTH(32))
  seg_dmda{TYPE(DM RAM) START(0x29000) END(0x29fff) WIDTH(32))
  seg_stak{TYPE(DM RAM) START(0x2e000) END(0x2ffff) WIDTH(32))
       /* memory declarations for default heap */
    seg_heap{TYPE(DM RAM) START(0x2e000) END(0x2ffff) WIDTH(32))
       /* memory declarations for custom heap */
    seg_heaq{TYPE(DM RAM) START(0x2e000) END(0x2dfff) WIDTH(32))
   } // End MEMORY

PROCESSOR p0 {
    LINK_AGAINST( $COMMAND_LINE_LINK_AGAINST)
OUTPUT( $COMMAND_LINE_OUTPUT_FILE )

SECTIONS {
  .seg_rth {
    INPUT_SECTIONS( $OBJECTS(seg_rth) $LIBRARIES(seg_rth))
    > seg_rth
  }
  .seg_init {
    INPUT_SECTIONS( $OBJECTS(seg_init) $LIBRARIES(seg_init))
    > seg_init
  }
  .seg_pmco {
    INPUT_SECTIONS( $OBJECTS(seg_pmco) $LIBRARIES(seg_pmco))
    > seg_pmco
  }
  .seg_pmda {
    INPUT_SECTIONS( $OBJECTS(seg_pmda) $LIBRARIES(seg_pmda))
    > seg_pmda
  }
  .seg_dmda {
    INPUT_SECTIONS( $OBJECTS(seg_dmda) $LIBRARIES(seg_dmda))
    > seg_dmda
  }
  .stackseg {
    ldf_stack_space = .;
    ldf_stack_length = 0x2000;
    > seg_stak
  }
  .heap {
    ldf_heap_space = .;
    ldf_heap_end = ldf_heap_space + 0x2000;
    ldf_heap_length = ldf_heap_end - ldf_heap_space;
    > seg_heap
  }
  .heaq {
    ldf_heaq_space = .;
    ldf_heaq_end = ldf_heaq_space + 0x2000;
  }
}
ldf_heaq_length = ldf_heaq_end - ldf_heaq_space;

} > seg_heaq
} // End SECTIONS
} // End PO

Code File Structure for TigerSHARC Processors

Figure 1-3 describes assembly code file structure for TigerSHARC processors. Looking at Figure 1-3, notice that an assembly source may contain preprocessor commands, such as \#include (to include other files in source code), \#ifdef (for conditional assembly), or \#define (to define macros).

Assembler directives, such as \.VAR, appear within sections to declare and initialize variables.

Figure 1-3. Assembly Code File Structure for TigerSHARC Processors

### Data Section
- .SECTION data1;
  - .VAR buffer1 [0x100] = 'buffer.dat.';

### Assembler Directive

### Data Section
- .SECTION data2;
  - .VAR buffer2;

### Code Section
- .SECTION program;
  - start:

### Assembler Label
- #ifdef XR0_SET_TO_2
  - xR0=0x2;;
- #else
  - xR0=0x1;;
- #endif

### Preprocessor Commands for Conditional Assembly
- J1 = buffer1;;
- JL1 = 0;;
- J2 = 1;;
- LC0 = 0x100;;
- this loop: [J+=J2] = XRO;;
- IF NLCOE, JUMP this_loop;;
Listing 1-2 shows a sample user-defined .ldf file for TigerSHARC processors. Looking at the file’s `SECTIONS{}` command, notice that the `INPUT_SECTION` commands map to the names of memory sections (such as program, data1, data2, ctor, heaptab, and so on) used in the example assembly sample program.

Listing 1-2. Example Linker Description File for TigerSHARC Processors

```markdown
ARCHITECTURE(ADSP-TS101)
SEARCH_DIR( $ADI_DSP\TS\lib )
$OBJECTS = $COMMAND_LINE_OBJECTS;

/* Internal memory blocks are 0x10000 (64k) */

MEMORY
{
    M0Code  { TYPE(RAM) START(0x00000000) END(0x0000FFFF) WIDTH(32) }
    M1Data  { TYPE(RAM) START(0x00080000) END(0x0008BFFF) WIDTH(32) }
    M1Heap  { TYPE(RAM) START(0x0008C000) END(0x0008C7FF) WIDTH(32) }
    M1Stack { TYPE(RAM) START(0x0008C800) END(0x0008FFFF) WIDTH(32) }
    M2Data  { TYPE(RAM) START(0x00100000) END(0x0010BFFF) WIDTH(32) }
    M2Stack { TYPE(RAM) START(0x0010C000) END(0x0010FFFF) WIDTH(32) }
    SDRAM   { TYPE(RAM) START(0x04000000) END(0x07FFFFFF) WIDTH(32) }
    MS0     { TYPE(RAM) START(0x08000000) END(0x0BFFFFFF) WIDTH(32) }
}
```
MS1
{ TYPE(RAM) START(0x0C000000) END(0x0FFFFFFF) WIDTH(32) }

PROCESSOR p0 /* The processor in the system */
{ OUTPUT($COMMAND_LINE_OUTPUT_FILE)

SECTIONS
{ /* List of sections for processor P0 */

code
{
  FILL(0xb3c00000)
  INPUT_SECTION_ALIGN(4)
  INPUT_SECTIONS( $OBJECTS(program) )
} >M0Code

data1
{
  INPUT_SECTIONS( $OBJECTS(data1) )
} >M1Data

data2
{
  INPUT_SECTIONS( $OBJECTS(data2) )
} >M2Data

/* Provide support for initialization, including C++ static initialization. This section builds a table of initialization function pointers. */
ctor
{
  INPUT_SECTIONS( $OBJECTS(ctor0) )
  INPUT_SECTIONS( $OBJECTS(ctor1) )
}
INPUT_SECTIONS( $OBJECTS(ctor2) )
INPUT_SECTIONS( $OBJECTS(ctor3) )
INPUT_SECTIONS( $OBJECTS(ctor) )
 } >M1Data

/* Table containing heap segment descriptors */
heaptab
 |
 INPUT_SECTIONS( $OBJECTS(heaptab) )
 } >M1Data

/* Allocate stacks for the application */
jstackseg
 |
 ldf_jstack_limit = .;
 ldf_jstack_base = . + MEMORY_SIZEOF(M1Stack);
 } >M1Stack

kstackseg
 |
 ldf_kstack_limit = .;
 ldf_kstack_base = . + MEMORY_SIZEOF(M2Stack);
 } >M2Stack

/* The default heap occupies its own memory block */
defheapseg
 |
 ldf_defheap_base = .;
 ldf_defheap_size = MEMORY_SIZEOF(M1Heap);
 } >M1Heap
}


**Code File Structure for Blackfin Processors**

Figure 1-4 describes the Blackfin processor’s assembly code file structure and shows how a program divides into sections that match the memory segmentation of Blackfin processors.

![Figure 1-4. Assembly Source File Structure for Blackfin Processors](image-url)

You can use sections in a program to group elements to meet hardware constraints. For example, the ADSP-BF535 processor has a separate program and data memory in Level 1 memory only. Level 2 memory and external memory are not separated into instruction and data memory.
Listing 1-3 on page 1-18 shows a sample user-defined linker description file (.ldf). Looking at the file’s `SECTIONS()` command, notice that the `INPUT_SECTION` commands map to sections `program`, `data1`, and `constdata`.

Listing 1-3. Example Linker Description File for Blackfin Processors

```assembly
ARCHITECTURE(ADSP-BF535)
SEARCH_DIR($ADI_DSP\Blackfin\lib)
#define LIBS libc.dlb, libdsp.dlb
$LIBRARIES = LIBS, librt535.dlb;
$OBJECTS = $COMMAND_LINE_OBJECTS;

MEMORY /* Define/label system memory */
{ /* List of global Memory Segments */
  MEM_PROGRAM (TYPE(RAM) START(0xF0000000) END(0xF002FFFF) WIDTH(8) )
  MEM_HEAP (TYPE(RAM) START(0xF0030000) END(0xF0037FFF) WIDTH(8) )
  MEM_STACK (TYPE(RAM) START(0xF0038000) END(0xF003DFFF) WIDTH(8) )
  MEM_SYSSTACK (TYPE(RAM) START(0xF003E000) END(0xF003FDFF) WIDTH(8) )
  MEM_ARGV (TYPE(RAM) START(0xF003FE00) END(0xF003FFFF) WIDTH(8) )
}

PROCESSOR p0 /* The processor in the system */
{ /* List of sections for processor P0 */
  OUTPUT($COMMAND_LINE_OUTPUT_FILE)

  SECTIONS
  { /* List of sections for processor P0 */
```
program
{
    /* Align all code sections on 2 byte boundary */
    INPUT_SECTION_ALIGN(2)
    INPUT_SECTIONS( $OBJECTS(program) $LIBRARIES(program))
    INPUT_SECTION_ALIGN(1)
    INPUT_SECTIONS( $OBJECTS(data1) $LIBRARIES(data1))
    INPUT_SECTION_ALIGN(1)
    INPUT_SECTIONS( $OBJECTS(constdata)$LIBRARIES(constdata))
    INPUT_SECTION_ALIGN(1)
    INPUT_SECTIONS( $OBJECTS(ctor)$LIBRARIES(ctor))
    INPUT_SECTION_ALIGN(2)
    INPUT_SECTIONS( $OBJECTS(seg_rth))
} >MEM_PROGRAM

stack
{
    ldf_stack_space = .;
    ldf_stack_end = ldf_stack_space +
        MEMORY_SIZEOF(MEM_STACK) - 4;
} >MEM_STACK

sysstack
{
    ldf_sysstack_space = .;
    ldf_sysstack_end = ldf_sysstack_space +
        MEMORY_SIZEOF(MEM_SYSSTACK) - 4;
} >MEM_SYSSTACK

heap
{
    /* Allocate a heap for the application */
    ldf_heap_space = .;
    ldf_heap_end = ldf_heap_space + MEMORY_SIZEOF(MEM_HEAP) - 1;
}
ldf_heap_length = ldf_heap_end - ldf_heap_space;
} >MEM_HEAP

argv
{| /* Allocate argv space for the application */
  ldf_argv_space = .;
  ldf_argv_end = ldf_argv_space + MEMORY_SIZEOF(MEM_ARGV) - 1;
  ldf_argv_length = ldf_argv_end - ldf_argv_space;
} >MEM_ARGV
|
|

Program Interfacing Requirements

You can interface your assembly program with a C or C++ program. The C/C++ compiler supports two methods for mixing C/C++ and assembly language:

- Embedding assembly code in C or C++ programs
- Linking together C or C++ and assembly routines

To embed (inline) assembly code in your C or C++ program, use the `asm()` construct. To link together programs that contain C/C++ and assembly routines, use assembly interface macros. These macros facilitate the assembly of mixed routines. For more information about these methods, see the VisualDSP++ 5.0 C/C++ Compiler and Library Manual for the appropriate target processor.

When writing a C or C++ program that interfaces with assembly, observe the same rules that the compiler follows as it produces code to run on the processor. These rules for compiled code define the compiler’s run-time environment. Complying with a run-time environment means following rules for memory usage, register usage, and variable names.
The definition of the run-time environment for the C/C++ compiler is provided in the *VisualDSP++ 5.0 C/C++ Compiler and Library Manual* for the appropriate target processor, which also includes a series of examples to demonstrate how to mix C/C++ and assembly code.

**Using Assembler Support for C Structs**

The assembler supports C `typedef/struct` declarations within assembly source. These assembler data directives and built-ins provide high-level programming features with C structs in the assembler.

**Data Directives:**

- `.IMPORT` — see on page 1-94
- `.EXTERN STRUC`—see on page 1-87
- `.STRUCT`—see on page 1-133

**C Struct in Assembly Built-Ins:**

- `OFFSETOF(struct/typedef,field)`—see on page 1-67
- `SIZEOF(struct/typedef)`—see on page 1-67

**Struct References:**

- `struct->field`—support nests; see “Struct References” on page 1-68

For more information on C struct support, refer to the “-flags-compiler” command-line switch on page 1-157 and to “Reading a Listing File” on page 1-38.
C structs in assembly features accept the full set of legal C symbol names, including those that are otherwise reserved in the appropriate assembler. For example,

- In the SHARC assembler, I1, I2, and I3 are reserved keywords, but it is legal to reference them in the context of the C struct in assembly features.

- In the TigerSHARC assembler, J1, J2, and J3 are reserved keywords, but it is legal to reference them in the context of the C struct in assembly features.

- In the Blackfin assembler, as an example, “x” and “z” are reserved keywords, but it is legal to reference them in the context of the C struct in assembly features.

The examples below show how to access the parts of the struct defined in the header file, but they are not complete programs on their own. Refer to your DSP project files for complete code examples.

Blackfin Example:

```
.IMPORT "Coordinate.h";
/* typedef struct Coordinate { */
  int X;
  int Y;
  int Z;
} Coordinate;/* /

.SECTION data1:

.STRUCT Coordinate Coord1 = {
  X = 1,
  Y = 4,
  Z = 7
};
```
.SECTION program:

    P0.l = Coord1->X;
    P0.h = Coord1->X;

    P1.l = Coord1->Y;
    P1.h = Coord1->Y;

    P2.l = Coord1->Z;
    P2.h = Coord1->Z;

    P3.l = Coord1+OFFSETOF(Coordinate,Z);
    P3.h = Coord1+OFFSETOF(Coordinate,Z);

SHARC Example:

.IMPORT "Samples.h";
    /* typedef struct Samples {
       int I1;
       int I2;
       int I3;
    } Samples; */

.SECTION/DM seg_dmda;

.STRUCT Samples Sample1 ={
    I1 = 0x1000,
    I2 = 0x2000,
    I3 = 0x3000
};

.SECTION/PM seg_pmco;
    doubleMe:
    /* The code may look confusing, but I2 can be used both
    as a register and a struct member name */
B2 = Sample1;
M2 = OFFSETOF(Sample1,I2);
R0 = DM(M2,I2);
R0 = R0+R0;
DM(M2,I2) = R0;

For better code readability, avoid using .STRUCT member names that have the same spelling as assembler keywords. This may not always be possible if your application needs to use an existing set of C header files.

Preprocessing a Program

The assembler includes a preprocessor that allows the use of C-style preprocessor commands in your assembly source files. The preprocessor automatically runs before the assembler unless you use the assembler’s -sp (skip preprocessor) switch. Table 2-2 on page 2-18 lists preprocessor commands and provides a brief description of each command.

You can see the command line that the assembler uses to invoke the preprocessor by adding the -v switch (on page 1-170) to the assembler command line or by selecting the Generate verbose output option on the Assemble page of the Project Options dialog box. See “Specifying Assembler Options in VisualDSP++” on page 1-173.

Use preprocessor commands to modify assembly code. For example, you can use the #include command to fill memory, load configuration registers, or set up processor parameters. You can use the #define command to define constants and aliases for frequently used instruction sequences. The preprocessor replaces each occurrence of the macro reference with the corresponding value or series of instructions.

For example, the MAXIMUM macro from #define MAXIMUM 100 is replaced with the number 100 during preprocessing.
For more information on the preprocessor command set, see “Preprocessor Command Reference” on page 2-17. For more information on the preprocessor usage, see “-flags-pp -opt1 [-opt2... ]” on page 1-159.

There is one important difference between the assembler preprocessor and compiler preprocessor. The assembler preprocessor treats the “.” character as part of an identifier. Thus, .EXTERN is a single identifier and will not match a preprocessor macro EXTERN. This behavior can affect how macro expansion is done for some instructions.

For example,

```c
#define EXTERN 0x123
.EXTERN Coordinate; /* EXTERN not affected by macro */
```

```c
#define MY_REG P0
MY_REG.1 = 14; /* MY_REG.1 is not expanded; */
/* "." is part of token */
```

### Using Assembler Feature Macros

The assembler includes the command to invoke preprocessor macros to define the context, such as the source language, the architecture, and the specific processor. These feature macros allow programmers to use preprocessor conditional commands to configure the source for assembly based on the context.

Table 1-5 lists the set of feature macros for Blackfin processors. Table 1-6 lists the set of family macros for Blackfin processors. Table 1-7 on
Table 1-5. Feature Macros for Blackfin Processors

<table>
<thead>
<tr>
<th>Feature Macro</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>-D_LANGUAGE_ASM=1</code></td>
<td>Always present</td>
</tr>
<tr>
<td><code>-D__ADSPBLACKFIN__=1</code></td>
<td>Always present</td>
</tr>
<tr>
<td><code>-D__ADSPLPBLACKFIN__=1</code></td>
<td>Always present for non-ADSP-BF535 processors</td>
</tr>
<tr>
<td><code>-D__ADSPBF50x__=1</code></td>
<td>Present when running:</td>
</tr>
<tr>
<td></td>
<td><code>easmlkfn -proc ADSP-BF504</code></td>
</tr>
<tr>
<td></td>
<td><code>easmlkfn -proc ADSP-BF504F</code></td>
</tr>
<tr>
<td></td>
<td><code>easmlkfn -proc ADSP-BF506F</code></td>
</tr>
<tr>
<td><code>-D__ADSPBF51x__=1</code></td>
<td>Present when running:</td>
</tr>
<tr>
<td></td>
<td><code>easmlkfn -proc ADSP-BF512</code></td>
</tr>
<tr>
<td></td>
<td><code>easmlkfn -proc ADSP-BF514</code></td>
</tr>
<tr>
<td></td>
<td><code>easmlkfn -proc ADSP-BF516</code></td>
</tr>
<tr>
<td></td>
<td><code>easmlkfn -proc ADSP-BF518</code></td>
</tr>
<tr>
<td><code>-D__ADSPBF52x__=1</code></td>
<td>Present when running:</td>
</tr>
<tr>
<td></td>
<td><code>easmlkfn -proc ADSP-BF522</code></td>
</tr>
<tr>
<td></td>
<td><code>easmlkfn -proc ADSP-BF523</code></td>
</tr>
<tr>
<td></td>
<td><code>easmlkfn -proc ADSP-BF524</code></td>
</tr>
<tr>
<td></td>
<td><code>easmlkfn -proc ADSP-BF525</code></td>
</tr>
<tr>
<td></td>
<td><code>easmlkfn -proc ADSP-BF526</code></td>
</tr>
<tr>
<td></td>
<td><code>easmlkfn -proc ADSP-BF527</code></td>
</tr>
<tr>
<td><code>-D__ADSPBF53x__=1</code></td>
<td>Present when running:</td>
</tr>
<tr>
<td></td>
<td><code>easmlkfn -proc ADSP-BF531</code></td>
</tr>
<tr>
<td></td>
<td><code>easmlkfn -proc ADSP-BF532</code></td>
</tr>
<tr>
<td></td>
<td><code>easmlkfn -proc ADSP-BF533</code></td>
</tr>
<tr>
<td></td>
<td><code>easmlkfn -proc ADSP-BF534</code></td>
</tr>
<tr>
<td></td>
<td><code>easmlkfn -proc ADSP-BF536</code></td>
</tr>
<tr>
<td></td>
<td><code>easmlkfn -proc ADSP-BF537</code></td>
</tr>
<tr>
<td></td>
<td><code>easmlkfn -proc ADSP-BF538</code></td>
</tr>
<tr>
<td></td>
<td><code>easmlkfn -proc ADSP-BF539</code></td>
</tr>
</tbody>
</table>

Note: This does not include the ADSP-BF535 processor.
Table 1-5. Feature Macros for Blackfin Processors (Cont’d)

<table>
<thead>
<tr>
<th>Macro Description</th>
<th>Processor Compatibility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ADSPBF54x</strong>=1</td>
<td>Present when running:</td>
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<tr>
<td></td>
<td>easmblkfn -proc ADSP-BF542</td>
</tr>
<tr>
<td></td>
<td>easmblkfn -proc ADSP-BF544</td>
</tr>
<tr>
<td></td>
<td>easmblkfn -proc ADSP-BF547</td>
</tr>
<tr>
<td></td>
<td>easmblkfn -proc ADSP-BF548</td>
</tr>
<tr>
<td></td>
<td>easmblkfn -proc ADSP-BF549</td>
</tr>
<tr>
<td><strong>ADSPBF56x</strong>=1</td>
<td>Present when running:</td>
</tr>
<tr>
<td></td>
<td>easmblkfn -proc ADSP-BF561</td>
</tr>
<tr>
<td><strong>ADSPBF59x</strong>=1</td>
<td>Present when running:</td>
</tr>
<tr>
<td></td>
<td>easmblkfn -proc ADSP-BF592-A</td>
</tr>
<tr>
<td>-D__ADSPBF512__=1</td>
<td>Present when running easmblkfn -proc ADSP-BF512 with the ADSP-BF512 processor</td>
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<tr>
<td>-D__ADSPBF514__=1</td>
<td>Present when running easmblkfn -proc ADSP-BF514 with the ADSP-BF514 processor</td>
</tr>
<tr>
<td>-D__ADSPBF516__=1</td>
<td>Present when running easmblkfn -proc ADSP-BF516 with the ADSP-BF516 processor</td>
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<tr>
<td>-D__ADSPBF522__=1</td>
<td>Present when running easmblkfn -proc ADSP-BF522 with the ADSP-BF522 processor</td>
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<tr>
<td>-D__ADSPBF523__=1</td>
<td>Present when running easmblkfn -proc ADSP-BF523 with the ADSP-BF523 processor</td>
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<td>-D__ADSPBF524__=1</td>
<td>Present when running easmblkfn -proc ADSP-BF524 with the ADSP-BF524 processor</td>
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<td>Present when running easmblkfn -proc ADSP-BF525 with the ADSP-BF525 processor</td>
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<td>Present when running easmblkfn -proc ADSP-BF526 with the ADSP-BF526 processor</td>
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<tr>
<td>-D__ADSPBF527__=1</td>
<td>Present when running easmblkfn -proc ADSP-BF527 with the ADSP-BF527 processor</td>
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<td>-D__ADSPBF531__=1</td>
<td>Present when running easmblkfn -proc ADSP-BF531 with the ADSP-BF531 processor</td>
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<tr>
<td>-D__ADSPBF532__=1</td>
<td>Present when running easmblkfn -proc ADSP-BF532 with the ADSP-BF532 processor</td>
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<tr>
<td>-D__ADSPBF533__=1</td>
<td>Present when running easmblkfn -proc ADSP-BF533 with the ADSP-BF533 processor</td>
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### Table 1-5. Feature Macros for Blackfin Processors (Cont’d)

<table>
<thead>
<tr>
<th>Macro Name</th>
<th>Description</th>
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<tbody>
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<td>-D__ADSPBF534__=1</td>
<td>Present when running easmb1kfn -proc ADSP-BF534 with the ADSP-BF534 processor</td>
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<tr>
<td>-D__ADSPBF535__=1</td>
<td>Present when running easmb1kfn -proc ADSP-BF535 with the ADSP-BF535 processor</td>
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<tr>
<td>-D__ADSP21535__=1</td>
<td>Present when running easmb1kfn -proc ADSP-BF536 with the ADSP-BF536 processor</td>
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<td>-D__ADSPBF536__=1</td>
<td>Present when running easmb1kfn -proc ADSP-BF537 with the ADSP-BF537 processor</td>
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<tr>
<td>-D__ADSPBF537__=1</td>
<td>Present when running easmb1kfn -proc ADSP-BF538 with the ADSP-BF538 processor</td>
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<tr>
<td>-D__ADSPBF538__=1</td>
<td>Present when running easmb1kfn -proc ADSP-BF539 with the ADSP-BF539 processor</td>
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<td>-D__ADSPBF539__=1</td>
<td>Present when running easmb1kfn -proc ADSP-BF542 with the ADSP-BF542 processor</td>
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<td>-D__ADSPBF542__=1</td>
<td>Present when running easmb1kfn -proc ADSP-BF544 with the ADSP-BF544 processor</td>
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<td>Present when running easmb1kfn -proc ADSP-BF547 with the ADSP-BF547 processor</td>
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<td>Present when running easmb1kfn -proc ADSP-BF548 with the ADSP-BF548 processor</td>
</tr>
<tr>
<td>-D__ADSPBF548__=1</td>
<td>Present when running easmb1kfn -proc ADSP-BF549 with the ADSP-BF549 processor</td>
</tr>
<tr>
<td>-D__ADSPBF549__=1</td>
<td>Present when running easmb1kfn -proc ADSP-BF504 with the ADSP-BF504 processor</td>
</tr>
<tr>
<td>-D__ADSPBF504__=1</td>
<td>Present when running easmb1kfn -proc ADSP-BF504F with the ADSP-BF504F processor</td>
</tr>
<tr>
<td>-D__ADSPBF504F__=1</td>
<td>Present when running easmb1kfn -proc ADSP-BF506F with the ADSP-BF506F processor</td>
</tr>
<tr>
<td>-D__ADSPBF506F__=1</td>
<td>Present when running easmb1kfn -proc ADSP-BF561 with the ADSP-BF561 processor</td>
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Table 1-6. Family Macros for Blackfin Processors

<table>
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<tr>
<th>Macro</th>
<th>Description</th>
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<tbody>
<tr>
<td>-D__ADSPBF506F__FAMILY__=1</td>
<td>Present when running: easmblkfn -proc ADSP-BF504 easmblkfn -proc ADSP-BF504F easmblkfn -proc ADSP-BF506F</td>
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<tr>
<td>-D__ADSPBF506__FAMILY__=1</td>
<td>Present when running: easmblkfn -proc ADSP-BF506</td>
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<td>-D__ADSPBF518__FAMILY__=1</td>
<td>Equivalent to -D__ADSPBF51x__</td>
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<td>-D__ADSPBF526__FAMILY__=1</td>
<td>Equivalent to -D__ADSPBF52x__</td>
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<tr>
<td>-D__ADSPBF527__FAMILY__=1</td>
<td>Equivalent to -D__ADSPBF52x__</td>
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<tr>
<td>-D__ADSPBF533__FAMILY__=1</td>
<td>Equivalent to -D__ADSPBF53x__</td>
</tr>
<tr>
<td>-D__ADSPBF535__FAMILY__=1</td>
<td>Present when running easmblkfn -proc ADSP-BF535 with the ADSP-BF535 processor</td>
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<tr>
<td>-D__ADSPBF537__FAMILY__=1</td>
<td>Equivalent to -D__ADSPBF53x__</td>
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<tr>
<td>-D__ADSPBF538__FAMILY__=1</td>
<td>Equivalent to -D__ADSPBF53x__</td>
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<tr>
<td>-D__ADSPBF548__FAMILY__=1</td>
<td>Equivalent to -D__ADSPBF54x__</td>
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<tr>
<td>-D__ADSPBF561__FAMILY__=1</td>
<td>Present when running easmblkfn -proc ADSP-BF561 with the ADSP-BF561 processor</td>
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<tr>
<td>-D__ADSPBF592__FAMILY__=1</td>
<td>Present when running easmblkfn -proc ADSP-BF592-A with the ADSP-BF592-A processor</td>
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Table 1-7. Feature Macros for SHARC Processors

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<tr>
<th>Macro</th>
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<tr>
<td>-D_LANGUAGE_ASM=1</td>
<td>Always present</td>
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<tr>
<td>-D__ADSP21000__=1</td>
<td>Always present</td>
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<tr>
<td>-D__ADSP21020__=1</td>
<td>Present when running easm21k -proc ADSP-21020 with the ADSP-21020 processors</td>
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<tr>
<td>-D__2102x=1</td>
<td>Present when running easm21k -proc ADSP-21020 with the ADSP-21020 processors</td>
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Table 1-7. Feature Macros for SHARC Processors (Cont’d)

<table>
<thead>
<tr>
<th>Feature Macro</th>
<th>Description</th>
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<tbody>
<tr>
<td>-D__ADSP21060__=1 -D__2106x__=1</td>
<td>Present when running easm21K -proc ADSP-21060 with the ADSP-21060 processors</td>
</tr>
<tr>
<td>-D__ADSP21061__=1 -D__2106x__=1</td>
<td>Present when running easm21K -proc ADSP-21061 with the ADSP-21061 processors</td>
</tr>
<tr>
<td>-D__ADSP21062__=1 -D__2106x__=1</td>
<td>Present when running easm21K -proc ADSP-21062 with the ADSP-21062 processors</td>
</tr>
<tr>
<td>-D__ADSP21065L__=1 -D__2106x__=1</td>
<td>Present when running easm21K -proc ADSP-21065L with the ADSP-21065L processors</td>
</tr>
<tr>
<td>-D__ADSP21160__=1 -D__2116x__=1</td>
<td>Present when running easm21K -proc ADSP-21160 with the ADSP-21160 processors</td>
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<tr>
<td>-D__ADSP21161__=1 -D__2116x__=1</td>
<td>Present when running easm21K -proc ADSP-21161 with the ADSP-21161 processors</td>
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<tr>
<td>-D__ADSP21261__=1 -D__2126x__=1</td>
<td>Present when running easm21K -proc ADSP-21261 with the ADSP-21261 processors</td>
</tr>
<tr>
<td>-D__ADSP21262__=1 -D__2126x__=1</td>
<td>Present when running easm21K -proc ADSP-21262 with the ADSP-21262 processors</td>
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<tr>
<td>-D__ADSP21266__=1 -D__2126x__=1</td>
<td>Present when running easm21K -proc ADSP-21266 with the ADSP-21266 processors</td>
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<tr>
<td>-D__ADSP21267__=1 -D__2126x__=1</td>
<td>Present when running easm21K -proc ADSP-21267 with the ADSP-21267 processors</td>
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<tr>
<td>-D__ADSP21362__=1 -D__2136x__=1</td>
<td>Present when running easm21K -proc ADSP-21362 with the ADSP-21362 processors</td>
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<td>-D__ADSP21363__=1 -D__2136x__=1</td>
<td>Present when running easm21K -proc ADSP-21363 with the ADSP-21363 processors</td>
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<tr>
<td>-D__ADSP21364__=1 -D__2136x__=1</td>
<td>Present when running easm21K -proc ADSP-21364 with the ADSP-21364 processors</td>
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<td>-D__ADSP21365__=1 -D__2136x__=1</td>
<td>Present when running easm21K -proc ADSP-21365 with the ADSP-21365 processors</td>
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<tr>
<td>-D__ADSP21366__=1 -D__2136x__=1</td>
<td>Present when running easm21K -proc ADSP-21366 with the ADSP-21366 processors</td>
</tr>
<tr>
<td>-D__ADSP21367__=1 -D__2136x__=1</td>
<td>Present when running easm21K -proc ADSP-21367 with the ADSP-21367 processors</td>
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</table>
Table 1-7. Feature Macros for SHARC Processors (Cont’d)

<table>
<thead>
<tr>
<th>Macro</th>
<th>Condition</th>
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</thead>
<tbody>
<tr>
<td>-D__ADSP21368__=1</td>
<td>Present when running <code>easm21K -proc ADSP-21368</code> with the ADSP-21368 processors</td>
</tr>
<tr>
<td>-D__2136x__=1</td>
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</tr>
<tr>
<td>-D__ADSP21369__=1</td>
<td>Present when running <code>easm21K -proc ADSP-21369</code> with the ADSP-21369 processors</td>
</tr>
<tr>
<td>-D__2136x__=1</td>
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</tr>
<tr>
<td>-D__ADSP21371__=1</td>
<td>Present when running <code>easm21K -proc ADSP-21371</code> with the ADSP-21371 processors</td>
</tr>
<tr>
<td>-D__2137x__=1</td>
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<tr>
<td>-D__ADSP21375__=1</td>
<td>Present when running <code>easm21K -proc ADSP-21375</code> with the ADSP-21375 processors</td>
</tr>
<tr>
<td>-D__2137x__=1</td>
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<td>-D__ADSP21462__=1</td>
<td>Present when running <code>easm21K -proc ADSP-21462</code> with the ADSP-21462 processors</td>
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<tr>
<td>-D__2146x__=1</td>
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<tr>
<td>-D__ADSP21465__=1</td>
<td>Present when running <code>easm21K -proc ADSP-21465</code> with the ADSP-21465 processors</td>
</tr>
<tr>
<td>-D__2146x__=1</td>
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<tr>
<td>-D__ADSP21467__=1</td>
<td>Present when running <code>easm21K -proc ADSP-21467</code> with the ADSP-21467 processors</td>
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<td>-D__2146x__=1</td>
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<tr>
<td>-D__ADSP21469__=1</td>
<td>Present when running <code>easm21K -proc ADSP-21469</code> with the ADSP-21469 processors</td>
</tr>
<tr>
<td>-D__2146x__=1</td>
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</tr>
<tr>
<td>-D__ADSP21471__=1</td>
<td>Present when running <code>easm21K -proc ADSP-21471</code> with the ADSP-21471 processors</td>
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<td>-D__2147x__=1</td>
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<tr>
<td>-D__ADSP21472__=1</td>
<td>Present when running <code>easm21K -proc ADSP-21472</code> with the ADSP-21472 processors</td>
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<td>-D__2147x__=1</td>
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<tr>
<td>-D__ADSP21475__=1</td>
<td>Present when running <code>easm21K -proc ADSP-21475</code> with the ADSP-21475 processors</td>
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<tr>
<td>-D__2147x__=1</td>
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<tr>
<td>-D__ADSP21478__=1</td>
<td>Present when running <code>easm21K -proc ADSP-21478</code> with the ADSP-21478 processors</td>
</tr>
<tr>
<td>-D__2147x__=1</td>
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</table>
### Table 1-7. Feature Macros for SHARC Processors (Cont’d)

<table>
<thead>
<tr>
<th>Macro Configurations</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>-D__ADSP21479___=1</code></td>
<td>Present when running <code>easm21K -proc ADSP-21479</code> with the ADSP-21479 processors</td>
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<td><code>-D__214x___=1</code></td>
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<tr>
<td><code>-D__214xx___=1</code></td>
<td></td>
</tr>
<tr>
<td><code>-D__ADSP21481___=1</code></td>
<td>Present when running <code>easm21K -proc ADSP-21481</code> with the ADSP-21481 processors</td>
</tr>
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<td><code>-D__214x___=1</code></td>
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<tr>
<td><code>-D__214xx___=1</code></td>
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<tr>
<td><code>-D__ADSP21482___=1</code></td>
<td>Present when running <code>easm21K -proc ADSP-21482</code> with the ADSP-21482 processors</td>
</tr>
<tr>
<td><code>-D__214x___=1</code></td>
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<tr>
<td><code>-D__214xx___=1</code></td>
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</tr>
<tr>
<td><code>-D__ADSP21483___=1</code></td>
<td>Present when running <code>easm21K -proc ADSP-21483</code> with the ADSP-21483 processors</td>
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<td><code>-D__214x___=1</code></td>
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<tr>
<td><code>-D__214xx___=1</code></td>
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</tr>
<tr>
<td><code>-D__ADSP21485___=1</code></td>
<td>Present when running <code>easm21K -proc ADSP-21485</code> with the ADSP-21485 processors</td>
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<td><code>-D__214x___=1</code></td>
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<td><code>-D__214xx___=1</code></td>
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<tr>
<td><code>-D__ADSP21486___=1</code></td>
<td>Present when running <code>easm21K -proc ADSP-21486</code> with the ADSP-21486 processors</td>
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<td><code>-D__ADSP21487___=1</code></td>
<td>Present when running <code>easm21K -proc ADSP-21487</code> with the ADSP-21487 processors</td>
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<tr>
<td><code>-D__ADSP21488___=1</code></td>
<td>Present when running <code>easm21K -proc ADSP-21488</code> with the ADSP-21488 processors</td>
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<td><code>-D__214xx___=1</code></td>
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<tr>
<td><code>-D__ADSP21489___=1</code></td>
<td>Present when running <code>easm21K -proc ADSP-21489</code> with the ADSP-21489 processors</td>
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<tr>
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Table 1-7. Feature Macros for SHARC Processors (Cont’d)

<table>
<thead>
<tr>
<th>-D__SHORT_WORD_CODE__=1</th>
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</tr>
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<tr>
<td></td>
<td>easm21K -swc -proc ADSP-21462</td>
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<tr>
<td></td>
<td>easm21K -swc -proc ADSP-21465</td>
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<td>easm21K -swc -proc ADSP-21467</td>
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<td>easm21K -swc -proc ADSP-21479</td>
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<td>easm21K -swc -proc ADSP-21480</td>
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<table>
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<th>-D__SIMDSHARC__=1</th>
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<td></td>
<td>easm21K -proc ADSP-21160</td>
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<td>easm21K -proc ADSP-21483</td>
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<td>easm21K -proc ADSP-21484</td>
</tr>
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<td>easm21K -proc ADSP-21485</td>
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<td>easm21K -proc ADSP-21486</td>
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<td>easm21K -proc ADSP-21487</td>
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<td>easm21K -proc ADSP-21488</td>
</tr>
<tr>
<td></td>
<td>easm21K -proc ADSP-21489</td>
</tr>
</tbody>
</table>
For .IMPORT headers, the assembler calls the compiler driver with the appropriate processor option, and the compiler sets the machine constants accordingly (and defines -D_LANGUAGE_C=1). This macro is present when used for C compiler calls to specify headers. It replaces -D_LANGUAGE_ASM.

For example,

```
easm21k -proc adsp-21262 assembly --> cc21K -proc adsp-21262
easmts -proc -ADSP-TS101 assembly --> ccts -proc ADSP-TS101
easmlkfn -proc ADSP-BF535 assembly --> ccblkfn -proc ADSP-BF535
```

Use the -verbose switch to verify what macro is default-defined. Refer to Chapter 1 in the VisualDSP++ 5.0 C/C++ Compiler and Library Manual of the appropriate target processor for more information.

---

Table 1-8. Feature Macros for TigerSHARC Processors

<table>
<thead>
<tr>
<th>Macro</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-D_LANGUAGE_ASM =1</td>
<td>Always present</td>
</tr>
<tr>
<td>-D__ADSPTS__=1</td>
<td>Always present</td>
</tr>
<tr>
<td>-D__ADSPTS101__=1</td>
<td>Present when running easmts -proc ADSP-TS101 with the ADSP-TS101 processor</td>
</tr>
<tr>
<td>-D__ADSPTS201__=1</td>
<td>Present when running easmts -proc ADSP-TS201 with the ADSP-TS201 processor</td>
</tr>
<tr>
<td>-D__ADSPTS202__=1</td>
<td>Present when running easmts -proc ADSP-TS202 with the ADSP-TS202 processor</td>
</tr>
<tr>
<td>-D__ADSPTS203__=1</td>
<td>Present when running easmts -proc ADSP-TS203 with the ADSP-TS203 processor</td>
</tr>
<tr>
<td>-D__ADSPTS20x__=1</td>
<td>Present when running easmts -proc ADSP-TS201 processor, easmts -proc ADSP-TS202 processor, easmts -proc ADSP-TS203 processor, asmts -proc ADSP-TS203 processor</td>
</tr>
</tbody>
</table>
**-D__VISUALDSPVERSION__ Predefined Macro**

The macro applies to all Analog Devices processors.

The **-D__VISUALDSPVERSION__** predefined macro provides product version information to VisualDSP++. The macro allows a preprocessing check to be placed within code and is used to differentiate between VisualDSP++ releases and updates.

**Syntax:**

```
-D__VISUALDSPVERSION__=0xMMmmUUxx
```

Table 1-9 explains the macro parameters.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MM</td>
<td>VersionMajor. The major release number; for example, 4 in release 4.5.</td>
</tr>
<tr>
<td>mm</td>
<td>VersionMinor. The minor release number; for example, 5 in release 4.5.</td>
</tr>
<tr>
<td>UU</td>
<td>VersionPatch. The number of the release update; for example, 6 in release 4.5, update 6.</td>
</tr>
<tr>
<td>xx</td>
<td>Reserved for future use (always 00 initially)</td>
</tr>
</tbody>
</table>

The **0xMMmmUUxx** information is obtained from the `<install_path>\System\VisualDSP.ini` file. Initially, **xx** is set to “00”.

If an unexpected problem occurs while trying to locate VisualDSP.ini or while extracting information from the VisualDSP.ini file, the **__VISUALDSPVERSION__** macro is not encoded to the VisualDSP++ product version. In the Error Check example below, the **-D__VISUALDSPVERSION__ 0xffffffff** string is displayed as part of an error message when the version information is unable to be encoded.
Code Example (Legacy):

```c
#if !defined(__VISUALDSPVERSION__)
#warning Building with VisualDSP++ 4.5 Update 5 or prior. No __VISUALDSPVERSION__ available.
#endif
```

Code Example (VisualDSP++ 4.5 Update 6 or Later):

```c
#if __VISUALDSPVERSION__ >= 0x04050600
#warning Building with VisualDSP++ 4.5 Update 6 or later
#endif
```

Code Example (Error Check):

```c
#if __VISUALDSPVERSION__ == 0xffffffff
#error Unexpected build problems, unknown VisualDSP++ Version
#endif
```

Code Examples (Assembly):

```c
#if __VISUALDSPVERSION__ == 0x05000000
/* Building with VisualDSP++ 5.0 */
.VAR VersionBuildString[] = 'Building with VisualDSP++ 5.0';
#elif __VISUALDSPVERSION__ == 0x04050600
/* Building with VisualDSP++ 4.5, Update 6 */
.VAR VersionBuildString[] = 'Building with VisualDSP++ 4.5 Update 6';
#else /* Building with unknown VisualDSP++ version */
.VAR VersionBuildString[] = 'Building with unknown VisualDSP++ version?';
#endif
```
Generating Make Dependencies

The assembler can generate make dependencies for a file, allowing VisualDSP++ and other makefile-based build environments to determine when to rebuild an object file due to changes in the input files. The assembly source file and any files identified in the #include commands, .IMPORT directives, or buffer initializations (in .VAR and .STRUCT directives) constitute the make dependencies for an object file.

When you request make dependencies for the assembly, the assembler produces the dependencies from buffer initializations. The assembler also invokes the preprocessor to determine the make dependency from #include commands, and the compiler to determine the make dependencies from the .IMPORT headers.

For example,

easmblkfn -proc ADSP-BF533 -MM main.asm
  "main.doj": "/VisualDSP/Blackfin/include/defBF532.h"
  "main.doj": "/VisualDSP/Blackfin/include/defBF533.h"
  "main.doj": "/VisualDSP/Blackfin/include/def_LPBlackfin.h"
  "main.doj": "main.asm"
  "main.doj": "input_data.dat"

The original source file main.asm is as follows:

... 
#include "defBF533.h"
...

.GLOBAL input_frame;
.BYTE input_frame[N] = "input_data.dat"; /* load in 256 values from a test file */
...

In this case, defBF533.h includes defBF532.h, which also includes def_LPBlackfin.h.
Reading a Listing File

A listing file (`.lst`) is an optional output text file that lists the results of the assembly process. Listing files provide the following information:

- **Address** – The first column contains the offset from the `.SECTION`'s base address.
- **Opcode** – The second column contains the hexadecimal opcode that the assembler generates for the line of assembly source.
- **Line** – The third column contains the line number in the assembly source file.
- **Assembly Source** – The fourth column contains the assembly source line from the file.

The assembler listing file provides information about the imported C data structures. It tells which imports were used within the program, followed by a more detailed section. It shows the name, total size, and layout with offset for the members. The information appears at the end of the listing. You must specify the `-l filename` option (as described on page 1-162) to produce a listing file.

Enabling Statistical Profiling for Assembly Functions

Use the following steps to enable statistical profiling in assembler sources.

1. When using the VisualDSP++ IDDE, use the Assemble page of the Project Options dialog box (Figure 1-6 on page 1-174) to select and/or set assembler functional options.

2. Select the Generate debug information option.
3. Mark ending function boundaries with `.end` labels in the assembler source.

For example,

```
.SECTION program:
.GLOBAL funk1:
funk1:
    ...  
    RTS;
funk1.end:
.GLOBAL funk2:
funk2:
    ... 
    RTS;
funk2.end:
```

If you have global functions without ending labels, the assembler provides warnings when debug information is generated.

```
.GLOBAL funk3:
funk3:
    ...  
    RTS;
[Warning ea1121] "test.asm":14 funk3: -g assembly with global function without ending label. Use 'funk3.end' or 'funk3.END' to mark the ending boundary of the function for debugging information for automated statistical profiling of assembly functions.
```
4. Add ending labels or selectively disable the warning by adding the -Wsuppress 1121 option to the Additional options field on the Assembly page (refer to “WARNING ea1121: Missing End Labels” on page 1-160 for more information).

5. Choose Statistical Profiling -> New Profile or Linear Profiling -> New Profile, as appropriate. Assembler functions automatically appear in the profiling window along with C functions. Click on the function name to bring up the source containing the function definition.
Assembler Syntax Reference

When developing a source program in assembly language, include preprocessor commands and assembler directives to control the program’s processing and assembly. You must follow the assembler rules and syntax conventions to define symbols (identifiers) and expressions, and to use different numeric and comment formats.

Software developers who write assembly programs should be familiar with:

- “Assembler Keywords and Symbols” on page 1-42
- “Assembler Expressions” on page 1-54
- “Assembler Operators” on page 1-55
- “Numeric Formats” on page 1-60
- “Comment Conventions” on page 1-64
- “Conditional Assembly Directives” on page 1-64
- “C Struct Support in Assembly Built-In Functions” on page 1-67
- “Struct References” on page 1-68
- “Assembler Directives” on page 1-71
Assembler Keywords and Symbols

The assembler supports predefined keywords that include register and bitfield names, assembly instructions, and assembler directives. The following tables list assembler keywords for supported processors. Although the keywords appear in uppercase, the keywords are case insensitive in the assembler’s syntax. For example, the assembler does not differentiate between MAX and max.

Table 1-10 lists the assembler keywords for Blackfin processors. Table 1-11 on page 1-45 lists the keywords for SHARC processors. Table 1-12 on page 1-48 lists the keywords for TigerSHARC processors.

Table 1-10. Blackfin Processor Assembler Keywords

<table>
<thead>
<tr>
<th>.ALIGN</th>
<th>.ASCII</th>
<th>.ASM_ASSERT</th>
<th>.ASSERT</th>
<th>.BSS</th>
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<td>.BYTE2</td>
<td>.BYTE4</td>
<td>.DATA</td>
<td>.ELIF</td>
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<tr>
<td>.ELSE</td>
<td>.ENDIF</td>
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<td>.EXTERN</td>
</tr>
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<td>.FILE_ATTR</td>
<td>.GLOBAL</td>
<td>.GLOBL</td>
<td>.IF</td>
</tr>
<tr>
<td>.INC/BINARY</td>
<td>.INCBIN</td>
<td>.IMPORT</td>
<td>.LEFTMARGIN</td>
<td>.LIST</td>
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<td>.LIST_DEFTAB</td>
<td>.LIST_LOCTAB</td>
<td>.LIST_WRAPDATA</td>
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<td>.NOLIST_WRAPDATA</td>
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<td>.PAGEWIDTH</td>
<td>.PREVIOUS</td>
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<td>.SHORT</td>
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Table 1-10. Blackfin Processor Assembler Keywords (Cont’d)

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Table 1-10. Blackfin Processor Assembler Keywords (Cont’d)

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### Table 1-10. Blackfin Processor Assembler Keywords (Cont’d)

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<th><em>DATE</em></th>
<th><em>FILE</em></th>
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### Table 1-11. SHARC Processor Assembler Keywords

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<table>
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<th>.ELSE</th>
<th>.ENDIF</th>
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</thead>
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<td>SYSCONCL</td>
</tr>
<tr>
<td>SYSCTL</td>
<td>SYSTAT</td>
<td>SYSTATCL</td>
<td></td>
</tr>
<tr>
<td>Misc. Register Group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AUTODMA0</td>
<td>AUTODMA1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BTBCMD</td>
<td>BTBDATA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BTB0TG0 through BTB0TG31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BTB1TG0 through BTB1TG31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BTB2TG0 through BTB2TG31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BTB3TG0 through BTB3TG31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BTB0TR0 through BTB0TR31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BTB1TR0 through BTB1TR31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BTB2TR0 through BTB2TR31</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 1-12. TigerSHARC Processor Assembler Keywords (Cont’d)

<table>
<thead>
<tr>
<th>BTB3TR0 through BTB3TR31</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTBLRU0 through BTBLRU31</td>
</tr>
<tr>
<td>CACMD0 CACMD2 CACMD4 CACMD8 CACMD10</td>
</tr>
<tr>
<td>CACMDALL</td>
</tr>
<tr>
<td>CADATA0 CADATA2 CADATA4 CADATA8 CADATA10</td>
</tr>
<tr>
<td>CADATAALL</td>
</tr>
<tr>
<td>CASTAT0 CASTAT2 CASTAT4 CASTAT8 CASTAT10</td>
</tr>
<tr>
<td>CASTATALL</td>
</tr>
<tr>
<td>CCAIRO CCAIR2 CCAIR4 CCAIR8 CCAIR10</td>
</tr>
<tr>
<td>CCAIRALL</td>
</tr>
<tr>
<td>CCNT0 CCNT1 CJMP CMCTL</td>
</tr>
<tr>
<td>DC4 through DC13</td>
</tr>
<tr>
<td>DCD0 DCD1 DCD2 DCD3 DCNT</td>
</tr>
<tr>
<td>DCNTCL DCNTST</td>
</tr>
<tr>
<td>DC50 DC51 DC52 DC53</td>
</tr>
<tr>
<td>DSTAT DSTATC</td>
</tr>
<tr>
<td>EMUCTL EMUDAT EMUIR EMUSTAT</td>
</tr>
<tr>
<td>IDCODE ILATCLH ILATCLL ILATH ILATL</td>
</tr>
<tr>
<td>ILATSTH ILATSTL IMASKH IMASKL INSTAT</td>
</tr>
<tr>
<td>INTEN INTCIL IVBUSLK IVDBG IVHW</td>
</tr>
<tr>
<td>IVDMA0 through IVDMA13</td>
</tr>
<tr>
<td>IVIRQ0 IVIRQ1 IVIRQ2 IVIRQ3 IVLINK0</td>
</tr>
<tr>
<td>IVLINK1 IVLINK2 IVLINK3 IVSW IVTIMER0HP</td>
</tr>
<tr>
<td>IVTIMER0LP IVTIMER1HP IVTIMER1LP</td>
</tr>
<tr>
<td>LBUFRX0 LBUFRX1 LBUFRX2 LBUFRX3</td>
</tr>
<tr>
<td>LBUFTX0 LBUFTX1 LBUFTX2 LBUFTX3</td>
</tr>
<tr>
<td>LCD LC1 KB2 KB3</td>
</tr>
</tbody>
</table>
Table 1-12. TigerSHARC Processor Assembler Keywords (Cont’d)

<table>
<thead>
<tr>
<th>LCTL0</th>
<th>LCTL1</th>
<th>LCTL2</th>
<th>LCTL3</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRCTL0</td>
<td>LRCTL1</td>
<td>LRCTL2</td>
<td>LRCTL3</td>
</tr>
<tr>
<td>LRSTAT0</td>
<td>LRSTAT1</td>
<td>LRSTAT2</td>
<td>LRSTAT3</td>
</tr>
<tr>
<td>LRSTATC0</td>
<td>LRSTATC1</td>
<td>LRSTATC2</td>
<td>LRSTATC3</td>
</tr>
<tr>
<td>LSTAT0</td>
<td>LSTAT1</td>
<td>LSTAT2</td>
<td>LSTAT3</td>
</tr>
<tr>
<td>LSTATC0</td>
<td>LSTATC1</td>
<td>LSTATC2</td>
<td>LSTATC3</td>
</tr>
<tr>
<td>LTCTL0</td>
<td>LTCTL1</td>
<td>LTCTL2</td>
<td>LTCTL3</td>
</tr>
<tr>
<td>LTSTAT0</td>
<td>LTSTAT1</td>
<td>LTSTAT2</td>
<td>LTSTAT3</td>
</tr>
<tr>
<td>LTSTATC0</td>
<td>LTSTATC1</td>
<td>LTSTATC2</td>
<td>LTSTATC3</td>
</tr>
<tr>
<td>MISR0</td>
<td>MISR1</td>
<td>MISR2</td>
<td>MISRCTL</td>
</tr>
<tr>
<td>RETI</td>
<td>RETIB</td>
<td>RETS</td>
<td>RTI</td>
</tr>
<tr>
<td>OSPID</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PMASKH</td>
<td>PMASKL</td>
<td>PRFM</td>
<td>PRFCNT</td>
</tr>
<tr>
<td>SERIAL_H</td>
<td>SERIAL_L</td>
<td>SFREG</td>
<td>SQCTL</td>
</tr>
<tr>
<td>SQCTLCL</td>
<td>SQSTAT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TESTMODES</td>
<td>TIMER0L</td>
<td>TIMER1L</td>
<td>TIMEROH</td>
</tr>
<tr>
<td>TMRIN0L</td>
<td>TMRIN0H</td>
<td>TMRIN1L</td>
<td>TMRIN1H</td>
</tr>
<tr>
<td>TRCBMASK</td>
<td>TRCBPTR</td>
<td>TRCBVAL</td>
<td></td>
</tr>
<tr>
<td>VIRTPT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WP0CTL</td>
<td>WP1CTL</td>
<td>WP2CTL</td>
<td>WP0STAT</td>
</tr>
<tr>
<td>WP2STAT</td>
<td>W0H</td>
<td>W0L</td>
<td>W1H</td>
</tr>
<tr>
<td>W2H</td>
<td>W2L</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Conditions which may be prefixed with X, Y, XY, NX, NY, and XY

<table>
<thead>
<tr>
<th>AEQ</th>
<th>ALE</th>
<th>ALT</th>
<th>MEQ</th>
<th>MLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLT</td>
<td>SEQ</td>
<td>SF1</td>
<td>SF0</td>
<td>SLT</td>
</tr>
</tbody>
</table>

Conditions which may be prefixed with J, K, NJ, and NK

| EQ | LE | LT | CBQ | CB1 |
Extend these sets of keywords with symbols that declare sections, variables, constants, and address labels. When defining symbols in assembly source code, follow these conventions:

- Define symbols that are unique within the file in which they are declared.

  If you use a symbol in more than one file, use the .GLOBAL assembly directive to export the symbol from the file in which it is defined. Then use the .EXTERN assembly directive to import the symbol into other files.

- Begin symbols with alphabetic characters.

  Symbols can use alphabetic characters (A–Z and a–z), digits (0–9), and the special characters “$” and “_” (dollar sign and underscore) as well as “.” (dot).

  Symbols are case sensitive; so INPUT_ADDR and INPUT_ADDR define unique variables.

  The dot, point, or period “.” as the first character of a symbol triggers special behavior in the VisualDSP++ environment. A symbol with a “.” as the first character cannot have a digit as the second character. Such symbols will not appear in the symbol table, which is accessible in the debugger. A symbol name in which the first two characters are dots will not appear even in the symbol table of the object.
Assembler Syntax Reference

The compiler and run-time libraries prepend “_” to avoid using symbols in the user namespace that begin with an alphabetic character.

- Do not use a reserved keyword to define a symbol.
- Match source and LDF sections’ symbols.

Ensure that .SECTION name symbols do not conflict with the linker’s keywords in the .ldf file. The linker uses sections’ name symbols to place code and data in the processor’s memory. For details, see the VisualDSP++ 5.0 Linker and Utilities Manual.

Ensure that .SECTION name symbols do not begin with the “.” (dot).
- Terminate the definition of address label symbols with a colon (:).
- The reserved word list for processors includes some keywords with commonly used spellings; therefore, ensure correct syntax spelling.

Address label symbols may appear at the beginning of an instruction line or stand-alone on the preceding line.

The following disassociated lines of code demonstrate symbol usage.

```
.BYTE2 xoperand; /* xoperand is a 16-bit variable */
.BYTE4 input_array[10]; /* input_array is a 32-bit wide */
    /* data buffer with 10 elements */
sub_routine_1: /* sub_routine_1 is a label */
.SECTION kernel; /* kernel is a section name */
```

Assembler Expressions

The assembler can evaluate simple expressions in source code. The assembler supports two types of expressions: constant expressions and symbolic expressions.
Constant Expressions

A constant expression is acceptable where a numeric value is expected in an assembly instruction or in a preprocessor command. Constant expressions contain an arithmetic or logical operation on two or more numeric constants. For example,

\[
2.9e-5 + 1.29 \\
(128 \times 48) / 3 \\
0x55\& \\
0x0f7.6r - 0.8r
\]

For information about fraction type support, refer to “Fractional Type Support” on page 1-61.

Symbolic Expressions

Symbolic expressions contain symbols, whose values may not be known until link-time. For example,

\[
\text{data}/8 \\
(data\_buffer1 + data\_buffer2) \& 0xF \\
\text{startup} + 2 \\
data\_buffer1 + \text{LENGTH}(data\_buffer2)\times 2
\]

Symbols in this type of expression are data variables, data buffers, and program labels. In the first three examples above, the symbol name represents the address of the symbol. The fourth example combines that meaning of a symbol with a use of the length operator (see Table 1-14).

Assembler Operators

Table 1-13 lists the assembler’s numeric and bitwise operators used in constant expressions and address expressions. These operators are listed in group order from highest precedence to lowest precedence. Operators with the highest precedence are evaluated first. When two operators have the same precedence, the assembler evaluates the left-most operator first.
Relational operators are supported only in relational expressions in conditional assembly, as described in “Conditional Assembly Directives” on page 1-64.

Table 1-13. Operator Precedence

<table>
<thead>
<tr>
<th>Operator</th>
<th>Usage Description</th>
<th>Designation</th>
<th>Processors</th>
</tr>
</thead>
<tbody>
<tr>
<td>(expression)</td>
<td>expression in parentheses evaluates first</td>
<td>Parentheses</td>
<td>All</td>
</tr>
<tr>
<td>~</td>
<td>Ones complement</td>
<td>Tilde</td>
<td>All</td>
</tr>
<tr>
<td>-</td>
<td>Unary minus</td>
<td>Minus</td>
<td>All</td>
</tr>
<tr>
<td>* / %</td>
<td>Multiply</td>
<td>Asterisk Slash Percentage</td>
<td>All</td>
</tr>
<tr>
<td>+ -</td>
<td>Addition Subtraction</td>
<td>Plus Minus</td>
<td>All</td>
</tr>
<tr>
<td>&lt;&lt; &gt;&gt;</td>
<td>Shift left Shift right</td>
<td></td>
<td>All</td>
</tr>
<tr>
<td>&amp;</td>
<td>Bitwise AND</td>
<td></td>
<td>All</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bitwise inclusive OR</td>
<td></td>
</tr>
<tr>
<td>^</td>
<td>Bitwise exclusive OR</td>
<td></td>
<td>TigerSHARC and SHARC</td>
</tr>
<tr>
<td>&amp;&amp;</td>
<td>Logical AND</td>
<td></td>
<td>TigerSHARC only</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Logical OR</td>
</tr>
</tbody>
</table>

If right-shifting a negative value, ones are shifted in from the MSB, which preserves the sign bit.
The assembler also supports special operators. Table 1-14 lists and describes special operators used in constant and address expressions.

Table 1-14. Special Assembler Operators

<table>
<thead>
<tr>
<th>Operator</th>
<th>Usage Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADDRESS(symbol)</td>
<td>Address of symbol</td>
</tr>
<tr>
<td>BITPOS(constant)</td>
<td>Bit position (Blackfin processors only)</td>
</tr>
<tr>
<td>HI(expression)</td>
<td>Extracts the most significant 16 bits of expression.</td>
</tr>
<tr>
<td>LO(expression)</td>
<td>Extracts the least significant 16 bits of expression.</td>
</tr>
<tr>
<td>LENGTH(symbol)</td>
<td>Length of symbol in number of elements (in a buffer/array)</td>
</tr>
</tbody>
</table>

The ADDRESS and LENGTH operators can be used with external symbols—apply them to symbols that are defined in other sections as .GLOBAL symbols.

Blackfin Processor Example:

The following example demonstrates how Blackfin assembler operators are used to load the length and address information into registers.

```c
#define n 20
...
.SECTION data1; /* data section */
.VAR real_data [n]; /* n=number of input sampless */

.SECTION program; /* code section */
P0.L = real_data;
P0.H = real_data;
P1=LENGTH(real_data); /* buffer's length */
LOOP loop1 LCO=P1;
```

The code fragment above initializes P0 and P1 to the base address and length, respectively, of the real_data buffer. The loop is executed 20 times.

The BITPOS() operator takes a bit constant (with one bit set) and returns the position of the bit. Therefore, BITPOS(0x10) would return 4 and BITPOS(0x80) would return 7. For example,

```assembly
#define DLAB 0x80
#define EPS 0x10
R0 = DLAB | EPS (z);
cc = BITSET (R0, BITPOS(DLAB));
```

**TigerSHARC Processor Example:**

The following example demonstrates how assembler operators are used to load the length and address information into registers (when setting up circular buffers in TigerSHARC processors).

```assembly
.SECTION data1: /* Data segment */
.VAR real_data[n]; /* n = number of input samples */
...
.SECTION program: /* Code segment */
/* Load the base address of */
/* the circular buffer */
JB3 = real_data::
    /* Load the index */
J3=real_data::
    /* Load the circular buffer length */
JL3 = LENGTH(real_data)::
    /* Set loop counter 0 with buffer length */
LCO = JL3::
```
start:
XR0 = CB [J3 += 1]:; /* Read data from the circular buffer */
if NLCOE, jump start;;

The code fragment above initializes JB3 and JL3 to the base address and length, respectively, of the real_data circular buffer. The buffer length value contained in JL3 determines when addressing wraps around the top of the buffer. For further information on circular buffers, refer to the Hardware Reference of the target processor.

SHARC Processor Example:

The following code example determines the base address and length of the real_data circular buffer. The buffer’s length value (contained in L5) determines when addressing wraps around to the top of the buffer (when setting up circular buffers in SHARC processors). For further information on circular buffers, refer to the Hardware Reference of the target processor.

.SECTION/DM seg_dmda; /* data segment */
.VAR real_data[n]; /* n=number of input samples */
...

.SECTION/PM seg_pmco; /* code segment */
  B5=real_data; /* buffer base address */
  /* I5 loads automatically */
  L5=length(real_data); /* buffer’s length */
  M6=1; /* post-modify I5 by 1 */
  LCNTR=length(real_data)
  ,DO loopend UNTIL LCE;
  /* loop counter=buffer’s length */
  FO=DM(I5,M6); /* get next sample */
...
loopend:
...
Although the SHARC assembler accepts the source code written with the legacy @ operator, it is recommended to use LENGTH() in place of @.

**Numeric Formats**

Depending on the processor architectures, the assemblers support binary, decimal, hexadecimal, floating-point, and fractional numeric formats (bases) within expressions and assembly instructions. Table 1-15 describes the notation conventions used by the assembler to distinguish between numeric formats.

Table 1-15. Numeric Formats

<table>
<thead>
<tr>
<th>Convention</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x[number]</td>
<td>The “0x” prefix indicates a hexadecimal number</td>
</tr>
<tr>
<td>b#number</td>
<td>The “b#” prefix indicates a binary number</td>
</tr>
<tr>
<td>B#number</td>
<td>The “B#” prefix indicates a binary number</td>
</tr>
<tr>
<td>number.number[e{+/-}number]</td>
<td>Entry for floating-point number</td>
</tr>
<tr>
<td>number</td>
<td>No prefix and no decimal point indicates a decimal number</td>
</tr>
<tr>
<td>number:r</td>
<td>The “r” suffix indicates a fractional number</td>
</tr>
</tbody>
</table>

Due to the support for b# and B# binary notation, the preprocessor stringization functionality is turned off, by default, to avoid possible undesired stringization. For more information, refer to the processor’s # (Argument), -stringize, and the assembler’s -flags-pp -opt1 [-opt2...] command-line switches.

**Representation of Constants in Blackfin**

The Blackfin assembler keeps an internal 32-bit signed representation of all constant values. Keep this in mind when working with immediate values. The immediate value is used by the assembler to determine the
instruction length (16 or 32 bit). The assembler selects the smallest opcode that can accommodate the immediate value.

If there is no opcode that can accommodate the value, semantic error ea5003 is reported.

**Examples:**

R0 = -64; /* 16-bit instruction: -64 fits into 7-bit immediate value */
R0 = 0xBF; /* 32-bit instruction: 191 fits into 16-bit immediate value */
R0 = 0xFFBF; /* ERROR: 65471 doesn't fit into 7 or 16-bit immediate values */
R0 = 0xFFFFBF; /* 32-bit instruction: -65 fits into 16-bit immediate value */
R0 = 0x8000; /* ERROR: 32768 doesn't fit into 7 or 16-bit immediate values */

**Fractional Type Support**

Fractional (fract) constants are specially marked floating-point constants to be represented in fixed-point format. A fract constant uses the floating-point representation with a trailing “r”, where r stands for fract.

The legal range is [-1..1). This means the values must be greater than or equal to -1 and less than 1. Fracts are represented as signed values.

For example,

```
.VAR myFracts[] = {0.5r, -0.5e-4r, -0.25e-3r, 0.875r};
/* Constants are examples of legal fracts */

.VAR OutOfRangeFract = 1.5r;
/* [Error …] Fract constant '1.5r' is out of range. Fract constants must be greater than or equal to -1 and less than 1. */
```
In Blackfin processors, fract 1.15 is a default. Use a /R32 qualifier (in .BYTE4/R32 or .VAR/R32) to support 32-bit initialization for use with 1.31 fracts.

1.31 Fracts

Fracts supported by Analog Devices processors use 1.31 format, which means a sign bit and “31 bits of fraction”. This is \(-1\) to \(+1\cdot2^{31}\). For example, 1.31 maps the constant 0.5r to \(2^{31}\).

The conversion formula used by processors to convert from floating-point format to fixed-point format uses a scale factor of 31.

For example,

```assembly
.VAR/R32 myFract = 0.5r;
   // Fract output for 0.5r is 0x4000 0000
   // sign bit + 31 bits
   // 0100 0000 0000 0000 0000 0000 0000 0000
   // 4 0 0 0 0 0 0 0 = 0x4000 0000 = 0.5r

.VAR/R32 myFract = -1.0r;
   // Fract output for -1.0r is 0x8000 0000
   // sign bit + 31 bits
   // 1000 0000 0000 0000 0000 0000 0000 0000
   // 8 0 0 0 0 0 0 0 = 0x8000 0000 = -1.0r

.VAR/R32 myFract = -1.72471041E-03r;
   // Fract output for -1.72471041E-03 is 0xFFC77C15
   // sign bit + 31 bits
   // 1111 1111 1100 0111 0111 1100 0001 0101
   // F F C 7 7 C 1 5
```

1-62 VisualDSP++ 5.0 Assembler and Preprocessor Manual
1.0r Special Case

1.0r is out-of-the-range fract. Specify 0x7FFF FFFF for the closest approximation of 1.0r within the 1.31 representation.

Fractional Arithmetic

The assembler provides support for arithmetic expressions using operations on fractional constants, consistent with the support for other numeric types in constant expressions, as described in “Assembler Expressions” on page 1-54.

The internal (intermediate) representation for expression evaluation is a double floating-point value. Fract range checking is deferred until the expression is evaluated. For example,

```
#define fromSomewhereElse 0.875r
.SECTION data1;
.VAR localOne = fromSomewhereElse + 0.005r;
    // Result .88r is within the legal range
.VAR xyz = 1.5r -0.9r;
    // Result .6r is within the legal range
.VAR abc = 1.5r;    // Error: 1.5r out of range
```

Mixed Type Arithmetic

The assembler does not support arithmetic between fracts and integers. For example,

```
.SECTION data1;
.VAR myFract = 1 - 0.5r;
```
Comment Conventions

The assemblers support C and C++ style formats for inserting comments in assembly sources. The assemblers do not support nested comments. Table 1-16 lists and describes assembler comment conventions.

Table 1-16. Comment Conventions

<table>
<thead>
<tr>
<th>Convention</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>/* comment */</td>
<td>A &quot;/* */&quot; string encloses a multiple-line comment</td>
</tr>
<tr>
<td>// comment</td>
<td>A pair of slashes &quot;//&quot; begin a single-line comment</td>
</tr>
</tbody>
</table>

Conditional Assembly Directives

Conditional assembly directives are used for evaluation of assembly-time constants using relational expressions. The expressions may include relational and logical operations. In addition to integer arithmetic, the operands may be the C structs in the SIZEOF() and OFFSETOF() assembly built-in functions that return integers.

The conditional assembly directives include:

- .IF constant-relational-expression;
- .ELIF constant-relational-expression;
- .ELSE;
- .ENDIF:
Conditional assembly blocks begin with an .IF directive and end with an .ENDIF directive. Table 1-17 shows examples of conditional directives.

Table 1-17. Relational Operators for Conditional Assembly

<table>
<thead>
<tr>
<th>Operator</th>
<th>Purpose</th>
<th>Conditional Directive Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>!</td>
<td>Not</td>
<td>.IF !0;</td>
</tr>
<tr>
<td>&gt;</td>
<td>Greater than</td>
<td>.IF ( SIZEOF(myStruct) &gt; 16 );</td>
</tr>
<tr>
<td>&gt;=</td>
<td>Greater than or equal to</td>
<td>.IF ( SIZEOF(myStruct) &gt;= 16 );</td>
</tr>
<tr>
<td>&lt;</td>
<td>Less than</td>
<td>.IF ( SIZEOF(myStruct) &lt; 16 );</td>
</tr>
<tr>
<td>&lt;=</td>
<td>Less than or equal to</td>
<td>.IF ( SIZEOF(myStruct) &lt;= 16 );</td>
</tr>
<tr>
<td>==</td>
<td>Equality</td>
<td>.IF ( 8 == SIZEOF(myStruct) );</td>
</tr>
<tr>
<td>!=</td>
<td>Not equal</td>
<td>.IF ( 8 != SIZEOF(myStruct) );</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&amp;&amp;</td>
<td>Logical AND</td>
<td>.IF (SIZEOF(char) == 2 &amp;&amp; SIZEOF(int) == 4);</td>
</tr>
</tbody>
</table>

Optionally, any number of .ELIF and .ELSE directive pairs may appear within a pair of .IF and .ENDIF directives. The conditional directives are each terminated with a semi-colon “;”, just like all existing assembler directives. Conditional directives do not have to appear alone on a line. These directives are in addition to the C-style #if, #elif, #else, and #endif preprocessing directives.

The .IF, .ELSE, .ELIF, and .ENDIF directives (in any case) are reserved keywords.

The .IF conditional assembly directive must be used to query about C structs in assembly using the SIZEOF() and/or OFFSETOF() built-in functions. These built-ins are evaluated at assembly time, so they cannot appear in expressions in #if preprocessor directives.

In addition, the SIZEOF() and OFFSETOF() built-in functions (see “C Struct Support in Assembly Built-In Functions” on page 1-67) can be...
used in relational expressions. Different code sequences can be included based on the result of the expression.

For example, \texttt{SIZEOF(struct/typedef/C\_base\_type)} is permitted.

The assembler supports nested conditional directives. The outer conditional result propagates to the inner condition, just as it does in C preprocessing.

Assembler directives are distinct from preprocessor directives, as follows:

- The \# directives are evaluated during preprocessing by the preprocessor. Therefore, preprocessor \#if directives cannot use assembler built-ins (see “C Struct Support in Assembly Built-In Functions” on page 1-67).

- The conditional assembly directives are processed by the assembler in a later pass. Therefore, you are able to write a relational or logical expression whose value depends on the value of a \#define. For example,

  \begin{verbatim}
  .IF tryit == 2:
      <some code>
  .ELIF tryit >= 3:
      <some more code>
  .ELSE:
      <some more code>
  .ENDIF:
  \end{verbatim}

  If you have “\#define tryit 2”, the code \texttt{<some code>} is assembled, and \texttt{<some more code>} is not assembled.

- There are no parallel assembler directives for C-style directives \#define, \#include, \#ifdef, \#if defined(name), \#ifndef, and so on.
C Struct Support in Assembly Built-In Functions

The assemblers support built-in functions that enable you to pass information obtained from the imported C struct layouts. The assemblers currently support two built-in functions: OFFSETOF() and SIZEOF().

OFFSETOF Built-In Function

The OFFSETOF() built-in function is used to calculate the offset of a specified member from the beginning of its parent data structure.

OFFSETOF(struct/typedef,memberName);

where:

struct/typedef – a struct VAR or a typedef can be supplied as the first argument

memberName – a member name within the struct or typedef (second argument)

For SHARC and TigerSHARC processors, OFFSETOF() units are in words. For Blackfin processors, OFFSETOF() units are in bytes.

SIZEOF Built-In Function

The SIZEOF() built-in function returns the amount of storage associated with an imported C struct or data member. It provides functionality similar to its C counterpart.

SIZEOF(struct/typedef/C_base_type);

where:

The SIZEOF() function takes a symbolic reference as its single argument. A symbolic reference is a name followed by none or several qualifiers to members.
The **SIZEOF()** function gives the amount of storage associated with:

- An aggregate type (structure)
- A C base type (int, char, and so on)
- A member of a structure (any type)

For example (Blackfin processor code):

```
.IMPORT "Celebrity.h";
.EXTERN STRUCT Celebrity StNick;
L3 = SIZEOF(Celebrity); // typedef
L3 = SIZEOF(StNick); // struct var of typedef
Celebrity
L3 = SIZEOF(char); // C built-in type
L3 = SIZEOF(StNick->Town); // member of a struct var
L3 = SIZEOF(Celebrity->Town); // member of a struct typedef
```

The **SIZEOF()** built-in function returns the size in the units appropriate for its processor. For SHARC and TigerSHARC processors, units are in words. For Blackfin processors, units are in bytes.

When applied to a structure type or variable, **SIZEOF()** returns the actual size, which may include padding bytes inserted for alignment. When applied to a statically dimensioned array, **SIZEOF()** returns the size of the entire array.

**Struct References**

A reference to a **struct VAR** provides an absolute address. For a fully qualified reference to a member, the address is offset to the correct location within the struct. The assembler syntax for **struct** references is “->”.

The following example references the address of **Member5** located within **myStruct**.
myStruct->Member5

If the struct layout changes, there is no need to change the reference. The assembler recalculates the offset when the source is reassembled with the updated header.

Nested struct references are supported. For example,

myStruct->nestedRef->AnotherMember

Unlike struct members in C, struct members in the assembler are always referenced with “->” (not “.”) because “.” is a legal character in identifiers in assembly and is not available as a struct reference.

References within nested structures are permitted. A nested struct definition can be provided in a single reference in assembly code, and a nested struct via a pointer type requires more than one instruction. Use the OFFSETOF() built-in function to avoid hard-coded offsets that may become invalid if the struct layout changes in the future.

Following are two nested struct examples for .IMPORT "CHeaderFile.h".

Example 1:
Nested Reference Within the Struct Definition with Appropriate C Declarations

C Code

```c
struct Location {  
  char Town[16];  
  char State[16];  
};

struct myStructTag {  
  int field1;
  struct Location NestedOne;  
};
```
Assembly Code (for Blackfin Processors)

.EXTERN STRUCT myStructTag _myStruct;
P3.L = LO(_myStruct->NestedOne->State);
P3.H = HI(_myStruct->NestedOne->State);

Example 2:
Nested Reference When Nested via a Pointer with
Appropriate C Declarations

When nested via a pointer, myStructTagWithPtr (which has pNestedOne) uses pointer register offset instructions.

C Code:

// from C header
struct Location {
    char Town[16];
    char State[16];
};

struct myStructTagWithPtr {
    int field1;
    struct Location *pNestedOne;
};

Assembly Code (for Blackfin Processors):

// in assembly file
.EXTERN STRUCT myStructTagWithPtr _myStructWithPtr;
P1.L = LO(_myStructWithPtr->pNestedOne);
P1.H = HI(_myStructWithPtr->pNestedOne);
P0 = [P1 + OFFSETOF(Location,State)];
Assembler Directives

Directives in an assembly source file control the assembly process. Unlike assembly instructions, directives do not produce opcodes during assembly. Use the following general syntax for assembler directives

```
.directive [/qualifiers | arguments];
```

Each assembler directive starts with a period (.) and ends with a semicolon (;). Some directives take qualifiers and arguments. A directive’s qualifier immediately follows the directive and is separated by a slash (/); arguments follow qualifiers. Assembler directives can be uppercase or lowercase; uppercase distinguishes directives from other symbols in your source code.

Table 1-18 lists all currently supported assembler directives. A description of each directive appears in the following sections. These directives were added for GNU compatibility.

Table 1-18. Assembler Directive Summary

<table>
<thead>
<tr>
<th>Directive</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>.ALIGN</td>
<td>(on page 1-76) Specifies an alignment requirement for data or code</td>
</tr>
<tr>
<td>.ALIGN_CODE</td>
<td>(on page 1-78) Specifies an alignment requirement for code. Note: TigerSHARC processors only.</td>
</tr>
<tr>
<td>.ASCII</td>
<td>(on page 1-80) Initializes ASCII strings. Note: Blackfin processors only.</td>
</tr>
<tr>
<td>.BSS</td>
<td>Equivalent to .SECTION/zero_init bsz; Refer to &quot; SECTION, Declare a Memory Section&quot; on page 1-125. Note: Blackfin processors only.</td>
</tr>
<tr>
<td>.BYTE</td>
<td>(on page 1-81) Defines and initializes one-, two-, and four-byte data objects, respectively. Note: Blackfin processors only.</td>
</tr>
<tr>
<td>.BYTE2</td>
<td></td>
</tr>
<tr>
<td>.BYTE4</td>
<td></td>
</tr>
<tr>
<td>.COMPRESS</td>
<td>(on page 1-85) Starts compression. Note: ADSP-2146x SHARC processors only.</td>
</tr>
</tbody>
</table>
### Table 1-18. Assembler Directive Summary (Cont'd)

<table>
<thead>
<tr>
<th>Directive</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>.DATA</td>
<td>Equivalent to .SECTION data1; Refer to &quot; SECTION, Declare a Memory Section&quot; on page 1-125. Note: Blackfin processors only.</td>
</tr>
<tr>
<td>.ELSE (on page 1-64)</td>
<td>Conditional assembly directive</td>
</tr>
<tr>
<td>.ENDIF (on page 1-64)</td>
<td>Conditional assembly directive</td>
</tr>
<tr>
<td>.ENDSEG (on page 1-131)</td>
<td>Legacy directive. Marks the end of a section. Used with legacy directive .SEGMENT that begins a section. Note: SHARC processors only.</td>
</tr>
<tr>
<td>.EXTERN (on page 1-85)</td>
<td>Allows reference to a global symbol</td>
</tr>
<tr>
<td>.EXTERN STRUCT (on page 1-87)</td>
<td>Allows reference to a global symbol (struct) that was defined in another file</td>
</tr>
<tr>
<td>.FILE (on page 1-89)</td>
<td>Overrides filename given on the command line; used by C compiler</td>
</tr>
<tr>
<td>.FILE_ATTR (on page 1-90)</td>
<td>Creates a attribute in the generated object file</td>
</tr>
<tr>
<td>.FORCECOMPRESS (on page 1-90)</td>
<td>Compresses the next instruction. Note: ADSP-2146x SHARC processors only.</td>
</tr>
<tr>
<td>.GLOBAL (on page 1-92)</td>
<td>Changes a symbol's scope from local to global</td>
</tr>
<tr>
<td>.GLOBL (on page 1-92)</td>
<td>Equivalent to .GLOBAL. Note: Blackfin processors only.</td>
</tr>
<tr>
<td>.IF (on page 1-64)</td>
<td>Conditional assembly directive</td>
</tr>
<tr>
<td>.IMPORT (on page 1-94)</td>
<td>Provides the assembler with the structure layout (C struct) information</td>
</tr>
<tr>
<td>.INC/BINARY (on page 1-96)</td>
<td>Includes the content of file at the current location</td>
</tr>
</tbody>
</table>
### Table 1-18. Assembler Directive Summary (Cont’d)

<table>
<thead>
<tr>
<th>Directive</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>.INCBIN</td>
<td>Equivalent to .INC/BINARY. Refer to “.INC/BINARY, Include Contents of a File” on page 1-96. Note: Blackfin processors only.</td>
</tr>
<tr>
<td>.LEFTMARGIN</td>
<td>Defines the width of the left margin of a listing</td>
</tr>
<tr>
<td>.LIST/.NOLIST</td>
<td>Starts listing of source lines</td>
</tr>
<tr>
<td>.LIST_DATA</td>
<td>Starts listing of data opcodes</td>
</tr>
<tr>
<td>.LIST_DATFILE</td>
<td>Starts listing of data initialization files</td>
</tr>
<tr>
<td>.LIST_DEFTAB</td>
<td>Sets the default tab width for listings</td>
</tr>
<tr>
<td>.LIST_LOCTAB</td>
<td>Sets the local tab width for listings</td>
</tr>
<tr>
<td>.LIST_WRAPDATA</td>
<td>Starts wrapping opcodes that don’t fit listing column</td>
</tr>
<tr>
<td>.LONG</td>
<td>Supports four-byte data initializer lists for GNU compatibility. Note: Blackfin processors only.</td>
</tr>
<tr>
<td>.MESSAGE</td>
<td>Alters the severity of an error, warning or informational message generated by the assembler</td>
</tr>
<tr>
<td>.NEWPAGE</td>
<td>Inserts a page break in a listing</td>
</tr>
<tr>
<td>.NOCOMPRESS</td>
<td>Terminates compression. Note: ADSP-2146x SHARC processors only.</td>
</tr>
<tr>
<td>.NOLIST</td>
<td>Stops listing of source lines</td>
</tr>
<tr>
<td>.NOLIST_DATA</td>
<td>Stops listing of data opcodes</td>
</tr>
<tr>
<td>.NOLIST_DATFILE</td>
<td>Stops listing of data initialization files</td>
</tr>
</tbody>
</table>
Table 1-18. Assembler Directive Summary (Cont'd)

<table>
<thead>
<tr>
<th>Directive</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>.NOLIST_WRAPDATA</td>
<td>Stops wrapping opcodes that do not fit listing column</td>
</tr>
<tr>
<td>(on page 1-103)</td>
<td></td>
</tr>
<tr>
<td>.PAGELENGTH</td>
<td>Defines the length of a listing page</td>
</tr>
<tr>
<td>(on page 1-111)</td>
<td></td>
</tr>
<tr>
<td>.PAGEWIDTH</td>
<td>Defines the width of a listing page</td>
</tr>
<tr>
<td>(on page 1-112)</td>
<td></td>
</tr>
<tr>
<td>.PORT</td>
<td>Legacy directive. Declares a memory-mapped I/O port.</td>
</tr>
<tr>
<td>(on page 1-114)</td>
<td>Note: SHARC processors only.</td>
</tr>
<tr>
<td>.PRECISION</td>
<td>Defines the number of significant bits in a floating-point value.</td>
</tr>
<tr>
<td>(on page 1-115)</td>
<td>Note: SHARC processors only.</td>
</tr>
<tr>
<td>.PREVIOUS</td>
<td>Reverts to a previously described .SECTION</td>
</tr>
<tr>
<td>(on page 1-117)</td>
<td></td>
</tr>
<tr>
<td>.PRIORITY</td>
<td>Allows prioritized symbol mapping in the linker</td>
</tr>
<tr>
<td>(on page 1-118)</td>
<td></td>
</tr>
<tr>
<td>.REFERENCE</td>
<td>Provides better information in an X-REF file.</td>
</tr>
<tr>
<td>(on page 1-121)</td>
<td>Note: Blackfin processors only.</td>
</tr>
<tr>
<td>.RETAIN_NAME</td>
<td>Stops the linker from eliminating a symbol</td>
</tr>
<tr>
<td>(on page 1-121)</td>
<td></td>
</tr>
<tr>
<td>.ROUND_NEAREST</td>
<td>Specifies the Round-to-Nearest mode.</td>
</tr>
<tr>
<td>(on page 1-122)</td>
<td>Note: SHARC processors only.</td>
</tr>
<tr>
<td>.ROUND_MINUS</td>
<td>Specifies the Round-to-Negative Infinity mode.</td>
</tr>
<tr>
<td>(on page 1-122)</td>
<td>Note: SHARC processors only.</td>
</tr>
<tr>
<td>.ROUND_PLUS</td>
<td>Specifies the Round-to-Positive Infinity mode.</td>
</tr>
<tr>
<td>(on page 1-122)</td>
<td>Note: SHARC processors only.</td>
</tr>
<tr>
<td>.ROUND_ZERO</td>
<td>Specifies the Round-to-Zero mode.</td>
</tr>
<tr>
<td>(on page 1-122)</td>
<td>Note: SHARC processors only.</td>
</tr>
<tr>
<td>.SECTION</td>
<td>Marks the beginning of a section</td>
</tr>
<tr>
<td>(on page 1-125)</td>
<td></td>
</tr>
<tr>
<td>.SEGMENT</td>
<td>Legacy directive. Replaced with the .SECTION directive.</td>
</tr>
<tr>
<td>(on page 1-131)</td>
<td>Note: SHARC processors only.</td>
</tr>
</tbody>
</table>
### Table 1-18. Assembler Directive Summary (Cont’d)

<table>
<thead>
<tr>
<th>Directive</th>
<th>Description</th>
</tr>
</thead>
</table>
| **.SEPARATE_MEM_SEGMENTS**  
(on page 1-131) | Specifies that two buffers should be placed into different memory segments by the linker.  
**Note:** TigerSHARC processors only. |
| **.SET**  
(on page 1-132) | Sets symbolic aliases |
| **.SHORT**  
(on page 1-132) | Supports two-byte data initializer lists for GNU compatibility.  
**Note:** Blackfin processors only. |
| **.STRUCT**  
(on page 1-133) | Defines and initializes data objects based on C typedefs from **.IMPORT** C header files |
| **.TEXT** | Equivalent to **.SECTION** program:  
Refer to “**.SECTION, Declare a Memory Section**” on page 1-125.  
**Note:** Blackfin processors only. |
| **.TYPE**  
(on page 1-137) | Changes the default data type of a symbol; used by C compiler |
| **.VAR**  
(on page 1-138) | Defines and initializes 32-bit data objects |
| **.WEAK**  
(on page 1-143) | Creates a weak definition or reference |
.ALIGN, Specify an Address Alignment

The .ALIGN directive forces the address alignment of an instruction or data item. The assembler sets the alignment of the section to match the largest alignment requirement specified in the section and inserts padding at each alignment location to ensure that the following item has the proper offset from the start of the section to maintain the requested alignment. The linker honors the alignment specified by the assembler when placing the section in memory, thus guaranteeing the integrity of the alignment of each element aligned with a .ALIGN directive.

You also can use the INPUT_SECTION_ALIGN(#number) LDF command (in the .ldf file) to force all the following input sections to the specified alignment. Refer to the VisualDSP++ 5.0 Linker and Utilities Manual for more information on section alignment.

Syntax:

.ALIGN expression;

where

expression – evaluates to an integer. It specifies an alignment requirement; its value must be a power of 2. When aligning a data item or instruction, the assembler adjusts the address of the current location counter to the next address that can be divided by the value of expression, with no remainder. The expression set to 0 or 1 signifies no address alignment requirement.

The linker stops allocating padding for symbols aligned by 16 or more.

In the absence of the .ALIGN directive, the default address alignment is 1.

Example:
In the following example, the assembler sets the alignment of the section to 4 to match the value specified in the second alignment directive. This satisfies the first alignment directive as well, since any item alignment on an address multiple of 4 is also aligned on a multiple of 2. If the target is a byte-addressed processor, such as Blackfin, there is no padding inserted between “single” and “samples” since .VAR creates a four-byte word of storage. If the target is a processor on which the .VAR directive reserves a one-address unit, such as SHARC, three words of padding follow “single” in the section produced by the assembler.

```assembly
... 
.ALIGN 1; /* no alignment requirement */ 
... 
.SECTION data1; 
.ALIGN 2; 
.VAR single; /* aligns the data item on the word boundary, 
at the location with the address value that can 
be evenly divided by 2 */ 
.ALIGN 4; 
.VAR samples1[100]="data1.dat"; 
/* aligns the first data item on the double-word 
boundary, at the location with the address value 
that can be evenly divided by 4; advances other 
data items consecutively */
```

The Blackfin assembler accepts .BYTE, .BYTE2, and .BYTE4 as well as .VAR.
.ALIGN_CODE, Specify an Address Alignment

Used with TigerSHARC processors only.

The .ALIGN_CODE directive forces the address alignment of an instruction within the .SECTION in which it is used. .ALIGN_CODE is similar to the .ALIGN directive, but whereas .ALIGN causes the code to be padded with 0s, .ALIGN_CODE pads with NOPs. The .ALIGN_CODE directive is used to align instructions.

Refer to the VisualDSP++ 5.0 Linker and Utilities Manual for more information on section alignment.

Syntax:

.ALIGN_CODE expression;

where

expression — evaluates to an integer. It specifies an alignment requirement; its value must be a power of 2. In TigerSHARC processors, the expression value is usually 4. When aligning a data item or instruction, the assembler adjusts the address of the current location counter to the next address that is divisible by the value of the expression. The expression set to 0 or 1 signifies no address alignment requirement.

In the absence of the .ALIGN_CODE directive, the default address alignment is 1.

Example:

.ALIGN_CODE 0; /* no alignment requirement */
...
.ALIGN_CODE 1; /* no alignment requirement */
...
.SECTION program;
.ALIGN_CODE 4;
JUMP LABEL:
    /* Jump instruction aligned to four word boundary. 
    If necessary, padding will be done with NOPs */
.ASCII

Used with Blackfin processors only.

The .ASCII directive initializes a data location with one or more characters from a double-quoted ASCII string. This is equivalent to the .BYTE directive. Note that the syntax differs from the .BYTE directive as follows:

- There is no “=” sign
- The string is enclosed in double-quotes, not single quotes

Syntax:

```
.ASCII "string";
```

Example:

```
.SECTION data1:

ASCII_String:
.TYPE ASCII_String,STT_OBJECT;
  .ASCII "ABCD";
.ASCII_String.end:

Byte_String:
.TYPE Byte_String,STT_OBJECT;
  .Byte = 'ABCD';
.Byte_String.end:
```
.BYTE, Declare a Byte Data Variable or Buffer

INFO Used with Blackfin processors only.

The .BYTE, .BYTE2, and .BYTE4 directives declare and optionally initialize one-, two-, and four-byte data objects, respectively. Note that the .BYTE4 directive performs the same function as the .VAR directive.

Syntax:

When declaring and/or initializing memory variables or buffer elements, use one of these forms:

```
.BYTE varName1, varName2, ...
.BYTE = initExpression1, initExpression2, ...
.BYTE varName1 = initExpression, varName2 = initExpression2, ...
.BYTE bufferName[] = initExpression1, initExpression2, ...
.BYTE bufferName[] = "fileName";
.BYTE bufferName[length] = "fileName";
.BYTE bufferName[length] = initExpression1, initExpression2, ...
```

where:

- varName – user-defined symbols that name variables
- bufferName – user-defined symbols that name buffers
- fileName – indicates that the elements of a buffer get their initial values from the fileName data file. The <fileName> parameter can consist of the actual name and path specification for the data file. If the initialization file is in current directory of your operating system, only the fileName need be given inside double quote (" ") characters. Note that when reading in a data file, the assembler reads in whitespace-separated lists of decimal digits or hex strings.

If the file name is not found in the current directory, the assembler looks in the directories in the processor include path. You may use the -I
switch (see on page 1-161) to add a directory to the processor include path.

Initializing from files is useful for loading buffers with data, such as filter coefficients or FFT phase rotation factors that are generated by other programs. The assembler determines how the values are stored in memory when it reads the data files.

Ellipsis (…) – represents a comma-delimited list of parameters.

\textit{initExpressions} parameters – sets initial values for variables and buffer elements

The optional $[\text{length}]$ parameter defines the length of the associated buffer in words. The number of initialization elements defines \textit{length} of an implicit-size buffer. The brackets $[ ]$ that enclose the optional $[\text{length}]$ are required. For more information, see the following .BYTE examples.

In addition, use a /R32 qualifier (.BYTE4/R32) to support 32-bit initialization for use with 1.31 fracts (see on page 1-61).

The following lines of code demonstrate .BYTE directives:

\begin{verbatim}
Buffer1:
    .TYPE Buffer1, STT_OBJECT;
    .BYTE = 5, 6, 7;
    // initialize three 8-bit memory locations
    // for data label Buffer1
    .BYTE samples[] = 123, 124, 125, 126, 127;
    // declare an implicit-length buffer and initialize it
    // with five 1-byte constants
    .BYTE4/R32 points[] = 1.01r, 1.02r, 1.03r;
    // declare and initialize an implicit-length buffer
    // and initialize it with three 4-byte fract constants
    .BYTE/2 Ins, Outs, Remains:
\end{verbatim}
Assembler

// declare three 2-byte variables zero-initialized by default
.BYTE4 demo_codes[100] = "inits.dat":
  // declare a 100-location buffer and initialize it with the contents of the inits.dat file;
.BYTE2 taps=100;
  // declare a 2-byte variable and initialize it to 100
.BYTE twiddles[10] = "phase.dat":
  // declare a 10-location buffer and load the buffer with contents of the phase.dat file
.BYTE4/R32 Fract_Byte4_R32[] = "fr32FormatFract.dat":

When declaring or initializing variables with .BYTE, consider constraints applied to the .VAR directive. The .VAR directive allocates and optionally initializes 32-bit data objects. For information about the .VAR directive, refer to information on page 1-138.

ASCII String Initialization Support

The assembler supports ASCII string initialization. This allows the full use of the ASCII character set, including digits and special characters.

In Blackfin processors, ASCII initialization can be provided with .BYTE, .BYTE2, or .VAR directives. The most likely use is the .BYTE directive where each char is represented by one byte versus a .VAR directive in which each char needs four bytes. The characters are stored in the upper byte of 32-bit words. The LSBs are cleared.

String initialization takes one of the following forms:

```
.BYTE symbolString[length] = 'initString', 0;
.BYTE symbolString[] = 'initString', 0;
```

Note that the number of initialization characters defines the optional length of a string (implicit-size initialization).
Assembler Syntax Reference

Example:

```
.BYTE k[13] = 'Hello world!', 0;
.BYTE k[] = 'Hello world!', 0;
```

The trailing zero character is optional. It simulates ANSI-C string representation.
.COMPRESS, Start Compression

Used with the ADSP-2146x SHARC processors only.

The .COMPRESS directive indicates that all of the following instructions in the source file should be compressed, if possible. The directive has effect on sections assembled as short word. Compression is canceled by a .NOCOMPRESS directive later in the source file (see on page 1-110).

.COMPRESS is advisory only:

- There is no guarantee that a particular instruction will be compressed.
- Instructions can be ‘uncompressed’ if they are near the end of a DO loop.
- Whether a particular instruction is compressed can change due to assembler enhancements or bug fixes.
- There are no warnings if instructions cannot be compressed.

Therefore, it is not recommended to create code layouts (tables with fixed size entries) that depend on particular instructions being compressed.

Syntax:

.COMPRESS;
.EXTERN, Refer to a Globally Available Symbol

The .EXTERN directive allows a code module to reference global data structures, symbols, and so on that are declared as .GLOBAL in other files. For additional information, see the .GLOBAL directive on page 1-92.

Syntax:

.EXTERN symbolName1[, symbolName2, ...];

where:

symbolName – the name of a global symbol to import. A single .EXTERN directive can reference any number of symbols on one line, separated by commas.

Example:

.EXTERN coeffs;

    // This code declares an external symbol to reference
    // the global symbol "coeffs" declared in the example
    // code in the .GLOBAL directive description.
.EXTERN STRUCT, Refer to a Struct Defined Elsewhere

The .EXTERN STRUCT directive allows a code module to reference a struct defined in another file. Code in the assembly file can then reference the data members by name, just as if they were declared locally.

Syntax:

.EXTERN STRUCT typedef structvarName;

where:

typedef – the type definition for a struct VAR

structvarName – a struct VAR name

The .EXTERN STRUCT directive specifies a struct symbol name declared in another file. The naming conventions are the same for structs as for variables and arrays:

- If a struct was declared in a C file, refer to it with a leading _.
- If a struct was declared in an .asm file, use the name “as is”, no leading underscore (_) is necessary.

The .EXTERN STRUCT directive optionally accepts a list, such as:

.EXTERN STRUCT typedef structvarName [, STRUCT typedef structvarName …]

The key to the assembler knowing the layout is the .IMPORT directive and the .EXTERN STRUCT directive associating the typedef with the struct VAR. To reference a data structure declared in another file, use the .IMPORT directive with the .EXTERN directive. This mechanism can be used for structures defined in assembly source files as well as in C files.

The .EXTERN directive supports variables in the assembler. If the program references struct members, .EXTERN STRUCT must be used because the
assembler must consult the struct layout to calculate the offset of the struct members. If the program does not reference struct members, you can use .EXTERN for struct VARs.

Example (SHARC code):

```assembly
.IMPORT "MyCelebrities.h":
    // 'Celebrity' is the typedef for struct var 'StNick'
    // .EXTERN means that '_StNick' is referenced within this
    // file, but not locally defined. This example assumes StNick
    // was declared in a C file and it must be referenced with
    // a leading underscore.
.EXTERN STRUCT Celebrity _StNick:
    // "isSeniorCitizen" is one of the members of the 'Celebrity'
    // type
    P3.L = LO( _StNick->isSeniorCitizen);
    P3.H = HI(_StNick->isSeniorCitizen);
```
.FILE, Override the Name of a Source File

The `.FILE` directive overrides the name of the source file. This directive may appear in the C/C++ compiler-generated assembly source file (.s). The `.FILE` directive is used to ensure that the debugger has the correct file name for the source file that had generated the object file.

Syntax:

```
.FILE "filename.ext";
```

where:

- `filename` — the name of the source file to associate with the object file. The argument is enclosed in double quotes.
**.FILE_ATTR, Create an Attribute in the Object File**

The `.FILE_ATTR` directive instructs the assembler to place an attribute in the object file which can be referenced in the .ldf file when linking. See the *VisualDSP++ 5.0 Linker and Utilities Manual* for more information.

Syntax:

```
.FILE_ATTR attrName1 [= attrVal1] [, attrName2 [= attrVal2]];]
```

where:

- `attrName` – the name of the attribute. Attribute names must follow the same rules for naming symbols.

- `attrVal` – sets the attribute to this value. If omitted, “1” is used. The value must be double-quoted unless it follows the rules for naming symbols (as described in “Assembler Keywords and Symbols” on page 1-42).

Examples:

```
.FILE_ATTR at1;
.FILE_ATTR at10=a123;
.FILE_ATTR at101=a123, at102, at103="999";
```

**.FORCECOMPRESS, Compress the Next Instruction**

- Used with the ADSP-2146x SHARC processors only.

The `.FORCECOMPRESS` directive causes the next instruction to be compressed, if possible. The directive has effect on sections that are assembled as short word. The directive overrides the effect of a previous `.NOCOMPRESS` directive (on page 1-110) for one instruction. Only the immediately following assembly instruction is affected by `.FORCECOMPRESS`, while `.COMPRESS` (on page 1-85) starts a sequence of `.COMPRESS`, instructions, and `.NOCOMPRESS`. 
.FORCECOMPRESS can override certain conservative assumptions normally made by the assembler, such as when an immediate value is an expression containing a symbol. In this case, the assembler normally does not generate a compressed instruction because the ultimate value of the symbolic expression may not fit in the immediate field of the compressed instruction.

.ForceCompress is advisory only:

- There is no guarantee that a particular instruction will be compressed.
- An instruction can be ‘uncompressed’ if it is near the end of a DO loop.
- Whether a particular instruction is compressed can change due to assembler enhancements or bug fixes.
- There are no warnings if an instruction cannot be compressed.

Therefore, it is not recommended to create code layouts (tables with fixed size entries) that depend on particular instructions being compressed.

Syntax:

.FORCECOMPRESS;
.GLOBAL, Make a Symbol Available Globally

The .GLOBAL directive changes the scope of a symbol from local to global, making the symbol available for reference in object files that are linked to the current one.

By default, a symbol has local binding, meaning the linker can resolve references to it only from the local file (that is, the same file in which it is defined). It is visible only in the file in which it is declared. Local symbols in different files can have the same name, and the linker considers them to be independent entities. Global symbols are visible from other files; all references from other files to an external symbol by the same name will resolve to the same address and value, corresponding to the single global definition of the symbol.

You change the default scope with the .GLOBAL directive. Once the symbol is declared global, other files may refer to it with .EXTERN. For more information, refer to the .EXTERN directive on page 1-85. Note that .GLOBAL (or .WEAK) scope is required for symbols that appear in RESOLVE commands in the .ldf file.

Syntax:

.GLOBAL symbolName1[, symbolName2,...];

where:

symbolName – the name of a global symbol. A single .GLOBAL directive may define the global scope of any number of symbols on one line, separated by commas.

Example (SHARC and TigerSHARC code):

.PROCESSOR: SHARC

.GLOBAL coeff[10]; // declares a buffer
.GLOBAL taps=100; // declares a variable
.GLOBAL coeffs, taps; // makes the buffer and the variable
// visible to other files

Example (Blackfin code):

.BYTE coeffs[10]; // declares a buffer
.BYTE4 taps=100; // declares a variable
.GLOBAL coeffs, taps; // makes the buffer and the variable
// visible to other files
.IMPORT, Provide Structure Layout Information

The .IMPORT directive makes struct layouts visible inside an assembler program. The .IMPORT directive provides the assembler with the following structure layout information:

- The names of typedefs and structs available
- The name of each data member
- The sequence and offset of the data members
- Information as provided by the C compiler for the size of C base types (alternatively, for the SIZEOF() C base types).

Syntax:

```assembly
.import "headerfilename1", "headerfilename2", ...
```

where:

- `headerfilename` – one or more comma-separated C header files enclosed in double quotes.

The system processes each .IMPORT directive and each file specified in an .IMPORT directive separately. Therefore, all type information must be available within the context for the individual file.

If `headerfile1.h` defines a type referenced in `headerfile2.h`, an attempt to import the second file into assembly will fail. One solution is to have the assembler call the compiler once for the set of import statements. The compiler then has all the information it needs when processing the second header file.

In other words, create a third file to be imported in place of `headerfile2.h`. This file would simply consist of these lines:

```c
#include "headerfile1.h"
#include "headerfile2.h"
```
The `IMPORT` directive does not allocate space for a variable of this type. Allocating space requires the `STRUCT` directive (see on page 1-133).

The assembler takes advantage of knowing the struct layouts. The assembly programmer may reference struct data members by name in assembler source, as one would do in C. The assembler calculates the offsets within the structure based on the size and sequence of the data members.

If the structure layout changes, the assembly code need not change. It just needs to get the new layout from the header file, via the compiler. Make dependencies track the `IMPORT` header files and know when a rebuild is needed. Use the `-flags-compiler assembler` switch (on page 1-157) to pass options to the C compiler for `IMPORT` header file compilations.

An `IMPORT` directive with one or more `EXTERN` directives allows code in the module to refer to a struct variable that was declared and initialized elsewhere. The C struct can be declared in C-compiled code or another assembly file.

The `IMPORT` directive with one or more `STRUCT` directives declares and initializes variables of that structure type within the assembler section in which it appears.

For more information, refer to the `EXTERN` directive on page 1-85 and the `STRUCT` directive on page 1-133.

Example:

```
IMPORT "CHeaderFile.h";
IMPORT "ACME_Illir.h", "ACME_IFir.h";
SECTION program;
// ... code that uses CHeaderFile, ACME_Illir, and
// ACME_IFir C structs
```
.INC/BINARY, Include Contents of a File

The .INC/BINARY directive includes the content of a file at the current location. You can control the search paths used via the \texttt{-i} command-line switch (on page 1-161).

Syntax:

\texttt{.INC/BINARY [ symbol = ] "filename" [,.skip [.count]];}

\texttt{.INC/BINARY [ symbol[] = ] "filename" [,.skip [.count]];}

where:

\textit{symbol} – the name of a symbol to associate with the data being included from the file

\textit{filename} – the name of the file to include. The argument is enclosed in double quotes.

The \textit{skip} argument skips a number of bytes from the start of the file.

The \textit{count} argument indicates the maximum number of bytes to read.

Example:

\texttt{.SECTION data1;}

\texttt{.VAR jim;}
\texttt{.INC/BINARY sym[] = "bert",10,6;}
\texttt{.VAR fred;}
\texttt{.INC/BINARY Image1[] = "photos/Picture1.jpg";}


.LEFTMARGIN, Set the Margin Width of a Listing File

The .LEFTMARGIN directive sets the margin width of a listing page. It specifies the number of empty spaces at the left margin of the listing file (.lst), which the assembler produces when you use the -l switch. In the absence of the .LEFTMARGIN directive, the assembler leaves no empty spaces for the left margin.

The assembler compares the .LEFTMARGIN and .PAGEWIDTH values against one another. If the specified values do not allow enough room for a properly formatted listing page, the assembler issues a warning and adjusts the directive that was specified last to allow an acceptable line width.

Syntax:

.LEFTMARGIN expression;

where:

expression — evaluates to an integer from 0 to 100. Default is 0. Therefore, the minimum left margin value is 0 and the maximum left margin value is 100. To change the default setting for the entire listing, place the .LEFTMARGIN directive at the beginning of your assembly source file.

Example:

.LEFTMARGIN 9; /* the listing line begins at column 10 */

You can set the margin width only once per source file. If the assembler encounters multiple occurrences of the .LEFTMARGIN directive, it ignores all of them except the last directive.
.LIST/.NOLIST, Listing Source Lines and Opcodes

The .LIST/.NOLIST directives (on by default) turn on and off the listing of source lines and opcodes.

If .NOLIST is in effect, no lines in the current source (or any nested source) are listed until a .LIST directive is encountered in the same source, at the same nesting level. The .NOLIST directive operates on the next source line, so that the line containing a .NOLIST appears in the listing and accounts for the missing lines.

The .LIST/.NOLIST directives do not take any qualifiers or arguments.

Syntax:

.LIST;

.NOLIST;

These directives can appear multiple times anywhere in a source file, and their effect depends on their location in the source file.
.LIST_DATA/.NOLIST_DATA, Listing Data Opcodes

The .LIST_DATA/.NOLIST_DATA directives (off by default) turn the listing of data opcodes on and off. When .Nolist_DATA is in effect, opcodes that correspond to variable declarations do not appear in the opcode column. Nested source files inherit the current setting of this directive pair, but a change to the setting made in a nested source file do not affect the parent source file.

The .LIST_DATA/.NOLIST_DATA directives do not take any qualifiers or arguments.

Syntax:

.LIST_DATA;

.NOLIST_DATA;

These directives can appear multiple times anywhere in a source file, and their effect depends on their location in the source file.
.LIST_DATFILE/.NOLIST_DATFILE, List Data Init Files

The .LIST_DATFILE/.NOLIST_DATFILE directives (off by default) turn the listing of data initialization files on and off. Nested source files inherit the current setting of this directive pair, but a change to the setting made in a nested source file will not affect the parent source file.

The .LIST_DATFILE/.NOLIST_DATFILE directives do not take any qualifiers or arguments.

Syntax:

.LIST_DATFILE;

.NOLIST_DATFILE;

These directives can appear multiple times anywhere in a source file, and their effect depends on their location in the source file. They are used in assembly source files, but not in data initialization files.

.LIST_DEFTAB, Set the Default Tab Width for Listings

Tab characters in source files are expanded to blanks in listing files under the control of two internal assembler parameters that set the tab expansion width. The default tab width is normally in control, but it can be overridden if the local tab width is explicitly set with a directive.

The .LIST_DEFTAB directive sets the default tab width, and the .LIST_LOCTAB directive sets the local tab width (see on page 1-102).

Both the default tab width and the local tab width can be changed any number of times via the .LIST_DEFTAB and .LIST_LOCTAB directives. The default tab width is inherited by nested source files, but the local tab width only affects the current source file.

Syntax:

---

1-100 	VisualDSP++ 5.0 Assembler and Preprocessor Manual
.LIST_DEFTAB expression:

where:

expression – evaluates to an integer greater than or equal to 0. In the absence of a .LIST_DEFTAB directive, the default tab width defaults to 4. A value of 0 sets the default tab width.

Example:

    // Tabs here are expanded to the default of 4 columns
    .LIST_DEFTAB 8;
    // Tabs here are expanded to 8 columns
    .LIST_LOCTAB 2;
    // Tabs here are expanded to 2 columns
    // But tabs in "include_1.h" will be expanded to 8 columns
    #include "include_1.h"
    .LIST_DEFTAB 4;
    // Tabs here are still expanded to 2 columns
    // But tabs in "include_2.h" will be expanded to 4 columns
    #include "include_2.h"
.LIST_LOCTAB, Set the Local Tab Width for Listings

Tab characters in source files are expanded to blanks in listing files under the control of two internal assembler parameters that set the tab expansion width. The default tab width is normally in control, but it can be overridden if the local tab width is explicitly set with a directive.

The .LIST_LOCTAB directive sets the local tab width, and the .LIST_DEFTAB directive sets the default tab width (see on page 1-100).

Both the default tab width and the local tab width can be changed any number of times via the .LIST_DEFTAB and .LIST_LOCTAB directives. The default tab width is inherited by nested source files, but the local tab width only affects the current source file.

Syntax:

.LIST_LOCTAB expression;

where:

expression – evaluates to an integer greater than or equal to 0. A value of 0 sets the local tab width to the current setting of the default tab width.

In the absence of a .LIST_LOCTAB directive, the local tab width defaults to the current setting for the default tab width.

Example: See the .LIST_DEFTAB example on page 1-100.
The `.LIST_WRAPDATA/.Nolist_WRAPDATA` directives control the listing of opcodes that are too big to fit in the opcode column. By default, the `.Nolist_WRAPDATA` directive is in effect.

This directive pair applies to any opcode that does not fit, but in practice, such a value almost always is the data (alignment directives can also result in large opcodes).

- If `.LIST_WRAPDATA` is in effect, the opcode value is wrapped so that it fits in the opcode column (resulting in multiple listing lines).
- If `.Nolist_WRAPDATA` is in effect, the printout is what fits in the opcode column.

Nested source files inherit the current setting of this directive pair, but a change to the setting made in a nested source file does not affect the parent source file.

The `.LIST_WRAPDATA/.Nolist_WRAPDATA` directives do not take any qualifiers or arguments.

**Syntax:**

```
.LIST_WRAPDATA;

.Nolist_WRAPDATA;
```

These directives can appear multiple times anywhere in a source file, and their effect depends on their location in the source file.
.LONG, Defines and Initializes 4-Byte Data Objects

Used with Blackfin processors only.

The .LONG directive declares and optionally initializes four-byte data objects. It is effectively equivalent to .BYTE4 initExpression1, initExpression2, ... For more information, see “.BYTE, Declare a Byte Data Variable or Buffer” on page 1-81.

Syntax:

When declaring and/or initializing memory variables or buffer elements, use the following format. Note that the terminating semicolon is optional.

```
.LONG initExpression1, initExpression2, ...[;]
.LONG constExpression1, constExpression2, ...[;]
```

where:

- `initExpressions` parameters – contain one or more comma-separated “symbol=value” expressions
- `constExpressions` parameters – contain a comma-separated list of constant values

The following lines of code demonstrate .LONG directives:

```
// Define an initialized variable
.LONG buf1=0x1234;

// Define two initialized variables
.LONG 0x1234, 0x5678, ...;

// Declare three 8 byte areas of memory, initialized to 3, 4, and 5 respectively
.LONG 0x0003, 0x0004, 0x0005;
```
.MESSAGE, Alter the Severity of an Assembler Message

The .MESSAGE directive can be used to alter the severity of an error, warning, or informational message generated by the assembler for all or part of an assembly source.

Syntax:

.MESSAGE/qualifier warnid1 [,warnid2, ...];

.MESSAGE/qualifier warnid1 [,warnid2, ...] UNTIL sym;

.MESSAGE/qualifier warnid1 [,warnid2, ...] FOR n LINES;

.MESSAGE/DEFAULT/qualifier warnid1 [,warnid2, ...];

where:

warnid1[,warnid2, ...] is a list of one or more message identification numbers.

A qualifier can be:

- ERROR – change messages to errors
- WARN – change messages to warnings
- INFO – change messages to informational messages
- SUPPRESS – do not output the messages
- RESTORE_CL – change the severity of the messages back to the default values they had at the beginning of the source file, after the command line arguments were processed, but before any DEFAULT directives have been processed.
• **RESTORE** – change the severity of the messages back to the default values they had at the beginning of the source file, after the command line arguments were processed, and after any **DEFAULT** directives have been processed.

• **POP** – change the severity of the messages back to what they were prior to the previous **MESSAGE** directive.

The **RESTORE**, **RESTORE_CL**, and **POP** qualifiers cannot be used with the **UNTIL**, **FOR**, or **DEFAULT** forms of the **MESSAGE** directive.

The **DEFAULT** qualifier cannot be used with the **UNTIL** or **FOR** forms of the **MESSAGE** directive.

The simple form of the **MESSAGE** directive changes the severity of messages until another **MESSAGE** directive is seen. It can be placed anywhere in a source file. Messages that could not be associated with a source line can be reported with line number 0. These cannot be altered in severity by a **MESSAGE** directive. This should be done by using the **-Werror**, **-Wwarn**, **-Winfo**, or **-Wsuppress** assembler switches; see “Assembler Command-Line Switch Descriptions” on page 1-147.

Example:

```assembly
.MESSAGE/ERROR 1049;
.SECTION program:
.VAR two[2]=1; // generates an error
.MESSAGE/SUPPRESS 1049;
.VAR three[3]=1,2; // generates no message
.MESSAGE/WARN 1049;
.VAR four[4]=1,2,3; // generates a warning
```

The temporary forms of the **MESSAGE** directive (**UNTIL** and **FOR**) changes the severity of messages until the specified label (or for the specified number of source lines). The temporary forms of the **MESSAGE** directive must start and end within a single **SECTION directive.**
Example (for TigerSHARC Processors):

.PROGRAM

.VAR one=1.0r; // generates a warning
.MESSAGE/ERROR 1177 UNTIL sym;
.VAR two=1.0r; // generates an error
.sym:
.VAR three=1.0r; // generates a warning
.MESSAGE/ERROR 1177 FOR 3 LINES;
.VAR apple;
.VAR four=1.0r; // generates an error
.VAR orange;
.VAR five=1.0r; // generates a warning

The **POP** qualifier changes the severity of the messages back to previous severities.

Example (for TigerSHARC Processors):

.MESSAGE/INFO 3012;
.PROGRAM
.RETI;; // generates an informational
.MESSAGE/ERROR 3012: RETI;; // generates an error
.MESSAGE/INFO 3012: RETI;; // generates an informational
.MESSAGE/POP 3012: RETI;; // generates an error - 2nd directive
.MESSAGE/POP 3012: RETI;; // generates an informational - 1st directive
.MESSAGE/POP 3012: RETI;; // generates a warning - the default for this message

The **DEFAULT** qualifier is used to redefine the default severity for messages. It can be placed anywhere in a source file. It only takes affect when the message severity has not been changed by a .MESSAGE directive.
Example (for TigerSHARC Processors):

```
.MESSAGE/DEFAULT/ERROR 1177;
.MESSAGE/DEFAULT/INFO 1177;
.SECTION program;
.VAR one=1.0r; // generates an informational
.MESSAGE/ERROR 1177;
.VAR two=1.0r; // generates an error
.MESSAGE/RESTORE 1177;
.VAR three=1.0r; // generates an informational
.MESSAGE/RESTORE_CL 1177;
.VAR four=1.0r; // generates a warning
```

The `-Werror number[,number], -Wwarn number[,number], -Wno-info, or -Wsuppress number[,number]` assembler switches have the same affect as the `DEFAULT` form of `.MESSAGE`.

Some error messages cannot be altered in severity.

Include files inherit any severity changes from the files which `#include` them. `.MESSAGE` directives in include files do not control the severity of messages generated after returning to the source file which included them.

A `.MESSAGE/DEFAULT` directive in an include file controls the severity of messages generated after returning to the source file which included them.
.NEWPAGE, Insert a Page Break in a Listing File

The .NEWPAGE directive inserts a page break in the printed listing file (.lst), which the assembler produces when you use the -l switch (on page 1-162). The assembler inserts a page break at the location of the .NEWPAGE directive.

The .NEWPAGE directive does not take any qualifiers or arguments.

Syntax:

.NEWPAGE;

This directive may appear anywhere in your source file. In the absence of the .NEWPAGE directive, the assembler generates no page breaks in the file.
.NOCOMPRESS, Terminate Compression

Used with the ADSP-2146x SHARC processors only.

The .NOCOMPRESS directive indicates that all of the following instructions in the source file should not be compressed.

Syntax:

.NOCOMPRESS;

The directive’s effect is canceled by a .COMPRESS directive (on page 1-85) later in the source file. The directive’s effect also is cancelled by a .FORCE-COMPRESS directive (on page 1-90) for one instruction only.
.PAGELENGTH, Set the Page Length of a Listing File

The .PAGELENGTH directive controls the page length of the listing file produced by the assembler when you use the -l switch (on page 1-162).

Syntax:

```
.PAGELENGTH expression;
```

where:

`expression` — evaluates to an integer 0 or greater. It specifies the number of text lines per printed page. The default page length is 0, which means the listing has no page breaks.

To format the entire listing, place the .PAGELENGTH directive at the beginning of your assembly source file. If a page length value greater than 0 is too small to allow a properly formatted listing page, the assembler issues a warning and uses its internal minimum page length (approximately 10 lines).

Example:

```
.PAGELENGTH 50;  // starts a new page after printing 50 lines
```

You can set the page length only once per source file. If the assembler encounters multiple occurrences of the directive, it ignores all except the last directive.
.PAGEWIDTH, Set the Page Width of a Listing File

The .PAGEWIDTH directive sets the page width of the listing file produced by the assembler when you use the -l switch.

Syntax:

.PAGEWIDTH expression;

where:

dexpression – evaluates to an integer

Depending on setting of the .LEFTMARGIN directive, this integer should be at least equal to:

- .LEFTMARGIN value plus 46 (for Blackfin processors)
- .LEFTMARGIN value plus 49 (for TigerSHARC processors)
- .LEFTMARGIN value plus about 66 (for SHARC processors)

You cannot set this integer to less than 46, 49, or 66, respectively. There is no upper limit. If .LEFTMARGIN = 0 and the .PAGEWIDTH value is not specified, the actual page width is set to any number over 46, 49, or 66, respectively.

To change the number of characters per line in the entire listing, place the .PAGEWIDTH directive at the beginning of the assembly source file.

Example:

.PAGEWIDTH 72; // starts a new line after 72 characters
   // are printed on one line, assuming
   // the .LEFTMARGIN setting is 0.
You can set the page width only once per source file. If the assembler encounters multiple occurrences of the directive, it ignores all of them except the last directive.
.PORT, Legacy Directive

Used with SHARC processors only.

The .PORT legacy directive assigns port name symbols to I/O ports. Port name symbols are global symbols that correspond to memory-mapped I/O ports defined in the .ldf file.

The .PORT directive uses the following syntax:

```
.PORT portName;
```

where:

`portName` – a globally available port symbol

Example:

```
.PORT p1; // declares I/O port P1
.PORT p2; // declares I/O port P2
```

To declare a port using the SHARC assembler syntax, use the .VAR directive (for port-identifying symbols) and the linker description file (for corresponding I/O sections). The linker resolves port symbols in the .ldf file.

For more information on the linker description file, see the VisualDSP++ 5.0 Linker and Utilities Manual.
.PRECISION, Select Floating-Point Precision

Used with SHARC processors only.

The .PRECISION directive controls how the assembler interprets floating-point numeric values in constant declarations and variable initializations. To configure the floating-point precision of the target processor system, you must set up control registers of the chip using instructions specific to the processor core.

Use one of the following options:

.PRECISION [=] 32;
.PRECISION [=] 40;

where:

The precision of 32 or 40 (default) specifies the number of significant bits for floating-point data. The equal sign (=) following the .PRECISION keyword is optional.

Note that the .PRECISION directive applies only to floating-point data. Precision of fixed-point data is determined by the number of digits specified. The .PRECISION directive applies to all floating-point expressions in the file that follow it up to the next .PRECISION directive.

Example:

.PRECISION=32: /* Selects standard IEEE 32-bit single-precision format. */

.PRECISION 40: /* Selects standard IEEE 40-bit format with extended mantissa. This is the default setting. */
The `.ROUND_` directives ([on page 1-122](#)) specify how the assembler converts a value of many significant bits to fit into the selected precision.
.PREVIOUS, Revert to the Previously Defined Section

The .PREVIOUS directive instructs the assembler to set the current section in memory to the section described immediately before the current one. The .PREVIOUS directive operates on a stack.

Syntax:

.PREVIOUS;

The following examples provide valid and invalid cases of the use of the consecutive .PREVIOUS directives.

Example of Invalid Directive Use:

.SECTION data1; // data
.SECTION code; // instructions
.PREVIOUS; // previous section ends, back to data1
.PREVIOUS; // no previous section to set to

Example of Valid Directive Use:

#define MACRO1

.SECTION data2; \
 .VAR vd = 4; \n .PREVIOUS;
.SECTION data1; // data
 .VAR va = 1;
 .SECTION program; // instructions
 .VAR vb = 2;
 MACRO1 // invoke macro
 .PREVIOUS;
 .VAR vc = 3;
evaluates as:

```assembly
.SECTION data1: // data
  .VAR va = 1;
.SECTION program: // instructions
  .VAR vb = 2;
  // Start MACRO1
.SECTION data2;
  .VAR vd = 4;
.PREVIOUS; // end data2, section program
  // End MACRO1
.PREVIOUS; // end program, start data1
  .VAR vc = 3;
```

**.PRIORITY, Allow Prioritized Symbol Mapping in Linker**

The `.PRIORITY` directive allows prioritized symbol mapping in the linker. The directive can be specified in three ways:

- For a symbol defined in the same file as the directive
- For a globally defined symbol
- For a local symbol in a different source file

**Syntax:**

```
.PRIORITY symbolName, priority;
.PRIORITY symbolName."sourcefile", priority;
```

where:

In the first case, `symbolName` is a global symbol or locally defined symbol. In the second case, `symbolName` is a symbol defined in `"sourcefile"`. 
Example:

```
.PRIORITY _foo, 35;     // Symbol with highest priority
.PRIORITY _main, 15;    // Symbol with medium priority
.PRIORITY bar, "barfile.asm", -10;  // Symbol with lowest priority
```

**Linker Operation**

After the absolute placement of symbols specified in the `.ldf` file’s `RESOLVE()` command (but before mapping commands are processed), the linker tries to map all symbols appearing in priority directives (in decreasing order of their priorities).

The prioritized symbol is placed into memory that contains only the `INPUT_SECTIONS()` command for input sections defining the symbol. Symbols with assigned priority are mapped after absolutely placed symbols, but before symbols without assigned priority.

The symbols are placed into memory segments based on the order that the segments are appear in the `.ldf` file. Therefore, an output section targeting a higher-priority memory segment should appear before an output section targeting a lower-priority segment.

**Example of Assembler Code:**

```
.section program;
    _func1:

    _func2:

.section L1_code;
    _L1_func:

    ...

.PRIORITY _L1_func,10;
.PRIORITY _func1,11;
.PRIORITY _func2,12:
```
Example of LDF Code:

L1_A  { INPUT_SECTIONS($OBJECTS(L1_code)) } > L1_A; //
L1_A  { INPUT_SECTIONS($OBJECTS(L1_code program)) } > L1_B;
L2    { INPUT_SECTIONS($OBJECTS(program)) } > L2;

The preceding two examples result in the linker executing the following three steps:

1. Because _func2 is assigned the highest priority (12) in the assembler code, the linker first tries to map it into the L1_B memory segment. If _func2 does not fit into L1_B, it tries the L2 segment.

2. Because _func1 is assigned the middle priority (11) in the assembler code, the linker first tries to map it into the L1_B memory segment. If _func2 does not fit into L1_B, it tries the L2 segment.

3. Because _L1_func is assigned the lowest priority (10) in the assembler code, the linker first tries to map it into the L1_A memory segment. If _L1_func does not fit into L1_A, it tries the L1_B segment.
.REFERENCE, Provide Better Info in an X-REF File

Used with Blackfin processors only.

The .REFERENCE directive is used by the compiler to provide better information in an X-REF file generated by the linker. This directive is used when there are indirect symbol references that would otherwise not appear in an X-REF file.

The .REFERENCE directive uses the following syntax:

```
.REFERENCE symbol;
```

where:

```
symbol – is a symbol
```

Example:

```
.REFERENCE P1;
.REFERENCE P2;
```

.RETAIN_NAME, Stop Linker from Eliminating Symbol

The .RETAIN_NAME directive stops the linker from eliminating the symbol when linking the generated object file. This directive has the same effect as the KEEP() LDF command has when used with the linker.

Syntax:

The .RETAIN_NAME directive uses the following syntax:

```
.RETAIN_NAME symbol;
```

where:

```
symbol – is a user-defined symbol
```

For information on KEEP(), refer to the VisualDSP++ 5.0 Linker and Utilities Manual.
.ROUND_, Select Floating-Point Rounding

Used with SHARC processors only.

The .ROUND_ directives control how the assembler interprets literal floating-point numeric data after .PRECISION is defined. The .PRECISION directive determines the number of bits to be truncated to match the number of significant bits (see on page 1-115).

The .ROUND_ directives determine how the assembler handles the floating-point values in constant declarations and variable initializations. To configure the floating-point rounding modes of the target processor system, you must set up control registers on the chip using instructions specific to the processor core.

The .ROUND_ directives use the following syntax:
.
.
.
.

where:

The mode string specifies the rounding scheme used to fit a value in the destination format. Use one of the following IEEE standard modes:

.ROUND_NEAREST; (default)
.ROUND_PLUS; (rounds to round-to-positive infinity)
.ROUND_MINUS; (rounds to round-to-negative infinity)
.ROUND_ZERO; (selects round-to-zero)

In the following examples, the numbers with four decimal places are reduced to three decimal places and are rounded accordingly.

.ROUND_NEAREST:
/* Selects Round-to-Nearest scheme; the default setting.
A 5 is added to the digit that follows the third decimal digit (the least significant bit - LSB). The result is truncated after the third decimal digit (LSB).
1.2581 rounds to 1.258
8.5996 rounds to 8.600
-5.3298 rounds to -5.329
-6.4974 rounds to -6.496
*/
.ROUND_ZERO;
/* Selects Round-to-Zero. The closer to zero value is taken.
The number is truncated after the third decimal digit (LSB).

1.2581 rounds to 1.258
8.5996 rounds to 8.599
-5.3298 rounds to -5.329
-6.4974 rounds to -6.497
*/
.ROUND_PLUS;
/* Selects Round-to-Positive Infinity. The number rounds to the next larger.
For positive numbers, a 1 is added to the third decimal digit (the least significant bit). Then the result is truncated after the LSB.
For negative numbers, the mantissa is truncated after the third decimal digit (LSB).

1.2581 rounds to 1.259
8.5996 rounds to 8.600
-5.3298 rounds to -5.329
-6.4974 rounds to -6.497
*/
.ROUND_MINUS;
/* Selects Round-to-Negative Infinity. The value rounds to the next smaller.
For negative numbers, a 1 is subtracted from the third decimal digit (the least significant bit).
Then the result is truncated after the LSB.
For positive numbers, the mantissa is truncated
after the third decimal digit (LSB).

1.2581 rounds to 1.258
8.5996 rounds to 8.599
-5.3298 rounds to -5.330
-6.4974 rounds to -6.498

*/
**.SECTION, Declare a Memory Section**

The **.SECTION** directive marks the beginning of a logical section mirroring an array of contiguous locations in your processor memory. Statements between one **.SECTION** directive and the following **.SECTION** directive (or the end-of-file instruction), comprise the content of the section.

**TigerSHARC and Blackfin Syntax:**

`.SECTION/qualifier [/qualifier] sectionName [sectionType];`

**SHARC Syntax:**

`.SECTION[/TYPE/qualifier sectionName [sectionType];`

- All qualifiers are optional, and more than one qualifier can be used.

**Common .SECTION Attributes**

The following are common syntax attributes used by the assembler:

- **sectionName** – section name symbol which is not limited in length and is case sensitive. Section names must match the corresponding input section names used by the .ldf file to place the section. Use the default .ldf file included in the `<install_path>/ldf` subdirectory of the VisualDSP++ installation directory, or write your own .ldf file.

- Some sections starting with “.” names have certain meaning within the linker. Do not use the dot (.) as the initial character in `sectionName`. 

---

VisualDSP++ 5.0 Assembler and Preprocessor Manual
1-125
The assembler generates re-locatable sections for the linker to fill in the addresses of symbols at link-time. The assembler implicitly prefixes the name of the section with the “.rela.” string to form a re-locatable section. To avoid ambiguity, ensure that your section names do not begin with “.rela.”

- `sectionType` – an optional ELF section type identifier. The assembler uses the default `SHT_PROGBITS` when this identifier is absent. For example, `.SECTION program SHT_DEBUGINFO;

Supported ELF section types are `SHT_PROGBITS`, `SHT_DEBUGINFO`, and `SHT_NULL`. These `sectionTypes` are described in the `ELF.h` header file, which is available from third-party software development kits. For more information on the ELF file format, see the VisualDSP++ 5.0 Linker and Utilities Manual.

If you select an invalid common qualifier or specify no common qualifier, the assembler exits with an error message.

Blackfin Example:

```asm
/* Declared below memory sections correspond to the default LDF's input sections. */
.SECTION/DOUBLE32 data1; /* memory section to store data */
.SECTION/DOUBLE32 program; /* memory section to store code */
```

### DOUBLE* Qualifiers

The `DOUBLE*` qualifier can be one of the following, listed in Table 1-19.

<table>
<thead>
<tr>
<th>Qualifier</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOUBLE32</td>
<td><code>DOUBLES</code> are represented as 32-bit types</td>
</tr>
<tr>
<td>DOUBLE64</td>
<td><code>DOUBLES</code> are represented as 64-bit types</td>
</tr>
<tr>
<td>DOUBLEANY</td>
<td>Section does not include code that depends on the size of <code>DOUBLE</code></td>
</tr>
</tbody>
</table>
The **DOUBLE** size qualifiers are used to ensure that object files are consistent when linked together and with run-time libraries. A memory section may have one **DOUBLE** size qualifier – it cannot have two **DOUBLE** size qualifiers. Sections in the same file do not have to have the same type size qualifiers.

Use of **DOUBLEANY** in a section implies that **DOUBLE**’s are not used in this section in any way that would require consistency checking with any other section.

**TigerSHARC-Specific Qualifiers**

In addition, the TigerSHARC-specific **qualifier1, qualifier2 ...** can be one of the following, listed in Table 1-20.

<table>
<thead>
<tr>
<th>CHAR8</th>
<th>CHAR32</th>
<th>CHARANY</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHARs are represented as 8-bit types. Shorts are represented as 16-bit types.</td>
<td>CHARs are represented as 32-bit types. Shorts are represented as 32-bit types.</td>
<td>Section does not include code that depends on the size of CHAR.</td>
</tr>
</tbody>
</table>

The **char** size qualifiers are used to ensure that object files are consistent when linked together and with run-time libraries. A section may have a **double** size qualifier and a **char** size qualifier. It cannot have two **char** size qualifiers. Sections in the same file do not have to have the same type size qualifiers.

Use of **CHARANY** in a section implies that **char** and **shorts** are not used in this section in any way that would require consistency checking with any other section.

**SHARC-Specific Qualifiers**

For the SHARC assembler, the .SECTION directive supports qualifiers that specify the size of data words in the section. A qualifier can specify restricted placement for the section. Each section that defines data or code...
must bear an appropriate size qualifier; the placement qualifier is optional. **Table 1-21** lists the SHARC-specific qualifiers.

### Table 1-21. SHARC-Specific Qualifiers

<table>
<thead>
<tr>
<th>Memory/Section Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PM or Code</strong></td>
<td>Section contains instructions and/or data in 48-bit words. By default, PM is assembled as <strong>SW</strong> on 2146x processors.</td>
</tr>
<tr>
<td><strong>DM or Data</strong></td>
<td>Section contains data in 40-bit words</td>
</tr>
<tr>
<td><strong>DATA64</strong></td>
<td>Section defines data in 64-bit words</td>
</tr>
<tr>
<td><strong>DMAONLY</strong></td>
<td>Placement qualifier for a section to be placed in memory and accessed through DMA only. The qualifier passes to the linker a request to place the section in a memory segment with the <code>DMAONLY</code> qualifier, which applies to memory accessed through the external parallel port of the ADSP-2126x and some ADSP-2136x processors.</td>
</tr>
<tr>
<td><strong>NW</strong></td>
<td>Placement qualifier for a normal-word section. Instructions will be assembled as normal 48-bit instructions and loaded into a 48-bit memory segment. Unlike PM sections, NW sections are always 48 bits and unaffected by the <code>-short-word-code</code> or <code>-swc</code> switch. See on page 1-169 for more information. <strong>Note:</strong> Applicable to the ADSP-2146x processors only.</td>
</tr>
<tr>
<td><strong>SW</strong></td>
<td>Placement qualifier for a 16-bit short-word section. Instructions will be assembled and loaded into a 16-bit short-word memory segment. Instructions will be assembled as compressed 16- or 32-bit instructions, if possible. See <code>-short-word-code</code> or <code>-swc</code> for more information. <strong>Note:</strong> Applicable to the ADSP-2146x processors only.</td>
</tr>
</tbody>
</table>

#### Example:

```
.SECTION/DM/DMAONLY seg_extm:
.VAR _external_var[100]:
```
Initialization Section Qualifiers

The .SECTION directive may identify “how/when/if” a section is initialized. The initialization qualifiers, common for all supported assemblers, are listed in Table 1-22.

Initialize data in a /NO_INIT or /ZERO_INIT section is ignored. For example, the assembler can generate a warning for the .VAR zz initialization.

<table>
<thead>
<tr>
<th>Qualifier</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO_INIT</td>
<td>The section is “sized” to have enough space to contain all data elements placed in this section. No data initialization is used for this memory section.</td>
</tr>
<tr>
<td>ZERO_INIT</td>
<td>Similar to /NO_INIT, except that the memory space for this section is initialized to zero at “load time” or “runtime”, if invoked with the linker’s -meminit switch. If the -meminit switch is not used, the memory is initialized at “load” time when the .Dxe file is loaded via VisualDSP++ IDDE, or boot-loaded by the boot kernel. If the memory initializer is invoked, the C/C++ run-time library (CRTL) processes embedded information to initialize the memory space during the CRTL initialization process.</td>
</tr>
<tr>
<td>RUNTIME_INIT</td>
<td>If the memory initializer is not run, this qualifier has no effect. If the memory initializer is invoked, the data for this section is set during the CRTL initialization process.</td>
</tr>
</tbody>
</table>

Example:

```
.SECTION/NO_INIT seg_bss;
.VAR big[0x100000];

.SECTION/ZERO_INIT seg_bsz;
.VAR big[0x100000];

Initialized data in a /NO_INIT or /ZERO_INIT section is ignored. For example, the assembler can generate a warning for the .VAR zz initialization.

.SECTION/NO_INIT seg_bss:
.VAR xx[1000];
.VAR zz = 25;   /* [Warning eal141] "example.asm":3 'zz': */
```
Likewise, the assembler generates a warning for an explicit initialization to 0 in a ZERO_INIT section.

```
.SECTION/ZERO_INIT seg_bsz:
.VAR xx[1000]:
.VAR zz = 0;
```

The assembler calculates the size of NO_INIT and ZERO_INIT sections exactly as for the standard SHT_PROGBITS sections. These sections, like the sections with initialized data, have the SHF_ALLOC flag set. Alignment sections are produced for NO_INIT and ZERO_INIT sections.

Table 1-23. Section Qualifiers, Section-Header-Types, and Section-Header-Flags

<table>
<thead>
<tr>
<th>.SECTION Qualifier</th>
<th>ELF SHT_ (Elf.h) Section-Header-Type</th>
<th>ELF SHF_ (Elf.h) Section-Header-Flag</th>
</tr>
</thead>
<tbody>
<tr>
<td>.SECTION/NO_INIT</td>
<td>SHT_NOBITS</td>
<td>SHF_ALLOC</td>
</tr>
<tr>
<td>.SECTION/ZERO_INIT</td>
<td>SHT_NOBITS</td>
<td>SHF_ALLOC, SHF_INIT</td>
</tr>
<tr>
<td>.SECTION/RUNTIME_INIT</td>
<td>SHT_PROGBITS</td>
<td>SHF_ALLOC, SHF_INIT</td>
</tr>
</tbody>
</table>

For more information, refer to the VisualDSP++ 5.0 Linker and Utilities Manual.
.SEGMENT and .ENDSEG, Legacy Directives

Used with SHARC processors only.

Releases of the ADSP-210xx DSP development software prior to VisualDSP++ 4.1 used the .SEGMENT and .ENDSEG directives to define the beginning and end of a section of contiguous memory addresses.

Although these directives have been replaced with the .SECTION directive, source code written with .SEGMENT/.ENDSEG legacy directives is accepted by the ADSP-21xxx assembler.

.SEPARATE_MEM_SEGMENTS

Used with TigerSHARC processors only.

The .SEPARATE_MEM_SEGMENTS directive allows you to specify two buffers the linker should try to place into different memory segments.

Syntax:

.SECTION data1;
.VAR buf1;
.VAR buf2;
.EXTERN buf3;
.SEPARATE_MEM_SEGMENTS buf1, buf2;
.SEPARATE_MEM_SEGMENTS buf1, buf3;

You can also use the compiler’s separate_mem_segments pragma to perform the same function. For more information, refer to your processor’s VisualDSP++ 5.0 C/C++ Compiler and Library Manual.
.SET, Set a Symbolic Alias

The .SET directive is used to alias one symbol for another.

Syntax:

```
.SET symbol1, symbol2
```

where:

- `symbol1` becomes an alias to `symbol2`.

Example:

```
.SET symbol1, symbol1
```

.SHORT, Defines and initializes 2-byte data objects

Used with Blackfin processors only.

The .SHORT directive declares and optionally initializes two-byte data objects. It is effectively equivalent to .BYTE2 `initExpression1, initExpression2, ...` For more information, see “.BYTE, Declare a Byte Data Variable or Buffer” on page 1-81.

Syntax:

When declaring and/or initializing memory variables or buffer elements, use this format. Note that the terminating semicolon is optional.

```
.SHORT initExpression1, initExpression2, ...;
.SHORT constExpression1, constExpression2, ...;
```

where:

- `initExpressions` parameters – contain one or more comma-separated “symbol=value” expressions
- `constExpressions` parameters – contain a comma-separated list of constant values
The following lines of code demonstrate .SHORT directives:

```assembly
// Declare three 2-byte variables, zero-initialized
.SHORT Ins, Outs, Remains;
// Declare a 2-byte variable and initialize it to 100
.SHORT taps=100;
// Declare three 2-byte areas of memory, initialized to 3, 4 and 5 respectively
.SHORT 0x3, 0x4, 0x5;
```

### .STRUCT, Create a Struct Variable

The .STRUCT directive allows you to define and initialize high-level data objects within the assembly code. The .STRUCT directive creates a struct variable using a C-style `typedef` as its guide from .IMPORT C header files.

**Syntax:**

```assembly
.SHORT typedef structName;
.SHORT typedef structName = {}
.SHORT typedef structName = {
   struct-member-initializers
   [, struct-member-initializers … ]
};
.SHORT typedef ArrayOfStructs [] =
   { struct-member-initializers
     [, struct-member-initializers … ]
   };
```

**where:**

- `typedef` – the type definition for a struct `VARstructName` – a struct name
- `struct-member-initializers` – per struct member initializers

The `{}` curly braces are used for consistency with the C initializer syntax. Initialization can be in “long” form or “short” form where data member
names are not included. The short form corresponds to the syntax in C compiler struct initialization with these changes:

- C compiler keyword `struct` is changed to `.struct` by adding the period (.)
- C compiler constant string syntax "MyString" is changed to 'MyString' by changing the double quotes (" ") into single quotes (' ')

The long form is assembler-specific and provides the following benefits:

- Provides better error checking
- Supports self-documenting code
- Protects from possible future changes to the layout of the `struct`. If an additional member is added before the member is initialized, the assembler will continue to offset to the correct location for the specified initialization and zero-initialize the new member.

Any members that are not present in a long-form initialization are initialized to zero. For example, if struct `StructThree` has three members (`member1`, `member2`, and `member3`), and

```
.PROCESS StructThree myThree {
  member1 = 0xaa,
  member3 = 0xff
};
```

`member2` will be initialized to 0 because no initializer was present for it. If no initializers are present, the entire struct is zero-initialized.

If data member names are present, the assembler validates that the assembler and compiler are in agreement about these names. The initialization of data struct members declared via the assembly `.STRUCT` directive is processor-specific.
Example 1. Long Form .STRUCT Directive

```asm
#define NTSC 1
// contains layouts for playback and capture_hdr
.import "comdat.h"
.struct capture_hdr myLastCapture = {
  captureInt = 0,
  captureString = 'InitialState'
};
.struct myPlayback playback = {
  theSize = 0,
  ready = 1,
  stat_debug = 0,
  last_capture = myLastCapture,
  watchdog = 0,
  vidtype = NTSC
};
```

Example 2. Short Form .STRUCT Directive

```asm
#define NTSC 1
// contains layouts for playback and capture_hdr
.import "comdat.h"
.struct capture_hdr myLastCapture = { 0, 'InitialState' };
.struct playback myPlayback = { 0, 1, 0, myLastCapture, 0, NTSC};
```

Example 3. Long Form .STRUCT Directive to Initialize an Array

```asm
.struct structWithArrays XXX = {
  scalar = 5,
  array1 = { 1,2,3,4,5 },
  array2 = { "file1.dat" },
  array3 = "WithBraces.dat" // must have { } within dat
};
```

In the short form, nested braces can be used to perform partial initializations as in C. In Example 4 below, if the second member of the struct is an
array with more than four elements, the remaining elements is initialized to zero.

Example 4. Short Form .STRUCT Directive to Initialize an Array

```
.STRUCT structWithArrays XXX = { 5, { 1,2,3,4 }, 1, 2 };
```

Example 5. Initializing a Pointer

A struct may contain a pointer. Initialize pointers with symbolic references.

```
.EXTERN outThere;
.VAR myString[] = 'abcde',0;
.STRUCT structWithPointer PPP = {
    scalar = 5,
    myPtr1 = myString,
    myPtr2 = outThere
};
```

Example 6. Initializing a Nested Structure

A struct may contain a struct. Use fully qualified references to initialize nested struct members. The struct name is implied.

For example, the reference “scalar” (“nestedOne->scalar” implied) and “nested->scalar1” (“nestedOne->nested->scalar1” implied).

```
.STRUCT NestedStruct nestedOne = {
    scalar = 10,
    nested->scalar1 = 5,
    nested->array = { 0x1000, 0x1010, 0x1020 }
};
```

.TYPE, Change Default Symbol Type

The .TYPE directive directs the assembler to change the default symbol type of an object. This directive may appear in the compiler-generated assembly source file (.s).

Syntax:

```
.TYPE symbolName, symbolType;
```

where:

- `symbolName` – the name of the object to which the `symbolType` is applied
- `symbolType` – an ELF symbol type STT_* Valid ELF symbol types are listed in the ELF.h header file. By default, a label has an STT_FUNC symbol type, and a variable or buffer name defined in a storage directive has an STT_OBJECT symbol type.
.VAR, Declare a Data Variable or Buffer

The .VAR directive declares and optionally initializes variables and data buffers. A variable uses a single memory location, and a data buffer uses an array of memory locations.

When declaring or initializing variables:

- A .VAR directive may appear only within a section. The assembler associates the variable with the memory type of the section in which the .VAR appears.
- A single .VAR directive can declare any number of variables or buffers, separated by commas, on one line.

Unless the absolute placement for a variable is specified with a RESOLVE() command (from an .ldf file), the linker places variables in consecutive memory locations. For example, .VAR d,f,k[50]; sequentially places symbols x, y, and 50 elements of the buffer z in the processor memory. Therefore, code example may look like:

```assembly
.SECTION data1;
.VAR d;
.VAR f;
.VAR k[50];
```

- The number of initializer values may not exceed the number of variables or buffer locations that you declare.
- The .VAR directive may declare an implicit-size buffer by using empty brackets [ ]. The number of initialization elements defines the length of the implicit-size buffer. At runtime, the length operator can be used to determine the buffer size. For example,

```assembly
.SECTION data1;
.VAR buffer [] = 1,2,3,4;
.SECTION program;
LO = LENGTH( buffer ); // Returns 4
```
Syntax:
The `.VAR` directive takes one of the following forms:

```
.VAR varName1[,varName2,...];
.VAR = initExpression1, initExpression2, ...;
.VAR bufferName[] = {initExpression1, initExpression2, ...};
.VAR bufferName[] = {"fileName"};
.VAR bufferName[length] = "fileName";
.VAR bufferName[length] = initExpression1, initExpression2, ...;
```

where:

- `varName` – user-defined symbols that identify variables
- `bufferName` – user-defined symbols that identify buffers
- `fileName` parameter – indicates that the elements of a buffer get their initial values from the `fileName` data file. The `fileName` can consist of the actual name and path specification for the data file. If the initialization file is in the current directory of your operating system, only the `fileName` need be given quotes. Note that when reading in a data file, the assembler reads in whitespace-separated lists of decimal digits or hex strings.

Initialization from files is useful for loading buffers with data, such as filter coefficients or FFT phase rotation factors that are generated by other programs. The assembler determines how the values are stored in memory when it reads the data files.

- Ellipsis (`...`) – a comma-delimited list of parameters
- `[length]` – optional parameter that defines the length (in words) of the associated buffer. When length is not provided, the buffer size is determined by the number of initializers.

- Brackets (`[ ]`) – enclosing the optional `[length]` is required. For more information, see the following `.VAR` examples.
initExpressions parameters – set initial values for variables and buffer elements.

With Blackfin processors, the assembler uses a /R32 qualifier (.VAR/R32) to support 32-bit initialization for use with 1.31 fracts (see on page 1-61).

The following code demonstrate some .VAR directives:

```assembly
.VAR buf1=0x1234;
    /* Define one initialized variable */
.VAR=0x1234, 0x5678;
    /* Define two initialized words */
.VAR samples[] = {10, 11, 12, 13, 14};
    /* Declare and initialize an implicit-length buffer since there are five values; this has the same effect as samples[5]. */
    /* Initialization values for implicit-size buffer must be in curly brackets. */
.VAR Ins, Outs, Remains;
    /* Declare three uninitialized variables */
.VAR samples[100] = "inits.dat";
    /* Declare a 100-location buffer and initialize it with the contents of the inits.dat file: */
.VAR taps=100;
    /* Declare a variable and initialize the variable to 100 */
.VAR twiddles[10] = "phase.dat";
    /* Declare a 10-location buffer and load the buffer with the contents of the phase.dat file */
.VAR Fract_Var_R32[] = "fr32FormatFract.dat";
```

All Blackfin processor memory accesses require proper alignment. Therefore, when loading or storing an N-byte value into the processor, ensure that this value is aligned in memory by N boundary; otherwise, a hardware exception is generated.

Blackfin Code Example:
In the following example, the 4-byte variables y0, y1, and y2 would be misaligned unless the .ALIGN 4; directive is placed before the .VAR y0; and .VAR y2; statements.

```
 SECTION data1;
 .ALIGN 4;
 .VAR X0;
 .VAR X1;
 .BYTE B0;
 .ALIGN 4: /* aligns the following data item "YO" on a word boundary: advances other data items consequently */
 .VAR Y0;
 .VAR Y1;
 .BYTE B1;
 .ALIGN 4: /* aligns the following data item "Y2" on a word boundary */
 .VAR Y2;
```

**.VAR and ASCII String Initialization Support**

The assemblers support ASCII string initialization. This allows the full use of the ASCII character set, including digits and special characters.

On SHARC and TigerSHARC processors, the characters are stored in the upper byte of 32-bit words. The least significant bits (LSBs) are cleared.

When using 16-bit Blackfin processors, refer to the .BYTE directive description on page 1-81 for more information.

String initialization takes one of the following forms:

```
.VAR symbolString[length] = 'initString', 0;
.VAR symbolString[] = 'initString', 0;
```

Note that the number of initialization characters defines length of a string.
For example,

`.VAR x[13] = 'Hello world!', 0;
`.VAR x[] = {'Hello world!', 0};

The trailing zero character is optional. It simulates ANSI-C string representation.

The assemblers also accept ASCII characters within comments. Note special characters handling:

`.VAR s1[] = {'1st line',13,10,'2nd line',13,10,0};
  /* carriage return */
`.VAR s2[] = {'say:"hello"',13,10,0}; /* quotation mark */
`.VAR s3[] = {'say:',39,'hello',39,13,10,0};
  /* simple quotation marks */
.WEAK, Support Weak Symbol Definition and Reference

The .WEAK directive supports weak binding for a symbol. Use this directive where the symbol is defined (replacing the .GLOBAL directive to make a weak definition) and the .EXTERN directive (to make a weak reference).

Syntax:

.weak symbol;

where:

symbol – the user-defined symbol

Although the linker generates an error if two objects define global symbols with identical names, it allows any number of instances of weak definitions of a name. All will resolve to the first, or to a single, global definition of a symbol.

One difference between .EXTERN and .WEAK references is that the linker does not extract objects from archives to satisfy weak references. Such references, left unresolved, have the value 0.

The .WEAK (or .GLOBAL scope) directive is required to make symbols available for placement through RESOLVE commands in the .ldf file.
Assembler Command-Line Reference

This section describes the assembler command-line interface and switch set. It describes the assembler's switches, which are accessible from the operating system's command line or from the VisualDSP++ environment.

This section contains:

- “Running the Assembler” on page 1-145
- “Assembler Command-Line Switch Descriptions” on page 1-147

Command-line switches control certain aspects of the assembly process, including debugging information, listing, and preprocessing. Because the assembler automatically runs the preprocessor as your program assembles (unless you use the -sp switch), the assembler's command line can receive input for the preprocessor program and direct its operation. For more information on the preprocessor, see Chapter 2, “Preprocessor”.

When developing a DSP project, you may find it useful to modify the assembler's default options settings. The way you set assembler options depends on the environment used to run the DSP development software.

See “Specifying Assembler Options in VisualDSP++” on page 1-173 for more information.
Running the Assembler

To run the assembler from the command line, type the name of the appropriate assembler program followed by arguments (in any order), and the name of the assembly source file.

- `easm21K [-switch1 [-switch2 ...]] sourceFile`
- `easmts [-switch1 [-switch2 ...]] sourceFile`
- `easmlkf [-switch1 [-switch2 ...]] sourceFile`

Table 1-24 explains these arguments.

Table 1-24. Assembler Command Line Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>easm21K</td>
<td>Name of the assembler program for SHARC, TigerSHARC, and Blackfin processors, respectively.</td>
</tr>
<tr>
<td>easmts</td>
<td>Name of the assembler program for SHARC, TigerSHARC, and Blackfin processors, respectively.</td>
</tr>
<tr>
<td>easmlkf</td>
<td>Name of the assembler program for SHARC, TigerSHARC, and Blackfin processors, respectively.</td>
</tr>
<tr>
<td><code>-switch</code></td>
<td>Switch (or switches) to process. The command-line interface offers many optional switches that select operations and modes for the assembler and preprocessor. Some assembler switches take a file name as a required parameter.</td>
</tr>
<tr>
<td><code>sourceFile</code></td>
<td>Name of the source file to assemble.</td>
</tr>
</tbody>
</table>

The name of the source file to assemble can be provided as:

- `ShortFileName` – a file name without quotes (no special characters)
- `LongFileName` – a quoted file name (may include spaces and other special path name characters)

The assembler outputs a list of command-line options when run without arguments (same as `-h[elp]`).
Assembler Command-Line Reference

The assembler supports relative path names and absolute path names. When you specify an input or output file name as a parameter, follow these guidelines for naming files:

- Include the drive letter and path string if the file is not in the current project directory.
- Enclose long file names in double quotation marks; for example, “long file name”.
- Append the appropriate file name extension to each file.

Table 1-25 summarizes file extension conventions accepted by the VisualDSP++ environment.

Table 1-25. File Name Extension Conventions

<table>
<thead>
<tr>
<th>Extension</th>
<th>File Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>.asm</td>
<td>Assembly source file</td>
</tr>
<tr>
<td></td>
<td>Note: The assembler treats files with unrecognized (or not existing) extensions as assembly source files.</td>
</tr>
<tr>
<td>.is</td>
<td>Preprocessed assembly source file</td>
</tr>
<tr>
<td>.h</td>
<td>Header file</td>
</tr>
<tr>
<td>.lst</td>
<td>Listing file</td>
</tr>
<tr>
<td>.doj</td>
<td>Assembled object file in ELF/DWARF-2 format</td>
</tr>
<tr>
<td>.dat</td>
<td>Data initialization file</td>
</tr>
</tbody>
</table>

Assembler command-line switches are case sensitive. For example, the following command line:

easmblkfn -proc ADSP-BF535 -l pList.lst -Dmax=100 -v -o bin\p1.doj p1.asm
runs the assembler with:

- `-proc ADSP-BF535` – specifies assembles instructions unique to
  ADSP-BF535 processors
- `-l pList.lst` – directs the assembler to output the listing file
- `-Dmax=100` – defines the preprocessor macro `max` to be 100
- `-v` – displays verbose information on each phase of the assembly
- `-o bin\p1.doj` – specifies the name and directory for the assembled
  object file
- `p1.asm` – identifies the assembly source file to assemble

**Assembler Command-Line Switch Descriptions**

This section describes the assembler command-line switches in ASCII col-
lation order. A summary of the assembler switches appears in Table 1-26.
A detailed description of each assembler switch starts on page 1-151.

Table 1-26. Assembler Command-Line Switch Summary

<table>
<thead>
<tr>
<th>Switch Name</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>-align-branch-lines</code> (on page 1-151)</td>
<td>Aligns branch lines to avoid ADSP-TS101 processor sequencer anomaly. Note: TigerSHARC processors only.</td>
</tr>
<tr>
<td>`-anomaly-detect id1[,id2,...]</td>
<td>all</td>
</tr>
<tr>
<td>`-anomaly-warn id1[,id2]</td>
<td>all</td>
</tr>
<tr>
<td>`-anomaly-workaround id1[,id2]</td>
<td>all</td>
</tr>
</tbody>
</table>
Table 1-26. Assembler Command-Line Switch Summary (Cont’d)

<table>
<thead>
<tr>
<th>Switch Name</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>-char-size-8</td>
<td>Adds /CHAR8 to .SECTIONs in the source file.</td>
</tr>
<tr>
<td>(on page 1-154)</td>
<td>Note: TigerSHARC processors only.</td>
</tr>
<tr>
<td>-char-size-32</td>
<td>Adds /CHAR32 to .SECTIONs in the source file.</td>
</tr>
<tr>
<td>(on page 1-154)</td>
<td>Note: TigerSHARC processors only.</td>
</tr>
<tr>
<td>-char-size-any</td>
<td>Adds /CHARANY to .SECTIONs in the source file.</td>
</tr>
<tr>
<td>(on page 1-154)</td>
<td>Note: TigerSHARC processors only.</td>
</tr>
<tr>
<td>-default-branch-np</td>
<td>Makes branch lines default to NP to avoid ADSP-TS101 processor sequencer anomaly.</td>
</tr>
<tr>
<td>(on page 1-155)</td>
<td>Note: TigerSHARC processors only.</td>
</tr>
<tr>
<td>-default-branch-p</td>
<td>Makes branch lines default to the Branch Target Buffer (BTB).</td>
</tr>
<tr>
<td>(on page 1-155)</td>
<td>Note: TigerSHARC processors only.</td>
</tr>
<tr>
<td>-Dmacro[^definition]</td>
<td>Passes macro definition to the preprocessor.</td>
</tr>
<tr>
<td>(on page 1-155)</td>
<td></td>
</tr>
<tr>
<td>-double-size-32</td>
<td>Adds /DOUBLE32 to .SECTIONs in the source file.</td>
</tr>
<tr>
<td>(on page 1-156)</td>
<td></td>
</tr>
<tr>
<td>-double-size-64</td>
<td>Adds /DOUBLE64 to .SECTIONs in the source file.</td>
</tr>
<tr>
<td>(on page 1-156)</td>
<td></td>
</tr>
<tr>
<td>-double-size-any</td>
<td>Adds /DOUBLEANY to .SECTIONs in the source file.</td>
</tr>
<tr>
<td>(on page 1-156)</td>
<td></td>
</tr>
<tr>
<td>-expand-symbolic-links</td>
<td>Enables support for Cygwin style paths.</td>
</tr>
<tr>
<td>(on page 1-157)</td>
<td></td>
</tr>
<tr>
<td>-expand-windows-shortcuts</td>
<td>Enables support for Windows shortcuts.</td>
</tr>
<tr>
<td>(on page 1-157)</td>
<td></td>
</tr>
<tr>
<td>(on page 1-157)</td>
<td></td>
</tr>
<tr>
<td>-flags-compiler -opt1</td>
<td>Passes each comma-separated option to the compiler.</td>
</tr>
<tr>
<td>...</td>
<td>(Used when compiling .IMPORT C header files.)</td>
</tr>
<tr>
<td>(on page 1-157)</td>
<td></td>
</tr>
<tr>
<td>-flags-pp -opt1</td>
<td>Passes each comma-separated option to the preprocessor.</td>
</tr>
<tr>
<td>...</td>
<td></td>
</tr>
<tr>
<td>(on page 1-159)</td>
<td></td>
</tr>
<tr>
<td>-g</td>
<td>Generates debug information (DWARF-2 format).</td>
</tr>
<tr>
<td>(on page 1-159)</td>
<td></td>
</tr>
</tbody>
</table>
Table 1-26. Assembler Command-Line Switch Summary (Cont’d)

<table>
<thead>
<tr>
<th>Switch Name</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>-h[elp]</td>
<td>Outputs a list of assembler switches. (on page 1-161)</td>
</tr>
<tr>
<td>-i</td>
<td>-I directory pathname</td>
</tr>
<tr>
<td>-l filename</td>
<td>Outputs the named listing file. (on page 1-162)</td>
</tr>
<tr>
<td>-li filename</td>
<td>Outputs the named listing file with #include files expanded. (on page 1-163)</td>
</tr>
<tr>
<td>-M</td>
<td>Generates make dependencies for #include and data files only; does not assemble. For example, -M suppresses the creation of an object file. (on page 1-163)</td>
</tr>
<tr>
<td>-MM</td>
<td>Generates make dependencies for #include and data files. Use -MM for make dependencies with assembly. (on page 1-163)</td>
</tr>
<tr>
<td>-Mo filename</td>
<td>Writes make dependencies to the filename specified. The -Mo option is for use with either the -M or -MM option. If -Mo is not present, the default is &lt;stdout&gt; display. (on page 1-164)</td>
</tr>
<tr>
<td>-Mt filename</td>
<td>Specifies the make dependencies target name. The -Mt option is for use with either the -M or -MM option. If -Mt is not present, the default is base name plus 'DOJ'. (on page 1-164)</td>
</tr>
<tr>
<td>-micaswarn</td>
<td>Treats multi-issue conflicts as warnings. Note: Blackfin processors only. (on page 1-164)</td>
</tr>
<tr>
<td>-no-anomaly-detect</td>
<td>Does not issue a warning or an error for an anomaly id. (on page 1-165)</td>
</tr>
<tr>
<td>-no-anomaly-workaround</td>
<td>Does not implement a workaround for an anomaly id. (on page 1-165)</td>
</tr>
<tr>
<td>-no-expand-symbolic-links</td>
<td>Disables support for Cygwin style paths. (on page 1-166)</td>
</tr>
<tr>
<td>-no-expand-windows-shortcuts</td>
<td>Disables support for Windows shortcuts. (on page 1-166)</td>
</tr>
</tbody>
</table>
Table 1-26. Assembler Command-Line Switch Summary (Cont’d)

<table>
<thead>
<tr>
<th>Switch Name</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>-no-temp-data-file (on page 1-166)</td>
<td>Suppresses writing temporary data to a disk file. Note: Blackfin processors only.</td>
</tr>
<tr>
<td>-no-source-dependency (on page 1-164)</td>
<td>Suppresses output of the source filename in the dependency output produced when ”-M” or ”-MM” has been specified.</td>
</tr>
<tr>
<td>-normal-word-code -nwc (on page 1-167)</td>
<td>Encodes input sections bearing the /PM qualifier (see Table 1-21) for execution from normal word memory. Note: ADSP-2146x processors only.</td>
</tr>
<tr>
<td>-o filename (on page 1-167)</td>
<td>Outputs the named object [binary] file.</td>
</tr>
<tr>
<td>-pp (on page 1-167)</td>
<td>Runs the preprocessor only; does not assemble.</td>
</tr>
<tr>
<td>-proc processor (on page 1-168)</td>
<td>Specifies a target processor for which the assembler should produce suitable code.</td>
</tr>
<tr>
<td>-save-temps (on page 1-168)</td>
<td>Saves intermediate files</td>
</tr>
<tr>
<td>-short-word-code -swc (on page 1-169)</td>
<td>Encodes input sections bearing the /PM qualifier (see Table 1-21) for execution from short word memory. Note: ADSP-2146x processors only.</td>
</tr>
<tr>
<td>-si-revision version (on page 1-169)</td>
<td>Specifies silicon revision of the specified processor.</td>
</tr>
<tr>
<td>-sp (on page 1-170)</td>
<td>Assembles without preprocessing.</td>
</tr>
<tr>
<td>-stallcheck={none</td>
<td>cond</td>
</tr>
<tr>
<td>-swc-exclude name1[,name2 …] (on page 1-170)</td>
<td>Excludes the named section(s) from the effect of the -short-word-code (-swc) switch. Note: ADSP-2146x processors only.</td>
</tr>
</tbody>
</table>
A description of each command-line switch includes information about case-sensitivity, equivalent switches, switches overridden/contradicted by the one described, and naming and spacing constraints on parameters.

### -align-branch-lines

This switch is used with TigerSHARC processors only.

The **-align-branch-lines** switch directs the assembler to align branch instructions (**JUMP, CALL, CJMP, CJMP_CALL, RETI, and RTI**) on quad-word
boundaries by inserting `NOP` instructions prior to the branch instruction. This may be done by adding `NOP` instructions in free slots in previous instruction lines.

`-anomaly-detect {id1[,id2...]|all|none}`

The `-anomaly-detect` switch directs the assembler to check for assembly code that may be affected by any of the hardware anomalies listed in the `id` switches. The `id` switch parameter is:

`id` – Anomaly identifier
The anomaly identifier syntax may use or omit dashes. For example, either `05-00-0245` or `05000245` are accepted. Additionally, `ids` specified override the `all` and `none` options. For example, `-anomaly-detect none,050000245` detects only anomaly `050000245`.

`all` – use all identifiers applicable to the given processor

`none` – ignore all identifiers not specifically provided (same as `-no-anomaly-detect all`)

If the check detects assembly code that will be affected by the specified anomaly (or anomalies), the assembler issues a warning. Using this option helps you detect and avoid code combinations affected by anomalies.

⚠ A warning can also be issued if the assembler always implements a code workaround for an anomaly, instead of just performing a check.

`-anomaly-warn {id1[,id2]|all|none}`

The `-anomaly-warn` switch directs the assembler to check assembly instructions against hardware anomalies. Switch parameters are:

`id` – anomaly identifier (for example, `05-00-0245` or `05000245`)

`all` – uses all identifiers known to the assembler
none – do nothing

This switch allows the user to control which anomaly warnings are to be displayed. Typically, code is assembled using the \texttt{-anomaly-warn all} selection. This will cause the assembler to issue a warning for all anomalies it knows about.

For example, the switch yields the following anomaly IDs.

\begin{verbatim}
05000165   05000209   05000227   05000244
05000245   F3F008    F3F013    F3F021
\end{verbatim}

Any combination of these warning IDs can be used as part of the command-line option.

The most recent list of anomalies can be obtained from the Analog Devices Web site, namely from:


\textbf{This switch is used with Blackfin processors only.}

\texttt{-anomaly-workaround \{id1[,id2...]|all|none\}}

The \texttt{-anomaly-workaround} switch directs the assembler to switch on any workaround instruction for a specific hardware anomaly. Switch parameters are:

\begin{itemize}
\item \texttt{id} – anomaly identifier (for example, \texttt{05-00-0245} or \texttt{05000245})
\item \texttt{all} – uses all identifiers applicable to the given processor (same as \texttt{-no-anomaly-workaround none})
\item \texttt{none} – ignore all identifiers not specifically provided (same as \texttt{-no-anomaly-workaround all})
\end{itemize}

The anomaly identifier syntax may use or omit dashes. For example, either \texttt{05-00-00245} or \texttt{050000245} are accepted. Additionally, specified ids over-
ride the all and none options. For example, -anomaly-workaround none,050000245 works around only anomaly 050000245.

The workaround may result in an assembler altering the user assembly code so that it cannot encounter the anomaly. The assembler may issue a warning to indicate that it has altered the user assembly code. This option overrules any default behavior for the anomaly.

A warning may be issued if the assembler always checks for the anomaly and has no workaround.

- **char-size-8**

The -char-size-8 switch directs the assembler to add /CHAR8 to .SECTIONs in the source file that do not have char size qualifiers. For .SECTIONs in the source file that already have a char size qualifier, this option is ignored and a warning is produced. For more information, see “.SECTION, Declare a Memory Section” on page 1-125.

ℹ️ This switch is used with TigerSHARC processors only.

- **char-size-32**

The -char-size-32 switch directs the assembler to add /CHAR32 to .SECTIONs in the source file that do not have char size qualifiers. For .SECTIONs in the source file that already have a char size qualifier, this option is ignored and a warning is produced. For more information, see “.SECTION, Declare a Memory Section” on page 1-125.

ℹ️ This switch is used with TigerSHARC processors only.

- **char-size-any**

The -char-size-any switch directs the assembler to add /CHARANY to .SECTIONs in the source file that do not have char size qualifiers. For .SECTIONs in the source file that already have a char size qualifier,
this option is ignored and a warning is produced. For more information, see “.SECTION, Declare a Memory Section” on page 1-125.

This switch is used with TigerSHARC processors only.

-**default-branch-np**

The `-default-branch-np` (branch lines default to NP) switch directs the assembler to stop branch instructions (JUMP, CALL) from using the branch target buffer (BTB). This can be used to avoid a sequencer anomaly present on the ADSP-TS101 processor only. It is still possible to make branch instructions use the BTB when `-default-branch-np` is used by adding the `(P)` instruction option; for example, JUMP lab1 (P);;

This switch is used with TigerSHARC processors only.

-**default-branch-p**

The `-default-branch-p` switch makes branch instructions (JUMP, CALL) use the branch target buffer (BTB). This is the default behavior. It is still possible to make branch instructions not use the BTB when `-default-branch-p` is used by adding the `(NP)` instruction option; for example, JUMP label (NP);;

This switch is used with TigerSHARC processors only.

-**Dmacro[=definition]**

The `-D` (define macro) switch directs the assembler to define a macro and pass it to the preprocessor. See “Using Assembler Feature Macros” on page 1-25 for the list of predefined macros.

For example,

```
-Dinput // defines input as 1
-Dsamples=10 // defines samples as 10
```
-double-size-32

The `-double-size-32` switch directs the assembler to add `/DOUBLE32` to `.SECTION` sections in the source file that do not have `double` size qualifiers. For `.SECTION` sections in the source file that already have a `double` size qualifier, this option is ignored and a warning is produced. For more information, see “.SECTION, Declare a Memory Section” on page 1-125.

-double-size-64

The `-double-size-64` switch directs the assembler to add `/DOUBLE64` to `.SECTION` sections in the source file that do not have `double` size qualifiers. For `.SECTION` sections in the source file that already have a `double` size qualifier, this option is ignored and a warning is produced. The `-double-size-any` flag should be used to avoid a linker warning when compiling C/C++ sources with `-double-size-64`.

Warning Example:

[Warning li2151] Input sections have inconsistent qualifiers as follows.

For more information, see “.SECTION, Declare a Memory Section” on page 1-125.

-double-size-any

The `-double-size-any` switch directs the assembler to add `/DOUBLEANY` to `.SECTION` sections in the source file that do not have `double` size qualifiers, making `SECTION` contents independent of size of `double` type. For `.SECTION` sections in the source file that already have a `double` size qualifier, this option is ignored and a warning is produced. For more information, see “.SECTION, Declare a Memory Section” on page 1-125.
**-expand-symbolic-links**

The `expand-symbolic-links` switch directs the assembler to correctly access directories and files whose name or path contain Cygwin path components.

**-expand-windows-shortcuts**

The `expand-windows-shortcuts` switch directs the assembler to correctly access directories and files whose name or path contain Windows shortcuts.

**-file-attr attr [=val]**

The `-file-attr` (file attribute) switch directs the assembler to add an attribute (`attr`) to the object file. The attribute will be given the value (`val`) or “1” if the value is omitted. `Attr` should follow the rules for naming symbols. `Val` should be double-quoted unless it follows the rules for naming symbols. See “Assembler Keywords and Symbols” on page 1-42 for more information on naming conventions.

**-flags-compiler**

The `-flags-compiler -opt1 [, -opt2 …]` switch passes each comma-separated option to the C compiler. The switch takes a list of one or more comma-separated compiler options that are passed on the compiler command line for compiling .IMPORT headers. The assembler calls the compiler to process each header file in an .IMPORT directive. It calls the compiler with the `debug-types` option along with any `-flags-compiler` switches given on the assembler command line.

For example,

```
// file.asm has .IMPORT "myHeader.h"

easmbkln -proc ADSP-BF535 -flags-compiler -I/Path -I. file.asm
```
Assembler Command-Line Reference

The rest of the assembly program, including its #include files, are processed by the assembler preprocessor. The -flags-compiler switch processes a list of one or more valid C compiler options, including the -D and -I options.

User-Specified Defines Options

-D (defines) options in an assembler command line are passed to the assembler preprocessor, but they are not passed to the compiler for .IMPORT header processing. If #defines are used for .IMPORT header compilation, they must be explicitly specified with the -flags-compiler switch.

For example,

```c
// file.asm has .IMPORT "myHeader.h"
easmb1kfn -proc ADSP-BF535 -DaDef -flags-compiler -DbDef,
-DbDefTwo=2 file.asm

// -DaDef is not passed to the compiler
ccblkfn -proc ADSP-BF535 -c -debug-types -DbDef -DbDefTwo=2
myHeader.h
```

See “Using Assembler Feature Macros” on page 1-25 for the list of predefined macros, including default macros.

Include Options

The -I (include search path) options and -flags-compiler arguments are passed to the C compiler for each .IMPORT header compilation. The compiler include path is always present automatically.

Use the -flags-compiler switch to control the order that the include directories are searched. The -flags-compiler switch attributes take precedence from the assembler’s -I options.
For example,

```
easmlkfn -proc ADSP-BF535 -I/aPath -DaDef -flags-compiler
-I/cPath,-I. file.asm
```

```
ccblkfn -proc ADSP-BF535 -c -debug-types -I/cPath -I. myHeader.h
```

The .IMPORT C header files are preprocessed by the C compiler preprocessor. The struct headers are standard C headers, and the standard C compiler preprocessor is needed. The rest of the assembly program (including its #include files) are processed by the assembler preprocessor.

Assembly programs are preprocessed using the pp preprocessor (the assembler/linker preprocessor) as well as -I and -D options from the assembler command line. However, the pp call does not receive the -flags-compiler switch options.

**-flags-pp [-opt1 [-opt2...]]**

The -flags-pp switch passes each comma-separated option to the preprocessor.

ℹ️ Use -flags-pp with caution. For example, if pp legacy comment syntax is enabled, the comment characters become unavailable for non-comment syntax.

**-g**

The -g (generate debug information) switch directs the assembler to generate complete data type information for arrays, functions, and the C structs. This switch also generates DWARF2 function information with starting and ending ranges based on the `myFunc: ... myFunc.end: label` boundaries, as well as line number and symbol information in DWARF2 binary format, allowing you to debug the assembly source files.
When the assembler’s -g switch is in effect, the assembler produces a warning when it is unable to match a *end label to a matching beginning label. This feature can be disabled using the -Wnumber[,number] switch (see on page 1-171).

**WARNING ea1121: Missing End Labels**

Warning ea1121 occurs on assembly file debug builds (using the -g switch) when a globally-defined function or label for a data object is missing its corresponding ending label, with the naming convention label + "end".

For example,

```
[Warning ea1121] "./gfxeng_thickarc.asm":42 _gfxeng_thickarc:
-g assembly with global function without ending label. Use
'_gfxeng_thickarc.end' or '_gfxeng_thickarc.END' to mark the
ending boundary of the function for debugging information for
automated statistical profiling of assembly functions.
```

The ending label marks the boundary of the end of a function. Compiled code automatically provides ending labels. Hand-written assembly code needs to have the ending labels explicitly added to tell the tool chain where the ending boundary is. This information is used to automate statistical profiling of assembly functions. It is also needed by the linker to eliminate unused functions and other features.

To suppress a specific assembler warning by unique warning number, the assembler provides the following option:

```
-Wsuppress 1121
```

It is highly recommended that warning ea1121 not be suppressed and the code be updated to have ending labels.
Functions (Code):

_gfxeng_vertspan:

[--sp] = fp;
...

rts;

Add an ending label after rts:. Use the suffix “.end” and begin the label with “.” to have it treated as an internal label that is not displayed in the debugger.

.global _gfxeng_vertspan;
_gfxeng_vertspan:
[--sp] = fp;
...

rts;
._gfxeng_vertspan.end:

-h[elp]

The -h (or -help) switch directs the assembler to output to standard output a list of command-line switches with a syntax summary.

-i

The -i directory (or -I) switch (include directory path) directs the assembler to append the specified directory (or a list of directories separated by semicolons “;”) to the search path for included files.

No space is allowed between -i and the path name.
Assembler Command-Line Reference

These files are:

- Header files (.h) included with the #include preprocessor command
- Data initialization files (.dat) specified with the .VAR assembly directive

The assembler passes this information to the preprocessor; the preprocessor searches for included files in the following order:

1. Directory for assembly program
2. \include subdirectory of the VisualDSP++ installation directory
3. Specified directory (or list of directories). The order of the list defines the order of multiple searches.

The current directory is the directory where the assembly service is, not the directory of the project. Usage of full path names for the -I switch on the command line is recommended.

For example,

easm21K -proc ADSP-21161 -I "\bin\include" file.asm

-l filename

The -l filename (listing) switch directs the assembler to generate the named listing file. Each listing file (.lst) shows the relationship between your source code and instruction opcodes that the assembler produces.

For example,

easmb1kfn -proc ADSP-BF533 -I \path -I. -l file.lst file.asm

The file name is a required argument to the -l switch. For more information, see “Reading a Listing File” on page 1-38.
**-li filename**

The -li (listing) switch directs the assembler to generate the named listing file with #include files. The file name is a required argument to the -li switch. For more information, see “Reading a Listing File” on page 1-38.

**-M**

The -M (generate make rule only) assembler switch directs the assembler to generate make dependency rules, suitable for the make utility, describing the dependencies of the source file. No object file is generated for -M assemblies. For make dependencies with assembly, use the -MM switch.

The output, an assembly make dependencies list, is written to stdout in the standard command-line format:

```
“target_file”: “dependency_file.ext”
```

dependency_file.ext may be an assembly source file, a header file included with the #include preprocessor command, a data file, or a header file imported via the .IMPORT directive.

The -Mo filename switch writes make dependencies to the filename specified instead of <stdout>. For consistency with the compilers, when -o filename is used with -M, the assembler outputs the make dependencies list to the named file. The -Mo filename takes precedence if both -o filename and -Mo filename are present with -M.

**-MM**

The -MM (generate make rule and assemble) assembler switch directs the assembler to output a rule, suitable for the make utility, describing the dependencies of the source file. The assembly of the source into an object file proceeds normally. The output, an assembly make dependencies list, is written to stdout. The only difference between -MM and -M actions is that the assembling continues with -MM. See -M for more information.
Assembler Command-Line Reference

-Mo filename

The -Mo (output make rule) assembler switch specifies the name of the make dependencies file that the assembler generates when you use the -M or -MM switch. If -Mo is not present, the default is <stdout> display. If the named file is not in the current directory, you must provide the path name in double quotation marks (" ").

The -Mo filename switch takes precedence over the -o filename switch.

-Mt filename

The -Mt filename (output make rule for named object) assembler switch specifies the name of the object file for which the assembler generates the make rule when you use the -M or -MM switch. If the named file is not in the current directory, you must provide the path name. If -Mt is not present, the default is the base name plus the .doj extension. See -M for more information.

-micaswarn

The -micaswarn switch treats multi-issue conflicts as warnings.

This switch is used with Blackfin processors only.

-no-source-dependency

The -no-source-dependency switch directs the assembler not to print anything about dependency between the .asm source file and the .doj object file when outputting dependency information. This switch can only be used in conjunction with the -M or -MM switches.
-no-anomaly-detect \{id1[,id2...]|all|none\}

The -no-anomaly-detect switch directs the assembler to switch off any check for a specific anomaly ID in the assembler. No assembler warning or error will be issued when the assembler encounters assembly code that the anomaly will have an impact upon. This option overrules any default behavior for the anomaly. The switch parameter is:

- id – anomaly identifier (for example, 05-00-0245 or 05000245)
- all – ignore all identifiers not specifically provided (same as -anomaly-detect none)
- none – use all identifiers applicable to the given processor (same as -anomaly-detect all)

The anomaly identifier syntax may use or omit dashes. For example, either 05-00-00245 or 050000245 are accepted. Additionally, specified ids override the all and none options. For example, -no-anomaly-detect all,050000245 detects only anomaly 050000245.

A warning may be issued if the assembler always implements a workaround for the anomaly instead of a check.

-no-anomaly-workaround \{id1[,id2...]|all|none\}

The -no-anomaly-workaround switch directs the assembler to switch off any workaround for a specific anomaly id in the assembler. The assembler will not alter the user assembly code so that it cannot encounter the anomaly. This option overrules any default behavior for the anomaly.

The switch parameter is:

- id – anomaly identifier (for example, 05-00-0245 or 05000245)
- all – ignore all identifiers not specifically provided (same as -anomaly-workaround none)
none — use all identifiers applicable to the given processor (same as -anomaly-workaround all)

The anomaly identifier syntax may use or omit dashes. For example, either 05-00-00245 or 050000245 are accepted. Additionally, specified ids override the all and none options. For example, -no-anomaly-workaround all, 050000245 works around only anomaly 050000245.

A warning may be issued if the assembler always checks for the anomaly and has no workaround.

-no-expand-symbolic-links

The no-expand-symbolic-links switch directs the assembler not to expand any directories or files whose name or path contain Cygwin path components.

-no-expand-windows-shortcuts

The -no-expand-windows-shortcuts switch directs the assembler not to expand directories or files whose name or path contain Windows shortcuts.

-no-temp-data-file

The -no-temp-data-file switch directs the assembler not to write temporary data to a memory (disk).

As part of a space saving measure, the assembler stores all data declarations into a file. This is to allow large sources to assemble more quickly by freeing valuable memory resources. By default, the temporary data files are stored into the system temporary folder (for example, C:\Documents and Settings\User\Local Settings\Temp) and is given the prefix “EasmblkfnNode”). These files are removed by the assembler but, if for any reason the assembler does not complete, these files will not be deleted and
persist in the temporary folder. These files can always be safely deleted in such circumstances after the assembler has stopped.

This command-line option allows the user to turn off this default feature. When turned off, all data is stored into internal memory and not written to the disk.

**-normal-word-code or -nwc**

The `-normal-word-code` or `-nwc` switch directs the assembler to encode input sections bearing the `/PM` qualifier (see Table 1-21) for execution from normal word memory.

ℹ️ The switch is used with the ADSP-2146x SHARC processors only.

**-o filename**

The `-o filename` (output file) switch directs the assembler to use the specified `filename` argument as the output file. This switch names the output, whether for conventional production of an object, a preprocessed, assemble-produced file (.is), or make dependency (-M). By default, the assembler uses the root input file name for the output and appends a .doj extension.

Some examples of this switch syntax are:

```bash
easmlkfn -proc ADSP-BF535 -pp -o test1.is test.asm
// preprocessed output goes into test1.is

easmlkfn -proc ADSP-BF535 -o -debug/prog3.doj prog3.asm
// specify directory and filename for the object file
```

**-pp**

The `-pp` (proceed with preprocessing only) switch directs the assembler to run the preprocessor, but stop without assembling the source into an object file. When assembling with the `-pp` switch, the .is file is the final
result of the assembly. By default, the output file name uses the same root name as the source, with the `.is` extension.

**-proc processor**

The `-proc processor` (target processor) switch specifies that the assembler produces code suitable for the specified processor.

The processor identifiers directly supported by VisualDSP++ 5.0 are listed in VisualDSP++ online Help.

For example,

```bash
easm21k -proc ADSP-21161 -o bin\p1.doj p1.asm
easmts -proc ADSP-TS201 -o bin\p1.doj p1.asm
easmlkfn -proc ADSP-BF533 -o bin\p1.doj p1.asm
```

If the processor identifier is unknown to the assembler, it attempts to read required switches for code generation from the file `<processor>.ini`. The assembler searches for the `.ini` file in the VisualDSP++ System folder. For custom processors, the assembler searches the section “proc” in the `<processor>.ini` file for key “architecture”. The custom processor must be based on an architecture key that is one of the known processors.

For example, `-proc Custom-xxx` searches the `Custom-xxx.ini` file.

See also the `-si-revision version` switch description for more information on silicon revision of the specified processor.

**-save-temps**

The `-save-temps` (save intermediate files) switch directs the assembler to retain intermediate files generated and normally removed as part of the assembly process.
-short-word-code or -swc

The -short-word-code or -swc switch directs the assembler to encode input sections bearing the /PM qualifier (see Table 1-21) for execution from short word memory.

The switch is used with the ADSP-2146x SHARC processors only.

-si-revision version

The -si-revision version (silicon revision) switch directs the assembler to build for a specific hardware revision. Any errata workarounds available for the targeted silicon revision will be enabled. The version parameter represents a silicon revision for the processor specified by the -proc processor switch.

For example,

easmb1kfn -proc ADSP-BF533 -si-revision 0.1

If silicon version “none” is used, no errata workarounds are enabled, whereas specifying silicon version “any” enables all errata workarounds for the target processor.

If the -si-revision switch is not used, the assembler will build for the target processor’s latest known silicon revision and will enable any errata workarounds appropriate for the latest silicon revision.

The __SILICON_REVISION__ macro is set by the assembler to two hexadecimal digits representing the major and minor numbers in the silicon revision. For example, 1.0 becomes 0x100 and 10.21 becomes 0xa15.

If the silicon revision is set to “any”, the __SILICON_REVISION__ macro is set to 0xffff. If the -si-revision switch is set to “none”, the assembler will not set the __SILICON_REVISION__ macro.
**Assembler Command-Line Reference**

- **sp**
  The `sp` (skip preprocessing) switch directs the assembler to assemble the source file into an object file without running the preprocessor. When the assembler skips preprocessing, no preprocessed assembly file (.is) is created.

- **stallcheck**
  The `-stallcheck = option` switch provides the following choices for displaying stall information:

  Table 1-27. `-stallcheck` Options
<table>
<thead>
<tr>
<th><code>-stallcheck</code> Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>-stallcheck=none</code></td>
<td>Displays no messages for stall information</td>
</tr>
<tr>
<td><code>-stallcheck=cond</code></td>
<td>Displays information about conditional stalls only (default)</td>
</tr>
<tr>
<td><code>-stallcheck=all</code></td>
<td>Displays all stall information</td>
</tr>
</tbody>
</table>

  This switch is used with Blackfin processors only.

- **swc-exclude name1[,name2]**
  The `-swc-exclude name` switch directs the assembler to exclude the named input section(s) from the effect of the `-short-word-code`/-swc switch.

  The switch is used with the ADSP-2146x SHARC processors only.

- **v[erbose]**
  The `-v` (or `-verbose`) switch directs the assembler to display version and command-line information for each phase of assembly.
-version

The -version (display version) switch directs the assembler to display version information for the assembler and preprocessor programs.

-w

The -w (disable all warnings) switch directs the assembler not to display warning messages generated during assembly.

-Werror number[,number]

The -Werror number switch turns the specified assembler messages into errors. For example, “-Werror 1177” turns warning message ea1177 into an error. This switch optionally accepts a list, such as [,number ...].

ℹ️ Some error messages cannot be altered in severity.

-Winfo number[,number]

The -Winfo number switch turns the specified assembler messages into informational messages. For example, “-Winfo 1177” turns warning message ea1177 into an informational message. This switch optionally accepts a list, such as [,number ...].

ℹ️ Some error messages cannot be altered in severity.

-Wno-info

The -Wno-info switch turns off all assembler informational messages.

-Wnumber[,number]

The -Wnumber (warning suppression) switch selectively disables warnings specified by one or more message numbers. For example, -W1092 disables warning message ea1092. Optionally, this switch accepts a list, such as [,number ...]. See also “-g” on page 1-159.
Assembler Command-Line Reference

-\texttt{-W\textit{suppress} \textit{number},\textit{number}}

The \texttt{-W\textit{suppress} \textit{number}} switch selectively turns off assembler messages. For example, \texttt{-W\textit{suppress} 1177} turns off warning message \texttt{ea1177}. Optionally, this switch accepts a list, such as \texttt{[,\textit{number} \ldots]}.

\begin{itemize}
  \item Some error messages cannot be altered in severity.
\end{itemize}

-\texttt{-W\textit{warn} \textit{number},\textit{number}}

The \texttt{-W\textit{warn} \textit{number}} switch turns the specified assembler messages into warnings. For example, \texttt{-W\textit{warn} 1154} turns error message \texttt{ea1154} into a warning. Optionally, this switch accepts a list, such as \texttt{[,\textit{number} \ldots]}.

\begin{itemize}
  \item Some error messages cannot be altered in severity.
\end{itemize}

-\texttt{-W\textit{warn-error}}

The \texttt{-W\textit{warn-error}} switch displays all the assembler warning messages as errors.
Specifying Assembler Options in VisualDSP++

Within the VisualDSP++ IDDE, specify tool settings for project builds. Use the Project menu to open the Project Options dialog box.

Figure 1-5 shows an example of the Project page of the Project Options dialog box showing selections for a Blackfin processors.

![Figure 1-5. Example: Project Options Dialog Box - Project Page](image)

This dialog box allows you to select the target processor, type and name of the executable file, as well as VisualDSP++ tools available for use with the selected processor.
When using the VisualDSP++ IDDE, use the **Assemble** page of the **Project Options** dialog box (Figure 1-6) to select and/or set assembler functional options.

Most dialog box options have corresponding assembler command-line switches described in “Assembler Command-Line Switch Descriptions” on page 1-147.

For more information, use the VisualDSP++ context-sensitive Help view to select information on assembler options you can specify in VisualDSP++. To do that, click on the toolbar’s “?” button and then click on the dialog box field or box for which you require information.

Use the **Additional options** field to enter appropriate command-line switches, file names, and options that do not have corresponding controls on the **Assemble** page but are available via command-line invocation.
Assembler options apply to directing calls to an assembler when assembling `.asm` files. Changing assembler options in VisualDSP++ does not affect the assembler calls made by the compiler during the compilation of `.c/.cpp` files.
The preprocessor program (pp.exe) evaluates and processes preprocessor commands in source files on all supported processors. The preprocessor commands direct the preprocessor to define macros and symbolic constants, include header files, test for errors, and control conditional assembly and compilation. The preprocessor supports ANSI C standard preprocessing with extensions, such as “?” and “…”.

The preprocessor is run by other build tools (assembler and linker) from the operating system’s command line or from within the VisualDSP++ 5.0 environment. The pp preprocessor can also operate from the command line with its own command-line switches.

This chapter contains:

- “Preprocessor Guide” on page 2-2
  Contains the information on building programs

- “Preprocessor Command Reference” on page 2-17
  Describes the preprocessor’s commands, with syntax and usage examples

- “Preprocessor Command-Line Reference” on page 2-39
  Describes the preprocessor’s command-line switches, with syntax and usage examples
This section describes preprocessor information used when building programs from a command line or from within the VisualDSP++ 5.0 environment. Software developers who use the preprocessor should be familiar with:

- “Writing Preprocessor Commands” on page 2-3
- “Header Files and #include Command” on page 2-4
- “Writing Macros” on page 2-7
- “Using Predefined Preprocessor Macros” on page 2-14
- “Specifying Preprocessor Options” on page 2-16

Compiler Preprocessor

The compiler has its own preprocessor that enables the use of preprocessor commands within C/C++ source. The compiler preprocessor automatically runs before the compiler. This preprocessor is separate from the assembler preprocessor and has some features that may not be used within your assembly source files. For more information, refer to the VisualDSP++ C/C++ Compiler and Library Manual for the target processor.

Assembler Preprocessor

The assembler preprocessor differs from the ANSI C standard preprocessor in several ways. First, the assembler preprocessor supports a “?” operator (see on page 2-37) that directs the preprocessor to generate a unique label for each macro expansion. Second, the assembler preprocessor does not treat “.” as a separate token. Instead, “.” is always treated as part of an identifier. This behavior matches the assembler’s behavior,
which uses “.” to start directives and accepts “.” in symbol names. For example, the following command sequence:

```c
#define VAR my_var
.VAR x;
```

does not cause any change to the variable declaration. The text “.VAR” is treated as a single identifier which does not match the macro name `VAR`.

The standard C preprocessor treats `.VAR` as two tokens ( “.” and “VAR”) and makes the following substitution:

```c
.my_var x;
```

The assembler preprocessor also produces assembly-style strings (single-quote delimiters) instead of C-style strings.

Finally, under command-line switch control, the assembler preprocessor supports legacy assembler commenting formats (“!” and “{ }”).

**Writing Preprocessor Commands**

Preprocessor commands begin with a pound sign (`#`) and end with a carriage return. The pound sign must be the first non-white space character on the line containing the command. If the command is longer than one line, use a backslash (`\`) and a carriage return to continue the command on the next line. Do not place any characters between the backslash and the carriage return. Unlike assembly directives, preprocessor commands are case sensitive and must be lowercase.

For more information on preprocessor commands, see “Preprocessor Command-Line Reference” on page 2-39.

For example,

```c
#include "string.h"
#define MAXIMUM 100
```
When the preprocessor runs, it modifies the source code by:

- Including system header files and user-defined header files
- Defining macros and symbolic constants
- Providing conditional assembly

Specify preprocessing options with preprocessor commands—lines that start with a `#` character. In the absence of commands, the preprocessor performs these three global substitutions:

- Replaces comments with single spaces
- Deletes line continuation characters (`\`)
- Replaces macro references with corresponding expansions

The following cases are notable exceptions to the described substitutions:

- The preprocessor does not recognize comments or macros within the file name delimiters of an `#include` command.
- The preprocessor does not recognize comments or predefined macros within a character or string constant.

**Header Files and `#include` Command**

Header (`.h`) files contain lines of source code to be included (textually inserted) into another source file. Typically, header files contain declarations and macro definitions.

The `#include` preprocessor command includes a copy of the header file at the location of the command. There are three forms for the `#include` command, as described next.
Preprocessor

System Header Files

Syntax:  #include <filename>

The file name is placed between a pair of angle bracket characters. The file name in this form is interpreted as a system header file. These files are used to declare global definitions, especially memory-mapped registers, system architecture, and processors.

Example:

#include <device.h>
#include <major.h>

System header files are installed in the …/VisualDSP/Blackfin/include folder for the processor family.

User Header Files

Syntax:  #include "filename"

The file name is placed within a pair of double quote characters. The file name in this form is interpreted as a user header file. These files contain declarations for interfaces between the source files of the program.

Example:

#include "defTS.h"
#include "fft_ovly.h"

Sequence of Tokens

Syntax:  #include text

In this case, text is a sequence of tokens subject to macro expansion by the preprocessor.
It is an error if after macro expansion the text does not match one of the two header file forms. If the text on the line after the `#include` is not placed between double quotes (as a user header file) or between angle brackets (as a system header file), the preprocessor performs macro expansion on the text. After that expansion, the line requires either of the two header file forms.

Unlike most preprocessor commands, the text after the `#include` is available for macro expansion.

Examples:

```c
/* define preprocessor macro with name for include file */
#define includelfilename "header.h"
/* use the preprocessor macro in an #include command */
#include includelfilename
/* the code above evaluates to #include "header.h" */

/* define preprocessor macro to build system include file */
#define syshdr(name) <name ## .h>
/* use the preprocessor macro in a #include command */
#include syshdr(adi)
/* the code above evaluates to #include <adi.h> */
```

**Include Path Search**

It is good programming practice to distinguish between system header files and user header files. The only technical difference between the two different notations is the directory search order that the assembler follows to locate the specified header file.

For example, when using Blackfin processors, the `#include <file>` search order is:

1. The include path specified by the `-I` switch
2. `<install_path>/VisualDSP/Blackfin/include` folders
The `#include "file"` search order is:

1. The local directory – the directory in which the source file resides
2. The include path specified by the `-I` switch
3. `<install_path>/VisualDSP/Blackfin/include` folders

If you use the `-I` and the `-I-` switches on the command line, the system search path (`#include < >`) is modified in such a manner that search the directories specified with the `-I` switch that appear before the directory specified with the `-I-` switch are ignored. For syntax information and usage examples on the `#include` preprocessor command, see `#include`.

**Writing Macros**

The assembler/linker preprocessor processes macros in assembly source files and linker description files (.ldf). Macros provide for text substitution.

The term `macro` defines a macro-identifying symbol and its corresponding definition that the preprocessor uses to substitute the macro reference(s).

For example, use macros to define symbolic constants or to manipulate register bit masks in an assembly program based on a macro argument, as follows:

```plaintext
/* Define a symbolic constant */
#define MAX_INPUT 256

/* Mask peripheral #x interrupt */
#define SIC_MASK(x) (1 << (((x)&0x1F))
```

Macros can be defined to repeat code sequences in assembly source code. When you pass parameters to a code macro, the macro serves as a general-purpose routine that is usable in many different programs.
The block of instructions that the preprocessor substitutes can vary with each new set of arguments.

A macro differs from a subroutine call. During assembly, each instance of a macro inserts a copy of the same block of instructions, so multiple copies of that code appear in different locations in the object code. By comparison, a subroutine appears only once in the object code, and the block of instructions at that location are executed for every call.

For more information, see:

- “#define” on page 2-19
- “Macro Definition and Usage Guidelines” on page 2-8
- “Examples of Multi-Line Code Macros with Arguments” on page 2-12
- “Debugging Macros” on page 2-13

**Macro Definition and Usage Guidelines**

A macro definition can be any text that may occur legally in the source file that references the macro. In assembly files, the macro may expand to include instructions, directives, register names, constants, and so on. In LDFs, a macro may expand to include LDF commands, memory descriptions and other items that are legal in an LDF. The macro definition may also have other macro names that are replaced with their own definitions.
The following guidelines are provided to help you construct macros and use them appropriately.

- **A macro definition** must begin with `#define` and must end with a carriage return.

- **Macro termination.** If a macro definition ends with a terminator on the instruction (one semicolon (`;`) for SHARC and Blackfin processors; two semicolons (`;;`) for TigerSHARC processors), do not place a terminator at the end of the macro (usage) in an assembly statement. However, if a macro definition does not end with a terminator, each instance of the macro usage must be followed by the terminator in the assembly statement.

Be consistent with regard to how you use terminators in macro definitions.

Examples shown in this section omit the terminator in the macro definition and use the terminator in the assembly text. Note that the `mac;` statement in the following Blackfin example has a “;”.

```
#define mac mrf = mrf+R2*R5(ssfr) // macro definition
R2 = R1-R0; // macro usage; set parameters
R5 = DM(I1,M0);
mac;
```

- **Line continuation.** A macro definition can be split across multiple lines for readability. When a macro definition is longer than one line, place a backslash (`\`) character at the end of each line (except the last line) for line continuation.

Incorrect:
```
#define MultiLineMacro
    instruction1:  \
    instruction2:  \
    instruction3
```

Correct:
```
#define MultiLineMacro
    instruction1:  \n    instruction2:  \n    instruction3
```
Notice that the backslash in the `#define` line is missing.

**Correct:**
```
#define MultiLineMacro  
   instruction1;   
   instruction2;   
   instruction3
```

No characters are permitted on a line after a backslash.

A warning is generated when there is white space after what might have been intended as a line continuation. For example,

```
#define macro1  
   instruction1:  
      (whitespace)
   instruction2;  
   instruction3
```

[Warning pp0003] "header.h":3
The backslash at the end of this line
is followed by whitespace
It is not a line continuation

- **Comments within #define.** Use C-style comments (`/*  comment */`) within multi-line macros. Otherwise, the line-continuation character (`\`) will cause the next line to be concatenated to the comment, thus becoming part of the comment.

The preprocessor supports C-style comments (`/*  comment */`) as well as C++-style comments (`//  comment`). The C-style comment has a delimiter at the start and end of the comment; the C++-style comment begins at the “/” and terminates at the end of the line.

The “terminates at the end of the line” aspect of C++-style comments renders “/” comments unsuitable within multi-line macro definitions. The line continuation character causes the next line to
be concatenated to the comment, thus becoming part of the com-
ment.

The following code fragment demonstrates the problem.

```c
#define macro \
  first line;  \
  second line
```

when expanded by writing “macro” in your .asm file, this code becomes:

```c
first line; second line
```

If you use C-style comments, you can write:

```c
#define macro \
  /* this macro has two lines */  \
  first line;  \
  /* and two comments */  \
  second line
```

which will expand to:

```c
first line; second line
```

However, if you use C++ style comments as shown below:

```c
#define macro \
  // this comment will devour the rest of the macro \
  first line;  \
  second line
```

the macro expands into an “empty” macro.
In the code above, the first line of the macro definition starts a comment. Since there are line-continuation characters, the logical end of line for that comment is the end of the macro. Thus, the code yields an “empty” macro.

- Macro nesting (macros called within another macro) is limited only by the memory available during preprocessing. Recursive macro expansion, however, is not allowed.

Refer to “#define” on page 2-19 for more information on the `#define` command.

**Examples of Multi-Line Code Macros with Arguments**

The following are examples of multi-line code macros with arguments.

**Blackfin Code Example:**

```c
#define false 0
#define xchg(xv,yv) \ 
P0=xv; \ 
P1=yv; \ 
R0=[P0]; \ 
R1=[P1]; \ 
[P1]=R0; \ 
[P0]=R1
```

**SHARC Code Example:**

```c
#define ccall(x) \ 
R2=I6; I6=I7; \ 
JUMP (pc, x) (db); \ 
DM(I7,M7)=R2; \ 
DM(I7, M7)=PC
```
Macro Usage in Code Section:

    <instruction code here>
    ccall(label1);
    <instruction code here>
label1: NOP;
    <instruction code here>

TigerSHARC Code Example:

#define copy (src,dest) \ 
    J0 = src::: \ 
    J1 = dest::: \ 
    R0 = [J0+0];: \ 
    [J1+0] = R0

Debugging Macros

If you get an unexpected syntax error from the assembler on a macro expansion, it can be helpful to debug the macro by looking at what the preprocessor produced post preprocessing. The intermediate file produced by the preprocessor is the .is output file.

From the VisualDSP++ IDDE, select the Save temporary files check box on the Assemble page of the Project Options dialog box. If you are running the assembler from the command line, add the -save-temps switch (see -save-temps).

Tips for Debugging Macros:

Assembly programmers may find it useful to include the processor system header files for pre-defined macros that are helpful to assembly language programmers for that processor family. These are known as “def headers”. For example, an ADSP-BF534 programmer would use:

    // Header is located in <install_path>/Blackfin/include
    #include "defBF534.h"
A symbol in your program may inadvertently use the same spelling as a #define in the def header. Typically, this results in a syntax error due to the symbol being replaced with a constant or constant expression, which is not what you intended.

For example, defBF534.h contains:

```c
#define ALARM 0x0002 /* Alarm Interrupt Enable */
```

If an assembly program uses `ALARM` as a symbol name, it will get a textual replacement of “0x0002”, making the program illegal, as demonstrated by the following code fragment.

```c
#include "defBF534.h"
#define FALSE 0
#define TRUE 1

.SECTION data1:

.VAR ALARM = FALSE;

[Error ea5004] "alarm.asm":7 Syntax Error in :
   .var 0x0002 = 1;
   syntax error is at or near text '0x0002'.
   Attempting error recovery by ignoring text until the ':'
```

**Using Predefined Preprocessor Macros**

In addition to macros you define, the `pp` preprocessor provides a set of predefined macros and feature macros that can be used in assembly code. The preprocessor automatically replaces each occurrence of the macro reference found throughout the program with the specified (predefined) value. The DSP development tools also define feature macros that can be used in your code.
The __DATE__, __FILE__, and __TIME__ macros return strings within the single quotation marks (' ') suitable for initializing character buffers. For more information, see “.VAR and ASCII String Initialization Support” on page 1-141.

Table 2-1 on page 2-15 describes the common predefined macros provided by the preprocessor. Table 1-5 on page 1-26 lists feature macros for Blackfin processors. Table 1-7 on page 1-29 lists feature macros for SHARC processors. Table 1-8 on page 1-34 lists feature macros for TigerSHARC processors. These processor-specific feature macros are defined by the project development tools to specify the architecture and language being processed.

Table 2-1. Common Predefined Preprocessor Macros

<table>
<thead>
<tr>
<th>Macro</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADI</td>
<td>Defines ADI as 1</td>
</tr>
<tr>
<td><strong>LastSuffix</strong></td>
<td>Specifies the last value of suffix that was used to build preprocessor generated labels</td>
</tr>
<tr>
<td><strong>LINE</strong></td>
<td>Replaces <strong>LINE</strong> with the line number in the source file that the macro appears on</td>
</tr>
<tr>
<td><strong>FILE</strong></td>
<td>Defines <strong>FILE</strong> as the name and extension of the file in which the macro is defined, for example, ‘macro.asm’</td>
</tr>
<tr>
<td><strong>TIME</strong></td>
<td>Defines <strong>TIME</strong> as current time in the 24-hour format ‘hh:mm:ss’, for example, ‘06:54:35’</td>
</tr>
<tr>
<td><strong>DATE</strong></td>
<td>Defines <strong>DATE</strong> as current date in the format ‘mm dd yyyy’, for example, ‘Oct 02 2000’</td>
</tr>
<tr>
<td>__LANGUAGE_ASM</td>
<td>Always set to 1</td>
</tr>
<tr>
<td>__LANGUAGE_C</td>
<td>Equals 1 when used for C compiler calls to specify .IMPORT headers. Replaces __LANGUAGE_ASM</td>
</tr>
</tbody>
</table>
-D__VISUALDSPVERSION____ Predefined Macro

The macro applies to all Analog Devices processors.

The -D__VISUALDSPVERSION__ predefined preprocessor macro provides VisualDSP++ product version information. The macro allows a pre-processing check to be placed within code. It can be used to differentiate between VisualDSP++ releases and updates. The assemblers and linker predefine -D__VISUALDSPVERSION__ in calls to the preprocessor.

For further information on the product version encoding (including parameters and examples), see “-D__VISUALDSPVERSION__ Predefined Macro” on page 1-35.

Specifying Preprocessor Options

When developing a DSP project, it may be useful to modify the preprocessor’s default options. Because the assembler, compiler, and linker automatically run the preprocessor as your program is built (unless you skip processing entirely), these project development tools can receive input for the preprocessor program and direct its operation. The way the preprocessor options are set depends on the environment used to run the project development software.

You can specify preprocessor options from the preprocessor’s command line or via the VisualDSP++ environment:

- From the operating system command line, select the preprocessor’s command-line switches. For more information on these switches, see “Preprocessor Command-Line Switches” on page 2-40.

- In the VisualDSP++ environment, select the preprocessor’s options in the Assemble or Link pages of the Project Options dialog box, accessible from the Project menu. Refer to “Specifying Assembler Options in VisualDSP++” on page 1-173 for the Assemble page.
Preprocessor Command Reference

This section provides reference information about the processor’s preprocessor commands and operators used in source code, including their syntax and usage examples. It provides the summary and descriptions of all preprocessor commands and operators.

The preprocessor reads code from a source file (.asm or .ldf), modifies it according to preprocessor commands, and generates an altered preprocessed source file. The preprocessed source file is an input file for the assembler or linker; it is purged when a binary object file (.doj) is created.

Preprocessor command syntax must conform to these rules:

- Must be the first non-whitespace character on its line
- Cannot be more than one line in length unless the backslash character (\) is inserted
- Cannot come from a macro expansion

The preprocessor operators are defined as special operators when used in a #define command.
Preprocessor Command Reference

Preprocessor Commands and Operators

Table 2-2 lists preprocessor commands. Table 2-3 lists preprocessor operators. Sections that begin on page 2-19 describe each of the preprocessor commands and operators.

Table 2-2. Preprocessor Command Summary

<table>
<thead>
<tr>
<th>Command/Operator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>#define (on page 2-19)</td>
<td>Defines a macro</td>
</tr>
<tr>
<td>#elif (on page 2-22)</td>
<td>Subdivides an #if … #endif pair</td>
</tr>
<tr>
<td>#else (on page 2-23)</td>
<td>Identifies alternative instructions within an #if … #endif pair</td>
</tr>
<tr>
<td>#endif (on page 2-24)</td>
<td>Ends an #if … #endif pair</td>
</tr>
<tr>
<td>#error (on page 2-25)</td>
<td>Reports an error message</td>
</tr>
<tr>
<td>#if (on page 2-26)</td>
<td>Begins an #if … #endif pair</td>
</tr>
<tr>
<td>#ifdef (on page 2-27)</td>
<td>Begins an #ifdef … #endif pair and tests if macro is defined</td>
</tr>
<tr>
<td>#ifndef (on page 2-28)</td>
<td>Begins an #ifndef … #endif pair and tests if macro is not defined</td>
</tr>
<tr>
<td>#include (on page 2-29)</td>
<td>Includes contents of a file</td>
</tr>
<tr>
<td>#line (on page 2-31)</td>
<td>Sets a line number during preprocessing</td>
</tr>
<tr>
<td>#pragma (on page 2-32)</td>
<td>Takes any sequence of tokens</td>
</tr>
<tr>
<td>#undef (on page 2-33)</td>
<td>Removes macro definition</td>
</tr>
<tr>
<td>#warning (on page 2-34)</td>
<td>Reports a warning message</td>
</tr>
</tbody>
</table>

Table 2-3. Preprocessor Operator Summary

<table>
<thead>
<tr>
<th>Command/Operator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td># (on page 2-35)</td>
<td>Converts a macro argument into a string constant. By default, this operator is OFF. Use the command-line switch -stringize to enable it.</td>
</tr>
<tr>
<td>## (on page 2-36)</td>
<td>Concatenates two tokens</td>
</tr>
<tr>
<td>? (on page 2-37)</td>
<td>Generates unique labels for repeated macro expansions</td>
</tr>
<tr>
<td>... (on page 2-20)</td>
<td>Specifies a variable-length argument list</td>
</tr>
</tbody>
</table>
The #define command defines macros.

When defining macros in your source code, the preprocessor substitutes each occurrence of the macro with the defined text. Defining this type of macro has the same effect as using the Find/Replace feature of a text editor, although it does not replace literals in double quotation marks (" ") and does not replace a match within a larger token.

For macro definitions longer than one line, place a backslash character (\) at the end of each line (except the last line) for readability; refer to the macro definition rules in “Writing Macros” on page 2-7.

You can add arguments to the macro definition. The arguments are symbols separated by commas that appear within parentheses.

Syntax:

```
#define macroSymbol replacementText
#define macroSymbol[(arg1,arg2,...)] replacementText
```

where:

*macroSymbol* – macro identifying symbol

*replacementText* – text to substitute each occurrence of *macroSymbol* in your source code
Examples:

```c
#define BUFFER_SIZE 1020
    /* Defines a macro named BUFFER_SIZE and sets its value to 1020. */

#define copy(src,dest)xr0=[J31+src ];;
[J31+dest] = xr0;;
    /* Define a macro named copy with two arguments. The definition includes two instructions that copy a word from memory to memory. For example,
    copy (0x3F,0xC0);
calls the macro, passing parameters to it. The preprocessor replaces the macro with the code:
    [xr0 = [j31+0x3F];;
    [j31+0xC0] = xr0;; */
```

Variable-Length Argument Definitions

A macro can also be defined with a variable-length argument list (by means of the `...` operator).

```c
#define test(a, ...) <definition>
```

For example, the code above defines a macro named test, which takes two or more arguments. It is invoked like any other macro, although the number of arguments can vary.
For example, in the macro definition, the __VA_ARGS__ identifier is available to take on the value of all of the trailing arguments, including the commas, all of which are merged to form a single item. See Table 2-4.

Table 2-4. Sample Variable-Length Argument List

<table>
<thead>
<tr>
<th>Sample Argument List</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>test(1)</td>
<td>Error; the macro must have at least one more argument than formal parameters, not counting &quot;...&quot;</td>
</tr>
<tr>
<td>test(1,2)</td>
<td>Valid entry</td>
</tr>
<tr>
<td>test(1,2,3,4,5)</td>
<td>Valid entry</td>
</tr>
</tbody>
</table>

For example, the following code

```c
#define test(a, ...) bar(a); testbar(__VA_ARGS__);
```

expands into:

```c
test (1,2) -> bar(1); testbar(2);
test (1,2,3,4,5) -> bar(1); testbar(2,3,4,5);
```
#elif

The #elif command (else if) is used within an #if ... #endif pair. The #elif includes an alternative condition to test when the initial #if condition evaluates as FALSE. The preprocessor tests each #elif condition inside the pair and processes instructions that follow the first true #elif. There can be an unlimited number of #elif commands inside one #if ... #endif pair.

Syntax:
#elif condition

where:

condition – expression to evaluate as TRUE (nonzero) or FALSE (zero)

Example:

#if X == 1
...
#else
#endif
#else

The #else command is used within an #if ... #endif pair. It adds an alternative instruction to the #if ... #endif pair. Only one #else command can be used inside the pair. The preprocessor executes instructions that follow #else after all the preceding conditions are evaluated as FALSE (zero). If no #else text is specified, and all preceding #if and #elif conditions are FALSE, the preprocessor does not include any text inside the #if ... #endif pair.

Syntax:
else

Example:

#if X == 1
  ...
#elif X == 2
  ...
#else
  ...
  /* The preprocessor includes text within the section and excludes all other text before #else when x!=1 and x!=2. */
#endif
Preprocessor Command Reference

**#endif**

The `#endif` command is required to terminate `#if ... #endif`, `#ifdef ... #endif`, and `#ifndef ... #endif` pairs. Ensure that the number of `#if` commands matches the number of `#endif` commands.

**Syntax:**

```
#endif
```

**Example:**

```
#if condition
...
...
#endif
/* The preprocessor includes text within the section only
   if the test is true. */
```
#error

The #error command causes the preprocessor to raise an error. The preprocessor uses the text following the #error command as the error message.

Syntax:

```c
#error messageText
```

where:

- `messageText` – user-defined text

To break a long `messageText` without changing its meaning, place a back-slash character (\) at the end of each line (except the last line).

Example:

```c
#ifndef __ADSPBF535__
#error \
  MyError: \
  Expecting a ADSP-BF535. \
  Check the Linker Description File!
#endif
```
Preprocessor Command Reference

#if

The #if command begins an #if ... #endif pair. Statements inside an #if ... #endif pair can include other preprocessor commands and conditional expressions. The preprocessor processes instructions inside the #if ... #endif pair only when condition that follows the #if evaluates as TRUE. Every #if command must terminated with an #endif command.

Syntax:
#if condition

where:

condition – expression to evaluate as TRUE (nonzero) or FALSE (zero)

Example:
#if x!=100 /* test for TRUE condition */
    ...
    /* The preprocessor includes text within the section if the test is true. */
#elif
#endif

More examples:
#if (x!=100) && (y==20)
#if defined(__ADSPBF535__)
The #ifdef (if defined) command begins an #ifdef ... #endif pair and instructs the preprocessor to test whether the macro is defined. Each #ifdef command must have a matching #endif command.

Syntax:
#define macroSymbol

where:

macroSymbol – macro identifying symbol

Example:

#define __ADSPBF535__
    /* Includes text after #ifdef only when __ADSPBF535__ has been defined. */
#endif
#ifndef

The #ifndef (if not defined) command begins an #ifndef ... #endif pair and directs the preprocessor to test for an undefined macro. The preprocessor considers a macro undefined if it has no defined value. Each #ifndef command must have a matching #endif command.

Syntax:
ifndef macroSymbol

where:

macroSymbol – macro identifying symbol

Example:

ifndef __ADSPBF535__
    /* Includes text after #ifndef only when __ADSPBF535__ is not defined. */
endif
#include

The `#include` command directs the preprocessor to insert the text from a header file at the command location. There are two types of header files: system and user. However, the `#include` command may be presented in three forms:

- `#include <filename>` – used with system header files
- `#include "filename"` – used with user header files
- `#include text` – used with a sequence of tokens

The sequence of tokens is subject to macro expansion by the preprocessor. After macro expansion, the text must match one of the header file forms.

The only difference to the preprocessor between the two types of header files is the way the preprocessor searches for them.

- System Header File `<fileName>` – The preprocessor searches for a system header file in this order: (1) the directories you specify, and (2) the standard list of system directories.
- User Header File “`fileName`” – The preprocessor searches for a user header file in this order:

1. Current directory – the directory where the source file that has the `#include` command(s) lives
2. Directories you specify
3. Standard list of system directories

Refer to “Header Files and `#include` Command” on page 2-4 for more information.
Preprocessor Command Reference

Syntax:

```c
#include <fileName>  // include a system header file
#include "fileName"  // include a user header file
#include macroFileNameExpansion
/* Include a file named through macro expansion.
   This command directs the preprocessor to expand the
   macro. The preprocessor processes the expanded text,
   which must match either <fileName> or "fileName". */
```

Example:

```c
#ifndef __ADSPBF535__
   /* Tests that __ADSPBF535__ has been defined. */
#include <stdlib.h>
#endif
```
#line

The #line command directs the preprocessor to set the internal line counter to the specified value. Use this command for error tracking purposes.

Syntax:
```
#line lineNumber "sourceFile"
```

where:
- `lineNumber` – line number of the source line
- `sourceFile` – name of the source file included in double quotation marks. The `sourceFile` entry can include the drive, directory, and file extension as part of the file name.

Example:
```
#line 7 "myFile.c"
```

All assembly programs have #line directives after preprocessing. They always have a first line with #line 1 "filename.asm" and they will also have #line directives to establish correct line numbers for text that came from include files as a result of the processed #include directives.
#pragma

The #pragma command is the implementation-specific command that modifies the preprocessor behavior. The #pragma command can take any sequence of tokens. This command is accepted for compatibility with other VisualDSP++ software tools. The pp preprocessor currently does not support any pragmas; therefore, it ignores any information in the #pragma command.

**Syntax:**

```plaintext
#pragma any_sequence_of_tokens
```

**Example:**

```plaintext
#pragma disable_warning 1024
```
The `#undef` command directs the preprocessor to undefine a macro.

**Syntax:**

```
#undef macroSymbol
```

**where:**

`macroSymbol` – macro created with the `#define` command

**Example:**

```
#undef BUFFER_SIZE /* undefines a macro named BUFFER_SIZE */
```
#warning

The `#warning` command causes the preprocessor to issue a warning. The preprocessor uses the text following the `#warning` command as the warning message.

**Syntax:**

```
#warning messageText
```

where:

- `messageText` – user-defined text

To break a long `messageText` without changing its meaning, place a backslash character (`\`) at the end of each line (except the last line).

**Example:**

```c
#ifndef __ADSPBF535__
#warning \
   MyWarning: \
   Expecting a ADSPBF535. \
   Check the Linker Description File!
#endif
```
The `#` (argument) “stringization” operator directs the preprocessor to convert a macro argument into a string constant. The preprocessor converts an argument into a string when macro arguments are substituted into the macro definition.

The preprocessor handles white space in string-to-literal conversions by:

- Ignoring leading and trailing white spaces
- Converting white space in the middle of the text to a single space in the resulting string

**Syntax:**

```
# toString
```

where:

- `toString` – macro formal parameter to convert into a literal string.

The `#` operator must precede a macro parameter. The preprocessor includes a converted string within double quotation marks (`""`).

This feature is off by default. Use the `-stringize` command-line switch to enable it.

**C Code Example:**

```
#define WARN_IF(EXPR)\
    fprintf(stderr,"Warning:""#EXPR "/n")

/* Defines a macro that takes an argument and converts the argument to a string. */
WARN_IF(current < minimum);
    /* Invokes the macro passing the condition. */
    fprintf(stderr,"Warning:""current < minimum""/n");
    /* Note that the #EXPR has been changed to current < minimum and is enclosed in " ". */
```
## (Concatenate)

The ## (concatenate) operator directs the preprocessor to concatenate two tokens. When you define a macro, you request concatenation with ## in the macro body. The preprocessor concatenates the syntactic tokens on either side of the concatenation operator.

**Syntax:**

token1##token2

**Example:**

```c
#define varstring(name) .VAR var_##name[] = {'name', 0};
varstring (error);
varstring (warning);
```

/* The above code results in */
```
.VAR var_error[] = {'error', 0};
.VAR var_warning[] = {'warning', 0};
```
? (Generate a unique label)

The “?” operator directs the preprocessor to generate unique labels for iterated macro expansions. Within the definition body of a macro (#define), you can specify one or more identifiers with a trailing question mark (?) to ensure that unique label names are generated for each macro invocation.

The preprocessor affixes “_num” to a label symbol, where num is a uniquely generated number for every macro expansion. For example,

```
abcd? ===> abcd_1
```

If a question mark is a part of the symbol that needs to be preserved, ensure that “?” is delimited from the symbol. For example, “abcd?” is a generated label, and “abcd ?” is not.

Example:

```
#define loop(x,y) mylabel?:x=1+1;
x=2+2;
yourlabel?:y=3*3;
y=5*5;
JUMP mylabel?;
JUMP yourlabel?;
loop (bz,kjb)
loop (lt,ss)
loop (yc,jl)
```

```
// Generates the following output:
mylabel_1:bz=1+1;bz=2+2;yourlabel_1:kjb=3*3;kjb=5*5;
JUMP mylabel_1;
JUMP yourlabel_1;
mylabel_2:lt=1+1;lt=2+2;yourlabel_2:ss=3*3;ss=5*5;
JUMP mylabel_2;
```
The last numeric suffix used to generate unique labels is maintained by the preprocessor and is available through a preprocessor predefined macro \texttt{\_\_LastSuffix\_} (see on page 2-15). This value can be used to generate references to labels in the last macro expansion.

The following example assumes the macro “\texttt{loop}” from the previous example.

// Some macros for appending a suffix to a label
#define makelab(a, b) a##b
#define Attach(a, b) makelab(a##_, b)
#define LastLabel(foo) Attach( foo. __LastSuffix__)

// jump back to label in the previous expansion
JUMP LastLabel(mylabel);

The above expands to (the last macro expansion had a suffix of 3):
JUMP mylabel_3:
Preprocessor Command-Line Reference

The **pp** preprocessor is the first step in the process of building (assembling, compiling, and linking) your programs. The **pp** preprocessor is run before the assembler and linker, using the assembler or linker as the command-line tool. You can also run the preprocessor independently from its own command line.

This section contains:

- “Running the Preprocessor”
- “Preprocessor Command-Line Switches” on page 2-40

Running the Preprocessor

To run the preprocessor from the command line, type the name of the program followed by arguments in any order.

```
pp [-switch1 [-switch2 ...]] [sourceFile]
```

Table 2-5 summarizes these arguments.

Table 2-5. Preprocessor Command Line Argument Summary

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>pp</strong></td>
<td>Name of the preprocessor program</td>
</tr>
<tr>
<td><code>-switch</code></td>
<td>Switch (or switches) to process. The preprocessor offers several switches that are used to select its operation and modes. Some preprocessor switches take a file name as a required parameter.</td>
</tr>
<tr>
<td><code>sourceFile</code></td>
<td>Name of the source file to process. The preprocessor supports relative path names and absolute path names. The <strong>pp.exe</strong> outputs a list of command-line switches when runs without this argument.</td>
</tr>
</tbody>
</table>
For example, the following command line
```
pp -Dfilter_taps=100 -v -o bin\p1.is p1.asm
```
runs the preprocessor with:
- `-Dfilter_taps=100` — defines the macro `filter_taps` as equal to 100
- `-v` — displays verbose information for each phase of the preprocessing
- `-o bin\p1.is` — specifies the name and directory for the intermediate preprocessed file
- `p1.asm` — specifies the assembly source file to preprocess

Most switches without arguments can be negated by prefixing `-no` to the switch. For example, `-nowarn` turns off warning messages, and `-nocs!` turns off omitting “!” style comments.

### Preprocessor Command-Line Switches

The preprocessor is controlled through the switches (or VisualDSP++ options) of other development tools, such as the compiler, assembler, and linker. Note that the preprocessor (pp.exe) can operate independently from the command line with its own command-line switches.

Table 2-6 lists `pp.exe` switches. A detailed description of each switch appears beginning on page 2-42.

<table>
<thead>
<tr>
<th>Switch Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>-cpredef</code> (on page 2-42)</td>
<td>Enables the “stringization” operator and provides C compiler-style preprocessor behavior</td>
</tr>
<tr>
<td><code>-cs!</code> (on page 2-43)</td>
<td>Treats as a comment all text after “!” on a single line</td>
</tr>
<tr>
<td>Switch</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td>-cs/*</td>
<td>Treats as a comment all text within /* */ (on page 2-43)</td>
</tr>
<tr>
<td>-cs/</td>
<td>Treats as a comment all text after // (on page 2-44)</td>
</tr>
<tr>
<td>-cs</td>
<td>Treats as a comment all text within { } (on page 2-44)</td>
</tr>
<tr>
<td>-csall</td>
<td>Accepts comments in all formats (on page 2-44)</td>
</tr>
<tr>
<td>-Dmacro[=definition]</td>
<td>Defines macro (on page 2-44)</td>
</tr>
<tr>
<td>-h[elp]</td>
<td>Outputs a list of command-line switches (on page 2-44)</td>
</tr>
<tr>
<td>-i</td>
<td>Outputs only makefile dependencies for include files specified in double quotes (on page 2-45)</td>
</tr>
<tr>
<td>-i</td>
<td>directory</td>
</tr>
<tr>
<td>-l</td>
<td>Indicates where to start searching for system include files, which are delimited by &lt; &gt; (on page 2-46)</td>
</tr>
<tr>
<td>-M</td>
<td>Makes dependencies only (on page 2-46)</td>
</tr>
<tr>
<td>-MM</td>
<td>Makes dependencies and produces preprocessor output (on page 2-47)</td>
</tr>
<tr>
<td>-Mo filename</td>
<td>Specifies filename for the make dependencies output file (on page 2-47)</td>
</tr>
<tr>
<td>-Mt filename</td>
<td>Makes dependencies for the specified source file (on page 2-47)</td>
</tr>
<tr>
<td>-o filename</td>
<td>Outputs named object file (on page 2-48)</td>
</tr>
<tr>
<td>-stringize</td>
<td>Enables stringization (includes a string in double quotes) (on page 2-48)</td>
</tr>
<tr>
<td>-tokenize-dot</td>
<td>Treats “.” (dot) as an operator when parsing identifiers (on page 2-48)</td>
</tr>
</tbody>
</table>
The following sections describe preprocessor command-line switches.

- **-cpredef**

  The **-cpredef** switch directs the preprocessor to produce C compiler-style strings in all cases. By default, the preprocessor produces assembler-style strings within single quotes (for example, `'string'`) unless the **-cpredef** switch is used.

  The **-cpredef** switch sets the following C compiler-style behaviors:

  - Directs the preprocessor to use double quotation marks rather than the default single quotes as string delimiters for any preprocessor-generated strings. The preprocessor generates strings for predefined...
macros that are expressed as string constants, and as a result of the stringize operator in macro definitions (see Table 2-1 on page 2-15 for the predefined macros).

- Enables the stringize operator (#) in macro definitions. By default, the stringize operator is disabled to avoid conflicts with constant definitions (see -stringize).
- Parses identifiers using C language rules instead of assembler rules. In C, the character “.” is an operator and is not considered part of an identifier. In the assembler, the “.” is considered part of a directive or label. With -cpredef, the preprocessor treats “.” as an operator.

The following example shows the difference in effect of the two styles.

```c
#define end last
// what label.end looks like with -cpredef
label.last // "end" parsed as ident and macro expanded

// what label.end looks like without -cpredef (asm rules)
label.end // "end" not parsed separately
```

- **-cs!**

  The -cs! switch directs the preprocessor to treat as a comment all text after “!” on a single line.

- **-cs/***

  The -cs/* switch directs the preprocessor to treat as a comment all text within /* */ on multiple lines.
Preprocessor Command-Line Reference

-**cs//**

The `-cs//` switch directs the preprocessor to treat as a comment all text after `//` on a single line.

-**cs{**

The `-cs{` switch directs the preprocessor to treat as a comment all text within `{ }` on multiple lines.

-**csall**

The `-csall` switch directs the preprocessor to accept comments in all formats.

-**Dmacro[=def]**

The `-Dmacro` switch directs the preprocessor to define a macro. If you do not include the optional definition string (`=def`), the preprocessor defines the macro as value 1. Similar to the C compiler, you can use the `-D` switch to define an assembly language constant macro.

Some examples of this switch are:

- `-Dinput // defines input as 1`
- `-Dsamples=10 // defines samples as 10`
- `-Dpoint="Start" // defines point as "Start"
- `-D_LANGUAGE_ASM=1 // defines _LANGUAGE_ASM as 1`

-**h[elp]**

The `-h` (or `-help`) switch directs the preprocessor to send to standard output the list of command-line switches with a syntax summary.
-i

The -i (less includes) switch may be used with the -M or -MM switches to direct the preprocessor to not output dependencies on any system files. System files are any files that are brought in using #include <>. Files included using #include " " (double quote characters) are included in the dependency list.

-i

The -idirectory (or -ldirectory) switch direct the preprocessor to append the specified directory (or a list of directories separated by semicolons) to the search path for included header files (see on page 2-29).

No space is allowed between -i and the path name.

The preprocessor searches for included files delimited by double quotation marks (" ") in this order:

1. The source directory (that is, the directory in which the original source file resides)

2. The directories in the search path supplied by the -I switch. If more than one directory is supplied by the -I switch, they are searched in the order that they appear on the command line.

3. The system directory (that is, the /include subdirectory of the VisualDSP++ installation directory)

The current directory is the directory where the source file lives, not the directory of the assembler program. Usage of full path names for the -I switch on the command line (omitting the disk partition) is recommended.
The preprocessor searches for included files delimited by `< >` in this order:

1. The directories in the search path supplied by the `-I` switch (subject to modification by the `-I-` switch, as shown in “-I-” on page 2-46. If more than one directory is supplied by the `-I` switch, the directories are searched in the order that they appear on the command line.

2. The system directory (that is, the \include subdirectory of the VisualDSP++ installation directory.

**-I-**

The `-I-` switch indicates where to start searching for system include files, which are delimited by `< >`. If there are several directories in the search path, the `-I-` switch indicates where in the path the search for system include files begins.

For example,

```
pp -Idir1 -Idir2 -I- -Idir3 -Idir4 myfile.asm
```

When searching for `#include "inc1.h"` the preprocessor searches in the source directory, then `dir1`, `dir2`, `dir3`, and `dir4` in that order.

When searching for `#include <inc2.h>` the preprocessor searches for the file in `dir3` and then `dir4`. The `-I-` switch marks the point where the system search path starts.

**-M**

The `-M` switch directs the preprocessor to output a rule (generate make rule only) suitable for the make utility, describing the dependencies of the source file. The output, a make dependencies list, is written to `stdout` in the standard command-line format.

```
target_file": "dependency_file.ext"
```
where:

\textit{dependency\_file\_ext} may be an assembly source file or a header file included with the \texttt{#include} preprocessor command.

When the \texttt{-o filename} switch is used with \texttt{-M}, the \texttt{-o} option is ignored. To specify an alternate target name for the make dependencies, use the \texttt{-Mt filename} switch. To direct the make dependencies to a file, use the \texttt{-Mo filename} switch.

\textbf{-MM}

The \texttt{-MM} switch directs the preprocessor to output a rule (generate make rule and preprocess) suitable for the make utility, describing the dependencies of the source file. The output, a make dependencies list, is written to \texttt{stdout} in the standard command-line format.

The only difference between \texttt{-MM} and \texttt{-M} actions is that the preprocessing continues with \texttt{-MM}. See \texttt{-M} for more information.

\textbf{-Mo filename}

The \texttt{-Mo} switch specifies the name of the make dependencies file (output make rule) that the preprocessor generates when using the \texttt{-M} or \texttt{-MM} switch. The switch overrides default of make dependencies to \texttt{stdout}.

\textbf{-Mt filename}

The \texttt{-Mt} switch specifies the name of the target file (output make rule for the named source) for which the preprocessor generates the make rule using the \texttt{-M} or \texttt{-MM} switch. The \texttt{-Mt filename} switch overrides the default \texttt{filename} is file. See \texttt{-M} for more information.
Preprocessor Command-Line Reference

-o filename

The -o switch directs the preprocessor to use (output) the specified filename argument for the preprocessed assembly file. The preprocessor directs the output to stdout when no -o option is specified.

-stringize

The -stringize switch enables the preprocessor stringization operator. By default, this switch is off. When set, this switch turns on the preprocessor stringization functionality (see # (Argument)) which, by default, is turned off to avoid possible undesired stringization.

For example, there is a conflict between the stringization operator and the assembler’s boolean constant format in the following macro definition:

#define bool_const b#00000001

-tokenize-dot

The -tokenize-dot switch parses identifiers using C language rules instead of assembler rules, without the need of other C semantics (see -cpredef for more information).

When the -tokenize-dot switch is used, the preprocessor treats “.” as an operator and not as part of an identifier. If the -notokenize-dot switch is used, it returns the preprocessor to the default behavior. The only benefit to the negative version is that if it appears on the command line after the -cpredef switch, it can turn off the behavior of “.” without affecting other C semantics.

-Uname

The -Uname switch directs the preprocessor to undefine a macro on the command line. The “undefine macro” switch applies only to macros
defined on the same command line. The functionality provides a way for users to undefine feature macros specified by the assembler or linker.

-**v[erbose]**

The `-v[erbose]` switch directs the preprocessor to output the version of the preprocessor program and information for each phase of the preprocessing.

-**version**

The `-version` switch directs the preprocessor to display version information for the preprocessor program.

-**w**

The `-w` (disable all warnings) switch directs the assembler not to display warning messages generated during assembly. Note that `-w` has the same effect as the `-nowarn` switch.

-**Wnumber**

The `-Wnumber` (warning suppression) switch selectively disables warnings specified by one or more message numbers. For example, `-W74` disables warning message `pp0074`.

-**warn**

The `-warn` switch generates (prints) warning messages (this switch is on by default). The `-nowarn` switch negates this action.
# INDEX

<table>
<thead>
<tr>
<th>Symbols</th>
</tr>
</thead>
<tbody>
<tr>
<td>? preprocessor operator, 2-37</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Numerics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0r fract, 1-63</td>
</tr>
<tr>
<td>1.15 fract, 1-61, 1-62</td>
</tr>
<tr>
<td>1.31 fract, 1-62</td>
</tr>
<tr>
<td>1.31 fracts, 1-82</td>
</tr>
<tr>
<td>32-bit initialization (used with 1.31 fracts), 1-82</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ASCII</th>
</tr>
</thead>
<tbody>
<tr>
<td>string directive, 1-71, 1-80</td>
</tr>
<tr>
<td>string initialization, 1-83, 1-119, 1-141</td>
</tr>
<tr>
<td>.asm files, 1-3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>assembler</th>
</tr>
</thead>
<tbody>
<tr>
<td>overview, 1-3</td>
</tr>
<tr>
<td>Blackfin family macros, 1-25</td>
</tr>
<tr>
<td>Blackfin feature macros, 1-25</td>
</tr>
<tr>
<td>command-line syntax, 1-145</td>
</tr>
<tr>
<td>debugging syntax errors, 2-13</td>
</tr>
<tr>
<td>directive syntax, 1-6, 1-71</td>
</tr>
<tr>
<td>expressions, constant and address, 1-54</td>
</tr>
<tr>
<td>file extensions, 1-146</td>
</tr>
<tr>
<td>instruction set, 1-6</td>
</tr>
<tr>
<td>keywords, 1-42</td>
</tr>
<tr>
<td>numeric bases, 1-60</td>
</tr>
<tr>
<td>operators, 1-56</td>
</tr>
<tr>
<td>producing code for specified processor, 1-168</td>
</tr>
<tr>
<td>program content, 1-6</td>
</tr>
<tr>
<td>running from command line, 1-145</td>
</tr>
<tr>
<td>run-time environment, 1-2</td>
</tr>
<tr>
<td>setting options, 1-144, 1-173</td>
</tr>
<tr>
<td>SHARC feature macros, 1-25</td>
</tr>
<tr>
<td>source files (.asm), 1-4</td>
</tr>
<tr>
<td>special operators, 1-57</td>
</tr>
<tr>
<td>symbols, 1-53</td>
</tr>
<tr>
<td>TigerSHARC feature macros, 1-26</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>absolute address, 1-68</td>
</tr>
<tr>
<td>ADDRESS () assembler operator, 1-57</td>
</tr>
<tr>
<td>ADI macro, 2-15</td>
</tr>
<tr>
<td>.ALIGN (address alignment) assembler directive, 1-76</td>
</tr>
<tr>
<td>-align-branch-lines assembler switch, 1-151</td>
</tr>
<tr>
<td>.ALIGN_CODE (code address alignment) assembler directive, 1-78</td>
</tr>
<tr>
<td>-anomaly-detect assembler switch, 1-152, 1-165</td>
</tr>
<tr>
<td>-anomaly-warn assembler switch, 1-152</td>
</tr>
<tr>
<td>-anomaly-workaround assembler switch, 1-153</td>
</tr>
<tr>
<td>arithmetic</td>
</tr>
<tr>
<td>fractional, 1-63</td>
</tr>
<tr>
<td>mixed fractional, 1-63</td>
</tr>
</tbody>
</table>
Index

assembler directives
  .ALIGN, 1-76
  .ALIGN_CODE, 1-78
  .ASCII, 1-80
  .BSS, 1-71
  .BYTE/.BYTE2/.BYTE4, 1-81
  .COMPRESS, 1-85
  conditional, 1-64
  .DATA, 1-72
  .EXTERN, 1-86
  .EXTERN STRUCT, 1-87
  .FILE_ATTR, 1-90
  .FILE (override filename), 1-89
  FORCEDCOMPRESS, 1-90
  .GLOBAL, 1-92
  .GLOBL, 1-72
  .IMPORT, 1-94
  .INC/BINARY, 1-73
  .LEFTMARGIN, 1-97
  .LIST, 1-98
  .LIST_DATA, 1-99
  .LIST_DATFILE, 1-100
  .LIST_DEFTAB, 1-100
  .LIST_LOCTAB, 1-102
  .LIST_WRAPDATA, 1-103
  .LONG, 1-104
  .MESSAGE, 1-105
  .NEWPAGE, 1-109, 1-121
  .NOCOMPRESS, 1-110
  .NOLIST, 1-98
  .NOLIST_DATA, 1-99
  .NOLIST_DATFILE, 1-100
  .NOLIST_WRAPDATA, 1-103
  .PAGEL, 1-114
  .PAGELength, 1-111
  .PAGEWIDTH, 1-112
  .PORT, 1-114, 1-121
  .PRECISION, 1-115, 1-117
  .PREVIOUS, 1-117
  .PRIORITY, 1-118
  .ROUND_MINUS, 1-122
  .ROUND_NEAREST, 1-122
  .ROUND_PLUS, 1-122
  .ROUND_ZERO, 1-122
  .SECTION, 1-125
  .SEGMEMT/.ENDSEG, 1-131
  .SEPARATE_MEM_SEGMENTS, 1-131, 1-132
  .SET, 1-75
  .SHORT, 1-132
  .SHORT EXPRESSION-LIST, 1-75
  .STRUCT, 1-133
  .TEXT, 1-75
  .TYPE, 1-137
  .VAR, 1-138
  .WEAK, 1-143
### assembler switches
- `-align-branch-lines`, 1-151
- `-anomaly-detect`, 1-152, 1-165
- `-anomaly-warn`, 1-152
- `-anomaly-workaround`, 1-153
- `-char-size-32`, 1-154
- `-char-size-8`, 1-154
- `-char-size-any`, 1-154
- `-D (define macro)`, 1-155, 1-158
- `-default-branch-np`, 1-155
- `-default-branch-p`, 1-155
- `-double-size-32`, 1-156
- `-double-size-64`, 1-156
- `-double-size-any`, 1-156
- `-expand-symbolic-links`, 1-157
- `-expand-windows-shortcuts`, 1-157
- `-flags-compiler`, 1-157
- `-flags-pp`, 1-159
- `-g (generate debug info)`, 1-159
- `-h (help)`, 1-161
- `-i (include directory path)`, 1-161
- `-l (include search path) option for the -flags-compiler switch`, 1-158
- `-li (listing with include)`, 1-163
- `-l (named listing file)`, 1-162
- `-micaswarn`, 1-164
- `-M (make rule only)`, 1-163
- `-MM (generate make rule and assemble)`, 1-163
- `-Mo (output make rule)`, 1-164
- `-Mt (output make rule for named object)`, 1-164
- `-no-anomaly-workaround`, 1-165
- `-no-expand-symbolic-links`, 1-166
- `-no-expand-windows-shortcuts`, 1-166
- `-normal-word-code`, 1-167
- `-no-source-dependency`, 1-164
- `-no-temp-data-file`, 1-166
- `-nwc (normal word code)`, 1-167
- `-o (output)`, 1-167
- `-pp (proceed with preprocessing)`, 1-167
- `-proc processor`, 1-168
- `-save-temps (save intermediate files)`, 1-168
- `-si-revision version (silicon revision)`, 1-169
- `-sp (skip preprocessing)`, 1-170
- `-stallcheck`, 1-170
- `-swc-exclude`, 1-170
- `-version (display version)`, 1-171
- `-v (verbose)`, 1-170
- `-Werror number`, 1-171
- `-Winfo number (informational messages)`, 1-171
- `-Wno-info (no informational messages)`, 1-171
- `-Wnumber (warning suppression)`, 1-171
- `-Wwarn-error`, 1-172
- `-Wwarn number`, 1-172

### assembly
- code, embedding (inline) in C/C++, 1-20
- language constant, 2-44
- language programs, writing, 1-4
- attributes, creating in object files, 1-90

### B
- backslash character, 2-19
- binary files, including, 1-73
- `BITPOS()` assembler operator, 1-57, 1-58
- Blackfin family macros, 1-25
- block initialization section qualifiers, 1-129
- branch
  - instructions, 1-152, 1-155
  - lines default to NP, 1-155
  - target buffer, 1-155
- `.BSS assembler directive`, 1-71
- built-in functions
  - `OFFSETOF`, 1-65, 1-67
  - `SIZEOF`, 1-65, 1-67
- `.BYTE/R32 assembler directive`, 1-82
Index

.BYTE/.BYTE2/.BYTE4 assembler directives, 1-81
C structs, in assembly source, 1-21
customer support, xiv

C/C++ run-time library, initializing, 1-129
CHAR32 section qualifier, 1-127
CHAR8 section qualifier, 1-127
CHARANY section qualifier, 1-127
-char-size-32 assembler switch, 1-154
-char-size-8 assembler switch, 1-154
circular buffers, setting, 1-58, 1-59
comma-separated options, 1-159
-compass assembler directive, 1-85
concatenate (##) preprocessor operator, 2-36
conditional assembly directives
  .ELIF, 1-64
  .ELSE, 1-64
  .ENDIF, 1-64
  .IF, 1-64
constant expressions, 1-55
conventions
  comment strings, 1-64
  file extensions, 1-146
  file names, 1-146
  numeric formats, 1-60
  user-defined symbols, 1-53
-cpredef (C-style definitions)
preprocessor switch, 2-42, 2-43
C programs, interfacing assembly, 1-20
C++ programs, interfacing assembly, 1-20
-c.Call (all comment styles) preprocessor switch, 2-44
-c.Call (comment style) preprocessor switch, 2-43
-c.Call /* (/* */ comment style) preprocessor switch, 2-43
-c.Call // (// comment style) preprocessor switch, 2-44
-c.Call ( { } comment style) preprocessor switch, 2-44

D
DATA64 (64-bit word section) qualifier, 1-128
.DAsembler directive, 1-72
_DATE__ macro, 2-15
.dat files, 1-3, 1-146
-D (define macro)
assembler switch, 1-155, 1-158
preprocessor switch, 2-44
depending
  generate information, 1-159
  macros, 2-13
depending macros, 2-13
-default-branch-np assembler switch, 1-155
default-branch-p assembler switch, 1-155
#define (macro) preprocessor command, 2-8, 2-19
dependencies, from buffer initialization, 1-37
directives list, assembler, 1-71
-__language__ macro, 1-34
dlb files, 1-5
DMAONLY section qualifier, 1-128
DM (data), 40-bit word section qualifier, 1-128
.doj files, 1-3
DOUBLE32|64|ANY section qualifiers, 1-126
double-size-32 assembler switch, 1-156
double-size-64 assembler switch, 1-156
double-size-any assembler switch, 1-156
DWARF2 function information, 1-159

E
-easm21k assembler driver, 1-2
easmblkfn assembler driver, 1-2
easmts assembler driver, 1-2
ELF.h header file, 1-126
ELF section types, 1-126
ELF conditional assembly directive, 1-64
#elif (else if) preprocessor command, 2-22
#else (alternate instruction) preprocessor command, 2-23
.ELSE conditional assembly directive, 1-64
.ENDIF conditional assembly directive, 1-64
#endif (termination) preprocessor command, 2-24
end labels
marking ending function boundaries, 1-39
missing, 1-160
end of a function, 1-160
.ENDSEG assembler directive, 1-131
#error (error message) preprocessor command, 2-25
-expand-symbolic-links assembler switch, 1-157
-expand-windows-shortucts assembler switch, 1-157
expressions, 1-55
.EXTERN (global label) assembler directive, 1-86
.EXTERN STRUCT assembler directive, 1-87
-flags-pp assembler switch, 1-159
-floating-point data, 1-115, 1-122
.FORCECOMPRESS assembler directive, 1-90
formats, numeric, 1-60
-four-byte data initializer lists, 1-73
-fractions, 1-63
constants, 1-61
mixed type arithmetic, 1-63
signed values, 1-61

G
-g (generate debug info) assembler switch, 1-159
.GLOBAL (global symbol) assembler directive, 1-72, 1-92
global symbols, 1-92

H
hardware anomalies (warnings), 1-153
header files (.h extension)
source files, 1-3
system, 2-5
tokens, 2-5
user, 2-5
hex value, decoding, 1-35
-h (help) assembler switch, 1-161, 2-44
HI() assembler operator, 1-57

I
-I assembler switch, see -flags-compiler switch
.IF conditional assembly directive, 1-64
#ifdef (test if defined) preprocessor command, 2-27
#ifndef (test if not defined) preprocessor command, 2-28

Index

# elif (else if) preprocessor command, 2-22
# else (alternate instruction) preprocessor command, 2-23
 .ELSE conditional assembly directive, 1-64
 .ENDIF conditional assembly directive, 1-64
 #endif (termination) preprocessor command, 2-24
 end labels
 marking ending function boundaries, 1-39
 missing, 1-160
 end of a function, 1-160
 .ENDSEG assembler directive, 1-131
 #error (error message) preprocessor command, 2-25
 -expand-symbolic-links assembler switch, 1-157
 -expand-windows-shortucts assembler switch, 1-157
 expressions, 1-55
 .EXTERN (global label) assembler directive, 1-86
 .EXTERN STRUCT assembler directive, 1-87
 -flags-pp assembler switch, 1-159
 floating-point data, 1-115, 1-122
 .FORCECOMPRESS assembler directive, 1-90
 formats, numeric, 1-60
 four-byte data initializer lists, 1-73
 fractions, 1-63
 constants, 1-61
 mixed type arithmetic, 1-63
 signed values, 1-61

 G
 -g (generate debug info) assembler switch, 1-159
 .GLOBAL (global symbol) assembler directive, 1-72, 1-92
 global symbols, 1-92

 H
 hardware anomalies (warnings), 1-153
 header files (.h extension)
 source files, 1-3
 system, 2-5
tokens, 2-5
 user, 2-5
 hex value, decoding, 1-35
 -h (help) assembler switch, 1-161, 2-44
 HI() assembler operator, 1-57

 I
 -I assembler switch, see -flags-compiler switch
 .IF conditional assembly directive, 1-64
 #ifdef (test if defined) preprocessor command, 2-27
 #ifndef (test if not defined) preprocessor command, 2-28

VisualDSP++ 5.0 Assembler and Preprocessor Manual

I-5
#if (test if true) preprocessor command, 2-26
-1 (include directory path) assembler switch, 1-161
preprocessor switch, 2-45
-I (include search-path) assembler option, 1-158
-1 (less includes) preprocessor switch, 2-45
#include (insert a file) preprocessor command, 2-4, 2-6, 2-29
initialization section qualifiers, 1-129
INPUT_SECTION_ALIGN() command, 1-76
input section alignment instruction, 1-76
intermediate source file (.is), 1-5
-I- (search system include files) preprocessor switch, 2-46
.is (preprocessed assembly) files, 1-168, 2-13

K
keywords, assembler, 1-42

L
.Language_Asm macro, 2-15
.Language_C macro, 2-15
_LastSuffix__ macro, 2-15, 2-38
.LeftMargin assembler directive, 1-97
legacy directives
.PORT, 1-114, 1-121
.Segment/.EndSeg, 1-131
Length () assembler operator, 1-57
-li (listing with include) assembler switch, 1-163
__Line__ macro, 2-15
#line (output line number) preprocessor command, 2-31
Linker Description Files (.ldf), 1-7, 1-8
.List assembler directive, 1-98
.List_Data assembler directive, 1-99
.List_DatFile assembler directive, 1-100
.List_Deftab assembler directive, 1-100
listing files
data initialization, 1-100
.lst extension, 1-5, 1-38
named, 1-162
opcodes, 1-99, 1-103
producing, 1-5
.List_Loctab assembler directive, 1-102
.List_WrapData assembler directive, 1-103
-l (named listing file) assembler switch, 1-162
Loc() assembler operator, 1-57
local symbols, 1-92
local tab width, 1-100, 1-102
.Long assembler directives, 1-104
long-form initialization, 1-134

M
macro argument, converting into string constant, 2-35
macros
Blackfin assembler, 1-26
debugging, 2-13
defining, 2-7, 2-8, 2-19, 2-20
definition, 1-25, 2-5
predefined by preprocessor, 2-14, 2-15
SHARC assembler, 1-26
TigerSHARC assembler, 1-26
make dependencies, 1-37, 1-95
-meminit linker switch, 1-129
memory
initializer, 1-129
RAM (random access memory), 1-128
sections, declaring, 1-125
types, 1-7, 1-128
Index

.MESSAGE assembler directive, 1-105
- -micaswarn assembler switch, 1-164
-M (make rule only)
    assembler switch, 1-163
    preprocessor switch, 2-46
-MM (make rule and assemble)
    assembler switch, 1-163
    preprocessor switch, 2-46, 2-47
-Mo (output make rule)
    assembler switch, 1-164
    preprocessor switch, 2-47
-Mt (output make rule for named file)
    assembler switch, 1-164
    preprocessor switch, 2-47

N
N boundary alignment, 1-140
nested struct references, 1-69
.NEWPAGE assembler directive, 1-109, 1-121
    -no-anomaly-workaround assembler switch, 1-165
.NOCOMPRESS assembler directive, 1-110
    -no-expand-symbolic-links assembler switch, 1-166
    -no-expand-windows-shortsucts assembler switch, 1-166
NO_INIT
    memory section, 1-130
    section qualifier, 1-129
.NOLIST assembler directive, 1-98
.NOLIST_DATA assembler directive, 1-99
.NOLIST_DATFILE assembler directive, 1-100
.NOLIST_WRAPDATA assembler directive, 1-103
-normal-word-code assembler switch, 1-167
-no-source-dependency assembler switch, 1-164
-no-temp-data-file assembler switch, 1-166
-nowarn preprocessor switch, 2-49
numeric formats, 1-60
NW (48-bit normal-word section) qualifier, 1-128
    -nwc assembler switch, 1-167

O
object files (.doj extension), 1-5
OFFSETOF() built-in function, 1-67
-o (output)
    assembler switch, 1-167
    preprocessor switch, 2-48
opcodes, large, 1-103

P
.PAGELENGTH assembler directive, 1-111
.PAGewidth assembly directive, 1-112
PM (48-bit word section) qualifier, 1-128
.PORT (declare port) assembler legacy directive, 1-114, 1-121
-pp (proceed with preprocessing) assembler switch, 1-167
#pragma preprocessor command, 2-32
.PRECISION assembler directive, 1-115, 1-117, 1-118
Index

predefined macros
__2106x__, 1-30
__2116x__ macro, 1-30
__2126x__ macro, 1-30
__2136x__, 1-30
__2146x__, 1-31
__214xx__, 1-31
__ADSP21000__, 1-29
__ADSP21020__, 1-29
__ADSP21060__, 1-30
__ADSP21061__, 1-30
__ADSP21062__, 1-30
__ADSP21065L__, 1-30
__ADSP21160__, 1-30
__ADSP21161__, 1-30
__ADSP21261__, 1-30
__ADSP21262__, 1-30
__ADSP21266__, 1-30
__ADSP21267__, 1-30
__ADSP21362__, 1-30
__ADSP21363__, 1-30
__ADSP21364__, 1-30
__ADSP21365__, 1-30
__ADSP21366__, 1-30
__ADSP21367__, 1-30
__ADSP21368__, 1-31
__ADSP21369__, 1-31
__ADSP21371__, 1-31
__ADSP21375__, 1-31
__ADSP21462__, 1-31
__ADSP21465__, 1-31
__ADSP21467__, 1-31
__ADSP21469__, 1-31
__ADSP21471__, 1-31
__ADSP21472__, 1-31
__ADSP21475__, 1-31
__ADSP21478__, 1-31
__ADSP21479__, 1-32
__ADSP21481__, 1-32
__ADSP21482__, 1-32
__ADSPBF504__, 1-28
__ADSPBF504F__, 1-28
__ADSPBF506F__, 1-28
__ADSPBF506__FAMILY__, 1-29
__ADSPBF506F__FAMILY__, 1-29
__ADSPBF50x__, 1-26
__ADSPBF512__, 1-27
__ADSPBF514__, 1-27
__ADSPBF516__, 1-27
__ADSPBF518__FAMILY__, 1-29
__ADSPBF51x__, 1-29
__ADSPBF522__, 1-27
__ADSPBF523__, 1-27
__ADSPBF524__, 1-27
__ADSPBF525__, 1-27
__ADSPBF526__, 1-27
__ADSPBF527__, 1-27
__ADSPBF528__FAMILY__, 1-29
__ADSPBF531__, 1-27
__ADSPBF532__, 1-27
__ADSPBF533__, 1-27
__ADSPBF534__, 1-28
__ADSPBF535__, 1-28
__ADSPBF535__FAMILY__, 1-29
__ADSPBF536__, 1-28
__ADSPBF537__, 1-28
__ADSPBF537__FAMILY__, 1-29
__ADSPBF538__, 1-28
__ADSPBF538__FAMILY__, 1-29
__ADSPBF539__, 1-28
__ADSPBF53x__, 1-26
Index

__ADSPBF542__, 1-28
__ADSPBF544__, 1-28
__ADSPBF547__, 1-28
__ADSPBF548__, 1-28
__ADSPBF548__FAMILY__, 1-29
__ADSPBF548M__FAMILY__, 1-29
__ADSPBF549__, 1-28
__ADSPBF54x__, 1-27
__ADSPBF561__, 1-28
__ADSPBF561__FAMILY__, 1-29
__ADSPBF566x__, 1-27
__ADSPBF592__FAMILY__, 1-29
__ADSPBF59x__, 1-27
__ADSPBLACKFIN__, 1-26
__ADSPLPBLACKFIN__, 1-26
__ADSPTS__, 1-34
__ADSPTS101__, 1-34
__ADSPTS201__, 1-34
__ADSPTS202__, 1-34
__ADSPTS203__, 1-34
__ADSPTS20x__, 1-34
__LANGUAGE_ASM, 1-26, 1-29, 1-34
__NORMAL_WORD_CODE__, 1-32
__SHORT_WORD_CODE__, 1-33
__SIMDSHARC__, 1-33

preprocessor
guide, 2-1, 2-2
assembly files, 2-17
command syntax, 1-7, 2-3, 2-17, 2-18, 2-39
-cpredef (C style) switch, 2-42
-csall (all comment styles) switch, 2-44
-cs/* (/* */ comment style) switch, 2-43
-cs// (// comment style) switch, 2-44
-cs[ {{ } } comment style] switch, 2-44
-cs switch, 2-43
-D (define macro) switch, 2-44
feature macros, 2-15
-h (help) switch, 2-44
-i (include directory) switch, 2-45
-i (less includes) switch, 2-45
-I- (search system include files) switch, 2-46
-M (make rule only) switch, 2-46
-MM (make rule and assemble) switch, 2-47
-Mo (output make rule) switch, 2-47
-Mt (output make rule for named file) switch, 2-47
-notokenize-dot switch, 2-48
-nowarn switch, 2-49
-o (output) switch, 2-48
output file (.is extension), 1-5
running from command line, 2-39
setting options, 2-16
source files, 2-17
-stringize switch, 2-48
system header files, 2-29
-tokenize-dot switch, 2-48
-Uname switch, 2-48
user header files, 2-29
-version (display version) switch, 2-49
-v (verbose) switch, 2-49
-warn (print warnings) switch, 2-49
-Wnumber (warning suppression) switch, 2-49
-w (skip warning messages) switch, 2-49

VisualDSP++ 5.0 Assembler and Preprocessor Manual 1-9
preprocessor commands
  #define, 2-19
  #elif, 2-22
  #else, 2-23
  #endif, 2-24
  #error, 2-25
  #if, 2-26
  #ifdef, 2-27
  #ifndef, 2-28
  #include, 2-29
  #line (counter), 2-31
  #pragma, 2-32
  #undef, 2-33
  #warning, 2-34
preprocessor macros
  common macros, 2-15
  ... preprocessor operator, 2-20
preprocessor operators
  ? (generate unique label), 2-37
  ## (concatenate), 2-36
  # (stringization), 2-35
  ... (variable-length argument list), 2-20
  .PREVIOUS assembler directive, 1-118
  -proc (target processor) assembler switch, 1-168
programs
  assembling, 1-4
  content, 1-6
  listing files, 1-38
  preprocessing, 1-24
  structure, 1-7
  writing in assembly, 1-3
project settings
  assembler, 1-173
  preprocessor, 1-24, 2-16

Q
qualifiers, 1-62, 1-105
question mark (?) preprocessor operator, 2-37

R
R32 qualifier, 1-62
relational
  expressions, 1-66
  operators, 1-56
RESOLVE() command (in LDF), 1-138
rounding modes, 1-122
  .ROUND_MINUS (rounding mode) assembler directive, 1-122
  .ROUND_NEAREST (rounding mode) assembler directive, 1-122
  .ROUND_PLUS (rounding mode) assembler directive, 1-122
  .ROUND_ZERO (rounding mode) assembler directive, 1-122
RUNTIME_INIT section qualifier, 1-129

S
-save-temps (save intermediate files) assembler switch, 1-168
searching, system include files, 2-46
section
  name symbol, 1-125
  qualifier, DM (data memory), 1-128
  qualifier, NW (normal-word memory), 1-128
  qualifier, PM (code and data), 1-128
  qualifier, RAM (random access memory), 1-128
  qualifier, SW (short-word memory), 1-128
  type identifier, 1-126
  .SECTION (start or embed a section) assembler directive, 1-125
  initialization qualifiers, 1-129
  .SEGMENT (legacy directive) assembler directive, 1-131
  .SEPARATE_MEM_SEGMENTS assembler directive, 1-131, 1-132
  .SET assembler directive, 1-75
  SHF_ALLOC flag, 1-130
<table>
<thead>
<tr>
<th><strong>Index</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>SHF_INIT flag, 1-130</td>
</tr>
<tr>
<td>SHORT assembler directives, 1-132</td>
</tr>
<tr>
<td>.SHORT EXPRESSION-LIST assembler directive, 1-75</td>
</tr>
<tr>
<td>short-form initialization, 1-134</td>
</tr>
<tr>
<td>-short-word-code assembler switch, 1-169, 1-170</td>
</tr>
<tr>
<td>SHT_DEBUGINFO section type, 1-126</td>
</tr>
<tr>
<td>SHT_NULL section type, 1-126</td>
</tr>
<tr>
<td>SHT_PROGBITS identifier, 1-126</td>
</tr>
<tr>
<td>memory section, 1-130</td>
</tr>
<tr>
<td>SHT_PROGBITS section type, 1-126</td>
</tr>
<tr>
<td><strong>SILICON_REVISION</strong> macro, 1-169</td>
</tr>
<tr>
<td>-si-revision (silicon revision) assembler switch, 1-169</td>
</tr>
<tr>
<td>SIZEOF() built-in function, 1-67</td>
</tr>
<tr>
<td>source files (.asm), 1-4</td>
</tr>
<tr>
<td>special characters, dot, 1-53</td>
</tr>
<tr>
<td>special operators, assembler, 1-57</td>
</tr>
<tr>
<td>-sp (skip preprocessing) assembler switch, 1-170</td>
</tr>
<tr>
<td>-stallcheck assembler switch, 1-170</td>
</tr>
<tr>
<td>stall information, 1-170</td>
</tr>
<tr>
<td>statistical profiling, enabling in assembler source, 1-38</td>
</tr>
<tr>
<td>string initialization, 1-83, 1-141</td>
</tr>
<tr>
<td># (stringization) preprocessor operator, 2-35</td>
</tr>
<tr>
<td>-stringize (double quotes) preprocessor switch, 2-48</td>
</tr>
<tr>
<td>struct</td>
</tr>
<tr>
<td>layout, 1-95, 1-133</td>
</tr>
<tr>
<td>references, 1-68</td>
</tr>
<tr>
<td>variable, 1-133</td>
</tr>
<tr>
<td>.STRUCT (struct variable) assembler directive, 1-133</td>
</tr>
<tr>
<td>symbol</td>
</tr>
<tr>
<td>See assembler symbols</td>
</tr>
<tr>
<td>assembler operator, 1-57</td>
</tr>
<tr>
<td>conventions, 1-53</td>
</tr>
<tr>
<td>types, 1-137</td>
</tr>
<tr>
<td>symbolic</td>
</tr>
<tr>
<td>alias, setting, 1-75</td>
</tr>
<tr>
<td>expressions, 1-55</td>
</tr>
<tr>
<td>syntax</td>
</tr>
<tr>
<td>assembler command line, 1-145</td>
</tr>
<tr>
<td>assembler directives, 1-71</td>
</tr>
<tr>
<td>constants, 1-55</td>
</tr>
<tr>
<td>instruction set, 1-6</td>
</tr>
<tr>
<td>macros, 2-7</td>
</tr>
<tr>
<td>preprocessor commands, 2-17</td>
</tr>
<tr>
<td>system header files, 2-5, 2-46</td>
</tr>
<tr>
<td>T</td>
</tr>
<tr>
<td>tab</td>
</tr>
<tr>
<td>characters in source files, 1-100, 1-102</td>
</tr>
<tr>
<td>width (changing), 1-100</td>
</tr>
<tr>
<td>width (default), 1-102</td>
</tr>
<tr>
<td>temporary data file, not written to a memory (disk), 1-166</td>
</tr>
<tr>
<td>.TEXT assembler directive, 1-75</td>
</tr>
<tr>
<td><strong>TIME</strong> macro, 2-15</td>
</tr>
<tr>
<td>-tokenize-dot (identifier parsing) preprocessor switch, 2-48</td>
</tr>
<tr>
<td>tokens, macro expansion, 1-25, 2-5</td>
</tr>
<tr>
<td>trailing zero character, 1-84</td>
</tr>
<tr>
<td>two-byte data initializer lists, 1-75</td>
</tr>
<tr>
<td>.TYPE (change default type) assembler directive, 1-137</td>
</tr>
<tr>
<td>U</td>
</tr>
<tr>
<td>-Uname (undefine macro) preprocessor switch, 2-48</td>
</tr>
<tr>
<td>#undef (undefine) preprocessor command, 2-33</td>
</tr>
<tr>
<td>unique labels, generating, 2-37</td>
</tr>
</tbody>
</table>
Index

user header files, 2-4

V

VA_ARGS__ identifier, 2-21
VAR and .VAR/INIT24 (declare variable)
   assembler directives, 1-81, 1-138
variable length argument list, 2-20
-version (display version)
   assembler switch, 1-171
   preprocessor switch, 2-49
VisualDSP++
   Assemble page, 1-38, 1-173, 1-174, 2-16
   Project Options dialog box, 1-38, 1-41,
      1-173, 1-174, 2-16
   setting assembler options, 1-38, 1-173, 1-174
   setting preprocessor options, 2-16
__VISUALDSPVERSION__ macro, 1-35,
   2-16
-v (verbose)
   assembler switch, 1-170
   preprocessor switch, 2-49

W

WARNING ea1121, missing end labels, 1-160
warnings
   multi-issue conflicts, 1-164
   printing, 2-49
   suppressing, See -Wnumber (warning suppression) preprocessor switch
   #warning (warning message) preprocessor command, 2-34
   -warn (print warnings) preprocessor switch, 2-49
   .WEAK assembler directive, 1-143
   weak symbol binding, 1-143
   -Werror number assembler switch, 1-171
   -Winfo number (informational messages) assembler switch, 1-171
   -Wno-info (no informational messages) assembler switch, 1-171
   -Wnumber (warning suppression) assembler switch, 1-171
   preprocessor switch, 2-49
   wrapping, opcode listings, 1-103
   writing assembly programs, 1-3
   -w (skip warning messages)
      assembler switch, 1-171
      preprocessor switch, 2-49
   -Wsuppress number assembler switch, 1-172
   -Wwarn-error assembler switch, 1-172
   -Wwarn number assembler switch, 1-172

Z

ZERO_INIT
   memory section, 1-130
   section qualifier, 1-129