Debug Manual

Abstract

This manual describes the Guardian debug facility (Debug) on HP NonStop™ systems.

Product Version

G07

Supported Release Version Updates (RVUs)

This publication supports G06.06 and all subsequent G-series RVUs until otherwise indicated by its replacement publication.

Part Number	Published
421921-003	January 2006

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Debug Manual

1. Introduction (continued)

2. Using Debug on TNS/R Processors

3. Debug Command Overview

4. Debug Commands

4. Debug Commands (continued)

A. Error Messages

A. Error Messages (continued)

A. Error Messages (continued)

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Manual Information

Abstract

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New and Changed Information

Changes in the G06.28 manual:

- Added these new error messages:
  - 102 on page A-25
  - 103 on page A-26
  - 104 on page A-26
  - 105 on page A-26
- Removed references to the obsolete commands, DT and ET, from Table D-2 on page D-3.
- Rebranded the terminology in the manual.

Changes in the G06.21 Manual

- Since product names are changing over time, this publication might contain both HP and Compaq product names
- Product names in graphic representations are consistent with the current product interface
- Updated B Command on page 4-7 to describe global breakpoints under the ALL option
- Updated Considerations on page 4-8 with information regarding specification and instances of global breakpoints
- Updated Considerations on page 4-25 with information regarding processor halt code %6005
- Updated the D command under Considerations on page 4-35 to distinguish between the D N address and the DN address
- Added the "SIG_IGN" system-supplied signal action to MH Command (TNS/R Native and OSS Processes) on page 4-62
- Added the D option to = Command on page 4-73
- Updated the ? command Examples on page 4-75

About This Manual

This manual describes the features and use of the Guardian debug facility, Debug.

This version of Debug runs on HP NonStop Series/RISC (TNS/R) processors. TNS/R processors are based on reduced instruction-set computing (RISC) technology.

This version of the HP NonStop operating system also supports execution of programs written for the HP NonStop Series (TNS) processor environment, although TNS processors are no longer supported. TNS processors were based on complex instruction-set computing (CISC) technology.

Who Should Use This Manual

Debug is a low-level debugging tool. It is intended to be used by system and application programmers.

To use this product, you must be familiar with the Transaction Application Language (TAL) or another programming language, such as pTAL, C, C++, COBOL, or Pascal. You must also be familiar with system hardware registers and addressing modes.

A high-level symbolic debugger, the Inspect product, is also provided by HP. Many people find it more convenient to use a symbolic debugger than a low-level debugger, because a symbolic debugger allows you to use the names of the symbols in your program rather than the addresses and registers that the compiler assigned. You might consider using the Inspect debugger if it is possible to do so. Using the Inspect debugger, however, requires that the Inspect monitor process (IMON) be running on the node. If you prefer a symbolic debugger, refer to the *Inspect Manual*.

Debug is a part of the operating system and is always available. Debug is required for debugging address spaces that the Inspect debugger cannot debug, such as:

- Monitor process
- Memory manager
- $SYSTEM disk process

How to Use This Manual

The organization of this manual:

Section	Description
Section 1, Introduction	Introduces and discusses how to make your process enter Debug, what happens once your process enters Debug, and how Debug breakpoints work.
Section 2, Using Debug on TNS/R Processors	Describes Debug use on TNS/R processors. It includes descriptions of TNS/R memory addressing, execution options, breakpoints on TNS/R processors, TNS/R registers, and correspondence between TNS/R and TNS environment registers.
Section 3, Debug Command Overview	Provides an overview of the Debug commands. It introduces all the commands, and describes the structure of the commands. It also discusses the register syntax, expression syntax, and address syntax for Debug commands.
Section 4, Debug Commands	Describes and explains the syntax for each of the Debug commands. In addition, this section explains how to set, clear, and display breakpoints. It also explains how to display and modify the contents of variables and registers.
Appendix A, Error Messages	Describes the Debug error messages.
Appendix B, ASCII Character Set	Describes the ASCII character set.
Appendix C, Command Syntax Summary	Provides a summary of the Debug command syntax.
Appendix D, Session Boundaries	Discusses Debug session boundaries; how particular Debug commands affect subsequent Debug sessions for the same process; and, for privileged debugging, how commands affect debugging on a processor.
Appendix E, Correspondence Between Debug and Inspect Commands	Shows the correspondence of Debug commands to Inspect low-level commands.
Appendix F, Sample Debug Sessions	Provides interactive sample programs that might be useful to the user.
Glossary	Defines terms used in the manual.

Related Reading

While using this manual, you might need to refer to some of the manuals described below. The following paragraphs provide a complete list of the manuals.

System Procedure Manuals

These manuals contain information related to Guardian procedure calls:

- *Guardian Procedure Calls Reference Manual*
- *Guardian Procedure Errors and Messages Manual*

Programming Tools Manuals

These manuals describe tools used in program development:

- *nld Manual*
- *noft Manual*
- *Binder Manual*
- *Inspect Manual*

Server Description Manual

The *NonStop S-Series Server Description Manual* provides a description of the system architecture.

Manual About The Command Interface

The *TACL Reference Manual* provides information related to the command interface.

Open System Services (OSS) Manuals

These manuals provide information regarding programming for the HP NonStop Open System Services (OSS) environment:

- *Open System Services Programmer's Guide*
- *Open System Services Library Calls Reference Manual*
- *Open System Services System Calls Reference Manual*

Language Reference Manuals

These manuals provide information regarding system programming and running applications on TNS/R processors:

- *Guardian Programmer's Guide* provides information about system programming.

- *Accelerator Manual* provides information regarding programming and running applications on TNS/R processors.

These manuals provide more information regarding specific source languages:

- *C/C++ Programmer's Guide*
- *COBOL Manual for TNS and TNS/R Programs*
- *TAL Programmer's Guide*
- *TAL Reference Manual*
- *pTAL Conversion Guide*
- *pTAL Reference Manual*

Notation Conventions

Hypertext Links

Blue underline is used to indicate a hypertext link within text. By clicking a passage of text with a blue underline, you are taken to the location described. For example:

> This requirement is described under Backup DAM Volumes and Physical Disk Drives on page 3-2.

General Syntax Notation

This list summarizes the notation conventions for syntax presentation in this manual.

UPPERCASE LETTERS. Uppercase letters indicate keywords and reserved words. Type these items exactly as shown. Items not enclosed in brackets are required. For example:

```
MAXATTACH
```

lowercase italic letters. Lowercase italic letters indicate variable items that you supply. Items not enclosed in brackets are required. For example:

```
file-name
```

computer type. `Computer type` letters within text indicate C and Open System Services (OSS) keywords and reserved words. Type these items exactly as shown. Items not enclosed in brackets are required. For example:

```
myfile.c
```

italic computer type. *`Italic computer type`* letters within text indicate C and Open System Services (OSS) variable items that you supply. Items not enclosed in brackets are required. For example:

```
pathname
```

[ ] Brackets. Brackets enclose optional syntax items. For example:

```
TERM [\system-name.]$terminal-name

INT[ERRUPTS]
```

A group of items enclosed in brackets is a list from which you can choose one item or none. The items in the list can be arranged either vertically, with aligned brackets on each side of the list, or horizontally, enclosed in a pair of brackets and separated by vertical lines. For example:

```
FC [ num  ]
   [ -num ]
   [ text ]

K [ X | D ] address
```

{ } Braces. A group of items enclosed in braces is a list from which you are required to choose one item. The items in the list can be arranged either vertically, with aligned braces on each side of the list, or horizontally, enclosed in a pair of braces and separated by vertical lines. For example:

```
LISTOPENS PROCESS { $appl-mgr-name }
                  { $process-name  }

ALLOWSU { ON | OFF }
```

| Vertical Line. A vertical line separates alternatives in a horizontal list that is enclosed in brackets or braces. For example:

```
INSPECT { OFF | ON | SAVEABEND }
```

… Ellipsis. An ellipsis immediately following a pair of brackets or braces indicates that you can repeat the enclosed sequence of syntax items any number of times. For example:

```
M address [ , new-value ]...

[ - ] {0|1|2|3|4|5|6|7|8|9}...
```

An ellipsis immediately following a single syntax item indicates that you can repeat that syntax item any number of times. For example:

```
"s-char..."
```

Punctuation. Parentheses, commas, semicolons, and other symbols not previously described must be typed as shown. For example:

```
error := NEXTFILENAME ( file-name ) ;

LISTOPENS SU $process-name.#su-name
```

Quotation marks around a symbol such as a bracket or brace indicate the symbol is a required character that you must type as shown. For example:

```
"[" repetition-constant-list "]"
```

Item Spacing. Spaces shown between items are required unless one of the items is a punctuation symbol such as a parenthesis or a comma. For example:

```
CALL STEPMOM ( process-id ) ;
```

If there is no space between two items, spaces are not permitted. In this example, no spaces are permitted between the period and any other items:

```
$process-name.#su-name
```

Line Spacing. If the syntax of a command is too long to fit on a single line, each continuation line is indented three spaces and is separated from the preceding line by a blank line. This spacing distinguishes items in a continuation line from items in a vertical list of selections. For example:

```
ALTER [ / OUT file-spec / ] LINE

   [ , attribute-spec ]...
```

!i and !o. In procedure calls, the !i notation follows an input parameter (one that passes data to the called procedure); the !o notation follows an output parameter (one that returns data to the calling program). For example:

```
CALL CHECKRESIZESEGMENT (  segment-id                    !i
                         , error       ) ;                 !o
```

!i,o. In procedure calls, the !i,o notation follows an input/output parameter (one that both passes data to the called procedure and returns data to the calling program). For example:

```
error := COMPRESSEDIT ( filenum ) ;                      !i,o
```

!i:i. In procedure calls, the !i:i notation follows an input string parameter that has a corresponding parameter specifying the length of the string in bytes. For example:

```
error := FILENAME_COMPARE_ (  filename1:length           !i:i
                            , filename2:length ) ;         !i:i
```

!o:i. In procedure calls, the !o:i notation follows an output buffer parameter that has a corresponding input parameter specifying the maximum length of the output buffer in bytes. For example:

```
error := FILE_GETINFO_ (  filenum                        !i
                        , [ filename:maxlen ] ) ;          !o:i
```

Notation for Messages

This list summarizes the notation conventions for the presentation of displayed messages in this manual.

Bold Text. Bold text in an example indicates user input typed at the terminal. For example:

```
ENTER RUN CODE
?123
CODE RECEIVED:      123.00
```

The user must press the Return key after typing the input.

Nonitalic text. Nonitalic letters, numbers, and punctuation indicate text that is displayed or returned exactly as shown. For example:

```
Backup Up.
```

lowercase italic letters. Lowercase italic letters indicate variable items whose values are displayed or returned. For example:

```
p-register
process-name
```

[ ] Brackets. Brackets enclose items that are sometimes, but not always, displayed. For example:

```
Event number = number [ Subject = first-subject-value ]
```

A group of items enclosed in brackets is a list of all possible items that can be displayed, of which one or none might actually be displayed. The items in the list can be arranged either vertically, with aligned brackets on each side of the list, or horizontally, enclosed in a pair of brackets and separated by vertical lines. For example:

```
proc-name trapped [ in SQL | in SQL file system ]
```

{ } Braces. A group of items enclosed in braces is a list of all possible items that can be displayed, of which one is actually displayed. The items in the list can be arranged either vertically, with aligned braces on each side of the list, or horizontally, enclosed in a pair of braces and separated by vertical lines. For example:

```
obj-type obj-name state changed to state, caused by
{ Object | Operator | Service }
```

```
process-name State changed from old-objstate to objstate
{ Operator Request. }
{ Unknown.          }
```

| Vertical Line. A vertical line separates alternatives in a horizontal list that is enclosed in brackets or braces. For example:

```
Transfer status: { OK | Failed }
```

% Percent Sign. A percent sign precedes a number that is not in decimal notation. The % notation precedes an octal number. The %B notation precedes a binary number. The %H notation precedes a hexadecimal number. For example:

```
%005400

%B101111

%H2F

P=%p-register E=%e-register
```

Notation for Management Programming Interfaces

This list summarizes the notation conventions used in the boxed descriptions of programmatic commands, event messages, and error lists in this manual.

UPPERCASE LETTERS. Uppercase letters indicate names from definition files. Type these names exactly as shown. For example:

```
ZCOM-TKN-SUBJ-SERV
```

lowercase letters. Words in lowercase letters are words that are part of the notation, including Data Definition Language (DDL) keywords. For example:

```
token-type
```

!r. The !r notation following a token or field name indicates that the token or field is required. For example:

```
ZCOM-TKN-OBJNAME       token-type ZSPI-TYP-STRING.          !r
```

!o. The !o notation following a token or field name indicates that the token or field is optional. For example:

```
ZSPI-TKN-MANAGER       token-type ZSPI-TYP-FNAME32.         !o
```

Change Bar Notation

Change bars are used to indicate substantive differences between this manual and its preceding version. Change bars are vertical rules placed in the right margin of changed portions of text, figures, tables, examples, and so on. Change bars highlight new or revised information. For example:

> The message types specified in the REPORT clause are different in the COBOL environment and the Common Run-Time Environment (CRE).
>
> The CRE has many new message types and some new message type codes for old message types. In the CRE, the message type SYSTEM includes all messages except LOGICAL-CLOSE and LOGICAL-OPEN.

1 Introduction

The Guardian debug facility (Debug) provides a tool for interactively debugging a running process. Using Debug, you can designate certain program code or memory locations as breakpoints. When these breakpoints are executed or accessed in the specified way (read, write, or change), your process enters the debug state.

While a process is in the debug state, you can interactively display and modify the contents of the process's variables, display and modify the contents of the process's registers, and set other breakpoints.

Debug is a low-level debugging facility. To use Debug, you should have a thorough understanding of the system hardware registers and the system addressing scheme. Refer to the server description manual appropriate for the system at your site.

These topics are covered in this section:

Execution Modes on TNS/R Systems

TNS/R systems can execute TNS/R native code, TNS code, and accelerated code. User processes run in all of these modes.

Native code is produced by a TNS/R native compiler and consists entirely of RISC instructions that have been optimized to take full advantage of the RISC architecture.

TNS code executes on RISC processors by millicode emulation.

Accelerated code is produced by the Accelerator, a program that processes a TNS object file to run more efficiently on a TNS/R processor. An accelerated object file consists of RISC instructions generated by the Accelerator as well as the original TNS instructions.

A TNS/R native process is a process that is initiated by executing a native program, which contains native code. A TNS process is a process that is initiated by executing a TNS or accelerated program, which contains TNS or accelerated object code.

Debug can be used with either type of process and with any of these execution modes. Functionally, Debug is the same for all of these cases, although there are minor differences in syntax, input and output formats, and so on. These differences are noted throughout the manual.

What User Access Is Required for Debugging

To debug a program, you must have both read and execute access to the file for that program. To debug code in the user library, you must also have read and execute access to that user library file. To debug system code or any privileged code, you must be executing under the local super ID (255, 255) and issue the PRV ON command.

How to Make a Process Enter Debug

There are six ways to force a process into the debug state:

- Using the RUND Command (or the TACL run option DEBUG)
- Invoking Debug From TACL for a Process on page 1-3
- Calling Debug From a Process on page 1-4
- Entering a Breakpoint in a Process on page 1-5
- Running Debug From the OSS Shell on page 1-6

Using the RUND Command

Running a program with the command interpreter RUND (run Debug) command causes the process to enter the debug state before the first instruction of the main procedure is executed.

Example:

```
10> RUND myprog
```

Using the TACL run option DEBUG is equivalent to using the RUND command. The following example uses the run option DEBUG and also requests a system-assigned name.

PROCESS_LAUNCH_ Procedure

You can run the debugger (Inspect or Debug) on a new process by passing the debug option bits to the PROCESS_LAUNCH_ procedure as a field in a structure, as illustrated in this example:

```
<initialize structure PARMS>
.                 .
PARMS.NAME_OPTIONS := 2;          ! Requests a system-assigned name.
PARMS.DEBUG_OPTIONS.<12> := 1;    ! Debug at first instruction.
PARMS.DEBUG_OPTIONS.<14> := 1;    ! Use debugger set in next bit.
PARMS.DEBUG_OPTIONS.<15> := 0;    ! Selects Debug as the debugger.
ERROR := PROCESS_LAUNCH_ ( PARMS, ERROR_DETAIL );
```

Invoking Debug From TACL for a Process

Run a program that you want to debug through the command interpreter, in this case the HP Tandem Advanced Command Language (TACL). While the program is executing, press the BREAK key to wake up the TACL process; the program continues executing. TACL returns to the command-input mode. At this point, either from the original terminal or at another terminal, find the processor number and process identification number (PIN) of the process (the executing program you want to debug) by using the TACL command STATUS:

```
STATUS *, TERM      ! from the same terminal
STATUS *, USER       ! from another terminal
```

Then enter this command indicating the process you want to debug:

```
{ DEBUG | DEBUGNOW }  [ cpu,pin | process-name ]

     [,TERM [[\sys-name.]$terminal-name .[#qualifier ]]]
```

`DEBUG | DEBUGNOW`

specifies that the Debug facility is to start debugging the selected process. If you do not specify a process, Debug starts debugging the process most recently started by the TACL process if that process still exists.

DEBUG causes the specified process to enter the debug state at the next instruction executing in unprivileged state. If the process is executing in privileged state, it will enter debug when it next returns to unprivileged execution.

DEBUGNOW causes the specified process to enter the debug state at the next instruction, which might be in the privileged state. DEBUGNOW can be invoked only by the local super ID (255, 255).

Standard security requirements are applied to the user of DEBUG. A process executing an ordinary (unlicensed) program can be put into debug state by the user that created it, by the supervisor of that group, or by the super ID. The user placing the process into debug must be at least as local as the one creating the process. A process running from a program that requires licensing (one that

contains CALLABLE or PRIV procedures) can be put into debug state only by the local super ID.

If a process is created privileged, it will never run unprivileged, so DEBUG would be ineffective; therefore, DEBUG is rejected for an initially privileged process. Use DEBUGNOW instead.

cpu,pin

is the processor in which the program to be debugged is executing and its process identification number.

process-name

is the process name of the program to be debugged. If you use the process-name form, the primary process of a process pair enters the debug state.

TERM [[*sys-name*.]$*terminal-name* [.#*qualifier*]]

TERM specifies the new home terminal of the process being debugged. If you omit TERM, Debug prompts appear on the original home terminal of the process. If you specify TERM but omit the terminal name, Debug uses the terminal from which you just entered this command. You must include the *sys-name* if the new home terminal is connected to a system other than the current default system.

Example:

```
(BREAK key pressed)
20> STATUS *,TERM
Process        Pri PFR %WT Userid  Program file     Hometerm
$Z159   1,152  123   R 000  9,215  $VOL1.SV1.POBJ   $T1
     .
     .
21> DEBUG 1,152
DEBUG $PC=0x7000D820
106,01,00152-
```

Calling Debug From a Process

Programs can include explicit calls to a debug facility. This method is quite useful for finding elusive error conditions. The procedures that call a debug facility invoke either Debug or the Inspect debugger depending on which debugger has been previously selected. These procedures can invoke the debug state for the current process or the designated process. The procedures are:

- DEBUG procedure, which invokes Debug for the current process
- PROCESS_DEBUG_ procedure, which can invoke Debug for either the current process or the called process
- DEBUGPROCESS procedure, which invokes Debug for the specified process

DEBUG Procedure

The DEBUG procedure causes the current process to enter the debug state at the call to Debug.

Example:

```
IF < THEN CALL DEBUG;
```

PROCESS_DEBUG_ Procedure

The PROCESS_DEBUG_ procedure can cause either the current process or the called process to enter the debug state at the call.

Example of invoking Debug for the current process:

```
IF < THEN CALL PROCESS_DEBUG_ ;    ! without parameters
```

Example of invoking Debug for another process identified by process handle:

```
ERROR := PROCESS_DEBUG_ ( PROCESSHANDLE, TERMINAL:LENGTH );
```

A *now* parameter in the PROCESS_DEBUG_ procedure immediately invokes the debug state. To use the *now* parameter, the calling process must be executing under the local super ID. The *now* parameter is required for debugging a system process, including an input/output process (IOP). The same security considerations apply to the use of PROCESS_DEBUG_ as to the use of the TACL DEBUG | DEBUGNOW command.

Note. Using PROCESS_DEBUG_ to cause the current process to enter the debug state may give unexpected results. To avoid any uncertainty, use DEBUG to cause the current process to enter the debug state.

DEBUGPROCESS Procedure

The DEBUGPROCESS procedure invokes debugging of the process specified by the *process-id* parameter. The *process-id* can be in either a timestamp format or a local or remote named format.

Example:

```
CALL DEBUGPROCESS (PROCESS-ID, ERROR );
```

A *now* parameter in the DEBUGPROCESS procedure immediately invokes the debug state for the specified process. To use the *now* parameter, the calling process must be executing under the local super ID (255, 255). The *now* parameter is required for debugging a system process, including an input/output process (IOP).

Entering a Breakpoint in a Process

To have a process enter the debug state at a particular code location, set a code breakpoint by using the B command when the process is in the debug state. Or, for a memory location, set a memory-access breakpoint by using the BM command. After

setting the breakpoint, resume execution. Debug prompts when the code location is executed or the memory location is accessed:

Example of a code breakpoint:

```
106,06,00125-B 0x700003B0          ! Set RISC breakpoint at 0x700003B0
        N: 0x700003B0      INS: ADDIU sp,sp,-24
106,06,00125-R                       ! Resume execution.

DEBUG P=%700003B0, E=%000207 UC.%00-BREAKPOINT- ($PC=0x700003B0)
106,06,00125-                        ! Awaiting input in debug state.
```

Running Debug From the OSS Shell

You can use Debug in the Open System Services (OSS) environment. When running a program from the OSS shell, you can cause it to enter the debug state before the first instruction of the main procedure is executed. This example causes the program ossprog to enter the debug state with Debug as the debugger:

```
$ run -debug -inspect=off ossprog
```

If the command line in the preceding example said -inspect=on, and if the program ossprog were compiled with SYMBOLS ON, then Inspect would be the debugger. When either of those two conditions are not satisfied, Debug is the debugger.

How to Select Debug as the Debugger

Debug is the default debugger; however, commands can set the Inspect debugger as the default debugger. If the Inspect debugger has been set as the default for a process, any new process created by the old process also uses the Inspect debugger unless the procedure creating the new process explicitly overrides using the Inspect debugger.

The following list indicates commands or procedures you can use to invoke process execution to ensure that Debug is the default debugger for a Guardian process. These methods are listed in the order of precedence, with the highest precedence first. For example, a process started with method 1 would override debugger selection potentially set in the process's program object file by method 3.

1. Specify Debug as the debugger in the PROCESS_LAUNCH_ procedure. For information on using this procedure, see the *Guardian Procedure Calls Reference Manual*.
2. In a RUND command to run your program through the command interpreter, specify INSPECT OFF. Also, in a RUND command, do not specify either the INSPECT or SAVEABEND parameters. (Either of these parameters selects the Inspect debugger.) For information on the RUND command, see the *TACL Reference Manual*.

   This RUND command is equivalent to method 1 above, because it is a method of creating a new process.

3. When linking the program object file, specify the nld or Binder command SET INSPECT OFF. Note that the command SET SAVEABEND ON also sets INSPECT ON. You might want to ensure that the command SET SAVEABEND OFF is also specified. If the program object file has already been created, you can accomplish the same thing by specifying the nld or Binder commands CHANGE INSPECT OFF and CHANGE SAVEABEND OFF for the file.

   For more information on nld commands, see the *nld Manual* and the *noft Manual*. For more information on Binder commands, see the *Binder Manual*. For more information on compiler directives, see the reference manual for the particular compiler.

Why a Process Enters Debug

There are several reasons a process might unexpectedly enter Debug by default:

- The process tried to call an undefined external procedure.
- The process called the DEBUG procedure.
- Another process specified the process in a call to the DEBUGPROCESS or PROCESS_DEBUG_ procedure.
- In the case of a TNS/R native process, the process received a signal and either the installed signal action was SIG_DEBUG or a user-supplied signal handler invoked Debug.
- In the case of a TNS/R native process that previously had been in the debug state, the installed signal action is SIG_DFL and the process received a signal for which the SIG_DFL action is normally process termination. For such a process, the SIG_DFL action for these signals becomes invocation of Debug. (This applies to all native signals and to most OSS signals.)
- In the case of a TNS process, a trap occurred and the process had previously neither specified its own trap-handling mechanism nor disabled traps by a call to the ARMTRAP procedure.

How to Determine Process State on a Trap or Signal

If a TNS process enters Debug because a trap occurred, Debug automatically displays the number of the trap. The trap numbers that can be displayed are:

Trap Number	**Trap Condition** (page 1 of 2)
0	Illegal address reference
1	Instruction failure
2	Arithmetic overflow
3	Stack overflow

Trap Number	Trap Condition (page 2 of 2)
4	Process loop-timer timeout
5	D-series limit does not fit into a C-series interface
8	(Under very unusual circumstances, a signal is delivered to a TNS process and appears as a trap 8.)
11	Memory manager read error
12	No memory available
13	Uncorrectable memory error. Note that this error should not occur because the millicode will halt the processor.

If a TNS/R native or OSS process enters Debug because it has received a signal, Debug automatically displays the name of the signal. Table 1-1 shows the TNS/R native signals and how they correspond to trap conditions in a TNS process. Additional signals are supported by Open System Services (OSS). For more information about OSS signals, see the signal(4) topic in the reference page, either online or in the *Open System Services System Calls Reference Manual*.

Table 1-1. Map of TNS/R Native Signals to Traps

Signal Name	Description	Trap Number
SIGABRT	Abnormal termination	(8)
SIGILL	Invalid hardware instruction	1
SIGFPE	Arithmetic overflow	2
SIGLIMIT	Limits exceeded	5
SIGMEMERR	Uncorrectable memory error	13
SIGMEMMGR	Memory manager disk read error	11
SIGNOMEM	No memory available	12
SIGSEGV	Invalid memory reference	0
SIGSTK	Stack overflow	3
SIGTIMEOUT	Process loop timeout	4

You can determine the TNS/R register settings (native mode) or the S, P, ENV, and L register settings (TNS or accelerated mode) at the time of the trap by displaying the register contents. Use the D command to display the contents of the TNS/R or TNS environment registers and to display the space identifier. The meanings of the various bits and the format of the Environment (ENV) register are illustrated in Figure 1-1 on page 1-9.

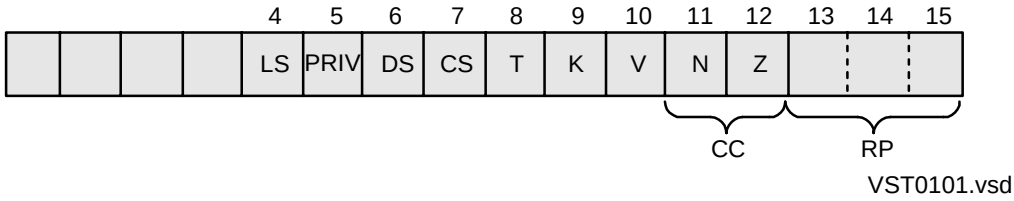
For more information about TNS/R registers, see Section 2, Using Debug on TNS/R Processors. For more information about space identifiers, see What Appears in the

Debug Header Message on page 1-10. For more information about space identifiers, see the appropriate server description manual for the processor that you are using.

Note. You cannot resume a process that entered Debug either because it received a nondeferrable signal or because a synchronous trap occurred. A signal is nondeferrable if it was generated by the system because the process cannot continue executing the instruction stream. The only traps from which you can resume are the looptimer trap and the arithmetic overflow trap, provided that the T and V bits are not both set in the ENV register.

Resuming from any of these nonresumable situations causes the process to be terminated with the same Guardian Stop message or OSS wait status as would have been generated had the signal or trap terminated the process without entering Debug. For additional information about signals and traps, refer to *Guardian Programmer's Guide*.

Figure 1-1. Environment Register (TNS Environment)



Field	Description	Bits	Values
LS	Library space	ENV.<4>	0 = Code space 1 = Library space
PRIV	Privileged	ENV.<5>	0 = Nonprivileged 1 = Privileged
DS	Data space	ENV.<6>	0 = User 1 = System
CS	Code space	ENV.<7>	0 = User 1 = System
T	Trap enable	ENV.<8>	0 = Disable 1 = Enable
K	Carry bit	ENV.<9>	1 = Carry
V	Overflow	ENV.<10>	0 = No overflow 1 = Overflow
N	Negative or numeric condition	ENV.<11>	See CC
Z	Zero or alphabetic	ENV.<12>	See CC
CC	Condition code	ENV.<11:12>	10 < CCL (numeric) 01 = CCE (alpha) 00 > CCG (special)
RP	Register stack pointer	ENV.<13:15>	

Ending a Debug Session

Two commands are provided for ending a Debug session: the STOP command and the EXIT command.

- The STOP command stops execution of the current process and deletes it.
- The EXIT command clears all breakpoints and resumes execution of the current process.

What Appears in the Debug Header Message

When a process enters Debug, regardless of the reason, Debug opens the home terminal. If Debug cannot open the home terminal, the process stops unless it cannot stop, in which case, it continues.

When Debug opens the home terminal, it prints a header message on the terminal. The header message displays the current values of the P or PC and the ENV registers, the current space identifier, and information as to why your process entered Debug.

These examples illustrate different Debug header messages:

```
DEBUG P=%001025, E=%000017, UC.%00 ! Gives current values of
101,01,00012-                      ! TNS environment P and ENV
                                   !  registers and space identifier.

DEBUG P=%037175, E=%000017, UC.%03 - TRAP #03 -!Process entered
Debug
099,00,00039-                      ! when it encountered
                                   !  a stack overflow.
```

Header Message Format

The format of the header message appears in the box below; the element descriptions follow:

```
DEBUG {P=P-register, E=ENV-register, space-identifier}[ info
]
      {PC=32-bit-address                              }
sys,cpu,pin [cmd]-
```

The elements reported in the Debug header message are explained as follows:

P-register is the 16-bit octal current value (P register) of the program counter for TNS or accelerated mode. Typically, this is where a breakpoint was specified.

32-bit-address is the 32-bit hexadecimal current value (PC register) of the program counter for native mode. Typically, this is where a breakpoint was specified.

ENV-register is the current value in octal of the TNS environment ENV register. For more information on register field descriptions, see Figure 1-1 on page 1-9. In native mode, only the PRIV and DS fields are valid.

space-identifier is one of these values:

UCr
SRL
SCr
SLr
UC.*segment-num*
UL.*segment-num*
SC.*segment-num*
SL.*segment-num*

The *space-identifier* defines the current code segment. UC indicates that the code segment is within the user code space. Within a user code space there can be up to 32 segments of code.

SRL indicates that the code is within one of the TNS/R native shared run-time library code spaces.

SC indicates that the code segment is within the system code space. SL indicates that the code segment is within the system library space.

An r indicates that the segment is within the code space for native object code. (UC with no r and no *segment-num* appears in some displays and is equivalent to UCr.) For a process in TNS or accelerated mode, the *segment-num* appears instead of an r and defines the particular code segment. SRL always refers to a space for native object code.

For more information about space identifiers, see the server description manual appropriate for your system.

[*info*] is the header message; it is described in the next subsection.

sys,*cpu*,*pin* [*cmd*] is the Debug prompt.

The value of *sys* is the node (system) number in decimal (assigned during SYSGEN).

The value of *cpu* is the number, in decimal, of the processor module where the process is executing.

The value of *pin* is the five-digit process identification number, in decimal, of the process.

The value of *cmd* is a Debug command. If the Debug command appears at the prompt, you can press RETURN to continue executing the command.

Header Message Information

These messages appear (as *info*) in the header to indicate why your process entered Debug:

- (no further information in the header message)

  One of the following occurred: a call to Debug, a call to an undefined external procedure, a Debug command entered through the command interpreter, a RUND command, or a memory-access breakpoint taken while executing system code. In the latter case, a message precedes the prompt.

`-BREAKPOINT-`

The process encountered a code breakpoint.

`-MEMORY ACCESS BREAKPOINT-`

The process encountered a memory-access breakpoint.

`-MEMORY ACCESS BREAKPOINT- (WHILE IN SYSTEM CODE)`

The process encountered a memory-access breakpoint while in system code. The Debug prompt occurs when execution exits system code.

`-MEMORY ACCESS BREAKPOINT- (WHILE IN LIBRARY CODE)`

The process encountered a memory-access breakpoint while in system library code. The Debug prompt occurs when execution exits the system library code.

`- RISC BREAKPOINT ($PC= 0x704205E0) -`

The process encountered a RISC breakpoint.

`- SIGNAL` *signal-name* `-`

The process received a signal, identified by *signal-name*, and the signal action in effect is SIG_DEBUG.

- TRAP *#nn* -

  The process encountered a trap, number *nn*, and no trap handler was specified for the process.

How to Use Debug

Once your process enters Debug, use the commands in Section 4, Debug Commands, to find out what is happening. You use Debug interactively by entering the Debug commands at the process' home terminal.

With Debug it is possible to establish one or more breakpoints, to display and modify the contents of variables, and to display and modify the contents of specified registers. It is also possible to trace and display stack markers, to calculate the value of expressions, and to redirect the Debug display to an output device.

Example of Debug Use

The following sample Debug session shows commands that display and modify the contents of a memory location, set a breakpoint, and resume program execution. The commands entered by the user are in bold so you can distinguish them from the Debug output.

```
DEBUG  P=%001025, E=%000017, UC.%00    ! Debug header message.
106,01,00012-D 14,2          ! Display 2 words starting at user data loc. %14.
000014:  020040 020040

106,01,00012-M 14,0          ! Modify user data loc. %14 by storing 0.

106,01,00012-B 1027          ! Set breakpoint at %001027
                             ! in current code segment.
   ADDR: UC.%00, %001027  INS: %127001

106,01,00012-R               ! Resume program execution.
```

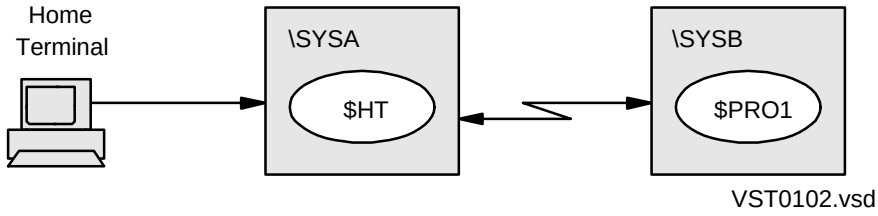
Program execution resumes.

Note. Unless you specify otherwise (either in the command itself or by using a BASE command), numeric values input to or output by Debug are in hexadecimal representation for commands referencing RISC addresses and in octal for commands referencing TNS addresses, except for the Debug prompt, where *sys*, *cpu*, and *pin* are in decimal.

Debugging on a Remote Node

Debug allows debugging from a remote node for two nodes connected in a network. From the terminal on your node, you can run a process on another node and debug it, or a process can be run or a new process started with a home terminal specified on another node. Debugging on a remote node is illustrated in Figure 1-2 on page 1-14.

Figure 1-2. Debugging a Remote Process



Example:

```
RUND \sysb.$vol3.subv4.oprog / NAME $pro1 /
```

To debug remotely, you use the same commands discussed under How to Make a Process Enter Debug on page 1-2. Specifically, the commands and procedures are:

Commands	RUND and DEBUG entered from the command interpreter
Procedures	PROCESS_LAUNCH_, PROCESS_DEBUG_, and DEBUGPROCESS

Necessary Compiler Listing

To debug a program, you need a compiler listing of the program. As your source-language compiler permits, you should specify these compiler directives:

`?LIST`	Lists the source program and enables other listings
`?MAP`	Specifies maps of the identifiers used in the source program
`?LMAP*`	Specifies a map of procedure entry points

Programmers familiar with the machine instructions might find a listing of the instruction codes helpful. These source-language compiler directives enable the listing of instruction codes:

`?CODE`	Lists instruction codes in octal for entire procedures
`?ICODE`	Lists instruction code mnemonics for entire procedures
`?INNERLIST`	Lists instruction code after each statement

How Debug Breakpoints Work

A breakpoint is a location (or “point”) in your program where you want to suspend execution so that you can then examine and perhaps modify the program’s state.

Example of a Code Breakpoint

For a code breakpoint, you specify a location in the code area where you want the process to enter the debug state just before execution of that code. The operating

system replaces the instruction in the specified location with a breakpoint instruction and stores the replaced instruction in a breakpoint table. No instructions are moved except when breakpoints are set and cleared.

Example of a Memory-Access Breakpoint

In addition to code breakpoints, the operating system allows memory-access breakpoints (one for each process). When you specify a memory-access breakpoint, you also specify the type of access that triggers the breakpoint. The actual types available depend on the processor, but possible types are:

- Read access
- Write access
- Read/Write access
- Change access

When you set a memory-access breakpoint, Debug assigns the address of the memory-access breakpoint location to a special processor register during execution of the process that set the breakpoint. If this location is accessed in the specified way, the processor hardware causes an interrupt that invokes the Debug procedure.

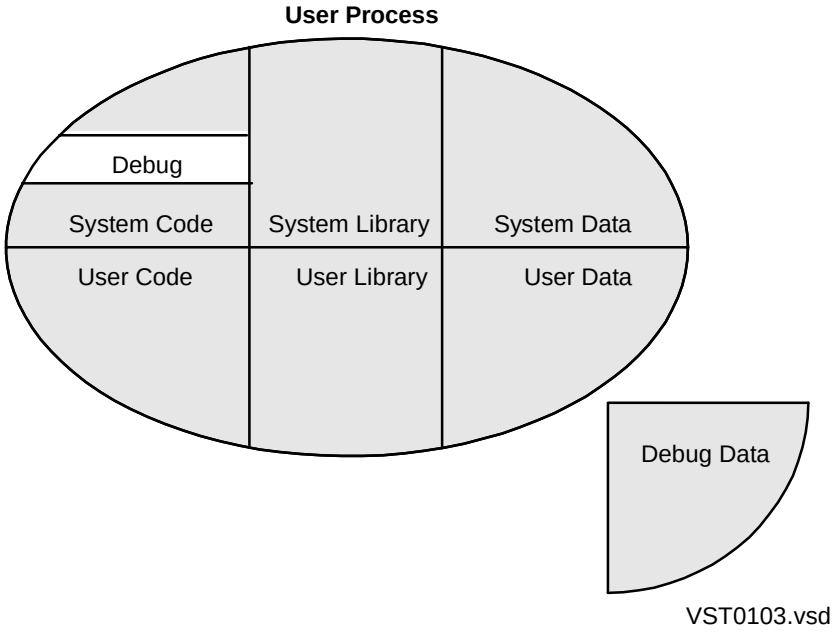
On a memory-access breakpoint, the invocation of Debug is delayed if it occurs within privileged code and the user is not privileged. For instance, suppose a user process calls a system library procedure and a memory-access breakpoint occurs during execution of privileged system code. Because the user is not permitted to debug privileged code (unless the PRV ON command has been successfully issued), invocation of Debug is deferred until the process is no longer executing privileged code. At the point where control is returned to Debug, if the process is still executing in either the system code or the system library space, Debug cannot modify code in that space (either directly or indirectly, by setting a breakpoint). Full use of nonprivileged Debug commands resumes when control is returned to Debug while the process is executing in the user program.

For other anomalies, see Considerations for Memory-Access Breakpoints on page 2-8.

Debug/Program Execution Environment

Debug executes in a private environment with its own stack; it does not use the environment of the procedure from which it was invoked. Debug does not use any processor registers of the process being debugged, so all registers are available to the user program. Debug runs as part of the original user process executing out of the system code portion of the process, as illustrated in Figure 1-3. Debug data is stored outside the user data area.

Figure 1-3. Debug/User Process Diagram

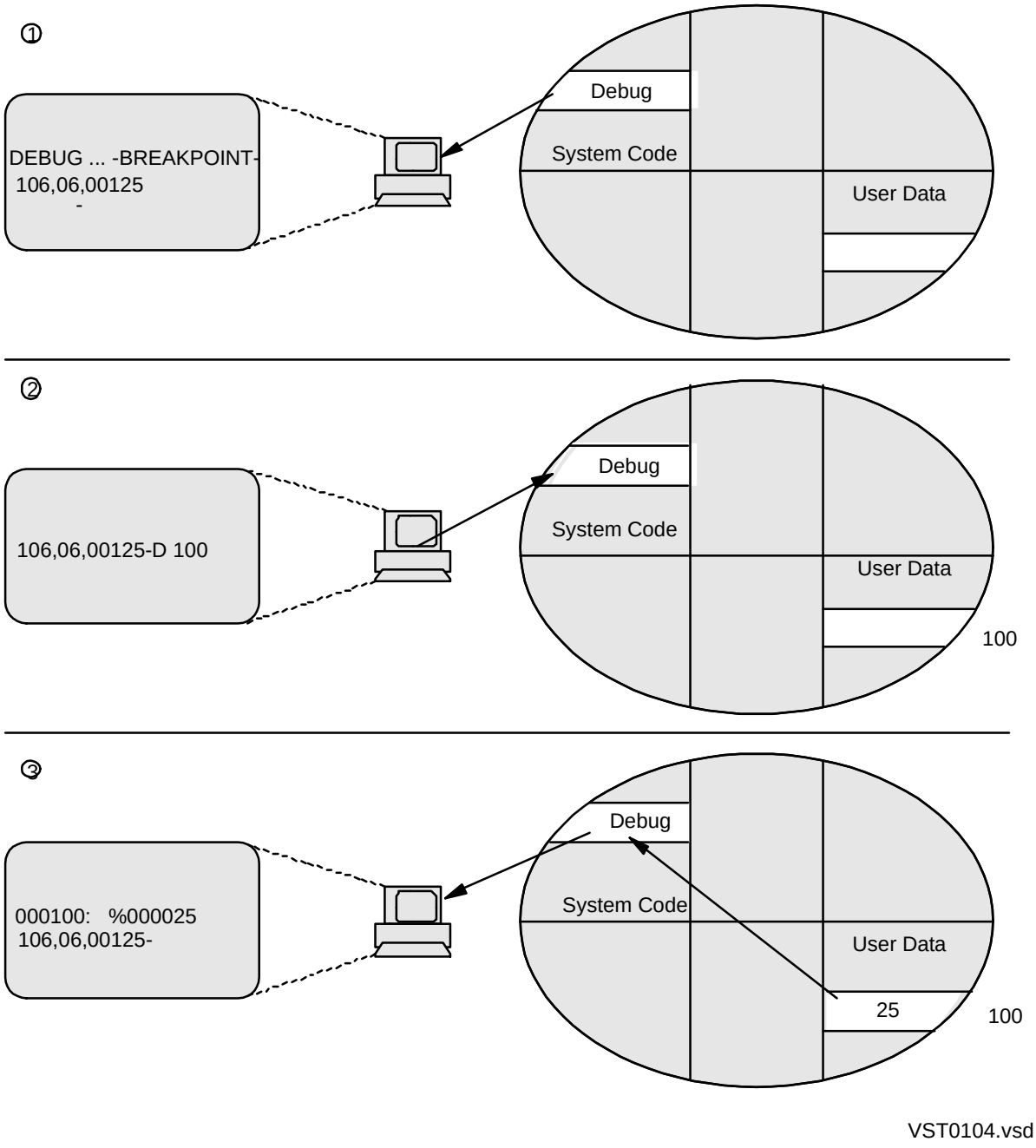


In a process being debugged, Debug displays output to the terminal and accepts input from the terminal as illustrated in Figure 1-4 on page 1-17. Panel 1 illustrates control going to a terminal at an assumed breakpoint. Then Debug requests input. Panel 2 illustrates a request to Debug to display data at location 100. Panel 3 illustrates Debug reading the location and returning the information, which is the value 25, to the terminal.

When several processes run the same program file in the same processor module, they share the code area. If a breakpoint is set in shared code using the default breakpoint mode, only the process that set the breakpoint enters the debug state when it executes or accesses the breakpoint location. If you are debugging in privileged mode, you can direct all processes to break at that location by specifying ALL when setting the breakpoint.

When a privileged memory-access breakpoint is set with the ALL attribute specified (for example, BM0,r,ALL), every other memory-access breakpoint in that processor is inhibited. The other breakpoints return to use when the privileged ALL breakpoint is cleared. Only one ALL memory-access breakpoint is allowed per processor.

Figure 1-4. Debug Displaying and Accepting Data



2 Using Debug on TNS/R Processors

When debugging on HP NonStop Series/RISC (TNS/R) processors in native mode, Debug provides information about the RISC state of the process so that you can debug at the RISC instruction level when necessary. Program execution in native mode consists entirely of RISC instructions and TNS/R register use.

When debugging programs in TNS or accelerated mode, you do not need to know the TNS/R architecture, except for some low-level debugging. You do, however, need to understand the HP NonStop Series (TNS) environment. Debug provides TNS breakpoints and information on the TNS environment registers.

For your convenience, this section provides an overview of information that you need to debug programs at the RISC instruction level. This section discusses these topics:

For debugging at the RISC instruction level, you are assumed to be familiar with the TNS/R machine architecture, which is described in the *NonStop S-Series Server Description Manual*.

TNS/R Memory Addressing

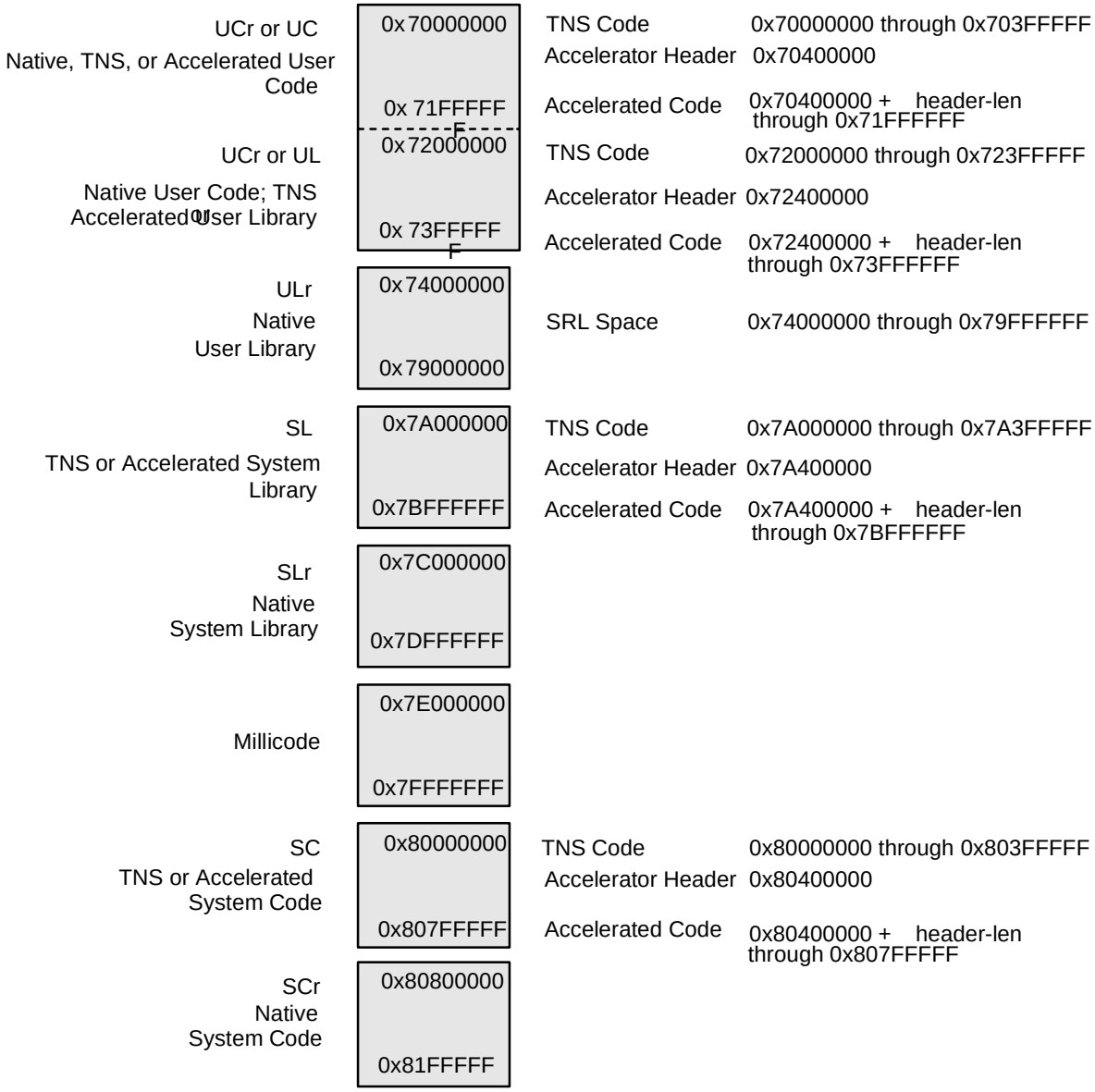
TNS/R memory is accessible through Debug with 32-bit addresses. Memory accessible while debugging in nonprivileged mode is:

- User code space (0x70000000 through 0x71FFFFFF)
- User library space (0x72000000 through 0x73FFFFFF)

While debugging in privileged mode, access to the system library space and system code space are permitted. Address ranges for the different code areas are illustrated in Figure 2-1 on page 2-2.

Hexadecimal is the default numeric base for 32-bit TNS/R addresses to be displayed by Debug or entered as input in Debug statements.

Figure 2-1. Diagram of TNS/R Memory



Execution Options

Three modes of execution are possible on a TNS/R system: TNS mode, accelerated mode, and native mode.

Much of the code in software products supplied by HP for TNS/R systems has been produced by TNS/R native compilers. Users can also use native compilers to produce their own native TNS/R code. For more information, see the *C/C++ Programmer's Guide* and the *pTAL Programmer's Guide.* Native code consists of RISC instructions that have been optimized to fully exploit the RISC architecture. Program files containing such code are called native program files.

Programs produced by compilers that are not TNS/R native compilers also execute on TNS/R systems. Such programs contain TNS object code. Program files containing TNS object code are called TNS program files.

For most TNS program files, you can significantly improve performance by processing them with the Accelerator to make use of performance features of the RISC instruction set.

The Accelerator processes a standard TNS object file and augments that file by adding the equivalent RISC instructions. TNS object files that have been optimized by the Accelerator are called accelerated object files, or accelerated program files if they include a main procedure.

Running accelerated program files can significantly improve performance over simply running TNS program files directly on the TNS/R processor. The Accelerator, however, provides optimization options that can affect debugging the program.

The following paragraphs provide an overview of execution options and describe how two Accelerator options affect debugging. For more information on using the Accelerator, see the *Accelerator Manual*.

Running Native Program Files

Debugging a native program is similar to debugging the RISC portions of an accelerated program, but you should be aware of a few differences.

- Most addresses in native mode must be expressed in 32-bit address form. For example, to set a breakpoint in native code, you must use the 32-bit address form to specify the breakpoint address:

  ```
  248,01,012-B 0x70451210
  ```

- Because of differences in stack layout and contents between native mode and TNS or accelerated mode, the method of specifying a particular stack frame to begin a stack trace differs. For more information on displaying a stack trace, see the description of the T Command on page 4-68.

- In native mode, local variables are sometimes cached in registers. Attempting to modify a local variable or use it for a purpose such as setting a memory-access breakpoint can have unexpected results.
- In highly optimized native object code, parameter values are sometimes cached in registers, making their exact location unpredictable.
- The PMAP command is not valid in native mode.
- In native mode, the D *register* commands display only TNS/R registers.

Running TNS Program Files

TNS program files generated by compilers and the Binder execute with their TNS instruction set because execution is facilitated by millicode. Millicode is assembled program code, consisting of RISC instructions, that implements various TNS low-level functions. Such functions include, but are not limited to, exception handlers, real-time translation routines, and the library of routines that implements the TNS instruction set (the equivalent of microcode in other processors).

TNS program files executed on TNS/R processors by the use of millicode in this way are said to be in “TNS execution mode.”

Running Accelerated Program Files

The Accelerator provides two options that affect optimization and debugging:

- ProcDebug
- StmtDebug

By default, the Accelerator optimizes programs across source-code statement boundaries to optimize procedure execution (that is, the ProcDebug option is on). The ProcDebug option generates RISC instructions that do not follow TNS statement boundaries, therefore producing optimized RISC instruction sequence.

The Accelerator also provides the StmtDebug option, which generates RISC instructions that optimize only within the code produced for any one source-code statement. The resulting code might not be as optimized as code generated by the ProcDebug option, but in this way you can debug individual TNS statements.

Considerations in Using the Accelerator

Consider these points when debugging accelerated programs.

- It is recommended that programs be compiled with SYMBOLS ON before they are accelerated, because the Accelerator can generate more efficient code with the information resulting from the SYMBOLS ON option.
- In rare cases, accelerated programs can have portions that are executed in TNS execution mode and portions that are executed in accelerated execution mode.

Portions executed in TNS execution mode result both from explicit instructions to the Accelerator not to optimize portions of code and from TNS instructions that the Accelerator cannot optimize.

Portions executed in accelerated execution mode consist of statements and procedures that were optimized by the Accelerator.

Types of Processes

A process that is initiated by executing a native program is called a TNS/R native process. A native process executes in the native operating environment of the TNS/R processor.

A process that is initiated by executing a TNS or accelerated program is called a TNS process. A TNS process executes in an emulated TNS operating environment.

TNS and RISC Execution Correspondence (Accelerated Mode)

In accelerated program files, there are two types of execution points where you can depend on exact correspondence between TNS and RISC states. These are:

- Memory-exact point: A point in an accelerated program where memory (but not necessarily the registers) is in a known state and contains exactly the values it would if the program had been running on a TNS processor. The memory, however, might have already been loaded in registers, so setting breakpoints to modify memory at these points might not achieve the desired results.

  Most statement boundaries are memory-exact points, and complex statements might contain several such points: at each function call, privileged instruction, and embedded assignment.

- Register-exact point: A point in an accelerated program where both memory and registers are in a known state that is equivalent to the state the program would be in if it had been running on a TNS processor.

  In accelerated execution mode, register-exact points occur at procedure calls and returns, and on entering and leaving accelerated execution mode.

The Debug PMAP command displays corresponding TNS and RISC code and marks memory-exact (>) and register-exact (@) points in the display.

The Debug D* command displays corresponding TNS and TNS/R register values.

Breakpoints

In accelerated program files, there are typically multiple RISC instructions per TNS instruction; therefore, any mapping from a breakpoint at a RISC instruction to a TNS

instruction would be approximate. Also, multiple RISC breakpoints could map to a single TNS instruction.

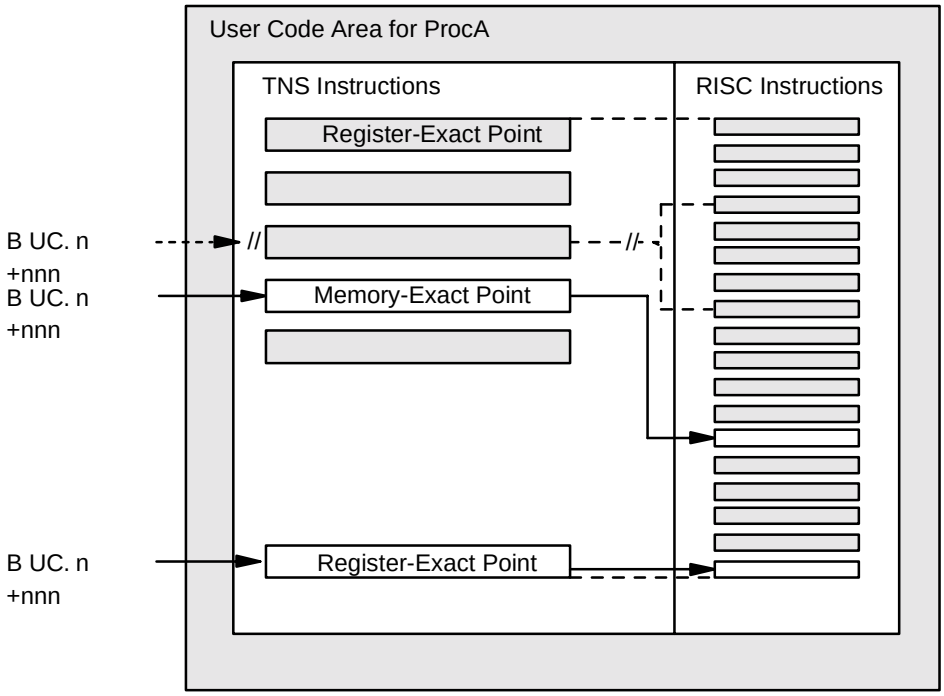
Breakpoint correspondence is illustrated in the following set of figures.

Setting TNS Breakpoints

Setting any allowable TNS breakpoint causes a corresponding breakpoint in the RISC code. You set a TNS breakpoint by using a B command that includes a reference to a TNS address (for example, a UC address). The PMAP command shows the allowable TNS location with > or @ characters. How TNS breakpoints correspond to RISC breakpoints is illustrated in Figure 2-2, which shows setting breakpoints in the user code area.

Note. TNS breakpoints can be set only at memory-exact or register-exact points because a corresponding RISC breakpoint can also be set. Some TNS breakpoints cannot be set at other points because there is no corresponding RISC instruction, as illustrated in the figure below with the double slash (//) symbol.

Figure 2-2. How TNS Breakpoints Can Correspond to RISC Breakpoints



Legend

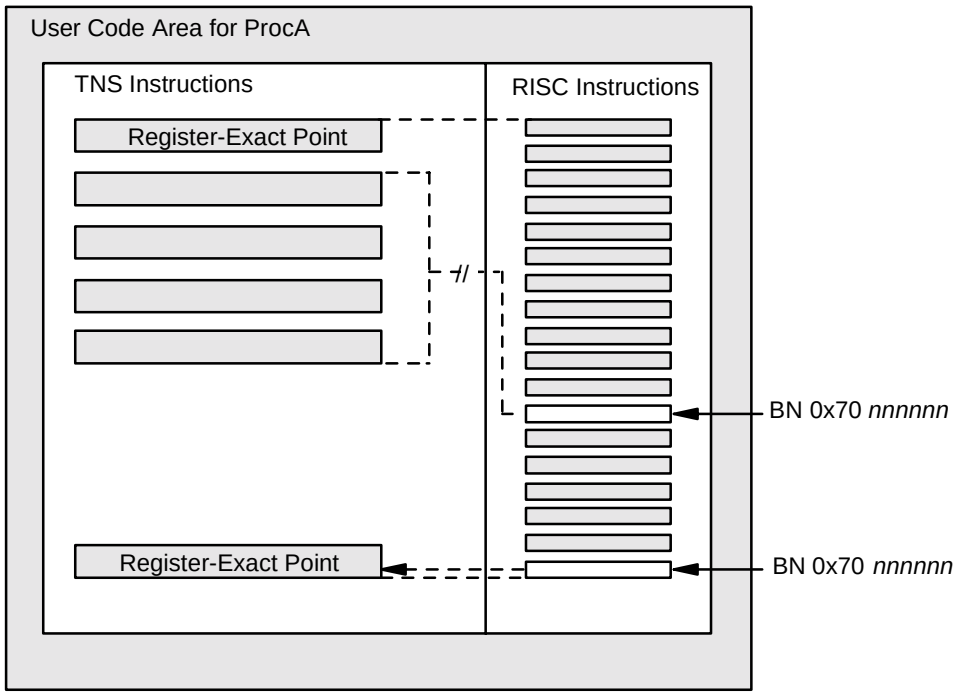
B UC. n +nnn specifies a TNS breakpoint

VST0202.vsd

Setting RISC Breakpoints

A RISC breakpoint is allowed on any valid RISC address. A RISC breakpoint in accelerated code does not cause a corresponding TNS breakpoint to be set even though a corresponding TNS instruction might exist. You set a RISC breakpoint by using a B command that includes the 32-bit address mode. How RISC breakpoints correspond to TNS instructions is illustrated in Figure 2-3, which shows setting breakpoints in the accelerated user code area.

Figure 2-3. How RISC Breakpoints Correspond to TNS Instructions



Legend

BN 0x70 *nnnnnn* specifies a RISC breakpoint

VST0203.vsd

Rules About RISC Breakpoints

These rules about breakpoints apply to accelerated programs:

- A breakpoint set on a TNS instruction also sets a breakpoint in the generated RISC instruction.
- Whether a TNS or RISC breakpoint is actually accessed depends on whether a process is executing in TNS or accelerated execution mode. A TNS breakpoint occurs in TNS execution mode; a RISC breakpoint occurs in accelerated execution mode.

- Setting a RISC breakpoint at any valid RISC address is allowed; however, only at register-exact points are both TNS/R memory and registers consistent with the TNS state.
- Setting a RISC breakpoint does not cause a TNS breakpoint even if there happens to be a corresponding TNS instruction. If you set a RISC breakpoint, it is assumed that you want to debug in the RISC state.
- Avoid modifying memory at memory-exact points; instead, you should modify memory only at register-exact points when debugging in accelerated execution mode.
- Modify register values only at register-exact points when debugging in accelerated execution mode.

Considerations for Memory-Access Breakpoints

Execution of additional instructions might affect the value of the memory location at the breakpoint and the value of the P-register.

The TNS P or the TNS/R $PC register contains the address of the next instruction to be executed. Conventionally, the contents of the P-register are incremented by one at the beginning of instruction execution so that, nominally, instructions are fetched (and executed) from ascending memory locations. Typically, the value of the P or $PC register that can be displayed at the breakpoint is one greater than the instruction that caused the breakpoint.

In Accelerated Execution Mode

In accelerated code, several more TNS instructions can be executed between the instruction that causes the breakpoint and the instruction where the breakpoint occurs.

When debugging accelerated code, consider this:

- Read-access memory-access breakpoints do not occur if the Accelerator has optimized the read from memory. This occurs when the Accelerator keeps the value in a register.

Differences Between Code and Memory-Access Breakpoints

When a code breakpoint is on an instruction that causes a memory-access breakpoint, the code breakpoint is reported first, then memory access-breakpoint is reported after resuming the program. The following examples show the results when there is only a memory-access breakpoint set and the results when a code breakpoint is placed on an instruction that produces a memory-access breakpoint.

TNS Example

This code sequence will be used to show the results of the interaction between memory-access breakpoints and code breakpoints, in TNS mode:

```
050,03,00009-i %74,4
%000074:  LADR  L+004     LLS     01      STOR  L+035     LDI    +000
```

The following example shows the program hitting a memory-access breakpoint. The displayed P address is one instruction address past the address of the instruction that caused the memory-access breakpoint. The memory-access breakpoint was triggered by the STOR instruction at %76.

```
050,03,00009-bm l+35   , w
XA: 0x0000005E     MAB: W       (DATA SEG)
050,03,00009-r
DEBUG P=%000077, E=%000207, UC.%00-MEMORY ACCESS BREAKPOINT-
MEMORY ACCESS BREAKPOINT OCCURRED AT $PC=0x7E004A60
```

The displayed $PC address is from the millicode used to emulate the TNS instructions.

The following example shows the results of having a code breakpoint on the instruction that will cause the memory-access breakpoint. First the code breakpoint is reported; the memory-access breakpoint is reported after resuming the program.

```
050,03,00014-bm l+35, w
XA: 0x0000005E     MAB: W       (DATA SEG)
050,03,00014-b %76
ADDR: UC.%00,%000076 INS: %044435 SEG: %020740
                     INS:   STOR  L+035
050,03,00014-r
DEBUG P=%000076, E=%000200, UC.%00-BREAKPOINT-
050,03,00014-r
DEBUG P=%000077, E=%000207, UC.%00-MEMORY ACCESS BREAKPOINT-
MEMORY ACCESS BREAKPOINT OCCURRED AT $PC=0x7E004A60
```

Native Example

This code sequence shows the results of the interaction between memory-access breakpoints and code breakpoints, in native mode:

```
050,03,00270-i 0x70000438, #4
70000438: ADDIU t0,sp,128      SW    t0,120(sp)     ADDIU t1,gp,-32750
70000444: SW    t1,176(sp)
```

The following example shows the program hitting a memory-access breakpoint. The displayed $PC address is one instruction address past the address of the instruction

that caused the memory-access breakpoint. The memory-access breakpoint was triggered by the store word (SW) instruction at 0x7000043C.

```
050,03,00270-bm $sp+#120, w
N: 0x4FFFFEA8     MAB: W
050,03,00270-r
DEBUG $PC=0x70000440 -MEMORY ACCESS BREAKPOINT-
MEMORY ACCESS BREAKPOINT OCCURRED AT $PC=0x70000440
```

This example shows the results from putting a breakpoint on a code location that causes a memory-access breakpoint:

```
050,03,00269-bm $SP + #120, w
N: 0x4FFFFEA8     MAB: W
050,03,00269-b 0x7000043c
N: 0x7000043C     INS: 0xAFA80078
                  INS: SW    t0,120(sp)
050,03,00269-r
DEBUG $PC=0x7000043C -RISC BREAKPOINT ($PC: 0x7000043C)-
050,03,00269-r
DEBUG $PC=0x7FF00E20 -MEMORY ACCESS BREAKPOINT-
MEMORY ACCESS BREAKPOINT OCCURRED AT $PC=0x7000043C
```

Observe that the first $PC address ($PC=0x7FF00E20), after executing the second R command in the above example, is outside the range of the program. But the second displayed $PC address ($PC=0x7000043C) is the location of the instruction that caused the memory-access breakpoint, not the location of the next instruction as shown previously. This is the result of resuming the program from the code breakpoint.

TNS/R Registers

Debug displays the values of the TNS/R hardware registers. The TNS/R registers include the 32 general-purpose registers $00 through $31, the arithmetic HI/LO registers, the program counter $PC, and the IEEE floating-point registers.

The TNS/R registers are:

$00	Hard wired to the value 0
$01 through $31	General-purpose registers
$HI, $LO	Arithmetic high and low registers
$PC	TNS/R program counter
$F00 through $F31	IEEE floating-point general purpose registers
$FCR31	IEEE floating-point status/control register

Alias names for registers $01 through $31 and $F00 through $F09 appear in this list:

Register	Alias	Register	Alias
$00			
$01	$AT	$16	$S0
$02	$V0	$17	$S1
$03	$V1	$18	$S2
$04	$A0	$19	$S3
$05	$A1	$20	$S4
$06	$A2	$21	$S5
$07	$A3	$22	$S6
$08	$T0	$23	$S7
$09	$T1	$24	$T8
$10	$T2	$25	$T9
$11	$T3	$26	$K0
$12	$T4	$27	$K1
$13	$T5	$28	$GP
$14	$T6	$29	$SP
$15	$T7	$30	$S8 or $FP
		$31	$RA
$F00	$F0	$F05	$F5
$F01	$F1	$F06	$F6
$F02	$F2	$F07	$F7
$F03	$F3	$F08	$F8
$F04	$F4	$F09	$F9

In TNS and accelerated modes, registers $01 through $10 contain temporary values for various operations. Registers $13 through $25 and $28 through $30 maintain TNS state information. For many registers, use depends on the execution mode: TNS mode, accelerated mode, or native mode. A summary of how TNS/R registers are used with the three execution modes is listed in Table 2-2 on page 2-13.

Note that Debug never reports valid contents for registers $26 and $27, which are reserved for use by low-level millicode.

Also note that floating-point registers are available only on native programs where floating-point instructions have been executed. Floating-point registers $F00 through $F09 can be entered as $F0 through $F9. Floating-point registers $F10 through $F31 and $FCR31 have no alias names.

TNS and TNS/R Register Correspondence

TNS/R processors maintain many of the TNS environment hardware and program registers. The location and contents of TNS environment registers might vary depending on the registers involved and the state of the process when Debug was entered.

Table 2-1 lists TNS environment registers and corresponding TNS/R implementation.

Table 2-1. TNS Register Implementation Summary

TNS Register	TNS/R Implementation
S	S register (stack pointer) is maintained in register $29 (alias $SP). The value is exact in TNS execution mode but approximate in accelerated execution mode, except at register-exact points. The value is a 32-bit byte address equivalent to the TNS S register value.
P	The P-register is inferred from the TNS/R PC register (program counter) in accelerated execution mode; it is retained in the PX register in TNS execution mode.
ENV	The ENV register is maintained in several different TNS/R registers and data locations. The bits from left to right are implemented as follows: < 0:15>Unused; must be 0 <16:19>Reserved; must be 0 <20>LS; 1 if executing in user library <21>PRIV; valid only if privileged <22>DS; 1 if executing TNS interrupt handler; valid only if privileged <23>CS; 1 if executing in TNS execution mode in system library <24>T; 1 if TNS arithmetic overflow traps are enabled <25>Undefined; see K register ($14, alias $T6) <26>V;1 if TNS arithmetic overflow occurred <27:31>CSPACEINDEX; set #0 through 31 within current code file
L	L register (frame pointer) is maintained in TNS/R register $30 (alias $S8 or $FP). The value always contains a 32-bit byte address equivalent to the TNS L register value.
CSPACEID	This is maintained in fields LS, CS, and CSPACEINDEX of ENV.
R0,R1,...R7	TNS register stack pointers are maintained in registers $16 through $23 (alias $S0 through $S7) in accelerated execution mode; values in accelerated execution mode are equal to the TNS register values only at register-exact points. Also, in TNS execution mode, register $22 (alias $S6) contains an extended address pointing to the register stack array that holds the TNS registers R0 through R7.

Table 2-2 on page 2-13 provides a summary of how TNS/R registers are used with native, TNS, and accelerated execution modes.

Table 2-2. TNS/R Register Use Summary (page 1 of 2)

Register	Alias	Native Execution Mode	TNS Execution Mode	Accelerated Execution Mode
$00		Zero constant	Zero constant	Zero constant
$01	$AT	Assembler temporary	Temporary	Temporary
$02, $03	$V0, $V1	Function values	Temporary	Temporary
$04..$07	$A0..$A3	Arguments	Temporary	Temporary
$08..$10	$T0..$T2	Temporary	Temporary	Temporary
$11	$T3	Temporary	Rj_Ptr (executor variable)	Temporary
$12	$T4	Temporary	Arg (executor variable)	Temporary
$13	$T5	Temporary	Iword (executor variable)	RA2 register
$14	$T6	Temporary	K (carry bit)	K (carry bit)
$15	$T7	Temporary	CC (condition code; <0, =0, >0)	CC (condition code)
$16	$S0	Saved variables	Do_Next	R0
$17	$S1	Saved variables	(spare)	R1
$18	$S2	Saved variables	Extended address in read-only memory of instruction decode tables	R2
$19	$S3	Saved variables	SG_Ptr. Extended absolute address in Kseg0 of system global (SG) data segment	R3
$20	$S4	Saved variables	RP wrap base (address of R0)	R4
$21	$S5	Saved variables	Cur_Cseg. Current code segment as an extended 32-bit address (can be UC, UL, SC, or SL)	R5
$22	$S6	Saved variables	RPX. Extended address pointing into register stack array holding TNS registers R0 through R7	R6

Table 2-2. TNS/R Register Use Summary (page 2 of 2)

Register	Alias	Native Execution Mode	TNS Execution Mode	Accelerated Execution Mode
$23	$S7	Saved variables	PX. Extended address in user space of next TNS instruction half word in current TNS code segment	R7
$24	$T8	Temporary	UC_CSeg. User code segment as an extended 32-bit address	UC_Cseg. User code segment as an extended 32-bit address
$25	$T9	Temporary	ENV. Environment register in stack-marker format	ENV. Environment register in stack-marker format
$26, $27	$K0, $K1	Reserved for kernel	Reserved for kernel	--
$28	$GP	Global pointer	RMap. Extended address of current TNS code segment's return map	RMap. Extended address of current TNS code segment's return map
$29	$SP	Stack pointer	SX. S register value as an extended 32-bit address	SX. S register value as an extended 32-bit address
$30	$S8/$FP	Saved variables	LX. L register value as an extended 32-bit address	LX. L register value as an extended 32-bit address
$31	$RA	Return address	Temporary	Temporary
$F00..$F31		When floating-point instructions have been used. $F00 through $F19 are temporary registers and $F20 through $F31 are saved registers.		
$FCR31		When floating-point instructions have been used		

The bits and the decoding for the $FCR31 register are as follows:

Bit	Meaning
<7> FS: 0 or 1	When the FS bit is set, denormalized results are flushed to 0.
<8> C: 0 or 1	The C bit is set to 1 if the condition is true, and the bit is cleared to 0 if the condition is false.
<14:19>: CAUSE	The CAUSE bits reflect the results of the most recently executed instruction. They identify the exceptions raised by the last floating-point operation and raise an interrupt or exception if the corresponding ENABLE bit is set. If more than one exception occurs on a single instruction, each appropriate bit is set. Note that the CAUSE bits are managed by the NonStop operating system, the user code has no access to them.
<20:24>: ENABLE	A floating-point exception is generated any time a CAUSE bit and the corresponding ENABLE bit are set. A floating-point operation that sets an enabled CAUSE bit forces an immediate exception.
<25:29>: FLAGS	The FLAG bits are cumulative and indicate that an exception was raised by an operation that was executed after the FLAG bits were explicitly reset. The FLAG bits are set to 1 if an IEEE 754 exception is raised; otherwise, they remain unchanged. A bit in the FLAG field is set only if the corresponding exception condition occurs and the corresponding trap is disabled.
<30:31>: Round Mode	These bits specify the rounding mode that the floating-point unit (FPU) uses for all floating-point operations.

3 Debug Command Overview

This section introduces all of the Debug commands (by functional groups), explains the structure of the commands, and shows the primary relationships between the commands. For more information on how to use the Debug commands, see Section 4, Debug Commands

Types of Debug Commands

The commands in Table 3-2 through 3-7 are grouped according to the various types of Debug commands:

- Breakpoint Commands
- Display Commands on page 3-3
- Modify Commands on page 3-4
- Environment Commands on page 3-5
- Privileged Commands on page 3-5
- Miscellaneous Commands on page 3-6

This grouping is useful in that it indicates some of the relationships between the commands. For example, the code breakpoint commands consist of the B and C commands. The B command sets code breakpoints, and the C command clears them.

Breakpoint Commands

There are two subgroups of breakpoint commands: code and memory-access. Table 3-1 on page 3-2 gives an overview of these commands.

A code breakpoint is a designated location in the code area that, when executed, causes the process to enter the debug state. The code breakpoint commands consist of the B and C commands.

A memory-access breakpoint is a designated location in memory that, when accessed in the specified way (read, write, write/read, or change), causes the process to enter the debug state. The operating system allows only one memory-access breakpoint for each process. The memory-access breakpoint commands consist of the BM and CM commands.

Table 3-1. Breakpoint Commands

Command	Meaning	Function	Description
B	Break	Set unconditional code breakpoint	The process enters the debug state when the breakpoint location is executed.
		Set conditional code breakpoint	Depending on the value of a specified variable, the process enters the debug state. The variable is checked when the breakpoint location is executed.
		Set trace code breakpoint	Debug lists the contents of specified variables when the breakpoint location is executed, then Debug resumes the process.
		Set execute code breakpoint	Debug executes a specified string of Debug commands when the breakpoint location is executed.
		Display breakpoints	Debug displays all currently set code and memory-access breakpoints for the process being debugged.
BM	Break on memory	Set unconditional memory-access breakpoint	The process enters the debug state when the breakpoint location is accessed or modified.
		Set conditional memory-access breakpoint	The process enters the debug state depending on the value of a specified variable. The variable is checked when the breakpoint location is accessed or modified.
		Set trace memory-access breakpoint	Debug lists the contents of specified variables when the breakpoint location is accessed or modified, then Debug resumes the process.
		Set execute memory-access breakpoint	Debug executes a specified string of Debug commands when the breakpoint location is accessed or modified.
C	Clear	Clear breakpoint	Debug clears one or all code breakpoints.
CM	Clear memory breakpoint	Clear memory-access breakpoint	Debug clears the memory-access breakpoint for the process being debugged.

Display Commands

The display commands are listed and described in Table 3-2 on page 3-3. In addition to these commands, the B command (a code breakpoint command) also displays all code and memory-access breakpoints for the process being debugged.

Table 3-2. Display Commands (page 1 of 2)

Command	Meaning	Function	Description
A	ASCII	Display data in ASCII	Displays the contents of specified variables in ASCII representation.
AMAP	Address Map	Displays address attribute information	Converts 16-bit address to 32-bit address, if necessary. It also displays attribute values of the address.
D	Display	Display data in numeric representation	Displays the contents of specified variables in numeric representation.
		Display register contents in numeric representation	Displays the contents of a specified register in numeric representation.
		Display space identifier in numeric representation	Displays the space identifier of the current code segment in numeric representation.
DJ	Display jump buffer	Display jump buffer contents	Displays the contents of a specified jump buffer in register format.
DN	Display	Display memory (32-bit addresses)	Displays memory in multiple formats: ASCII, RISC or TNS instruction code, or various numeric formats.
F[ILES]	Files	Display file name and error information	Displays file name and latest file error number associated with an open file, or displays all files opened by the process.
FN	Find number	Memory search	Searches memory to find a 16-bit number.
FNL	Find number long	Memory search	Searches memory to find a 32-bit number.
I	Instruction code	Display data in instruction-code format	Displays the contents of specified variables as instruction code.
IH	Info handler	Display information about signal handlers	Displays information about the actions taken by a process when it receives various signals.
LMAP	List map	Map a code address	Displays the name of the procedure, the offset from the base of the procedure, and the code space, where a specified address lies.

Table 3-2. Display Commands (page 2 of 2)

Command	Meaning	Function	Description
PMAP	Print code map	Display corresponding blocks of TNS and RISC code	Displays the contents of specified memory as TNS code and corresponding RISC code for accelerated programs.
T	Trace	Trace stack markers	Displays key attributes of the process's stack frames (procedure activations), up to ten at a time.
=	Equal	Compute a value	Computes and displays the value of an expression in decimal, hexadecimal, octal, binary, ASCII, or instruction code. Translates and displays an expression as both forms of the ENV register: the hardware ENV register and the stack marker ENV register.

Modify Commands

The modify commands are listed in Table 3-3.

Table 3-3. Modify Commands

Command	Meaning	Function	Description
M	Modify	Modify data	Modifies the contents of specified variables.
		Modify register contents	Modifies the contents of a specified register.
		Modify space identifier	Modifies the current space identifier in order to cause a different code segment to become the current code segment.
MH	Modify handling	Modify signal handling	Modifies signal handling by associating a new signal handler or signal action with a signal.

Note. You can change the current location of a process running in TNS or accelerated mode by modifying the value of the P register. If the process is a multiple-segment process, you must also change the space identifier. You change the space identifier in order to change the location of the process to a different code segment. It is also possible to change the current location of a process running in native mode, but doing so requires knowledge of native mode internals and is beyond the scope of this manual.

Environment Commands

The environment commands are listed in Table 3-4.

Table 3-4. Debug Environment Commands

Command	Meaning	Function	Description
BASE	Numeric base	Set numeric base	Sets numeric base for input to Debug, output displays by Debug, or both.
VQ	Vector Q segment	Change selectable segment	Changes the selectable segment currently viewed by the debugger.
VQA	Vector QA segment	Set selectable segment to absolute segment	Set the current selectable data segment to the specified absolute segment number.
?	Segment	Display code segment and selectable data segment information	Displays space identifier for current code segment, displays segment ID for current selectable data segment brought into use by USESEGMENT or SEGMENT_USE_, and displays segment ID for current selectable data segment brought into use by Debug VQ command.

Privileged Commands

Table 3-5 contains commands for privileged users only. Privileged commands are those permitted only if they have been enabled by use of the PRV ON command. To successfully issue the PRV ON command, the process being debugged must be executing under the local super ID. (Privileged debugging is distinct from the privileged state of process execution, which permits a process to perform privileged operations that are normally permitted only to the operating system.)

The privileged commands include those that have address parameters to:

- Access data and code in the kernel address space.
- Plant code breakpoints in code containing PRIV or CALLABLE procedures, including licensed UC, UL, UCr, SRLs, or system code and library.
- Modify code.

Table 3-5. Privileged Commands (page 1 of 2)

Command	Meaning	Description
FREEZE	Freeze	Disables the processor and asserts a freeze on other processors.
HALT	Halt	Halts the processor.

Table 3-5. Privileged Commands (page 2 of 2)

Command	Meaning	Description
PRV	Privileged	Enables or disables the use of privileged commands.
V	Vector	Allows access to other address spaces.
VQA	Vector	Sets the current selectable data segment to the specified absolute segment number.

Miscellaneous Commands

Miscellaneous Debug commands are listed in Table 3-6.

Table 3-6. Process Control Commands

Command	Meaning	Description
FC	Fix command	Fix Debug command. Allows you to edit the last Debug command that you entered.
EX[IT]	Exit	Exits the Debug session.
H[ELP]	Help	Displays requested help information about a Debug command, variable, or all help topics.
INSPECT	Run Inspect	Switches to the Inspect debugger.
P[AUSE]	Pause	Pauses (suspends) the process for a specified time.
R	Resume	Resumes program execution (leaves the debug state).
S[TOP]	Stop	Stops process execution.

Multiple Commands on a Line

Debug allows multiple commands on a line, each separated by a semicolon (;). This feature allows you to enter very sophisticated and powerful command lines while debugging.

Command Structure

Most of the Debug commands have one function and one syntax definition. However, the A, B, BM, D, and M commands have more than one function. For these commands, each function has its own definition and its own syntax.

For example, the B command has five functions: set unconditional code breakpoint, set conditional code breakpoint, set trace code breakpoint, set execute code breakpoint, and display code and memory-access breakpoints. Although all of these functions deal with setting breakpoints, each function has a unique description and a unique syntax.

Capitalization in Commands

Note that uppercase and lowercase letters are interchangeable in Debug commands. The syntax shows keywords in uppercase letters.

Default Commands

Certain Debug commands have defaults. A default for a command is a variant of the command that is executed when you simply press RETURN at the Debug prompt without actually entering the command. Default commands are valid only when certain conditions exist. Whenever a default command would be a valid entry, the command name appears in the Debug prompt. For example:

```
251,06,00024 (FN)-
```

This prompt signifies that if you press RETURN, the default version of the FN command is executed. Note that you can also enter other commands when Debug displays this prompt.

More information about default commands is given in the descriptions of the commands that have defaults.

Table 3-1 on page 3-2 through Table 3-5 on page 3-5, list the function or functions of each command and give a brief description of each function.

Notation for Privileged Commands

Underlined keywords or characters in command syntax are available to privileged users only. Keywords or characters that are not underlined are available to both privileged and nonprivileged users.

Register Syntax

Several Debug commands have register names as parameters or registers specified in expressions. The form of a *register* specification is:

register

represents the contents of a processor register for that process. It can be either a TNS/R register or a TNS environment register.

A TNS/R register is one of the following:

```
{ $00 | $01 | ... | $31 }
{ $HI | $LO             }
{ $PC                   }
{ $F00 | $F01 | ... | $F31 }
{ $FCR31                 }
```

Alias names for registers $01 through $31 and $F00 through $F09 appear in the following list. For more information, see TNS/R Registers on page 2-10

Register	Alias	Register	Alias
$00			
$01	$AT	$16	$S0
$02	$V0	$17	$S1
$03	$V1	$18	$S2
$04	$A0	$19	$S3
$05	$A1	$20	$S4
$06	$A2	$21	$S5
$07	$A3	$22	$S6
$08	$T0	$23	$S7
$09	$T1	$24	$T8
$10	$T2	$25	$T9
$11	$T3	$26	$K0
$12	$T4	$27	$K1
$13	$T5	$28	$GP
$14	$T6	$29	$SP
$15	$T7	$30	$S8 or $FP
		$31	$RA
$F00	$F0	$F05	$F5
$F01	$F1	$F06	$F6
$F02	$F2	$F07	$F7
$F03	$F3	$F08	$F8
$F04	$F4	$F09	$F9

A TNS environment register is one of these:

```
{ S | P | E | L | SP }
{ R0 | R1 | ... | R7 }
{ RA | RB | ... | RH }
```

S	specifies the S register.
P	specifies the P register.
E	specifies the ENV register.
L	specifies the L register.

SP	specifies the space identifier.
R0 through R7	specify one of the registers in the register stack.
RA through RH	is an alternative specification for the eight stack registers, where RA is the current top of stack, RB is the next one down, and so forth.

Expression Syntax

Several Debug commands have address and count parameters that are supplied in the form of an expression. An expression can represent a 16-bit integer, a 32-bit integer, or ASCII characters.

The format of an *expression*:

```
term [ { + } term ]...
       { - }
```

The *term* parameter is of the form:

value [*op value*]...

The *value* parameter has one of these forms:

(*expression*)

is an expression in parentheses to be treated as a single value.

'*c1[c2[c3[c4]]]*'

is an apostrophe followed by 1 through 4 ASCII characters, *c1*, *c2, c3*, *c4* and a trailing apostrophe.

PCB *expression*

represents the address of the specified PCB. The *expression* parameter is a value that indicates the number of the PCB. PCB is allowed only in privileged mode.

number[.*number*]

is an integer value to be treated as a 16-bit word or a 32-bit word. It represents a 32-bit word if [.*number*] is present or if *number* is too large to be represented in a 16-bit word.

The format of the *number* parameter:

[+ | - | % | # | %H | 0X] *integer*

The value of *number* is negative if - is present and positive if - is absent. The + is an optional unary plus.

The other prefixes affect the interpretation of *number* as follows:

%	represents an octal number; octal is the default numeric base except for the DN command and N address mode.
#	represents a decimal number.
%H |0X	represents a hexadecimal number.

register

represents the contents of one of the processor registers for that process; see Register Syntax on page 3-7.

K [X | D] *address*

is a value that allows memory-based variables in its calculation.

K	gets the contents of the specified address.
X	loads a 16-bit word from the specified address with sign extension.
D	loads a 32-bit word from the specified address.
address	is the specified 16-bit address. For the format, see Address Syntax on page 3-12.

op

is one of these arithmetic operators:

*	Unsigned multiply
/	Unsigned divide
<<	Left shift (unsigned 32-bit shift)
>>	Right shift (unsigned 32-bit shift)

These operators have the same precedence. The order of execution is left to right. To control order, you can use parentheses.

Considerations

- Debug evaluates a particular expression at the time you enter the command containing that expression.
- A register's value is the contents of that register at the time you enter the command that references it.
- Extended addressing and N addresses use 32-bit addresses.
- A 32-bit address can be entered as a value that cannot be represented in 16 bits or *high-word.low-word*. The 32-bit value is preferred to the *high-word.low-word* form.

If a command requires a 16-bit expression, the evaluated expression must be represented in 16 bits. A syntax error occurs if the evaluated expression cannot be represented in 16 bits.

If the command allows a 32-bit expression, the evaluated expression is always 32 bits long, with the sign extended into the high-order word. However, when a 32-bit word expression is displayed with the = command, it is always shown as a 16-bit word value if it can be expressed in 16-bit word.

- The default numeric base in expressions is octal, except for the DN command and N address mode, where the default base is hexadecimal.
- The BASE command overrides the default numeric base.
- In a value notation of the form *number.number*, the notation for the numeric base of the input value is not required in both halves of the value notation. For example, suppose that you are entering a decimal value but the default base is octal: the base notation # is required only in the first half of the value, but it is allowed in both halves. Both of these forms are equivalent:

```
#8.#823
#8.823
```

Examples

```
Expression

#27
'AB'
'A'
4*3+2
4*(3+2)
177777/2
-(177777/2)
-1
-1.0
2.1000
(2.1000)<<1
%h23
%h8009.3000
%h8009.%h3000
$T8                          ! Contents of TNS/R register $T8
$PC+4                        ! Contents of TNS/R register $PC plus 4
R1                           ! Contents of TNS register 1
L-2                          ! Contents of TNS register L minus 2
R1.R0                          ! Contents of TNS registers 0 and 1

175,07,00068-D L+3           ! Display L+3 (that is, display contents
000003: %000033              ! of word addressed by the sum of the
                               ! contents of TNS register L plus 3)
```

Address Syntax

Many Debug commands require you to specify an address. The syntax for an address is as follows:

```
[ 32-bit-address ] | [ TNS-style ] | [ Q-mode  ] | [ N-mode
]
```

32-bit-address

defines the 32-bit address where the code or data is located.

TNS-style

defines the code or data segment address for TNS users. The syntax for the *TNS-style* address is as follows:

```
[address-mode]offset [ indirection-type [index]]
```

address-mode

defines the code or data segment where the address is located. The value of *address-mode* can be one of the following:

UC[.*segment-num*,]

indicates that the address is in the TNS user code space. The *segment-num* parameter defines the particular code segment within the user code space. The value of *segment-num* must be in the valid range, which (in octal) is 0 through %37. If you omit *segment-num*, Debug uses 0.

UL[.*segment-num*,]

indicates that the address is in the TNS user library space. The *segment-num* parameter defines the particular library code segment within the user library space. The value of *segment-num* must be in the valid range, which (in octal) is 0 through %37. If you omit *segment-num*, Debug uses 0.

SC[.*segment-num*,]

indicates that the address is in the TNS system code space. SC is allowed only in privileged mode. The *segment-num* defines the particular code segment within the system code space. If you omit *segment-num*, Debug uses 5.

The value of *segment-num* must be in the range 5 through %37 (octal).

SL[.*segment-num*,]

indicates that the address is in the TNS system library space. SL is allowed only in privileged mode. The *segment-num* parameter defines the particular

code segment within the system code space. If you omit *segment-num*, Debug uses 0.

The value of *segment-num* must be in the range 0 through %37 (octal).

UD[,]

indicates that the address is in the user data segment.

- C indicates an address in the current TNS code segment (user code space or user library space).
- L indicates an L-relative address (procedure parameters or local variables) in the user data segment.
- S indicates an S-relative address (subprocedure parameters or sublocal variables) in the user data segment.
- G indicates a system-global relative address in the system data segment. G is allowed only in privileged mode.

offset

is an expression giving the address, relative to the indicated *address-mode*.

indirection-type

specifies that the address is to be used as an indirect address. The value of *indirection-type* must be one of the following:

- I use the indirect address as a word address.
- S use the indirect address as a byte address.
- IX use the indirect address as an extended word address.
- SX use the indirect address as an extended byte address or as a 32-bit address.
- IG use the indirect address as a system global word address; this type is allowed only in privileged mode.
- SG use the indirect address as a system global byte address; this type is allowed only in privileged mode.

index

is an expression to be used as an offset from the base address. The *index* parameter is a byte offset if *prefix* is N or if *indirection-type* is S, SX, or SG; otherwise, *index* is 16-bit word offset.

Q-mode

indicates that the address is in the current selectable data segment. Q indicates an address within the currently assigned selectable segment. The syntax for *Q-mode* is as follows:

Q *offset* [*indirection-type* [*index*]]

See the definitions of *offset*, *indirection-type*, and *index* above.

N-mode

Indicates that the user is in a 32-bit address mode.

N Use N mode to indicate addresses in native or accelerated code, RISC stacks, native globals and heap areas, flat segments or the currently in-use selectable segment, or anywhere 32-bit addressing is convenient.

In nonprivileged mode, you can specify addresses in user space, 0 through 0x7FFFFFFF. (Not all of these addresses are valid in any process environment, and some ranges are reserved for privileged access.)

In privileged mode, you can specify all available addresses.

Considerations

- If you omit *address-mode* and if *offset* is a 16-bit word expression, Debug assumes one of two address modes depending on where *address* appears. If *address* appears in a B, C, or I command, omitting *address-mode* causes Debug to use a C-relative code address in the current TNS code segment (same as C *address-mode*).
  - If *address* appears in a D, A, FN, or M command, omitting *address-mode* causes Debug to use a G-relative address in the TNS user data segment.
- If you omit *address-mode* and if *offset* is a 32-bit expression, Debug assumes extended addressing.
- To indicate an address in a flat segment, use *N-mode* address and specify a 32-bit RISC address in the flat segment range as returned by the ALLOCATESEGMENT or SEGMENT_ALLOCATE_ procedure call.
- When using UC and UD as a default, the user needs to take the following into consideration:
  - If the command deals with code, UC is assumed as the default.
  - If the command deals with data, UD is assumed as the default.
- Direct addressing versus indirect addressing

  There are two basic forms of the display command: the direct form and the indirect form. The direct form is used to display direct variables, value parameters, contents of pointers, and the addresses in reference parameters. The indirect form is used to display indirect variables (arrays), objects of pointers, and the values of reference parameters.

  Using the Direct Form

  In the following example, the programmer wants to display the contents of some global variables. The first action is to refer to the map of global identifiers located at the end of the compiler listing:

```
DB^BUF            VARIABLE      INT    G+010       INDIRECT
DB^COUNTREAD      VARIABLE      INT    G+011       DIRECT
DB^ERRCNT         VARIABLE      INT    G+007       DIRECT
```

To display the contents of the direct variable DB^COUNTREAD, this display command is entered:

```
106,01,00012-D 11       ! Display user global location %11
```

Debug displays the following:

```
000011: %000310
```

To display the contents of the pointer variable DB^BUF, this display command is entered:

```
106,01,00012-D 10        ! Display global location %10
```

Debug displays the following:

```
000010: %000116    ! A word address
```

To display the FNUM value parameter of a procedure, the procedure's map of identifiers is referred to:

```
   ERRCNT            VARIABLE       INT    L-004        INDIRECT
   ERRORNUM          VARIABLE       INT    L-003        INDIRECT
   FNUM              VARIABLE       INT    L-005        DIRECT
```

Then this display command is entered:

```
215,00,00035-D L-5       ! Display L-relative location -5
```

Debug displays the following:

```
000370: %000002
```

Using the Indirect Form

To display the contents of an indirect array, the indirect form of the display command is used.

For example, to display the first element of DB^BUF, the relative-address I form of the display command is entered:

```
215,00,00035-D 10I      ! Display indirect, using user global location %10
```

Debug uses location G[%10] as the indirect address of the location to be displayed. The following is displayed:

```
000116:  %063162
```

As another example, suppose the programmer wants to display in character form 20 words of the indirect array DB^BUF, starting with word [20]. This requires use of the indirect, indexed form of the display command. This command is entered:

```
215,00,00035-A 10I #20,#20
```

Debug calculates the address of the first word to be displayed by adding 20 to the address value of G[%10]. Twenty words are displayed, in character form, starting at the calculated location:

```
000142:  .12.  .34.  .5 .  .gr.  .ap.  .e .  .la.  .ne.
000152:  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
000162:  .  .  .  .  .  .  .  .
```

Displaying the contents of an indirect byte array requires that the indirect byte address be converted to its word equivalent. This is accomplished by using the indirection type S in the address for the display command.

For example, to display (in character form) %20 bytes pointed to by the string pointer SDB^BUF,

```
.
SDB^BUF           VARIABLE    STRING  G+020     INDIRECT
.
```

this command is entered:

```
215,00,0003500-A20S,10
000116:  .fr.  .ed.  .  .  .  .  .  .  .  .  .  .  .  .
```

This converts the string address to a word address and displays %10 words starting at that location (G[%116]).

- Displaying Variables in Extended Data Segments

  The command syntax for displaying variables in extended data segments (selectable segments or flat segments) is similar to that for setting breakpoints in extended data segments.

  To display data in a flat segment, use the N address mode to display a 32-bit RISC address within the flat segment range. You can obtain the address of a flat segment within your program by using the ALLOCATESEGMENT or SEGMENT_ALLOCATE_ procedure call. For example, assuming 0x42000A6F is an address within a flat segment, this command displays the contents of the word at that address:

```
106,05,00134-DN 0x42000A6F
42000A6F:  0x0000007E
```

  Addresses in selectable segments can be expressed in a number of ways.

  For example, suppose that, as in the third example in Set Unconditional Code Breakpoint on page 4-7, the programmer has allocated a selectable segment by using either the ALLOCATESEGMENT or SEGMENT_ALLOCATE_ procedure, giving it segment ID 10. Again suppose that the segment has not been brought into use by a call to either USESEGMENT or SEGMENT_USE_, and that no other segment is in use. This time, rather than set a breakpoint, the programmer wants to display the contents of word 80 of that segment. First a VQ command is needed:

```
215,00,00035-VQ#10
215,00,00035-
```

  Then this command displays the contents of the 16-bit word 80:

```
215,00,00035-DQ#80
%000080:  %177777
```

  The same location could be displayed using extended addressing, with any of these commands:

```
d 100 + #80<<1
d 2000000 + #80*2
d 2000000 + #160
d 2000240
d 10240
d 10#160
```

4 Debug Commands

This section describes Debug commands. Table 4-1 summarizes all of the available Debug commands. Then the descriptions of each command are written on the subsequent pages.

Command Summary

Table 4-1 summarizes the Debug commands. Note that some commands are available only to privileged users. These commands are indicated with a check (√) in Table 4-1.

Table 4-1. Debug Command Summary (page 1 of 2)

Command	Priv Only	Purpose	Page
A Command		Display data in ASCII	4-3
AMAP Command		Provide information about an address	4-6
B Command		Set code breakpoint, and display code and memory-access breakpoints	4-7
BASE Command		Set numeric base for input, output, or both	4-22
BM Command		Set memory-access breakpoint	4-24
C Command		Clear code breakpoint	4-32
CM Command		Clear memory-access breakpoint	4-33
D Command		Display data, registers, and space identifier in numeric formats	4-33
DJ Command		Display jump buffer contents in register format	4-40
DN Command		Display memory contents in a specified format	4-41
EX[IT] Command		Exit the Debug session and resume process execution	4-45
F[ILES] Command		Display file name, file number, and error information for open files	4-46
FC Command		Correct or change Debug command	4-47
FN Command		Search memory to find a particular 16-bit number	4-48
FNL Command		Search memory to find a particular 32-bit number	4-49
FREEZE Command	√	Disable processors	4-50
HALT Command	√	Halt a processor	4-51

Table 4-1. Debug Command Summary (page 2 of 2)

Command	Priv Only	Purpose	Page
H[ELP] Command		Display help information about Debug commands	4-51
I Command		Display data as instruction code	4-52
IH Command (TNS/R Native and OSS Processes)		Display information about signal handling	4-54
INSPECT Command		Transfer control to the Inspect debugger	4-55
LMAP Command		Display the name of the procedure, and the offset from the base of the procedure, where a specified address lies	4-57
M Command		Modify data, registers, or space identifier	4-58
MH Command (TNS/R Native and OSS Processes)		Modify signal handling	4-62
P[AUSE] Command		Pause (suspend) process for specified period	4-63
PMAP Command (Accelerated Programs)		Print corresponding blocks of accelerated code	4-64
PRV Command		Enable or disable privileged debugging	4-65
R Command		Resume process execution	4-66
S[TOP] Command		Stop process execution	4-67
T Command		Display a stack-marker traceback or procedure-name traceback	4-68
V Command	√	Enable access to other address spaces	4-71
VQ Command		Change selectable data segment currently viewed by Debug	4-72
VQA Command	√	Set the current selectable data segment to the specified absolute segment number	4-73
= Command		Compute and display value of an expression	4-73
? Command		Display identifiers for the current code segment and for the selectable data segment that is currently in use	4-75

A Command

The A command displays the contents of a process' variables in ASCII representation. The syntax for this command:

```
A address [ , length ] [, data-display-format ]
   [ , [ OUT ] output-dev ]
```

address

is the address of the first character to be displayed. For more information, see Address Syntax on page 3-12.

length

specifies the number of 16-bit words to be displayed by Debug and must be one of the following:

count

is an expression designating the number of 16-bit words to be displayed.

T *entry-size* * *num-entries*

specifies that the display is to be in table format. The *entry-size* * *num-entries* parameter is an expression specifying the number of 16-bit words to be displayed. The display consists of *num-entries* blocks, each block consisting of *entry-size* words.

If you omit *length*, one 16-bit word is displayed.

data-display-format

specifies the format options in which data is displayed. The *data-display-format* has this format:

{ B | B1 | C | B2 | S | B4 | L }

B | B1 | C	display data in character format.
B2 | S	display characters in 2-byte groups representing a 16-bit word. This is the default format option.
B4 | L	display characters in 4-byte groups representing a 32-bit word.

[OUT] *output-dev*

specifies where the display is directed. Debug output can be directed to an output device, a process, or a spooler collector. Debug output cannot be directed to a disk file. If you omit *output-dev*, Debug assumes the home terminal.

output-dev has these formats:

Syntax for a device other than a disk:

```
[ node.]{device-name[.qualifier ]}
        {ldev-number              }
```

Syntax for a named process:

[*node*.]*process-name*[:*seq-no*][.*qual-1*[.*qual-2*]]

Syntax for an unnamed process:

[*node*.]$:*cpu*:*pin*:*seq-no*

For syntax descriptions of these process and device names, see the *Guardian Procedure Calls Reference Manual*.

Examples

```
050,03,00009-a %62/2
%000031:    'ab'
050,03,00009-a %62/2, #40/2
%000031:    'ab'    'cd'    'ef'    'go'    'me'    ' d'    'at'    'a.'
%000041:    '..'    '..'    '..'    '..'    '..'    '..'    '..'    '..'
%000051:    '..'    '..'    '..'    '..'
050,03,00009-a L+3s, #40/2, b
%000031:abcdefgome data.......................
050,03,00009-a L3s, #40/2, b2
%000031:    'ab'    'cd'    'ef'    'go'    'me'    ' d'    'at'    'a.'
%000041:    '..'    '..'    '..'    '..'    '..'    '..'    '..'    '..'
%000051:    '..'    '..'    '..'    '..'
050,03,00009-a L3s, #40/2, b4
%000031: 'ab.cd' 'ef.go' 'me. d' 'at.a.' '.....' '.....' '.....' '.....'
%000051: '.....' '.....'
050,03,00009-A Q #40/2, T5*4
%000024:    '.a'    'bc'    'de'    'fg'    '..'
%000031:    '..'    '..'    '..'    '..'    '..'
%000036:    '..'    '..'    '..'    '..'    '..'
%000043:    '..'    '..'    '..'    '..'    '..'
050,03,00009-a n 0x00080029, T5*4, c
00080028:.abcdefg..
00080032:..........
0008003C:..........
00080046:..........
050,03,00009-A L+4sx, T5*4, L
%000024: '.a.bc' 'de.fg' '.....' '.....' '.....'
%000036: '.....' '.....' '.....' '.....' '.....'
050,03,00009-
```

AMAP Command

The AMAP command provides information about a specified address in 32-bit form. This information is displayed when you use the AMAP command:

- KIND, which specifies the address mode (UC, UL, SC, or SL) and the execution mode (TNS, AXCEL, native, or unknown).
- ATTRIBUTE, which specifies one or more of the following: resident, read only, code, SRL, enter vector, priv to read, priv to write, priv to break, is zero page, and none.

The syntax for the AMAP command is as follows:

```
AMAP address
```

address

specifies the user input address. For more information about addressing, see Address Syntax on page 3-12.

Examples

```
050,03,00272-amap 0x7C369070
Address: 0x7C369070
Address location attribute: 0x0B678000
Kind = 0x000B: SL (NATIVE)
Attributes: Read Only, Code, Priv to Read, Priv To Write,
             Priv to Break
```

B Command

The B command sets code breakpoints and displays code and memory-access breakpoints. The B command has five functions:

- Set Unconditional Code Breakpoint on page 4-7
- Set Conditional Code Breakpoint on page 4-11
- Set Trace Code Breakpoint on page 4-13
- Set Execute Code Breakpoint on page 4-15
- Display Breakpoints on page 4-16

Each function is defined by a unique syntax. Each function and its syntax is described in the following pages.

Set Unconditional Code Breakpoint

The B command can set an unconditional code breakpoint. An unconditional code breakpoint causes the process to enter the debug state each time the breakpoint location is executed. The unconditional form of the B command is:

```
B address [, ALL ]
```

address

is the code address where the breakpoint is to occur. For more information, see Address Syntax on page 3-12. The address mode must follow these guidelines:

- Use UC, UL, SC, SL, and C address modes for TNS code.
- Use 32-bit extended address or N address mode for native or accelerated code.
- You must be privileged to set a breakpoint in protected code areas, which include:
  - All system code: SC, SL, SCr, SLr
  - Code anywhere in a UC, UL, UCr, or SRL space that contains PRIV or CALLABLE procedures
- To set a breakpoint in a UC, UL or SRL space, you must have read access to the object file for that library.

ALL

indicates that the breakpoint applies to all processes in the processor executing the code being debugged. The ALL option is allowed only in privileged mode. A global breakpoint (this is, a breakpoint set with the ALL option) is delivered to any process that executes the code location that is breakpointed. A private breakpoint (without the ALL option) is delivered only to the process that created the breakpoint.

Considerations

- When you set a breakpoint, Debug displays information describing this breakpoint. For more information on the information displayed, see Display Breakpoints on page 4-16.
- When debugging accelerated programs, you can set breakpoints in TNS code only on instructions that are register-exact points or memory-exact points. These points are marked in displays by the I and PMAP commands. For more information, see Section 2, Using Debug on TNS/R Processors.
- A global breakpoint is associated with a particular memory object, regardless of any process. The breakpoint persists as long as the containing memory object exists; the breakpoint disappears when the memory object is deleted. By contrast, a private breakpoint is associated with a particular memory object within a particular process; the breakpoint disappears when the object disappears or the process terminates.
  - A global breakpoint in system code, or in a system library, persists until the processor is reloaded.
  - A global breakpoint in a public SRL or public DLL persists as long as that SRL or DLL persists. The breakpoint disappears if the SRL is untitled or the processor is reloaded.
  - A global breakpoint in user code, a user library, private SRL, or private DLL persists as long as at least one process is executing that code, library, SRL, or DLL. The breakpoint disappears when no process is executing that code, library, SRL, or DLL.
  - A global breakpoint in an OSS shared memory object persists as long as the object persists.

Examples

```
215,01,00012-b 4+16

215,01,00012-b ul.2, 10+42

215,01,00012-b uc.1, 2047

215,01,00012-B 226+30

215,01,00012-B C 226+30          ! Equivalent to the preceding command
248,02,00022-B SL.2, 23243+332   ! Break in system library segment 2
                                 ! at the instruction at
                                 ! address %23243+332
248,02,00022-B 0X70023FE4        ! Break in user code at RISC
                                 ! address 0x70023FE4 (native mode)
```

The following example uses the I command to display user code to determine a register-exact point (marked with an @ sign) at which to set a breakpoint. The subsequent B command sets a breakpoint at offset %215 in user code.

```
244,00,00084-I UC.0,207, 20

000207:  STOR  L+026    > LADR  L+023,I    LADR  L+003      LADR  L+027,I
000213:  PUSH    722      XCAL    003    @ STRP    7        LDI    +001
000217:  LDD   L+001      LADR  L+003      LDI    +000      LDI    +016
000223:  PUSH    755      XCAL    000    @ STOR  L+017    > LDI    -001
244,00,00084-B UC.0, 215

   @ ADDR: UC.%00, %000215  INS: %000107
```

Examples of Setting Unconditional Code Breakpoints

Appendix F, Sample Debug Sessions provides examples that illustrate setting unconditional code breakpoints in a procedure and a subprocedure written in TAL (TNS mode). The following example shows the setting of unconditional code breakpoints in a function written in C (native mode).

In a C Function (Native Mode). Suppose the programmer wants a process to enter the debug state at line 115 of this example:

```
101    int getloc(void)
102    {
103       int loc_num, i_val, tm, *row;
.
.
115       if (i_val == loc_num)
116          return nextloc (row, loc_num);
```

In a native program, the address of the base of a function or procedure can be determined using the noft utility. After noft has been started and the name of the object file has been provided, the function getloc is specified with the listproc command:

```
noft> listproc getloc
```

This command causes noft to display the base address of the function getloc.

```
Procedure :     #   Address
   getloc :      2   0x70000448
```

The address displayed is then supplied as input to the dumpaddress command. This command causes noft to display disassembled native code starting at the beginning of getloc for forty 32-bit words:

```
noft> dumpaddress 0x70000448 for 40 words
```

The resulting display includes the RISC code associated with source line 115. (The source line number is multiplied by 1000 in the display.)

```
Procedure  Src Line   Address    Long Word   Instructions
-------------------------------------------------------------
--
 .
 [getloc 115000]  0x700004a4  0x8fae008c    lw  t6,0x8c(sp)
 [getloc 115000]  0x700004a8  0x8faf0088    lw  t7,0x88(sp)
 [getloc 115000]  0x700004ac  0x0000000000  nop
 [getloc 115000]  0x700004b0  0x15cf0009    bne t6,t7,0x700004d8
 [getloc 115000]  0x700004b4  0x0000000000  nop
 .
```

The display shows the first instruction associated with line 115 to be at 0x700004A4. A breakpoint is placed at that location:

```
106,06,00125-B 0x700004A4          ! (set breakpoint)
        N: 0x700004A4      INS: LW    t6,140(sp)
106,06,00125-R                     ! (resume)
```

The process enters the debug state each time the instruction at RISC address 0x700004A4 is executed.

```
DEBUG PC=0x700004A4 -RISC BREAKPOINT ($PC:0x700004A4)-
```

Note. In optimized code, instructions might be rearranged in the object file. Where possible, noft indicates this by a “+” or “-” in the dumpaddress display. In highly optimized code, you might have to rely on your own judgment to decide where a breakpoint is appropriate.

For more information about how to use the noft utility, see the *nld Manual* and the *noft Manual.*

Set Conditional Code Breakpoint

The B command can set a conditional code breakpoint. A conditional code breakpoint causes a process to enter the debug state when both the breakpoint location is executed and a specified variable matches a predetermined condition. The conditional form of the B command is:

```
B address

   {, {test-address |register} [& mask] op constant[, ALL ]}
   { [, ALL ] , {test-address | register}[& mask]
                                          op constant }
```

address

is the code address where the breakpoint is to occur. For more information, see Address Syntax on page 3-12. The address mode must follow the same guidelines as those stated earlier in this section for specifying the code address when setting an unconditional code breakpoint.

test-address

is the address of the variable to be tested. The syntax for *test-address* is the same as the Address Syntax on page 3-12, but it is limited to only data locations and the Q-mode syntax is not allowed. If *test-address* is an N mode address, *test-address* refers to a 32-bit variable.

register

is a processor register. For more information, see Register Syntax on page 3-7.

For a TNS process, when registers R0 through R7 are specified, the values in the registers are evaluated when the breakpoint is executed. Other registers are evaluated to a memory location pointed by the registers when the breakpoint is executed.

For a TNS/R process, any register except the floating-point registers can be used.

mask

is an expression. The *mask* parameter is logically ANDed with the value of the *register* parameter or the value pointed to by the *test-address* parameter and the *constant* parameter before the condition is tested. The comparison values are treated as signed values. The value for *mask* is 32 bits if a TNS/R *register* or an N mode *test-address* value is used; otherwise, the value is 16 bits.

If you omit *mask*, Debug uses -1 (0xFFFF for a 16-bit *constant* or 0xFFFFFFFF for a 32-bit *constant*).

op

is a relational operator and must be one of the following:

<	break if the variable is less than *constant*. This operator does a signed comparison.
>	break if the variable is greater than *constant*. This operator does a signed comparison.
=	break if the variable is equal to *constant*.
# | <>	break if the variable is not equal to *constant*.

constant

is an expression. The value is 32 bits if a TNS/R *register* or an N-mode *test-address* is used; otherwise, it is 16 bits.

ALL

specifies an attribute for the breakpoint only if you are debugging in privileged mode as described under the PRV command. For more information, see Set Unconditional Code Breakpoint on page 4-7.

Considerations

- When you set a breakpoint, Debug displays information describing this breakpoint. For a description of the information displayed, see Display Breakpoints on page 4-16.
- When debugging accelerated programs, you can set breakpoints in TNS code only on instructions that are register-exact or memory-exact points. These points are marked in displays by the I and PMAP commands. For more information, see Rules About RISC Breakpoints on page 2-7.
- When the N-mode address form is used for the *test-address*, *mask,* and *constant* refer to a 32-bit value. Otherwise, a 16-bit value is assumed.
- When TNS/R *register* is used, *mask* and *constant* refer to 32-bit values. For TNS *register*, a 16-bit value is assumed.
- If a Q-mode address is required for *test-address*, the Q-mode address can be converted to a 32-bit address with the AMAP command if the program has a selectable segment in use. For example, to obtain the address location of the 10th 16-bit word of the selectable segment, enter the command AMAP Q#10. The result, 0x00080014, can be entered for the *test-address* value. Alternatively, the byte address offset can be added to 0x00080000 to get the *test-address* value in a selectable segment.

Examples

```
106,03,00040-B 100 + 117, L + 14 > 500
106,03,00040-B UC.2, 526, L+3 = 0
106,03,00040-B C, 2I, R4 <> 1
106,03,00040-B UL.1, 325, L+5 > 3
248,00,00045-B N 0x70450F1C, $T2 & 0xF000FFFF < 0x17
                  ! Break in RISC code if the 32-bit value in $T2 logically
                  ! ANDed with the mask value is less than 0x17.
```

Examples of Setting Conditional Code Breakpoints

The address where the breakpoint is located is determined in the same manner as previously described in Set Unconditional Code Breakpoint on page 4-7. For examples, see Appendix F, Sample Debug Sessions.

Set Trace Code Breakpoint

The B command can set a trace code breakpoint. A trace code breakpoint causes Debug to list the contents of one or more registers or memory locations each time the breakpoint location is executed. The trace form of the B command is:

```
B address {, {register | start-address} ? count [, ALL ]   }
            { [, ALL ], {register | start-address} ? count }
```

address

is the code address where the breakpoint is to occur. For more information, see Address Syntax on page 3-12. The address mode must follow the same guidelines as those stated earlier in this section for specifying the code address when setting an unconditional code breakpoint. The *address* parameter is limited to code locations only.

register

is a processor register. For more information, see Register Syntax on page 3-7.

For a TNS process, when registers R0 through R7 are specified, the values in the registers are evaluated when the breakpoint is executed. Other registers are evaluated to a memory location pointed by the registers when the breakpoint is executed.

For a TNS/R process, any register except the floating-point registers can be used.

start-address

is the address of the first variable to be listed. The syntax for *start-address* is the same as the Address Syntax on page 3-12, but it is limited to only data

locations and the Q-mode syntax is not allowed. If *start-address* is an N mode address, *start-address* refers to a 32-bit variable.

?

means list.

count

is an expression indicating the number of 16-bit words to be displayed. The value is stored in 32 bits if a TNS/R register or N-mode *start-address* is used; otherwise, it is stored in 16 bits. If *count* is stored in 32 bits, only the value in the lower-order 16 bits are used to determine the number of 16-bit words to be displayed.

If a TNS stack register R0 through R7 is specified, the value for *count* has to be 1 in order to display the 16-bit contents of the register. To display a range of the stack registers, enter the starting register and *count* values. For example, to display all eight stack registers, enter R0?#8.

If a TNS/R register is specified, the value for *count* has to be 2 in order to display the 32-bit contents of *register* as two 16-bit values. To display a range of the TNS/R registers, enter the starting *register* and *count* values. For example, to display all 32 registers, enter $00?#64.

ALL

For more information on the description of this option, see Set Unconditional Code Breakpoint on page 4-7.

Considerations

- Debug displays this header each time the breakpoint location is executed:
  - TNS and accelerated modes

    TRACE *code-address, space-identifier*

    This header gives the address where the break occurred. In TNS or accelerated mode, *code-address* is a C-relative address, which gives the address of the break relative to the identified TNS code segment. An r in the *space-identifier*, instead of a segment index, indicates native code; that is, SCr, SLr, and so forth. (UC appearing without a segment index is equivalent to UCr.)

  - RISC

    TRACE $PC=*code-address*

    In native mode, *code-address* is a 32-bit hexadecimal value.

- When you set a breakpoint, Debug displays information describing this breakpoint. For a description of the information displayed, see Display Breakpoints on page 4-16.
- When debugging accelerated programs, you can set breakpoints in TNS code only on instructions that are register-exact points or memory-exact points.These points are marked in displays by the I and PMAP commands. For more information, see Section 2, Using Debug on TNS/R Processors.

Examples

```
106,01,00012-B 4+52, 5?10
106,01,00012-B UC.2, 423, 3?10
106,01,00012-B UL.1, 5+23, 40?3
248,01,00012-B N 0X70451210, 0x2323 ? 0x100
```

Example of Setting a Trace Code Breakpoint

The address where the breakpoint is located is determined in the same manner as previously described in Set Unconditional Code Breakpoint on page 4-7. For more information on an example of setting a trace code breakpoint, see Appendix F, Sample Debug Sessions.

Set Execute Code Breakpoint

The B command can set an execute code breakpoint. An execute code breakpoint causes Debug to execute a specified string of Debug commands when the breakpoint location itself is executed.

After executing the specified command string, Debug prompts for additional Debug commands, unless the specified command string contains an R (resume) command.

The execute form of the B command is:

```
B address {, ( command-string ) [, ALL ]   }
          { [, ALL], ( command-string ) }
```

address

is the code address where the breakpoint is to be placed. For more information, see Address Syntax on page 3-12. The address mode must follow the same guidelines as those stated earlier in this section for specifying the code address when setting an unconditional code breakpoint.

command-string

is a string of Debug commands separated by semicolons (;) that is saved when you enter the breakpoint and executed when the breakpoint is executed. The string of Debug commands is not examined for syntax errors until it is executed.

ALL

For the description of this option, see Set Unconditional Code Breakpoint on page 4-7 under the B command.

Considerations

When debugging accelerated programs, you can set breakpoints in TNS code only on instructions that are register-exact or memory-exact points. These points are marked in displays by the I and PMAP commands. For more information, see Rules About RISC Breakpoints on page 2-7.

Examples

```
106,04,00192-b 5 + 3, (d; t; r)
106,04,00192-b uc.2, 100+2, (d;t;r)
248,04,00092-B N 0X7002D058, (D;T;R)
```

Display Breakpoints

The B command can display currently set breakpoints for the process being debugged. In addition, as each breakpoint is set, Debug displays information describing that breakpoint.

The display breakpoints form of the B command is:

```
B [ * ]
```

* displays RISC breakpoints set as a result of setting TNS breakpoints in an accelerated program. Without the asterisk (*), only breakpoints explicitly set in a B or BM command are displayed.

Considerations

For more information on how Debug displays the breakpoint information, see the display formats described on the following pages.

Format of the Code Breakpoint Display

Debug displays TNS and native code breakpoints in this form:

TNS code breakpoint:

```
[@ | >] code-segment, addr-16      INS: instr SEG:memory-seg
                                    [PIN: { <pin-num> | ALL }
]
                                   INS: mnemonic-instr
       [ condition      ]
       [ trace          ]
       [ command-string ]
```

Native code breakpoint:

```
[^--] N: addr-32          INS: instr-32
                          INS: mnemonic-instr-32
      [ condition      ]
      [ trace          ]
      [ command-string ]
```

`>`	(greater-than sign) denotes a memory-exact point, for accelerated programs only.
`@`	(commercial at sign) denotes a register-exact point, for accelerated programs only.
code-segment	defines the TNS code segment where the breakpoint is set. Segments are: UC.*segment-num* ! in user code space UL.*segment-num* ! in user library space SC.*segment-num* ! in system code space (privileged only) SL.*segment-num* ! in system library space (privileged only) Characters appearing in the display before UC, UL, SC, or SL indicate that the breakpoint is set on corresponding TNS and RISC instructions as follows:
addr-16	is the 16-bit word address where the breakpoint is set. This address is within the specified code segment.
instr	is the octal value of the instruction at the address defined by *code-segment*, *addr-16*. This value is the value of the instruction at the time the breakpoint was set. While the breakpoint is set, the content of *code-segment*, *addr-16* is a BPT (TNS) instruction (000451).
SEG	is the segment in memory where the breakpoint is set.
memory-seg	the memory segment.

pin-num	is the PIN number, available only on privileged mode.
mnemonic-instr	is the mnemonic decode of the *instr* binary value.
^--	indicates that the displayed output is RISC corresponding to a previous TNS breakpoint. This is shown only with the B* command.
N	indicates that the breakpoint is in RISC code.
addr-32	is the 32-bit address in RISC code where the breakpoint is set.
instr-32	is the RISC instruction at the address *addr-32*, which was replaced by the RISC instruction BREAK.
mnemonic-nstr-32	is the mnemonic RISC decode of the *instr-32* binary value.

The displays for *condition*, *trace*, and *command-string* are described separately later in this section.

Example

This is an example, in TNS breakpoint format, of what is displayed by Debug in response to the B command:

```
050,03,00013-B UC.0,%5
ADDR: UC.%00,%000005 INS: %002035 SEG: %020737
                     INS:   ADDS   +035
```

This is an example of a display for a breakpoint on a TNS instruction in a program that was accelerated and, therefore, has RISC instructions. Debug sets a breakpoint in the RISC instruction that corresponds to the TNS instruction.

```
050,03,00032-b
@ ADDR: UC.%00,%000005 INS: %002035 SEG: %020737
                       INS:   ADDS   +035
050,03,00032-b *
@ ADDR: UC.%00,%000005 INS: %002035 SEG: %020737
                       INS:   ADDS   +035
 ^--N: 0x7042001C      INS: 0x27BD004E
                       INS: ADDIU sp,sp,78
```

This is an example of the display for a breakpoint in native format:

```
050,03,00266-B 0x70000390 + (#3 * #4)
N: 0x7000039C     INS: 0x00002025
                  INS: OR    a0,$0,$0
```

Format of the Memory-Access Breakpoint Display

Debug displays memory-access (MAB) breakpoints in this form:

```
{XA: | N:} mab-addr [ - ] MAB: access ( seg-type )
                                [PIN: { <pin-num> | ALL } ]

   [ condition      ]
   [ trace          ]
   [ command-string ]
```

`{XA: | N: }` XA is a 32-bit extended address given when the MAB is on a data location. N is given when the MAB is on a RISC stack location or a code location. A MAB can be put on a TNS code location only in privileged mode.

`mab-addr` indicates the 32-bit absolute address where the memory-access breakpoint is set.

`-` indicates that this memory-access breakpoint is inhibited.

When a privileged memory-access breakpoint is set with the ALL option specified, the memory-access breakpoints for all other processes are inhibited and "-" appears in the display.

When the privileged ALL breakpoint is cleared, the memory-access breakpoints for all of the other processes return to use and "-" no longer appears in the display.

`access` indicates the type of memory access that triggers the breakpoint and can be one of these access types:

```
R     ! Break on a read access.
RW    ! Break on a read/write access.
W     ! Break on a write access.
C     ! Break on change access.
```

`seg-type` indicates the type of segment that *`mab-addr`* points into. Segment types are:

```
DATA SEG          ! current data segment, in octal (TNS only)
Q segment-id      ! selectable segment, in octal
UC.segment-num    ! in user code space, in octal (TNS)
UL.segment-num    ! in user library space, in octal (TNS)
SC.segment-num    ! in system code space, in octal (TNS and PRV
only)
SL.segment-num    ! in system library space, in octal TNS and PRV
only)
```

`PIN: { <pin-num> ALL}` For more information, see Format of the Code Breakpoint Display on page 4-17.

The displays for *condition, trace*, and *command-string* are described separately later in this section.

Example

For memory-access breakpoint examples, see Appendix F, Sample Debug Sessions.

Format of the Conditional Breakpoint Display

For a conditional breakpoint (code or memory-access), Debug displays the conditional information under the normal breakpoint information. The *condition* parameter is displayed in one of these two forms:

The 32-bit display form:

```
{register | test-address } & mask {< } constant
                                  {> }
                                  {= }
                                  {# }
```

register	is one of the TNS/R registers.
test-address	is a 32-bit address.
mask	is an expression as defined under Set Conditional Code Breakpoint on page 4-11.
<, >, =, #	is less than, greater than, equal, and not equal, respectively.
constant	is an expression as defined under Set Conditional Code Breakpoint on page 4-11.

The 16-bit display form:

```
{register |test-address } [ {I} [index] ]& mask {< } constant
                          [ {IX}        ]       {> }
                          [ {IG}        ]       {= }
                                                {# }
```

register	is one of the TNS stack registers (R0 through R7) as described under Register Syntax on page 3-7.
test-address	is a 16-bit address or a 32-bit address.
I, IX, IG	is integer indirect, integer extended indirect, and integer indirect global, respectively. These indirect types can be used with 16-bit addresses only.

index	is an offset from the base address. This can be used with 16-bit addresses only.
mask	is an expression as defined under Set Conditional Code Breakpoint on page 4-11.
constant	is an expression as defined under Set Conditional Code Breakpoint on page 4-11..

Example

For conditional breakpoint examples, see Appendix F, Sample Debug Sessions.

Format of the Trace Breakpoint Display

For a trace breakpoint (code or memory-access), displays the trace information under the normal breakpoint information. The *trace* parameter is displayed in one of these two forms:

The 32-bit display form:

```
{register | start-address } ? count
```

register	is one of the TNS/R registers.
start-address	is a 32-bit address.
?	is the trace indicator.
count	is the number of 16-bit words to be displayed. The value of *count* can be either 16 bits or 32 bits. If it is 32 bits, only the lower 16 bits are used for the number of 16-bit words to display.

The 16-bit display form:

```
{ register | start-address }[ { I  } [index] ]  ?  count
                              { IX }
                              { GX }
```

register	is one of the TNS/R stack registers (R0 through R7) as described under Register Syntax on page 3-7.
start-address	is a 16-bit address or a 32-bit address.
I, IX, GX	is integer indirect, integer extended indirect, and integer indirect global. These indirect types can be used with 16-bit addresses only.

index	is an offset from the base address. It can be used with 16-bit addresses only.
?	is the trace indicator.
count	is the number of 16-bit words to be displayed.

Example

For trace breakpoint examples, see Appendix F, Sample Debug Sessions.

Format of the Command-String Display

For an execute mode breakpoint (code or memory-access), Debug displays the value of *command-string* that was entered with the breakpoint.The *command-string* parameter is displayed in this form:

```
( command-string )
```

BASE Command

The BASE command changes the default base for numeric values displayed by Debug and accepted by Debug as command input. The form of the BASE command is:

```
BASE [ STANDARD    | S ] [ IN  | I ]
     [ OCTAL       | O ] [ OUT | O ]
     [ DECIMAL     | D ]
     [ HEXADECIMAL | H ]
```

`STANDARD | S`

Generally, input and output base defaults are determined by each command:

- Hexadecimal for the DN command and commands that use the N-address mode.
- Octal for most other commands.

The default base is STANDARD for both the IN and OUT options.

`OCTAL | O`

specifies that octal is the base for input or displayed numeric values.

`DECIMAL | D`

specifies that decimal is the base for input or displayed numeric values.

`HEXADECIMAL | H`

specifies that hexadecimal is the base for input or displayed numeric values.

`IN | I`

changes the base only for numeric values being entered.

`OUT | O`

changes the base only for numeric values being displayed.

Considerations

- If the command omits both IN and OUT, the command affects both values being entered and values displayed.
- Once issued, the BASE command is in effect until either you enter another BASE command that overrides a previous command or the process terminates.
- The command BASE, with no options, cancels any previous BASE command and sets standard defaults for both input and output.
- The ? command displays the current settings for BASE.
- The N address mode is not affected by the BASE command.
- The BASE command has no effect on these displays:
  - The *sys*,*cpu*,*pin* parameters in Debug's prompt, which are decimal
  - User code and user library segment numbers, and system code and system library segment numbers, which are octal

Examples

This command series changes the base on input and output to hexadecimal, decimal, and octal for arithmetic with the = command.

```
215,05,00069-BASE H; = 7000/2          ! Hexadecimal
       = 0x3800 %0034000 #14336 '8.'

215,05,00069-BASE D; = 7000/2          ! Decimal
       = #003500 %006654 0x0DAC '..'

215,05,00069-BASE; = 7000/2            ! Octal (the default)
       = %003400 #01792 0x0700 '..'
```

This command displays the contents of TNS environment register R0. The default base for output is octal.

```
215,05,00069-D R0
  *REG*  %002377
```

This command series changes the base for output to hexadecimal and displays the contents of R0 again.

```
215,05,00069-BASE H O; D R0
  *REG*  0x04FF
```

This command series changes the base for output to decimal and displays the contents of R0 again.

```
215,05,00069-BASE D O; D R0
  *REG*  #01279
```

This command series changes the base for output to the standard value, which is octal for the TNS state, and displays the contents of R0 again.

```
215,05,00069-BASE S O; D R0
  *REG*  %002377
```

For more examples of the BASE command, see Appendix F, Sample Debug Sessions.

BM Command

The BM command sets memory-access breakpoints. The BM command has four functions:

- Set unconditional memory-access breakpoint
- Set conditional memory-access breakpoint
- Set trace memory-access breakpoint
- Set execute memory-access breakpoint

Each function is defined by a unique syntax. Each function and its syntax is described on the following pages.

Set Unconditional Memory-Access Breakpoint

The BM command can set an unconditional memory-access breakpoint. An unconditional memory-access breakpoint causes the process to enter the debug state each time the breakpoint location is accessed in the specified manner (reading, writing, or changing). The unconditional form of the BM command is:

```
BM address , access [, ALL ]
```

address

is the address where the breakpoint is to occur. For more information, see Address Syntax on page 3-12.

access

indicates the type of memory access that triggers the breakpoint.

R Break on a read access

R
W Break on a read/write access

W
R Break on a read/write access; equivalent to RW

W Break on a write access

C Break on a change access

ALL

specifies a privileged attribute for the memory-access breakpoint. ALL specifies that the breakpoint applies to all processes in the processor executing the process being debugged. The ALL option is allowed only if you are debugging in privileged mode as described under the PRV command.

Considerations

- Only one memory-access breakpoint can be set for each process.
- If a privileged memory-access breakpoint is set with the ALL option specified, all other memory-access breakpoints set for processes in the same processor are inhibited. When the privileged breakpoint with the ALL option is cleared, the other breakpoints return to use.
- When you set a breakpoint, Debug displays information describing this breakpoint. For a description of the information displayed, see “Display Breakpoints” under the B command.
- If a memory-access breakpoint was planted during a nonprivileged debugging session and is triggered by the execution of privileged code, control is not returned to Debug until the process is no longer executing privileged code. At the point where control is returned to Debug, if the process is still executing in either the system code or the system library space, you are not allowed to modify code in that space (either directly or indirectly, by setting a code breakpoint). If you want to return to a procedure that was called earlier and that is not in system code or system library, you can execute a T command and set a breakpoint at a location based on the activation record of that procedure as shown in the stack trace.

  If the memory-access breakpoint was planted during a privileged debugging session, control passes to debug immediately.
- For a conditional breakpoint, the system attempts to evaluate the condition as soon as the memory access is detected. However, that evaluation occurs in a restricted environment in which absent pages cannot be made present. If the condition requires accessing an absent page, the condition is tentatively deemed to be “true”

and control is passed to Debug in the normal way. If the triggering code is privileged but the breakpoint was not, the process continues to run until it exits to unprivileged code. At that point, Debug is entered and evaluates the condition. The condition might be different at that time, if the condition variable was modified by the code executed in the meantime. (This issue is not a concern if the condition variable is the same as the location being watched for the breakpoint or if it lies in the same memory page.)

- A read-access memory-access breakpoint will not occur in an accelerated program if the Accelerator has optimized the read from memory. This occurs when the Accelerator keeps the value in a register.
- If a global memory access breakpoint, to break on write access, is planted in priv mode, and a code breakpoint is then planted at the same address as the memory access breakpoint, trying to install (write) the code breakpoint will trigger the memory access breakpoint that was set previously. Since a priv Memory Access Breakpoint is taken immediately, this causes the program to drop into Lobug seen as halt %6005. A privileged user can resume out of Lobug.

Examples

```
215,01,00012-BM L2,W
215,01,00012-BM Q (2.1000)<<1,R W
215,01,00012-BM UC.1, L+3, W
215,01,00012-BM UL.3, 4+23, R
```

Set Conditional Memory-Access Breakpoint

The BM command can set a conditional memory-access breakpoint. A conditional memory-access breakpoint causes the process to enter the debug state when both the breakpoint location is accessed in the specified manner and a specified variable matches a predetermined condition. The conditional form of the BM command is:

```
BM address , access

  {, {test-address | register }[& mask] op constant[, ALL ]}
  { [, ALL ] {test-address | register } [& mask]op constant}
```

address

is the address where the breakpoint is to occur. For more information, see Address Syntax on page 3-12.

access

indicates the type of memory access that triggers the breakpoint.Valid options depend on the type of processor you are using, as noted in the following list:

R	Break on a read access
RW	Break on a read/write access
WR	Break on a read/write access; equivalent to RW
W	Break on a write access

register

is a processor register. For more information on this parameter, see Register Syntax on page 3-7.

For a TNS process, when registers R0 through R7 are specified, the values in the registers are evaluated when the breakpoint is executed. Other registers are evaluated to a memory location pointed to by the registers when the breakpoint is executed.

For a TNS/R process, any register except the floating-point registers can be used.

test-address

is the address of the variable to be compared with *constant*. The syntax for *test-address* is the same as the syntax for Address Syntax on page 3-12. However, *test-address* is limited to data locations only (it cannot access UC, UL, SC, SL, and C). For more information, see Address Syntax on page 3-12. If *address* is an N-mode address, *test-address* refers to a 32-bit variable.

mask

is an expression. The *mask* parameter is logically ANDed with the value of the *register* parameter or the value pointed to by *test-address* and *constant* before the condition is tested. The comparison values are treated as signed values. The value for *mask* is 32 bits if a TNS/R *register* or an N-mode *test-address* value is used; otherwise, the value is 16 bits.

If you omit *mask*, Debug uses -1 (0xFFFF for a 16-bit *constant* or 0xFFFFFFFF for a 32-bit *constant*).

op

is a relational operator and must be one of the following:

<	break if the variable is less than *constant*. This operator does a signed comparison.

>	break if the variable is greater than *constant*. This operator does a signed comparison.
=	break if the variable is equal to *constant*.
# | <>	break if the variable is not equal to *constant*.

constant

is an expression. The value is 16 bits unless *address* is an N mode address, in which case the value will be 32 bits.

ALL

For the description of this option, see Set Unconditional Memory-Access Breakpoint on page 4-24.

Considerations

- For information about setting an unconditional memory-access breakpoint, see Considerations on page 4-25.
- Change access is not allowed with conditional memory-access breakpoint.

Examples

```
099,01,00012-BM L2, W, R0 5 & 11 <> 0
099,01,00012-BM UC.2, 4+3, W, L+2 > 5
099,01,00012-BM UL.1, 20I, R, R5=0
099,01,00012-BM $sp+#44, w, $a1 <> 0x80020004
```

For more examples of setting conditional memory-access breakpoints, see Appendix F, Sample Debug Sessions.

Set Trace Memory-Access Breakpoint

The BM command can set a trace memory-access breakpoint. A trace memory-access breakpoint causes Debug to list the contents of specified variables each time the breakpoint location is accessed in the specified manner. The trace form of the BM command is:

```
BM address , access

   {, {register | start-address } ? count [, ALL ]    }
   { [ , ALL  ] {register | start-address } ? count }
```

address

is the address where the breakpoint is to occur. For more information, see Address Syntax on page 3-12.

access

indicates the type of memory access that triggers the breakpoint. Valid options depend on the type of processor you are using, as noted in list:

R	Break on a read access
RW	Break on a read/write access
WR	Break on a read/write access; equivalent to RW
W	Break on a write access

register

is a processor register. For more information, see Set Trace Code Breakpoint on page 4-13 for description of this parameter.

start-address

is the address of the first variable to be listed. The syntax for *start-address* is the same as the Address Syntax on page 3-12, limited to data locations only.

?

means list.

count

is a 16-bit expression representing the number of 16-bit words to be listed.

ALL

For more information, see Set Unconditional Memory-Access Breakpoint on page 4-24 for the description of this option.

Considerations

- Change access is not allowed with trace memory-access breakpoint.
- Debug displays this header each time the breakpoint location is accessed in the specified manner:
  - TNS and accelerated modes

    TRACE *code-address, space-identifier*

    This header gives the address where the break occurred. In TNS or accelerated mode, *code-address* is a C-relative address, which gives the address of the break relative to the identified code segment. An r in the *space-identifier*, in place of the segment index, indicates native code; that is, SCr, SLr, and so forth. (UC appearing without a segment index is equivalent to UCr.)
  - RISC mode

    TRACE $PC=*code-address*

    In native mode, *code-address* is a 32-bit hexadecimal value.
- For infromation about setting an unconditional memory-access breakpoint, see Considerations on page 4-25.

Examples

```
106,01,00012-BM L2, W, (2.1000)<<1 ? #16
106,01,00012-BM UC.2, 524, W, L+3 ? 6
106,01,00012-BM C 200, R, R0 ? 10
106,01,00012-BM 0x00080030, w, $a1 ? 2
```

For more example for strace memory-access breakpoint, see Appendix F, Sample Debug Sessions.

Set Execute Memory-Access Breakpoint

The BM command can set an execute memory-access breakpoint. An execute memory-access breakpoint causes Debug to execute a specified string of Debug commands when the breakpoint location itself is accessed in the specified manner.

After executing the specified command string, Debug prompts for additional Debug commands, unless the specified command string contains an R (resume) command.

The execute form of the BM command is:

```
BM address , access

   {, ( command-string ) [, ALL ]   }
   { [ , ALL ] ( command-string ) }
```

address

is the address where the breakpoint is to occur. For more information, see Address Syntax on page 3-12.

indicates the type of memory access that triggers the breakpoint. Valid options depend on the type of processor you are using, as noted in this list:

R	Break on a read access
RW	Break on a read/write access
WR	Break on a read/write access; equivalent to RW
W	Break on a write access

command-string

is a string of Debug commands separated by semicolons (;) that is saved when you enter the breakpoint and is executed when the breakpoint is executed. The string of Debug commands is not examined for syntax errors until it is executed.

ALL

For more information on this option, see Set Unconditional Memory-Access Breakpoint on page 4-24.

Considerations

- For more information on setting an unconditional memory-access breakpoint, see Considerations on page 4-25.
- Change access is not allowed with execute memory-access breakpoint.

Examples

```
100,01,00011-BM L+2, R, (D; T; R)
100,01,00011-BM UC.2, 400, W, (D;T;R)
100,01,00011-BM SC.0, 2342, W, (D;T;R)
248,02,00067-BM 0x4FFFFEFC, R, (D;T;R)
```

C Command

The C command clears one or all code breakpoints (unconditional, conditional, trace, and execute). The form of the C command is:

```
C [ address ]
  [ * | 0   ]
  [ -1      ]
```

address

is the code address of the breakpoint to be cleared. For more information, see Address Syntax on page 3-12. Any address mode used to set a code breakpoint may be used to clear one. Any code breakpoint can be cleared without privilege, even if privilege was required to set it.

Address value 0 clears all code breakpoints for the current process but does not affect breakpoints set with the ALL option; privilege is not required.

Address value -1 clears all code breakpoints set in this processor, including those set in and for other processes and those set with the ALL option; this value is valid only if you are debugging in privileged mode.

If you omit *address*, Debug clears the current breakpoint.

* clears all breakpoints for the current process; this is equivalent to specifying the address value 0.

Examples

```
106,01,00012-C 527+215      ! Clears the breakpoint at %000744.
106,01,00012-C UC.2,325     ! Clears breakpoint in user code segment 2.
106,01,00012-C0               ! Clears all breakpoints in the current process.
106,01,00012-C -1             ! Clears all breakpoints in the processor.
248,02,00012-C 0x7045FEF0   ! Clears the breakpoint in RISC code.
```

CM Command

The CM command clears the memory-access breakpoint for the process being debugged. The form of the CM command is:

```
CM [ , ALL  ]
```

ALL

clears the memory-access breakpoint with the ALL option specified. You can specify ALL only if you are debugging in privileged mode as described under the PRV command.

Example

```
106,01,00012-CM
```

D Command

The D command displays numeric data. The default format is octal, but the format can be specified by the *mode* option or by the BASE command.

```
D address [ , length ] [ , data-display-format ]
   [ , [ OUT ] output-dev ]  [ : d-base ]
```

address

is the address of the first variable to be displayed. For more information, see Address Syntax on page 3-12.

length

specifies the number of words to be displayed by Debug and must be one of the following:

count

is an expression designating the number of 16-bit words to be displayed.

T *entry-size * num-entries*

specifies that the display is to be in table format. The *entry-size * num-entries* parameter is an expression specifying the number of 16-bit words to be displayed. The display consists of *num-entries* blocks, each block consisting of *entry-size* words.

If you omit *length*, one 16-bit word is displayed.

data-display-format

specifies the format options in which data is displayed. The *data-display-format* has this format:

{ B | B1 | C | B2 | S | B4 | L }

B|B1|C	Display data in character format.
B2|S	Display data in 16-bit word format. These are the default format options.
B4|L	Display data in 32-bit format.

[OUT] *output-dev*

specifies where the display is directed. Debug output can be directed to an output device, a process, or a spooler collector. Debug output cannot be directed to a disk file. If you omit *output-dev*, Debug assumes the home terminal.

output-dev has these formats.

Syntax for a device other than a disk:

```
[ node.]{device-name[.qualifier ] }
        {ldev-number               }
```

Syntax for a named process:

[*node*.]*process-name*[:*seq-no*][.*qual-1*[.*qual-2*]]

Syntax for an unnamed process:

[*node*.]$:*cpu*:*pin*:*seq-no*

For syntax descriptions of these process and device names, see the *Guardian Procedure Calls Reference Manual.*

d-base

specifies the display base. The *d-base* parameter has this format:

{ % | # | D | H | O }

These format options have these meanings:

%|O	displays numeric information in octal.
#|D	displays numeric information in decimal.
H	displays numeric information in hexadecimal.

If you omit *d-base*, the default is octal unless the BASE command was used to specify a different default output base.

Considerations

- The D N address (with space between the letters) is not the same as the DN address. The D command is used to display data in 16-bit word groups, while the DN command has different syntax and is issued to display data in 32-bit word groups.
- For displaying data in ASCII, use the A command.
- For displaying data in machine instruction, use the I command.

Examples

```
050,03,00009-d L+3
%000026: %000062
050,03,00009-d %000062/2, #20
%000031: %060542 %061544 %062546 %063557 %066545 %020144 %060564 %060415
%000041: %005000 %000000 %000000 %000000 %000000 %000000 %000000 %000000
%000051: %000000 %000000 %000000 %000000
050,03,00009-D L3S, #40/2 , b  :h
%000031: 61 62   63 64   65 66   67 6F   6D 65   20 64   61 74   61 0D
%000041: 0A 00   00 00   00 00   00 00   00 00   00 00   00 00   00 00
%000051: 00 00   00 00   00 00   00 00
050,03,00009-D L3s, #40/2, b4 :h
%000031: 0x61626364  0x6566676F  0x6D652064  0x6174610D  0x0A000000
%000043: 0x00000000  0x00000000  0x00000000  0x00000000  0x00000000
050,03,00009-d Q #40/2, T5*4, c :h
%000024: 00 61   62 63   64 65   66 67   00 0000
%000031: 00 00   00 00   00 00   00 00   00 0000
%000036: 00 00   00 00   00 00   00 00   00 0000
%000043: 00 00   00 00   00 00   00 00   00 00
050,03,00009-d L+4sx, T5*4, l :h
%000024: 0x00616263  0x64656667  0x00000000  0x00000000  0x00000000
%000036: 0x00000000  0x00000000  0x00000000  0x00000000  0x00000000
050,03,00009-D n 0x00080029, T5*4, s :h
00080028: 0x0061  0x6263  0x6465  0x6667  0x0000
00080032: 0x0000  0x0000  0x0000  0x0000  0x0000
0008003C: 0x0000  0x0000  0x0000  0x0000  0x0000
00080046: 0x0000  0x0000  0x0000  0x0000  0x0000
050,03,00009-
```

Display Register Contents

The D command can display registers. The display-register form of this command is:

```
D [ register ] [ , [ OUT ] output-dev ]
  [ *        ]
```

register

represents the contents of one of the processor registers for the process. For more information, see Register Syntax on page 3-7.

If you omit *register*, Debug displays the current values of the TNS/R registers when in native mode, and the TNS environment registers when in TNS or accelerated mode. In addition, Debug displays the space identifier of the current code segment.

These notes apply to TNS environment registers:

E	specifies the ENV register. When asked to display the ENV register, Debug translates the meaning of its contents.
SP	specifies the space identifier of the current code segment.
*	displays all registers, including TNS/R registers and TNS environment registers when the process is an accelerated mode. Without the asterisk (*), only TNS/R registers are displayed in native process; only TNS environment registers are displayed in TNS or accelerated mode.

This note applies to TNS/R registers:

$F00 through $F31 and $FCR31	specify the IEEE floating-point registers. These registers are available only after a program has executed floating-point instructions. When specified to display the $FCR31 register, Debug translates the meaning of the bits for the register. For more information, see TNS/R Registers on page 2-10.

[OUT] *output-dev*

specifies where the display is directed. Debug output can be directed to an output device, a process, or a spooler collector. Debug output cannot be directed to a disk file. If you omit *output-dev*, Debug assumes the home terminal.

The *output-dev* parameter has these formats:

Syntax for a device other than a disk:

[*node*.]{*device-name*[.*qualifier*] }
{*ldev-number* }

Syntax for a named process:

[*node*.]*process-name*[:*seq-no*][.*qual-1*[.*qual-2*]]

Syntax for an unnamed process:

[*node*.]$:*cpu*:*pin*:*seq-no*

For syntax descriptions of these process and device names, see the *Guardian Procedure Calls Reference Manual.*

Examples Specific to Debugging in TNS

```
 EXECUTION MODE = TNS

 050,03,00020-d *
       S=%000060 P=%000177 E=%000207 L=%000023 SP=UC.%00
 ENV IS:               T   CCG RP7
 EXAMPLE_FILL_ARRAY + %000073
 *REG*  %000010 %000055 %000000 %000066 %000000 %000000 %000140 %000166
050,03,00020-d e
 ENV IS:               T   CCG RP7
050,03,00020-d sp
 SPACEID: UC.%00
050,03,00020-d r7
 *REG*:  %000166
```

Examples Specific to Debugging in Accelerated Mode

```
050,03,00023-d *
*** WARNING: TNS STATE MAY NOT BE WHERE YOU THINK IT IS ***
       S=%000060 P=%000177 E=%000307 L=%000023 SP=UC.%00
 ENV IS:               TK  CCG RP7
 EXAMPLE_FILL_ARRAY + %000073
 *REG*  %177000 %177767 %000062 %000021 %000005 %000050 %000140 %000166
 EXECUTION MODE = ACCELERATED
       $PC: 0x7042023C  $HI: 0x000016C2  $LO: 0x0DA329FC

 $00:  $00: 0x00000000  $AT: 0x00000001  $V0: 0x7E000000  $V1: 0x00000000
 $04:  $A0: 0x0008002E  $A1: 0x00000037  $A2: 0x00000000  $A3: 0x00000000
 $08:  $T0: 0x00000061  $T1: 0x00000005  $T2: 0x00000001  $T3: 0x70420220
 $12:  $T4: 0x00000037  $T5: 0x8006FC14  $T6: 0xFFFFFFFF  $T7: 0x00050000
 $16:  $S0: 0xFFFFFE00  $S1: 0xFFFFFFF7  $S2: 0x00000032  $S3: 0x00000011
 $20:  $S4: 0x00000005  $S5: 0x00000028  $S6: 0x00000060  $S7: 0x00000076
 $24:  $T8: 0x70000000  $T9: 0x00000080  $K0: 0xA713A713  $K1: 0xA713A713
 $28:  $GP: 0x70400A00  $SP: 0x00000060  $S8: 0x00000026  $RA: 0x7042023C
050,03,00023-d e
*** WARNING: TNS STATE MAY NOT BE WHERE YOU THINK IT IS ***
 ENV IS:               TK  CCG RP7
050,03,00023-d sp
*** WARNING: TNS STATE MAY NOT BE WHERE YOU THINK IT IS ***
 SPACEID: UC.%00
050,03,00023-d $SP
 *REG*:  0x00000060
050,03,00023-d r7
*** WARNING: TNS STATE MAY NOT BE WHERE YOU THINK IT IS ***
 *REG*:  %000166
```

Note. D SP and D $SP refer to two different registers.

Example Specific to Debugging in Native Mode

```
EXECUTION MODE = NATIVE
050,03,00267-d *
       $PC: 0x70000568  $HI: 0x00000D38  $LO: 0x221FC20C


 $00:  $00: 0x00000000  $AT: 0x00000001  $V0: 0x00000000  $V1: 0x00000000
 $04:  $A0: 0x00080030  $A1: 0x4FFFFEBB  $A2: 0x00000000  $A3: 0x00000000
 $08:  $T0: 0x00000067  $T1: 0x00000007  $T2: 0x00000001  $T3: 0x00000007
 $12:  $T4: 0x4FFFFEBB  $T5: 0x00004003  $T6: 0xFFFFFFFF  $T7: 0x80C27F00
 $16:  $S0: 0x00000000  $S1: 0xFFFFFFFF  $S2: 0xFFFFFFFF  $S3: 0xFFFFFFFF
 $20:  $S4: 0xFFFFFFFF  $S5: 0xFFFFFFFF  $S6: 0xFFFFFFFF  $S7: 0xFFFFFFFF
 $24:  $T8: 0x00000000  $T9: 0xC40014EC  $K0: 0xA713A713  $K1: 0xA713A713
 $28:  $GP: 0x08007FF0  $SP: 0x4FFFFE68  $S8: 0xFFFFFFFF  $RA: 0x7000066C

050,03,00267-d $GP
 *REG*:  0x08007FF0
050,03,00267-d $pc
 *REG*:  0x70000568
```

If a program has executed IEEE floating-point instructions, the D or D * command can be used to display the floating-point registers as this example shows:

```
050,03,00269-d *
 EXECUTION MODE = NATIVE
       $PC: 0x70001A0C  $HI: 0x00000000  $LO: 0x00000000
 $00:  $00: 0x00000000  $AT: 0x70000018  $V0: 0x00000005  $V1: 0x00000000
 $04:  $A0: 0x00000000  $A1: 0x01000000  $A2: 0x4FFFFEBC  $A3: 0x08006063
 $08:  $T0: 0xFEFFFFFF  $T1: 0x47E00000  $T2: 0x0000000E  $T3: 0x40000000
 $12:  $T4: 0x47F00000  $T5: 0x40000000  $T6: 0x00000000  $T7: 0x47F00000
 $16:  $S0: 0x4FFFFEBC  $S1: 0x00000080  $S2: 0x4FFFFEBC  $S3: 0xFFFFFFFF
 $20:  $S4: 0xFFFFFFFF  $S5: 0xFFFFFFFF  $S6: 0xFFFFFFFF  $S7: 0xFFFFFFFF
 $24:  $T8: 0x7F800000  $T9: 0x70001864  $K0: 0xA702A702  $K1: 0xA702A702
 $28:  $GP: 0x08008180  $SP: 0x4FFFFE58  $S8: 0xFFFFFFFF  $RA: 0x70001A08

    $FCR31: 0x00005014
    FS=0 C=0 CAUSE=OI FLAGS=OI Round Mode=0=RN

 $F01.$F00: 0x40000000.00000000      $F03.$F02 0x40000000.00000000
 $F05.$F04: 0x47E00000.00000000      $F07.$F06 0x40000000.00000000
 $F09.$F08: 0x47F00000.00000000      $F11.$F10 0x40000000.00000000
 $F13.$F12: 0x40280000.00000000      $F15.$F14 0xFFFFFFFF.FFFFFFFF
 $F17.$F16: 0x47F00000.00000000      $F19.$F18 0x7FF00000.7F800000
 $F21.$F20: 0xFFFFFFFF.FFFFFFFF      $F23.$F22 0xFFFFFFFF.FFFFFFFF
 $F25.$F24: 0xFFFFFFFF.FFFFFFFF      $F27.$F26 0xFFFFFFFF.FFFFFFFF
 $F29.$F28: 0xFFFFFFFF.FFFFFFFF      $F31.$F30 0xFFFFFFFF.FFFFFFFF
```

DJ Command

The DJ command displays the contents of a specified jump buffer in register format. The form of the DJ command is:

```
DJ  32-bit-address
```

32-bit-address

is the RISC address of a jump buffer.

Considerations

- The DJ command causes a subset of the TNS/R registers to be displayed. Registers that are not saved in the jump buffer are not displayed.
- The default numeric base for the DJ command is hexadecimal.
- A jump buffer is used for saving the context of a process. For more information about jump buffers and their use, refer to the descriptions of the SETJMP_, LONGJMP_, SIGSETJMP_, and SIGLONGJMP_ procedures in the *Guardian Procedure Calls Reference Manual.*

Example

```
245,02,00033-DJ 0x80001920
$s0: 0xFFFFFFFF
$s1: 0xFFFFFFFF
$s2: 0xFFFFFFFF
$s3: 0xFFFFFFFF
$s4: 0xFFFFFFFF
$s5: 0xFFFFFFFF
$s6: 0xFFFFFFFF
$s7: 0xFFFFFFFF
$s8: 0xFFFFFFFF
$sp: 0x4FFFFE98
$gp: 0x08009610
$ra: 0x700003E8
```

DN Command

The DN command displays memory contents in multiple formats: namely, ASCII, RISC instruction code, TNS instruction code, binary, octal, decimal, or hexadecimal. The DN command parameters specify this information:

- Address, or the beginning address, of the memory that Debug should display
- Count of the items to be displayed and the format you are using to enter the count
- Display format that Debug should use to display the memory contents

The syntax of the DN command is:

```
DN 32-bit-address [ count-format ] [ display-format ]
```

32-bit-address

is the RISC address, or beginning RISC address, of the memory to be displayed.

count-format has this form:

```
{ FOR | , } count [ count-size ] [ BY columns ]
```

{ FOR | , }

specifies that instructions for *count-format* follow in the command. You must begin the *count-format* with a FOR or a comma (,). A count format and a display format can appear in either order in a DN command.

count

is an expression specifying the number of 32-bit items to be displayed. The default base for *count* is hexadecimal.

count-size

specifies the number of bytes in the count unit. The format of *count-size* is:

{ B1 | B2 | B3 | B4 }

B1 specifies 1 byte, B2 specifies 2 bytes, and so forth. The default size is B4.

The number of bytes that Debug will display is *count* times *count-size*.

BY *columns*

specifies the number of items to be displayed in a row. This option allows you to control the number of columns for data displayed in a table format. Valid numbers are integers beginning with 1. If the number of items fills a line of output, Debug automatically wraps the displayed line.

If you omit BY *columns*, Debug determines the number of items to display on a line.

display-format has this form:

```
{ IN| : } [ S | U ] display-type [ display-size ]
```

`{ IN| : }`

specifies that the *display-format* (output) follow in the command. You must begin *display-format* with an IN or a colon (:). In a DN command, a *count-format* specification and a *display-format* specification can appear in either order.

`[ S | U ]`

specifies signed or unsigned displays for octal and decimal numbers. In a signed (S) display for a negative value, a minus sign (-) precedes the value. In an unsigned (U) display, no sign appears. This option is ignored with other numeric bases. The default specification is U.

display-type

specifies the format of the display. The format of *display-type* is:

```
{ A           }
{ I           }
{ R | N       }
{ T           }
{ B | %B      }
{ O | %O | % }
{ D | %D | # }
{ H | %H | X }
```

The descriptions of these formats are:

A	displays ASCII code.
I	auto-select instruction decoding based on a process type.
R | N	displays RISC instruction code.
T	displays TNS instruction code.
B | %B	displays information in binary.
O | %O | %	displays information in octal.
D | %D | #	displays information in decimal.
H | %H | X	displays information in hexadecimal.

The default format is determined by a preceding BASE command If no BASE command has been entered, the default format is H, which displays 32 bits (4 bytes).

display-size

indicates the number of bytes in the displayed item. Valid sizes are integer values of 1 through 4.

The default display sizes for the display types are as follows:

Format	Display Type	Size in Bytes
A	ASCII	2
R	RISC instruction code	4
T	TNS instruction code	2
B	Binary	1
O	Octal	2
D	Decimal	2
H	Hexadecimal	4

Considerations

- Use this command to display memory using 32-bit addresses. DN is especially convenient for displaying 32-bit data. It is suitable for data in both flat and selectable data segments, as well as data in RISC program globals and stacks, and RISC code.
- The D command (with or without the N address mode) and the DN command can be used in TNS, accelerated, or native processes.
- The command displays information to the home terminal for the Debug process.
- The entered address does not need to fill 32 bits, but Debug treats it as if it were 32 bits long. For example, the address “DN 1234” is valid, but in RISC execution mode, Debug assumes that its value is 0x00001234. The default input base is hexadecimal.
- The default base is hexadecimal for all components of the command. You can override the default base by using a prefix as described in Expression Syntax on page 3-9. The applicable prefixes are:

  % for octal

  # for decimal

- The default base is hexadecimal. You can override the default base by setting the display format in the DN command.

- All displays contain the full display address along the left-hand side of the display. For example, the output from the command “DN $SP, 10” is formatted as follows:

```
4FFFFA78: 0x08000680  0x70011D94  0x00000004  0xFFFFFFF7
4FFFFA88: 0x00000000  0x00000000  0x4FFFFB30  0x7C260D48
4FFFFA98: 0x00000000  0x00000000  0x08000680  0x50000000
4FFFFAA8: 0x00000004  0x00000000  0x4FFFFB40  0x00000000
```

- It is your responsibility to ensure the compatibility of the count format with the display format. If *count-size* exceeds *display-size*, Debug truncates the memory displayed to the display size. If *display-size* exceeds *count-size*, Debug displays memory up to *count-size*.
- Display addresses do not need to be aligned on 16-bit or 32-bit boundaries. A display command displays the address given in the stated format correctly independent of the byte alignment of the address.

Examples

This command displays eight hexadecimal values. The *display-size* is the default size, which is 4 bytes.

```
248,06,024-DN 0x70000, #8
70000000: 0x004C004C  0x137219A9  0x2CEF3457  0x349C94B0
70000010: 0x39F73AB3  0x3B683E90  0x3F8E3FCB  0x40814140
```

This command displays eight hexadecimal two-byte values:

```
248,06,024-DN 0x70000, #8 B2
70000000: 0x004C004C  0x137219A9  0x2CEF3457  0x349C94B0
```

This command displays eight hexadecimal two-byte values, two bytes at a time:

```
248,06,024-DN 0x70000, #8 B2 IN H 2
70000000: 0x004C  0x004C  0x1372  0x19A9
70000008: 0x2CEF  0x3457  0x349C  0x94B0
```

This command is equivalent to the preceding command but uses different options:

```
48,06,024-DN 0x70000, #8 B2:H 2
70000000: 0x004C  0x004C  0x1372  0x19A9
70000008: 0x2CEF  0x3457  0x349C  0x94B0
```

This command displays eight two-byte octal values, with four values to a column:

```
48,06,024-DN 0x70000, #8 B2 BY 4:O 2
70000000: 0x000114  0x000114  0x011562  0x014651
70000008  0x026357  0x032127  0x032234  0x112260
```

This command displays eight hexadecimal values, with three values to a row:

```
248,06,024-DN 0x70000, #8 BY 3
70000000: 0x004C004C  0x137219A9  0x2CEF3457
```

```
7000000C: 0x349C94B0  0x39F73AB3  0x3B683E90
70000018: 0x3F8E3FCB  0x40814140
```

This command displays eight RISC instructions:

```
248,06,024-DN 0x70000, #8 : R
70000000: SYSCALL             BEQ   k1,s2,0x700006 SLTIU ....
7000000C: ORI   gp,a0,0x34B0  XORI  s7,t7,0x3AB3   XORI ....
70000018: LUI   t6,0x3FCB     MTC0  at,8
```

This command displays the same memory locations as nonsensical TNS instructions:

```
248,06,024-DN 0x70000, #8 : T
70000000:  STAR    4      STAR    4      BOX    +162,5
70000006:  BAZ    -127    COMW    357    LDX   G+127,6
7000000C:  LDX   G+234,6  LDX   G+260,6  NSTO  S-027
70000012:  NSTO  G+263,5  NSTO  L+150,5  NSTO  G+220,7
70000018:  NSTO  G+016,7  NSTO  L-013,7  LOAD  G+201
7000001E:  LOAD  L+100
```

EX[IT] Command

The EXIT (or EX) command exits a debug session. The form of the EXIT command is:

```
EX[IT]
```

Considerations

- You typically enter an EXIT command when you are finished debugging and want to continue executing the process. When you enter this command, Debug performs various cleanup functions, including the following:
  - It clears all breakpoints for the current process.
  - It resumes execution of the process.

  If you then reenter Debug, the default base for numeric input and output is set back to the standard base (hexadecimal for TNS/R registers and addresses, octal for TNS environment registers and addresses).
- You cannot resume a process that entered Debug either because it received a nondeferrable signal or because a synchronous trap occurred. A signal is nondeferrable if it was generated by the system because the process cannot continue executing the instruction stream. The only traps from which you can resume are the looptimer trap and the arithmetic overflow trap, provided that the T and V bits are not both set in the ENV register.
- If you enter an EXIT command on a nonresumable process, the process is deleted after Debug exits with the same Guardian Stop message or OSS wait status as would have been generated had the signal or trap terminated the process without entering Debug.

F[ILES] Command

The FILES (or F) command displays the file name and the latest file-management error number associated with an open file. The form of the FILES command is:

```
F[ILES] [ file-number ]
```

file-number

is a 16-bit word expression representing the file number returned from the open operation on the file whose information is to be displayed.

The value -1 causes Debug to display the error associated with the last open, create, purge, or AWAITIO operation that failed.

If you omit *file-number*, Debug displays the file number and other information for all of the process's open files.

The FILES command displays the file information in this form:

```
[ file-number ]  { file-name }          error   [ suberror ]
                 {?file-name }
                 { ???       }
```

file-number	is displayed in decimal only for currently open files. The file number is displayed only if you enter the FILES command without *file-number* (to display all files). File number -1 denotes the current error and detail information, which appears in the first line in the display.
file-name	is displayed as a fully qualified external file name for file names available to Debug.
?*file-name*	a question mark displayed in front of the file name indicates that the current name is unavailable. The displayed name is the originally opened name, which can occur, for example, if a remote disk file is open and the network goes down.
???	is displayed if the file name is not available to Debug.
error	is displayed in decimal as a 6-digit signed integer.
suberror	is a detail error value displayed in decimal only for values other than zero.

Examples

```
106,00,00030-F 4
       \SYS1.$SYSTEM.SYS50.OSIMAGE           #-00006

106,00,00031-F
# -1   ???                                   # 00014
#001   \SYS1.$DATA.INFO.NAMES                 #-00008  00001
#004   \SYS1.$SYSTEM.SYS50.OSIMAGE           #-00024
#005   \SYS1.$:15:122:1263433                 # 00000
#006  ?\SYS2.$TRAMP.TEST.FILE                    # 00210
```

FC Command

The FC command alters the last Debug command that was entered. The form of the FC command is:

```
FC
```

When you enter the FC command, Debug displays the last command line and prompts you for an “editing template.” Enter the editing template under the line just displayed. Debug then displays the command line in its new state, and Debug again permits you to enter an editing template. When you are finished editing, press RETURN at the prompt, and Debug automatically reexecutes the command.

To indicate the type of editing to be performed, there are three subcommands that you can enter in the editing template:

Subcommand	Description
R	Replace (followed by a replacement string)
I	Insert (followed by an insertion string)
D	Delete

In addition, replacement is implied if a subcommand begins with any nonblank character other than R, I, or D.

The FC command is implemented in other software. For more information about the FC command, refer to the *TACL Reference Manual.*

FN Command

The FN command searches memory to find a particular number. The FN command starts at a specified address and searches memory until one of the following occurs:

- A 16-bit word is reached whose contents logically ANDed with *mask*, and it equals the result of *value* logically ANDed with *mask*.
- A 16-bit word address ending in 17 binary zeros is reached.

The form of the FN command is:

```
FN [ address [ , value ] [ & mask ] ]
```

address

is the address at which the FN command starts to search memory. The *address* parameter must be on an even byte boundary. For more information, see Address Syntax on page 3-12.

value

is any expression that evaluates to a valid 16-bit number.

mask

is any expression that evaluates to a valid 16-bit number.

Considerations

- If you omit *value* and *mask*, the FN command uses the *value* and *mask* specified by the previous FN command but starts searching at the newly specified address.
- If you omit *address*, *value*, and *mask*, the FN command uses the *value* and *mask* specified by the previous FN command and starts searching at the address where the previous FN command terminated.
- The FN command has a default that provides a shorthand way of finding repeated occurrences of a value. If you execute an FN command and a match is found, Debug responds with the standard prompt followed by (FN). For example:

  ```
  251,06,024-(FN)-
  ```

  If you then press RETURN, the effect is the same as entering an FN command with no parameters; that is, Debug continues searching for the same value starting at the address where the previous FN command terminated. You can continue pressing RETURN in this manner until the Debug prompt does not contain (FN) (indicating that no match was found).
- Two possible uses for this command are finding data structures with particular values and finding code that has moved slightly because of a minor change.

Examples

```
106,00,00014-FN UC.1, 1, 3 & 2

106,00,00014-FN 5, 23 & 2

248,01,00023-FN N 0x80020000, 0x33  ! Find the number 0x33 starting at
                                    ! the specified RISC address.
```

FNL Command

The FNL command searches memory to find a 32-bit number. The FNL command starts at a specified address and searches memory until one of the following occurs:

- A word is reached whose contents logically ANDed with *mask*, and it equals the result of *value* logically ANDed with *mask*.
- A byte address ending in 17 binary zeros is reached.

The form of the FNL command is:

```
FNL [ address [ , value ] [ & mask ] ]
```

address

is the address at which the FNL command starts to search memory. The *address* parameter must be on an even byte boundary. For more information, see Address Syntax on page 3-12.

value

is any expression that evaluates to a valid 32-bit number.

mask

is any expression that evaluates to a valid 32-bit number.

Considerations

- The FNL command has a default that provides a shorthand way of finding repeated occurrences of a value. If you execute an FNL command and a match is found, Debug responds with the standard prompt followed by (FNL). For example:

  ```
  251,06,00024-(FNL)
  ```

  If you then press RETURN, the effect is the same as entering an FNL command with no parameters; that is, Debug continues searching for the same value starting at the address where the previous FNL command terminated. You can continue pressing RETURN in this manner until the Debug prompt does not contain (FNL) (indicating that no match was found).

- Two possible uses for this command are finding data structures with particular values and finding code that has moved slightly because of a minor change.

If you omit *value* and *mask*, the FNL command uses the *value* and *mask* specified by the previous FNL command but starts searching at the newly specified address.

- If you omit *address*, *value*, and *mask*, the FNL command uses the *value* and *mask* specified by the previous FNL command and starts searching at the address where the previous FNL command terminated.

Examples

The following shows the search for a 32-bit word starting with string 45. The mask indicates that we are to ignore the contents of the lower 16 bits of the 32-bit word as well as the lower 16 bits of our search pattern.

050,03,00272-**fnl q, '45xx' & 0xffff0000**

0008002C: 0x34353637

For more FNL Command examples, see Appendix F, Sample Debug Sessions.

FREEZE Command

The FREEZE command disables the processor and asserts a freeze on other processors that have freeze enabled. The form of the FREEZE command is:

```
FREEZE
```

Considerations

- The FREEZE command is allowed only if you are debugging in privileged mode as described under the PRV command.
- Once a processor is frozen, a service provider can use the service processor (SP) to examine the current processor and another frozen processor.

Example

```
245,02,00033-FREEZE      ! Freezes the current processor, 02 in this example,
                         ! and asserts a freeze on other processors.
```

HALT Command

The HALT command halts the processor. The form of the HALT command is:

```
HALT
```

Considerations

- The HALT command is allowed only if you are debugging in privileged mode as described under the PRV command.
- Any running processors will declare the halted processor as being down.
- Once a processor is halted, a service provider can use the service processor (SP) to examine the processor.

Example

```
245,02,00033-HALT        ! Halts the current processor, 02 in this example.
```

H[ELP] Command

The HELP (or H) command displays help information about Debug commands. The form of the HELP command is:

```
H[ELP] [ debug-command   ]
       [ <variable-item> ]
```

debug-command

specifies the command whose syntax Debug is to display.

<variable-item>

specifies a variable item whose syntax Debug is to display. A variable item represents an item that you supply in a Debug command. The values you can specify for *variable-item* might vary depending on the release of Debug that you are using.

The *variable-item* parameter must be enclosed in angle brackets.

You can specify either *debug-command* or *<variable-item>*, but not both. If you omit both *debug-command* and *<variable-item>*, Debug displays all the available Debug commands and variables. Privileged Debug commands and options appear only if you are debugging in privileged mode as described under the PRV command.

Considerations

The HELP command is not available if the priority of the process being debugged is greater than or equal to the priority of the memory manager.

I Command

The I command displays instruction code. The default instruction set depends on the process type, but the instruction set can be specified by the *mode* parameter. The display syntax of this command is as follows:

```
I address [ , length ]

   [ , [ OUT ] output-dev ] [ : mode ]
```

address

is the address of the first variable to be displayed. For more information, see Address Syntax on page 3-12.

length

specifies the number of instructions to be displayed by Debug.

[OUT] *output-dev*

specifies where the display is directed. Debug output can be directed to an output device, a process, or a spooler collector. Debug output cannot be directed to a disk file. If you omit *output-dev*, Debug assumes the home terminal.

The *output-dev* parameter has these formats.

Syntax for a device other than a disk:

```
[ node.]{device-name[.qualifier ] }
        {ldev-number              }
```

Syntax for a named process:

[*node*.]*process-name*[:*seq-no*][.*qual-1*[.*qual-2*]]

Syntax for an unnamed process:

[*node*.]$:*cpu*:*pin*:*seq-no*

For syntax descriptions of these process and device names, see the *Guardian Procedure Calls Reference Manual.*

mode

specifies the instruction set options. The *mode* parameter has this format:

```
{ T | N | R }
```

These format options have these meanings:

T displays TNS instruction code.

N displays RISC instruction code.

R displays RISC instruction code.

If you omit *mode*, the default is based on the address that is currently being used.

Considerations

For an accelerated program, the I command displays the specified address area in TNS instruction code and marks points of correspondence between TNS and RISC instructions as follows:

- A commercial at sign (@) marks a register-exact point.
- A greater-than sign (>) marks a memory-exact point.

These points are the TNS environment P register values on which you can set breakpoints. For more information on these points, see TNS and RISC Execution Correspondence (Accelerated Mode) on page 2-5.

Examples From a TNS Program

```
050,03,00013-I %104
%000104:  ADDS   +002
050,03,00013-I %104, #10
%000104:  ADDS   +002      LADR  L+006      LLS     01       PUSH    700
%000110:  ADDS   +032      LOAD  L-003      PUSH    700      ADDS   +006
%000114:  LDLI   +200      LDI    -007
050,03,00013-I Q #40/2, 5 :r
00080028: SUBU  t4,v1,at         UNKNOWN 64000000       NOP
00080034: NOP                    NOP
050,03,00013-
```

Example From an Accelerated Program

```
050,03,00014-I %104, #10
%000104: @ ADDS   +002      LADR  L+006      LLS     01       PUSH    700
%000110:  ADDS    +032      LOAD  L-003      PUSH    700      ADDS   +006
%000114: > LDLI   +200      LDI    -007
050,03,00014-
```

Examples From a Native Program

```
050,03,00267-I 0x70000464
70000464: ADDIU sp,sp,-128
050,03,00267-I $pc - (4*4), 4
70000558: LW    s0,52(sp)        LW    s1,56(sp)        LW    ra,60(sp)
70000564: NOP
050,03,00267-I Q #40/2, 6 :t
%000024:  ADRA    1        LDD   G+143,5    LDD   G+145,6    LDD   G+147,7
%000030:  NOP              NOP
050,03,00267-
```

IH Command (TNS/R Native and OSS Processes)

The IH command displays information about signal handling for all signals or for a specified signal. The form of the IH command is:

```
IH [ signal-name ]
```

signal-name

specifies a signal for which signal-handling information is to be displayed. The TNS/R native signals are:

```
{ SIGSEGV | SIGILL | SIGFPE | SIGABRT       }
{ SIGSTK | SIGLIMIT | SIGMEMMGR | SIGNOMEM  }
{ SIGMEMERR | SIGTIMEOUT                    }
```

Additional signals are supported by Open System Services (see Considerations below). If *signal-name* is not specified, information is displayed for all signals, including both TNS/R native signals and OSS signals.

Considerations

- Because only TNS/R native or OSS processes can have signal handlers, the IH command is allowed only on such processes. For more information on signals, refer to the description of the SIGACTION_INIT_ procedure in the *Guardian Procedure Calls Reference Manual*.
- Open System Services supports additional signals that can be specified for *signal-name*. For more information about OSS signals, OSS users can refer to the signal(4) topic in the reference page, either online or in the *Open System Services System Calls Reference Manual*.
- The first column of the IH command display shows the name of each signal for which information is provided.

The second column shows a “P” if the signal handler for that signal is privileged or “N” if the signal handler is nonprivileged.

The third column shows the starting address of each signal handler.

The fourth and fifth columns show the mask values that indicate which signals to block when each signal handler is executing. (Only the lower 64 bits are displayed of the 128 bits that are available; the upper 64 bits are reserved.)

The sixth column shows the flags fields that modify the behavior of each signal handler.

Example

```
245,02,00033-IH    ! Display signal handling information for all the signals
Signal      Priv/Non    Handler      Mask[0:31]   Mask[32:63]  Flags
SIGHUP          N       0xFFFC0000   0x00000000   0x00000000   0x00000000
SIGINT          N       0xFFFC0000   0x00000000   0x00000000   0x00000000
SIGQUIT         N       0xFFFC0000   0x00000000   0x00000000   0x00000000
SIGILL          N       0x70002204   0x00000000   0x00000000   0x00000000
SIGURG          N       0xFFFC0001   0x00000000   0x00000000   0x00000000
SIGABRT         N       0xFFFC0000   0x00000000   0x00000000   0x00000000
SIGIO           N       0xFFFC0001   0x00000000   0x00000000   0x00000000
SIGFPE          N       0x70002204   0x00000000   0x00000000   0x00000000
SIGKILL         N       0xFFFC0000   0x00000000   0x00000000   0x00000000
SIGSEGV         N       0x70002204   0x00000000   0x00000000   0x00000000
SIGPIPE         N       0xFFFC0000   0x00000000   0x00000000   0x00000000
SIGALRM         N       0xFFFC0000   0x00000000   0x00000000   0x00000000
SIGTERM         N       0xFFFC0000   0x00000000   0x00000000   0x00000000
SIGUSR1         N       0xFFFC0000   0x00000000   0x00000000   0x00000000
SIGUSR2         N       0xFFFC0000   0x00000000   0x00000000   0x00000000
SIGCHLD         N       0xFFFC0001   0x00000000   0x00000000   0x00000000
SIGRECV         N       0xFFFC0001   0x00000000   0x00000000   0x00000000
SIGSTOP         N       0xFFFC0000   0x00000000   0x00000000   0x00000000
SIGTSTP         N       0xFFFC0000   0x00000000   0x00000000   0x00000000
SIGMEMERR       N       0x70002204   0x00000000   0x00000000   0x00000000
SIGSTK          N       0x70002204   0x00000000   0x00000000   0x00000000
SIGTIMEOUT      N       0x70002204   0x00000000   0x00000000   0x00000000
SIGLIMIT        N       0x70002204   0x00000000   0x00000000   0x00000000
SIGCONT         N       0xFFFC0001   0x00000000   0x00000000   0x00000000
SIGTTIN         N       0xFFFC0000   0x00000000   0x00000000   0x00000000
SIGTTOU         N       0xFFFC0000   0x00000000   0x00000000   0x00000000
SIGABEND        N       0xFFFC0000   0x00000000   0x00000000   0x00000000
```

INSPECT Command

The INSPECT command starts the Inspect debugger from Debug. The form of the INSPECT command is

```
INSPECT
```

Considerations for Switching From Debug to Inspect

- The Inspect debugger updates its breakpoint list upon being invoked from Debug.
- Privileged breakpoints are added only if the Inspect debugger has SET PRIV MODE ON. For this to happen, you must have (1) been in the Inspect debugger and entered the SET PRIV MODE ON command, (2) invoked Debug, entered the PRV command, and set breakpoints, and (3) reinvoked the Inspect debugger.
- Conditional breakpoints set by Debug are always evaluated conditionally, regardless of whether you are using the Inspect debugger or Debug.
- The Inspect LIST BREAKPOINTS command lists information about breakpoints set in Debug. If the breakpoint has attributes not allowed for Inspect breakpoints (for example, it is a conditional breakpoint that uses a mask), the Inspect debugger lists the breakpoint type as one of the following:

  ```
  Code DEBUG
  Data DEBUG
  ```

  The breakpoint description can include this information:

  ```
  CONDITIONAL       !  Conditional Debug breakpoint
  ALL PROCESSES     !  Applies to all processes
  PRIV              !  Set by Debug in privileged mode
  ```

- The Inspect debugger does not list Debug breakpoints if the command:
  - Includes the AS COMMANDS option
  - Is the FB command

△ **Caution.** When returning control to the Inspect debugger after you have used Debug to set “all process” breakpoints in system code and system library spaces, a deadlock can occur if the Inspect component process DMON calls the procedure in which you set a breakpoint.

Considerations for Switching From Inspect to Debug

- To switch from the Inspect debugger back to Debug, use the SELECT DEBUGGER DEBUG command.
- From the Inspect debugger, you can invoke Debug only on object programs that are in the hold state. You cannot use Debug on Pathway Screen COBOL programs.
- Conditional breakpoints that were set by using the Inspect debugger are reported unconditionally in Debug.
- If you invoke Debug from within the Inspect debugger and the process being debugged terminates, control returns to the Inspect debugger. The Inspect session terminates if there are no other processes being debugged; otherwise, the Inspect debugger resets the current program and issues a prompt.

- If you invoke Debug from an Inspect process being used to debug multiple processes, there is a possibility of both the Inspect process and Debug competing to control the terminal. You might consider using either the Inspect or Debug pause command to eliminate the contention.
- If the Inspect debugger is used to set breakpoints on STOP or ABEND, the Inspect debugger reports the event even if the event occurs when Debug is being used to debug the process.
- If PRV ON occurred earlier in Debug or SET PRIV MODE ON occurred earlier in Inspect, you do not need to reissue PRV ON to Debug.

Example

This command switches from Debug to the Inspect debugger.

```
244,02,00033-INSPECT
INSPECT - Symbolic Debugger - ...
244,02,00033  MYPROG  #MYPROC^MAIN.#29004(SMYPROG)
-MYPROG-
.
.
.
-MYPROG- SELECT DEBUGGER DEBUG          ! Go back to Debug.
DEBUG P=%000236, E=%000207, UC.%00
244,02,00033-
```

LMAP Command

The LMAP command displays the name of the procedure, the offset from the base of the procedure, and the code space, where a specified address lies. The form of the LMAP command is:

```
LMAP address
```

address

is the address that is to be translated to a procedure name plus offset. For more information, see Address Syntax on page 3-12.

Considerations

- If you use the V command to vector to another process (V is a privileged command), LMAP works only for global code areas (SC, SL, SCr, SLr); local code addresses in the program of the target process are rejected.
- The LMAP command displays nothing if the address is outside any procedure or if no name is available.
- The offset is displayed only if it is nonzero.

- The LMAP command is not available when the process in Debug is one that does not allow page faults.

Examples

```
243,01,00282-lmap sl.7,24137          ! an address in SL.07
EMTEXT + %17226 (SL.07)

243,01,00282-lmap n 0x7a0e50be        ! same location as a 32-bit address
EMTEXT + %17226 (SL.07)

243,01,00282-lmap n 0x7A6CDBAC        ! an address in accelerated code
EMSTEXT + %17226 (acc SL.07)

243,01,00071-lmap n 0x700015ac        ! an address in a native program
PROGRAM + 0x5EC (UCr)

242,01,00040-lmap n 0x76068130        ! an address in a native SRL
printf (SRL ZCRTLSRL)
```

M Command

The M command has these functions:

- To modify the contents of a process's variable
- To modify the contents of one of a process's registers, or to modify the space identifier of the current code segment

Each function is defined by a unique syntax. Each function and its syntax is described on the following pages.

Modify Variables

The M command can modify the contents of a process's variables. The modify-variable form of the M command is:

```
M address [ , new-value ] ...
```

address

is the address of the first variable to be modified. For more information, see Address Syntax on page 3-12. The only address modes allowed while in nonprivileged mode are L, S, Q, and N. All address modes are allowed for a process while in privileged mode.

new-value

is a 16-bit word expression representing the new contents of the modified variables. A series of more than one *new-value* separated by commas modifies consecutive ascending memory locations. A 16-bit word is used for *new-value*

unless an N-mode address is used, in which case a 32-bit word is used for *new-value*.

If you omit *new-value*, Debug prompts for a 16-bit word expression to represent the new contents of the variable. The prompt is of the form:

```
address:  current-value <-
```

address

is the address of the word to be modified.

current-value

is the current value of the indicated variable.

You can enter one value at the prompt. If you enter a value, Debug prompts for a value for the next consecutive location. If you enter a blank, *current-value* is unchanged and Debug prompts for a value for the next location. If you enter nothing, *current-value* is unchanged and Debug returns to its command-input mode.

Considerations

When N addressing mode is used, the *current-value* displayed and the *new-value* received are 32-bit numbers; the default base is hexadecimal.

Examples

```
106,01,00012-m L-3I,1,2,3
248,01,00023-M N 0X80020000, 0, 0, 0    ! Change four 32-bit
                                        ! values to 0.
```

For more examples that use the M command, see Appendix F, Sample Debug Sessions.

Modify Register Contents

The M command can modify the contents of one of a process's registers. The modify-register form of the M command is:

```
M register [ , new-value ]
```

register

represents one of the registers for that process; see Register Syntax on page 3-7.

new-value

is a 16-bit word expression representing the new contents of the designated register. The *new-value* parameter is a space identifier if you specify SP for *register*.

If *register* is a TNS/R register, *new-value* is a 32-bit value and you enter *new-value* in hexadecimal.

If you omit *new-value*, Debug prompts for a 16-bit word expression to represent the new contents of the register. The prompt is of the form:

```
register:  current-value <-
```

register

is the register to be modified.

current-value

is the current value of the indicated register.

You can enter one value at the prompt.

When you specify SP for *register*, *new-value* is of the form:

```
{ UC[.segment-num ] }
{ UL[.segment-num ] }
{ SC[.segment-num ] }
{ SL[.segment-num ] }
```

UC indicates the user code space.

UL indicates the user library space.

SC indicates the system code space (valid only in privileged mode).

SL indicates the system code space (valid only in privileged mode).

segment-num

defines the particular library code segment within the user code or user library space, and it must be an octal number identifying any allowed segment. If you omit *segment-num,* Debug uses 0.

Considerations

- When you want to change the current location of a process running in TNS or accelerated mode, you modify the value of the P register. If the process is a multiple-segment process, you must also change the space identifier. You change the space identifier in order to change the location of the process to a different code segment.

  (It is also possible to change the current location of a process running in native mode, but doing so requires knowledge of native mode internals and is beyond the scope of this manual.)

- In the TNS environment, ENV.<0:7> cannot be modified by specifying E for the *register* parameter, except in privileged mode. However, in nonprivileged mode, Debug does allow you to modify ENV.<4> and ENV.<7> by specifying SP for the *register* parameter.

  The LS (ENV.<4>) and CS (ENV.<7>) fields in the ENV register must agree with the UC, UL, SC, and SL fields in the space identifier. Therefore, to modify ENV.<4> or ENV.<7>, set *new-value* for the SP *register* parameter as follows:

new-value	changes ENV.<4> to	changes ENV.<7> to
UC	0	0
UL	1	0
SC (priv mode only)	0	1
SL (priv mode only)	1	1

  Note that a nonprivileged user cannot set CS to 1, which would be system code or system library.

- When modifying the bit values of the $FCR31 register, the modification is made to the local copy maintained by Debug. Although you can display the modified value of the register, the copy that is placed in the original $FCR31 register when the program resumes might be different than the modified value. Bits cannot be set in undefined fields of the register, and the value of the CAUSE field cannot be modified. Applying only selected bit fields reduces program failure when the program is resumed.

Examples

```
147,01,00029-MR0
 *REG*:  %000031 <- 0

147,01,00033- M SP
 SPACEID:  UL.2 <- UC.00

147,01,00033- M SP,UC          ! Defaults to UC.00

248,01,00033-M $V0, -1         ! Set register $V0 to -1.

248,02,00022-M $T0             ! Change register $T0 to the value
0x70452312.
*REG*:  0x00000EF0 <- 0x70452312
```

MH Command (TNS/R Native and OSS Processes)

The MH command can modify signal handling by specifying a new signal handler or signal action for a specified signal. The form of the MH command is:

```
MH signal-name , { sigaction | 32-bit-address }
```

signal-name

specifies the signal for which signal handling is to be modified. The TNS/R native signals are:

```
{ SIGSEGV | SIGILL | SIGFPE | SIGABRT       }
{ SIGSTK | SIGLIMIT | SIGMEMMGR | SIGNOMEM  }
{ SIGMEMERR | SIGTIMEOUT                       }
```

Additional signals are supported by Open System Services. For more information, see Considerations on page 4-62.

sigaction

specifies one of the system-supplied signal actions:

```
{ SIG_DFL | SIG_ABORT | SIG_DEBUG | SIG_IGN }
```

32-bit-address

is the RISC address of a user-supplied signal handler.

Considerations

- Because only TNS/R native and OSS processes can have signal handlers, the MH command is allowed only on such processes. For more information on signals, refer to the description of the SIGACTION_INIT_ procedure in the *Guardian Procedure Calls Reference Manual.*

- Open System Services supports additional signals that can be specified for *signal-name*. For more information about OSS signals, OSS users can refer to the signal(4) topic in the reference page, either online or in the *Open System Services System Calls Reference Manual.*
- A user-written procedure must meet certain requirements to function as a signal handler. For more information on how to write a signal handler, refer to the description of the SIGACTION_INIT_ procedure in the *Guardian Procedure Calls Reference Manual.*
- If you are running Debug as the super ID (255, 25), a signal handler that you install with the MH command might or might not be capable of executing in privileged mode depending on whether the signal handler it replaced was capable of executing in privileged mode. The level of privilege will be unchanged. If you are not running Debug as the super ID, you can install only a nonprivileged signal handler.
- You can use the IH command to verify that the new signal handler or handler action is in effect after installing it with the MH command.

Examples

In this example, the MH command is used to specify a signal handler for the signal SIGFPE and then, for verification, the IH command is used to display signal-handling information for the same signal.

```
243,04,00019-MH SIGFPE, oxh00030000
243,04,00019-IH SIGFPE
Signal       Priv/Non     Handler     Mask[0:31]  Mask[32:63] Flags
SIGFPE           N        0x00030000  0x00000000  0x098700A1  0x000816E4
```

P[AUSE] Command

The PAUSE (or P) command momentarily suspends process execution. This command is particularly useful when you are simultaneously debugging several processes at the same terminal. The form of the PAUSE command is:

```
P[AUSE] pause-time
```

pause-time

is an expression that specifies the length of time, in 0.01-second units, that the process is to pause for.

Example

```
119,01,00012-P #1000   ! Pauses the process (01,012) for 10 seconds.
```

PMAP Command (Accelerated Programs)

The PMAP command prints corresponding blocks of TNS and RISC instruction code. The form of the PMAP command is:

```
PMAP address [ , count ] [ , [ OUT ] output-dev ]
```

address

is a code address. For more information, see Address Syntax on page 3-12. The address-mode parameters allowed for a code address are as follows:

- UC, UL, SL, and C address modes are allowed while in nonprivileged mode. N address mode is also allowed for addresses in any native code space and for addresses in accelerated code spaces UC, UL, and SL.
- Any address mode appropriate for the processor is allowed while in privileged mode.

count

is an expression representing the number of instructions to be displayed. Valid values for *count* are integers. Debug displays the minimum number of blocks of instructions that includes the *count* number of instructions.

[OUT] *output-dev*

specifies where the display is directed. Debug output can be directed to an output device, a process, or a spooler collector. Debug output cannot be directed to a disk file. If you omit *output-dev*, Debug assumes the home terminal.

output-dev has these formats.

Syntax for a device other than a disk:

```
[ node.]{device-name[.qualifier ] }
    {ldev-number       }
```

Syntax for a named process:

```
[ node.]process-name[:seq-no][.qual-1[.qual-2] ]
```

Syntax for an unnamed process:

```
[ node.]$:cpu:pin:seq-no
```

- For syntax descriptions of these process and device names, see the *Guardian Procedure Calls Reference Manual.*

Considerations

- The PMAP command is allowed only on TNS or RISC code in accelerated program areas.

- If the name you specify for *output-dev* happens to match a register name, a syntax error might result. To avoid any possibility of ambiguity, include the keyword OUT before *output-dev,* which informs Debug that the name refers to an output device. For example, suppose a printer is named $S1, which is also the name of a TNS/R register. Specifying OUT $S1 on the PMAP command tells Debug that $S1 is an output device.

PMAP Display Format

The PMAP command displays the specified address area in TNS instruction code followed by RISC instruction code. These conventions apply to the display:

- RISC addresses are represented in hexadecimal.
- TNS addresses are represented in octal.
- A commercial at sign (@) marks a register-exact point.
- A greater-than sign (>) marks a memory-exact point.

Register-exact and memory-exact points are the TNS P register values on which you can set breakpoints. For more information on these points, see Section 2, Using Debug on TNS/R Processors.

Examples

For examples that use the PMAP command, see Appendix F, Sample Debug Sessions.

PRV Command

The PRV command enables or disables privileged debugging commands.The form of the PRV command is:

```
PRV [ ON | OFF ]
```

ON

specifies that privileged debugging commands be enabled.

OFF

specifies that privileged debugging commands be disabled.

If you do not specify either ON or OFF, ON is the default.

△ **Caution.** Use privileged commands with extreme caution, because they allow you to perform operations that could halt the system.

Considerations

- The PRV ON command requires that the process you are debugging be executing under the local super ID (255, 155). After you specify the PRV ON command, you can enter any of the privileged commands or options.
- Privileged debugging is never available automatically. Before using the privileged Debug commands and options, you must always issue the PRV ON command; the security subsystem then decides whether you have the proper access to be granted privileged debugging. The only exception is where a process falls into a debugging session that is already privileged because of an earlier PRV ON command from Debug (or a SET PRIV MODE ON command from Inspect) during the life of the process.
- The privileged Debug commands are:
  - The FREEZE, HALT, PRV, V, and VQA commands
  - Access data and code in the kernel address space (Kseg0 and Kseg2).
  - Plant code breakpoints in code containing PRIV or CALLABLE procedures, including licensed UC, UL, UCr, SRLs, or system code and library.
  - Commands that modify user code.

Example

For examples that use the R command, see Appendix F, Sample Debug Sessions.

R Command

The R command causes the application process to leave the debug state and resume execution.

You can specify a conditional resume. For a conditional resume, Debug executes the R command only if the specified relation between the two expressions is true. A conditional resume is particularly useful to include in a command string on an execute code breakpoint or execute memory-access breakpoint.

The form of the R command is:

```
R [ expression-1 op expression-2 ]
```

expression-1

is a 16-bit word expression.

op

is one of these operators:

< resume if *expression-1* is less than *expression-2*. This operator does an unsigned comparison.

> resume if *expression-1* is greater than *expression-2*. This operator does an unsigned comparison.

= resume if *expression-1* is equal to *expression-2*.

<> resume if *expression-1* is not equal to *expression-2*.

expression-2

is a 16-bit word expression.

Considerations

- You cannot resume a process that entered Debug either because it received a nondeferrable signal or because a synchronous trap occurred. A signal is nondeferrable if it was generated by the system because the process cannot continue executing the instruction stream. The only traps from which you can resume are the looptimer trap and the arithmetic overflow trap, provided that the T and V bits are not both set in the ENV register.

  If you enter an R command on a nonresumable process, the process is deleted after Debug exits with the same Guardian Stop message or OSS wait status as would have been generated had the signal or trap terminated the process without entering Debug.

Example

This command sets an execute memory-access breakpoint at offset %42 with two conditional resume requests:

```
100,02,00033-BM 42, (R K17 < 12; R R0 < 54;)
```

S[TOP] Command

The STOP (or S) command deletes an application process. The form of the STOP command is:

```
S[TOP]
```

Note. The process deletion is treated as a normal deletion (for example, a system message -5 is sent to the creator of the deleted process).

T Command

The T command traces back and displays the contents of up to 10 stack markers, starting from the current stack marker or a designated stack marker. The T command can either report the procedure names or translate the PC register (native mode) or the ENV register (TNS or accelerated mode) in each stack marker. The form of the T command is:

```
T [ & ] [ N ] [ options ] [ , [ OUT ] output-dev ]
```

`&` specifies that Debug is to begin the display with the frame immediately following the last frame displayed. You can use this option to display successive blocks of frames.

`N` specifies that Debug is to display a trace of procedure names rather than the translated ENV or PC registers.

`options`

gives Debug the conditions to assume when starting the trace. The *`options`* parameter is a list of one or more of the following, separated by commas:

`[`*`register`* `[=]]` *`expression`*

tells Debug to start the trace as though the specified register had the specified value. If the register is a 16-bit register, only the low-order 16 bits of the expression are used. You can include as many [*`register`* [=]] *`expression`* specifications as are necessary to indicate where to start the trace. You can omit *`register`* = , in which case Debug assumes the L register.

`MODE { N[ATIVE] | T[NS] | A[CCELERATED] }`

specifies the execution mode that Debug is to assume when starting the stack trace. If you omit this option, Debug assumes the execution mode of the current process.

`AT` *`expression`*

specifies the address of a word on the stack whose content is a native code address. Debug assumes that this word is the return address stored by a procedure, and attempts to begin the trace with the stack frame of that procedure.

`J` *`32-bit-address`*

specifies that the stack trace start from the context saved in a jump buffer. The *`32-bit-address`* parameter is the RISC address of the jump buffer.

[OUT] *output-dev*

specifies where the display is directed. Debug output can be directed to an output device, a process, or a spooler collector. Debug output cannot be directed to a disk file. If you omit *output-dev*, Debug assumes the home terminal.

The *output-dev* parameter has these formats.

Syntax for a device other than a disk:

[*node*.]{*device-name*[.*qualifier*] }
{*ldev-number* }

Syntax for a named process:

[*node*.]*process-name*[:*seq-no*][.*qual-1*[.*qual-2*]]

[*node*.]$:*cpu*:*pin*:*seq-no*

For syntax descriptions of these process and device names, see the *Guardian Procedure Calls Reference Manual*.

Considerations

- If the process being debugged contains threads, Debug displays a stack trace for only the thread currently in effect.
- If the name you specify for *output-dev* happens to match a register name, a syntax error might result. To avoid any possibility of ambiguity, include the keyword OUT before *output-dev,* which informs Debug that the name refers to an output device. For example, suppose a printer is named $S1, which is also the name of a TNS/R register. Specifying OUT $S1 on the T command tells Debug that $S1 is an output device.
- In a stack trace displayed by the T command, the top line represents the most recently called procedure, the second line represents the next most recently called procedure, and so on. For example, in the following trace, PROMPT called CHECKRECEIVE.

```
%004251: %002223  E=%000000 L=%004072  CHECKRECEIVE + %000250
%004070: %006163  E=%000000 L=%003634  PROMPT + %001064
```

- There are two ways to start a stack trace at a particular stack frame in native mode. One way is to indicate where the frame is and which procedure built the frame. Do this by including the appropriate *register* = *expression* specifications in the T command. For example:

```
T$RA 0x70302304, $30 0xFFFFFFFF
```

An alternate and easier way is to examine the stack for a value that is likely to be a RISC PC address (that is, a value that addresses the SCr, SLr, UCr, or SRL code space) and provide the address of that value as the *expression* for the AT parameter.

- The T command has a default that provides a shorthand way of displaying successive blocks of stack frames. If you execute a T command and the subsequent Debug prompt ends with (T)-, this indicates that additional stack frames remain to be displayed. For example:

  ```
  149,06,00024 (T)-
  ```

  You can display the remaining stack frames simply by pressing RETURN. This executes a default command of the form

  T & *options*

  where *options* are the options you specified for the previous T command. Executing this default command displays the next block of stack frames. You can continue pressing RETURN until all stack frames have been displayed (the Debug prompt no longer contains (T)-).

- This routine displays a stack frame of any type. The format depends upon the information available, including the emulation mode, TNS P, and RISC pc address. The output line holds this form:

  ```
  addr    pc  Virtual frame ptr              id
  addr    pc  E                    L         id
  addr    P   E                    L         id
  ```

  where:

  addr is the location of the source of the data (16 or 32 bits), or empty;

  pc is the RISC pc (32 bits);

  P is the TNS P (16 bits);

  E is the TNS environment (stack-marker form, 16 bits);

  L is the TNS L (16 bits);

  id is the procedure name and offset if requested and available, or the code space location.

  The standard base is hexadecimal for 32-bit data and octal for 16-bit data.

- A stack trace may include both TNS/R native mode stack frames and TNS or accelerated mode stack frames. If so, a blank line indicates each change of execution mode.
- RISC stack frame addresses grow from larger to smaller addresses. TNS stack frame addresses grow from smaller to larger addresses.
- When the N option is specified, Debug displays both the procedure name and the offset into the procedure.
- The N option format does not work when you are debugging these processes:
  - Monitor process.

- A disk process whose object code resides on the disk being debugged, typically $SYSTEM.

- The N option format always works for user processes and system input/output processes (IOPs) other than those mentioned in the preceding list.

Examples

For examples that use the T command, see Appendix F, Sample Debug Sessions.

V Command

The V command enables you to access address spaces of other processes. The items affected are the current code, current data, registers, and the Q segment. The Q segment is the current selectable segment as viewed by Debug. The form of the V command is:

```
V [ expression-16 ]
```

expression-16

is the PIN of the desired process. If you omit *expression-16*, the current PIN reverts to the one in use when the process entered Debug.

Particular V command values have meaning as follows:

V	returns to the current process's values.
V -1	sets values as follows: code = 5 (system code) data = 1 (system global data) Q = undefined
V *pin*	sets values as follows: code = *pin's* code data = *pin's* data Q = *pin's* current in-use segment registers = *pin's* registers

Considerations

- You can specify V only if you are debugging in privileged mode.
- If you use the V command to switch Debug's view to another process, you cannot then enter Inspect commands for that process; an attempt to do so produces an error message.

Example

This example makes Debug's current view the state of PIN 23 in processor 2 and then sets a breakpoint in the process:

```
245,02,00033-V #23
245,02,00033-B 0x7000DE88
```

VQ Command

The VQ command changes the segment ID for the current selectable data segment (as viewed by Debug). The form of the VQ command is:

```
VQ [ expression-16 ]
```

expression-16

is the segment ID of the segment that is to be the current selectable data segment (Q segment). If you omit *expression-16*, the current segment ID reverts to the one in use when the process entered Debug.

Considerations

- The VQ command affects only the current segment ID as viewed during debugging. It does not change the current segment ID seen by the program itself. The segment ID seen by the program is the result of a previous call to either the USESEGMENT or SEGMENT_USE_ procedure.
- If the specified segment ID is not allocated, an error occurs.

Example

```
106,01,00012-VQ 2
```

VQA Command

The VQA command sets the current selectable data segment to the specified absolute segment number. The syntax of the VQA command is:

```
VQA [ expression-16 ]
```

expression-16

is the specified segment ID of the segment that is to be the current selectable data segment (Q segment). If you omit *expression-16*, the current segment ID reverts to the one in use when the process entered Debug.

Considerations

- The VQA command affects only the current segment ID as viewed during debugging. It does not change the current segment ID seen by the program itself.
- If the specified segment ID is not allocated, an error occurs.

Example

```
050,03,00266-vqa #1024
```

= Command

The = command computes and displays the value of an expression. This value can be displayed in octal, decimal, hexadecimal, binary, ASCII, RISC instruction code, or TNS instruction code.

The = command can also translate and display an expression as both forms of the TNS environment ENV register: the hardware ENV register and the stack marker ENV register.

The form of the = command is:

```
= expression [ : [ A ] ]
               [ B ]
               [ D ]
               [ E ]
               [ H ]
               [ N ]
               [ O ]
               [ R ]
               [ T ]
               [ # ]
                [ % ]
```

`A, B, D, E, H, N, O, R, T, #,` and `%`

specify the base in which Debug is to display the computed value

`A` denotes ASCII.

`B` denotes binary.

`D` denotes decimal.

`E` translates and displays *`expression`* as both the hardware ENV register and the stack marker ENV register.

`H` denotes hexadecimal.

`N` denotes RISC instruction code.

`O` denotes octal.

`R` denotes RISC instruction code.

`T` denotes TNS instruction code.

`#` denotes decimal.

`%` denotes octal.

If you do not supply a base notation or do not reset the default numeric base with the BASE command, Debug assumes octal.

Considerations

- When a 32-bit word *`expression`* is displayed with the = command, it is shown as a 16-bit word value whenever possible; that is, the high-order word is dropped if it is merely a sign extension (0 or 177777).

Examples

For more information on the examples that use the = command, see Appendix F, Sample Debug Sessions.

? Command

The ? command displays the following:

- The space identifier for the current code segment.
- Either the segment ID for the current selectable data segment that was brought into use when the process being debugged called USESEGMENT or SEGMENT_USE_, or the segment ID last specified by you in a Debug VQ command.

  The segment ID is in octal.

  The VQ command does not change the process segment ID that resulted from the process's last call to USESEGMENT or SEGMENT_USE_. When the process resumes execution, it uses this segment ID.

  If no selectable data segment exists, the word NONE appears.
- The current specified base of input and output.
- The current home terminal.
- The current PRV setting.

The form of the ? command is:

```
?
```

Examples

```
254,03,00012-prv on
        254,03,00012-?
         BASE SEGMENTS:  SYSTEM DATA = %000001
                         SYSTEM CODE = %000005
                          SYSTEM LIB = %020400
                           USER DATA = %020777
                       V PIN = 014  (#012)
                    USE SEGMENT ID = NONE
                  BASE STANDARD IN
                  BASE STANDARD OUT
         TERM \RAMBLER.$ZTN00.#PTYRVSD
         PRV = ON
```

A Error Messages

This appendix lists the error messages that can occur when you enter a Debug command.

1

```
The breakpoint table is full.
```

Cause. The code breakpoint table is full. The new breakpoint cannot be entered.

Effect. The command is not executed.

Recovery. Clear an existing breakpoint to provide space in the table, then try again.

2

```
Trace routine encountered a syntax error.
```

Cause. The command, as entered, has invalid syntax, or the command is allowed only in privileged mode and the debugging session is in nonprivileged mode.

Effect. The command is not executed.

Recovery. Correct the command, and try again. For a privileged mode command, if you are the super ID (255,255), enter the PRV command and try again.

3

```
?error-number
```

Cause. An error occurred on an input-output request. The value of *error-number* is the decimal number of the file-system error that occurred.

Effect. None.

Recovery. See the file-system errors in the *Guardian Procedure Errors and Messages Manual* for corrective action. For example, the error “?14” (file-system error 14) reports that a specified device does not exist on the particular system.

4

```
Breakpoint already exists.
```

Cause. A breakpoint is already set at the specified location, or a memory-access breakpoint is already set. The new breakpoint cannot be entered.

Effect. None.

Recovery. Informational message only; no corrective action is needed.

7

```
PRV ON is required to perform command.
```

Cause. The PRV ON command must be executed in order to use a privileged command.

Effect. The command is not executed.

Recovery. Enter the PRV ON command and try again.

8

```
Could not get memory to hold break information.
```

Cause. The command attempts to set a breakpoint with a command string, but Debug requires system buffer space that is not available.

Effect. The command is not executed.

Recovery. There is no corrective action possible for the entered command. If possible, try to debug your process on a different processor. Otherwise, enter the break (B) or break memory (BM) command without the command string.

9

```
An arithmetic overflow occurred while computing the address.
```

Cause. The specified command requested Debug to convert a number that will overflow 32 bits or to perform an arithmetic operation that will overflow the available space.

Effect. The command is not executed.

Recovery. Correct the command so that no overflow occurs, and try again.

11

```
FRAME number, number
```

Cause. The trace (T) command encountered an error while attempting to analyze the stack.

Effect. The command might or might not display some output information.

Recovery. Contact your service provider with all the necessary information to reproduce the problem.

13

```
Internal error: Cannot access COMPADRS <reason>.
```

Cause. An error occurred while attempting to display information pointed at by the COMPADRS field of the breakpoint table. The reason is provided with the error message, which can be one of the following:

OK	Occurs as an informational message only.
Bad PIN	The specified PIN number is invalid.
Address not valid	The specified address is invalid.
Unsupported	The specified Debug version is not supported by the memory manager.
KSEG1 address given	Address specified in KSEG1 form is not valid.
REGSAVE required	REGSAVE is required to qualify the address for the specified address.
Out of bounds	Read or write went beyond the limits of the allocated memory.
Illegal Access	Read or write access is illegal.
Cannot Access	An unrecoverable error occurred while attempting to access memory.

Effect. Break information cannot be displayed.

Recovery. Try to fix the problem for the stated reason by clearing the breakpoint and retrying the command. If retrying fails, contact your service provider with the description of the problem.

14

```
Address is in a relative data segment, but the program or the VQ command is
not using the segment.
```

Cause. The address was within the extended data segment or selectable segment, but the address type was not being used in the process that is being debugged.

Effect. None.

Recovery. Check the program to make sure that it is using a data segment at this point in the program. Also, check that you are debugging the correct program.

15

```
Internal error: Cannot decode 1-byte long instructions.
```

Cause. Internal error occurred indicating that Debug cannot decode 1-byte instructions.

Effect. None.

Recovery. This error should not occur. If it does, contact your service provider with the description of the problem.

16

```
Page fault is not allowed for this PIN. Cannot execute command.
```

Cause. The PIN that is being debugged has a higher priority than the memory manager. The code that is needed to process the command might need to be swapped into memory, which cannot be done under these conditions.

Effect. The command is not executed.

Recovery. Depending on the command being used, it might be necessary to display the raw data and decode it on a different process or try the command on a different process.

17

```
String terminator (‘) is missing.
```

Cause. A string terminator was not specified. String can be 1, 2, 3, or 4 bytes long.

Effect. None.

Recovery. Make sure that the missing string terminator is specified and try again.

18

```
Missing closing parenthesis.
```

Cause. A matching closing parenthesis was not found.

Effect. The command is not executed.

Recovery. Enter a closing parenthesis and try again.

19

```
Invalid PIN.
```

Cause. The specified PIN is not valid. You did not specify the correct address, or the PIN is in a different processor than where you are debugging.

Effect. The command is not executed.

Recovery. Verify that the PIN is in the processor where you are debugging, or make sure that the address is correct.

20

```
Specified number is greater than 0xFFFF.
```

Cause. The specified number was greater than what the command expected.

Effect. The command is not executed.

Recovery. Specify a value that can fit in a 16-bit word and try again.

21

```
Incorrect syntax or end of command expected.
```

Cause. Either an incorrect syntax was provided or the end of a command was expected.

Effect. The command is not executed.

Recovery. Look over the syntax for the command in the help line and make sure that you provide the correct syntax.

22

```
Internal error: current output device matches new output device.
```

Cause. An attempt was made to specify an output device that is the same as the one that is currently being used.

Effect. The command is not executed.

Recovery. Make sure that the specified output device is not the same as the terminal device that is currently being used.

23

```
Specified device name is invalid.
```

Cause. The specified output device was invalid.

Effect. The command is not executed.

Recovery. Specify a valid output device and try again.

24

```
Output device is missing or output is directed to disk.
```

Cause. The name of the output device was not found, or the name was identified as a disk device.

Effect. The command is not executed.

Recovery. Make sure that an output device is specified and that it is not a disk device.

25

```
Comma (,) expected.
```

Cause. A comma (,) needs to be specified after the space ID and before the offset.

Effect. The command is not executed.

Recovery. Specify the comma and try again.

26

```
Space ID number is too large.
```

Cause. The specified space ID is larger than the number of spaces available in the code file. The code file has a maximum of 31 spaces (decimal).

Effect. The command is not executed.

Recovery. Check the number of code spaces in the listing of the code file. (The space number is usually specified in octal.) Make sure that the number is not larger than what is available for use.

27

```
Address requires valid PIN.
```

Cause. The given address requires a valid PIN.

Effect. The command is not executed.

Recovery. Make sure that the address relates to the correct PIN.

28

```
SC address is invalid.
```

Cause. The specified SC address was not valid.

Effect. The command is not executed.

Recovery. Specify a valid SC address and try again.

29

```
TNS-style segment specified for native program.
```

Cause. The program is native, but the specified address is in TNS format.

Effect. The command is not executed.

Recovery. Specify the address for a native program and try again.

30

```
Only direct and SX allowed for native program.
```

Cause. A form other than direct or indirect extended string was specified. The only address forms for a native program are direct and indirect extended string.

Effect. The command is not executed.

Recovery. Check how address is used in the program. If the address is an extended address, then only SX is allowed for a native program.

31

```
Internal error: ADDRESS_CREATE_.
```

Cause. An unrecognized indirect address type was encountered.

Effect. The command is not executed.

Recovery. Contact your service provider with description of the encountered problem.

32

```
Start of accelerated code location is not found.
```

Cause. The program is not an accelerated program.

Effect. The command is not executed.

Recovery. Do not use the PMAP command unless the program is accelerated.

33

```
End of accelerated code location is not found.
```

Cause. While attempting to execute the PMAP command, an address that was beyond the end of the accelerated code was found. More information might have been provided before this error occurred.

Effect. The command is not executed.

Recovery. Change the starting PMAP address or reduce the count value, and try again.

34

```
Start of TNS code location is not found.
```

Cause. Could not find the starting address of the TNS code in the accelerated program.

Effect. The command is not executed.

Recovery. Check the specified address to the PMAP command.

35

```
End of TNS code location is not found.
```

Cause. Could not find the ending address of the TNS code in the accelerated program.

Effect. The command either is not executed or it might be partially executed.

Recovery. The count value of the PMAP command might be beyond the end of the code. Reduce the count value and try again.

36

```
Start of TNS code location is invalid.
```

Cause. An attempt to use a RISC code address to find a TNS address in the accelerated program has failed, because the address does not point to a TNS code location.

Effect. The command is not executed.

Recovery. Make sure that the address assigned to the PMAP command is valid and try again.

37

```
Invalid count.
```

Cause. The count value was not valid for the specified command.

Effect. The command is not executed.

Recovery. Check the specified count value and make sure that it does not exceed the limit. Generally, the maximum count value is 3767 or 16383 (decimal) for most commands.

38

```
Invalid output base.
```

Cause. The output base value for the DN command was invalid. You must specify one of the following as an output base value: A, B, D, H, I, O, R, or T.

Effect. The command is not executed.

Recovery. Specify one of the listed output base values and try again.

39

```
Display size must be 1, 2, 3, or 4.
```

Cause. The specified number, after the output base of the DN command, must be 1, 2, 3, or 4.

Effect. The command is not executed.

Recovery. Specify one of the option numbers and try again.

40

```
Internal error: DUMP_NATIVE_COMMAND.
```

Cause. The space needed to display the information for the DN command was larger than the space available.

Effect. The command is not executed.

Recovery. Contact your service provider with the description of the problem.

41

```
PMAP address is not TNS or accelerated code.
```

Cause. The PMAP command cannot be used on native code.

Effect. The command is not executed.

Recovery. Do not use the PMAP command on native code.

42

```
Address and PIN combination is invalid.
```

Cause. The LMAP command cannot be used on some processes. The code necessary to process the command might need to be swapped.

Effect. The command is not executed.

Recovery. If the address is not in process where the code space is located, vector to the correct PIN and then enter the command.

43

```
LMAP command initialization failed.
```

Cause. The LMAP command initialization failed for the given address.

Effect. The command is not executed.

Recovery. Check the address assigned to the LMAP command. If the address is not valid, make sure that you specify a valid address. If the address is valid, contact your service provider.

44

```
Internal error: HIST_FORMAT_ error:error-number.
```

Cause. The HIST_FORMAT_ function returned an internal error when the LMAP command was used.

Effect. The command either might not be executed or it might be partially executed.

Recovery. Check the address assigned to the LMAP command. If the address is not valid, make sure that you specify a valid address. If the address is valid, contact your service provider.

45

```
Unsuccessful turning OFF of PRV.
```

Cause. Debug encountered an error when attempting to turn off the privileged mode.

Effect. The command is not executed.

Recovery. Check the PRV setting with the? command; it might already be set to OFF.

46

```
Unsuccessful turning ON of PRV.
```

Cause. Debug was not able to turn on the privileged mode. You must be the super ID (255, 255) in order to use the privileged mode.

Effect. The command is not executed.

Recovery. If you are a privileged user, log on the system as the super ID (255,255) and try the PRV ON command again.

47

```
Expecting one of the following: =, <>, <, >, or ?.
```

Cause. One of the possible values was not specified.

Effect. The command is not executed.

Recovery. Specify one of the values listed in the message text and try again.

48

```
Error accessing memory: reason.
```

Cause. Debug could not access memory. See error message 13 for the list of reasons.

Effect. The command is not executed.

Recovery. Check the address in the specified command to make sure that it is valid. Make sure that the PIN still exists.

49

```
FN reached address boundry. To continue, enter the following address:
address.
```

Cause. The FN command stops every time it reaches a byte address where the low-order 17 bits are zero.

Effect. The command stops searching.

Recovery. To continue the search in the next unitary segment, enter the FN command with the given 32-bit address.

50

```
FN stopped searching at the following address: address, reason.
```

Cause. The FN command stopped searching at the indicated address for the given reason (see error message 13 for the list of reasons). This error normally occurs when the end of the allocated memory is reached.

Effect. The executed command cannot go beyond the indicated address.

Recovery. Specify new values for the FN command or enter some other Debug command that you want.

51

```
FNL reached address boundry. To continue, enter the following address:
address.
```

Cause. The FNL command stops every time it reaches a byte address where the low-order 17 bits are zero.

Effect. The command stops searching.

Recovery. To continue the search in the next unitary segment, specify the FNL command with the given 32-bit address.

52

```
FNL stopped searching at the following address: address, reason.
```

Cause. The FNL command stopped searching at the indicated address for the given reason (see error message 13 for the list of reasons). This normally occurs when the end of the allocated memory for the program is reached.

Effect. The executed command cannot go beyond the indicated address.

Recovery. Specify new values for the FNL command or enter some other Debug command that you want.

53

```
Absolute-segment number is too large.
```

Cause. The specified absolute-segment number for the VQA command was larger than the number of absolute segments.

Effect. The command is not executed.

Recovery. Make sure that the specified absolute-segment number is within the range of the VQA command.

54

```
Cannot use absolute-segment number.
```

Cause. The specified absolute-segment number for the VQA command cannot be used.

Effect. The command is not executed.

Recovery. Contact your service provider with the description of the problem.

55

```
Cannot restore user segment.
```

Cause. The VQ command cannot restore the original segment that was being used by the program.

Effect. The command might or might not be executed.

Recovery. Check the current user segment syntax with the ? command. If you had not specified the correct value, specify a correct value for the user segment and try again. If the user segment value you specified is correct, contact your service provider with the description of the problem.

56

```
Cannot restore current segment in vectored PIN.
```

Cause. The VQ command attempted to restore the current segment indicated in the PCB of the vectored PIN, but the attempt failed.

Effect. The command might or might not be executed.

Recovery. Check the current user segment syntax with the ? command. If you had not specified the correct value, specify a correct value for the user segment and try again. If the user segment value you specified is correct, contact your service provider with the description of the problem.

57

```
Segment number is invalid or requires PRV ON.
```

Cause. The specified segment number in the VQ command was greater than the last valid segment ID, or the specified segment ID is accessible only through privileged mode.

Effect. The command is not executed.

Recovery. Make sure that the segment number you specified is not greater than the segment ID. If the segment number is correctly specified, then make sure that you are in privileged mode.

58

```
Cannot use segment.
```

Cause. The VQ command could not access the segment number.

Effect. The command is not executed.

Recovery. Make sure that the specified segment number has been allocated by the program.

59

```
Invalid PFS.
```

Cause. The F command did not find a valid process file segment (PFS).

Effect. The command is not executed.

Recovery. The process might not have PFS allocated for the current PIN at this point of process startup. This error can also indicate that Debug or some other part of the operating system has a problem. If this problem persists, contact your service provider.

60

```
Invalid MAB access type.  Expecting R, RW, W, or C.
```

Cause. You did not indicate whether a memory-access breakpoint was a READ, READ-WRITE, WRITE, or change (C) breakpoint.

Effect. The command is not executed.

Recovery. Specify one of the valid memory access types listed in the message text and retry the command.

61

```
Address is not in code location.
```

Cause. The memory manager indicated that the specified address is not a code location.

Effect. The command is not executed.

Recovery. Make sure that specified address is in the code space (verify the address with the AMAP command, if necessary).

62

```
Command string is not allowed or was specified previously.
```

Cause. Either command strings are not allowed or one had been specified previously.

Effect. The command is not executed.

Recovery. Do not use command strings when the change (C) access type is specified with the BM command.

63

```
Condition or trace breakpoint is not allowed.
```

Cause. You specified a combination of options for the BM command that is not allowed.

Effect. The command is not executed.

Recovery. Do not use conditions or trace breakpoint when the C access type is specified with the BM command.

64

```
IX, IG, and I are not allowed for extended address.
```

Cause. An extended address was specified for the trace or condition clause on a breakpoint. The IX, IG, and I options cannot be used with an extended address.

Effect. The command is not executed.

Recovery. If an extended address must be used, use SX to allow indexing.

65

```
Memory is absent and page fault is not allowed.
```

Cause. When attempting to set a memory access breakpoint (MAB), the page was not found, and a page fault is not allowed on a process.

Effect. None.

Recovery. Use the C command to clear the MAB, if necessary. Make sure that the memory manager has sufficiently high priority. Check the code to see if code breakpoint can be set instead of MAB.

66

```
Cannot set TNS breakpoint at this location because there is no corresponding
RISC breakpoint. Use the PMAP command to find matching RISC location near
this TNS location.
```

Cause. An attempted was made to set a TNS breakpoint in an accelerated program. A TNS breakpoint can be set only at a memory-exact or a register-exact point.

Effect. The command is not executed.

Recovery. Use the PMAP command to find the appropriate TNS locations or set breakpoint in the accelerated RISC code.

67

```
CM command required to clear MAB.
```

Cause. An attempt was made to clear a memory-access breakpoint using the C command.

Effect. The command is not executed.

Recovery. Use the CM command to clear the MAB.

68

```
Need code address to find and clear breakpoint.
```

Cause. An attempt was made to clear a breakpoint using the C command, but no code address was specified. The C command without an address can be used only if the current program location is at a breakpoint.

Effect. The command is not executed.

Recovery. Specify an address to the C command, or use some other option available in the C command syntax.

69

```
Breakpoint matching address not found.
```

Cause. The specified address to the C command could not be found in the breakpoint table.

Effect. The command is not executed.

Recovery. Use the B or B* command to see the contents of the breakpoint table.

70

```
Invalid conversion base.
```

Cause. The specified output base was not acceptable for the indicated command. The acceptable base set for the equal (=) command are as follows: A, B, H, E, N, O, R, T, #, and %. Other commands have more restricted sets. For more information on the description of the Debug commands, see Debug Commands on page 4-1.

Effect. The command is not executed.

Recovery. Specify the appropriate base and try again.

71

```
Base E not allowed when value cannot be stored in 16-bits.
```

Cause. The specified value for the = command did not fit into 16 bits. Converting a value to E register requires the value to fit in 16 bits.

Effect. The command is not executed.

Recovery. Make sure that the value that you specified fits into 16 bits.

72

```
Multiple commas (,,) found.
```

Cause. Multiple commas were found. The syntax is meaningless.

Effect. The specified command is not executed.

Recovery. Fix the syntax and try again.

73

```
Multiple display-format found or syntax is invalid.
```

Cause. The display-format was specified more than once, or the specified syntax was invalid.

Effect. The command is not executed.

Recovery. Fix the command and try again.

74

```
Expected display-format of B, B1, B2, B4, C, S, or L.
```

Cause. A valid display-format value was not specified.

Effect. The command is not executed.

Recovery. Specify one of the valid display-format values listed in the message text and try again.

75

```
Count value appears more than once or syntax is invalid.
```

Cause. Either more than one count value was specified or the syntax was invalid.

Effect. The command is not executed.

Recovery. Check the syntax, and make the necessary corrections and try again.

76

```
Expected %, #, D, H, or O.
```

Cause. One of the possible base values was not specified.

Effect. The command is not executed.

Recovery. Specify one of the possible output base values listed in the message text and try again.

77

```
Expected T, N, or R.
```

Cause. One of the specified values (T, N, or R) was not specified.

Effect. The command is not executed.

Recovery. To override the I command's base value, specify T for TNS instructions, and N or R for RISC instructions.

78

```
Invalid signal name.
```

Cause. The specified signal name did not match any of the known signals.

Effect. The command is not executed.

Recovery. Check the signal names that are available using the IH command without parameters.

79

```
Attempt to get signal information failed.
```

Cause. The attempt to access information about the signal failed.

Effect. The command is not executed.

Recovery. Check the syntax of the command that you are using. If the syntax is correctly specified, contact your service provider with the description of the problem.

80

```
Expected SIG_DFL, SIG_ABORT, SIG_DEBUG, or SIG_IGN.
```

Cause. One of the expected options was not specified when using the MH command.

Effect. The command is not executed.

Recovery. Make sure that one of the options in the message text is specified and try again.

81

```
Attempt to modify signal information failed.
```

Cause. An attempt to modify signal information failed.

Effect. The command is not executed.

Recovery. Check the syntax to make sure that it is correct. Also, make sure that the PIN is correct. If this error persists, contact your service provider.

82

```
Cannot change another process’s registers.
```

Cause. You attempted to modify registers while vectored to another process.

Effect. The command is not executed.

Recovery. You must be debugging the same PIN you started with in order to change register values. See the #DEBUGPROCESS command in the *TACL Reference Manual* to start debugging a process that is already active.

83

```
Space ID must be 0 through 31 (decimal).
```

Cause. The specified space ID was out of range. Space IDs are limited to the range 0 through 31(decimal).

Effect. The command is not executed.

Recovery. Check the number you specified. Specify the numeric prefix (%, #, or 0X), if necessary.

84

```
Cannot modify V PIN memory.
```

Cause. You attempted to modify an address location that might be a code location or the address might not be resident.

Effect. The command is not executed.

Recovery. If you want to modify this address, you must debug the process directly, not vector to it. See the #DEBUGPROCESS command in the *TACL Reference Manual* to start debugging a process directly. You can get more information about the address with the AMAP command.

85

```
Command is either invalid or requires PRV ON.
```

Cause. You specified a command that was either invalid or required privileged mode.

Effect. The command is not executed.

Recovery. If you know the command you specified is valid, check to see if it is a privileged command. If it is a privileged command, first issue the PRV ON command, then specify the command you want to use. You must be the super ID (255,255) in order to access the privileged commands.

86

```
Attempting to create an address for selectable segment when no selectable
segments are in use.
```

Cause. An attempt to create an address for a selectable segment was made, but there is no selectable segment in use.

Effect. The command is not executed.

Recovery. The program must allocate a selectable segment before attempting to create an address for it.

87

```
TNS or accelerated program required.
```

Cause. The attempt to set a TNS register on a native program failed.

Effect. The command is not executed.

Recovery. Make sure that your are specifying the correct register name for the program type.

88

```
Code segment number is out of range.
```

Cause. The specified code segment number was out of range.

Effect. The command is not executed.

Recovery. Make sure that you specify a segment number that is within the range.

89

```
Internal error: CHANGE_T16R.
```

Cause. An internal error occurred for a native program.

Effect. The command is not executed.

Recovery. Contact your service provider with the description of the encountered problem.

90

```
Internal error: CHANGE_T9.
```

Cause. An unknown emulation mode error occurred.

Effect. The command is not executed.

Recovery. Contact your service provider with the description of the encountered problem.

91

```
TNS starting address is zero.
```

Cause. The PMAP command encountered an error indicating that the starting value for the TNS address was zero.

Effect. The command might be partially executed.

Recovery. Make sure that the specified address is correct and try again.

92

```
TNS ending address is zero.
```

Cause. The PMAP command encountered an error indicating that ending-value of the TNS address was zero.

Effect. The command might be partially executed.

Recovery. Make sure that the address and the length specified for the PMAP command are correct.

93

```
Cannot access Inspect while vectored to another PIN.
```

Cause. You attempted to use an Inspect command while vectored to another PIN.

Effect. None.

Recovery. If you want to use Inspect commands, you must vector back to the PIN where you started from by entering the V command with no parameters.

94

```
Attempt to switch to Inspect failed.
```

Cause. The attempt to switch to the Inspect debugger failed.

Effect. None.

Recovery. Make sure that DMON is running in the processor where you are working.

95

```
Expecting: standard, octal, decimal, hexadecimal, S, O, D, or H.
```

Cause. The BASE command indicated that the user did not specify one of the expected options (standard, octal, decimal, hexadecimal, S, O, D, or H).

Effect. The specified command is not executed.

Recovery. Specify one of the given options and try again.

96

```
Expecting: In, Out, I, or O.
```

Cause. The BASE command asked whether the specified base was for an input or for an output.

Effect. The specified command is not executed.

Recovery. Indicate whether the base is an input or an output.

97

```
Bad information in jump buffer.
```

Cause. The DJ command encountered an error while attempting to process the information in the jump buffer that is pointed to by the specified address.

Effect. The specified command is not performed.

Recovery. Specify an appropriate address and try again.

98

```
TNS address pointed to PEP area.
```

Cause. The specified TNS address for the BREAK command pointed to word 0 or word 1 of the procedure entry table.

Effect. The command is not executed.

Recovery. Make sure that you have specified the correct address for the break (B) command.

99

```
OSP is not a supported option.
```

Cause. You attempted to use the OSP option, which is not available on this version of Debug.

Effect. The command is not executed.

Recovery. Try the command without the OSP option.

100

```
PIN does not use IEEE floating point.
```

Cause. The command referenced a floating-point register, but either the PIN does not use IEEE floating-point instructions or an IEEE floating-point instruction is not executed at this point in the program.

Effect. The command is not executed.

Recovery. If you think the program at this PIN uses IEEE floating-point instructions, you might need to delay the command until an IEEE floating-point instruction is executed and the IEEE floating-point usage flag is enabled in the program control block (PCB).

101

```
IEEE floating-point registers cannot be used here.
```

Cause. An IEEE floating-point register was referenced in the specified command syntax. Unlike the general purpose registers $00 through $31, IEEE floating-point register values cannot be used in the syntax of some commands, because Debug can handle only 32-bit integer expressions and it cannot determine if the specified IEEE floating-point register is used as a 32-bit integer.

Effect. The command is not executed.

Recovery. If you need the contents of the IEEE floating-point registers, first display the value of the register and then use this value with the command syntax. Note that the register value must be an integer that can be expressed in 32-bit form.

102

```
Cannot set the Memory Access Breakpoint at this address as a code breakpoint
already exists at given location.
```

Cause. The command tried to set a Memory Access Breakpoint at a location where a code breakpoint either exists in same process or in all processes in same processor.

Effect. The command is not executed.

Recovery. Try the command after removing the existing code breakpoint at the same location.

103

```
Cannot set the code breakpoint at this address as Memory Access Breakpoint
already exists at given location.
```

Cause. The command tried to set a code breakpoint at a location where a Memory Access Breakpoint either exists in same process or in all processes in same processor.

Effect. The command is not executed.

Recovery. Try the command after removing the existing Memory Access Breakpoint at the same location.

104

```
Cannot set the Memory Access Breakpoint in all processes at this address as a
code breakpoint already exists at given location.
```

Cause. The command tried to set an all process Memory Access Breakpoint at a location where a code breakpoint either exists in same process or in all processes in same processor.

Effect. The command is not executed.

Recovery. Try the command after removing the existing code breakpoint at the same location.

105

```
Cannot set the code breakpoint in all processes at this address as Memory
Access Breakpoint already exists at given location.
```

Cause. The command tried to set an all process code breakpoint at a location where a Memory Access Breakpoint either exists in same process or in all processes in same processor.

Effect. The command is not executed.

Recovery. Try the command after removing the existing Memory Access Breakpoint at the same location.

B ASCII Character Set

Char	Octal		Hex	Dec	Meaning	Ordinal
	Left	Right				
NUL	000000	000000	0	0	Null	1
SOH	000400	000001	1	1	Start of heading	2
STX	001000	000002	2	2	Start of text	3
ETX	001400	000003	3	3	End of text	4
EOT	002000	000004	4	4	End of transmission	5
ENQ	002400	000005	5	5	Enquiry	6
ACK	003000	000006	6	6	Acknowledge	7
BEL	003400	000007	7	7	Bell	8
BS	004000	000010	8	8	Backspace	9
HT	004400	000011	9	9	Horizontal tabulation	10
LF	005000	000012	A	10	Line feed	11
VT	005400	000013	B	11	Vertical tabulation	12
FF	006000	000014	C	12	Form feed	13
CR	006400	000015	D	13	Carriage return	14
SO	007000	000016	E	14	Shift out	15
SI	007400	000017	F	15	Shift in	16
DLE	010000	000020	10	16	Data link escape	17
DC1	010400	000021	11	17	Device control 1	18
DC2	011000	000022	12	18	Device control 2	19
DC3	011400	000023	13	19	Device control 3	20
DC4	012000	000024	14	20	Device control 4	21
NAK	012400	000025	15	21	Negative acknowledge	22
SYN	013000	000026	16	22	Synchronous idle	23
ETB	013400	000027	17	23	End of transmission block	24
CAN	014000	000030	18	24	Cancel	25
EM	014400	000031	19	25	End of medium	26
SUB	015000	000032	1A	26	Substitute	27
ESC	015400	000033	1B	27	Escape	28
FS	016000	000034	1C	28	File separator	29
GS	016400	000035	1D	29	Group separator	30
RS	017000	000036	1E	30	Record separator	31
US	017400	000037	1F	31	Unit separator	32

Char	Octal		Hex	Dec	Meaning	Ordinal
	Left	Right				
SP	020000	000040	20	32	Space	33
!	020400	000041	21	33	Exclamation point	34
"	021000	000042	22	34	Quotation mark	35
#	021400	000043	23	35	Number sign	36
$	022000	000044	24	36	Dollar sign	37
%	022400	000045	25	37	Percent sign	38
&	023000	000046	26	38	Ampersand	39
'	023400	000047	27	39	Apostrophe	40
(	024000	000050	28	40	Opening parenthesis	41
)	024400	000051	29	41	Closing parenthesis	42
*	025000	000052	2A	42	Asterisk	43
+	025400	000053	2B	43	Plus	44
,	026000	000054	2C	44	Comma	45
-	026400	000055	2D	45	Hyphen (minus)	46
.	027000	000056	2E	46	Period (decimal point)	47
/	027400	000057	2F	47	Right slash	48
0	030000	000060	30	48	Zero	49
1	030400	000061	31	49	One	50
2	031000	000062	32	50	Two	51
3	031400	000063	33	51	Three	52
4	032000	000064	34	52	Four	53
5	032400	000065	35	53	Five	54
6	033000	000066	36	54	Six	55
7	033400	000067	37	55	Seven	56
8	034000	000070	38	56	Eight	57
9	034400	000071	39	57	Nine	58
:	035000	000072	3A	58	Colon	59
;	035400	000073	3B	59	Semicolon	60
<	036000	000074	3C	60	Less than	61
=	036400	000075	3D	61	Equals	62
>	037000	000076	3E	62	Greater than	63
?	037400	000077	3F	63	Question mark	64
@	040000	000100	40	64	Commercial at sign	65
A	040400	000101	41	65	Uppercase A	66
B	041000	000102	42	66	Uppercase B	67

Char	Octal		Hex	Dec	Meaning	Ordinal
	Left	Right				
C	041400	000103	43	67	Uppercase C	68
D	042000	000104	44	68	Uppercase D	69
E	042400	000105	45	69	Uppercase E	70
F	043000	000106	46	70	Uppercase F	71
G	043400	000107	47	71	Uppercase G	72
H	044000	000110	48	72	Uppercase H	73
I	044400	000111	49	73	Uppercase I	74
J	045000	000112	4A	74	Uppercase J	75
K	045400	000113	4B	75	Uppercase K	76
L	046000	000114	4C	76	Uppercase L	77
M	046400	000115	4D	77	Uppercase M	78
N	047000	000116	4E	78	Uppercase N	79
O	047400	000117	4F	79	Uppercase O	80
P	050000	000120	50	80	Uppercase P	81
Q	050400	000121	51	81	Uppercase Q	82
R	051000	000122	52	82	Uppercase R	83
S	051400	000123	53	83	Uppercase S	84
T	052000	000124	54	84	Uppercase T	85
U	052400	000125	55	85	Uppercase U	86
V	053000	000126	56	86	Uppercase V	87
W	053400	000127	57	87	Uppercase W	88
X	054000	000130	58	88	Uppercase X	89
Y	054400	000131	59	89	Uppercase Y	90
Z	055000	000132	5A	90	Uppercase Z	91
[	055400	000133	5B	91	Opening bracket	92
\	056000	000134	5C	92	Back slash	93
]	056400	000135	5D	93	Closing bracket	94
^	057000	000136	5E	94	Circumflex	95
_	057400	000137	5F	95	Underscore	96
`	060000	000140	60	96	Grave accent	97
a	060400	000141	61	97	Lowercase a	98
b	061000	000142	62	98	Lowercase b	99
c	061400	000143	63	99	Lowercase c	100
d	062000	000144	64	100	Lowercase d	101
e	062400	000145	65	101	Lowercase e	102

Char	Octal Left	Octal Right	Hex	Dec	Meaning	Ordinal
f	063000	000146	66	102	Lowercase f	103
g	063400	000147	67	103	Lowercase g	104
h	064000	000150	68	104	Lowercase h	105
i	064400	000151	69	105	Lowercase i	106
j	065000	000152	6A	106	Lowercase j	107
k	065400	000153	6B	107	Lowercase k	108
l	066000	000154	6C	108	Lowercase l	109
m	066400	000155	6D	109	Lowercase m	110
n	067000	000156	6E	110	Lowercase n	111
o	067400	000157	6F	111	Lowercase o	112
p	070000	000160	70	112	Lowercase p	113
q	070400	000161	71	113	Lowercase q	114
r	071000	000162	72	114	Lowercase r	115
s	071400	000163	73	115	Lowercase s	116
t	072000	000164	74	116	Lowercase t	117
u	072400	000165	75	117	Lowercase u	118
v	073000	000166	76	118	Lowercase v	119
w	073400	000167	77	119	Lowercase w	120
x	074000	000170	78	120	Lowercase x	121
y	074400	000171	79	121	Lowercase y	122
z	075000	000172	7A	122	Lowercase z	123
{	075400	000173	7B	123	Opening brace	124
|	076000	000174	7C	124	Vertical line	125
}	076400	000175	7D	125	Closing brace	126
~	077000	000176	7E	126	Tilde	127
DEL	077400	000177	7F	127	Delete	128

C Command Syntax Summary

Register Syntax

```
register
```

The *register* parameter can be either a TNS/R register or a TNS environment register. A TNS/R register has one of these formats:

```
{ $00| $01 | ... | $31 }
{ $HI | $LO            }
{ $PC                  }
{ $F00| $F01 | ... | $F31 }
{ $FCR31                  }
```

Alias names are also valid for registers $01 through $31and $F00 through $F09 as follows:

Register	Alias	Register	Alias
$00			
$01	$AT	$16	$S0
$02	$V0	$17	$S1
$03	$V1	$18	$S2
$04	$A0	$19	$S3
$05	$A1	$20	$S4
$06	$A2	$21	$S5
$07	$A3	$22	$S6
$08	$T0	$23	$S7
$09	$T1	$24	$T8
$10	$T2	$25	$T9
$11	$T3	$26	$K0
$12	$T4	$27	$K1
$13	$T5	$28	$GP
$14	$T6	$29	$SP
$15	$T7	$30	$S8 or $FP
		$31	$RA
$F00	$F0	$F05	$F5
$F01	$F1	$F06	$F6
$F02	$F2	$F07	$F7
$F03	$F3	$F08	$F8
$F04	$F4	$F09	$F9

A TNS environment register has one of these formats:

```
{ S | P | E | L | SP }
{ R0 | R1 | ... | R7 }
{ RA | RB | ... | RH }
```

Expression Syntax

```
term [ { + } term ]...
       { - }
```

The *term* parameters is of the form:

```
value [ op value ]...
```

The *value* parameter has one of these forms:

```
( expression )
'c1[c2[c3[c4]]]'
PCB expression              ! privileged mode only
number[.number]
K [ X | D ] address
```

The *number* parameter has one of these two forms:

```
[ + | - | % | # | %H | 0X ] integer
register
```

The value of *op* is one of these arithmetic operators:

```
*
/
<<
>>
```

Address Syntax

```
[ 32-bit-address ] | [ TNS-style ] | [ Q-mode ] | [ N-mode ]
```

The *TNS-style* address has this format:

```
[ address-mode ] offset [ indirection-type [ index ] ]
```

The *address-mode* parameter has one of these values:

```
UC[.segment-num, ]
UL[.segment-num, ]
SC[.segment-num, ]     ! privileged mode only
SL[.segment-num, ]     ! privileged mode only
UD[,]
C
L
S
```

```
Q
G                          ! privileged mode only
```

The *indirection-type* parameter has one of these values:

```
I
S
IX
SX
IG                    ! privileged mode only
SG                     ! privileged mode only
```

The Q-mode address has these format:

```
offset [indirection-type ]
```

The N-mode address has this format:

```
N
```

A Command

```
A address [ , length ] [ , data-display-format ]
   [ , [ OUT ] output-dev ]
```

The *length* parameter has one of these two forms:

```
count
T entry-size * num-entries
```

The *data-display-format* parameter has this format:

```
{ B |  B1 | C | B2 | S | B4 | L }
```

The *output-dev* parameter is described later in this appendix under Output-Device Syntax.

AMAP Command

```
AMAP address
```

B Command

Set Unconditional Code Breakpoint

```
B address [, ALL ]
```

The ALL option is allowed only in privileged mode.

Set Conditional Code Breakpoint

```
B address

 {, {register |start-address }[& mask] op constant [, ALL] }
 { [, ALL] , {register |start-address }[& mask] op constant }
```

op is:

```
{ < | > | = | <> }
```

The ALL option is allowed only in privileged mode.

Set Trace Code Breakpoint

```
B address {, {register |start-address } ? count [, ALL ]   }
            { [ , ALL ] {register |start-address }? count }
```

The ALL option is allowed only in privileged mode.

Set Execute Code Breakpoint

```
B address {, ( command-string ) [, ALL ]   }
            {  [, ALL ] ( command-string ) }
```

The ALL option is allowed only in privileged mode.

Display Breakpoints

```
B [ * ]
```

BASE Command

```
BASE [ STANDARD    | S ] [ IN  | I ]
     [ OCTAL       | O ] [ OUT | O ]
     [ DECIMAL     | D ]
     [ HEXADECIMAL | H ]
```

BM Command

Set Unconditional Memory-Access Breakpoint

```
BM address , access [, ALL ]
```

access is:

R
RW
WR
W
C

The ALL option is allowed only in privileged mode.

Set Conditional Memory-Access Breakpoint

```
BM address , access

 {, {register | start-address }[& mask] op constant [, ALL ]}
 { [, ALL ] {register | start-address }[& mask] op constant }
```

The value of *access* is one of the following:

R
RW
WR
W

The *op* parameter has this format:

```
{ < | > | = | <> }
```

The ALL option is allowed only in privileged mode.

Set Trace Memory-Access Breakpoint

```
BM address , access

   {, {register | start-address } ? count [, ALL ]   }
   {  [, ALL ] {register | start-address } ? count }
```

The value of *access* is one of the following:

R
RW
WR
W

The ALL option is allowed only in privileged mode.

Set Execute Memory-Access Breakpoint

```
BM address , access

   {, ( command-string ) [, ALL ]   }
   { [, ALL ] ( command-string ) }
```

The value of *access* is one of the following:

```
R
RW
WR
W
```

The ALL option is allowed only in privileged mode.

C Command

```
C [ address ]
  [ *   | 0   ]
  [ -1        ]
```

CM Command

```
CM [ , ALL ]
```

D Command

Display Variables

```
D address [ , length ] [ , data-display-format ]

   [ , [ OUT ] output-dev ] [ : d-base ]
```

The *length* parameter has one of these two formats:

```
count
T entry-size * num-entries
```

The *data-display-format* parameter has this format:

```
{ B | B1 | C | B2 | S | B4 | L }
```

The *output-dev* parameter is described later in this appendix under Output-Device Syntax on page C-9.

d-base has this format:

```
{ % | # | D | H | O }
```

Display Register Contents

```
D [ register ] [ , [ OUT ] output-dev ]
  [ *        ]
```

The *output-dev* parameter is described later in this appendix under Output-Device Syntax on page C-9.

DJ Command

```
DJ 32-bit-address
```

DN Command

```
DN 32-bit-address [ count-format ] [ display-format ]
```

The *count-format* parameter has this format:

```
{ FOR | , } count [ count-size ] [ BY columns ]
```

The value of *count-size* is one of the following:

```
{ B1 | B2 | B3 | B4 }
```

The *display-format* parameter has this format:

```
{ IN | : } [ S | U ] display-type [ display-size ]
```

The value of *display-type* is one of the following:

```
{ A           }
{ I           }
{ T           }
{ B | %B      }
{ O | %O | % }
{ D | %D | # }
{ H | %H | X }
```

EX[IT] Command

```
EX[IT]
```

F[ILES] Command

```
F[ILES] [ file-number ]
```

FC Command

```
FC
```

FN Command

```
FN [ address [ , value ] [ & mask ] ]
```

FNL Command

```
FNL [ address [ , value ] [ & mask ] ]
```

FREEZE Command

```
FREEZE
```

The FREEZE command is allowed only in privileged mode.

HALT Command

```
HALT
```

The HALT command is allowed only in privileged mode.

H[ELP] Command

```
H[ELP] [ debug-command   ]
       [ variable-item   ]
```

I Command

```
I address [ , length ]

   [ , [ OUT ] output-dev ] [ : mode ]
```

The *output-dev* parameter is described later in this appendix under Output-Device Syntax on page C-9.

The *mode* parameter has this format:

```
{ T | N | R   }
```

IH Command

```
IH [ signal-name ]
```

The IH command is allowed only on native processes.

INSPECT Command

```
INSPECT
```

LMAP Command

```
LMAP address
```

M Command

Modify Variables

```
M address [ , new-value ] ...
```

Modify Register Contents

```
M register [ , new-value ]
```

MH Command

```
MH signal-name , { sigaction | 32-bit-address }
```

The MH command is allowed only on native processes.

Output-Device Syntax

The *output-dev* parameter has these formats.

Syntax for a device other than a disk is:

```
[ node.]{device-name[.qualifier ] }
        {ldev-number              }
```

Syntax for a named process is:

```
[ node.]process-name[:seq-no][.qual-1[.qual-2] ]
```

Syntax for an unnamed process is:

```
[ node.]$:cpu:pin:seq-no
```

P[AUSE] Command

```
P[AUSE] pause-time
```

PMAP Command

```
PMAP address [ , count ] [ , [ OUT ] output-dev ]
```

The PMAP command is allowed only on accelerated programs.

PRV Command

```
PRV [ ON | OFF ]
```

△ **Caution.** Use privileged commands with extreme caution, because they allow you to perform operations that could halt the system. Note that only the local super ID (255, 255) is allowed to use the PRV ON command.

R Command

```
R [ expression-1 op expression-2 ]
```

The *op* parameter has this format:

```
{ < | > | = | <> }
```

S[TOP] Command

```
S[TOP]
```

T Command

```
T [ & ] [ N ] [ options ] [ , [ OUT ] output-dev ]
```

The *options* parameter is one or more of the following, separated by commas:

[*register* [=]] *expression*

MODE { N[ATIVE] | T[NS] | A[CCELERATED] }

AT *expression*

J *32-bit-address*

The *output-dev* parameter is described in Output-Device Syntax on page C-9.

V Command

```
V [ QA ] [ expression-16 ]
```

The V command is allowed only in privileged mode.

VQ Command

```
VQ [ expression-16 ]
```

VQA Command

```
VQA [ expression-16 ]
```

The VQA command is allowed only in privileged mode.

= Command

```
= expression [ : [ # ] ]
               [ % ]
               [ B ]
               [ A ]
               [ N ]
               [ E ]
               [ H ]
               [ R ]
               [ T ]
```

? Command

```
?
```

D Session Boundaries

Typically, a Debug session begins when Debug is invoked for a process and the Debug prompt is displayed on the process's home terminal. Typically, the session ends when you leave Debug (EXIT command), resume process execution (R command), or stop the process (S command). Most Debug commands affect only the current debugging session. The effects of certain commands, however, cross session boundaries.

For example if your current Debug session is the result of setting a breakpoint in a previous session, this current session can inherit options set in the previous session. The effects of nonprivileged Debug commands can persist as long as the process being debugged executes. They cannot affect another process.

Privileged commands, however, can affect a whole processor and can persist even if the particular process being debugged goes away.

The possible scope of Debug commands, both nonprivileged and privileged, is illustrated in Figure D-1 on page D-2.

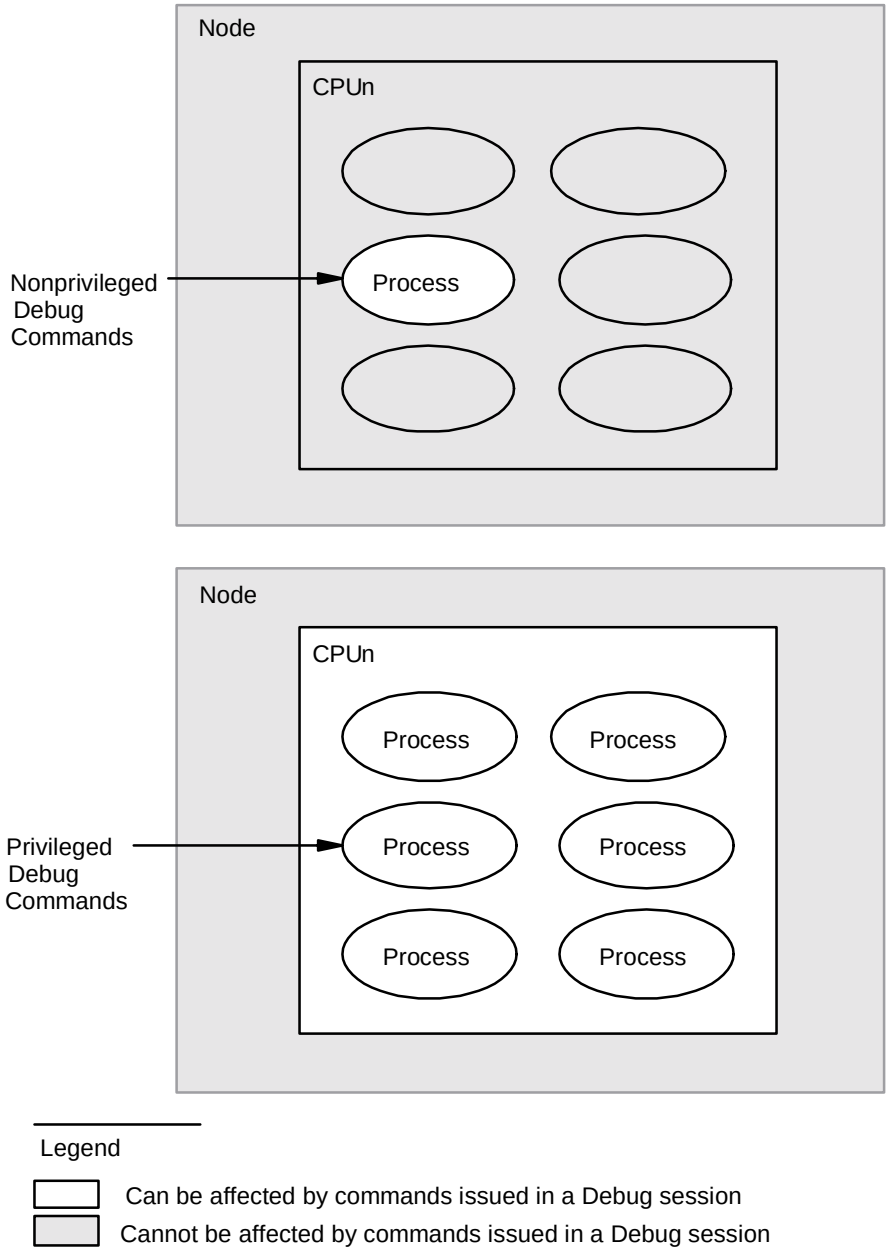
Command persistence of nonprivileged commands is summarized in Table D-1. The table is based on the assumption that you do not issue a command to override or cancel the particular commands.

Table D-1. Nonprivileged Command Persistence (With Scope of a Process)

Command	Resume Command	Creates a New Process	Process Stops/Abends	Canceling Command
BASE	Retained	Retained *	Canceled	BASE
B (code breakpoint)	Retained	Retained *	Canceled	C
BM (memory-access breakpoint)	Retained	Retained *	Canceled	CM; inhibited by a BM ALL privileged command

* The commands are retained for the old process. No commands from debugging the old process are inherited by the new process.

Figure D-1. Scope of Debug Commands' Effects



If you issue privileged commands (described under the PRV command), commands are effective for the processor. The particular process you are debugging can go away, but the command persists. The commands can be canceled during the privileged debugging of any process in the processor. Command persistence of privileged commands is summarized in Table D-2 on page D-3.

Table D-2. Privileged Command Persistence (With Scope of the Processor)

Command	Resume Command	Process Stops/Abends	Canceling Operation
PRV	Retained	Canceled	N / A
B ... ALL (code breakpoint)	Retained	Retained	C –1 command; memory or code space cleared
BM ... ALL (memory-access breakpoint)	Retained	Retained	CM ALL; memory or code space cleared
FREEZE *	N / A	N / A	Lobug R (resume) command or reload the processor
HALT	N / A	N / A	Lobug command that starts processor or reloads the processor

* The FREEZE command can affect other processors in a system, depending on switch settings made through the Remote Console Process (RCP).

Note. Invoking and debugging in the Inspect debugger and returning to Debug has no effect on session-inherited attributes. Debug retains the effects of the previous commands issued in the Debug environment. Debug commands do not affect the Inspect debugger. Privilege mode set in the Inspect debugger is retained in Debug. For more information on using the Inspect debugger, see the INSPECT command description in Section 4, Debug Commands and the *Inspect Reference Manual*.

Correspondence Between Debug and Inspect Commands

Table E-1 shows the correspondence of Debug commands to Inspect low-level commands. The low-level Inspect debugger also supports high-level Inspect commands. For more information about Inspect commands, see the *Inspect Manual*.

Table E-1. Correspondence Between Debug and Inspect Commands (page 1 of 2)

Debug Command	Low-Level Inspect Command	Command Description for Debug and Low-Level Inspect
A	A	Display data or registers in ASCII
AMAP	—	Provide information about an address
B	B	Set code breakpoint
BASE	SET RADIX	Set numeric base for input, output, or both
BM	BM	Set memory-access breakpoint
C	C	Clear code breakpoint
CM	CM	Clear memory-access breakpoint
D	D	Display data or registers in a specified numeric format
DJ	—	Display jump buffer contents in register format
DN	—	Display memory in the specified format
EX[IT]	—	Exit the debug session
F[ILES]	F	File status query
FC	FC	Edit or repeat command
FN	FN	Search memory for 16-bit number
FNL	—	Search memory for 32-bit number
FREEZE	—	Disable the processor and assert a freeze on other processors
H[ELP]	HELP	Display commands
HALT	—	Halt a processor
I	I	Display data or registers in RISC code or TNS code
IH	—	Display information about signal handling
INSPECT	SELECT DEBUGGER DEBUG	Switch from Inspect to Debug or from Debug to Inspect

Table E-1. Correspondence Between Debug and Inspect Commands (page 2 of 2)

Debug Command	Low-Level Inspect Command	Command Description for Debug and Low-Level Inspect
LMAP	—	Display procedure name and offset that corresponds to a specified address
M	M	Modify data and registers
MH	—	Modify signal handling
P[AUSE]	P	Pause program execution
PMAP	ICODE	Display TNS and RISC instruction code
PRV	SET PRIV MODE	Enable or disable privileged debugging
R	R	Resume program execution
S[TOP]	S	Stop the current program
T	T	Trace stack markers
V	—	Enable access to another address space
VQ	VQ	Change selectable segment
VQA	—	Set the current selectable data segment to absolute segment number
?	?	Display segment ID (code and data)
=	=	Compute a value

F Sample Debug Sessions

This section of the manual provides step-by-step demonstrations of using Debug commands for debugging TNS, accelerated, and native programs. For more information on TNS programs, accelerated programs, and native programs, see Section 2, Using Debug on TNS/R Processors in this manual.

We provide the source listing (Example F-1 on page F-2), which can be compiled with either a TAL or pTAL compiler. We also provide TNS and native program listings. When going through the examples, you should refer to the compiled listings; otherwise, the examples will not make much sense to you.

Overview of Example Program

The first few lines of the source code listing show declarations of various procedures. For more information about these procedures, see the *Guardian Procedure Calls Reference Manual*. Following the procedure declarations, there are three global variables, INT MY_TERMNUM, INT array PROCESS_HANDLE, and an extended STRING pointer SP that is initialized to starting address of 2000000 (octal).

Following the global variables, there is the EXAMPLE_INIT procedure, which has a set of local variables and some code that uses some of the procedure declared at the beginning of the program. The code manipulates both local and global variables. Note that the EXAMPLE_INIT procedure opens a terminal file. We will write data to and read data from this file to demonstrate the use of various Debug commands.

The EXAMPLE_FILL_ARRAY procedure takes a single parameter. This procedure also has some local variables and code. The code manipulates global and local variables. This procedure reads and writes the terminal opened by the EXAMPLE_INIT procedure.

Finally, we have the EXAMPLE_MAIN procedure, which is declared as the MAIN of the program. This procedure calls the EXAMPLE_INIT procedure, allocates memory segments, then calls the EXAMPLE_FILL_ARRAY procedure several times, passing in a different memory segment number on each call.

Example F-1. Example Source Code for SDEMO1

```
    7.01  ?NOLIST, SOURCE $system.system.extdecs (DEBUG, FILE_OPEN_,
    7.11  ?  INITIALIZER, PROCESS_GETINFO_, PROCESSHANDLE_NULLIT_,
    7.111 ?  SEGMENT_ALLOCATE_, SEGMENT_USE_, WRITEREADX)
    8     ?LIST
    8.1   INT         my_termnum;
    8.101 INT         process_handle [0:9];
    8.11  STRING .EXT sp := %2000000D;

    8.22  PROC example_init;
    8.23  BEGIN
    8.3     INT      error_init;
    8.301   INT .EXT handle_ptr;
    8.302   STRING   hometerm [0:47];
    8.304   INT      hometerm_len;
    8.305   STRING  .hometerm_ptr;

    8.307   INITIALIZER; ! external system procedure
    8.308   error_init := PROCESSHANDLE_NULLIT_ (process_handle);
    8.31    error_init := PROCESS_GETINFO_ (process_handle,
    8.311      !fname:max!, !fname-len!, !priority!,
    8.312      !mom!, hometerm:48, hometerm_len);
    8.313   error_init := FILE_OPEN_ (hometerm:hometerm_len, my_termnum);

    8.317   IF error_init <> 0 THEN
    8.32      DEBUG;

    8.34    @hometerm_ptr := @hometerm [0];
    8.341   @handle_ptr := $WADDR_TO_EXTADDR (@process_handle [0]);
    8.35  END; -- example_init

    9     PROC example_fill_array (array_num);
    9.01    INT array_num;
    9.1   BEGIN
    9.101   INT         count_read;
    9.11    INT         error_fill_array;
    9.111   STRING     .in_out_msg [0:47];
    9.112   STRING .EXT segment_ptr;
    9.114   error_fill_array := SEGMENT_USE_ (array_num);
    9.12    IF error_fill_array <> 0 THEN
    9.121     DEBUG;
    9.122   sp [0] := array_num;
    9.123   @segment_ptr := @sp [41];
    9.124   in_out_msg [0] ':=' "enter some data" & %h0D0A; -- CR LF
    9.13    WRITEREADX (my_termnum, in_out_msg, 17, 48, count_read);
    9.14    segment_ptr ':=' in_out_msg [0] FOR count_read bytes;
    9.2   END; -- example_fill_array

    9.3    PROC example_main MAIN;
   10     BEGIN
   11.02    INT     error_main;
   11.03    INT     error_detail;

   12       example_init;

   12.007   error_main := SEGMENT_ALLOCATE_ (1, 131064D, !filename;len!,
error_detail);
   12.02    IF error_main <> 0 THEN
   12.021     DEBUG;
   12.022   error_main := SEGMENT_ALLOCATE_ (2, 131064D, !filename;len!,
error_detail);
   12.03    IF error_main <> 0 THEN
   12.031     DEBUG;
   12.032   error_main := SEGMENT_ALLOCATE_ (17, 258000D, !filename;len!,
error_detail);
   12.04    IF error_main <> 0 THEN
   12.05      DEBUG;

   12.2     example_fill_array (1);
   12.3     example_fill_array (2);
   13       example_fill_array (17);
```

```
14     END; -- example_maim
```

TNS Program Example

Example F-2 on page F-4 is a TNS program, obtained by compiling the source code (Example F-1 on page F-2) with TAL. Before we demonstrate the use of the Debug commands, we first need to compile this program to obtain an object file. The TAL compiler command entered is as follows:

```
TAL /IN sdemo1, OUT $S.#ldemo1/ demo1;  OPTIMIZE 0, LIST, NOINSPECT
```

OPTIMIZE 0 is used to make debugging easier. It forces intermediate results into memory instead of being held in the registers. While this makes debugging easier, it also results in slower code execution. For more information about using other OPTIMIZE values, refer to the *TAL Reference Manual*.

The following is the TNS example program that we will use to demonstrate the use of various Debug commands.

The TNS example program does not do much, but it has enough function to illustrate the use of most of the Debug commands.

The listing below shows the output of the TAL compiler and BINSERV, the binder. Observe these three parts of the listing:

- The 6-digit column shown on the left side of each procedure gives the relative offset, in octal, for the first instruction of the line.
- The register addresses of variables declared in the procedure are shown at the end of the procedure.
- The ENTRY POINT MAP shown at the end of the listing gives the base address for each procedure. If you don't have the program listing you can use the binder LMAP command to show information (for example, BIND LMAP FROM demo1).

Note. If you try these examples, there might be some differences between your output information and ours. These differences might be caused by changes to the program, changes to the compiler, the program running on a different system and processor, process number, and having a different terminal name. The following is the object file listing of the source program in Example F-1 on page F-2, minus some of the output information that is not relevant to our discussion.

Example F-2. TNS Example Compiled Listing

```
      ?  optimize 0, list, noinspect

     7.01  000000 0  0   ?NOLIST, SOURCE $system.system.extdecs (DEBUG, FILE_OPEN_,
     8.1   000000 0  0   INT         my_termnum;
     8.101 000000 0  0   INT         process_handle [0:9];
     8.11  000000 0  0   STRING .EXT sp := %2000000D;

     8.22  000000 0  0   PROC example_init;
     8.23  000000 1  0   BEGIN
     8.3   000000 1  1     INT      error_init;
     8.301 000000 1  1     INT .EXT handle_ptr;
     8.302 000000 1  1     STRING   hometerm [0:47];
     8.304 000000 1  1     INT      hometerm_len;
     8.305 000000 1  1     STRING  .hometerm_ptr;

     8.307 000000 1  1     INITIALIZER; ! external system procedure
     8.308 000007 1  1     error_init := PROCESSHANDLE_NULLIT_ (process_handle);
     8.31  000017 1  1     error_init := PROCESS_GETINFO_ (process_handle,
     8.311 000017 1  1        !fname:max!, !fname-len!, !priority!,
     8.312 000017 1  1        !mom!, hometerm:48, hometerm_len);
     8.313 000045 1  1     error_init := FILE_OPEN_ (hometerm:hometerm_len,
my_termnum);

     8.317 000063 1  1     IF error_init <> 0 THEN
     8.32  000066 1  1       DEBUG;

     8.34  000067 1  1     @hometerm_ptr := @hometerm [0];
     8.341 000072 1  1     @handle_ptr := $WADDR_TO_EXTADDR (@process_handle [0]);
     8.35  000076 1  1   END; -- example_init

ERROR_INIT                      Variable       INT             Direct         L+001
HANDLE_PTR                      Variable       INT             EXT Pointer    L+002
HOMETERM                        Variable       STRING          Direct         L+004
HOMETERM_LEN                    Variable       INT             Direct         L+034
HOMETERM_PTR                    Variable       STRING          Indirect       L+035

     8.4   000000 0  0
     9.    000000 0  0   PROC example_fill_array (array_num);
     9.01  000000 1  0     INT array_num;
     9.1   000000 1  0   BEGIN
     9.101 000000 1  1     INT         count_read;
     9.11  000000 1  1     INT         error_fill_array;
     9.111 000000 1  1     STRING     .in_out_msg [0:47];
     9.112 000000 1  1     STRING .EXT segment_ptr;

     9.114 000000 1  1     error_fill_array := SEGMENT_USE_ (array_num);
     9.12  000015 1  1     IF error_fill_array <> 0 THEN
     9.121 000020 1  1       DEBUG;
     9.122 000021 1  1     sp [0] := array_num;
     9.123 000024 1  1     @segment_ptr := @sp [41];
     9.124 000031 1  1     in_out_msg [0] ':=' "enter some data" & %h0D0A; -- CR LF
     9.13  000050 1  1     WRITEREADX (my_termnum, in_out_msg, 17, 48, count_read);
     9.14  000066 1  1     segment_ptr ':=' in_out_msg [0] FOR count_read bytes;
     9.2   000073 1  1   END; -- example_fill_array

ARRAY_NUM                       Variable       INT             Direct         L-003
COUNT_READ                      Variable       INT             Direct         L+001
ERROR_FILL_ARRAY                Variable       INT             Direct         L+002
IN_OUT_MSG                      Variable       STRING          Indirect       L+003
SEGMENT_PTR                     Variable       STRING          EXT Pointer    L+004

     9.21  000000 0  0
     9.3   000000 0  0   PROC example_main MAIN;
    10.    000000 1  0   BEGIN
    11.02  000000 1  1     INT     error_main;
    11.03  000000 1  1     INT     error_detail;
    12.    000000 1  1     example_init;

    12.007       error_main := SEGMENT_ALLOCATE_ (1, 131064D, !filename;len!,
error_detail);
```

```
    12.02  000021 1  1     IF error_main <> 0 THEN
    12.021 000024 1  1       DEBUG;
    12.022      error_main := SEGMENT_ALLOCATE_ (2, 131064D, !filename;len!,
error_detail);
    12.03  000044 1  1     IF error_main <> 0 THEN
    12.031 000047 1  1       DEBUG;
    12.032      error_main := SEGMENT_ALLOCATE_ (17, 258000D, !filename;len!,
error_detail);
    12.04  000070 1  1     IF error_main <> 0 THEN
    12.05  000073 1  1       DEBUG;

    12.2   000074 1  1     example_fill_array (1);
    12.3   000077 1  1     example_fill_array (2);
    13.    000102 1  1     example_fill_array (17);
    14.    000105 1  1   END; -- example_maim

ERROR_DETAIL                    Variable       INT             Direct         L+002
ERROR_MAIN                      Variable       INT             Direct         L+001
                                                               GLOBAL MAP
DEBUG                           Proc                           External
EXAMPLE_FILL_ARRAY              Proc                           %000000
EXAMPLE_INIT                    Proc                           %000000
EXAMPLE_MAIN                    Proc                           %000000
FILE_OPEN_                      Proc           INT             External
INITIALIZER                     Proc           INT             External
MY_TERMNUM                      Variable       INT             Direct
#GLOBAL+000
PROCESSHANDLE_NULLIT_           Proc           INT             External
PROCESS_GETINFO_                Proc           INT             External
PROCESS_HANDLE                  Variable       INT             Direct
#GLOBAL+001
SEGMENT_ALLOCATE_               Proc           INT             External
SEGMENT_USE_                    Proc           INT             External
SP                              Variable       STRING          EXT Pointer
#GLOBAL+013
WRITEREADX                      Proc                           External

                                                               LOAD MAPS

ENTRY POINT MAP BY NAME FOR FILE: \NODE.demo1
SP  PEP BASE   LIMIT  ENTRY  ATTRS    NAME                     DATE     TIME
00  003 000104 000210 000104         EXAMPLE_FILL_ARRAY       1998-07-08 14:53
00  002 000005 000103 000005         EXAMPLE_INIT             1998-07-08 14:53
00  004 000211 000320 000211 M       EXAMPLE_MAIN             1998-07-08 14:53

                                                               LOAD MAPS

DATA BLOCK MAP BY NAME FOR FILE: \NODE.demo1
 BASE   LIMIT  TYPE    MODE    NAME                             DATE      TIME
 000000 000014 COMMON  WORD    #GLOBAL                        1998-07-08 14:53
```

To start debugging the program in Example F-2 on page F-4, enter `RUND demo1.` If the program starts in Inspect, then it was not compiled with the compiler directives shown. To switch to Debug, enter the Inspect command SELECT DEBUGGER DEBUG. This output is displayed:

```
DEBUG P=%000211, E=%000207, UC.%00
```

Break command

The first Debug command that we are going to demonstrate is the break (B) command. To look at the *before* and *after* result that occurs when running the EXAMPLE_INIT procedure of our sample program, we put a breakpoint at the beginning and at the end of the procedure. From the ENTRY POINT MAP (Example F-2 on page F-4), we find that the EXAMPLE_INIT procedure starts at SP 0 and ENTRY 5 (octal).

Thus, we enter UC.0,%5 at the prompt, which gives us the breakpoint at the beginning of EXAMPLE_INIT procedure:

```
050,03,00013-B UC.0,%5
ADDR: UC.%00,%000005 INS: %002035 SEG: %020737
INS:   ADDS   +035
```

Selecting a location near the end of the EXAMPLE_INIT procedure, we find that relative offset 76 (octal) is near the end of the procedure. Thus, adding 76 (octal) to the starting location gives us the ending breakpoint location of the procedure.

Note. The octal prefix, %, is used in our examples to emphasize the numeric base of the numbers shown.

```
050,03,00013-B UC.0,%5+%76
ADDR: UC.%00,%000103 INS: %125003 SEG: %020737
INS:   EXIT    03
```

We resume the program and get to the first breakpoint as follows:

```
050,03,00013-R
DEBUG P=%000005, E=%000207, UC.%00-BREAKPOINT-
```

LMAP Command

The P value indicates that we have hit the breakpoint at the beginning of the EXAMPLE_INIT procedure. You can confirm this by passing the P register to the LMAP command as follows:

```
050,03,00013-LMAP P
EXAMPLE_INIT (UC.00)
```

Displaying Variable Values

We can look at the *before* contents of the program's global variable MY_TERMNUM, located at the program's GLOBAL + 0, and the EXAMPLE_INIT procedure variables HOMETERM_LEN and HOMETERM. HOMETERM_LEN and HOMETERM are located at L + 34 and L + 4 (octal), respectively. (See the object program listing in Example F-2 on page F-4.) We use the D command for displaying numeric variables and the A command for displaying string variables,

```
050,03,00013-D UD,%0
%000000: %000000
050,03,00013-D L%34
%000056: %000000
050,03,00013-A L%4, #48/2, B
%000026................................................
```

We used #48/2 for the length of the A command based on the declaration of the HOMETERM array. The array was declared as [0:47], which is 48 (decimal) bytes long.

For the A command, the length in is 16-bit words. Thus, we divide 48 by 2 to get 2 bytes per 16-bit word. We also use the B display format to group the output into bytes rather than using the 16-bit words default.

Checking for Open Files

We check for opened files using the find (F) command. We find that there is no opened file at this point in our example.

```
050,03,00013-F
# -1   ???                      # 00000
```

We advance to the breakpoint at the end of the EXAMPLE_INIT procedure using the resume (R) command and verifying our location with the LMAP command. The result:

```
050,03,00013-R
DEBUG P=%000103, E=%000217, UC.%00-BREAKPOINT-
050,03,00013-LMAP P
EXAMPLE_INIT + %76 (UC.00)
```

We can look at the various data locations using the A and D commands, to see the changes to the variables after we hit the end breakpoint.

```
050,03,00013-D UD,%0
%000000: %000001
050,03,00013-D L%34
%000056: %000023
050,03,00013-A L%4, %24/2, B
%000024:\M5.$ZTN00.#PTAZJAC.
```

We used the value found for HOMETERM_LEN variable, located at L%34, for the length of the A command. We round up the result to the next even number before dividing by 2; otherwise, you can lose a byte of information. We also specified the output to display in byte-form instead of 16-bit word-form by using the B option. (Options C or B1 could also have been used.)

If we again check for open files by entering the F command, we find that file number 1 is opened. The name of the file matches the file name we saw at the HOMETERM variable with the A command, above.

```
050,03,00013-F
# -1   ???                        # 00000
#001   \M5.$ZTN00.#PTAZJAC        # 00000
```

Output Display Conversion

Here, we illustrate how to convert from octal to decimal for displaying output data. The default output for the D command is octal. We can change the output display using the *d-base* option. (Use HELP D and HELP *d-base* for syntax information.) We will look at the contents of the program's global PROCESS_HANDLE array in the default form and in the decimal form. The PROCESS_HANDLE array starts at the program's global

address 1 and is 10 16-bit words long. For information about how we obtained these numbers, see Example F-2 on page F-4. Here, we omit UD for the address because UD is the default option for the D command. The commands entered and the outputs displayed:

```
050,03,00013-d 1, #10

%000001: %000400 %000000 %000003 %000015 %000000 %000000 %000014 %130212
%000011: %000000 %000062

050,03,00013-d 1, #10 :d

%000001: #00256  #00000  #00003  #00013  #00000  #00000  #00012  #45194
%000011: #00000  #00050
```

Using Extended Addressing

At this point in the EXAMPLE_INIT procedure, the local extended integer pointer, HANDLE_PTR, located at L + 2, has been set to the program's global array, PROCESS_HANDLE, starting at UD + 1. We can display the information in PROCESS_HANDLE using two methods: reading the pointer address stored at L+2 and L+3 and then using that address to display the information in PROCESS_HANDLE, or we can use the extended integer indirect clause in the address part of the D command.

Note. Because Debug is not case-sensitive, you can use lowercase or uppercase letters when entering Debug commands.

When displaying the extended pointer, we will set the display format to group in 4 bytes, thus using B4. For the second part of the display, we need to divide the extended pointer value by 2 because extended pointers are byte-aligned and the address specified to the D command must be word aligned when referencing the user data area. Both methods are shown here:

```
050,03,00013-D L+%2, %2 , B4 :h

%000024: 0x00000002

050,03,00013-d 0x00000002 /2, #10 :D

%000001: #00256  #00000  #00003  #00013  #00000  #00000  #00012  #45194
%000011: #00000  #00050

050,03,00013-D L+%2IX, #10 :D

%000001: #00256  #00000  #00003  #00013  #00000  #00000  #00012  #45194
%000011: #00000  #00050
```

BASE Command

Most Debug commands have default base for numeric input and output. The default input can be overridden by prefixing the number with the appropriate numeric prefix (% for octal, # for decimal, or 0x or %h for hexadecimal). The default output of some Debug commands can be changed with an output base as was shown in the previous

D example. The following specifies the output value to be a decimal for the D command.

```
050,03,00013-BASE DECIMAL OUT

050,03,00013-d 1, #10

#00001: #00256  #00000  #00003  #00013  #00000  #00000  #00012  #45194
#00009: #00000  #00050
```

Note. Both of the address output and the data output are displayed in decimal format. Contrast this with the :D option in the example, where only the data output changes base.

? Command

We use the ? command to see the current setting of the base:

```
050,03,00013-?

USE SEGMENT ID = NONE

BASE STANDARD IN
BASE DECIMAL OUT
TERM \M5.$ZTN00.#PTAZJAC
PRV = OFF
```

We change the base for the output from decimal to standard and use the ? command to check the result:

```
050,03,00013-BASE STANDARD OUT

050,03,00013-?

USE SEGMENT ID = NONE

BASE STANDARD IN
BASE STANDARD OUT
TERM \M5.$ZTN00.#PTAZJAC
PRV = OFF
```

B Command (Continued)

In the above examples, we used the EXAMPLE_INIT procedure to demonstrate some of the Debug commands. We will now set breakpoints in the EXAMPLE_MAIN procedure in order to demonstrate other Debug commands.

We stop the program after segments 1 and 2 are allocated at offsets 21 and 44 (octal), respectively, in the main procedure EXAMPLE_MAIN.

Under the ENTRY POINT MAP in Example F-2 on page F-4, the EXAMPLE_MAIN procedure starts at 211 (octal). When we enter the breakpoint, we do not need to qualify the address with the segment, because the breakpoint is in the segment we are currently in. So instead of entering UC.0, %211+%21, we can enter %211+%21. One way to enter the address of breakpoints is by specifying the base address and its offset with the command, which emphasizes the relative offset in the procedure. Another way

is to enter the sum of the offset and the base %255 (44 + 211), as shown in the example below. After entering the breakpoints we resume to the location.

```
050,03,00013-B %211+%21
ADDR: UC.%00,%000232 INS: %040401 SEG: %020737
                          INS:   LOAD  L+001
050,03,00013-B %255
ADDR: UC.%00,%000255 INS: %040401 SEG: %020737
                          INS:   LOAD  L+001
050,03,00013-R
DEBUG P=%000232, E=%000217, UC.%00-BREAKPOINT-
```

Modify Command

Here, we demonstrate the use of the modify (M) command. At this point in our example, we simulate an error returned from a call to the SEGMENT_ALLOCATE_ procedure by modifying the value in the ERROR_MAIN variable, located at L 1, to have a nonzero value. First we display the location for ERROR_MAIN, then modify the location.

```
050,03,00013-D L 1
%000016: %000000
050,03,00013-M L 1, -1
```

We resume to see the call to Debug. We display the value in the ERROR_MAIN variable in an octal format (default) and in a decimal format. We then resume to the next breakpoint.

Note. A call to Debug produces a different message at the stop than when we hit a breakpoint.

```
050,03,00013-R
DEBUG P=%000236, E=%000227, UC.%00
050,03,00013-D L 1
%000016: %177777
050,03,00013-D L 1 :D
%000016: #65535
050,03,00013-R
DEBUG P=%000255, E=%000217, UC.%00-BREAKPOINT-
```

Again, we simulate an error returned from the call to the SEGMENT_ALLOCATE_ procedure by modifying the value in the ERROR_MAIN variable to have a nonzero value. This time we use the M command interactively:

```
50,03,00013-M L 1
%000016: %000000 <- 4
%000017: %000000 <-
050,03,00013-R
DEBUG P=%000261, E=%000207, UC.%00
```

Clearing Breakpoints with *

The following example demonstrates clearing breakpoints using * with the C command. First, we use the B command to view all the breakpoints we have set in the EXAMPLE_MAIN procedure. We then clear the breakpoints using the C * command and show that they are gone.

```
050,03,00013-B

ADDR: UC.%00,%000005 INS: %002035 SEG: %020737
                          INS:   ADDS   +035
ADDR: UC.%00,%000103 INS: %125003 SEG: %020737
                          INS:   EXIT    03

ADDR: UC.%00,%000232 INS: %040401 SEG: %020737
                          INS:   LOAD  L+001
ADDR: UC.%00,%000255 INS: %040401 SEG: %020737
                          INS:   LOAD  L+001

050,03,00013-C *

050,03,00013-B
```

Trace Command

In the following example, we use the EXAMPLE_FILL_ARRAY procedure to illustrate the use of the trace (T) command, and the use of the N option with the T command. We first set breakpoints at the beginning and near the end of the procedure and resume to the first breakpoint. After reaching the breakpoint, we use the T and TN commands to trace the stack and show the names.

```
050,03,00013-B %104

ADDR: UC.%00,%000104 INS: %002002 SEG: %020737
                          INS:   ADDS   +002

050,03,00013-b %104+%73

ADDR: UC.%00,%000177 INS: %125004 SEG: %020737
                          INS:   EXIT    04

050,03,00013-r

DEBUG P=%000104, E=%000207, UC.%00-BREAKPOINT-

050,03,00011-t

         %000104   E=%000200  L=%000023    ENV:   T  UC.%00
%000021:%000310    E=%000200  L=%000015    ENV:  T  UC.%00

050,03,00013-tn

         %000104    E=%000200   L=%000023   EXAMPLE_FILL_ARRAY + %000000
000021:  %000310    E=%000200   L=%000015   EXAMPLE_MAIN + %000077
```

Clearing Breakpoint of Current Location

If the program is stopped at a code breakpoint, you need to specify only the C command to clear the breakpoint. We look at the breakpoints both before and after this operation.

```
050,03,00013-b

ADDR: UC.%00,%000104 INS: %002002 SEG: %020737
                          INS:   ADDS   +002
ADDR: UC.%00,%000177 INS: %125004 SEG: %020737
                          INS:   EXIT    04

050,03,00013-c

050,03,00013-b

ADDR: UC.%00,%000177 INS: %125004 SEG: %020737
                          INS:   EXIT    04
```

? Command

The EXAMPLE_FILL_ARRAY procedure makes one of the previously allocated segments available for the program use. We can see the current segment being used with the ? command by displaying the ARRAY_NUM parameter at location L-3.

```
050,03,00013-?

USE SEGMENT ID = NONE

BASE STANDARD IN
BASE STANDARD OUT
TERM \M5.$ZTN00.#PTAZJAC
PRV = OFF

050,03,00013-d l-3

%000020: %000001
```

When we resume the program, it puts data segment 1 in use, then prompts us for some data. We enter "abcdefg". The program puts the input data in a local buffer, then moves it to the data segment. At this point, we arrive at the breakpoint that is at the end of the procedure. Using the ? command, we can see that segment 1 is being used.

```
050,03,00013-r

enter some data

abcdefg

DEBUG P=%000177, E=%000207, UC.%00-BREAKPOINT-

050,03,00013-?

USE SEGMENT ID = %000001

BASE STANDARD IN
BASE STANDARD OUT
TERM \M5.$ZTN00.#PTAZJAC
PRV = OFF
```

Displaying String Output

The local buffer, IN_OUT_MSG, is an indirect string. This means that we need to use the pointer at L 3 to find the address of the data, divide it by 2 to convert from a string address to a word address, then display the information. We can do this in one step or two steps by using the indirect form as shown below:

```
050,03,00013-d l 3
%000026: %000062
050,03,00013-a %62/2, #8/2, c
%000031:abcdefgo
050,03,00013-a l3s, #8/2, c
%000031:abcdefgo
```

Note. The last character returned is an "o," because we use the same buffer for input and output. The "o" is from the word "some" in our prompt string "enter some data." An additional item to note about the above example: The address 62 (octal) returned from the D L 3 command is in the user data (UD) area. We could have entered the A command as A UD,%62/2, #8/2,C to obtain the same result. In other words, if a space qualifier is not specified for the A or D command, UD is assumed.

Displaying Data Using Q Address

We can display some data in the selectable segment using the Q address mode. The extended indirect pointer, SP, is used to store the ARRAY_NUM in location 0 of the selectable segment. We can separate the characters by using the C grouping option and hexadecimal output format.

We can also see the results of moving the procedure's buffer into the selectable segment. Because the data is stored at byte offset 41, we need to round down to the previous even byte (40). We then divide by 2 to convert to a 16-bit word address offset.

```
050,03,00013-d q0, c :h
%000000: 01 00
050,03,00013-a q #40/2, #10/2, c
%000024:.abcdefg..
```

Displaying Data Using Extended Address

The EXAMPLE_FILL_ARRAY procedure does not update the extended indirect pointer SP located at the program's global 12, so it is pointing to the beginning of the selectable segment. We can repeat the A and D commands above, using SP as a string extended address.

In this case, because the S indirection type indicates a string (byte), *index* is a byte offset, which eliminates the need of dividing the address by 2. Instead of using the `a q #40/2, #10/2, c` command in the above example, we can also enter it as: a `ud,12sx#40,#10/2,c`.

```
050,03,00013-d 12ix, c :h
%000000: 01 00
050,03,00013-a 12sx + #40, #10/2, c
%000024:.abcdefg..
```

Note. For the A command, we are using this address form:
offset [indirection-type [index]].

The EXAMPLE_FILL_ARRAY procedure has a local extended string pointer, SEGMENT_PTR, located at L 4. The pointer is set to offset 41 of SP. We can repeat the A commands above, using SEGMENT_PTR.

```
050,03,00013-a L4sx, #10/2, c
%000024:.abcdefg..
```

We resume the program so that it stops the next time we reach the end of EXAMPLE_FILL_ARRAY procedure. The ? command shows us which segment is in use.

```
050,03,00013-r
enter some data
tuvwxyz
DEBUG P=%000174, E=%000207, UC.%00-BREAKPOINT-
050,03,00013-?
USE SEGMENT ID = %000002

BASE STANDARD IN
BASE STANDARD OUT
TERM \M5.$ZTN00.#PTAZJAC
PRV = OFF
```

VQ Command

The ? command above shows that segment ID 2 is in use. The VQ command allows us to switch to any segment available to the program. In this example, we first use the VQ command to switch to segment 1, which had the “abcdefg” data inserted the last time the EXAMPLE_FILL_ARRAY procedure was called. We then modify the data at location 0x2ff0 in the segment to demonstrate the FN command.

```
050,03,00013-vq 1

050,03,00013-?

USE SEGMENT ID = %000001


BASE STANDARD IN
BASE STANDARD OUT
TERM \M5.$ZTN00.#PTAZJAC
PRV = OFF

050,03,00013-m q 0x2ff0,'bc'
```

FN Command

We can use the FN command to find the location of a 16-bit word that matches a value. The value must be aligned on an even-byte address boundary. The "abcdefg" we entered earlier was placed into the selectable segment 1 starting on an odd byte (41), so we start looking for the "bc" part of the character segment, which starts at an even byte. We have also modified the selectable segment with "bc" at offset 0x2ff0, which is an even address.

```
050,03,00013-fn q 0, 'bc'

%000025: 0x6263

050,03,00013 (FN)-

%027760: 0x6263

050,03,00013 (FN)-

DEBUG error 50: FN stopped searching at the following address:
0x0009FFF8
Address not valid
```

Pressing return on the (FN) prompt caused the FN command to continue searching. After the second return, we encountered the end of the selectable segment and an error was reported. Note that the addresses are given in octal word offsets, followed by the contents of the 16-bit word.

= Command

In the following example, we show how the = command complements other Debug commands. In this case, we show that the output octal address specified in the FN command, can be specified with the = command to convert the octal address to a hexadecimal address. When we specify the address to the = command, note that it is the same one used in the modify command. If we specify the data found at the location to the = command, we find "bc," the characters entered in the FN command above.

```
050,03,00013-=%027760
= %027760  #12272  0x2FF0  '/.'
050,03,00013-= 0x6263
= %061143  #25187  0x6263  'bc'
```

If we want to find a specific bit pattern and are not interested in the other bits, we can use the mask. In the following example we look for a "c" in the second byte of the 16-bit word and ignore the other bits.

Note below that the "x" of the “xc” is ignored. The 0x62, (binary "b") is also ignored when finding the match to our search.

```
 050,03,00013-fn q 0, 'xc' & 0x00ff
%000025: 0x6263
050,03,00013 (FN)-
%027760: 0x6263
050,03,00013 (FN)-
```

We resume the program and enter a different data pattern from what is contained in segments 1 and 2. The selectable segment 17 is longer than segment 1 or 2. We use this to show some variations on the commands.

```
050,03,00013-r
enter some data
0123456789
DEBUG P=%000177, E=%000207, UC.%00-BREAKPOINT-
050,03,00013-?
USE SEGMENT ID = %000021
BASE STANDARD IN
BASE STANDARD OUT
TERM \M5.$ZTN00.#PTAZJAC
PRV = OFF
```

AMAP Command

If the N prefix is used with an address, the address must be in a 32-bit form. The N prefix also changes the formatting of the output display for some Debug commands. In this example, we use the AMAP command to convert the Q address to a 32-bit address and use the converted address for the A command.

```
050,03,00013-amap q #40/2

Address: 0x00080028
Kind = 0x0013: Unknown
Attributes: none

050,03,00013-a n 0x00080028, #10, c

00080028:.0123456789.........
```

Note. Adding the N prefix to the A command changed the output display to decimal byte address.

DN Command

The following shows the use of the DN command:

```
050,03,00013-dn 0x00080028, #10  :a

00080028: ..012. .3456. .789.. ......
00080038: ...... ...... ...... ......
00080048: ...... ......
```

Note. The DN command is not the same as D N (with space between the letters). For more information about the differences between the DN and D N commands, refer to Section 4, Debug Commands, of this manual.

Modify Data Using 32-bit address

For the next example we modify a 32-bit word in the selectable segment. We use the M command with an N address prefix to do the 32-bit operation.

```
050,03,00013-amap q #140000

Address: 0x000A22E0
Kind = 0x0013: Unknown
Attributes: none

050,03,00013-m n 0x000A22E0

0x000A22E0  :  0x00000000  <- '3456'
0x000A22E4  :  0x00000000  <-
```

FNL Command

We use the FNL command to find data in 32-bit form. Because the value we are searching for is 32-bit, the specified address must be aligned on a even 4-byte boundary (last digit must be hexadecimal 0, 4, 8, or C).

```
050,03,00013-fnl q0, '3456'

0008002C: 0x33343536

050,03,00013 (FNL)-

** DEBUG error 51: FNL reached address boundary.  To continue, enter the following
address:
0x000A0000

050,03,00013-FNL 0x000A0000

000A22E0: 0x33343536

050,03,00013 (FNL)-

** DEBUG error 52: FNL stopped searching at the following address:
0x000BEFD0
Address not valid
```

Note. The output addresses for the FNL command are hexadecimal byte addresses. The FNL command stops the search at either the end of the segment or when the low-order 17 bits of the address are zero. If the address boundary is reached, it is necessary to restart only the command with the address. The value to search for is the same as the last search.

We can also look for a specific pattern within the 32-bit word while ignoring the other bits. We use the FNL command with a mask to look only for the bit pattern 0x3435 in the second and third byte of the word.

```
050,03,00013-FNL  q0, 0x00343500 & 0x00ffff00

0008002C: 0x33343536

050,03,00013 (FNL)-
```

Stopping the Program

Before we move to the examples we are going to demonstrate below, we must first stop the program using the STOP command.

Additional Breakpoint Options

Next, we demonstrate some variations on the B and BM commands. We run the object file in Example F-2 on page F-4 several times to show the various options with the B and BM commands. The first example will show the breakpoint tracing.

We put a breakpoint near the beginning of the EXAMPLE_FILL_ARRAY procedure and show the content of the ARRAY_NUM parameter. We also put a breakpoint at the end of EXAMPLE_FILL_ARRAY and show the data in the selectable segment at a 40-byte offset for 16 bytes.

In order to ensure that the output values are within the scope of the procedure we are debugging, we need to make sure that the address reference in the trace clause is evaluated within the context of the procedure. So, we put a breakpoint after the stack has been set up and resume to the breakpoint. First we look at the code to find an appropriate location at put the breakpoint. In this case, this location is right after the stack has been set up and initialized.

```
050,03,00009-i %104, 20

%000104:  ADDS   +002      LADR  L+006      LLS     01       PUSH    700
%000110:  ADDS   +032      LOAD  L-003      PUSH    700      ADDS   +006
%000114:  LDLI   +200      LDI    -007      PUSH    711      XCAL    006
%000120:  STOR  L+002      LOAD  L+002      CMPI   +000      BEQL   +001

050,03,00009-b %117

ADDR: UC.%00,%000117 INS: %127006 SEG: %020707
                          INS:   XCAL    006

050,03,00009-r

DEBUG P=%000117, E=%000227, UC.%00-BREAKPOINT-
```

We then clear the breakpoint and put in another breakpoint with the trace clause.

```
050,03,00009-c
050,03,00009-b %117, l-3 ? 1

ADDR: UC.%00,%000117 INS: %127006 SEG: %020707
                          INS:   XCAL    006
L  %177775                           ? %000001

050,03,00009-b %104+%73, n 0x00080028 ? #16/2

ADDR: UC.%00,%000177 INS: %125004 SEG: %020707
                          INS:   EXIT    04

N  0x00080028               ? 0x00000008
```

We resume the program and enter some data at the prompt. Observe that the value of ARRAY_NUM is shown as we enter the procedure, and the selectable segment is shown as the procedure ends.

```
050,03,00009-r

TRACE 0x004F , UC.%00
0x0010: 0x0001

enter some data

abcdefg

TRACE 0x007F , UC.%00
0x0014: 0x0061  0x6263  0x6465  0x6667  0x0000  0x0000  0x0000  0x0000
TRACE 0x004F , UC.%00
0x0010: 0x0002

enter some data

hijklmnop

TRACE 0x007F , UC.%00
0x0014: 0x0068  0x696A  0x6B6C  0x6D6E  0x6F70  0x0000  0x0000  0x0000
TRACE 0x004F , UC.%00
0x0010: 0x0011

enter some data

uvwxyz0123

TRACE 0x007F , UC.%00
0x0014: 0x0075  0x7677  0x7879  0x7A30  0x3132  0x3300  0x0000  0x0000
```

Conditional Breakpoint

The next example shows a conditional breakpoint. We stop at a code breakpoint in EXAMPLE_FILL_ARRAY when parameter ARRAY_NUM is greater than 16. We first run the object code in Example F-2 on page F-4: *RUND demo1*.

```
050,03,00010-b %117

 ADDR: UC.%00,%000117 INS: %127006 SEG: %020707
                           INS:   XCAL    006

050,03,00010-r

DEBUG P=%000117, E=%000227, UC.%00-BREAKPOINT-

050,03,00010-c
050,03,00010-b %117, L-3 > #16

ADDR: UC.%00,%000117 INS: %127006 SEG: %020707
                           INS:   XCAL    006
 L  %177775             & %177777     > %000020

050,03,00010-r

enter some data

abcdefg

enter some data

lmnopqrst

DEBUG P=%000117, E=%000227, UC.%00-BREAKPOINT-

050,03,00010-d L-3 :d

%000020: #00017
```

Execute Breakpoint

The next example shows the execute breakpoint using the BM command. We first run the object code: *RUND demo1*.

We put a memory-access breakpoint on the first word of data pointed to by the IN_OUT_MESSAGE pointer in the EXAMPLE_FILL_ARRAY procedure. We stop at the beginning of the procedure and look at the value of the IN_OUT_MESSAGE pointer.

```
050,03,00027-b %104

ADDR: UC.%00,%000104 INS: %002002 SEG: %020737
                          INS:   ADDS   +002

050,03,00027-r

DEBUG P=%000104, E=%000207, UC.%00-BREAKPOINT-

050,03,00027-d l3

%000026: %000000
```

The pointer has not been set at this point in the program. We put a breakpoint a few instructions ahead and look at the pointer again.

```
050,03,00027-b %104+%15

ADDR: UC.%00,%000121 INS: %040402 SEG: %020737
                          INS:   LOAD  L+002

050,03,00027-r

DEBUG P=%000121, E=%000217, UC.%00-BREAKPOINT-

050,03,00027-d L3

%000026: %000062
```

Now the stack has been set up, so there is a value in the pointer. Remember that this is a string pointer, so the value is a byte offset into the UD area. Because we no longer need the code breakpoints, we clear them. We use the BM command to set a memory-access breakpoint. We also use the command-string option to make an execute breakpoint.

```
050,03,00027-c *

050,03,00027-bm L3s, w, (lmap p;a L3s, #40/2, c;r)

XA: 0x00000032   MAB: W   (DATA SEG)
    (LMAP P;A L3S, #40/2, C;R)
```

Because we are using an indirect variable, we need to be at a location where the pointer has been established. For information about indirect addressing, see Section 3, Debug Command Overview. Thus the address of 0x00000032 shown in the output for the BM command is in the user data segment (UD). Whenever the location is written, we execute the LMAP command, the A command, and resume.

Resuming gives us these outputs:

```
050,03,00027-r

DEBUG P=%000145, E=%000202, UC.%00-MEMORY ACCESS BREAKPOINT-
MEMORY ACCESS BREAKPOINT OCCURRED AT $PC=0x7E007EE4
EXAMPLE_FILL_ARRAY + %41 (UC.00)
%000031:eN00.#PTAZJA.........................

DEBUG P=%000145, E=%000202, UC.%00-MEMORY ACCESS BREAKPOINT-
MEMORY ACCESS BREAKPOINT OCCURRED AT $PC=0x7E007EF0
EXAMPLE_FILL_ARRAY + %41 (UC.00)
%000031:en00.#PTAZJA.........................

enter some data

abcdefg

DEBUG P=%000171, E=%000317, UC.%00-MEMORY ACCESS BREAKPOINT-
MEMORY ACCESS BREAKPOINT OCCURRED AT $PC=0x7E007EF0
EXAMPLE_FILL_ARRAY + %65 (UC.00)

%000031:abcdefgome data.......................

DEBUG P=%000145, E=%000202, UC.%00-MEMORY ACCESS BREAKPOINT-
MEMORY ACCESS BREAKPOINT OCCURRED AT $PC=0x7E007EE4
EXAMPLE_FILL_ARRAY + %41 (UC.00)
%000031:ebcdefgome data.......................

DEBUG P=%000145, E=%000202, UC.%00-MEMORY ACCESS BREAKPOINT-
MEMORY ACCESS BREAKPOINT OCCURRED AT $PC=0x7E007EF0
EXAMPLE_FILL_ARRAY + %41 (UC.00)
%000031:encdefgome data.......................

enter some data

uvwxyz

DEBUG P=%000171, E=%000317, UC.%00-MEMORY ACCESS BREAKPOINT-
MEMORY ACCESS BREAKPOINT OCCURRED AT $PC=0x7E007EF0
EXAMPLE_FILL_ARRAY + %65 (UC.00)
%000031:uvwxyzsome data.......................
DEBUG P=%000145, E=%000202, UC.%00-MEMORY ACCESS BREAKPOINT-
MEMORY ACCESS BREAKPOINT OCCURRED AT $PC=0x7E007EE4
EXAMPLE_FILL_ARRAY + %41 (UC.00)
%000031:evwxyzsome data.......................

DEBUG P=%000145, E=%000202, UC.%00-MEMORY ACCESS BREAKPOINT-
MEMORY ACCESS BREAKPOINT OCCURRED AT $PC=0x7E007EF0
EXAMPLE_FILL_ARRAY + %41 (UC.00)
%000031:enwxyzsome data.......................

enter some data

0123456789

DEBUG P=%000171, E=%000317, UC.%00-MEMORY ACCESS BREAKPOINT-
MEMORY ACCESS BREAKPOINT OCCURRED AT $PC=0x7E007EF0
EXAMPLE_FILL_ARRAY + %65 (UC.00)
%000031:0123456789 data.......................
```

Note. There is already some text in the data area of the first breakpoint. This procedure is reusing some of the data area the EXAMPLE_INIT procedure used in previous examples. Thus, if we had entered our breakpoint at the beginning of the program as "bm n 0x32, w," we would have stopped in the EXAMPLE_INIT and EXAMPLE_FILL_ARRAY procedures.

The memory-access breakpoint is triggered when anything is written to the 16-bit word. In this case, we get two interrupts at EXAMPLE_FILL_ARRAY + %41: one when the "e" is put into the word, and another when the "n" is put into the word. This double interrupt is true only when the code putting the data in the memory location is doing byte operations and the code is not PRIV. The next break happens after the data is entered. In the second case, the data is transferred in the PRIV system procedure, so the breakpoint is reported after the end of the PRIV procedure.

Accelerated Program Example

Debugging accelerated programs is similar to debugging TNS programs, with some differences between the two. In this subsection, we discuss the differences between TNS and accelerated programs.

To generate an accelerated object file, we use the `demo1` program in Example F-2 on page F-4 and get an accelerated program as follows:
`AXCEL demo1,ademo1`. Because the `ademo1` object file does not have significant information, the listing is not provided here. For more information about using the Accelerator refer to the *Accelerator Manual*.

Break Command

We run the `ademo1` object file and put a breakpoint at EXAMPLE_INIT procedure. When we specify the B command in an accelerated program, we are actually entering two breakpoints, one in TNS code and another in RISC code.

```
RUND ademo1

DEBUG P=%000211, E=%000207, UC.%00

050,03,00032-b %5

@ ADDR: UC.%00,%000005 INS: %002035 SEG: %020737
                       INS:   ADDS   +035

050,03,00032-r

DEBUG P=%000005, E=%000207, UC.%00-BREAKPOINT-
```

Using of the B command to insert a TNS code breakpoint and using the B* command to insert a RISC code breakpoint:

```
050,03,00032-b   ! TNS breakpoint

@ ADDR: UC.%00,%000005 INS: %002035 SEG: %020737
                          INS:   ADDS   +035

050,03,00032-b *  ! RISC breakpoint

@ ADDR: UC.%00,%000005 INS: %002035 SEG: %020737
                          INS:   ADDS   +035

 ^--N: 0x7042001C     INS: 0x27BD004E
                      INS: ADDIU sp,sp,78
```

PMAP Command

We can enter TNS code breakpoints only at memory-exact and register-exact points. If we enter the PMAP command at a TNS location, we get a set of RISC code output that corresponds to the set of TNS code that performs the same functions.

Below, the output shows that TNS address %5 is a register-exact point, which corresponds to RISC address 0x7042001C. (Note that 0x is omitted on the address output because of space constraints.)

```
050,03,00032-pmap %05

%000005: @ BPT              ADDS   +010

7042001C: BREAK INSPECT RISC     LUI at,0x7FFF          ADD   $0,sp,at
```

The TNS code and RISC code locations currently have breakpoints. We can see the instructions that were in the original code by entering the B * command or by clearing the breakpoints with the C command and entering the PMAP command again.

```
050,03,00032-c

050,03,00032-pmap %05

%000005: @ ADDS   +035      ADDS   +010

7042001C: ADDIU sp,sp,78         LUI at,0x7FFF          ADD   $0,sp,at
```

We are allowed to set TNS code breakpoints only at locations that are register-exact or memory-exact. To see other TNS locations where we are allowed to set breakpoints, we can specify the address and the length with the PMAP command, as shown in this example:

```
050,03,00032-pmap %5 , #14
%000005: @ ADDS   +035      ADDS   +010

7042001C: ADDIU sp,sp,78         LUI at,0x7FFF          ADD   $0,sp,at

%000007: > LDI    +000      LDI    -010      PUSH    711      XCAL    002

70420028: LI    s1,-8            SH    $0,-2(sp)        SH    s1,0(sp)
70420034: JAL   0x7A5D91F0       LI    a0,11

%000013: @ STRP    7        LDI    +000      LADR  G+001      DLLS    01
%000017:  LDLI   +300       LDI    -002      PUSH    733      XCAL    003

7042003C: LI    s0,2             LI    s2,-16384        LI    s3,-2
70420048: ADDIU sp,sp,8          SWL   s0,-6(sp)        SWR   s0,-3(sp)
70420054: SH    s2,-2(sp)        SH    s3,0(sp)         JAL   0x7C2CB64C
70420060: LI    a0,19
```

Observe that TNS address %7 is a memory-exact point and that TNS address %13 is the next register-exact point.

We set a breakpoint at the next register-exact point and display the registers, as follows:

```
050,03,00032-b %13

@ ADDR: UC.%00,%000013 INS: %000107 SEG: %020737
                         INS:   STRP    7

050,03,00032-r

DEBUG P=%000013, E=%000317, UC.%00-BREAKPOINT-

050,03,00032-d *

 S=%000057 P=%000013 E=%000317 L=%000022 SP=UC.%00
 ENV IS:               TK  CCE RP7
 EXAMPLE_INIT + %000006
 *REG*  %000000 %104010 %000002 %177630 %177440 %000031 %002404 %002412

 EXECUTION MODE = ACCELERATED

       $PC: 0x7042003C  $HI: 0x0000246F  $LO: 0x8881FC7E

 $00:  $00: 0x00000000  $AT: 0x70000000  $V0: 0x7E000000  $V1: 0x00000000
 $04:  $A0: 0x0000257D  $A1: 0x00000000  $A2: 0x0000000B  $A3: 0x80022438
 $08:  $T0: 0x7042003C  $T1: 0x7042003C  $T2: 0x70400000  $T3: 0x70400000
 $12:  $T4: 0x0000FD13  $T5: 0x8006FC14  $T6: 0xFFFFFFFF  $T7: 0x00000000
 $16:  $S0: 0x00000000  $S1: 0x7A5D8808  $S2: 0x00000002  $S3: 0xFFFFFF98
 $20:  $S4: 0xC5FFFF20  $S5: 0x00000019  $S6: 0x00000504  $S7: 0x0000050A
 $24:  $T8: 0x70000000  $T9: 0x00000080  $K0: 0xA713A713  $K1: 0xA713A713
 $28:  $GP: 0x70400A00  $SP: 0x0000005E  $S8: 0x00000024  $RA: 0x7A5D9A2C
```

This example shows that an error occurs if an attempt is made to set a TNS code breakpoint at a location that is not a memory-exact or register-exact point. To resolve the error, use the PMAP command to find a matching RISC location near the TNS location.

```
050,03,00032-b %17

DEBUG error 66: Cannot set TNS breakpoint at this location because there is no
corresponding RISC breakpoint.
```

You can set a breakpoint on any RISC code location. Below, we set a code breakpoint and resume the program. When it gets to the breakpoint, we display the registers.

```
050,03,00032-b 0x7042004c

 N: 0x7042004C     INS: 0xABB0FFFA
                   INS: SWL   s0,-6(sp)

050,03,00032-r

DEBUG P=%000013, E=%000317, UC.%00-RISC BREAKPOINT ($PC: 0x7042004C)-

050,03,00032-d *
```

```
*** WARNING: TNS STATE MAY NOT BE WHERE YOU THINK IT IS ***

S=%000063 P=%000013 E=%000317 L=%000022 SP=UC.%00
ENV IS:               TK  CCE RP7
EXAMPLE_INIT + %000006
*REG*  %000002 %104010 %140000 %177776 %177440 %000031 %002404 %002412

EXECUTION MODE = ACCELERATED

       $PC: 0x7042004C  $HI: 0x0000246F  $LO: 0x8881FC7E

 $00:  $00: 0x00000000  $AT: 0x70000000  $V0: 0x7E000000  $V1: 0x00000000
 $04:  $A0: 0x0000257D  $A1: 0x00000000  $A2: 0x0000000B  $A3: 0x80022438
 $08:  $T0: 0x7042003C  $T1: 0x7042003C  $T2: 0x70400000  $T3: 0x70400000
 $12:  $T4: 0x0000FD13  $T5: 0x8006FC14  $T6: 0xFFFFFFFF  $T7: 0x00000000
 $16:  $S0: 0x00000002  $S1: 0x7A5D8808  $S2: 0xFFFFC000  $S3: 0xFFFFFFFE
 $20:  $S4: 0xC5FFFF20  $S5: 0x00000019  $S6: 0x00000504  $S7: 0x0000050A
 $24:  $T8: 0x70000000  $T9: 0x00000080  $K0: 0xA713A713  $K1: 0xA713A713
 $28:  $GP: 0x70400A00  $SP: 0x00000066  $S8: 0x00000024  $RA: 0x7A5D9A2C
```

Because we are not at a register-exact point, the displayed registers issued a warning message. The warning message indicates that the TNS registers might not contain the correct values at this point of the program. If we need to find a memory-exact or register-exact location near this RISC location, we can specify the RISC location to the PMAP command.

Note that the RISC register $PC is specified to the PMAP command. For an accelerated program, the RISC registers can be used in expressions to commands.

```
050,03,00032-pmap $pc , 7

%000013: @ BPT              LDI    +000      LADR  G+001      DLLS    01
%000017:  LDLI   +300      LDI    -002      PUSH    733      XCAL    003

7042003C: BREAK INSPECT RISC     LI    s2,-16384        LI    s3,-2
70420048: ADDIU sp,sp,8          BREAK INSPECT RISC     SWR   s0,-3(sp)
70420054: SH    s2,-2(sp)        SH    s3,0(sp)         JAL   0x7C2CB64C
70420060: LI    a0,19

%000023: @ STOR  L+001

70420064: SH    s0,2(fp)
```

Next, we clear the breakpoints and set a breakpoint on the next memory-exact point. Before resuming, we use the LMAP command to find the address of the routine to which the JAL instruction is jumping.

```
050,03,00032-c *

050,03,00032-b %23

@ ADDR: UC.%00,%000023 INS: %044401 SEG: %020737
                         INS:   STOR  L+001

050,03,00032-lmap 0x7C2CB64C

$PROCESSHANDLE_NULLIT_ (SLr)

050,03,00032-r

DEBUG P=%000023, E=%000217, UC.%00-BREAKPOINT-
```

This time the PROCESS_HANDLE array starting the program GLOBAL +1 should be initialized with nulls. We can confirm this by displaying the information:

```
050,03,00032-d 1, #10:H
%000001: 0xFFFF  0xFFFF  0xFFFF  0xFFFF  0xFFFF  0xFFFF  0xFFFF  0xFFFF
%000011: 0xFFFF  0xFFFF
```

STOP Command

We stop the program by entering the STOP command.

Native Program Example

To show the use of Debug commands on a program compiled with a native compiler, we compiled the sample program in Example F-1 on page F-2 with pTAL as follows:

Example F-3. pTAL Compiled Listing

```
PTAL /IN demo1, OUT $S.#ldemo1/ tdemo1; optimize 0
Copyright (c) 1992-1995, Tandem Computers Incorporated
       Directives = ?OPTIMIZE 0
Source file:  [1] \node.ndemo1  1998-07-08 14:53:11

    7.010   0  0    ?NOLIST, SOURCE $system.system.extdecs (DEBUG, FILE_OPEN_,
    8.100   0  0    INT         my_termnum;
    8.101   0  0    INT         process_handle [0:9];
    8.110   0  0    STRING .EXT sp := %2000000D;
    8.220   1  0    PROC example_init;
    8.230   1  1    BEGIN
    8.300   1  1      INT      error_init;
    8.301   1  1      INT .EXT handle_ptr;
    8.302   1  1      STRING   hometerm [0:47];
    8.304   1  1      INT      hometerm_len;
    8.305   1  1      STRING  .hometerm_ptr;
    8.307   1  1      INITIALIZER; ! external system procedure
    8.308   1  1      error_init := PROCESSHANDLE_NULLIT_ (process_handle);
    8.310   1  1      error_init := PROCESS_GETINFO_ (process_handle,
    8.311   1  1         !fname:max!, !fname-len!, !priority!,
    8.312   1  1         !mom!, hometerm:48, hometerm_len);
    8.313   1  1      error_init := FILE_OPEN_ (hometerm:hometerm_len, my_termnum);
    8.317   1  1      IF error_init <> 0 THEN
    8.320   1  1        DEBUG;
    8.340   1  1      @hometerm_ptr := @hometerm [0];
    8.341   1  1      @handle_ptr := $WADDR_TO_EXTADDR (@process_handle [0]);
    8.350   1  1    END; -- example_init

ERROR_INIT                    INT(16)
                              %HB6       %H2     LOCAL VARIABLE
HANDLE_PTR                    INT(16) EXT POINTER
                              %HB0       %H4     LOCAL VARIABLE
HOMETERM                      STRING [0:47]
                              %H80       %H30    LOCAL VARIABLE
HOMETERM_LEN                  INT(16)
                              %H7E       %H2     LOCAL VARIABLE
HOMETERM_PTR                  STRING POINTER
                              %H78       %H4     LOCAL VARIABLE

    9.      1  0    PROC example_fill_array (array_num);
    9.010   1  0      INT array_num;
    9.100   1  1    BEGIN
    9.101   1  1      INT         count_read;
    9.110   1  1      INT         error_fill_array;
    9.111   1  1      STRING     .in_out_msg [0:47];
    9.112   1  1      STRING .EXT segment_ptr;
    9.114   1  1      error_fill_array := SEGMENT_USE_ (array_num);
    9.120   1  1      IF error_fill_array <> 0 THEN
    9.121   1  1        DEBUG;
    9.122   1  1      sp [0] := array_num;
    9.123   1  1      @segment_ptr := @sp [41];
    9.124   1  1      in_out_msg [0] ':=' "enter some data" & %h0D0A; -- CR LF
    9.130   1  1      WRITEREADX (my_termnum, in_out_msg, 17, 48, count_read);
    9.140   1  1      segment_ptr ':=' in_out_msg [0] FOR count_read bytes;
    9.200   1  1    END; -- example_fill_array

ARRAY_NUM                     INT(16)
                              %H82       %H2     LOCAL PARAMETER
COUNT_READ                    INT(16)
                              %H7E       %H2     LOCAL VARIABLE
ERROR_FILL_ARRAY              INT(16)
                              %H7C       %H2     LOCAL VARIABLE
IN_OUT_MSG                    STRING [0:47]
                              %H4C       %H30    LOCAL VARIABLE
```

```
SEGMENT_PTR                     STRING EXT POINTER
                                %H48       %H4     LOCAL VARIABLE
   9.300   1  0    PROC example_main MAIN;
   10.      1  1    BEGIN
   11.020   1  1      INT     error_main;
   11.030   1  1      INT     error_detail;
   12.      1  1      example_init;
  12.007   1   error_main := SEGMENT_ALLOCATE_ (1, 131064D, !filename;len!,
error_detail);
   12.020   1  1      IF error_main <> 0 THEN
   12.021   1  1        DEBUG;
   12.022   1   error_main := SEGMENT_ALLOCATE_ (2, 131064D, !filename;len!,
error_detail);
   12.030   1  1      IF error_main <> 0 THEN
   12.031   1  1        DEBUG;
   12.032   1   error_main := SEGMENT_ALLOCATE_ (17, 258000D, !filename;len!,
error_detail);
   12.040   1  1      IF error_main <> 0 THEN
   12.050   1  1        DEBUG;
   12.200   1  1      example_fill_array (1);
   12.300   1  1      example_fill_array (2);
   13.      1  1      example_fill_array (17);
   14.      1  1    END; -- example_maim

ERROR_DETAIL                    INT(16)
                                %H44       %H2     LOCAL VARIABLE
ERROR_MAIN                      INT(16)
                                %H46       %H2     LOCAL VARIABLE


                                Global Map
MY_TERMNUM                      INT(16)
                                %H0        %H2     _GLOBAL
PROCESS_HANDLE                  INT(16) [0:9]
                                %H2        %H14    _GLOBAL
SP                              STRING EXT POINTER
                                %H18       %H4     _GLOBAL
```

To make the program executable, we must also run NLD on the compiled object to create an executable object. We use this command:

```
NLD tdemo1 -o ndemo1 -set inspect off -s
```

We also need to get some address information about various procedures from the `noft` listing. For more information about using `noft`, see the *nld Manual* and the *noft Manual*. For our example, we specify `noft` commands as follows:

```
NOFT out $s.#lndemo1;f ndemo1; lp * d
```

Example F-4. `noft` **Listing of pTAL Program**

```
                          Out File : $s.#lnexp1
                       Object File : $NATIV1.CRGMAN.nexp1
                       File Format : ELF
                             Scope : (none)
                              Case : Sensitive
********  List of Procedures  ********
                            Number : 2
                              Name : EXAMPLE_INIT
                           Address : 0x70000390
                              Size : 212 bytes
                       Subprocedure : No
                         Visibility : External
                  Optimization Level : (unknown)
                    Parent Procedure : (none)
                         Source File : Source name stripped
                            Number : 3
                              Name : EXAMPLE_FILL_ARRAY
                           Address : 0x70000464
                              Size : 268 bytes
                       Subprocedure : No
                         Visibility : External
                  Optimization Level : (unknown)
                    Parent Procedure : (none)
                         Source File : Source name stripped
                            Number : 4
                              Name : EXAMPLE_MAIN
                           Address : 0x70000570
                              Size : 320 bytes
                       Subprocedure : No
                         Visibility : External
                  Optimization Level : (unknown)
                    Parent Procedure : (none)
                         Source File : Source name stripped
```

Break Command

Here, we demonstrate breakpoints using the EXAMPLE_INIT procedure in our native program in Example F-3 on page F-28. In the following example, we demonstrate issuing breakpoints at the global scope of our program. Later, we will demonstrate breakpoints within a local procedure.

To start debugging the native program example, we enter the following command. (If the program starts in Inspect, enter the SELECT DEBUGGER DEBUG to access Debug.)

```
RUND ndemo1
DEBUG $PC=0x70000570
```

For this example, we look at the *before* and *after* results that occur as a result of executing the EXAMPLE_INIT procedure. We put a breakpoint near the beginning and near the end of the procedure. (This is similar to what we did for the TNS example.) From the `noft` listing in Example F-4, we find that EXAMPLE_INIT starts at 0x70000390. We put a breakpoint three instructions after the beginning breakpoint so that the stack can be set up. Each instruction is 4 bytes long. We use the B command to specify the first breakpoint.

```
050,03,00266-B 0x70000390 + (#3 * #4)
N: 0x7000039C     INS: 0x00002025
                  INS: OR    a0,$0,$0
```

Selecting a location near the end of the EXAMPLE_INIT procedure in our `noft` listing, we see that EXAMPLE_INIT is 212 (decimal) bytes long. To make sure we that get to the end of the procedure we want to work with, rather than a procedure that precedes it, it is important that we find the starting address of the instruction that is second from the end of the procedure. We ensure the correct location by subtracting 8 bytes (2 * 4) from the length of the procedure. To find the ending address of EXAMPLE_INIT, we add 8 to its beginning address. The following shows this formula:

```
050,03,00266-B 0x70000390 + (#212 - #8)
N: 0x7000045C     INS: 0x03E00008
                  INS: JR    ra
```

We resume the program and let it hit the first breakpoint.

```
050,03,00266-R
DEBUG $PC=0x7000039C -RISC BREAKPOINT ($PC: 0x7000039C)-
```

LMAP Command

The $PC value shows that we have hit the breakpoint at the beginning of EXAMPLE_INIT, but we can confirm this using the LMAP command. We pass the $PC register to the LMAP command.

```
050,03,00266-LMAP $PC
EXAMPLE_INIT + 0xC (UCr)
```

Displaying Variable Values

We can look at the content of program's global variable MY_TERMNUM located a program _GLOBAL + 0, and the procedure variables HOMETERM_LEN and HOMETERM located at stack + %H7E and stack + %H80, respectively. Note that hexadecimal numbers can be entered with the numeric prefix %H or 0X. Also note that _GLOBAL has the address 0x08000000. We will see this address when we look at the HANDLE_PTR variable in the EXAMPLE_INIT procedure, later in the example.

We used %H30/2 for the length of the A command based on the declaration in the listing. The array was declared as [0:47], which is 48 (decimal) bytes long. For the A command, the length is the number of 16-bit words. Because there are 2 bytes per 16-bit word, we divide the length by 2. We also use the B display format to group the output into bytes rather than the default of 16-bit words.

```
050,03,00266-D N 0x08000000, 1 :H
08000000: 0x0000
050,03,00266-D N $SP + %H7E , 1:D
4FFFFEAE: #00000
050,03,00266-A N $SP + %H80, %h30/2, B
4FFFFEB0:................................................
```

Checking for Open Files

We check for open files using the find (F) command. We find that there is no open file at this point in our example.

```
050,03,00266-F
# -1   ???                                                  # 00000
```

We advance to the breakpoint at the end of the EXAMPLE_INIT procedure using the resume command, and verify our location with the LMAP command:

```
050,03,00266-R
DEBUG $PC=0x7000045C -RISC BREAKPOINT ($PC: 0x7000045C)-
050,03,00266-LMAP $PC
EXAMPLE_INIT + 0xCC (UCr)
```

N-address Mode

We look at the various data locations again:

```
050,03,00266-D N 0x08000000, 1 :H
08000000: 0x0001
050,03,00266-D N $SP + %H7E , 1:D
4FFFFEAE: #00019
050,03,00266-A N $SP + %H80, #20/2, B
4FFFFEB0:\M5.$ZTN00.#PTUGRB0.
```

We used the value found for HOMETERM_LEN at $SP + %H7E for the length of the A command. We rounded the result up to the next even number before dividing by 2. We also specified the output to be displayed in byte-form instead of 16-bit word-form. (The letters C or B1 could have been used instead of B for the same result.)

In executing the above commands, we used the N-address mode. This is a common practice with native programs, because they use 32 bit-words and hexadecimal values more often than TNS or accelerated programs.

DN Command

Many programmers prefer to use the DN command for displaying output information. For working with 32-bit operations, the 32-bit byte-form is used (programmers do not need to convert from 16-bit word-form). Also, twice as much information is displayed and hexadecimal is the default display format. In the following example, we display the variables discussed above using the DN command.

The length is the number of 32-bit words to display. The :H 2 part of the first command below breaks the output into two-byte hexadecimal groups. The :D part of the second command breaks the output into two-byte decimal groups.

```
050,03,00266-DN 0x08000000, 1 :H 2

08000000: 0x0001  0x0100

050,03,00266-DN $SP + %H7E, 1:D

4FFFFEAE: #00019  #23629

050,03,00266-DN $sp + %h80, #20/4  :A

4FFFFEB0: .\M5.. .$ZTN. .00.#. .PTUG.
4FFFFEC0: .RB0..
```

We again check for open files. This time file number 1 is opened with the name shown with the A command and the DN :A command.

```
050,03,00266-F

# -1   ???                                                  # 00000
#001   \M5.$ZTN00.#PTUGRB0                                  # 00000
```

FC Command

The default output for the DN command is hexadecimal. We can change the output using the base option. (Use HELP DN for syntax information.) Below, we use the FC command to change the command. We can look at the contents of the program's global variable PROCESS_HANDLE array in the default form and in decimal form. The PROCESS_HANDLE array starts at program _GLOBAL address 2 and is five 32-bit words long.

```
050,03,00266-DN 0x08000000 + %H2, #5

08000002: 0x01000000  0x0003010A  0x00000000  0x000BDB4C
08000012: 0x00000032

050,03,00266-FC

             DN 0x08000000 + %H2, #5
.............                      :D
             DN 0x08000000 + %H2, #5 :D
.............
08000002: #00256  #00000  #00003  #00266  #00000  #00000  #00011  #56140
08000012: #00000  #00050
```

At this point in the procedure, the local extended integer pointer, HANDLE_PTR, located at $SP + %HB0, is set to the program's global array, PROCESS_HANDLE, starting at _GLOBAL + 2. Thus, we know the address for _GLOBAL is 0x08000002.

We can display the information in PROCESS_HANDLE by using two steps: reading the pointer address stored at $SP + %HB0 and then using that address to display the information in PROCESS_HANDLE. Alternatively, we can use the extended string indirect-clause in the address part of the display command. The following shows both methods:

```
050,03,00266-DN $SP + %HB0

4FFFFEE0: 0x08000002

050,03,00266-DN 0x08000002, #5 :D

08000002: #00256  #00000  #00003  #00266  #00000  #00000  #00011  #56140
08000012: #00000  #00050  0x000B  0xDB4C

050,03,00266-DN ($SP + %HB0)SX, #5:D

08000002: #00256  #00000  #00003  #00266  #00000  #00000  #00011  #56140
08000012: #00000  #00050
```

= Command

We can use the = command to see a value in various bases. For example, if we take the value of the fourth 16-bit word of the PROCESS_HANDLE array and use it in the = command, we get the following:

```
050,03,00266-= #00266

 = %000412  #00266  0x010A  '..'
```

We stop the program after segments 1and 2 have been allocated in the main procedure of EXAMPLE_MAIN. We see from the `noft` listing that the procedure starts at 0x70000570 and is 320 (decimal) bytes long.

I Command

We need to analyze the code to see where to put the breakpoints. Note that the decoding instruction uses decimal numbers frequently. We can assume that unless the number is prefixed with a 0x, it is a decimal number when it appears in the decoding instruction.

```
050,03,00266-I 0x70000570, (#320 / 4)

70000570: ADDIU sp,sp,-72        SW    ra,60(sp)        SW    s0,56(sp)
7000057C: JAL   0x70000390       NOP                    LUI a0,0xC800
70000588: LI    a1,1             LUI a2,0x1
70000590: ORI   a2,a2,0xFFF8     ADDIU t6,sp,68         SW    t6,20(sp)
7000059C: SW    $0,44(sp)        JAL   0x7F8051A8       NOP
700005A8: OR    s0,v0,$0         SH    s0,70(sp)
700005B0: LH    t7,70(sp)        NOP                    BEQ   t7,$0,0x700005D0
700005BC: NOP                    JAL   0x7C369070       NOP
700005C8: BEQ   $0,$0,0x700005D0 NOP
700005D0: LUI a0,0xC800          LI    a1,2             LUI a2,0x1
700005DC: ORI   a2,a2,0xFFF8     ADDIU t8,sp,68         SW    t8,20(sp)
700005E8: JAL   0x7F8051A8       NOP
700005F0: OR    s0,v0,$0         SH    s0,70(sp)        LH    t9,70(sp)
700005FC: NOP                    BEQ   t9,$0,0x70000618 NOP
70000608: JAL   0x7C369070       NOP
70000610: BEQ   $0,$0,0x70000618 NOP                    LUI a0,0xC800
7000061C: LI    a1,17            LUI a2,0x3             ORI   a2,a2,0xEFD0
70000628: ADDIU t0,sp,68         SW    t0,20(sp)
70000630: JAL   0x7F8051A8       NOP                    OR    s0,v0,$0
7000063C: SH    s0,70(sp)        LH    t1,70(sp)        NOP
70000648: BEQ   t1,$0,0x70000660 NOP
70000650: JAL   0x7C369070       NOP                    BEQ   $0,$0,0x70000660
7000065C: NOP                    LI    a0,1             JAL   0x70000464
70000668: NOP                    LI    a0,2
70000670: JAL   0x70000464       NOP                    LI    a0,17
7000067C: JAL   0x70000464       NOP                    OR    a0,$0,$0
70000688: JAL   0x7F808C98       NOP
70000690: BEQ   $0,$0,0x70000698 NOP                    LW    s0,56(sp)
7000069C: LW    ra,60(sp)        NOP                    JR    ra
700006A8: ADDIU sp,sp,72         NOP
```

LMAP Command (Continued)

Note that address 0x7000057C contains a JAL. The address points to the EXAMPLE_INIT procedure. We can see this using the LMAP command:

```
050,03,00266-LMAP 0x70000390

EXAMPLE_INIT (UCr)
```

After the NOP in the delay slot, we see the parameters being set up for the next JAL. The SEGMENT_ALLOCATE_ procedure can accept a variable number of parameters; register A0 is a mask indicating which parameters are being passed. Some of the parameters are passed in registers and others are passed on the stack. Register A1 contains the segment number and A2, the length. The pointer to ERROR_DETAIL, $SP + 68, is stored at $SP + 20. So, for the first call to SEGMENT_ALLOCATE_, we see this sequence of output:

```
7000057C:                                               LUI a0,0xC800
70000588: LI    a1,1             LUI a2,0x1
70000590: ORI   a2,a2,0xFFF8     ADDIU t6,sp,68         SW    t6,20(sp)
7000059C: SW    $0,44(sp)        JAL   0x7F8051A8       NOP
```

The results from SEGMENT_ALLOCATE_ are stored in ERROR_MAIN, at $SP + 70, the result is also put in register T7 and compared against the zero constant in register $0. If the results are not equal, we fall into the next JAL, which is the call to Debug. The following shows this sequence:

```
700005A8: OR    s0,v0,$0         SH    s0,70(sp)
700005B0: LH    t7,70(sp)        NOP                    BEQ   t7,$0,0x700005D0
700005BC: NOP                    JAL   0x7C369070       NOP
```

Note. If a compiler optimization level other than 0 is used, it is unlikely that the return value from SEGMENT_ALLOCATE_ would be stored in memory. It would probably just be kept in a register.

We can confirm that the JAL in the above sequence is a call to Debug by using the LMAP command:

```
050,03,00266-LMAP 0x7C369070
DEBUG (SLr)
```

This does not work all the time. For example, the call to SEGMENT_ALLOCATE_ goes through a gateway to provide a protection layer between PRIV and non-PRIV code. Gateway and millicode addresses cannot be interpreted by the LMAP command. The following is the address for SEGMENT_ALLOCATE_ shown in an earlier code sequence. Below, we show the information the AMAP command provides about the address:

```
050,03,00266-LMAP 0x7F8051A8
050,03,00266-AMAP 0x7F8051A8
Address: 0x7F8051A8
Kind = 0x000B: SL (NATIVE)
Attributes: Read Only, Code, Entry Vector, Priv To Write
```

Break Command (Continued)

Below, we put a breakpoint after the first call to SEGMENT_ALLOCATE_ and after the second call to SEGMENT_ALLOCATE_:

```
050,03,00266-B 0x700005B0
N: 0x700005B0     INS: 0x87AF0046
                  INS: LH    t7,70(sp)
050,03,00266-B 0x70000600
 N: 0x70000600     INS: 0x13200005
                   INS: BEQ   t9,$0,0x70000618
```

At the first location, we stopped just as the ERROR_MAIN value at $SP + 70 was about to be loaded into register T7. In the second case, the value was already loaded in register T9 and we are about to branch based on the content in this register. We resume to the first location.

```
050,03,00266-R
DEBUG $PC=0x700005B0 -RISC BREAKPOINT ($PC: 0x700005B0)-
```

DN Command (Continued)

At this point in our example, we simulate an error returned from the call to SEGMENT_ALLOCATE_ by modifying the value in ERROR_MAIN at $SP + 70 to

have a nonzero value. First we display the location, then we modify the location. Finally, we display the location again.

```
050,03,00266-DN $SP + #70 :H 2
4FFFFF2E: 0x0000  0x0000
050,03,00266-D N $SP + #70
4FFFFF2E: 0x0000
050,03,00266-M  $SP + #70, -#1
050,03,00266-DN $SP + #70 :H
4FFFFF2E: 0xFFFF0000
```

The ERROR_MAIN variable is 2 bytes or 16 bits out of a 32-bit word. The first command we used was the DN command to display the 32-bit word as two 16-bit words. The second display we used is the D command with the N-address option to show one 16-bit word. We used the M command without the N-address option to assign a 16-bit value to the word. We could have also used the M command with the N-address option, but we would have needed to keep the value of the lower 16 bits of the 32-bit word unchanged, by entering their value. In that case, the command we would have entered is M N $SP + #70, 0xFFFF0000.

We resume and see the call to Debug, then resume to the next breakpoint. The call to Debug produces a different message at the stop than when we hit a breakpoint.

```
050,03,00266-R
DEBUG $PC=0x700005C8
050,03,00266-R
DEBUG $PC=0x70000600 -RISC BREAKPOINT ($PC: 0x70000600)-
```

Modifying Register Contents

We simulate an error returned from the call to SEGMENT_ALLOCATE_ by modifying the value used in the branch instruction to have a nonzero value. This time we use the modify command to change the register interactively. First, we display the current code location, clear the break at the location, and see the instruction at the location. Then we modify the value, display the register, and resume.

```
050,03,00266-I $PC
70000600: BREAK INSPECT RISC
050,03,00266-C $PC
050,03,00266-I $PC
70000600: BEQ   t9,$0,0x70000618
050,03,00266-M $T9
*REG*:  0x00000000 <- 4
050,03,00266-D $T9
*REG*:  0x00000004
050,03,00266-R
DEBUG $PC=0x70000610
```

Clearing Breakpoints

We view all the remaining breakpoints we have set, clear them, then show that they are gone:

```
050,03,00266-B

 N: 0x7000039C     INS: 0x00002025
                        INS: OR    a0,$0,$0
        N: 0x7000045C     INS: 0x03E00008
                        INS: JR    ra
        N: 0x700005B0     INS: 0x87AF0046
                        INS: LH    t7,70(sp)

050,03,00266-C *

050,03,00266-B
```

Setting Breakpoints Within a Procedure

In our first native code breakpoint example, we use the EXAMPLE_INIT procedure to emphasize debugging more on a global scope. The following example uses, the EXAMPLE_FILL_ARRAY procedure to emphasize debugging on a narrower (local) scope. In this example we demonstrate the B command as well as other Debug commands that we did not use with the EXAMPLE_INIT procedure.

I Command

We set breakpoints near the beginning and near the end of EXAMPLE_FILL_ARRAY procedure and resume to the first breakpoint. From our `noft` listing, we find that the procedure starts at 0x70000464 and is 268 bytes long. If we look at the first few instructions of the procedure, we observe:

```
050,03,00266-I 0x70000464, #10

70000464: ADDIU sp,sp,-128       SW    ra,60(sp)        SW    a0,128(sp)
70000470: SW    s1,56(sp)        SW    s0,52(sp)        LUI a0,0x8000
7000047C: LH    a1,130(sp)       SW    $0,44(sp)
70000484: JAL   0x7F805228       NOP
```

The first five instructions set up the stack for the EXAMPLE_FILL_ARRAY procedure. The instruction at 0x70000478 sets up the parameters for JAL at 0x70000484. This JAL is the call to the SEGMENT_USE_ procedure.

B Command

We put the beginning breakpoint at 0x70000478 and the end breakpoint at the second instruction from the end of the procedure.

```
050,03,00266-B 0x70000478

N: 0x70000478     INS: 0x3C048000
                  INS: LUI a0,0x8000

050,03,00266-B 0x70000464 + #268 - (4 * 2)

N: 0x70000568     INS: 0x03E00008
                  INS: JR    ra
```

T Command

We resume the program. After reaching the breakpoint, we use the T and TN commands to trace the stack and show the names:

```
050,03,00266-t

DEBUG $PC=0x70000478 -RISC BREAKPOINT ($PC: 0x70000478)-

050,03,00266-t

            0x70000478  VFP=0x4FFFFEE8 UCr
0x4FFFFE9C: 0x7000066C  VFP=0x4FFFFF30 UCr

050,03,00266-tn

             0x70000478  VFP=0x4FFFFEE8  EXAMPLE_FILL_ARRAY + 0x14

0x4FFFFE9C:  0x7000066C  VFP=0x4FFFFF30  EXAMPLE_MAIN + 0xFC
```

Clear Breakpoint at the Current Location

If the program is stopped at a code breakpoint, you need to specify only the C command to clear the breakpoint. We will look at the breakpoints before and after this operation.

```
050,03,00266-b

 N: 0x70000478     INS: 0x3C048000
                   INS: LUI a0,0x8000
 N: 0x70000568     INS: 0x03E00008
                   INS: JR    ra

050,03,00266-c

050,03,00266-b

N: 0x70000568     INS: 0x03E00008
                  INS: JR    ra
```

The EXAMPLE_FILL_ARRAY procedure uses one of the previously allocated segments. We can see the current segment in use with the ? command and display the ARRAY_NUM parameter at $SP + %h82. Note that ARRAY_NUM is only 2 bytes long. The *:d* part of the command caused the 32-bit word to break into two 16-bit words.

```
050,03,00266-?

 USE SEGMENT ID = NONE
 BASE STANDARD IN
 BASE STANDARD OUT
 TERM \M5.$ZTN00.#PTUGRB0
 PRV = OFF

050,03,00266-DN $sp+ %h82, 1 :d

4FFFFEEA: #00001  #00000
```

When we resume the program, it puts data segment 1 into use, then prompts us for some data. We enter "abcdefg". The program places the input data in a local buffer, then moves it to the data segment. At this point of our example, we arrive at the

breakpoint that is at the end of the procedure. Using the ? command, we see that segment 1 is being used.

```
050,03,00266-r
enter some data
abcdefg
DEBUG $PC=0x70000568 -RISC BREAKPOINT ($PC: 0x70000568)-
050,03,00267-?
USE SEGMENT ID = %000001


BASE STANDARD IN
BASE STANDARD OUT
TERM \M5.$ZTN00.#PTUGRB0
PRV = OFF
```

Displaying Data Using Q Address

We can display some data in the selectable segment using the Q-address mode. The extended indirect pointer, SP, was used to store the ARRAY_NUM in location 0 of the selectable segment. We can separate the characters by using the C grouping option and the hexadecimal output format.

We can also see the results of moving the procedure's buffer into the selectable segment. Because the data was stored at byte offset 41, we need to round down to the previous even byte (40). We then divide the offset 40 by 2 to convert to a 16-bit word address.

```
050,03,00266-d q 0, c :h
%000000: 01 00
050,03,00266-a q #40/2, #12/2, c
%000024:.abcdefg....
```

Displaying Output in Hexadecimal

Note that the output address, for the commands we used above, is given as 16-bit word offsets in octal. To see the hexadecimal byte offset, we can use the DN command. However, we need to first get the 32-bit address of the selectable segment.

AMAP Command

We use the AMAP command to get the 32-bit address of the selectable segment.

```
050,03,00266-AMAP Q
Address: 0x00080000
Kind = 0x0013: Unknown
Attributes: none
```

DN Command

Then display the information shown under the “Displaying Data Using Q Address” using the DN command.

```
050,03,00266-DN 0x00080000, 1 : h 1
00080000: 0x01 0x00 0x00 0x00
050,03,00266-DN 0x00080000 + #40, #12/4 :a
00080028: ..abc. .defg. ......
```

Using DN Command with Extended String Address

The EXAMPLE_FILL_ARRAY procedure does not update the extended indirect pointer SP located at program _GLOBAL + %H18, so it is pointing to the beginning of the selectable segment. We can repeat the DN commands above, using SP as an string extended address.

Note. The DN command we are using has this address form: offset [indirection-type [index]].

```
50,03,00266-DN 0x08000000 + %h18sx, 1 :h 1
00080000: 0x01 0x00 0x00 0x00
050,03,00266-DN 0x08000000 + %h18sx#40, #12/4 :a
00080028: ..abc. .defg. ......
```

The EXAMPLE_FILL_ARRAY procedure has a local extended string pointer, SEGMENT_PTR, located at $SP + %h48. The pointer is set to offset 41 of SP. We can repeat the above commands, using the location for the SEGMENT_PTR pointer.

```
050,03,00266-DN $SP +%h48sx, #12/4 :a
00080029: .abcd. .efg.. ......
```

We resume the program so it stops the next time we reach the end of the EXAMPLE_FILL_ARRAY procedure. The ? command shows the segment that iscurrently being used.

```
050,03,00266-r
enter some data
tuvwxyz
DEBUG $PC=0x70000568 -RISC BREAKPOINT ($PC: 0x70000568)-
050,03,00266-?
USE SEGMENT ID = %000002


BASE STANDARD IN
BASE STANDARD OUT
TERM \M5.$ZTN00.#PTUGRB0
PRV = OFF
```

VQ Command

We switch to another selectable segment with the VQ command and modify the data in the segment in preparation to demonstrate the FN command.

```
050,03,00266-vq 1

050,03,00266-?

USE SEGMENT ID = %000001


 BASE STANDARD IN
 BASE STANDARD OUT
 TERM \M5.$ZTN00.#PTUGRB0
 PRV = OFF

050,03,00266- M Q 0x2ff0, 'bc'
```

FN Command

We can use the FN command to find the location of a 16-bit word that matches a value. The value must be aligned on an even byte boundary. The "abcdefg" data we entered was placed into the selectable segment 1 starting on an odd byte (41), so we start by looking for a "bc," which is the first character starting on an even byte. We also modified the selectable segment with an "bc" at offset 0x2ff0, which is an even address.

```
050,03,00266-FN Q 0, 'bc'

%000025: 0x6263

050,03,00266 (FN)-

%027760: 0x6263

050,03,00266 (FN)-

** DEBUG error 50: FN stopped searching at the following address: 0x0009FFF8
Address not valid
```

Pressing return at the (FN) prompt causes the FN command to continue searching. After the second return, we encounter the end of the selectable segment, and an error is reported.

Note. The FN command specifies the output address offset for 16-bit words in octal.

To find out the byte address in hexadecimal form, we can use the AMAP command to convert the Q-address into a 32-bit address and use the = command to add in the 16-bit offset. Furthermore, we enter the data found at the location to the = command and find that the value equals "bc."

```
050,03,00266-AMAP Q 0

Address: 0x00080000
Kind = 0x0013: Unknown
Attributes: none

050,03,00266-= 0x00080000 + (%000025 * 2)
```

```
 = %00002000052  #524330  0x0008002A  '...*'
050,03,00266-= 0x6263
= %061143  #25187  0x6263  'bc'
```

Finding Bit Patterns

If we want to find a bit pattern and do not care what is in the other bits, we can use masking. In the following example, we look for a "c" in the second byte of the 16-bit word and ignore the other bits. The "x" is the value we were looking for, and the 0x62, "b", was ignored when finding the match.

```
050,03,00266-fn q 0, 'xc' & 0x00ff
%000025: 0x6263
050,03,00266 (FN)-
%027760: 0x6263
050,03,00266 (FN)-
```

We resume the program again and enter a different data pattern from what is contained in segments 1 and 2. The selectable segment 17 is longer than segment 1 or segment 2. We use this to show some variations on the commands.

```
050,03,00266-r
enter some data
0123456789
DEBUG $PC=0x70000568 -RISC BREAKPOINT ($PC: 0x70000568)-
050,03,00266-?
USE SEGMENT ID = %000021

BASE STANDARD IN
BASE STANDARD OUT
TERM \M5.$ZTN00.#PTUGRB0
PRV = OFF
```

For the next example, we modify a 32-bit word in the selectable segment. We use the modify command with an N-address prefix to do the 32-bit operation.

```
050,03,00266-AMAP Q #140000
Address: 0x000A22E0
Kind = 0x0013: Unknown
Attributes: none
050,03,00266-m n 0x000A22E0
0x000A22E0  :  0x00000000  <- '3456'
0x000A22E4  :  0x00000000  <-
```

FNL Command

We use the FNL command to find the 32-bit data. The value is 32-bit, so the address given must be aligned on an even quad byte.

```
050,03,00266-FNL Q 0 , '3456'

0008002C: 0x33343536

050,03,00266 (FNL)-

** DEBUG error 51: FNL reached address boundary.  To continue, enter the
following address:
0x000A0000

050,03,00266-fnl 0x000A0000

000A22E0: 0x33343536

050,03,00266 (FNL)-

** DEBUG error 52: FNL stopped searching at the following address:
0x000BEFD0
Address not valid
```

Note. The output addresses for the FNL command are hexadecimal byte addresses.

The FNL and FN commands stop the search either at the end of the segment or when the low-order 17 bits of the address are zero. If the address boundary is reached, it is only necessary to restart the command with the address. The value to search for will be the same as for the last search.

Searching for Specific Bit Patterns

We can look for a specific pattern within the 32-bit word, while ignoring the other bits. In this example, we use the FNL command with a mask to look only for the bit pattern 0x3435 in the second and third byte of the word:

```
050,03,00266-FNL  q0, 0x00343500 & 0x00ffff00

0008002C: 0x33343536

050,03,00266 (FNL)-
```

STOP Command

Before we move to the rest of the native program examples, we enter the STOP command to stop the program.

Additional Breakpoint Options

In the following examples, we demonstrate some variations on the B and BM commands by running the Example F-3, pTAL Compiled Listing several times.

Tracing Breakpoint

Here, we demonstrate the breakpoint tracing capability. First, we run the program as follows: RUND ndemo1. We then set the base output to hexadecimal to make the outputs more familiar for native code programmers.

```
DEBUG $PC=0x70000570

050,03,00265-base hex out

050,03,00265-b 0x70000478

N: 0x70000478     INS: 0x3C048000
                  INS: LUI a0,0x8000

050,03,00265-r

DEBUG $PC=0x70000478 -RISC BREAKPOINT ($PC: 0x70000478)-

050,03,00265-c

050,03,00265-= $SP + %h82


= %11777777352  #1342177002  0x4FFFFEEA  'O...'

050,03,00265-b 0x70000478, N 0x4FFFFEEA ? 1

N: 0x70000478     INS: 0x3C048000
                  INS: LUI a0,0x8000
N  0x4FFFFEEA                       ? 0x00000001

050,03,00265-b 0x70000464 + #268 - (4 * 2), N 0x00080028 ? #16/2

N: 0x70000568     INS: 0x03E00008
                  INS: JR    ra
N  0x00080028                       ? 0x00000008

050,03,00265-r

TRACE $PC=0x70000478
4FFFFEEA: 0x0001
enter some data

abcdefg

TRACE $PC=0x70000568
00080028: 0x0061  0x6263  0x6465  0x6667  0x0000  0x0000  0x0000  0x0000
TRACE $PC=0x70000478
4FFFFEEA: 0x0002
enter some data

hijklmnop

TRACE $PC=0x70000568
00080028: 0x0068  0x696A  0x6B6C  0x6D6E  0x6F70  0x0000  0x0000  0x0000
TRACE $PC=0x70000478
4FFFFEEA: 0x0011
enter some data

uvwxyz0123

TRACE $PC=0x70000568
00080028: 0x0075  0x7677  0x7879  0x7A30  0x3132  0x3300  0x0000  0x0000
```

Conditional Breakpoint

The next example shows the conditional breakpoint. We stop a code breakpoint in the EXAMPLE_FILL_ARRAY procedure when the ARRAY_NUM parameter is greater than 16. (Note that the third call to the EXAMPLE_FILL_ARRAY procedure is 17 in the native object code listing above.) We put a breakpoint in the EXAMPLE_FILL_ARRAY

procedure after the SP register has been set up, so that we point to the correct location for ARRAY_NUM. First we run the program as follows: `RUND ndemo1`.

```
050,03,00267-b 0x70000478

 N: 0x70000478     INS: 0x3C048000
                   INS: LUI a0,0x8000

050,03,00267-r

DEBUG $PC=0x70000478 -RISC BREAKPOINT ($PC: 0x70000478)-

050,03,00267-c

050,03,00267-b 0x70000478, 0x4FFFFEEA > #16

 N: 0x70000478     INS: 0x3C048000
                   INS: LUI a0,0x8000
              %047777.177352      & %177777     > %000020

050,03,00267-r

enter some data

abcdefg

enter some data

lmnopqrst

DEBUG $PC=0x70000478 -RISC BREAKPOINT ($PC: 0x70000478)-

050,03,00267-dn $sp+%h82 :d

4FFFFEEA: #00017  #00000
```

The ARRAY_NUM variable is a 16-bit (2 bytes long) number, so we enter the condition address as a 32-bit address without an N prefix. If we want to have a conditional breakpoint on a 32-bit number, we would prefix the conditional address with the N.

Execute Breakpoint

The next example shows the execute breakpoint using the BM command. First we run the pTAL compiled listing: `RUND ondemo1`.

We put a memory-access breakpoint on the first 16-bit word of data pointed to in the IN_OUT_MESSAGE array of the EXAMPLE_FILL_ARRAY procedure. We stop near the beginning of EXAMPLE_FILL_ARRAY and look at the data in IN_OUT_MESSAGE.

```
050,03,00269-b 0x70000478

N: 0x70000478     INS: 0x3C048000
INS: LUI a0,0x8000

050,03,00269-r

DEBUG $PC=0x70000478 -RISC BREAKPOINT ($PC: 0x70000478)-

050,03,00269-dn $SP + %H4c, %h30/4 :a

4FFFFEB4: .$ZTN. .00.#. .PTK9. .AAB..
4FFFFEC4: ...... ...... ...... ......
4FFFFED4: ...... ...... ...... ......
```

The data in the current location is junk, left on the stack from the EXAMPIL_INIT procedure that we used in previous examples.

Next, we clear the code breakpoint and add a memory-access breakpoint on the data. We include a command string to make the breakpoint an execute breakpoint.

```
050,03,00269-bm $SP + %H4c, w, (TN; dn $SP + %H4c, %h30/4 :a; R)

N: 0x4FFFFEB4     MAB: W (TN; DN $SP + %H4C, %H30/4 :A; R)

050,03,00269-r

DEBUG $PC=0x7E007EE4 -MEMORY ACCESS BREAKPOINT-
MEMORY ACCESS BREAKPOINT OCCURRED AT $PC=0x7E007EE4
            7E00.7EE4  4FFF.FE68  Mil
            7000.04EC  4FFF.FEE8  EXAMPLE_FILL_ARRAY + 0x88
4FFF.FE9C:  7000.066C  4FFF.FF30  EXAMPLE_MAIN + 0xFC
4FFFFEB4: .eZTN. .00.#. .PTK9. .AAB..
4FFFFEC4: ...... ...... ...... ......
4FFFFED4: ...... ...... ...... ......

DEBUG $PC=0x7E007EF0 -MEMORY ACCESS BREAKPOINT-
MEMORY ACCESS BREAKPOINT OCCURRED AT $PC=0x7E007EF0
            7E00.7EF0  4FFF.FE68  Mil
            7000.04EC  4FFF.FEE8  EXAMPLE_FILL_ARRAY + 0x88
4FFF.FE9C:  7000.066C  4FFF.FF30  EXAMPLE_MAIN + 0xFC
4FFFFEB4: .enTN. .00.#. .PTK9. .AAB..
4FFFFEC4: ...... ...... ...... ......
4FFFFED4: ...... ...... ...... ......

enter some data

abcdefg

DEBUG $PC=0x70000530 -MEMORY ACCESS BREAKPOINT-
MEMORY ACCESS BREAKPOINT OCCURRED AT $PC=0x7E007EF0
            7000.0532  4FFF.FEE8  EXAMPLE_FILL_ARRAY + 0xCE
4FFF.FE9C:  7000.066C  4FFF.FF30  EXAMPLE_MAIN + 0xFC
4FFFFEB4: .abcd. .efgo. .me d. .ata..
4FFFFEC4: ...... ...... ...... ......
4FFFFED4: ...... ...... ...... ......

DEBUG $PC=0x7E007EE4 -MEMORY ACCESS BREAKPOINT-
MEMORY ACCESS BREAKPOINT OCCURRED AT $PC=0x7E007EE4
            7E00.7EE4  4FFF.FE68  Mil
            7000.04EC  4FFF.FEE8  EXAMPLE_FILL_ARRAY + 0x88
4FFF.FE9C:  7000.0678  4FFF.FF30  EXAMPLE_MAIN + 0x108
4FFFFEB4: .ebcd. .efgo. .me d. .ata..
4FFFFEC4: ...... ...... ...... ......
4FFFFED4: ...... ...... ...... ......

DEBUG $PC=0x7E007EF0 -MEMORY ACCESS BREAKPOINT-
MEMORY ACCESS BREAKPOINT OCCURRED AT $PC=0x7E007EF0
            7E00.7EF0  4FFF.FE68  Mil
            7000.04EC  4FFF.FEE8  EXAMPLE_FILL_ARRAY + 0x88
4FFF.FE9C:  7000.0678  4FFF.FF30  EXAMPLE_MAIN + 0x108
4FFFFEB4: .encd. .efgo. .me d. .ata..
4FFFFEC4: ...... ...... ...... ......
4FFFFED4: ...... ...... ...... ......

enter some data

uvwxyz

DEBUG $PC=0x70000530 -MEMORY ACCESS BREAKPOINT-
MEMORY ACCESS BREAKPOINT OCCURRED AT $PC=0x7E007EF0
            7000.0532  4FFF.FEE8  EXAMPLE_FILL_ARRAY + 0xCE
4FFF.FE9C:  7000.0678  4FFF.FF30  EXAMPLE_MAIN + 0x108
4FFFFEB4: .uvwx. .yzso. .me d. .ata..
4FFFFEC4: ...... ...... ...... ......
4FFFFED4: ...... ...... ...... ......
```

```
DEBUG $PC=0x7E007EE4 -MEMORY ACCESS BREAKPOINT-
MEMORY ACCESS BREAKPOINT OCCURRED AT $PC=0x7E007EE4
            7E00.7EE4  4FFF.FE68  Mil
            7000.04EC  4FFF.FEE8  EXAMPLE_FILL_ARRAY + 0x88
4FFF.FE9C:  7000.0684  4FFF.FF30  EXAMPLE_MAIN + 0x114
4FFFFEB4: .evwx. .yzso. .me d. .ata..
4FFFFEC4: ...... ...... ...... ......
4FFFFED4: ...... ...... ...... ......

DEBUG $PC=0x7E007EF0 -MEMORY ACCESS BREAKPOINT-
MEMORY ACCESS BREAKPOINT OCCURRED AT $PC=0x7E007EF0
            7E00.7EF0  4FFF.FE68  Mil
            7000.04EC  4FFF.FEE8  EXAMPLE_FILL_ARRAY + 0x88
4FFF.FE9C:  7000.0684  4FFF.FF30  EXAMPLE_MAIN + 0x114
4FFFFEB4: .enwx. .yzso. .me d. .ata..
4FFFFEC4: ...... ...... ...... ......
4FFFFED4: ...... ...... ...... ......

enter some data

0123456789

DEBUG $PC=0x70000530 -MEMORY ACCESS BREAKPOINT-
MEMORY ACCESS BREAKPOINT OCCURRED AT $PC=0x7E007EF0
            7000.0532  4FFF.FEE8  EXAMPLE_FILL_ARRAY + 0xCE
4FFF.FE9C:  7000.0684  4FFF.FF30  EXAMPLE_MAIN + 0x114
4FFFFEB4: .0123. .4567. .89 d. .ata..
4FFFFEC4: ...... ...... ...... ......
4FFFFED4: ...... ...... ...... ......
```

Note that at the first breakpoint, there is already some text in the data area. This procedure is reusing some of the data area that the EXAMPLE_INIT procedure used. Thus, if we had entered our breakpoint at the beginning of the program as "bm n 0x4FFFFEB4, w," we would have stopped in the EXAMPLE_INIT and EXAMPLE_FILL_ARRAY procedures.

The memory-access breakpoint is triggered when anything is written to the 16-bit word. In this case, we get two interrupts: one when the "e" is put into the word, and another when the "n" is put into the word. This double interrupt is true only when the code placing the data in the memory location is doing byte operations and the code is not PRV. The next break happens after the data is entered. In second case, the data is transferred in the PRV system procedure so the breakpoint is reported after the end of the PRV procedure. In the following subsection, we discuss privileged commands.

Privileged Commands

Certain commands and addresses are restricted unless PRV has been turned ON. This is allowed only when the user is the super ID (255, 255). In order to run the following commands, you need to be the super ID. Use Debug commands on another program running in the same processor. The environment to run Debug can be chosen arbitrarily. For our example program, we used the File Utility Program (FUP). If you are debugging in Inspect, enter the command SELECT DEBUGGER DEBUG to access Debug.

```
$DATA06 CRGTT 9> fup /cpu 3, debug/

INSPECT - Symbolic Debugger - T9673D40 - (30SEP97)   System \M5
Copyright Tandem Computers Incorporated 1983, 1985-1997
INSPECT

050,03,00010  FUP  #FUP^MAIN + %0I _FUP_select debugger debug

DEBUG P=%120301, E=%000207, UC.%00
```

Using G-address Mode to Access Data

The G-address mode allows access to data in the system's global area. Attempting to use the G-address mode when you are not a privileged user results in an error.

```
050,03,00010-D G 123I, T#8*#12 :h

** DEBUG error 7: PRV ON is required to perform command.

050,03,00010-?

USE SEGMENT ID = %002000


 BASE STANDARD IN
 BASE STANDARD OUT
 TERM \M5.$ZTN00.#PTYX5AA
 PRV = OFF

050,03,00010-PRV ON

050,03,00010-?

BASE SEGMENTS:  SYSTEM DATA = %000001
                SYSTEM CODE = %000005
                SYSTEM LIB = %020400
                USER DATA = %020754
                USER CODE = %020736
V PIN = 012  (#010)
```

```
USE SEGMENT ID = %002000


BASE STANDARD IN
BASE STANDARD OUT
TERM \M5.$ZTN00.#PTYX5AA
PRV = ON

050,03,00010-D G 123I, T#8*#12 :h

%155457: 0xFFFF  0x0000  0x0000  0x0000  0x0000  0x0000  0x0000  0x0000
%155467: 0x0000  0x0000  0x0000  0x0000  0x0000  0x0000  0x0000  0x0000
%155477: 0x0000  0x0000  0x0000  0x0000  0x0000  0x0000  0xFFFF  0x0000
%155507: 0xFFFF  0x0000  0x0000  0x0000  0x0000  0x0000  0x0000  0x0000
%155517: 0x0000  0x0000  0x0000  0x0000  0x0000  0x0000  0x0000  0x0000
%155527: 0x0000  0x0000  0x0000  0x0000  0x0000  0x0000  0xFFFF  0x0000
%155537: 0xFFFF  0x0000  0x0000  0x0000  0x0000  0x0000  0x0000  0x0000
%155547: 0x0000  0x0000  0x0000  0x0000  0x0000  0x0000  0x0000  0x0000
%155557: 0x0000  0x0000  0x0000  0x0000  0x0000  0x0000  0xFFFF  0x0000
%155567: 0xFFFF  0x0000  0x0000  0x0000  0x0000  0x0000  0x0000  0x0000
%155577: 0x0000  0x0000  0x0000  0x0000  0x0000  0x0000  0x0000  0x0000
%155607: 0x0000  0x0000  0x0000  0x0000  0x0000  0x0000  0xFFFF  0x0000
```

The current setting of PRV can be viewed with the ? command. Also, when PRV is set, additional segments are shown.

Address Range Limitation

Certain address ranges are not allowed for a command when PRV is set to OFF. Following are two examples of this:

```
050,03,00010-amap G 123I

** DEBUG error 7: PRV ON is required to perform command.

050,03,00010-PRV
050,03,00010-amap G 123I

Address: 0x8003B65E
Kind = 0x0013: Unknown
Attributes: Priv To Read, Priv To Write

050,03,00010-PRV OFF
050,03,00010-DN 0x8003B65E, #24 by 4 :h

** DEBUG error 7: PRV ON is required to perform command.

050,03,00010-prv on
050,03,00010-DN 0x8003B65E, #24 by 4 :h

8003B65E: 0xFFFF0000  0x00000000  0x00000000  0x00000000
8003B66E: 0x00000000  0x00000000  0x00000000  0x00000000
8003B67E: 0x00000000  0x00000000  0x00000000  0xFFFF0000
8003B68E: 0xFFFF0000  0x00000000  0x00000000  0x00000000
8003B69E: 0x00000000  0x00000000  0x00000000  0x00000000
8003B6AE: 0x00000000  0x00000000  0x00000000  0xFFFF0000
```

Note. To turn PRV mode on, we can enter only PRV, not PRV ON. For the remainder of the example, we use only PRV.

Finding information in the process control block (PCB) involves accessing addresses that require the privileged mode to be turned on (the use of the PRV or PRV ON

commands). If we want to look at information in another PIN's PCB, or our own, we can use the PCB option on the D command.

```
050,03,00010-D PCB #265 + #8, 2 :h
80C26F28: 0xA8A8  0x0109
050,03,00010-= %ha8
= %000250  #00168  0x00A8  '..'
050,03,00010-= 0x0109
= %000411  #00265  0x0109  '..'
```

In this example, we are looking at the PCB for PIN 265, starting at byte offset 8 for two 16-bit words. Byte 8 has the starting priority, and byte 9 has the current priority. Bytes 10 and 11 make up a 16-bit word that contains the PIN. Note that the PIN matches the one we entered.

We have the example program running as PIN 265 in the same processor. The program has a breakpoint at the end of the EXAMPLE_FILL_ARRAY procedure. First, we look at the breakpoint table.

```
050,03,00010-B
N: 0x70000568     INS: 0x03E00008           PIN: #00265
                  INS: JR    ra
```

With the privileged mode enabled, we can see breakpoints to all the processes. Thus, while running PIN 10, we also see PIN 265's breakpoint.

V Command

We can use the V command to view and manipulate information for another PIN. In this example, we vector to PIN 265. We use the ? command to see the environment before and after the V command has been entered.

```
050,03,00010-?
BASE SEGMENTS:  SYSTEM DATA = %000001
                SYSTEM CODE = %000005
                SYSTEM LIB = %020400
                USER DATA = %020754
                USER CODE = %020736
V PIN = 012  (#010)
USE SEGMENT ID = %002000

BASE STANDARD IN
BASE STANDARD OUT
TERM \M5.$ZTN00.#PTYX5AA
PRV = ON
050,03,00010-V #265
```

```
050,03,00010-?

BASE SEGMENTS:  SYSTEM DATA = %000001
                SYSTEM CODE = %000005
                SYSTEM LIB = %020400
                V PIN = 411  (#265)

USE SEGMENT ID = %000002


BASE STANDARD IN
BASE STANDARD OUT
TERM \M5.$ZTN00.#PTYX5AA
PRV = ON
```

We can display information in PIN 265's _GLOBAL data as follows:

```
050,03,00010-DN 0x08000002, %h14/4 :D

08000002: #00256  #00000  #00003  #00265  #00000  #00000  #00011  #43155
08000012: #00000  #00050
```

As we saw in the examples above, the program is currently using selectable segment 2. We can use various Debug commands to see the contents of the selectable segments:

```
050,03,00010-vq 1
050,03,00010-D Q 0, 1,b:d

%000000: 001 000

050,03,00010-vq 2
050,03,00010-D Q 0, 1,b:d

%000000: 002 000

050,03,00010-vq #17
050,03,00010-D Q 0, 1,b:d

%000000: 000 000
```

Code Breakpoints

We can use commands such as M or FNL on the program we have vectored to. We can also place code breakpoints. The following shows the code *before* and *after* the breakpoint is placed near the beginning of the EXAMPLE_FILL_ARRAY procedure.

```
050,03,00010-i %h70000464, 10

70000464: ADDIU sp,sp,-128       SW    ra,60(sp)        SW    a0,128(sp)
70000470: SW    s1,56(sp)        SW    s0,52(sp)        LUI a0,0x8000
7000047C: LH    a1,130(sp)       SW    $0,44(sp)
70000484: JAL   0x7F805228       NOP                    OR    s0,v0,$0
70000490: SH    s0,124(sp)       LH    t6,124(sp)       NOP
7000049C: BEQ   t6,$0,0x700004B4 NOP

050,03,00010-b %h70000478

N: 0x70000478     INS: 0x3C048000          PIN: #00265
                  INS: LUI a0,0x8000

050,03,00010-i %h70000464, 10

70000464: ADDIU sp,sp,-128       SW    ra,60(sp)        SW    a0,128(sp)
70000470: SW    s1,56(sp)        SW    s0,52(sp)        BREAK INSPECT RISC
7000047C: LH    a1,130(sp)       SW    $0,44(sp)
70000484: JAL   0x7F805228       NOP                    OR    s0,v0,$0
70000490: SH    s0,124(sp)       LH    t6,124(sp)       NOP
7000049C: BEQ   t6,$0,0x700004B4 NOP
```

While in privileged mode, it is possible to clear all the breakpoints set on all the processes in a processor.

In this example, we first use the V command to go back to our own process and show the environment with the ? command. Then we show the breakpoint table before and after the C -1 command.

```
050,03,00010-V
050,03,00010-?

BASE SEGMENTS:  SYSTEM DATA = %000001
                SYSTEM CODE = %000005
                SYSTEM LIB = %020400
                USER DATA = %020754
                USER CODE = %020736
V PIN = 012  (#010)

USE SEGMENT ID = NONE
 BASE STANDARD IN
 BASE STANDARD OUT
 TERM \M5.$ZTN00.#PTYX5AA
 PRV = ON

 050,03,00010-B

 N: 0x70000568     INS: 0x03E00008           PIN: #00265
                   INS: JR    ra
 N: 0x70000478     INS: 0x3C048000           PIN: #00265
                   INS: LUI a0,0x8000

050,03,00010-C -1

050,03,00010-B
```

STOP Command

We stop the program by entering the STOP command.

Glossary

This glossary defines technical terms related to the design of the operating system, to HP system architecture, and to the Debug facility. The following definitions should help you interpret the information on using Debug.

absolute extended address. An address that can be used, when the processor module is in privileged mode, to access any byte of virtual memory in the processor module.

accelerate. To use the Accelerator program to generate an accelerated object file.

accelerated mode. The operational environment in which Accelerator-generated RISC instructions execute.

accelerated object code. The RISC instructions that result from processing a TNS object file with the Accelerator.

accelerated object file. The object file that results from processing a TNS object file with the Accelerator. An accelerated object file contains the original TNS object code, the accelerated object code and related address map tables, and any binder and symbol information from the original TNS object file.

Accelerator. A program that processes a TNS object file and produces an accelerated object file. Most TNS object code that has been accelerated runs faster on TNS/R processors than TNS object code that has not been accelerated.

breakpoint. A location in a program at which execution is suspended so that you can examine and modify the program's state. A breakpoint can occur just before the execution of a specific instruction (instruction breakpoint), or it can occur when a specific memory location is accessed in a specified way (memory-access breakpoint).

A TNS breakpoint is an instruction breakpoint within a sequence of TNS instructions. A RISC breakpoint is an instruction breakpoint within a sequence of RISC instructions. In accelerated code, a TNS breakpoint can be placed only at a memory-exact point or at a register-exact point; Debug sets a corresponding RISC breakpoint.

byte. A group of eight consecutive bits; the smallest addressable unit of memory.

C-series system. A system that is running a C-release version of the HP NonStop operating system.

central processing unit (CPU). Traditionally, the main data processing unit of a computer. A HP system has multiple cooperating processors rather than a single processor, and processors are sometimes loosely called processors.

CISC. See complex instruction-set computing (CISC).

code image. The part of an object file that contains the machine instructions that make up procedures in one or more code segments.

code segment. A segment that contains program instructions to be executed plus related information. Code segments cannot be altered by an application program; therefore, they are read from disk but are never written back to disk.

complex instruction-set computing (CISC). A processor architecture based on a large instruction set, characterized by numerous addressing modes, multicycle machine instructions, and many special-purpose instructions. Contrast with reduced instruction-set computing (RISC).

converted process. An executing program that was written to take advantage of at least one feature of D-series systems. Contrast with unconverted process.

CPU. See central processing unit (CPU).

creation process ID. See process ID.

CRTPID. See process ID.

current selectable data segment. The selectable data segment that is being accessed by a process. A process specifies the current selectable data segment by calling the SEGMENT_USE_ or USESEGMENT procedure. Debug can put another segment in use if a VQ command is issued.

D-series system. A system that is running a D00.00 or later version of the HP NonStop operating system.

data segment. A type of segment whose logical pages contain information to be processed by the instructions in the related code segment.

extended data segment. An area of virtual memory used to contain data. An extended data segment is allocated with contiguous addresses and is treated programmatically as a single object. The two types of extended data segments are selectable segments and flat segments. Extended data segments are allocated by the ALLOCATESEGMENT or SEGMENT_ALLOCATE_ Guardian procedure.

file number. An integer that represents a particular instance of an open of a file. A file number is returned by an open procedure and is used in all subsequent input-output procedures to refer to the file. Internally, the file number is an index into the file table.

file system. A set of operating system procedures and data structures that provides for communication between a process and a file, which can be a disk file, a device other than a disk, or another process.

flat segment. An extended data segment that has a distinct range of relative addresses within the environment for the current process. Contrast with selectable segment.

Guardian. An environment available for interactive or programmatic use with the HP NonStop operating system. Processes that run in the Guardian environment use the Guardian system procedure calls as their application program interface; interactive

users of the Guardian environment use the HP Tandem Advanced Command Language (TACL) or another HP product's command interpreter. Contrast with Open System Services (OSS).

high PIN. A process identification number (PIN) in the range 256 or higher.

Home Terminal.)þ(1) The terminal from which a process is started. (2)þThe terminal from which the ENFORM command is entered. (3)þThe terminal whose name is returned by a call to the MYTERM procedure, or the name returned in the *hometerm* parameter of the PROCESS_GETINFO_ procedure.

HP NonStop operating system. The operating system for HP NonStop systems.

HP NonStop Series (TNS). HP computers that support the HP NonStop operating system and that are based on complex instruction-set computing (CISC) technology. TNS processors implement the TNS instruction set. Contrast with HP NonStop Series/RISC (TNS/R).

HP NonStop Series/RISC (TNS/R). HP computers that support the HP NonStop operating system and that are based on reduced instruction-set computing (RISC) technology. TNS/R processors implement the RISC instruction set and are upwardly compatible with the TNS system-level architecture. TNS/R processors include the NSR-L and NSR-N processors. Contrast with HP NonStop Series (TNS).

Lobug. A low-level debugger available to service providers.

low PIN. A process identification number (PIN) in the range 0 through 254.

memory-exact point. A location in an accelerated program at which the values in memory (but not necessarily in the register stack) are the same as they would be if the program were running on a TNS processor. Most source statement boundaries are memory-exact points. Complex statements might contain several such points: at each function call, privileged instruction, and embedded assignment. Contrast with register-exact point.

memory manager. A system process that manages physical memory in a processor module.

message system. A set of operating system procedures and data structures that handles the mechanics of exchanging messages between processes.

millicode. RISC instructions that implement various TNS low-level functions such as exception handling, real-time translation routines, and library routines that implement the TNS instruction set. Millicode is functionally equivalent to TNS microcode.

module. A physical grouping of procedures and data structures.

monitor. A system process that performs housekeeping tasks and creates and deletes processes in its processor module.

named process. A process to which a process name was assigned when the process was created. Contrast with unnamed process.

native-compiled RISC instructions. See RISC instructions.

native mode. See TNS/R native mode.

native object code. See TNS/R native object code

native object file. See TNS/R native object file.

native process. See TNS/R native process.

native signal. See TNS/R native signal."

network. Two or more nodes linked together for intersystem communication.

node. A system of one or more processors. Although the term is meaningful only when more than one system is linked into a network, the design of HP systems for operation in networks makes this term preferable to "system" in many contexts.

node name. The portion of a file name that identifies the system through which the file can be accessed.

node number. The internal identifier for the node on which file access occurs.

NonStop Open System Services (OSS). An application programmatic interface (API) to the HP NonStop operating system and associated tools and utilities. See to Open System Services (OSS) for a more complete definition.

NSR-L processor. The NonStop System RISC Model L processor (NSR-L processor) is the first HP NonStop Series/RISC processor.

object file. A file, generated by a compiler or binder, that contains machine instructions and other information needed to construct the code spaces and initial data for a process. The file may be a complete program that is ready for immediate execution, or it may be incomplete and require binding with other object files before execution.

Open System Services (OSS). An open system environment available for interactive or programmatic use with the HP NonStop operating system. Processes that run in the OSS environment use the OSS application program interface; interactive users of the OSS environment use the OSS shell for their command interpreter. Contrast with Guardian.

OSS. See Open System Services (OSS).

OSS signal. A signal model defined in the POSIX.1 specification and available to TNS processes and TNS/R native processes in the OSS environment. OSS signals can be sent between processes.

PFS. See process file segment (PFS).

physical memory. The semiconductor memory that is part of every processor module.

PIN. See process identification number (PIN).

privileged mode. 1. The state in which privileged debugging commands are enabled. The right to use Debug's privileged commands must be acquired by using the PRV ON command and does not depend on whether the process is executing privileged code. To acquire privileged debugging rights, the process being debugged must be executing under the local super ID (255, 255). 2. A process state that permits a process to perform privileged operations. Normally, only the operating system executes in privileged mode for such operations as sending data over an interprocessor bus, initiating input-output operations, calling privileged procedures, and accessing system tables.

ProcDebug. An Accelerator option that directs the Accelerator to perform optimization across statement boundaries. This option typically produces faster-executing code than the StmtDebug option, but debugging the program might be more difficult because it might not be possible to set a breakpoint at some statement boundaries. ProcDebug is the Accelerator default action. Contrast with StmtDebug.

process. An instance of execution of a program.

process file name. A file name that identifies a process.

process file segment (PFS). An extended data segment that is automatically allocated to every process and contains operating system data structures such as file-system data structures and memory-management pool data structures.

process handle. A D-series 20-byte data structure that identifies a named or unnamed process in the network. A process handle identifies an individual process; thus, each process of a process pair has a unique process handle.

process ID. A system structure that serves as an address of a process. The structure contains a processor number, process identification number (PIN), creation timestamp or process name, and system number (optional). It is sometimes called a creation timestamp process ID (CRTPID).

process identification number (PIN). An unsigned integer that identifies a process in a processor module. Internally, a PIN is used as an index into the process control block (PCB) table.

process name. A name that can be assigned to a process when the process is created. A process name uniquely identifies a process or process pair in a system.

program. A set of instructions that a computer is capable of executing.

program file. An executable object file. See to object file.

reduced instruction-set computing (RISC). A processor architecture based on a relatively small and simple instruction set, a large number of general-purpose registers, and an optimized instruction pipeline that supports high-performance instruction execution. Contrast with complex instruction-set computing (CISC).

register-exact point. A location in an accelerated program at which the values in both memory and the register stack are the same as they would be if the program were running on a TNS processor. Register-exact points are also memory-exact points. Contrast with memory-exact point.

relative extended address. An address that can be used when the processor module is in privileged or nonprivileged mode to access the user code, user library, and user data spaces of the process. A relative extended address can also be used in privileged mode to access the system code, system library, and system data spaces of the process.

RISC. See reduced instruction-set computing (RISC).

RISC instructions. Register-oriented 32-bit machine instructions that are directly executed on TNS/R processors. RISC instructions execute only on TNS/R systems, not on TNS systems. Contrast with TNS instructions.

selectable segment. An extended data segment that shares the same relative address space with all other selectable segments allocated by a process (and therefore does not have a distinct range of relative addresses within the current environment). Contrast with flat segment.

signal. A means by which a native or OSS process can be notified of or affected by an event occurring in the system. Some signals are used to notify a process when certain errors occur that prevent it from continuing execution of the current code stream. See also TNS/R native signal and OSS signal. Contrast with trap.

signal handler. A procedure that is executed when a signal is received by a process.

StmtDebug. An Accelerator option that directs the Accelerator to optimize instructions only within the code produced for any one statement. Instructions are not optimized across statements. This option typically produces less-optimized code than the ProcDebug option. However, debugging is easier than with the ProcDebug option because the beginning of every statement in the source program is a memory-exact point. Contrast with ProcDebug.

super ID. The user ID that permits unrestricted access to the system. On Guardian systems, it is user number 255,255; on OSS systems, it is the root user.

synthetic process ID. An identifier that might allow an unconverted server process to communicate with a high-PIN requester process. A synthetic process ID has a PIN of 255.

system. All the processors, memory, controllers, peripheral devices, and related components that are directly connected together by buses and interface wiring to form a cooperative processing unit.

system name. The identifier for the node on which file access occurs.

system number. The internal identifier for the node on which file access occurs.

system process. A process whose primary purpose is to manage system resources rather than to solve a user's problem. A system process is essential to a system-provided service. Failure of a system process often causes the processor module to fail. Most system processes are automatically created when the processor module is cold loaded. Contrast with user process.

TNS. See HP NonStop Series (TNS).

TNS instructions. Stack-oriented, 16-bit instructions defined as part of the TNS environment. On TNS systems, TNS instructions are implemented by microcode; on TNS/R systems, TNS instructions are implemented by millicode routines or by translation to an equivalent sequence of RISC instructions. Contrast with RISC instructions.

TNS mode. The operational environment in which TNS instructions execute.

TNS object code. The TNS instructions that result from processing source code with a TNS language compiler. TNS object code executes on both TNS and TNS/R systems.

TNS or accelerated mode. The operational environments in which either TNS instructions or Accelerator-generated RISC instructions execute. Contrast with TNS/R native mode.

TNS/R. See HP NonStop Series/RISC (TNS/R).

TNS/R native mode. The operational environment in which native-compiled RISC instructions execute.

TNS/R native object code. The RISC instructions that result from processing program source code with a TNS/R native compiler. TNS/R native object code executes only on TNS/R systems, not on TNS systems.

TNS/R native object file. A file created by a TNS/R native compiler that contains RISC instructions and other information needed to construct the code spaces and the initial data for a TNS/R native process.

TNS/R native process. A process initiated by executing a TNS/R native object file.

TNS/R native signal. A signal model available to TNS/R native processes in the Guardian and OSS environments. TNS/R native signals are used for error exception handling.

trap. A software mechanism that stops program execution and holds the cause of a processing problem. In TNS Guardian processes, traps occur as the result of errors that prevent the continued execution of the code stream. Contrast with signal.

trap handler. A location in a program where execution begins if a trap occurs. A process can specify a trap handler by a call to the ARMTRAP procedure.

unconverted process. A process that does not take advantage of the extended features of D-series systems. Contrast with converted process.

unnamed process. A process to which a process name was not assigned when the process was created. Contrast with named process.

user process. A process whose primary purpose is to solve a user's problem. A user process is not essential to the availability of a processor module. A user process is created only when the user explicitly creates it. Contrast with system process.

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