Suite56™ DSP Tools

User's Manual, Release 6.3

DSPS56TOOLSUM/D
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MOTOROLA

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About this Book

This manual is a guide to Motorola code-development tools, such as simulators of digital signal processors, hardware evaluation modules, debuggers, compilers, assemblers, and linkers. It does not replace the reference manuals and on-line help available with these tools. Rather, it serves as your introduction, orienting you and indicating how to get the most from these tools. With this manual, you'll be better able to judge which Motorola products will meet your particular needs for generating and debugging code for digital signal processors.

If you have already chosen specific Motorola products, this manual explains how to combine and use those products effectively. Furthermore, this manual is meant to be platform-independent; whether you are working on a Unix work station, Windows NT, or other host, this manual provides general guidance about getting the most from Motorola code-development tools.

Audience

This manual is intended for software developers, applications programmers, or hardware developers who are evaluating Motorola products or who are just beginning to develop projects using Motorola components. It introduces you to generating and debugging code for digital signal processors with Motorola tools.

Prerequisites

We assume that you are familiar with the host computer (i.e., the development platform) where you are developing your own application or product and that if you encounter difficulties there, you can consult your system administrator or other technical support. Motorola code-development tools run on the following platforms:

- Windows NT
- Windows 95
- Hewlett-Packard HP-UX
- Sun OS 4
- Sun Solaris

We also assume that you are fluent in the programming language—whether C or assembly language—for your project, and that if you have difficulties with it, you will consult your favorite language manual. If you are developing your application in C, then of course you need a C cross-compiler installed on your development system. (Section 1.1, "Compilers," on page 1-2, offers more information about available C cross-compilers.) Likewise, if you have decided to program in assembly language, then you need an appropriate cross-assembler installed on your host. (Section 1.2, "Assemblers," on page 1-3, offers more information about available cross-assemblers.)

As you work, you will need the reference manual for your cross-compiler or assembler. There is a specific manual for each of the Motorola cross-compilers; there is a single manual to cover all the available Motorola assemblers. You can retrieve copies of those manuals from the Motorola website:

http://www.motorola-dsp.com/documentation

Similarly, you can find documentation for Motorola digital signal processors, including their technical data sheets, their family reference manuals, and their device-specific reference or user's manuals at the same website.

To download examples of code that appear in this manual, go to the following website:

http://www.motorola-dsp.com/documentation/downloadable

Organization

This manual is organized into several chapters.

- Chapter 1, "Selecting Tools," covers possible configurations of Motorola tools and devices.
- Chapter 2, "Testing Your Hardware Installation," supplies trouble-shooting guidelines in the unlikely event you encounter difficulty while installing Motorola tools.
- Chapter 3, "Debugging C and Assembly Code," walks you through both C and assembly programs, showing you how to set break points; how to create watch lists; how to integrate C with assembly programs in the same application; how to use memory control and map files.
- Chapter 4, "Tips about Special Projects," is based on information gleaned from Motorola customers who have used these development tools successfully in their own projects.
- Chapter 5, "Answers to Frequently Asked Questions," collects handy information to help you customize your development environment and to avoid known pitfalls.

A glossary and an index complete the manual.

Conventions

This manual uses the following notation conventions:

- `Courier monospaced type` indicates commands, command parameters, code, expressions, data types, and directives.
- Curly brackets `{}` are used in two ways.

  In the context of the syntax of commands (for example, in a reference manual), they enclose a list of command parameters from which you must choose one; the curly brackets are not part of the command; you do not need to enter the curly brackets.

  In the context of arguments passed to the Motorola simulator or Motorola ADS debugger, they enclose a C expression for evaluation. In this context, you must enter the curly brackets.
- Square brackets `[]` enclose optional command parameters; for example, `wait[count(seconds)]` indicates that count is an optional parameter. The square brackets themselves are not part of the command; you do not need to enter them.
- A slash between items in a list of optional parameters indicates that only one item from that list may be used as a parameter to that command; that is, the items are alternatives to each other. For example, this command `log [c/s/p] filename` indicates that `log c filename` is a valid command, that `log s filename` is a valid command, but `log c s filename` is not a valid command.
- Commands can be abbreviated; in the reference manuals and in this manual, for example, `wait` indicates that you can type `w` for the `wait` command.
- Ellipsis (that is, three consecutive periods) in a command indicate that you can repeat the preceding field. For example, the command `save address_block . . .` indicates that you can save more than one block at a time.
- All source code examples are in C or assembly code.

Acronyms and Abbreviations

The following list defines the acronyms and abbreviations used in this document.

ADM	application development module (a board)
ADS	application development system (an ADM, a command converter, host interface card, cables, and accompanying software)
DSP	digital signal processor
EPROM	erasable, programmable, read-only memory
EVM	evaluation module (a board)
FIR	finite impulse response (a type of filter)

GSM	global system for mobile communication
GUI	graphic user interface
IIR	infinite impulse response (a type of filter)
JTAG	Joint Test Action Group (an industry-wide consortium)
LTP	long-term predictor (an algorithm used in digital signal processing)
OnCE™	On-Chip Emulation (a protocol and circuitry comprising a debugging module)
PROM	programmable, read-only memory
ROM	read-only memory

Bibliography

The following documents are available from the Motorola Literature Distribution Center (LDC) or on the Motorola website: http://www.motorola-dsp.com/documentation.

Motorola DSP Application Development System (ADS) User’s Manual (DSPASDUM/D)

Motorola DSP Simulator Reference Manual (web only)

Motorola DSP56300 Family Optimizing C Compiler User’s Manual (and other family-specific compiler manuals)

Motorola DSP Assembler Reference Manual (web only)

Motorola DSP Linker/Librarian Reference Manual (web only)

Motorola DSP56303 ADM Reference Manual (and other device-specific ADM manuals, web only)

Motorola DSP56303 EVM Reference Manual (and other device-specific EVM manuals, web only)

Motorola DSP56300 Family Manual (DSP56300FM/AD)

Motorola DSP56600 Family Manual (DSP56600FM/AD)

Motorola DSP56800 Family Manual (DSP56800FM/AD)

Chapter 1
Selecting Tools

This chapter explains which Motorola Suite56 tools will enable you to accomplish which tasks; it describes the tools briefly and provides illustrations showing how to make the tools work together as you generate and debug code for digital signal processors.

The simplest code-development cycle in digital signal processing begins, as in Figure 1-1, when you compile a high-level program, link its object code to any libraries or other object files you may need, and execute the results either in a Suite56 simulator or through a Suite56 hardware debugger. Motorola's Suite56 offers an entire toolset for such a cycle, including a compiler, linker, simulator, and hardware debugger. Other companies, such as Tasking Software BV, also provide a toolset for this cycle. Additionally, you can "mix and match" tools from Motorola with other toolsets. This chapter offers recommendations about selecting tools to meet your needs.

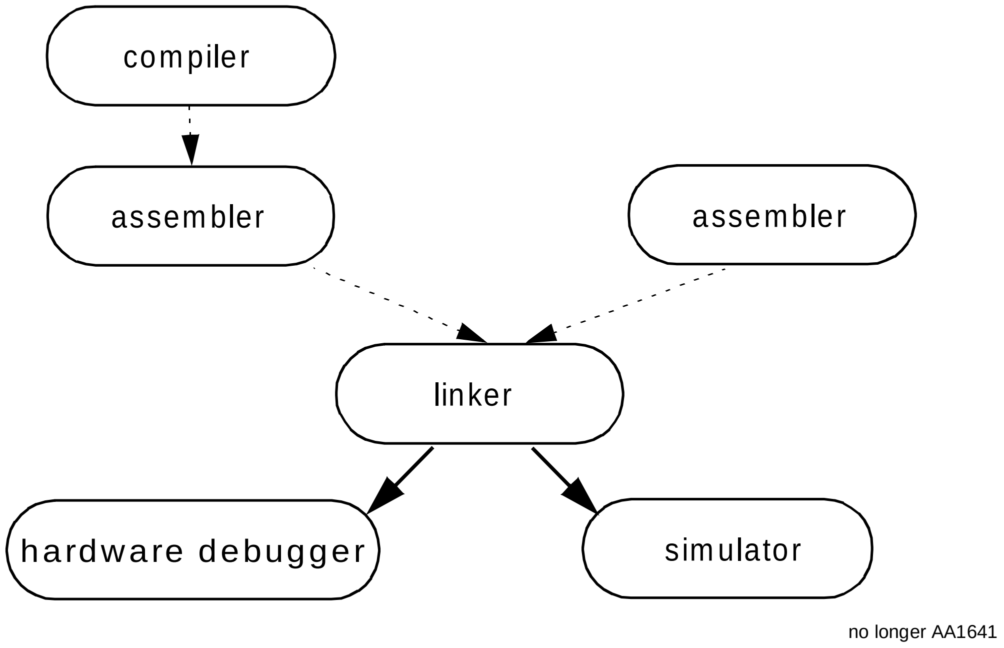


Figure 1-1. Simple Code Development Cycle: Compile, Link, Execute to Debug

1.1 Compilers

Motorola recommends purchase of the Tasking C compiler for the DSP56300 and DSP56600 families of digital signal processors. Motorola markets the m568c C compiler for the DSP56800 family. Alternatively, Motorola distributes enhanced versions of the ANSI-compliant GNU C compiler. These compilers are specific to *families* of Motorola devices; that is, the `g563c` is an optimizing C compiler for the DSP56300 family of devices, and the `g566c` for the DSP56600 family. There is no GNU C Compiler for the DSP56800 Family. From its website, Motorola distributes these enhanced, optimizing, GNU C compilers along with device-specific utilities, such as preprocessors, to give you greater control over the runtime environment. Each of those optimizing, family-specific C compilers implements the C programming language according to ANSI X3.159-1989.

The Suite56 C preprocessor that Motorola distributes also conforms to an ANSI standard. It facilitates inclusion of arbitrary text files, supports conditional compilation, allows macro definition and expansion. In fact, as an independent program, the preprocessor may be used as a general purpose macro preprocessor.

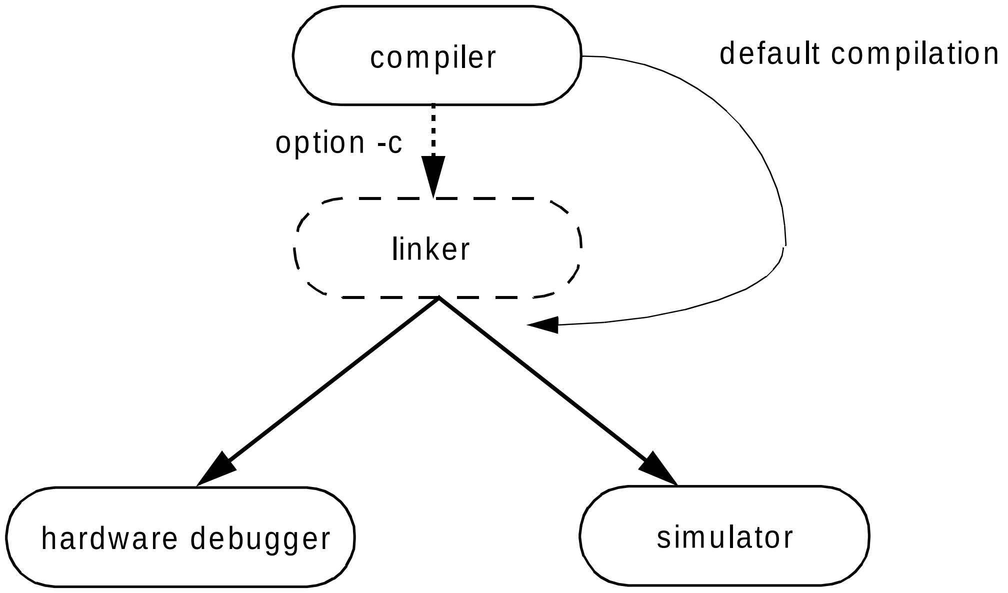


Figure 1-2. Compiling by Default or with the Option -c

By default, when you compile a C program with the Suite56 compiler, it silently calls the assembler and then the linker to produce executable object code, as in Figure 1-2. If your project can be contained in a straightforward C source file that does not require linking to external libraries or other object files, then default compilation offers you a streamlined path to project development. In contrast, if you choose the option `-c`, then the compiler silently calls only the assembler, to produce object files that must be explicitly linked.

This option to link explicitly is obviously a good choice under several different conditions:

- if your project consists of many, large C source files; if those files are compiled with option -c, then changes to one file will simply require recompilation of that file and relinking to the others; you can save the time required to recompile the unchanged files;
- if your project consists of a mixture of C source and assembly code;
- if your project needs to link to existing libraries or other object-code modules.

1.2 Assemblers

Each Motorola digital signal processor recognizes a set of machine instructions. A Suite56 *assembler* translates mnemonic operation codes (recognizable by humans) into machine instructions recognized by a Motorola digital signal processor. An assembler also accepts mnemonic directives indicating how it should behave. Suite56 assemblers, for example, accept `include` directives, allowing you to put include files into applications based on assembly code.

Suite56 assemblers understand algebraic expressions as arguments to directives and as immediate operands in certain instructions. Suite56 assemblers also accept user-defined macros, even nested macros, converting them into appropriate sequences of machine instructions. Suite56 assemblers support conditional assembly, and they provide a suite of transcendental functions (such as sine, cosine, natural logarithm) widely used in digital signal processing. These features are documented in the *Motorola DSP Assembler Reference Manual*. Figure 1-3 on page 1-4 illustrates some of the features of these Suite56 assemblers.

An assembler can produce various kinds of output:

- a relocatable object file (option `-b`)
- a listing of the source program (option `-l`)
- an object file with symbolic information from the source file (option `-g`)
- verbose reports about its progress (option `-v`)
- a report about loadtime and runtime memory use (option `-mu`)
- an absolutely located object file or executable object file (option `-a`) or relocatable overlays (default)

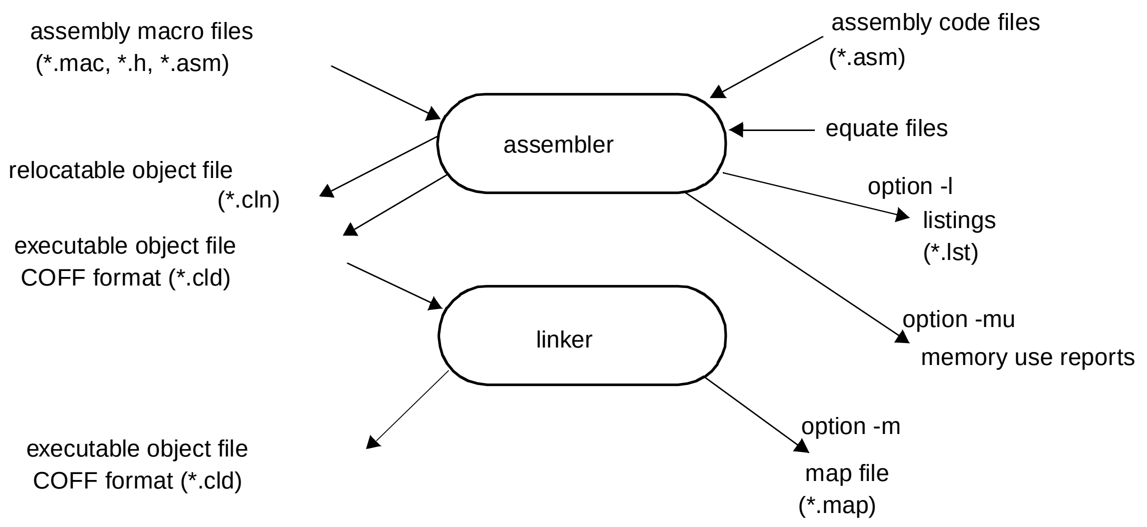


Figure 1-3. Input and Output of the Assembler

1.3 Linkers

A *linker* combines relocatable object files (such as files generated by a compiler or an assembler) or object modules (such as parts of a library) into a single, new, *absolute* executable file. With the option `-i`, the Suite56 linker can also produce a single, new, *relocatable* file; such output can then in turn be linked itself, thus giving you a way to link *incrementally* to produce a final executable file.

The executable output of a linker can be used in a variety of ways:

- it can be executed on a target platform;
- it can be loaded into a simulator and executed there;
- it can be downloaded into a system in development;
- it can be converted to Motorola S-record format to program into various types of non-volatile memory (e.g., Flash, EPROM, PROM);
- it can be sent to Motorola to generate mask ROM for devices that include ROM;
- it may include symbolic information from the source code to use in a debugger (option `-g`).

In addition to its executable output, the Suite56 linker can optionally produce other kinds of output:

- map files (option `-m`);
- sorted list of symbols and their load-time values (option `-m` also).

You can control the Suite56 linker by means of command files. With the option `-f`, you can control the linker through a command-line file. With the option `-r`, you can use a memory-control file as in Figure 1-4.

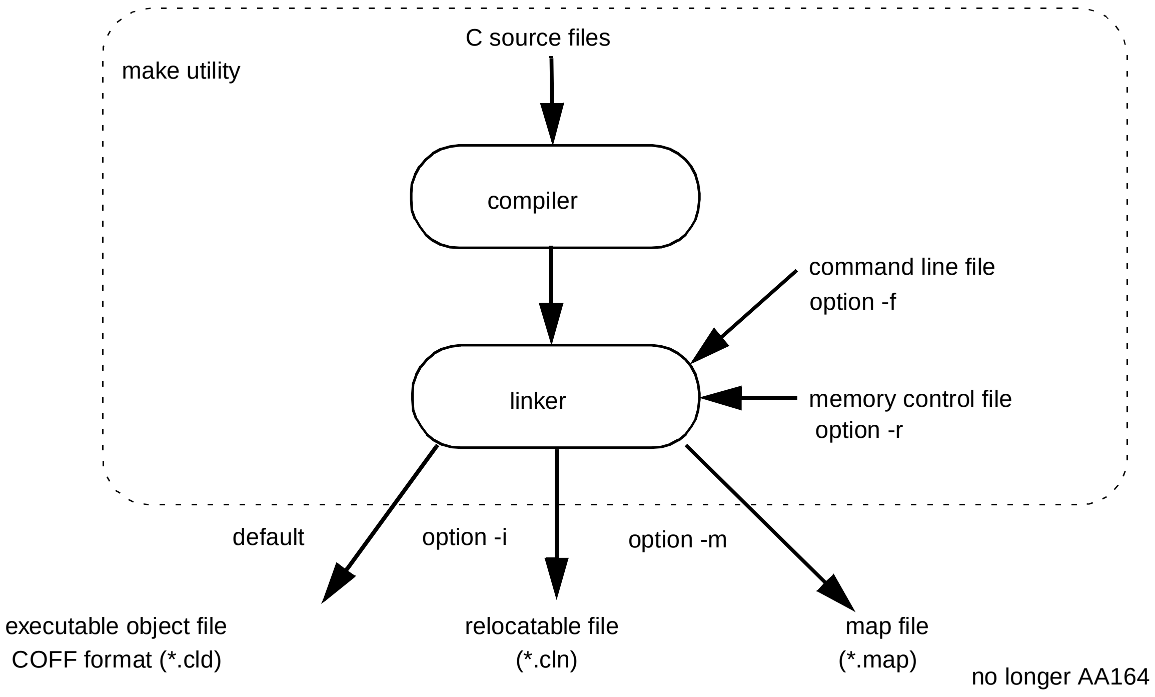


Figure 1-4. Input and Output of the Linker

One of the most powerful features of the Suite56 linker is its facility for memory control files. Through a memory control file, you can manage how the linker fills in addresses in relocatable object files. This ability means that you can place sections of code precisely in memory on your target device, at designated addresses according to your directives to the linker in memory control files. This facility is indispensable, of course, for managing overlays of sections in program memory, X data memory, or (on certain Motorola digital signal processors) Y data memory. For details about memory maps for specific Motorola devices, see the memory map chapters of the device family manual (e.g., *DSP56300 Family Manual*) and device user's manual (e.g., *DSP56307 User's Manual*). For an example of a memory control file and memory map file, see Section 3.5, "Exploiting Memory Control Files," on page 3-25 in this manual, as well as the *Motorola DSP Linker/Librarian Reference Manual*.

1.4 Simulators

A Suite56 simulator is a *software* implementation of a hardware device, such as a digital signal processor. As such, a simulator is advantageous in a number of ways:

- Whereas hardware for code development may be costly or limited in number, software simulators can serve any number of developers.
- As software, a simulator may be more portable—in the sense of traveling from office to home, for example—than comparable hardware for code development.
- Simulators can be reset remotely, unlike hardware for code development. If you are working remotely (from home, for example), a simulator reset is much less cumbersome than a physical hardware reset.
- Suite56 simulators also offer detailed profiles of code execution—profiles unavailable through hardware for code development.

A Suite56 simulator exactly reproduces the following functions:

- all core functions, including pipelining and exception processing;
- most peripheral activity;
- all internal and external memory access of a Motorola digital signal processor.

In short, Suite56 simulators enable you to evaluate a target digital signal processor comprehensively. They also enable you to emulate your own algorithms entirely in software and thus to evaluate how those algorithms behave with your target hardware. In fact, evaluation of algorithms is one of the chief uses of a simulator. Figure 1-5 illustrates a typical use of a simulator to emulate a device in an audio application.

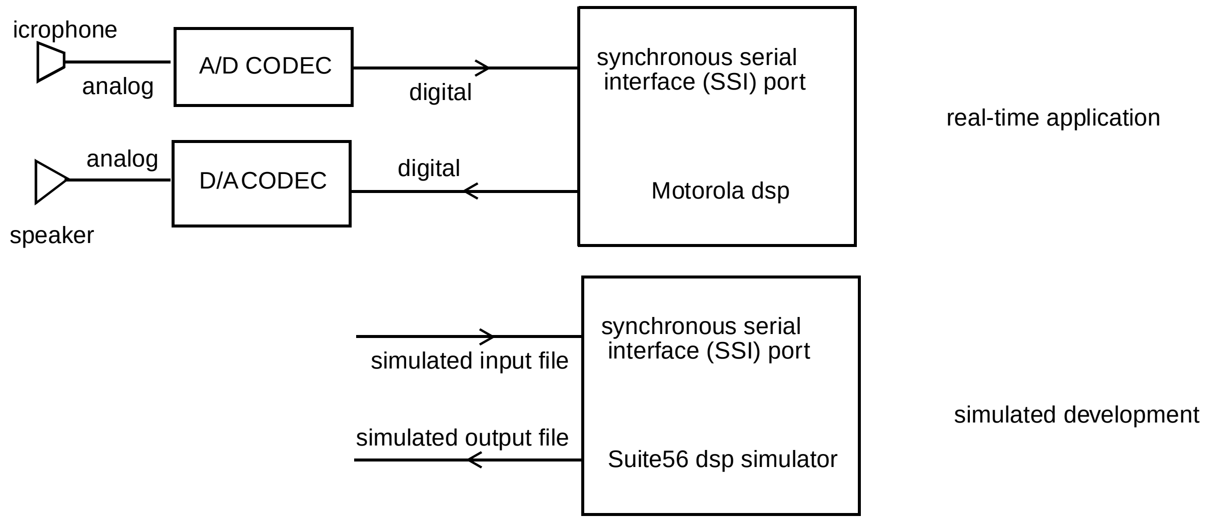


Figure 1-5. Typical Use of a Simulator in a Filtering Application

1.4.1 Data Streams and the Simulator

A simulator is also a reasonable choice when you frequently have to download very large files that would be slow or cumbersome to download from a hardware debugger to a target board. In fact, Suite56 simulators implement several types of data streams expressly for such activity. The *Motorola DSP Simulator Reference Manual* documents these data streams in Chapter 3, “Device I/O and Peripheral Simulation,” and Section 4.2.1, "Generating Interrupts and Real-Time Stimuli of Pins," on page 4-4 in this manual offers suggestions for using simulated data streams. These data streams facilitate various kinds of data communication.

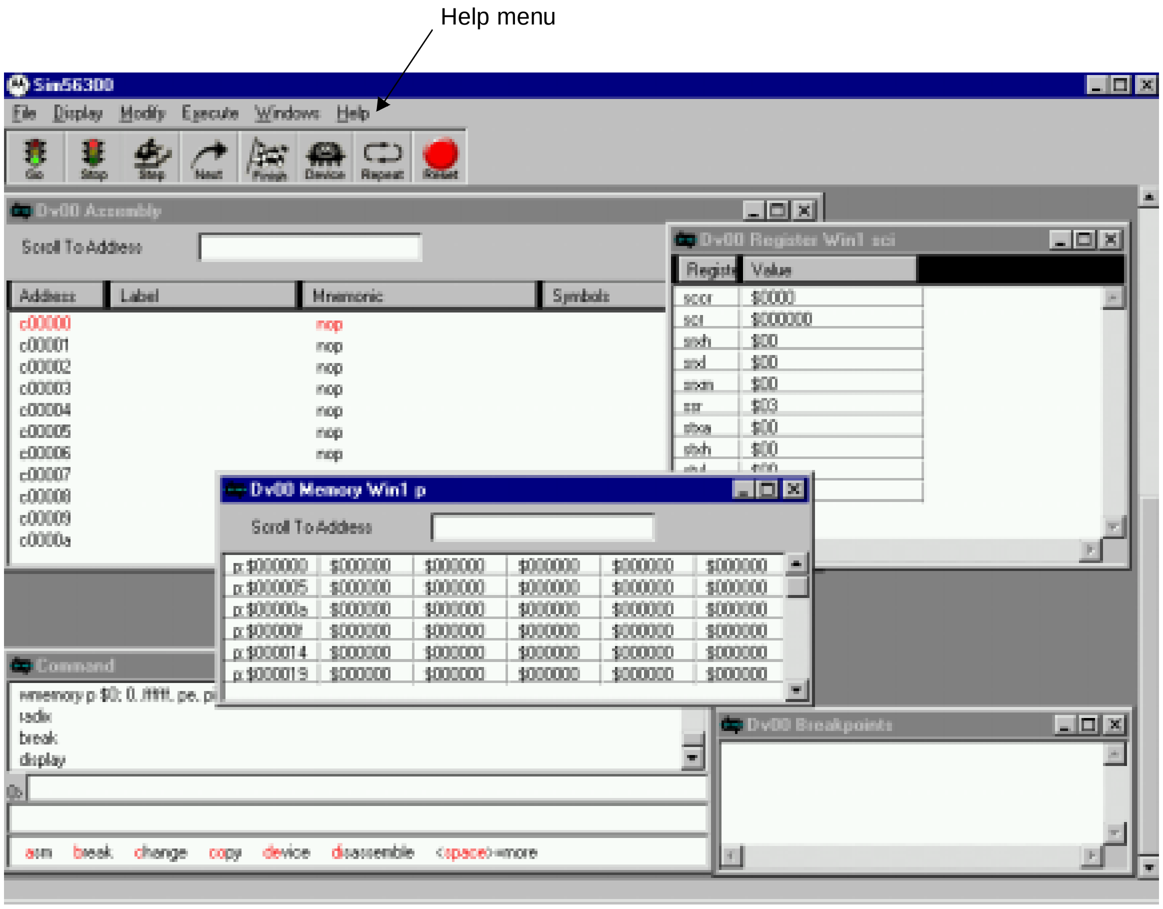
- From a host to a single memory address to simulate the interface to custom memory-mapped peripherals
- From a host to a single memory address to bypass on-chip peripherals
- To a host from a single memory address
- From a host to a pin or a group of pins
- To a host from a pin or a group of pins
- From pin to pin on the same simulated device (Connect the pins by means of the `input` command.)
- From pin to pin on different simulated devices (Create up to 32 simulated digital signal processors by means of the `device` command, and interconnect them by means of the `input` command.)
- From a memory address on one simulated device to a memory address on another simulated device

Moreover, when you need to analyze internal workings of a target digital signal processor, a simulator is a good choice because it allows you to control such internals as the instruction pipeline—a facility generally hard to access through hardware. A simulator also allows you to monitor program results without disturbing the internal instruction pipeline.

1.4.2 User Interfaces to the Simulator

The Suite56 simulator offers a graphic user interface with windows, menus, and online help, as in Figure 1-6 on page 1-8. There are several ways of starting the Suite56 simulator. For example, if you are working on an NT platform and want to run the simulator for the DSP56300 family, use one of the following alternatives:

- Double-click its shortcut icon on your desktop.
- From your **Start** menu, choose **Programs**; then choose Motorola DSP Software Development Tools, and then choose DSP56300 Simulator.
- From your **Start** menu, choose **Run**; then type `gui56300` in the prompt window.



Address	Label	Mnemonic	Symbols
c00000		nop	
c00001		nop	
c00002		nop	
c00003		nop	
c00004		nop	
c00005		nop	
c00006		nop	
c00007			
c00008			
c00009			
c0000a			

Registe	Value
sccr	$0000
sci	$000000
srxh	$00
srxl	$00
srxm	$00
ssr	$03
stxa	$00
stxh	$00
stxl	$00

p:$000000	$000000	$000000	$000000	$000000	$000000
p:$000005	$000000	$000000	$000000	$000000	$000000
p:$00000a	$000000	$000000	$000000	$000000	$000000
p:$00000f	$000000	$000000	$000000	$000000	$000000
p:$000014	$000000	$000000	$000000	$000000	$000000
p:$000019	$000000	$000000	$000000	$000000	$000000

```
wmemory p $0: 0..ffff, pe, pi
radix
break
display
```

asm break change copy device disassemble <space>=more

Figure 1-6. Graphic User Interface of the Simulator

Suite56 simulators offer a text-based interface as well; it can be invoked interactively through a console window or in batch mode through a command file. For example, to run this interface of the simulator for the DSP56300 family, type the command `sim56300` at a command prompt of your operating system. Figure 1-7 on page 1-10 shows the text-based, command-line interface of the simulator.

The *Motorola DSP Simulator Reference Manual* documents options available for both interfaces of the simulator. In this manual, the answer to a frequently asked question offers guidelines for customizing your interface to a Suite56 simulator (Section 5.1, "How do I customize Suite56 tools for my tasks?," on page 5-1).

1.4.3 Debugging with the Simulator

The Suite56 simulator is well adapted to debug application code aimed at a digital signal processor. To do so, you load object code—whether compiled C code or assembly code—into the memory map of the simulated device. (The memory map of each simulated device is documented in the memory map chapters of the device family manual (e.g., *DSP56300 Family Manual*) and device user’s manual (e.g., *DSP56307 User’s Manual*).) The simulator then executes that code as the target device would do, displaying the contents of device registers and memory locations, so you can see what is happening as your application executes on your virtual device.

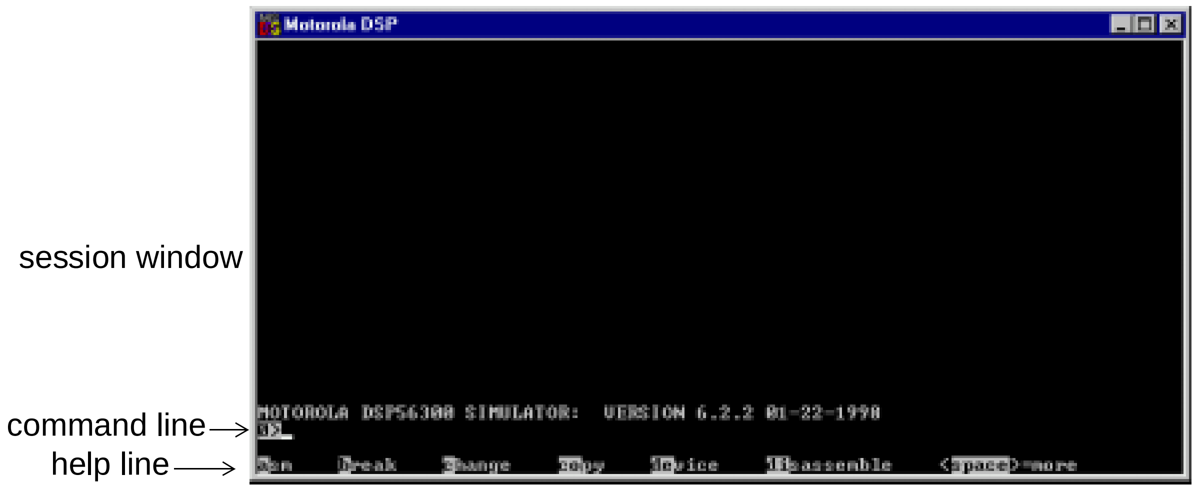
Besides *seeing* the contents of registers and memory locations, you can also *change* the contents interactively through the simulator. Likewise, you can set both unconditional and conditional breakpoints in code, at registers, and at memory locations. As a further aid to debugging, the simulator also provides a single-line assembler. With the ASM command, you can enter individual assembly instructions, which the simulator then executes. In other words, using the ASM command, Suite56 simulators let you patch code as you are debugging.

For details about displaying register contents, setting breakpoints, and using the single line assembler, see the *Motorola DSP Simulator Reference Manual* and the online help available with the simulator.

1.4.4 Online Help for the Simulator

Whether you are using the graphic or text-based interface, there is online help for each command. Through the graphic user interface, of course, online help is available from the **Help** menu on the menubar of the main window, as in Figure 1-6 on page 1-8.

In the text-based, command-line interface (as in Figure 1-7), when you type a command on the command line, then the syntax of that command appears automatically on the help line. If you type a question mark after a command on the command line, then more help, in addition to the command syntax, appears in the window.



```
MOTOROLA DSP56300 SIMULATOR:  VERSION 6.2.2 01-22-1998
0>_
Asm    Break    Change    Copy    Device    Disassemble    <space>=more
```

Figure 1-7. Text-Based Interface of the Simulator

1.5 Hardware Debugger: ADS

Like a simulator, a Suite56 hardware debugger, often referred to as the ADS or application development system, allows you to evaluate a target digital signal processor comprehensively and to evaluate how your algorithms behave with respect to your target hardware.

To manage input and output, a Suite56 debugger offers highly advantageous facilities. An ADS can, in fact, read data into the target device while running; it can also read data out of a target device and into a host while running. That is, the hardware debugger behaves like a device driving the host port to offer you much better control over simulated I/O.

A Suite56 ADS supports source-level symbolic debugging of both C and assembly programs, and it offers debugging commands to support simultaneous development with multiple devices.

Figure 1-8 shows you the hardware components (host-bus interface card, interface cables, command converter, and application development module) of a typical Suite56 ADS hardware debugger. In addition to the visible components, the system also includes software running on your development platform (the host computer) and in the command converter.

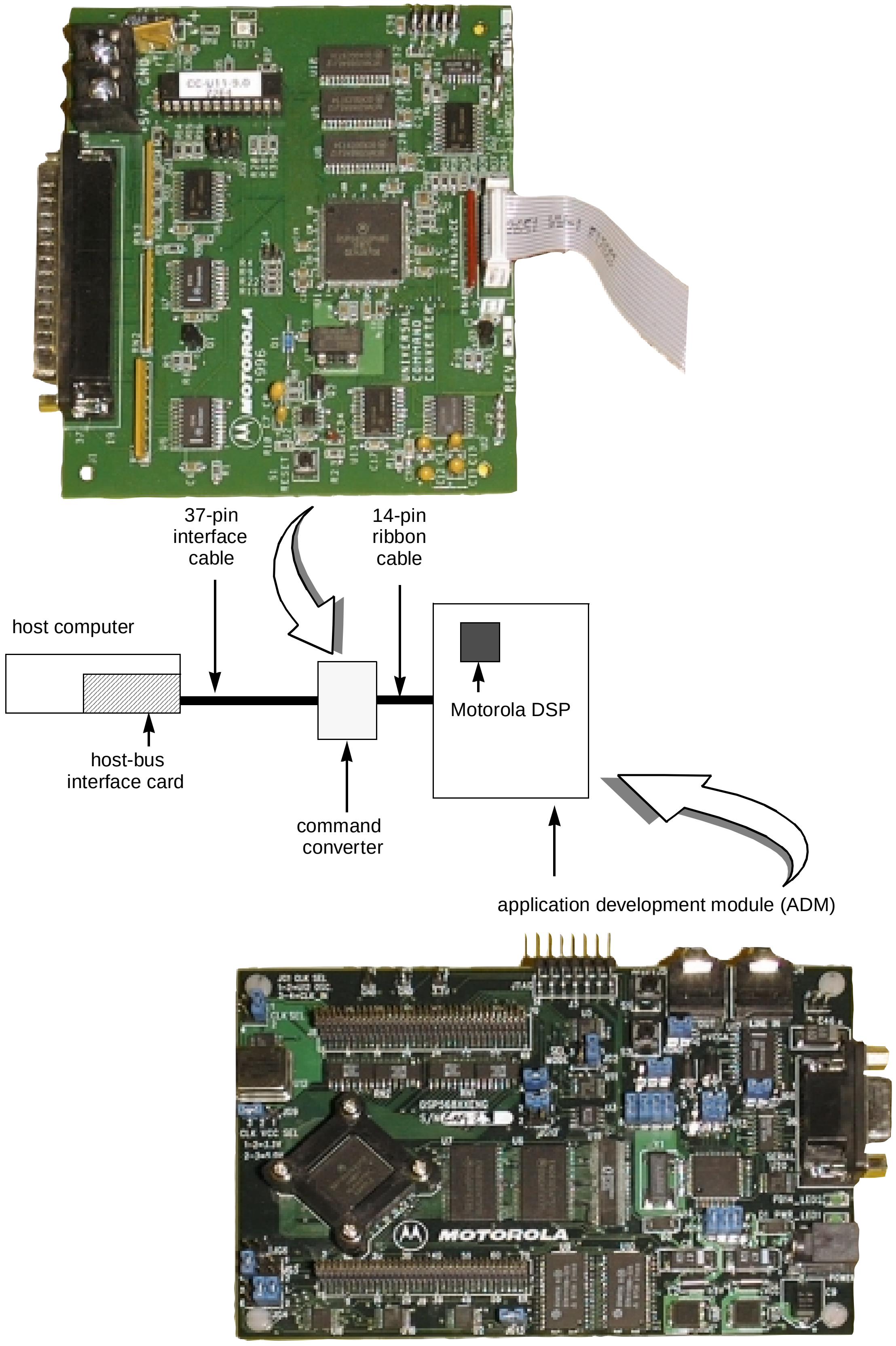


Figure 1-8. Parts of the Hardware Debugger (ADS)

1.5.1 User Interfaces to the Debugger

The Suite56 debugger offers a graphic user interface with windows, menus, and online help for interactive debugging, as in Figure 1-9 on page 1-13. There are several ways of starting the Suite56 hardware debugger. For example, if you are working on an NT platform and want to run the hardware debugger for the DSP56300 family, you use one of the following alternatives:

- Double-click its shortcut icon on your desktop.
- From your **Start** menu, choose **Programs**; then choose Motorola DSP Software Development Tools, and then choose DSP56300 Hardware Debugger.
- From your **Start** menu, choose **Run**; then type `gds56300` in the prompt window.

For customers who prefer command-line control, the Suite56 debugger offers a text-based interface as well, invoked interactively through a console window or in batch mode through a command file. For example, to run the text-based, command-line interface of the hardware debugger for the DSP56300 family, you type the command `ads56300` at your operating system prompt.

The *Motorola DSP ADS User's Manual* documents options available for both interfaces of the debugger. Through those options, you can customize your development environment, as we suggest in Section 3.1, "Initializing a Debugging Environment," on page 3-1.

1.5.2 Online Help for the Debugger

There is online help for each command and for each register through the Suite56 ADS debugger. In the graphic user interface, of course, online help is available from the **Help** menu on the menubar of the main window, as in Figure 1-9.

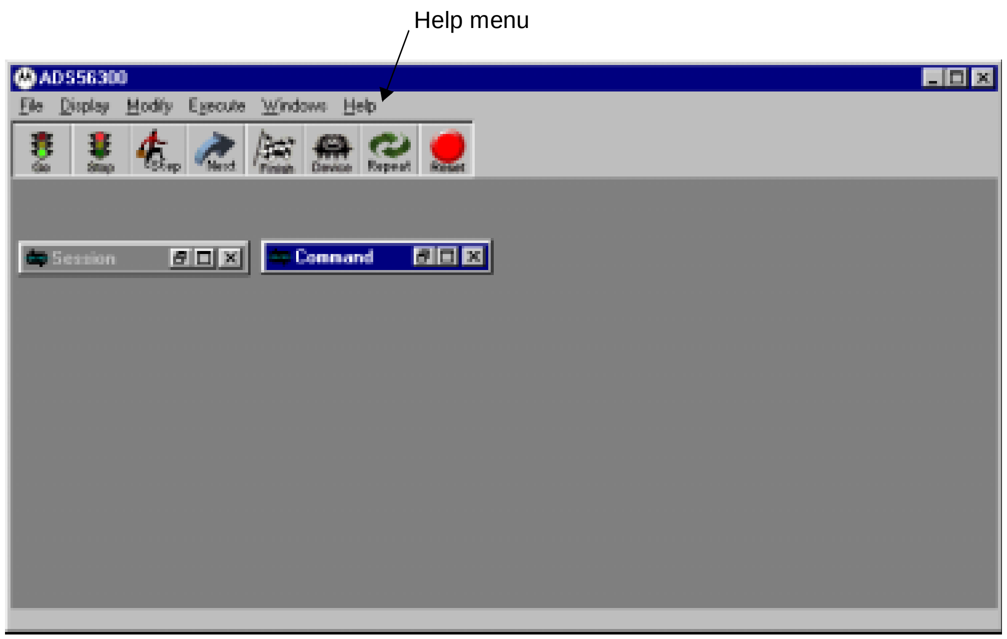


Figure 1-9. Graphic User Interface of the Hardware Debugger

In the text-based, command-line interface, when you type a command on the command line, then the syntax of that command appears automatically on the help line. If you type a question mark after a command on the command line, then more help, in addition to the command syntax, appears in the window.

Chapter 2
Testing Your Hardware Installation

The manual for each Motorola Suite56 tool (such as a compiler, an assembler, the linker, a simulator, a hardware debugger) includes a chapter explaining how to install that tool. The manuals for platform-dependent tools, such as the Suite56 ADS hardware debugger, also include an appendix of platform-specific details. This chapter assumes that you have followed the steps outlined in those installation guides and offers simple tests to check your installation. It begins with Figure 2-1, showing you how the Suite56 application development module (ADM) is conventionally set up, as part of a Suite56 application development system (ADS).

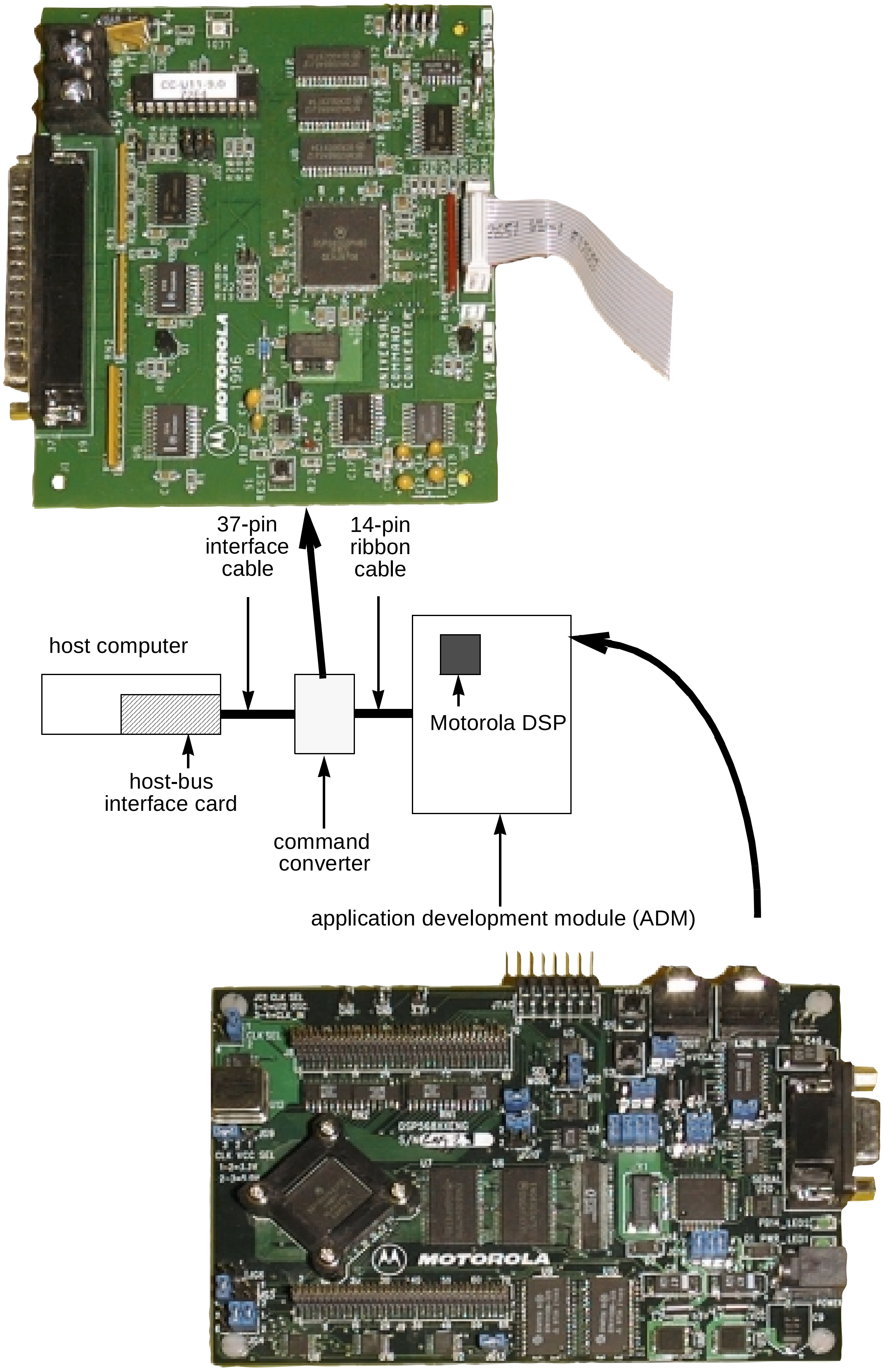


Figure 2-1. Setting up a Suite56 ADS with its ADM

2.1 Testing Your Installation of the Command Converter

If you have installed these Suite56 tools:

- a hardware debugger, such as the `ads56300` or gds56300,
- a host-bus interface board, such as the 16-bit ISA bus for PC-compatible and Hewlett-Packard workstations or the SBus for Sun and Sparc workstations,
- corresponding software device drivers, and
- the command converter,

to communicate with a target device, then we recommend that you perform either one the following tests to determine whether your installation of the command converter was successful.

2.1.1 Testing through the Graphic User Interface

To test your installation of the command converter through the graphic user interface to your Suite56 tools, follow these steps:

1. Start the hardware debugger. If you are working on a PC-compatible machine running Windows NT, for example, there are several different ways to start a hardware debugger, such as `gds56300`.
   — From your NT **Start** menu, select **Programs**, and then click on the item `Motorola DSP`. (If the debugger you want to start does not appear as an item among the Programs in your Start menu, then you may want to re-install your debugger from your Motorola Suite56 Toolkit CD-ROM.)
   — From your NT **Start** menu, select **Run**. When the command window opens, type the command in Example 2-1.
   — If you have created a shortcut icon of the Suite56 hardware debugger on your desktop, then of course you simply click on that icon.
2. In the debugger, type the commands in Example 2-2 on page 2-4.

2.1.2 Testing through the Command-Line Interface

If you prefer the command-line interface to your Suite56 tools, then test your installation of the command converter through the following steps:

1. Start the hardware debugger. For example, if you are using the debugger for the DSP56300 family, type the command in Example 2-1. To start the hardware debugger for other families, type the appropriate command, such as `ads56800` for the DSP56800 family or `ads56600` for the DSP56600 family.

Example 2-1. Start the Debugger

```
C:\> ads56300
```

2. In the debugger, type the commands in Example 2-2.

Example 2-2. Test Commands for the Command Converter

```
> cforce r
> cdisplay x:0..10
```

2.1.3 Understanding the Test Results

In Example 2-2, the initial “`c`” in both commands indicates that the command is directed to the command converter. The first debugger command, `cforce r`, resets the command converter. If the debugger indicates an error, such as “unable to reset command converter,” at that point, then you need to examine your installation of the parts communicating with the command converter (i.e., the host-bus interface card and the 37-pin, parallel, interface cable).

The second command, `cdisplay x:0..10`, displays output. A display of any arbitrary data is a good indication. However, if the debugger indicates an error, such as “unable to read command converter memory,” then you need to examine your installation of the command converter.

If both commands are successful, and you see a display of some arbitrary data, then you can be sure your installation of the command converter is correct. That is, your development host can communicate through the host-bus interface card, the Suite56 software tools, the software drivers, and the Suite56 command converter successfully, so you can proceed to the next test.

2.2 Testing Your Installation of a Target Board

If you have successfully completed the test in Section 2.1, "Testing Your Installation of the Command Converter," and you have also connected a target device such as:

- a Suite56 application development module (e.g., DSP563xx ADM),
- a Suite56 evaluation module (e.g., DSP563xx EVM), or
- your own target board,

then we recommend that you complete your installation test by typing the commands in Example 2 -3. (The same commands work whether you are using the graphic user interface or the command-line interface.)

Example 2 -3. Test Commands for the Target Device

```
> force s
> display
```

In contrast to the previous test, where both commands were prefixed by “`c`” to direct them to the command converter, these commands are directed to the application development module, the evaluation module, or your own target board. The first command, `force s`, resets both the command converter and the target device. The second command displays the contents of registers on the target device.

If both commands execute successfully and, as a consequence, you see register contents, then you can be sure that your hardware installation is correct. If you encounter difficulty at this point, then check whether the cable between the command converter and the target device is working properly. If your cable is sound and your target device is a Suite56 product (e.g., Suite56 ADM or EVM), then contact your Motorola distributor for help in determining whether your target board is defective and requires replacement.

2.3 Testing a Low-Frequency Target Device

For any low-frequency target device (i.e., less than 2MHz), you must set the command converter and the Suite56 ADS debugger software to the proper serial clock frequency. To do so, use the **`host`** command with the option **`clock`** followed by the frequency, as in Example 2 -4.

The default radix of the Suite56 ADS debugger is hexadecimal. Consequently, to express a frequency in decimal digits, we prefix it by this character: `‘`.

Example 2 -4. Setting Low Frequencies in Suite56 Tools

```
> host clock ‘32            ; sets the frequency to 32 kHz
> host clock $32             ; sets the frequency to 50 kHz
```

2.4 Choosing a Connector for the EVM Power Supply

Most Suite56 evaluation modules have a 2.1 millimeter receptacle to connect the external power supply. Modules to support the DSP56800 family, however, are exceptional in this respect: they have a 2.5 mm receptacle. A 2.5 mm connector will connect all modules, but the recommended 2.1 mm connector for the 2.1 mm modules and a 2.5 mm connector for the 2.5 mm modules are recommended to provide a secure power connection.

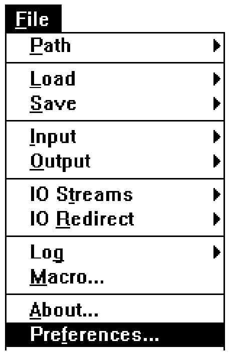
Chapter 3
Debugging C and Assembly Code

This chapter walks you through sample programs in both C and assembly language to highlight the debugging facilities in Suite56 tools, particularly the hardware debugger (such as `ads56800` or `gds56300`) and the simulator (such as `sim56600` or `gui56300`). The interfaces—both graphic and text-based—to the Suite56 simulator were deliberately designed to be as similar as possible to those of the Suite56 ADS debugger. You can use one very much as you use the other. Consequently, throughout this chapter, we will refer to the graphic user interface and the text-based interface without distinguishing the simulator from the Suite56 hardware debugger.

3.1 Initializing a Debugging Environment

There are many ways to customize your debugging environment, whether you use the graphic user interface or the text-based, command-line interface. The following sections outline those possibilities. For more detail about each topic, see the *Motorola ADS User's Manual*, particularly Chapter 3 about commands and Chapter 4 about the graphic user interface, or the *Motorola DSP Simulator Reference Manual*, Chapter 9, about its graphic user interface.

3.1.1 Choosing Preferences

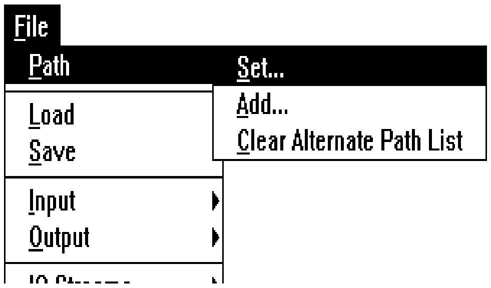


To control which windows open automatically when you start the debugger, in the graphic user interface, choose the **File** menu, and choose **Preferences**. When the Preferences dialogue box opens, select the windows that you want to open automatically at start up. Additionally, if you click the Font button in that dialogue box, another dialogue box opens for you to choose from the fonts available on your system.

In the text-based interface, you set your preferences in a resource macro file, as documented in the reference manual and explained in Section 5.1, "How do I customize Suite56 tools for my tasks?," on page 5-1.

3.1.2 Defining Paths and Working Directories

A Suite56 tool, by default, looks for input files and places output files in the current working directory. It can also redirect its search for files and its output to other specified directories by means of a path. For every target device, the debugger can maintain a distinct path, so you can organize input and output files for each target device separately.

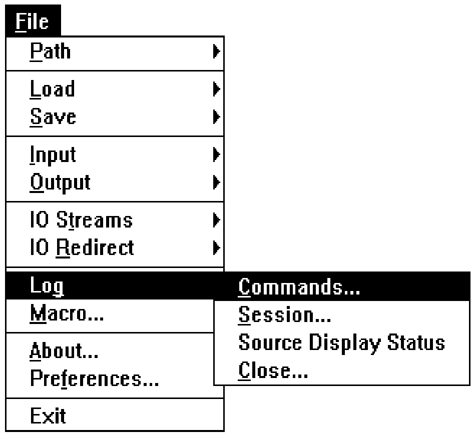


In the graphic user interface, to set the current working directory and to define a path to alternate directories for the current device, choose the **File** menu, and select **Path**. You can then **Set** the current working directory, **Add** other directories as alternates, or **Clear** the list of directories for that device.

In the text-based interface, you specify a current working directory and paths to alternate directories through environment variables that you define. You define those environment variables “on the fly” in a command window of your operating system, or alternatively in a resource macro file, as explained in Section 5.2, "I’m tired of initializing my development environment every time I start work. Is there any way to save my development environment?," on page 5-2.

3.1.3 Logging Commands for Later Reuse

One of the most useful features of a Suite56 tool is its ability to log commands that you issue. You can then save those logged commands in a file and reuse the file later to repeat that command sequence. The log file that you create in this way is an ordinary ASCII text file; you can edit it with your favorite text editor.



To create a log file of commands, in the graphic user interface, from the **File** menu, choose **Log**, and then choose **Commands**. A dialogue box opens for you to indicate where you want to save the file containing the logged commands. Any commands you issue to the tool after that point will be logged in that file to be saved automatically as executable macros.

Later, when you want to stop logging commands, from the **File** menu, choose **Close**. A dialogue box appears for you to indicate which log to close.

Anytime you want to repeat that sequence of logged commands, from the **File** menu, choose **Macro**. A dialogue box appears for you to indicate which file you want to execute.

From the text-based, command-line interface, you can also save a sequence of commands in a log file. You type the **`log`** command with two parameters: the option “**`c`**” to indicate that you want to log only commands and the argument of a file name for the log file. With a third option, you can also indicate whether you want to overwrite an existing file or append new commands to an existing file, as in Example 3 -1.

To reuse such a command log file later, simply type the name of the log file on the command line. (In the graphic user interface, the command line is located in the Command window.) If you have difficulty with this step, check the answers to the FAQs about command log files on page 5-3.

Example 3 -1. Logging Commands to a File for Reuse

```
> log c mycommands.cmd -a ; appends commands to mycommands.cmd
> log c mycommands.cmd -o ; overwrites mycommands.cmd with new commands
```

3.1.4 Logging a Session for Later Review

In addition to logging commands for later reuse, you can also log the entire contents of a session. You might want to log the contents of a session for review later. You would not execute a session log file, as it contains displayed data in addition to executable commands.

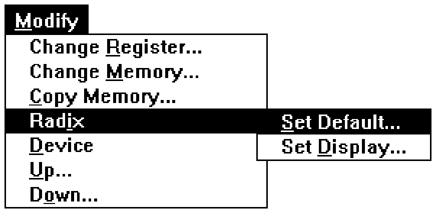
To log a session in the graphic user interface, from the **File** menu, choose **Log**, and then select **Session**. A dialogue box appears for you to indicate where you want to save the file containing the session.

To stop logging a session, from the **File** menu, choose **Close**. A dialogue box appears for you to indicate which log to close.

From the text-based, command-line interface, you can also save a session in a log file. Type the **`log`** command with the option **`s`** (to indicate that you want to log a session) and with the optional argument of a file name for the log file. With a third option, you can also indicate whether you want to overwrite an existing file (option **`-o`**) or append new contents to an existing file (option **`-a`**).

3.1.5 Setting the Radix

Whether you are using the graphic user interface or the text-based interface, you can set the radix for the *display* of the contents of registers before you display them. (The radix is the basis for computing the value of digits as numbers. For example, the digits 32 in decimal radix represent the value thirty-two and in hexadecimal radix, they represent fifty.) In the Suite56 ADS, the default radix for the display of register contents is hexadecimal. You set the default display radix to another base in the graphic user interface from the **Modify** menu by choosing **Radix**. In the text-based interface, type the command `radix` followed by the option to indicate the base you prefer (**`b`** for binary, **`d`** for decimal, **`f`** for floating-point, **`h`** for hexadecimal).



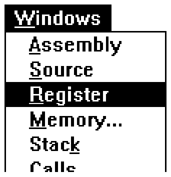
When you *enter* data by typing , you can control its radix (regardless of the default display radix) by preceding it with a radix indicator:

•$ for hexadecimal

•‘ for decimal

•% for binary

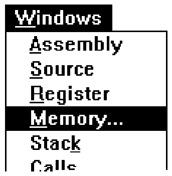
3.1.6 Displaying Registers



To display registers in the graphic user interface, from the **Windows** menu, choose **Register**. A dialogue box appears for you to indicate which registers you want to display. The Suite56 tool will then open a window, labeled with the device and registers you have chosen, and display the register names and values.

To display registers in the text-based interface, type the command `display` with no options to display all enabled registers, or with option **`on`** followed by the list of registers you want to see for a more selective display.

3.1.7 Displaying Memory



To display blocks of memory in the graphic user interface, from the **Windows** menu, choose **Memory**. A dialogue box appears for you to indicate which parts of memory you want to display. (The parts available for display vary according to the target device.) The Suite56 tool will then open a window, labeled with the device and memory blocks you have chosen, and display the block names and values. That window is interactive: you can both see and modify memory contents there.

To display memory in the text-based interface, type the command **`display`** with no options to display all enabled memory blocks, or with option **on** followed by the list of memory blocks you want to see for a more selective display.

3.2 Source-Level Debugging in C

The C code in Example 3 -2 on page 3-7 implements a long-term predictor (LTP). This type of code often appears in such applications as GSM vocoders and other voice compression algorithms.

The routine `main` initializes two input buffers and then invokes the routine `ltp`. This routine consists of an internal and external loop, which together compute a sum of products calculated from elements of the two input arrays. In other words, `ltp` implements a convolution. To do so, it uses these features:

- The two arrays, `signal_lin[]` and `signal_dpri[]`, are vectors of fractions.
- Fractional multiplication is performed by `result = lmult (inp1, inp2).`
- Fractional addition is performed by `result = add_long (inp1, inp2).`

With this example, we will highlight these debugging tasks: setting breakpoints and using the **go** command effectively; defining a watch list; tracing; evaluating C expressions (Don’t forget the curly brackets!); and casting.

Note: The C code in Example 3 -2 will not actually link successfully. It lacks the definition of two C library routines, `add_long();` and `lmult();`. Because both of those routines are platform-dependent, in a linkable example, we use `#define` for those definitions.

3.2.1 Compiling to Debug

When you are preparing to debug a C program with Suite56 tools, you must compile the program in *debug mode* with debugging symbols to retain information useful for debugging in the executable code. The compiler option for debug mode is **`-g`** if you are using a Suite56 C compiler, such as `g563c` for the DSP56300 family of devices or `g566c` for the DSP56600 family.

Example 3 -2.   A Sample C Program: ltp.c

```
int signal_lin[40], signal_dpri[120], nc;
volatile int c;
void main ()
{
     int i;
     for (i=0; i<120; i++)
          signal_dpri[i] = i;
     for (i=0; i<40; i++)
          signal_lin[i] = 40 - i;
     c = ltp ();
}
int ltp()
{
     long rj, lparam;
     int i, j, ind1, ind2;    short tmp;

     lparam=0L;          nc=39;          tmp=38;
     ind2 = 39;          ind1 = 0;
     for ( i = 39; i < 120; i++){
          ++tmp;
          rj=0L;
          for( j = 0; j< 40; j++) {
               rj=add_long(rj,lmult(signal_lin[ind1],
                    signal_dpri[ind2]));
               ind1++; ind2--;
          }
          ind1 -= 40;
          ind2 += 41;
          if (rj >  lparam) {
               lparam=rj;
               nc = tmp;
          }
        }
        nc++;
        return (nc);
}
```

$$rj = \Sigma\,(signal\_lin_i * signal\_dpri_j)$$

3.2.2 About Software Breakpoints in a C Program

This section discusses software breakpoints in debugging a C program. For details about hardware breakpoints, see the family reference manual (e.g., *Motorola DSP56600 Family Manual*) and the device manual (e.g., *Motorola DSP56602 User's Manual*), particularly chapters about the OnCE module and programming practices, for your target device. Section 4.3, "Finding Well Hidden Bugs," on page 4-7, also offers guidance about hardware breakpoints.

Software breakpoints are used to specify that a particular action be taken whenever a certain condition is met. In this way, software breakpoints are very similar to hardware breakpoints. However, software breakpoints are more limited than hardware breakpoints in that:

- software breakpoints can only be set on the first word of an instruction (they cannot be set to detect the access of registers or data memory)
- software breakpoints must be set in RAM (they cannot be set in ROM)

Despite the above limitations, it is recommended that you use software breakpoints instead of hardware breakpoints whenever possible. Why? Because, effectively only one hardware breakpoint can be set at a time whereas a virtually unlimited number of software breakpoints can be set.

Software breakpoints can have several different effects. How you set the breakpoint depends in part on the effects that you want to achieve:

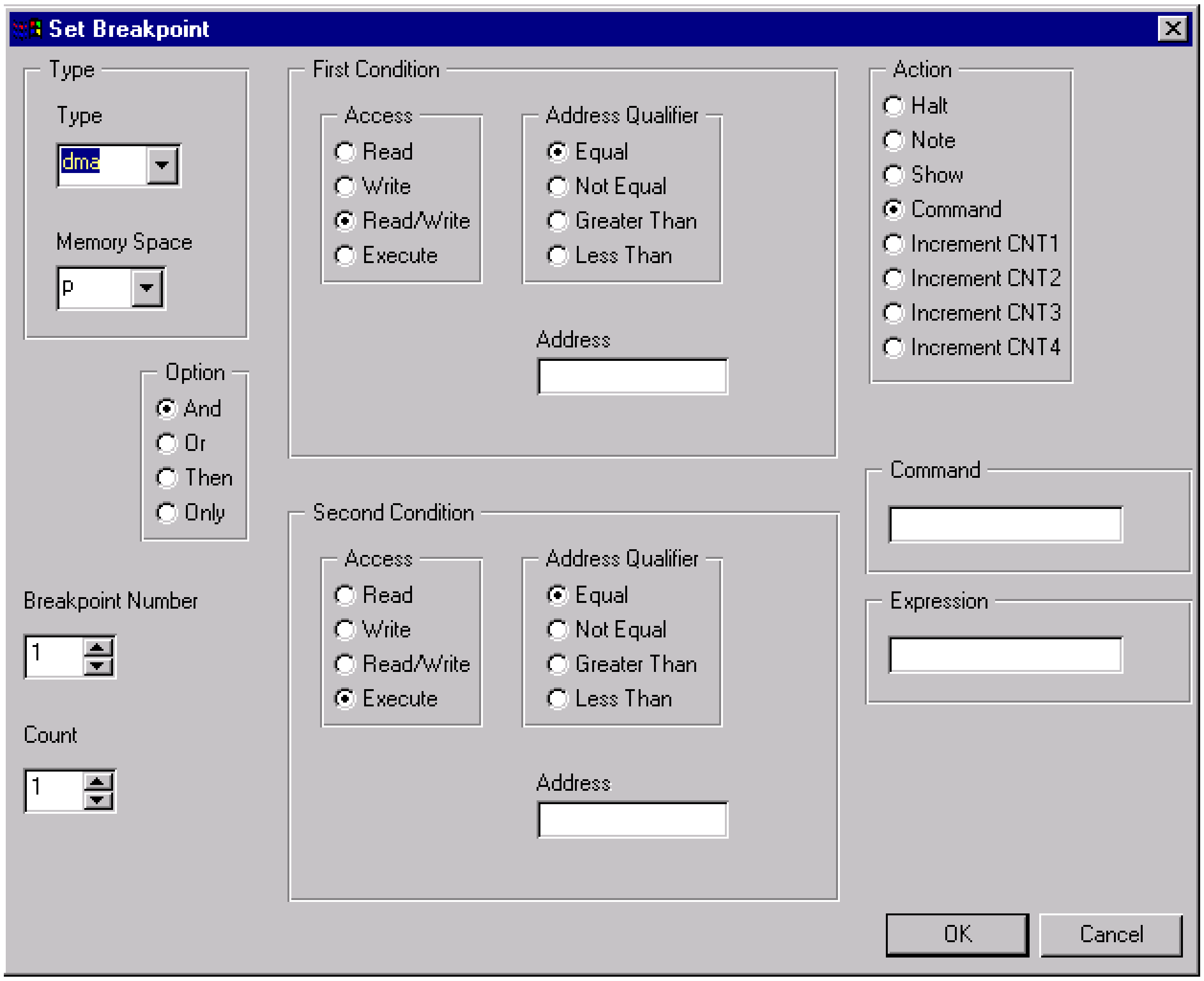
- A breakpoint causes execution of a program to halt and control of execution to return to the user. This kind of breakpoint is known as a halt breakpoint.
- In addition to halting, a breakpoint can also increment a counter so you can see how often a piece of code has been executed.
- In addition to halting, a breakpoint can also write to a Session window, so you can see whether a piece of code has been executed.
- A breakpoint may also be set in the program *data* so that as specific memory locations or registers are accessed, the break occurs. Section 4.3, "Finding Well Hidden Bugs," on page 4-7, explains more about those breakpoints.

Regardless of how you set them, breakpoints are numbered, so that you can refer to them as you watch them, disable them (i.e., turn them off), reenable them (i.e., turn them on again), or direct execution to continue until it reaches a particular breakpoint. Moreover, you can set more than one breakpoint at the same place to achieve more than one effect (e.g., concurrently halt, increment a counter, write to the Session window, and execute a user-defined routine).

3.2.3 Setting Software Breakpoints in a C Program

The following procedure details the exact steps required to set a software breaktpoint.

1. From the **Execute** menu, choose **Breakpoints**, then select **Set Software**. The **Set Breakpoints** dialog box shown in Figure 3-1 appears.


Set Breakpoint

Type — Type: dma; Memory Space: p

Option: [✓ And] Or Then Only

Breakpoint Number: 1

Count: 1

First Condition — Access: Read Write [✓ Read/Write] Execute; Address Qualifier: [✓ Equal] Not Equal Greater Than Less Than; Address:

Second Condition — Access: Read Write Read/Write [✓ Execute]; Address Qualifier: [✓ Equal] Not Equal Greater Than Less Than; Address:

Action: Halt Note Show [✓ Command] Increment CNT1 Increment CNT2 Increment CNT3 Increment CNT4

Command:

Expression:

Figure 3-1. Setting a Software Breakpoint

2. Under **Breakpoint Number** select the number you want to assign to this breakpoint. The default number that is shown is the next available number. Breakpoint numbers do not have to be consecutive, they can be assigned arbitrarily. For example, it may be convenient to allocate breakpoints so that one function is assigned breakpoints 1 to 10, another 11 to 20, and so on.

3. Under **Count** secify how many times the Debugger should encounter the breakpoint before performing the action. For example, if you set the count to 3, the breakpoint will be triggered the third time that the breakpoint is encountered. Real time execution will be affected if you set the count to more than one.
4. If you have assigned an input file, you can mark EOF. The breakpoint will be acted upon when the input file reaches an end-of-file. If you have marked EOF, under **Input File Number** select the number of the input file. The input file number is the number that you designated when you assigned the input file.
5. Under **Type** select the type of software breakpoint to set. If you select **al**, the breakpoint will always be acted upon. Breakpoint types other than **al** are conditional and device specific.
6. Under **Address**, type the address where you want the breakpoint to be set. For example, to set a breakpoint at address $103 in p memory, type: `p:$103`

Note: This address *must* be the first word of an instruction.

Note: If you have set the breakpoint type (in step 5) to a conditional breakpoint (that is, any type other than al), the breakpoint can *only* be set to an address which contains a nop. Setting the breakpoint to an address which contains any other opcode will cause your program to execute incorrectly.

7. Under **Expression** you can type an expression. The expression will be evaluated when the address you specified is reached. If the expression is true, the breakpoint will be triggered. If the expression is false, no action is taken and program execution continues. Be aware that a side effect of evaluating an expression (whether it is true or false) is that the program will not be executed in real time.
8. Under **Action** select what action is taken when the breakpoint is encountered:

Table 3-1. Software Breakpoint Actions

Breakpoint	Resulting Action
Halt	Stops program execution when the breakpoint is encountered.
Note	Displays the breakpoint expression in the Session window each time it is true. Program execution continues. The display in the Session window is not updated until program execution stops.
Show	Displays the enabled register/memory set. Program execution continues.
Command	Executes a Debugger command at the breakpoint. Device execution commands, such as TRACE or GO, will not execute.
Increment[n]	Increments the n counter by one.

9. If the action specified is to execute a command, under **Command** type the Debugger command.
10. Click **OK**.

3.2.4 To Clear a Software Breakpoint

1. From the **Execute** menu, choose **Breakpoints**, then select **Clear**.
   The **Clear Breakpoints** dialog box shown in Figure 3-2 displays a list of all the current breakpoints.

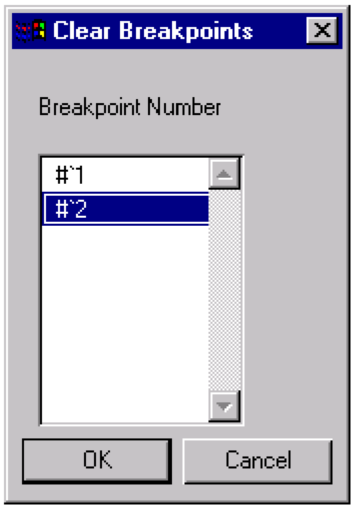


Figure 3-2. Clear Breakpoints Dialog Box

2. Select the breakpoint you want removed so that it is highlighted.
   If you are clearing consecutive breakpoints, you can click and drag to highlight more than one breakpoint. Or hold down the CTRL key while clicking on breakpoints to select more than one.

3. Click **OK**.
   The breakpoints you selected are now deleted.
   Breakpoints will not be renumbered. For example, if you have set breakpoints #1, #2, and #3, and then clear breakpoint #2, the remaining breakpoints will be numbered #1 and #3.

Notice that breakpoints are indicated in the Assembly window and the Source window (if applicable). Enabled breakpoints appear in blue. Disabled breakpoints appear in pink.

3.2.5 About Hardware Breakpoints

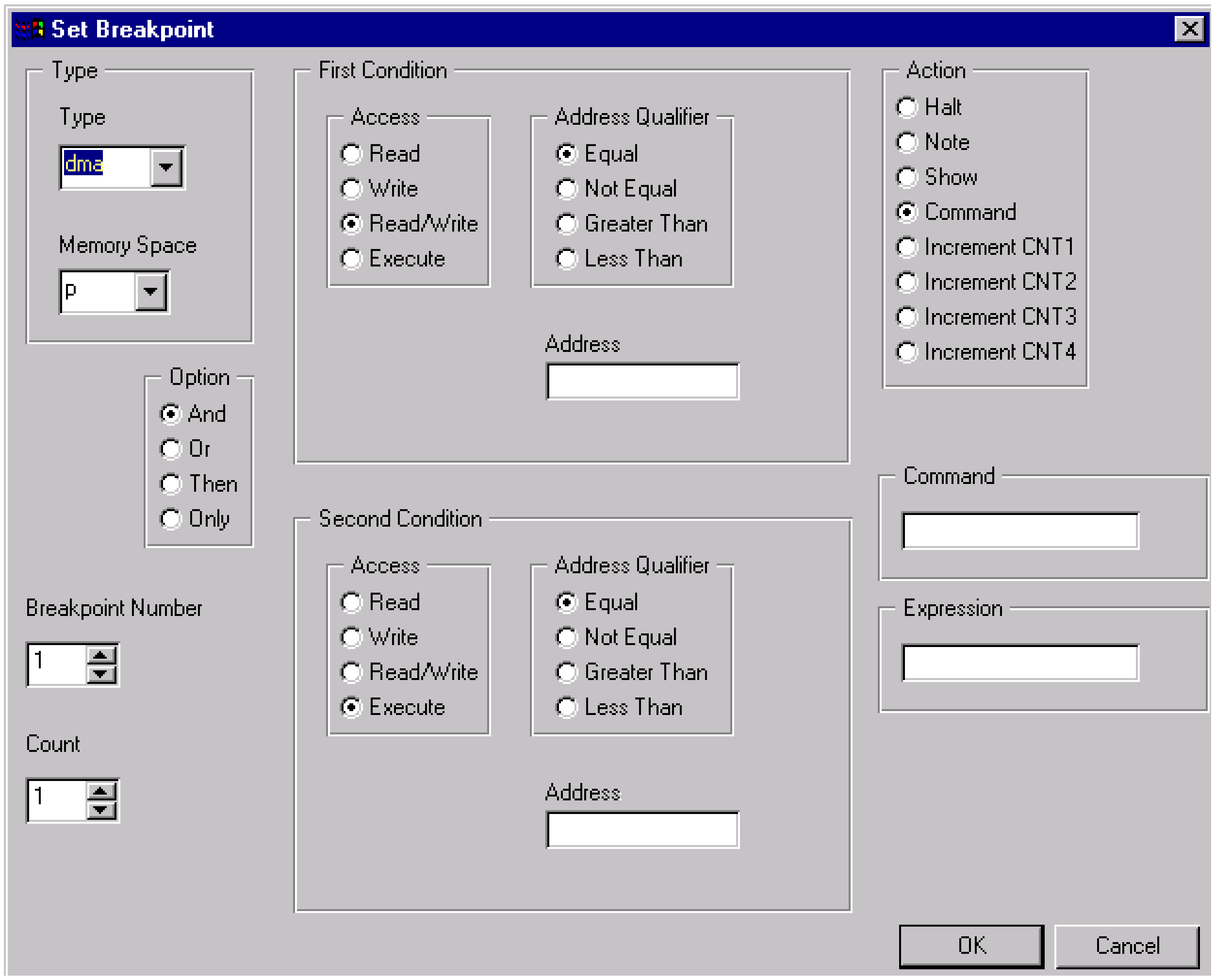
Hardware breakpoints are used to specify that a particular action be taken whenever a certain condition is met. In this way, hardware breakpoints are very similar to software breakpoints. However, there are some differences. Hardware breakpoints:

- use the OnCE circuitry on the device
- can break on the execution of an instruction
- can be set in ROM or RAM
- can be set to detect an access of data memory

Although hardware breakpoints are more flexible than software breakpoints, you will want to use hardware breakpoints judiciously. In effect, only one hardware breakpoint can be enabled at any time.

3.2.6 To Set a Hardware Breakpoint

1. From the **Execute** menu, choose **Breakpoints**, then select **Set Hardware**. The dialog box in Figure 3-3 appears.



Set Breakpoint

Type — Type: dma; Memory Space: p

Option: [✓ And] Or Then Only

Breakpoint Number: 1

Count: 1

First Condition — Access: Read Write [✓ Read/Write] Execute; Address Qualifier: [✓ Equal] Not Equal Greater Than Less Than; Address:

Second Condition — Access: Read Write Read/Write [✓ Execute]; Address Qualifier: [✓ Equal] Not Equal Greater Than Less Than; Address:

Action: Halt Note Show [✓ Command] Increment CNT1 Increment CNT2 Increment CNT3 Increment CNT4

Command:

Expression:

Figure 3-3. Setting a Hardware Breakpoint

2. Under **Type** select the type of hardware breakpoint to set. Breakpoint types are device specific. See Table 3-2 for an explanation of each type of breakpoint.
3. Under **Memory Space**, select the memory space in which the breakpoint is to be set.
4. Under **First Condition** specify the conditions under which the breakpoint occurs. Under **Access** indicate what kind of access should be detected by the breakpoint. For example, if you want the breakpoint to detect when a memory location is read but not written to, select **Read**. If you want either a read or a write to be detected, chose **Read/Write**, etc.
   Under **Address Qualifier** indicate the qualifier for the address location.
   Under **Address** type the address that the breakpoint references.

5. Under **Option**, indicate whether a second condition should be considered. **And** indicates that both conditions must be met to trigger the breakpoint. **Or** indicates that either condition can be met. **Then** indicates that the **First Condition** must be satisfied followed by the **Second Condition**. **Only** indicates that only the first condition must be met to trigger the breakpoint.
6. Under **Second Condition** specify the conditions for the second condition. This will only apply if you have indicated so under **Option** in step 5.
7. Under **Breakpoint Number** select the number you want to assign to this breakpoint. The default number shown is the next available number.
   Breakpoint numbers do not have to be consecutive, they can be assigned arbitrarily. For example, it may be convenient to allocate breakpoints so that one function is assigned breakpoints 1 to 10, another uses 11 to 20, and so on.
8. Under **Count** specify how many times the Debugger should encounter the breakpoint before stopping. For example, if you set the count to 3, the breakpoint will be triggered the third time that the breakpoint is encountered.
   Specifying a count will not affect real time execution.
9. Under **Expression** you can type an expression. The expression will be evaluated when the first (and second) condition you specified is satisfied. If the expression is true, the breakpoint will be triggered. If the expression is false, no action is taken and program execution continues.
10. Under **Action** select what action is taken when the breakpoint is encountered:

Table 3-2. Hardware Breakpoint Actions

Breakpoint	Resulting Action
Halt	Stops program execution when the breakpoint is encountered.
Note	Displays the breakpoint expression in the Session window each time it is true. Program execution continues. The display in the Session window is not updated until program execution stops.
Show	Displays the enabled register/memory set. Program execution continues.
Command	Executes a Debugger command at the breakpoint. Device execution commands, such as TRACE or GO, will not execute.
Increment[n]	Increments the n counter by one.

11. If the action specified is to execute a command, under **Command** type the Debugger command.
12. Click **OK**.

3.2.7 To Clear a Hardware Breakpoint

1. From the **Execute** menu, choose **Breakpoints**, then select **Clear**.
   The **Clear Breakpoints** dialog box, shown in Figure 3-2 on page 3-11, displays a list of all the current breakpoints.
2. Select the breakpoint you want removed so that it is highlighted.
   If you are clearing consecutive breakpoints you can click and drag to highlight more than one breakpoint. Or hold down the CTRL key while clicking on breakpoints to select more than one.
3. Click **OK**.
   The breakpoints you selected are now deleted.
   Breakpoints will not be renumbered. For example, if you have set breakpoints #1, #2, and #3, and then clear breakpoint #2, the remaining breakpoints will be numbered #1 and #3.

Notice that breakpoints are indicated in the Assembly window and the Source window (if applicable). Enabled breakpoints appear in blue. Disabled breakpoints appear in pink.

3.2.8 Defining a Watch List for a C Program

A watch list consists of C expressions, registers, memory locations, and general expressions that will be displayed throughout a trace and each time you encounter a breakpoint. In other words, a watch list consists of the items you want “to keep an eye on” as you are debugging. You define the list by adding items to it or taking items off the list.

One note of caution: when you add a C expression to a watch list, you must enclose the C expression in curly brackets, `{}`. In general, when you enter C expressions in a Suite56 simulator or Suite56 ADS hardware debugger, you must enclose the C expression in curly brackets.

A watch list is device-specific; if you are working with more than one target device, then you can define more than one watch list.

In the graphic user interface, there are two different ways to add items to a watch list:

- From the **Display** menu, choose **Watch**, and then select **Add**. A dialogue box appears for you to enter the register, memory location, or C expression to watch. You also choose the radix for the item in that window.
- From the **Windows** menu, choose **Watch**. A dialogue box appears for you to enter the register, memory location, or C expression to watch. You also choose the radix for the item and indicate which window to associate with the watched item.

In the text-based interface, to define a watch list, use the **watch** command, as in Example 3 -3.

Example 3 -3. Defining a Watch List

```
> watch r0                        ; adds the register to the watch list
> watch x:0                      ; adds memory location to the watch list
> watch {signal_lin[ind1]}        ; adds item of array to the watch list
> watch                           ; displays the current watch list
```

To remove an item from a watch list, in the graphic user interface, from the **Display** menu, choose **Watch**, and then select **Off**. A dialogue box appears for you to select items to remove from the watch list.

To remove an item from a watch list in the text-based interface, use the **watch** command followed by the number of the watch item and the **off** option, as in Example 3 -4

Example 3 -4. Removing Items from a Watch List

```
> watch              ; displays current watch list to show item numbers
> watch off          ; removes all items from the watch list
> watch #1 off       ; removes first item from the watch list
```

3.2.9 Evaluating C Expressions

As you are debugging, you can use any valid C expression as an argument to the **b**reak, **e**valuate, **ty**pe, and **wat**ch commands. When you use C expressions as arguments, you must enclose the expression in curly brackets, {}.

In addition to the usual C operators, Suite56 tools offer two additional operators for use in C expressions. The operator “#” makes it easier to refer to elements of an array. The operator “$” enables you to refer to registers directly in expressions. (This use of the operator “$” in C expressions within curly brackets differs from its use to set a hexadecimal radix in assembly code.)

To see how an expression will be evaluated (for example, before you actually use it in a command), in the graphic user interface, from the **Display** menu, choose **Evaluate**. A dialogue box opens for you to type the expression to evaluate. In the text-based interface, type the **e**valuate command followed by the expression you want to see.

To evaluate a C expression in the graphic user interface (i.e., to use it in a command), in the Command window, type the expression enclosed in curly brackets on the command line.

3.2.10 Casting in a C Program

Suite56 tools support these kinds of casts for both basic C types and user-defined types (i.e., those defined by `typedef`):

- `(type)`
- `(type *)`
- `(enum enumeration_tag)`
- `(enum enumeration_tag *)`
- `(struct structure_tag *)`
- `(union union_tag *)`

3.2.11 Tracing in a C Program

Suite56 tools offer tracing so you can continuously see the values in any registers or memory locations that interest you as your program executes. Before you begin tracing, you indicate whether you want to trace by execution cycles, by lines of C code, or by assembled instructions. You also indicate how many cycles, lines, or instructions you want to trace and whether to halt execution for breakpoints.

To trace in the graphic user interface, from the **Execute** menu, choose **Trace**. A dialogue box appears for you to indicate cycles, lines, or instructions, how many, and whether to halt at breakpoints.

To trace in the text-based interface, type the **`trace`** command with options and parameters to indicate how you want the trace to proceed.

Use the **Next** button on the toolbar to *skip over subroutine calls* and step through execution *routine by routine*. In other words, the **Next** button recognizes which assembly instructions make up a C routine, effectively executes each routine to completion, and then steps from that executed routine to the first instruction of the next routine. (See Section 3.3.2, "Tracing Assembly Code," on page 3-23, for suggestions about stepping through code instruction by instruction.)

3.2.12 Using C-Specific Commands

As you have seen, the debugging commands in Suite56 tools are available to you through menu items in the graphic user interface and as commands to enter in the Command window. Most of the debugging commands available through Suite56 tools—`break`, `evaluate`, `finish`, `go`, `next`, `step`, `trace`, `until`, `watch`—apply to both C programs and assembly programs. There are a few commands specific to C programs, however.

These are the C-specific debugging commands:

- **`do`**`wn` moves down the C function call stack. In the graphic user interface, from the **Modify** menu, choose **Down**.
- **`fr`**`ame` designates the current frame in the C function call stack. (The current frame determines the scope for evaluation.) In the graphic user interface, from the **Display** menu, choose **Call Stack**.
- **`red`**`irect` redirects standard input (`stdin`) and standard output (`stdout` and `stderr`). With it, you can make `stdin` take data from a file and send standard output to files. In the graphic user interface, from the **File** menu, choose **I/O Redirect**.
- **`str`**`eams` enables and disables input and output on the host side for C programs. In the graphic user interface, from the **File** menu, choose **I/O Streams**.
- **`ty`**`pe` accepts a C expression enclosed in curly brackets `{}` as its argument and displays the type of the return value of that expression. In the graphic user interface, from the **Display** menu, choose **Type**.
- **`up`** moves up the C function call stack. In the graphic user interface, from the **Modify** menu, choose **Up**.
- **`wh`**`ere` displays the C function call stack. With no options, it displays the entire stack. With a numeric option, you tell it how many frames of the stack to display. In the graphic user interface, from the **Display** menu, choose **Call Stack**.

3.2.13 Profiling a C Program

After you have loaded your C program into a Suite56 simulator, you can profile the program as it executes. The profiler counts the number of instructions of each type in the program, calculates their percentage of the program, and analyzes the number and type of instructions actually executed. It also analyzes addressing modes used with respect to instruction types. It assesses interaction between subroutines during execution. It computes the runtime of the program execution in terms of clock cycles. Finally, it places its results in two files; one file, with the extension `.log`, is an ordinary ASCII text file, formatted in 80 columns; the other, with the extension `.ps`, contains a PostScript version of the same results for nicely formatted output from a PostScript printer with appropriate fonts. Only the Suite56 simulator offers these profiling facilities.

To profile your program, in the graphic user interface of the simulator, first load both memory and symbols. Next, from the **File** menu, choose **Log**, and then select **Profile**. A dialogue box appears for you to indicate the name and location of the log file to contain the profile that the tool will generate. Profiling will continue until you click the **File** menu again and choose **Close**. A dialogue box opens for you to indicate that you want to close the Profile log file. Closing that file will end that profile.

In the text-based interface of the simulator, first load your executable program, both symbols and memory. Then use the **`lo`**`g` command with two arguments: the option **`p`** to indicate profile and a name for the profile log file. A third option indicates whether to append the profile to an existing file (option **`-a`**), to overwrite any existing file of the same name (option **`-o`**), or to cancel the profile if a file of the same name already exists (option **`-c`**). To end a profile, use the **`lo`**`g` command with the option **`off`**.

3.3 Symbolic Debugging in Assembly Code

The assembly code in Example 3 -5 implements a basic finite impulse response filter. FIR filters are widely used in digital signal processing. The include file, `iodata.h`, in Example 3 -6 on page 3-21 saves registers onto a stack and restores them from that stack. It also uses Suite56 debugging facilities (e.g., the `debug` instruction) to manage simulated input. For more about simulated input, see Section 4.2.1, "Generating Interrupts and Real-Time Stimuli of Pins," on page 4-4, and Section 5.8, "How do I simulate input and output?," on page 5-5.

Example 3 -5. A Finite Impulse Response Filter in Assembly Code: fir.asm

```
opt     cex,mex,cre,cc,mu
        page    132,66,0,10
        section filter

        include "iodata.h"
        define  P_MEM "0"
        define  X_MEM "1"
        define  Y_MEM "2"
        define  L_MEM "3"

data_points     equ     20              ;number of points to process


        org     y:
data_in         ds      1
data_out        ds      1
                set     i   0
                xdef    coefficients
coefficients            dupa    coef,-
21.0/231.0,14.0/231.0,39.0/231.0,54.0/231.0,59.0/231.0,54.0/231.0,39.0
/231.0,14.0/231.0,-21.0/231.0
                dc      coef
                set     i   i+1
                endm
num_taps        equ     i               ;number of taps in filter
reg_stack       ds      10              ;stack space for registers

        org     x:0
buffer          dsm     data_points     ;saved data out
states          dsm     num_taps        ;filter states

        org     p:0
        jmp     begin

        dup     $100-*
        nop
        endm

        org     p:$100
begin
        move    #reg_stack,r7            ;point to register stack
        move    #0,sp                    ;clear stack pointer
        move    #states,r1               ;point to filter states
        move    #num_taps-1,m1           ;mod(num_taps)
        move    #coefficients,r5         ;point to filter coefficients
        move    #num_taps-1,m5           ;mod(num_taps)
        move    #buffer,r6               ;point to storage buffer
        move    #data_points-1,m6        ;mod(data_points)

        move    #0,x0
        rep     #num_taps
        move    x0,x:(r1)+               ;clear tap states
        rep     #data_points
        move    x0,x:(r6)+                ;clear data points

        .loop
        do      #data_points,end_fir      ;one loop for each tap

        IODATA  input_data,1,1,Y_MEM,data_in    ;read data from ADS
        move    y:data_in,x0                    ;get sample

        jsr     fir_filter

        move    a,y:data_out                    ;output sample
        IODATA  output_data,1,1,Y_MEM,data_out  ;write data to ADS

        move    a,x:(r6)+                       ;save data
end_fir
        .endl

fir_filter
        clr     a x0,x:(r1)+ y:(r5)+,y0         ;save first state
        rep     #num_taps-1
        mac     x0,y0,a x:(r1)+,x0 y:(r5)+,y0
        macr    x0,y0,a (r1)-
        rts

        endsec
        end
```

Example 3 -6. A Header File for the FIR Example: iodata.h

```
IODATA  macro label,filenumber,count,memoryspace,address
        move   x0, y:(r7)+                     ; save register in y data
        move    r0, y:(r7)+
        move    r1, y:(r7)+
        move    #>((?filenumber<<8)|count),x0   ;(file# << 8) | count
        move    #>?address,r0                   ;address
        move    #>memoryspace,r1                ;memory space
label   debug
        move    y:-(r7), r1                     ; restore register
        move    y:-(r7), r0
        move    y:-(r7), x0
        ENDM
```

Note that in Example 3 -6, the “?” symbol used in the move commands(i.e. `move #>?address,r0)` is a special macro substitution syntax.

3.3.1 Setting Breakpoints in Assembly Code

This section discusses software breakpoints in debugging an assembly program. The observations about software breakpoints in Section 3.2.2, "About Software Breakpoints in a C Program," on page 3-8, also apply to software breakpoints in assembly code.

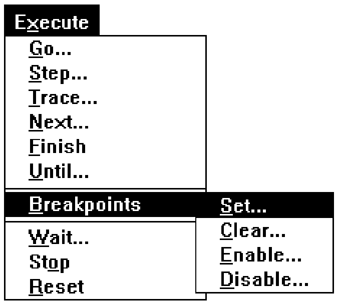
For details about hardware breakpoints, see the family reference manual (e.g., *Motorola DSP56600 Family Manual*) and the device manual (e.g., *Motorola DSP56602 User's Manual*), particularly chapters about the OnCE module and programming practices, for your target device. Section 4.3, "Finding Well Hidden Bugs," on page 4-7, also offers guidance about hardware breakpoints.

Breakpoints can have several different effects. How you set the breakpoint depends in part on the effects that you want to achieve:

- To set a halt breakpoint.

  In the graphic user interface, double-click in the Assembly window on the instruction where you want the break to occur. The break command then appears automatically in the Command window, and the Assembly window highlights the address you clicked.

- To set a breakpoint that increments a counter:



In the graphic user interface, from the **Execute** menu, choose **Breakpoint**, and then select **Set**. A dialogue box appears for you to indicate in the **Action** pane which counter to increment.

•To set a breakpoint that writes to a Session window:

In the graphic user interface, from the **Execute** menu, choose **Breakpoint**, and then select **Set**. In the dialogue box that appears then, indicate **Note** in the **Action** pane of the window.

Regardless of how you set them, breakpoints are numbered, so that you can refer to them as you watch them, disable them (i.e., turn them off), reenable them (i.e., turn them on again), or direct execution to continue until it reaches a particular breakpoint. Moreover, you can set more than one breakpoint at the same place to achieve more than one effect (e.g., halt and increment a counter and write to the Session window and execute a user-defined routine).

To continue execution after a breakpoint, in the graphic user interface, click the **Go** button. In the text-based interface, type the **g**o command on the command line.

To disable a breakpoint, in the graphic user interface, double-click on it in the Assembly window. Alternatively, from the **Execute** menu, choose **Breakpoints**, and then select **Disable**. In the text-based interface, use the `break` command followed by the number of the breakpoint and the option `off`.

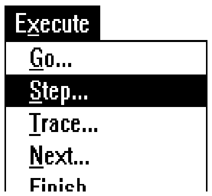
3.3.2 Tracing Assembly Code

Suite56 tools offer tracing so you can continuously see the contents of any registers or memory locations that interest you as your program executes. Before you begin tracing, you indicate whether you want to trace by execution cycles or by assembly instructions. You also indicate how many cycles or instructions you want to trace and whether to halt execution for breakpoints.

To trace in the graphic user interface, in **Execute** menu, choose **Trace**. A dialogue box appears for you to indicate cycles or instructions, how many, and whether to halt at breakpoints.

To trace in the text-based interface, type the `trace` command with options and parameters to indicate how you want the trace to proceed.

When you are using Suite56 tools, you can also step through assembly programs instruction-by-instruction with the **Step** button on the toolbar or the `step` command in the Command window. If the source code window is open, stepping will move one executable line of source code. Macros consisting of several instructions, such as debugging macros, will be executed all at once.



You can also step through in *groups* of instructions. In the graphic user interface, from the **Execute** menu, when you choose **Step**, a dialogue box appears for you to indicate in the **Count** pane how many instructions make a step. For the same effect, you can also use the `count` option of the `step` command in the Command window.

For a different effect, use the **Next** button on the toolbar to step through *routine by routine*. In other words, the **Next** button recognizes which instructions make up a routine, effectively executes each routine to completion, and then steps from that executed routine to the first instruction of the next routine.

3.4 Calling Assembly Code from C Code

C compilers—whether distributed by Motorola or by another supplier of software tools—observe *calling conventions* (i.e., conventions about how information flows between a routine that calls a piece of code and the piece of code that is called) usually documented in the reference manual for that compiler. The documentation about the calling conventions of a given compiler usually indicates how the compiler uses the underlying hardware: where the compiler can expect to find incoming data, such as parameters passed to a routine; where the compiler should place outgoing data, such as the return values of routines; how symbols are handled; and so forth.

One convention of the Suite56 C compilers (.e.g., `g563c` or `g566c`) is that they prefix every symbol with an upper-case **`F`**. When you compile a C program that calls other C routines, the compiler silently handles this convention, prefixing every called routine with the requisite **`F`**. When you compile a C program that calls routines written in assembly code, however, you must observe this convention yourself: in the assembly code, prefix **`F`** to the names of assembly routines called by your C program and declare those routines **`global`** so that your C program can access them; in the C program, declare the called routine **`extern`**.

Example 3 -7 on page 3-24 shows you a C program that calls an assembly program in this way. The assembly routine is declared **`extern`** in the C program. In Example 3 -8 on page 3-25, you can also see the assembly program with its **`global`** declaration and its required **`F`** prefixing the name of the called routine.

Example 3 -7. A C program That Calls Assembly Code

```
extern int norm_l(int);

void func(long int Acc, long int Lcr[])
{
    int i;
    int Exp;

    Exp = norm_l( Acc ) ;
    for ( i = 0 ; i < 15 ; i ++ ) {
        Lcr[i] = Lcr[i] << Exp;
    }
}
```

Example 3 -8. An Assembly Routine Called by a C Program

```
        section norm_routine_in_asm
        global Fnorm_l
Fnorm_l
        ; Receives parameter in a, returns normalized value in a
        clb     a,b
        neg     b
        move    b,a
        rts
        endsec
```

3.5 Exploiting Memory Control Files

This example, showing you how to use a memory control file to locate sections at specific addresses in X memory on a target device, is based on the Suite56 assembler for the DSP56300 family. The principles it illustrates about memory control files also apply to other target devices. The example uses two simple files of assembly code, `section_a.asm` (in Example 3 -9) and `section_b.asm` (in Example 3 -10). As you can see, the assembly code in `section_a.asm` fills a 256-word block of X memory on the target device with zeroes, and `section_b.asm` fills a 16-word block of X memory with ones.

Example 3 -9. A Sample Assembly File for Memory Mapping: section_a.asm

```
        section section_a
        org x:
        bsc $ff,0
        endsec
```

Example 3 -10. A Sample Assembly File for Memory Mapping: section_b.asm

```
        section section_b
        org x:
        bsc $10,$ff
        endsec
```

To assemble those two files, we use the commands to the assembler in Example 3 -11. The option `-b` makes the assembler produce object files. Since no other option appears in each command, the assembler will produce relocatable object files.

Example 3 -11. Assembling Two Relocatable Object Files

```
> asm56300 -b section_a.asm
> asm56300 -b section_b.asm
```

The commands in Example 3 -11 create relocatable object files, `section_a.cln` and `section_b.cln`, that can then be linked. For the purpose of this example, we assume that we want the block of zeroes set up by `section_a.asm` to start at location `x:$333` and the block of ones set up by `section_b.asm` to start at `x:$555`. We use the memory control file in Example 3 -12 to place those blocks at the target locations.

Example 3 -12. A Memory Control File: sec.ctl

```
        section section_b
        base x:$555
        section section_a x:$333
```

The two files are linked with the command in Example 3 -13. The option **`-b`** indicates that an object file will be created as linker output. The option **`-m`** indicates that a map file named `out.map` will be created as well. (That file is of particular interest to us in this example.) The option **`-r`** indicates that the linker should consult a memory control file (in this example, named `sec.ctl`) to determine where to place sections in memory on the target device.

Example 3 -13. Command to Link Memory Control File to Object Files

```
> dsplnk -b -mout.map -rsec.ctl section_a section_b
```

You see the contents of the resulting map file in Example 3 -14. When you use memory control files (as we did in this example), check the resulting map file to determine whether you achieved the memory mapping that you expected. By consulting the user’s manual of the target device (in this example, DSP56300), particularly the chapter about memory mapping, we know that certain parts of X memory are reserved; those parts are marked `UNUSED` in the map file. If those reserved portions of memory were in use, then we would know that our program was mapping memory inappropriately, and we would consequently search for the source of that bug.

Example 3 -14. A Memory Map File: out.map

```
Motorola DSP Linker  Version 6.2.1   98-05-22  10:29:21  out.map  Page 1

                        Section Link Map by Address

X Memory (0 - default)

Start    End     Length    Section
0000     0332      819     UNUSED
0333     0431      255     section_a
0432     0554      291     UNUSED
0555     0564       16     section_b
0565     FFFF    64155     UNUSED

                         Section Link Map by Name

Section                Memory       Start     End           Length
GLOBAL                 None
section_a              X (0)        0333      0431             255
section_b              X (0)        0555      0564              16
```

Chapter 4
Tips about Special Projects

The tips about special projects in this chapter were collected from Motorola customers and application developers engaged in “real world” projects.

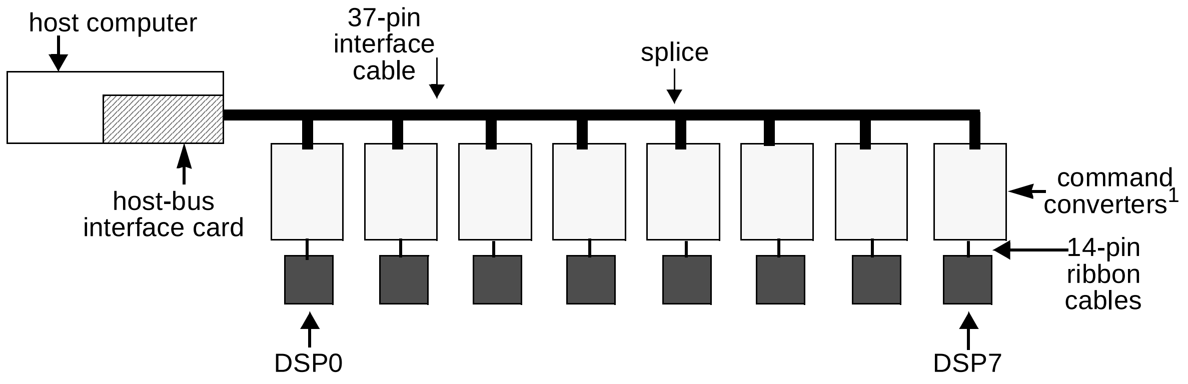
4.1 Managing Projects with Multiple Devices

Both the Suite56 ADS debugger and the Suite56 simulator support your code generation and debugging for *multiple* digital signal processors of the same family.

4.1.1 Connecting Multiple Devices to the Suite56 ADS Debugger

If you plan to use the Suite56 ADS debugger with multiple digital signal processors, you must first consider whether or not the digital signal processors have a JTAG interface.

If your project involves multiple digital signal processors that do not have a JTAG interface, then you need one command converter per device for debugging through a Suite56 ADS debugger. You can connect as many as eight devices in this way. Using a single 37-pin interface cable, splice the command converters to the host computer (your development platform), and connect each command converter to one of the non-JTAG digital signal processors through a 14-pin ribbon cable, as in Figure 4-1.



Notes: 1. There is a jumper setting on each command converter to select address, DSP0 . . . DSP7.

Figure 4-1. Connecting Non-JTAG Devices for Debugging

In contrast, if all the digital signal processors in your project have a JTAG interface, then you can connect up to 24 such devices through a single command converter for debugging through a Suite56 ADS debugger. From the point of view of the debugger, the digital signal processor nearest TDO (test data output signal) on the JTAG interface of the command converter is numbered device 0, and the digital signal processor nearest TDI (test data input signal) on the JTAG interface of the command converter is the highest numbered device, as in Figure 4-2. Connect each digital signal processor through its own TDO to the TDI of its successor.

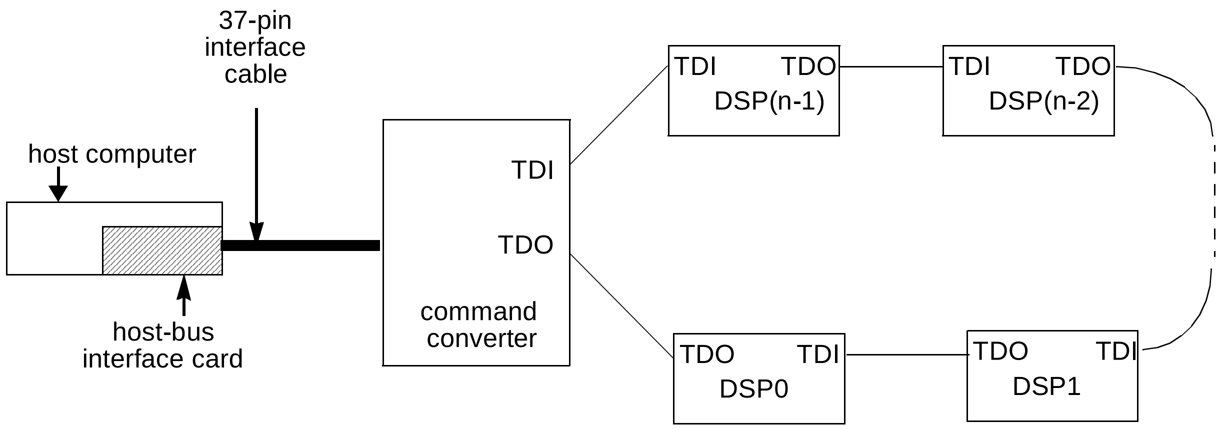
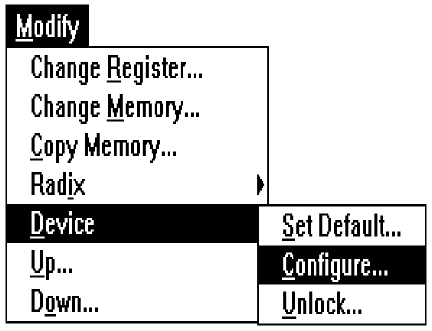


Figure 4-2. Connecting Devices through Their JTAG Interfaces for Debugging

4.1.2 Simulating Multiple Devices

In a Suite56 simulator, there are facilities to support your code development aimed at multiple digital signal processors. The `sim56300`, for example, simulates all the individual digital signal processors in the DSP56300 family. It can simulate as many as 32 of them at once.



To set up a simulation of multiple devices, in the graphic user interface, from the **Modify** menu, choose **Device**, and then select **Configure**. A dialogue box appears for you to indicate the characteristics of one digital signal processor. Assign it a device number in the **Device** pane of the dialogue box. Indicate its type (e.g., 56301) in the **Device Type** pane, and configure it **On**. Then click **OK**. Repeat this procedure for each of your multiple devices.

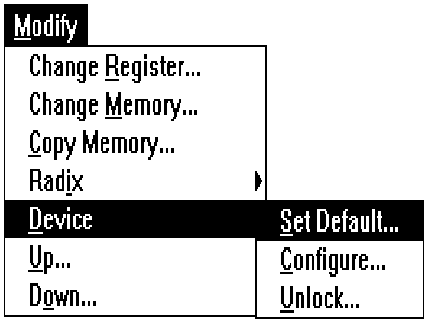
In the text-based interface, use the **`device`** command with a device number and device type as parameters, followed by the option **`ON`**.

As long as a simulated device is configured **`ON`**, it is active during execution commands such as **Go**, **Step**, or **Trace**, and responds to them appropriately. To make a given device inactive (so that it no longer responds to execution commands), configure it as **`OFF`**.

A simulator maintains a separate window of each of these types for each simulated device:

- Assembly window to display the assembled code loaded for that device;
- Breakpoints window to display the breakpoints defined for that device;
- Calls window to display function calls to that device;
- Input window to display simulated input to that device;
- Memory window to display designated locations on that device;
- Output window to display simulated output from that device;
- Register window to display designated registers of that device with their contents;
- Session window to display session activity with respect to that device;
- Stack window to display the C function stack (if appropriate);
- Source window to display C source code (if appropriate);
- Watch window to display items on a watch list for that device.

Those windows are titled with the device number (e.g., Dv00 Assembly or Dv28 Source) to help you identify data associated with each device.



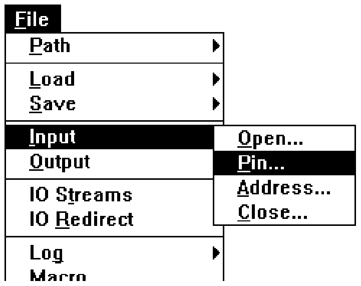
A Suite56 simulator can also profile multiple devices separately. For each device in turn, in the **Modify** menu, choose **Device**, and then select **Set Default**. While a given device is the default, in the **File** menu, choose **Log**, and then select **Profile**. A dialogue box appears for you to indicate the name and location of the log file in which to save the profile for that device. Repeat these steps to create a separate profile for each device in turn.

In the text-based interface, use the **`log`** command with a device number and file name as parameters and the option **`P`** to indicate profile.

A Suite56 simulator simulating multiple devices can be especially useful when you are developing real-time application code for a single target device, as we explain in Section 4.2.4, "Simulating Communication between Serial Devices," on page 4-6.

4.1.3 Simulating Communication between Multiple Devices

Use simulated input to simulate communication between multiple devices. In fact, you can simulate tying pins together and connecting to different memory locations.



To tie pins together (so that the output from one pin becomes input to another pin), from the **File** menu, select **Input**, and then choose **Pins**. A dialogue box appears for you to indicate which pins to tie together. In the same dialogue box, you also indicate devices by number, so that you can tie together pins on the same device or on different devices (if you are working on a simulation of multiple devices).

To connect one memory location to another (so that the value read from one location becomes the value written to another), from the **File** menu, choose **Input**, and then select **Address**. A dialogue box opens for you to indicate which memory locations to connect. Again, the locations may be on the same device or on different devices, so you can also indicate the device of the source location.

4.2 Developing Real-Time Applications

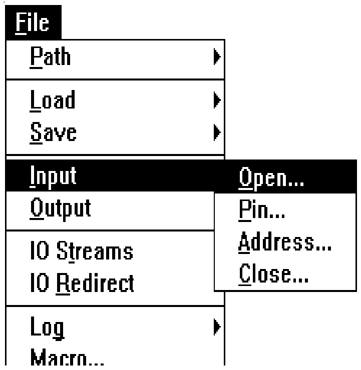
This section suggests ways in which Suite56 tools assist in the following tasks, typical of real-time applications:

- generating interrupts and real-time stimuli of pins;
- exercising peripherals;
- generating output with time-critical information;
- simulating communication between serial devices.

4.2.1 Generating Interrupts and Real-Time Stimuli of Pins

To simulate interrupts to your target digital signal processor, apply a pin file to the interrupt pin. A pin file contains ordinary ASCII text of zeroes and ones to represent low and high signals. To ease the chore of creating and maintaining such a file, a Suite56 simulator accepts certain syntax, documented in the *Motorola Simulator Reference Manual*, so that `(01)`, for example, means “repeat zero followed by one continuously,” and `(01)#5` means “repeat zero followed by one five times.” The same manual also documents the format of input files to simulate more complicated real-time stimuli.

To see a list of valid pin names for the current device in a Suite56 simulator, type the command **`help pin`** on the command line in the Command window. The list then appears in the Session window.



To apply a pin file, in the **File** menu, choose **Input**, and then select **Open**. A dialogue box appears for you to indicate in the **From** pane that the input comes from a file and in the **To** pane that it applies to a pin. In the **File Name** pane, you indicate the name of the input file.

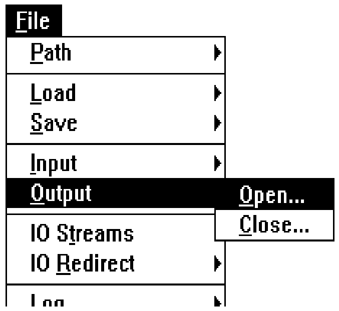
In the text-based interface, use the `input` command with the pin name and file name as parameters to apply a pin file to a pin.

4.2.2 Exercising Peripherals

To exercise the peripherals of your target device, simulate input and output on the pins associated with the peripherals. The *Motorola Simulator Reference Manual* documents the format of both simulated input and output files in Chapter 3, “Device I/O and Peripheral Simulation.” You have a choice of “raw” pin I/O format, which consists of zeroes and ones in a continuous bit stream, or simplified format, where the simulator takes responsibility for converting the bit stream to intelligible chunks of data (such as 8- or 32-bit words, floating-point values, hexadecimal numbers, etc.).

To see a list of simulated peripherals, type the command `help periph` on the command line in the Command window. The list appears in the Session window.

To apply simulated input to a peripheral, in the **File** menu, choose **Input**, and select **Open**. A dialogue box appears for you to indicate in the **From** pane that the input comes from a file and in the **To** pane that it applies to a peripheral. In the **File Name** pane, indicate the name of the input file.



To capture simulated output, in the **File** menu, choose **Output**, and select **Open**. A dialogue box appears for you to indicate in the **From** pane that the output comes from a peripheral and in the **To** pane that it goes to a file. In the **File Name** pane, you indicate the name of the output file.

In the text-based interface, use the commands `input` and `output` with the peripheral name and file name as parameters.

4.2.3 Generating Output with Time-Critical Information

Simulated output can consist of pairs of items, where the first item of each pair is a cycle number and the second is the actual output datum. The cycle number indicates relative time, so in this way, a Suite56 simulator produces output with time-critical information. You can capture this timed output from peripherals, memory, ports, pins, or registers.

To simulate time-critical output, in the **File** menu, choose **Output**, and then select **Open**. When the dialogue box appears, check the **Timed** check box, indicate File in the **To** pane, indicate Peripheral (or Memory, Port, Pin, or Register, depending on the source of your time-critical output) in the **From** pane. Indicate the file name in the **File Name** pane.

In the text-based interface, use the command **o**`utput` with the peripheral (or memory, port, pin, or register) name and file name as parameters followed by the option **`T`** to indicate timed data.

4.2.4 Simulating Communication between Serial Devices

Certain real-time applications require responses from a target digital signal processor interleaved with serial input at every cycle. For example, input of complicated wave forms through a synchronous serial interface may require this interleaving of serial input and response on a per-cycle basis.

One way to simulate this situation is to use a Suite56 simulator to simulate two devices. One simulated device represents the real-time target device. The second simulated device runs a separate program to generate input (such as the complicated wave forms in our example) for the first simulated device through its synchronous serial interface (i.e., its SSI). The simulator clock implicitly synchronizes the two simulated devices for you.

More specifically, here are the steps to follow:

1. Configure two devices, device 1 and device 2, in the simulator.

   In the **Modify** menu, choose **Device**, and then select **Configure**. A dialogue box appears for you to configure device 1. Click **OK**.

   Repeat these steps for device 2.

2. Set device 2 as the default device.

   In the **Modify** menu, choose **Device**, and then select **Set Default**.

3. Load the program to generate input into device 2.

   In the **File** menu, choose **Load**, and then select **Memory**. A dialogue box appears for you to indicate which file to load into the current device.

4. Tie the output of the second device to the SSI input pin of the first simulated device.

   In the **File** menu, choose **Input**, and then select **Pins**. A dialogue box appears for you to indicate that you want to tie the output of device 2 to the SSI input of device 1.

5. Execute your program. For example, click the **Go** button.

4.3 Finding Well Hidden Bugs

This section suggests techniques for locating well hidden bugs in an application: setting breakpoints on memory and registers and exploiting hardware breakpoints.

In addition to the software breakpoints we highlighted in other parts of this manual—those you set by clicking on a line of C code or an assembly instruction—the Suite56 ADS hardware debugger also supports hardware breakpoints on digital signal processors with OnCE breakpoint circuitry. In the DSP56300 and DSP56600 families, for example, there are OnCE facilities for two hardware breakpoints on each device. The DSP56600 family also has a hardware trace buffer (not to be confused with the software trace facilities for stepping through code). And the DSP56300, -600, and -800 families have counters to increment with breakpoints. You access these hardware breakpoint facilities through the `break` command or through the graphic user interface, as explained in the following sections.

4.3.1 Setting Breakpoints on Memory

In Example 3 -14 on page 3-27, we recommend that you produce map files to analyze where your program is located in memory on your target device. If you discover by checking the map files produced by your program that your program is blundering into memory locations on your target device that you did not anticipate, then you should consider setting a breakpoint on a *range of addresses* in memory. Likewise, if you suspect for any other reason that pointers in your program are misdirected toward inappropriate addresses, consider setting a breakpoint on a range of addresses.

In Section 3.2.3, "Setting Software Breakpoints in a C Program," on page 3-9, we showed how to set breakpoints in C code, and similarly, in Section 3.3.1, "Setting Breakpoints in Assembly Code," on page 3-22, we showed how to set them in assembly code. Breakpoints are equally easy to set on memory locations and on registers, both in a Suite56 simulator and in a Suite56 ADS debugger. In a Suite56 simulator, in fact, you can set a *series* of breakpoints (not just one per execution), and you can set more than one breakpoint per location (e.g., one to halt, another to increment a counter, another to write to a log file when execution reaches that location).

To set a breakpoint on an address in memory, follow these steps:

1. Set the default device.

   In the **Modify** menu, choose **Device**, and then select **Set Default**.

2. Load your program, both memory and symbols.

   In the **File** menu, choose **Load**, and then select **Memory**. A dialogue box appears for you to indicate **Memory** and **Symbols** as well as the name of the file to load.

3. Open the device window to display memory.

   In the **Windows** menu, choose **Memory**. A dialogue box appears for you to indicate a part of memory to display. Your choice there will automatically open a window titled with the device number and portion of memory (P for program, X for X data, Y for Y data, if your target device includes Y data memory).

4. Set the breakpoint.

   In the device memory window that just appeared, click on a location to set a breakpoint there.

   OR

   In the **Execute** menu, choose **Breakpoints**, and select **Set**. A dialogue box appears for you to indicate characteristics of the breakpoint, as in Figure 4-3 on page 4-9.

   — Set its type as Memory in the **Type** pane.

   — Set the access you are watching for (read, write, or read and write) in the **Access** pane. If your target device includes a DMA controller for direct memory access, then you can also indicate that type in the **Access** pane.

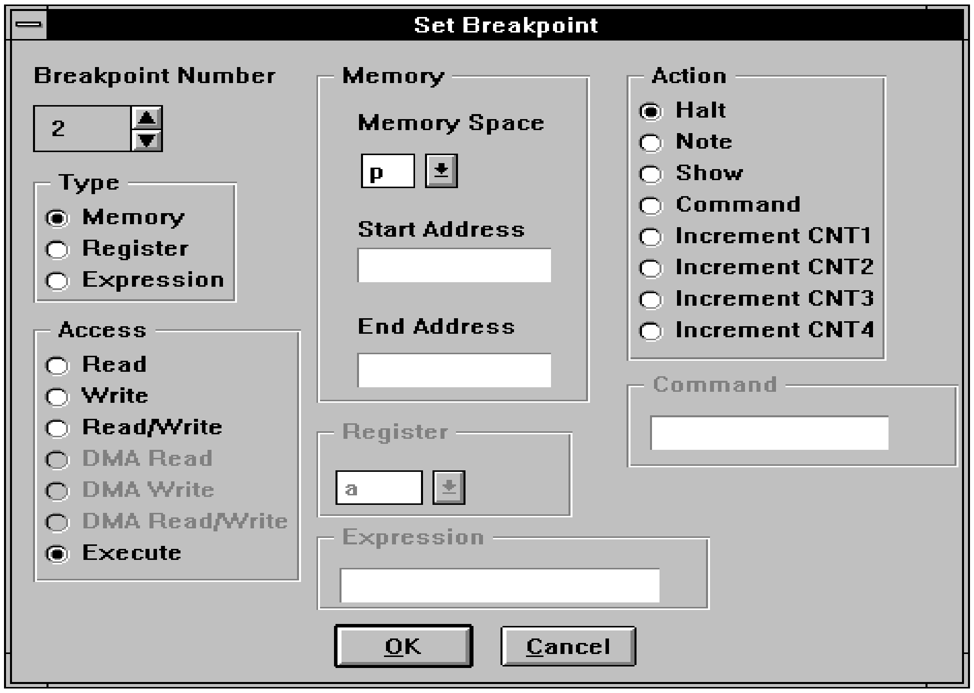
   — Indicate the memory space (whether P for program memory, X for X data, or Y for Y data) that interests you in the **Memory** pane.

   — For a *range of memory* addresses, indicate the start address and end address in the **Memory** pane as well.

   — If you want the simulator to perform special actions, such as halting execution, incrementing a counter, or executing a command at the breakpoint, then indicate that action in the **Action** pane.

5. Execute.

   Click **OK** in the dialogue box where you have indicated the characteristics of the breakpoint. Then click **Go** on the toolbar.


Set Breakpoint

Breakpoint Number: 2

Type: [✓ Memory] Register Expression

Access: Read Write Read/Write DMA Read DMA Write DMA Read/Write [✓ Execute]

Memory
Memory Space: p
Start Address:
End Address:

Register: a

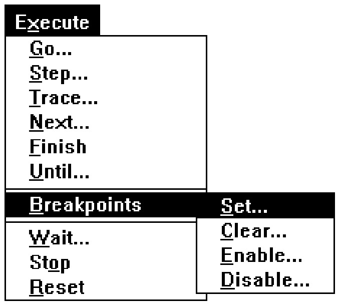
Expression:

Action: [✓ Halt] Note Show Command Increment CNT1 Increment CNT2 Increment CNT3 Increment CNT4

Command:

Figure 4-3. Dialogue Box to Set a Breakpoint in Memory

4.3.2 Setting Breakpoints on Registers



To set a breakpoint on a register, follow the steps in Section 4.3.1, "Setting Breakpoints on Memory," on page 4-7, choosing Register (rather than Memory) each time. In other words, you can set a breakpoint on a register either by clicking on the register contents in a device-register window, or by choosing **Execute//Breakpoints//Set** from the menu.

Chapter 5
Answers to Frequently Asked Questions

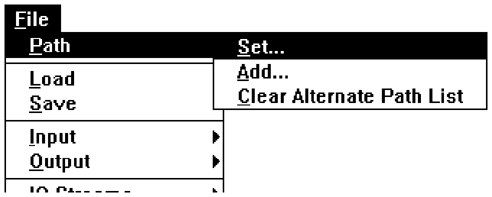
The answers to frequently asked questions that appear in this chapter were collected from the Motorola DSP Helpdesk. You can also find updated FAQs at the Motorola website:

`http://www.mot.com/SPS/DSP/faq`

5.1 How do I customize Suite56 tools for my tasks?

There are a number of ways to customize your Suite56 tools. Customizations for each tool are documented in the manual for that tool (e.g., *Motorola DSP Simulator Reference Manual*, *Motorola DSP Application Development System User's Manual*). To get you started, here are a few customizations that other Motorola customers have found useful:

- Set a path to directories where you store input and output files.

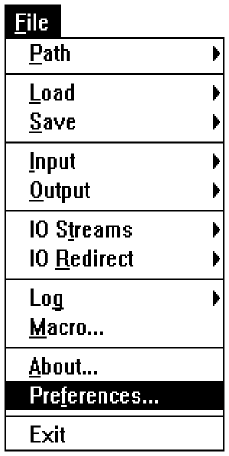


In the graphic user interface, from the **File** menu, choose **Path**, and then select **Set**. A dialogue box opens for you to indicate a path to a directory. Use the conventional notation appropriate for your operating system.

In the text-based interface, use the `path` command followed by the path to the directory you want to indicate in the conventional notation appropriate for your operating system.

If you are working on a project that requires multiple devices, you may want to define a path with a distinct directory for each device. In the graphic user interface, from the **File** menu, choose **Path**, and then select **Add** to add other directories to an existing path. In the text-based interface, when you use the `path` command, the option **+** adds a directory to an existing path; the option **-** removes a directory from an existing path.

- Choose which windows open automatically when you start a session.



In the graphic user interface, from the **File** menu, choose **Preferences**. A dialogue box opens for you to indicate which windows to open and whether to save window status when you exit the tool. In the same dialogue box, you also click the **Font** button to open another dialogue box for you to indicate which font (family, style, and size) you prefer.

•Save a log file of frequently used commands.

In the graphic user interface, from the **File** menu, choose **Log**, and then select **Commands**. A dialogue box opens for you to indicate where you want to save the file containing the logged commands. Any commands you issue to the debugger after that point will be logged in that file to be saved automatically as executable macros.

In the text-based, type the **`lo`**`g` command with two options: the option **`c`** to indicate that you want to log only commands and the optional argument of a file name for the log file. You can also indicate whether you want to overwrite an existing file (option **`o`**) or append new commands to an existing file (option **`a`**) with a third option.

In either interface, to reuse the command log file, simply type the name of the command log file on the command line.

5.2 I’m tired of initializing my development environment every time I start work. Is there any way to save my development environment?

Yes: Suite56 tools, such as the simulator and ADS debugger, recognize a file named `startup.cmd` in the directory from which you start the tool. In fact, when they start, both tools search for that file. If it exists in the directory where the tool starts, then the tool will execute the commands in that file as it starts.

If your are working on Windows NT, and you prefer to start the tool from the Start menu, then you need to customize your Start menu by modifying the Advanced NT Properties of the shortcut to the tool. To do so, left-click on the menubar; a menu appears for you to choose Properties; in the dialogue box that appears, choose the “Start Menu Programs” tab; on that tab, click the Advanced button to open Explorer on the Start menu; locate the “Motorola DSP Software Development Tools” folder; display its contents; left-click on the name of the tool; a menu appears for you to choose its Properties; in the dialogue box that appears, choose the Shortcut tab; on the Shortcut tab, in the Target text box, add the name of the command file as a parameter to the command that starts the tool.

You can create a `startup.cmd` file either by logging commands (as explained in Section 5.1) or by writing its contents yourself with an ordinary text editor. Use the same syntax as you use for commands on the command line of the tool, and use the same conventions for indicating paths, directories, file names, and so forth as appropriate for your operating system.

If you work on more than one development project, you can define a separate `startup.cmd` file in its own project directory for each of your projects.

5.3 I logged a sequence of commands to a command log file. How do I run that sequence of commands again?

There are at least two different ways to run a sequence of commands that you have saved in a command log file.

One, simply type the *name* of the command log file on the command line. In the graphic user interface to Suite56 tools, the command line is located in the Command window. In the text-based interface, the command line is located near the bottom of the main window.

Alternatively, in the **Execute** menu, choose **Macros**. A dialogue box appears for you to indicate the name of the command log file that you want to execute.

5.4 I logged a sequence of commands to a command log file and tried to run it. No luck. What should I do?

First check the access privileges of your command log file with respect to your operating system. Your command log file must be *executable*. On a PC-compatible platform running NT, for example, the file extension must be `.cmd` to be executable by Suite56 tools.

Next, check the actual location of your command file with respect to the *path* you have defined for your Suite56 tools. If they do not agree, either update your path to include the actual location of your command log file, or move your command log file to a location within the path that you have defined.

5.5 I'm having trouble debugging at low frequencies.

For any low-frequency target device (i.e., less than 2MHz), you must set the command converter and the Suite56 ADS debugger software to the proper target operation frequency. To do so, use the **`ho`**`st` command with the option **`clock`** followed by the frequency, as in Example 5 -1.

The default radix of the Suite56 ADS debugger is hexadecimal. Consequently, to express a frequency in decimal digits, we prefix it by this character: `'`.

Example 5 -1. Setting Low Frequencies in Suite56 Tools

```
> host clock ‘32              ; sets the frequency to 32 kilo herz
> host clock 32               ; sets the frequency to 50 kilo herz
```

5.6 How do I halt in mid-cycle in a Suite56 simulator?

Generally, execution does not halt in mid-cycle in the Suite56 simulators. However, control-C entered as a command interrupts on an instruction boundary. In certain very special cases, this command may meet your needs.

For customers who require a compiled version of a Suite56 simulator (e.g., for use in Verilog models), there is a specialized function, `dsp_execp`, to halt on a clock phase. Example 5 -2 shows you its signature.

Example 5 -2. Signature of dsp_execp

```
#if BLM
/* this function is similar to dsp_exec, except that it executes just a
single clock phase rather than an entire device cycle
 */

int
dsp_execp (int devindex)
```

The usual `dsp_exec` call is actually made up of a series of calls to internal phase functions. Example 5 -3 shows you that function as it is implemented in `simutil.c`.

Example 5 -3. The Function dsp_exec

```
void
dsp_exec (int devindex)
{
    if ((devindex < 0) ||
        (devindex >= dv_const.maxdevices) ||
        !(dv_var = dv_const.sv[devindex]))
    {
        return;
    }
    if (!dv_var)
        return;
    dsp_exec_t0_pos(devindex);
    dsp_exec_t0_neg(devindex);
    dsp_exec_t1_pos(devindex);
    (void)dsp_exec_t1_neg(devindex);
}
```

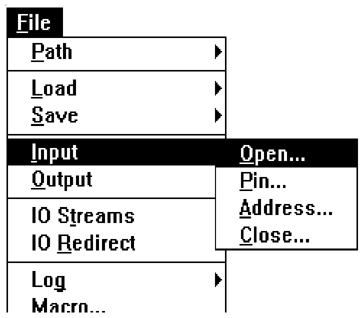
5.7 Can I link my customized libraries to a Suite56 simulator?

Yes, you can link customized libraries to a Suite56 simulator. In the standard distribution of software that comprises the simulator, there is a make file for the components of the simulator on your development platform. Edit that make file to link your customized libraries before the standard Suite56 libraries of the simulator. Then type `make` at the operating system prompt in the directory where the make file is located to relink the components of the Suite56 simulator.

5.8 How do I simulate input and output?

A Suite56 simulator enables you to simulate input as simple or timed. *Timed input* consists of pairs of numbers, where one item in the pair represents the cycle number (i.e., the time) at which the other item will be used as input. As timed input, a datum will remain in effect and may be read zero, one, or as many times as specified until the cycle number is met, and then the next pair is started.

Likewise, output may be simple or timed. *Timed output* consists of pairs of cycle numbers (i.e., the output time) and data.



To simulate input, from the **File** menu, choose **Input**, and then select **Open**. A dialogue box appears for you to indicate characteristics of the input: whether it is timed; whether it will come from your terminal or from a file; if from a file, then the name of the file; whether the data is directed to memory, a port, a pin, a register, or an on-chip peripheral device. In the same dialogue box, indicate the radix of the input data.

Likewise, to simulate output, from the **File** menu, choose **Output**, and then select **Open**. A dialogue box appears for you to indicate the characteristics of the output: whether it is timed; whether it should appear on your terminal or in a file; if in a file, then the name of the file; which part of the target device is the source of the output data.

5.9 How do I plot memory use?

For the DSP56000, DSP56300, and DSP56600 families there are profiling facilities in the corresponding Suite56 simulators.

When you assemble your application, use the option **`-mu`** to report loadtime memory use, and use the option **`-g`** to include debugging information in the output of the assembler. Then load your assembled application into your Suite56 simulator.

After loading the assembled application into the simulator, then from the **File** menu, choose **Log**, and select **Profile**. A dialogue box appears for you to indicate the location and name of a log file to save the profile that the simulator will generate for you.

Then execute your application in the usual way. The profile appears in two files: an ordinary ASCII-file with the extension `.log`, and a PostScript file with the extension `.ps`. You can view the contents of the .log file through any text editor or the PostScript file through a PostScript viewer. The same information appears in both files:

- a routine call graph;
- a graph of dependencies between routines in your application;
- a list of which parts of your application executed;
- indications of program flow and control;
- lists of instructions used by instruction type;
- lists of memory locations and the number of reads and writes to those locations.

5.10 How do I get a listing with cycle counts?

When you assemble your application, use the option **`cc`** to enable cycle counts in the listing file produced by the assembler.

5.11 My program runs, but I want it to go faster.

First, consider whether the algorithm you are using can be reduced in any way. You may need to consult other software engineers or exploit tools such as Matlab to help you with this part of the problem.

Once you are sure that you are implementing the most efficient algorithms for your application, then assemble it with the options **-mu** for a loadtime memory-use report and **-g** to retain debugging information in the assembled output.

Next, load your application in the usual way into a Suite56 simulator, and profile it, as we suggested in Section 5.9 .

We strongly recommend that you analyze the loadtime memory-use report and the profile of your application before you begin optimizations to be sure that you optimize portions of your program that actually make a difference in its performance.

5.12 My program runs, but it is too big.

Assemble your application with the option **-mu** to report loadtime memory use. Then profile your program as suggested in Section 5.9 . Analyze the loadtime memory-use report and the profile before you begin optimizing to be sure that you locate portions of your code that truly affect its memory use. As a last resort, consider designing code overlays for your application. See the *Motorola Linker/Librarian Reference Manual* for detailed documentation of memory control files to produce code overlays, and see the device family manual (e.g., *DSP56600 Family Manual*) and device-specific user’s manual (e.g., *DSP56309 User’s Manual*) for documentation of the memory maps of your target Motorola device.

5.13 What does this error message mean?

```
DOS/4GW error (2001): exception 0Eh (page fault) at 237:8
```

The error, exception, and page fault mean you are using the old, outdated DOS version of a Suite56 tool, which depended on a memory extension mechanism that did not always work reliably. We urge you to use the NT or Windows 95 version of the tool instead. (Contrary to urban myth, the NT and‘95 versions of Suite56 tools are not greater “resource hogs” than the DOS version.)

Glossary

absolute executable file is an object file in which the assembler and linker have filled in, for every symbol, its ultimate location on its target hardware (i.e., the final address in memory of that symbol).

ADM application development module is a hardware component, a device-specific board, a part of an application development system.

ADS application development system is a Suite56 product comprised of hardware (host-bus interface card, interface cables, command converter, and application development module) and software (drivers, debugger, command-line interface, graphic user interface) for generation and debugging of application code aimed at digital signal processors.

assembler is a software program to translate human-readable symbols, directives, labels, and mnemonic instructions into machine-readable data, instructions, and locations for a particular hardware device, such as a digital signal processor.

breakpoint is a place in a software routine or hardware procedure where an interrupt occurs.

compiler is a software program to translate human-readable programs in a given programming language (such as C or C++) into object files to assemble and link for execution on a particular hardware device.

cross-assembler is an assembler capable of running on one hardware device (usually a development platform) to produce assembled files executable on a different hardware device (such as a target digital signal processor).

cross-compiler is a compiler capable of running on one hardware device (usually a development platform) to produce files ready to assemble and link for execution on a different hardware device (such as a target digital signal processor).

current working directory is the location in the file system of a development platform where the operating system and other applications (e.g., compilers, assemblers, linkers) search for input and place output unless otherwise directed.

EVM evaluation module is a hardware component, a device-specific board, used either as an evaluation tool or as part of an application development system.

GUI graphic user interface is a software program to display windows, menus, and buttons and to capture keyboard- and mouse-input on a computer monitor.

halt breakpoint is one which stops program execution.

linker is a software program that accepts object files from a compiler, assembler, library, or other source, along with hardware-specific directives to produce an absolute executable file.

overlaying is a strategy of repeatedly using the same location in memory for the execution of different pieces of code at different times during the execution in order to maximize limited memory.

radix is the basis for computing the value of a group of digits. For example, the digits 32 represent the number thirty-two when the radix is decimal but the number fifty when the radix is hexadecimal; likewise, the digits 101 represent one-hundred one in decimal radix, but five in binary radix.

relocatable object file is one in which the locations of symbols in memory are expressed relatively. The file can thus be relocated on the basis of an absolute position supplied later to produce an absolute executable file before execution.

simulation is a software implementation of a hardware phenomenon.

simulator is a program implementing hardware phenomena in software.

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