Digital Alpha VME 4/224 and 4/288 Single-Board Computers

User Guide and Technical Description

Order Number: EK–DAVME–TD. B01

This manual describes the Digital Alpha VME 4 module. It provides configuration and installation procedures and describes the module's built-in features, including the console code and diagnostics.

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Preface

Purpose of this Manual

This manual describes the Digital Alpha VME 4 module. It provides configuration and installation procedures and describes the module's built-in features, including the console code and diagnostics.

Intended Audience

This manual is for OEM system integrators who have extensive knowledge of single-board computers (SBCs). Their task is to integrate Digital Alpha VME 4 modules into their own systems. The system integrators need information about the Digital Alpha VME 4 module's physical and environmental specifications and performance. They also need information, such as register descriptions, to program the module.

A secondary audience consists of manufacturing technicians who install the module and field technicians who diagnose problems and replace modules.

This manual does not explain how to use specific operating system programming interfaces. For this information, see the appropriate operating system documentation.

Structure of this Manual

This manual consists of 13 chapters, an appendix, and an index.

- Chapter 1, Product Overview, provides a general product description, lists product features and functional specifications, and identifies physical and environmental requirements.
- Chapter 2, Installation Procedures, explains how to unpack and install the Digital Alpha VME 4 module. This chapter also introduces diagnostics and troubleshooting and provides repair and warranty information.

- Chapter 3, Operating the Digital Alpha VME 4 Computer, explains how to use the Digital Alpha VME 4 module's controls and indicators, introduces console mode and environment variables, and provides pointers to information on booting operating systems and updating firmware.
- Chapter 4, Diagnostics, describes the Digital Alpha VME 4 power-on self-test (POST) diagnostics and ROM based diagnostics (RBDs).
- Chapter 5, System Address Mapping, describes the mapping of 34-bit processor physical address space to memory and I/O space addresses. This chapter also includes discussions on address translations.
- Chapter 6, Cache and Memory Subsystem, describes the cache and memory subsystem. This chapter includes discussions on error handling and describes the subsystem's address space and registers.
- Chapter 7, PCI Host Bridge, describes the PCI host bridge that resides between the PCI local bus and the system bus. This chapter discusses the interfaces to the system bus and PCI bus and describes the related address space and registers.
- Chapter 8, PCI bus, describes the PCI bus, the base of the I/O subsystem. The chapter describes the various I/O devices and their registers.
- Chapter 9, Nbus, decribes the Digital Alpha VME 4 module's Nbus. The discussion includes the Nbus address space and registers. This chapter also includes information on ROM, the Super I/O chip, the keyboard and mouse controller, the time-of-year (TOY) clock, interval timer registers, the watchdog timer, and nonvolatile RAM (NVRAM).
- Chapter 10, VME Interface, describes the interface that handles the VMEbus and its interacations with the PCI bus. The chapter describes master and slave address spaces, address mapping, registers, and communication. The chapter also discusses system controller operation, byte swapping addressing, and interface initialization.
- Chapter 11, System Interrupts, describes Digital Alpha VME 4 system interrupts and how the module can be reset.
- Chapter 12, Console Primer, introduces you to the Digital Alpha VME 4 console and explains how to use basic console commands.
- Chapter 13, Console Commands, describes the Digital Alpha VME 4 console commands.
- Appendix A, Module Connector Pinouts, provides pinout information for the Digital Alpha VME 4 module connectors.

Conventions

This section defines terminology, abbreviations, and other conventions used in this manual.

Abbreviations

- Register access

  The following list describes the register bit and field abbreviations:

Bit/Field Abbreviation	Description
MBZ (must be zero)	Bits and fields specified as MBZ must be zero.
RO (read only)	Bits and fields specified as RO can be read but not written.
RW (read/write)	Bits and fields specified as RW can be read and written.
WO (write only)	Bits and fields specified as WO can be written but not read.

- Binary multiples

  The abbreviations K, M, and G (kilo, mega, and giga) represent binary multiples and have the following values:

  K = 2^{10} (1024)

  M = 2^{20} (1,048,576)

  G = 2^{30} (1,073,741,824)

  For example:

2 KB	= 2 kilobytes	= $2 * 2^{10}$ bytes
4 MB	= 4 megabytes	= $4 * 2^{20}$ bytes
8 GB	= 8 gigabytes	= $8 * 2^{30}$ bytes

Addresses

Unless otherwise noted, addresses and offsets are hexadecimal values.

Bit Notation

Multiple-bit fields can include contiguous and noncontiguous bits contained in angle brackets (<>). Multiple contiguous bits are indicated by a pair of numbers separated by a colon (:). For example, <9:7,5,2:0> specifies bits 9, 8, 7, 5, 2, 1, and 0. Similarly, single bits are frequently indicated with angle brackets. For example, <27> specifies bit 27.

Caution

Cautions indicate potential damage to equipment or loss of data.

Data Field Size

The term INT*nn*, where *nn* is one of 2, 4, 8, 16, 32, or 64, refers to a data field of *nn* contiguous NATURALLY ALIGNED bytes. For example, INT4 refers to a NATURALLY ALIGNED longword.

Data Units

The following data unit terminology is used throughout this manual.

Term	Words	Bytes	Bits	Other
Byte	1/2	1	8	—
Word	1	2	16	—
Longword/Dword	2	4	32	Longword
Quadword	4	8	64	2 Longwords
Octaword	8	16	128	2 Quadwords
Hexword	16	32	256	2 Octawords

Examples

The prompts, input, and output in examples are shown in a monospaced font. Interactive input is differentiated from prompts and system output with bold type. For example:

```
>>> echo This is a test.
This is a test.
```

Ellipsis points indicate that a portion of an example is omitted.

Keyboard Keys

The following keyboard key conventions are used throughout this manual.

Convention	Example
Control key sequences are represented as Ctrl/*x*. Press Ctrl while you simultaneously press the *x* key.	Ctrl/C
In plain text, key names match the name on the actual key.	Return key
In tables, key names match the name of the actual key and appear in a box.	Return

Names and Symbols

The following table lists typographical conventions used for names of various items throughout this manual.

Items	Example
Bits	**sysBus<32:2>**
Commands	**boot** command
Command arguments	*address* argument
Command options	**-sb** option
Environment variables	AUTO_ACTION
Environment variable values	HALT
Files and pathnames	/usr/foo/bar
Pins	LIRQ pin
Register symbols	VIP_ICR register
Signals	**iogrant** signal
Variables	*n*, *x*, *mydev*

Note

Notes emphasize particularly important information.

Numbering

Numbers are decimal or hexadecimal unless otherwise indicated. The prefix 0x indicates a hexadecimal number. For example, 19 is decimal, but 0x19 and 0x19A are hexadecimal (see also Addresses). Otherwise, the base is indicated by a subscript; for example, 100_2 is a binary number.

Ranges and Extents

Ranges are specified by a pair of numbers separated by two periods (..) and are inclusive. For example, a range of integers 0..4 includes the integers 0, 1, 2, 3, and 4.

Extents are specified by a pair of numbers in angle brackets (<>) separated by a colon (:) and are inclusive. Bit fields are often specified as extents. For example, bits <7:3> specifies bits 7, 6, 5, 4, and 3.

Register and Memory Figures

Register figures have bit and field position numbering starting at the right (low-order) and increasing to the left (high-order).

Memory figures have addresses starting at the top and increasing toward the bottom.

Syntax

The following syntax elements are used throughout this manual. Do not type the syntax elements when entering information.

Element	Example	Description
[ ]	[**-file *filename***]	The enclosed items are optional.
|	- | + | =	Choose one of two or more items. Select one of the items unless the items are optional.
{}	{- | + | =}	You must specify one (and only one) of the enclosed items.
()	—	You must specify the enclosed items together.
. . .	*arg* . . .	You can repeat the preceding item one or more times.

UNPREDICTABLE and UNDEFINED

In this manual, the terms UNPREDICTABLE and UNDEFINED are used. Their meanings are different and must be carefully distinguished.

In particular, only privileged software (that is, software running in kernel mode) can trigger UNDEFINED operations. Unprivileged software cannot trigger UNDEFINED operations. However, either privileged or unprivileged software can trigger UNPREDICTABLE results or occurrences.

UNPREDICTABLE results or occurrences do not disrupt the basic operation of the processor. The processor continues to execute instructions in its normal manner. In contrast, UNDEFINED operations can halt the processor or cause it to lose information.

The terms UNPREDICTABLE and UNDEFINED can be further described as follows:

- UNPREDICTABLE
  - Results or occurrences specified as UNPREDICTABLE might vary from moment to moment, implementation to implementation, and instruction to instruction within implementations. Software can never depend on results specified as UNPREDICTABLE.
  - An UNPREDICTABLE result might acquire an arbitrary value subject to a few constraints. Such a result might be an arbitrary function of the input operands or of any state information that is accessible to the process in its current access mode. UNPREDICTABLE results may be unchanged from their previous values.

Operations that produce UNPREDICTABLE results might also produce exceptions.

- An occurrence specifed as UNPREDICTABLE might happen or not based on an arbitrary choice function. The choice function is subject to the same constraints as are UNPREDICTABLE results and, in particular, must not constitute a security hole.

  Specifically, UNPREDICTABLE results must not depend upon, or be a function of the contents of memory locations or registers that are inaccessible to the current process in the current access mode.

  Also, operations that might produce UNPREDICTABLE results must not write or modify the contents of memory locations or registers to which the current process in the current access mode does not have access. They must also not halt or hang the system or any of its components.

  For example, a security hole would exist if some UNPREDICTABLE result depended on the value of a register in another process, on the contents of processor temporary registers left behind by some previously running process, or on a sequence of actions of different processes.

- UNDEFINED

  - Operations specified as UNDEFINED can vary from moment to moment, implementation to implementation, and instruction to instruction within implementations. The operation can vary in effect from nothing, to stopping system operation.

  - UNDEFINED operations can halt the processor or cause it to lose information. However, UNDEFINED operations must not cause the processor to hang, that is, reach an unhalted state from which there is no transition to a normal state in which the machine executes instructions. Only privileged software (that is, software running in kernel mode) can trigger UNDEFINED operations.

For More Information

Document	Order Number	Company
CY7C9640 Specification		Cypress Semiconductor Corp.
DECchip 21040–AA Specification	EC–N0752–72	Digital Equipment Corp.
DECchip 21064–AA Microprocessor Hardware Reference Manual	EC–N0079–72	Digital Equipment Corp.
DECchip 21072–AA Core Logic Chip Set	EC–N0648–72	Digital Equipment Corp.
Digital UNIX Installation Guide	AA–PS2DD–TE	Digital Equipment Corp.
Intel SIO82378 Chip Specification		Intel Corp.
Internetworking with TCP/IP, Vol I, Principles, Protocols and Architecture, Second edition, Prentice Hall.		
PCI Local Bus Specification		Intel Corp.
NCR 53C810 Specification		National Cash Register Co.
NCR 53C720 Programming Guide		National Cash Register Co.
SIO Chip (82378ZB) and 8259 Data Sheets		Intel Corp.
VIC64 Specification		Cypress Semiconductor Corp.
VxWorks Digital AXPvme Single-Board Computers Hardware Supplement	AA-QA5HA-TE	Digital Equipment Corp.
VxWorks Programmer's Guide	AA–Q3YLB–TE	Digital Equipment Corp.

1
Product Overview

1.1 Product Description

The Digital Alpha VME 4/224 and 4/288 MHz single-board computers are based on the 21064A Alpha processor chip. The Digital Alpha VME 4/224 comes preconfigured with 512 KB cache, and the Digital Alpha VME 4/288 comes preconfigured with 2 MB cache.

The board utilizes the Peripheral Component Interconnect (PCI) as the on-board bus for the interconnection of high performance SCSI, Ethernet, and VME interfaces, as well as the connection of industry-standard PCI mezzanine cards (PMCs—IEEE P1386.1 standard).

The Digital Alpha VME 4 processors are supported by the VxWorks for Alpha and Digital UNIX operating systems.

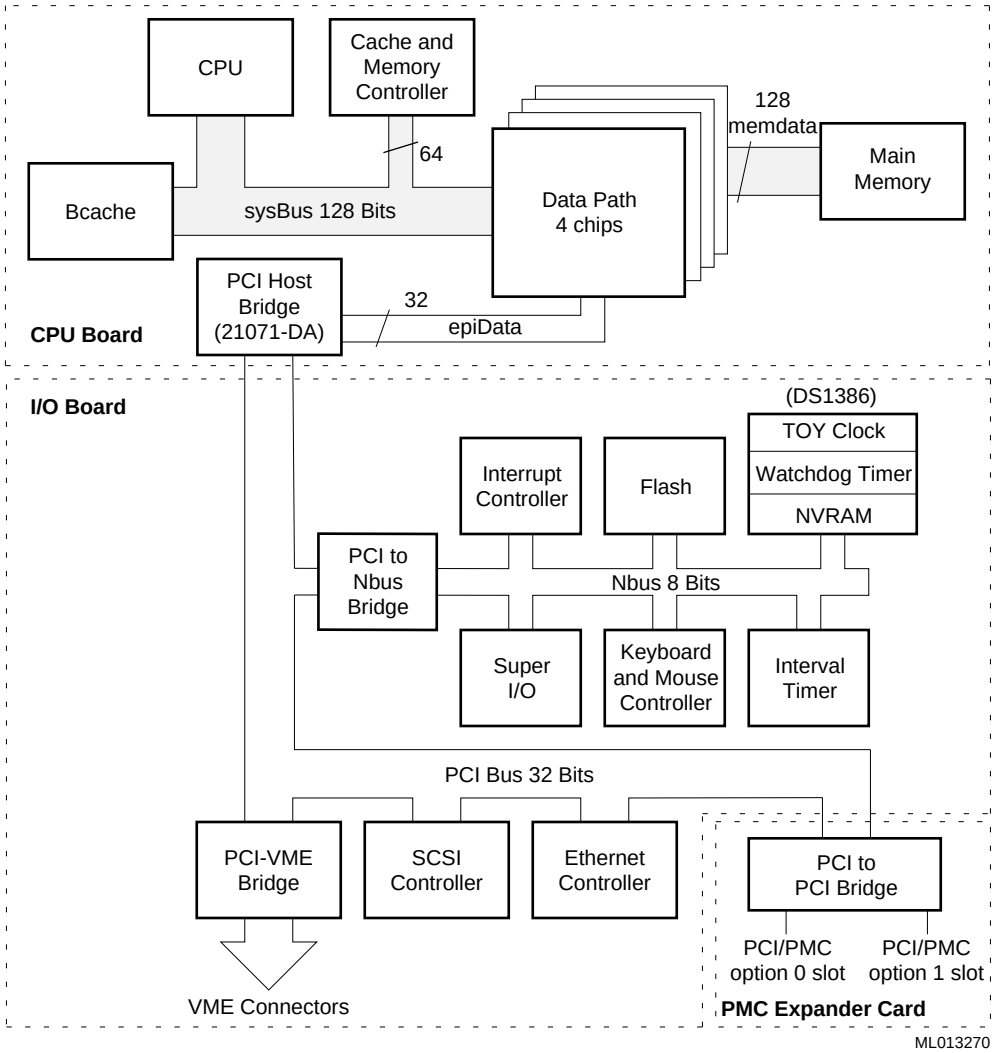
1.2 Functional Specifications

Table 1–1 lists the Digital Alpha VME 4 processor functional specifications. Figure 1–1 is a block diagram of the Digital Alpha VME 4 processor.

Table 1–1 Digital Alpha VME 4 Functional Specifications

Item	Description
Alpha AXP processor	21064A Alpha processor with on-chip 16 KB instruction and 16 KB data caches IEEE and VAX floating point.
Peformance	At 288 MHz, 238.51 SPECfp92, 188.84 SPECint92, 5.44 SPECfp95, and 4.69 SPECint95.
Network features	DECchip 21040 PCI Ethernet controller DMA (bus master), 256 byte send and receive FIFO, double bandwidth with full duplex Ethernet (PCI based).
Network Interconnect	10BASE-T Ethernet (twisted pair).
Memory	Cache - 512 KB or 2 MB using cache modules. Main memory ECC protected 8, 16, 32, 64, and 128 MB using memory DIMMS on 128-bit data bus with single-bit error detection. Accessible from the CPU, PCI, and VMEbus. 4 MB flash EPROM. 32 KB NVRAM.
SCSI-2	NCR 53C810 PCI based SCSI-2 processor single-ended 8-bit with DMA, up to 10 MB transfer rate with connection through the VMEbus P2 connector.
Serial and parallel interfaces	Two asynchronous DEC423 ports, 75 to 19200 baud through front panel MMJ connectors. Keyboard and mouse support for graphics options on either the secondary breakout module or the PMC I/O companion card. Extended parallel port through the secondary breakout module.
Clocks and timers	Real-time clock with battery backup. Three 16-bit timers. Watchdog timer with programmable reset.
VMEbus	High performance PCI to VME64 interface chip capable of DMA transfers, implemented with the VIC64 interface chip.
PCI expansion	Accepts one double-width or two single-width PCI mezzanine card (PMC) modules with optional I/O companion card.
Physical	6U VME form factor requiring two adjacent slots. Three adjacent slots are required with the optional PMC I/O companion card.

Figure 1–1 Digital Alpha VME 4 Block Diagram



1.3 Physical and Environmental Requirements

The Digital Alpha VME 4 module requires a VME chassis with sufficient cooling. You must have at least 200 linear feet/minute (lfm) of airflow at an ambient temperature of not more than 40°C (104°F) across the processor heatsink.

Table 1–2 shows the physical and environmental specifications for the Digital Alpha VME 4 module. Table 1–3 shows the power supply current and power dissipation for the Digital Alpha VME 4 module. Stresses beyond those specified may cause permanent damage to the module.

Table 1–2 Physical and Environmental Specifications

Characteristic	Specification
Industry standard	VME 6U module
Operating temperature	0°C to 40°C (32°F to 104°F)
Storage temperature	–40°C to 66°C (–40°F to 151°F)
Temperature change	20°C/hour (36°F/hour)
Relative humidity	5% to 95% (noncondensing)
Airflow	200 lfm minimum at 40°C ambient inlet air temperature, over the large square processor heatsink and cache
Vibration:	Operating in a suitable enclosure
	0.5 g Pk 22.1–260 Hz
	0.25 g Pk 200–500 Hz

Table 1–3 Typical Peak Power Supply Current and Module Power Dissipation

CPU Modules w/128 MB Memory	Amps @ 5 V	Amps @ 12 V (note 1)	Amps @−12 V	Module Heat Dissipation
Alpha VME 4/224	12.0 A	0.2 A	0.01 A	62 W
Alpha VME 4/288	13.5 A	0.2 A	0.01 A	70 W
Options	**Amps @ 5 V**	**Amps @ 12 V**	**Amps @−12 V**	**Power Dissipation**
SCSI Termination	0.8 A max.	0.0 A	N/A	4 W max.
PMC Option Slot Budget	3.0 A max.	N/A	N/A	15 W max.

Notes

Power and heat dissipation assumes nominal voltages (5.0 V, 12.0 V, and −12 V). Power numbers are based on actual measured data. Add 10% to the current and power values for a worst-case power and heat scenario.

SCSI Termination is enabled by default. You can disable this option by resetting the jumper on the primary breakout module as explained in Section 8.2.1.

For more information about the PMC option slot budget, see the documentation supplied with your PMC option.

2

Installation Procedures

This chapter describes how to unpack, configure, install, and verify proper operation of the Digital Alpha VME 4 module.

2.1 Unpacking

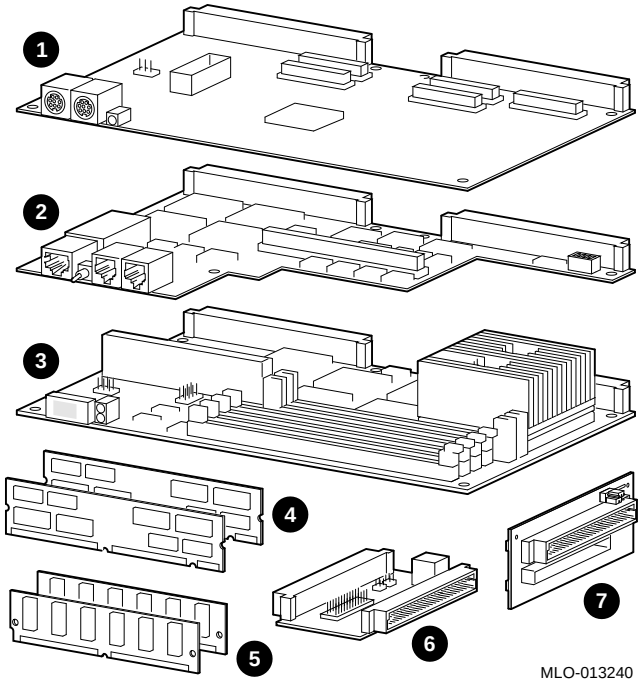
Your Digital Alpha VME 4 hardware kit contains the items listed in Table 2–1. Save the original packing material in case a factory return is necessary.

Caution

You must install the primary breakout module (54-24663-01) included in your hardware kit (see Figure 2–7). Applying power to the Digital Alpha VME 4 module **WITHOUT** that primary breakout module in place, or **WITH** the breakout module included with the AXPvme 160, 166, or 230 (P/N 54–22605–01) in place may damage your backplane, the Digital Alpha VME 4 module, or both.

Figure 2–1 shows the Digital Alpha VME 4 module and its options.

Figure 2–1 Digital Alpha VME 4 Module Components



❶ Optional PMC I/O companion card

❷ I/O module

❸ Digital Alpha VME 4 module

❹ Memory modules

❺ Cache memory modules

❻ Secondary breakout module

❼ Primary breakout module

Table 2–1 lists Digital Alpha VME 4 hardware kit items. The kits in Table 2–1 contain hardware only. The option you receive may also include software licenses or software, depending on what is ordered.

Table 2–1 Digital Alpha VME 4 Hardware Kit Items

Item	Part Number
Digital Alpha VME 4/224 Kit	
Digital Alpha VME 4 module I/O assembly	70–32976–04 (includes 512 KB cache) (54–24325–04 + 54–24319–01)
Digital Alpha VME 4 Primary breakout module [1]	54–24663–01
Digital Alpha VME 4 Secondary breakout module	54–24729–01
Alpha VME 4/228 and 4/288 Single-Board Computers User's Guide and Technical Description	EK–DAVME–TD
Antistatic wriststrap	12–36175–01
Digital Alpha VME 4/288 Kit	
Digital Alpha VME 4 module I/O assembly	70-32976-02 (includes 2 MB cache) (54–24325–02 + 54–24319–01)
Digital Alpha VME 4 Primary breakout module [1]	54–24663–01
Digital Alpha VME 4 Secondary breakout module	54–24729–01
Alpha VME 4/228 and 4/288 Single-Board Computers User Guide and Technical Description	EK–DAVME–TD
Antistatic wriststrap	12–36175–01
Optional PMC I/O Companion Card	
PMC I/O Companion Card	54–24665–01
Y cable	17-04230-01

[1] Installation necessary for operation of VME 4 module I/O assembly.

To install the Digital Alpha VME 4 module, you must also have one or more of the memory and cache module sets listed in Tables 2–2 and 2–3. Each kit contains two modules.

Table 2–2 Digital Alpha VME 4 Memory Modules

Memory Size (MB)	Kit Number	Part Number
16	EBMXM-DB	54–24659–AB
32	EBMXM-EB	54–24659–AA
64	EBMXM-FB	54–24645–AA

Table 2–3 Digital Alpha VME 4 Cache Memory Modules

Memory Size	Kit Number	Part Number	Quantity
512 KB	EBMXC–BA	54–24685–AA	2
2 MB	EBMXC–DB	54–24683–AA	2

Depending on how you plan to use the Digital Alpha VME 4 system, you may need one or more of the items listed in Table 2–4 that *are not* part of the Digital Alpha VME 4 kit.

In order to attach a local disk, a 50-pin IDC SCSI cable is required and must be properly terminated. The exact cable requirements depend upon the enclosure, disk mounting, and so forth. A PC "internal SCSI cable" will work if you are connecting to an internal disk and the cable has a SCSI terminator, or if the last disk (or other SCSI device) has an internal terminator. You can use the Digital SCSI cables listed in Table 2–4 for this purpose.

To attach a printer to the parallel port of the secondary breakout module (54-24729-01), use any standard parallel port printer cable that has a 26 pin IDC connector on one end (for example, 17-04060-01). When you connect the cable, make sure pin 1 of the cable is on pin 1 of the connector that is mounted on the breakout module.

Table 2–4 Additional Hardware Installation Items

Item	Supplier	Part Number
Serial line cable for console and auxiliary terminals	Digital	BC16E– *nn*[1]
IEEE 802.3 Twisted-pair transceiver to ThinWire	Digital	DETTR–AA
IEEE 802.3 Twisted-pair transceiver to twisted-pair	Digital	DETTR–BB
10BASET loopback connector	Digital	12-35619-01 (H4082-AA)
SCSI 20.32 cm (8 in), 30.48 cm (12 in), or 53.34 cm (21 in) cable with a 50-pin female IDC connector for connection to the Alpha VME breakout module and a female IEEE (Champ) connector for connection to external drives[2]	Digital	17-01244-01, -02, -03
SCSI 102.87 cm (40.5 in) cable with six 50-pin female IDC connectors and an included 50-pin IDC SCSI terminator for connection to the Alpha VME breakout module and up to 4 internal drives with the terminator on the last connector	Digital	17–03459–02
SCSI 220.98 cm (87 in) cable with five 50-pin female IDC connectors for connection to the Alpha VME breakout module and up to 4 internal drives and a female IEEE (Champ) connector for connection to external drives[2]	Digital	17-03036-01
Parallel port cable (example)	Digital	17-04060-01

[1]The *nn* = cable length.

[2]A Champ SCSI terminator (PN H8574-A) might be required if external drives are not connected.

2.2 Installation

To install the Digital Alpha VME 4 module, perform the following steps:

1. Select two adjacent slots in your VME backplane for the Digital Alpha VME 4 module. If you are installing a PMC I/O companion card, you will need to select three adjacent slots. Refer to Section 2.2.1 for instructions on how to install the PMC I/O companion card.

Caution

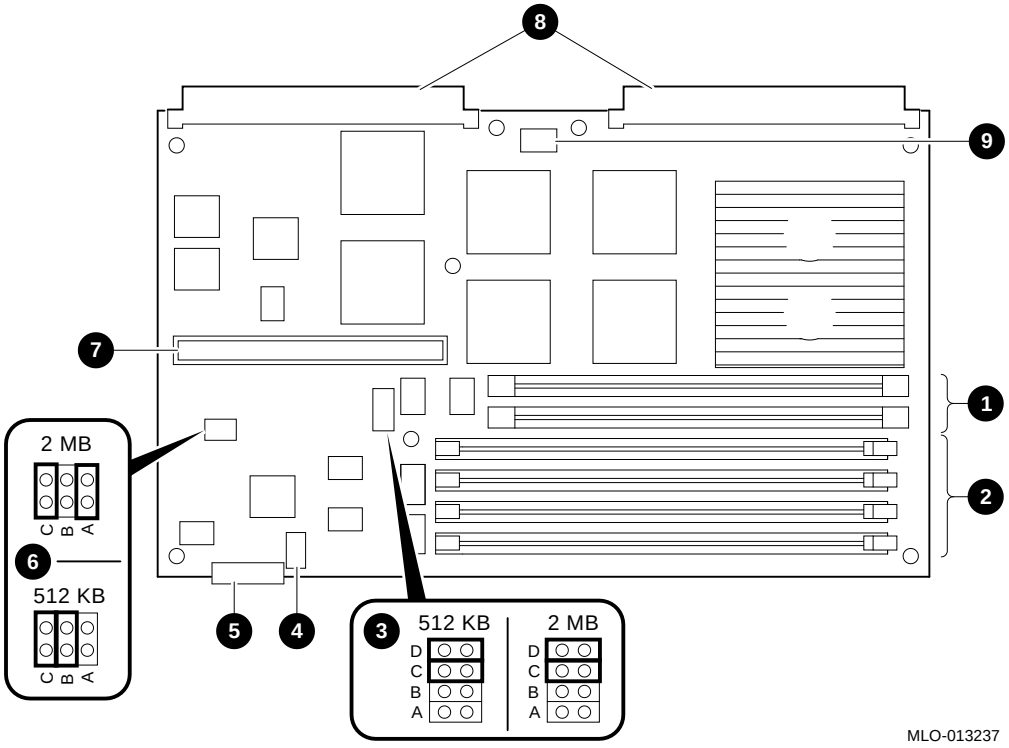
Static electricity can destroy the circuits on the modules in your Digital Alpha VME 4 kit. When you handle modules wear the antistatic wriststrap with the wire clipped to the frame of your VME chassis. Also, place the modules on top of the conductive plastic bags they came in while you work.

Note

There must be sufficient space on the back of the VME backplane slot or slots selected to install the primary breakout module. The Digital Alpha VME 4 primary breakout module requires a minimum of 38.1 mm (1.5 in).

Figure 2–2 and Figure 2–3 show the layout of Digital Alpha VME 4 and the I/O modules.

Figure 2–2 Digital Alpha VME 4 Module Layout



❶ Cache memory connectors

❷ Memory connectors

❸ Cache configuration select jumper (J9)

❹ Power and VME slave activity/watchdog timeout LEDs

❺ Status display

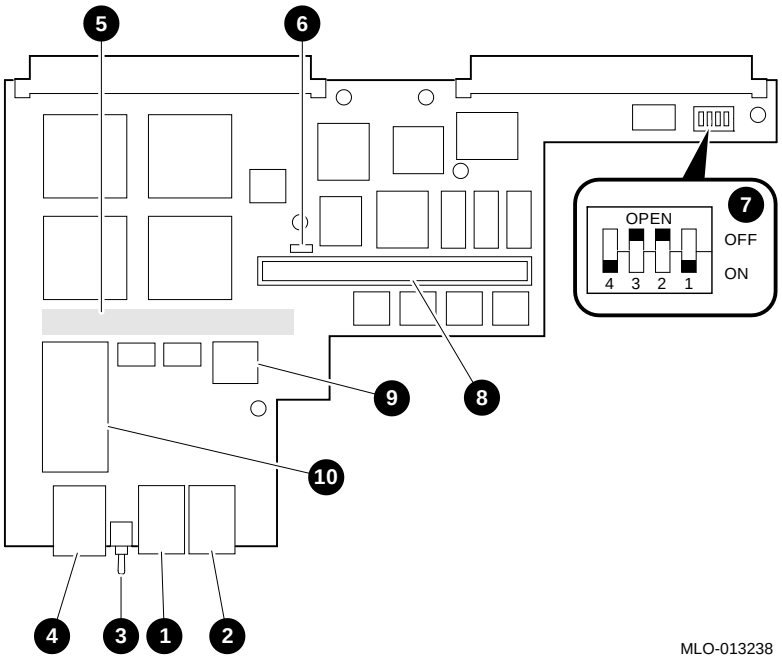
❻ Cache memory size and speed select jumper (J10)

❼ I/O module connector

❽ VME connectors

❾ SROM (8 pin)

Figure 2–3 I/O Module Layout



1. Console serial port
2. Auxiliary serial port
3. Reset/halt switch
4. Twisted pair Ethernet connector
5. Connector to CPU module (on back of I/O module)
6. Debug jumper (not installed for normal operation)
7. Configuration switchpack
8. PMC I/O companion card connector
9. Ethernet Address ROM
10. NVRAM/TOY clock

2. Set the configuration switches on the I/O module as outlined in Table 2–5, Table 2–6, and Table 2–7. Also refer to Figure 2–3 for the configuration switch location.

Table 2–5 Digital Alpha VME 4 Module Configuration Switches

Switch	Setting	Function
1	Closed	Supplies +5 V from the VMEbus +5 V Standby signal to the time-of-year (TOY) clock and the nonvolatile random-access memory (NVRAM) to supplement the internal battery when the Digital Alpha VME 4 module is turned off.
	Open	Does not supply power from the VMEbus +5 V Standby signal. The internal battery will last for about 10 years with the Digital Alpha VME 4 module power turned off.
2	Closed	Enables writing of flash ROMs under program control.
	Open	Disables writing of flash ROMs.
3	Closed	Resets the Digital Alpha VME 4 module on VMEbus Reset signal.
	Open	Does not reset the Digital Alpha VME 4 module on VMEbus Reset signal.
4	Closed	Digital Alpha VME 4 module is VMEbus system controller.
	Open	Digital Alpha VME 4 module is not VMEbus system controller.

Table 2–6 Supported Switch Settings for Digital Alpha VME 4 Modules in Slot 1 (System Controller)

Switch	Setting
1	Closed
2	Open
3	Open[1]
4	Closed[1]

[1]These switches are *required* to be in the indicated positions for reliable system operation during a VMEbus Reset.

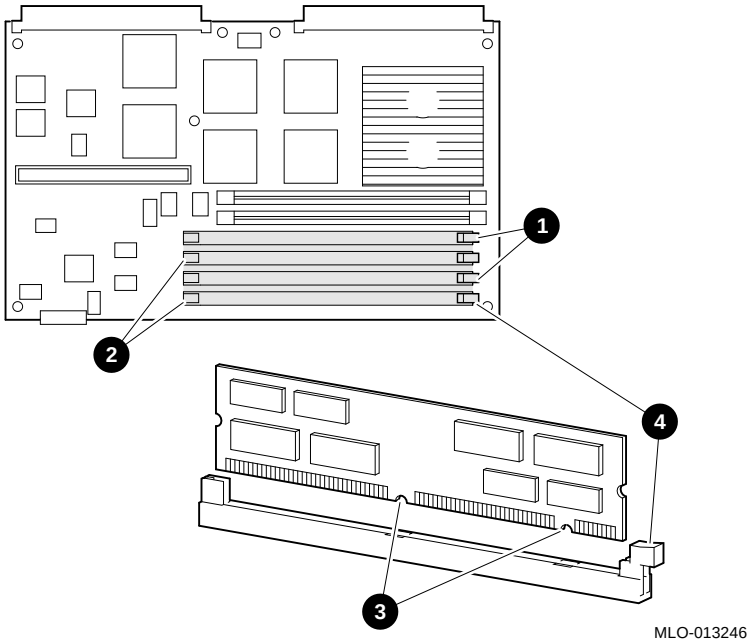
Table 2–7 Supported Switch Settings for Digital Alpha VME 4 Modules in Other Than Slot 1 (Nonsystem Controller)

Switch	Setting
1	Closed
2	Open
3	Closed[1]
4	Open[1]

[1]These switches are *required* to be in the indicated positions (one opened, one closed) for reliable system operation during a VMEbus Reset.

3. Install the memory module on your Digital Alpha VME 4 module (Figure 2–4) in the following manner:
   - Populate bank 0 first, then bank 1, if necessary.
   - Memory installed in a bank must be the same size and speed.
   - Align pin 1 of the memory module with pin 1 on the connector. The position of the orientation notches (see ❸ in Figure 2–4) assure proper connectivity.

Figure 2–4 Installing the Main Memory Modules



❶ Memory bank 0 slots A and B

❷ Memory bank 1 slots A and B

❸ Orientation notches

❹ Memory connector

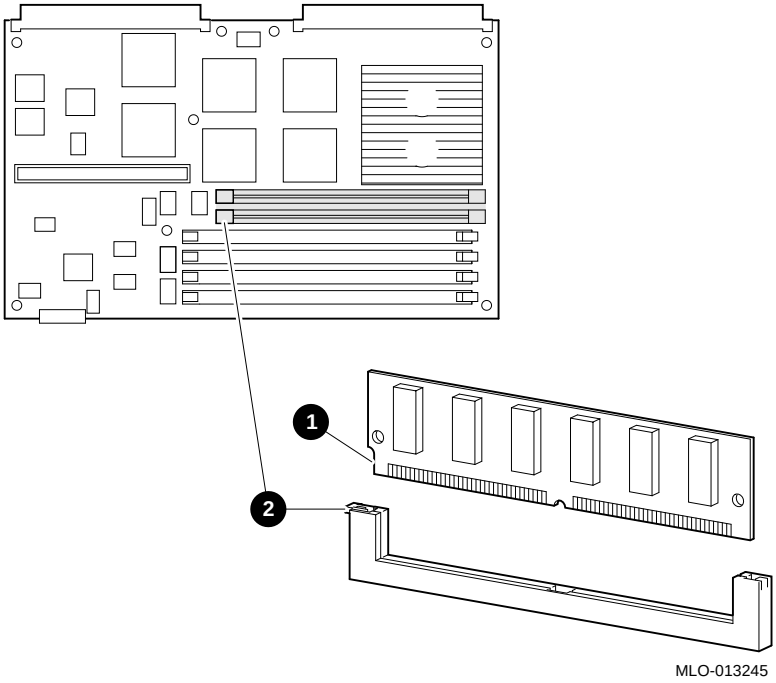
Table 2–8 shows all possible valid memory configurations.

Table 2–8 Digital Alpha VME 4 Memory Configurations

Memory Size (MB)	Bank 0 Slot A	Bank 0 Slot B	Bank 1 Slot A	Bank 1 Slot B
16	8	8		
32	8	8	8	8
32	16	16		
48	8	8	16	16
64	16	16	16	16
64	32	32		
96	16	16	32	32
96	32	32	16	16
128	32	32	32	32

4. Cache memory DIMMs are installed on your Digital Alpha VME 4 module by Digital. Pin 1 of the DIMM is aligned with pin 1 on the cache connector. The position of the orientation notch on the cache memory DIMM in Figure 2–5 (see ❶) denotes the location of pin 1.

Figure 2–5 Cache Memory Modules



❶ Orientation notch

❷ Cache memory connector

5. The J9 and J10 jumpers are preconfigured for your Digital Alpha VME 4 module by Digital. Table 2–9, Table 2–10, and Figure 2–2 show jumper settings and locations for informational purposes only.

Table 2–9 J9 Cache Jumper Settings

Size	A	B	C	D
512 KB	Out	Out	In	In
2 MB	Out	Out	In	In

Table 2–10 J10 Cache Jumper Settings

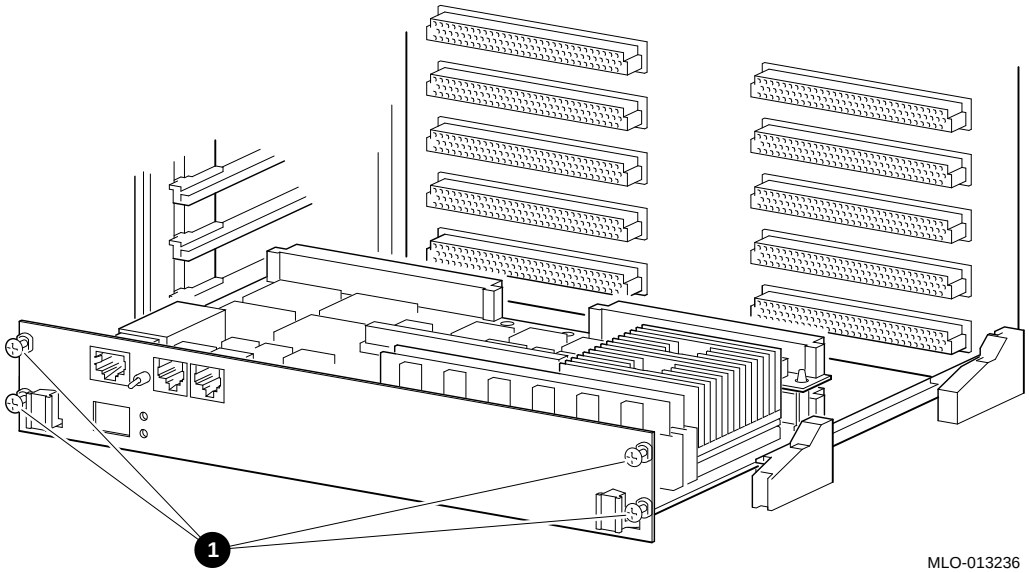
A	B	C	Total Size	Speed
In	In	In	Disable cache	
In	In	Out	Reserved	
In	Out	In	2 MB	12 ns
In	Out	Out	Reserved	
Out	In	In	512 KB	15 ns
Out	In	Out	Reserved	
Out	Out	In	Reserved	
Out	Out	Out	Reserved	

Note

If you are installing the PMC I/O companion card, proceed to Section 2.2.1 later in this chapter and complete the installation instructions before continuing on to step 6.

6. Install the Digital Alpha VME 4 module into the VME chassis (refer to Figure 2–6). Note that the module requires two adjacent backplane slots. Secure the module with screws as shown in callout ❶.

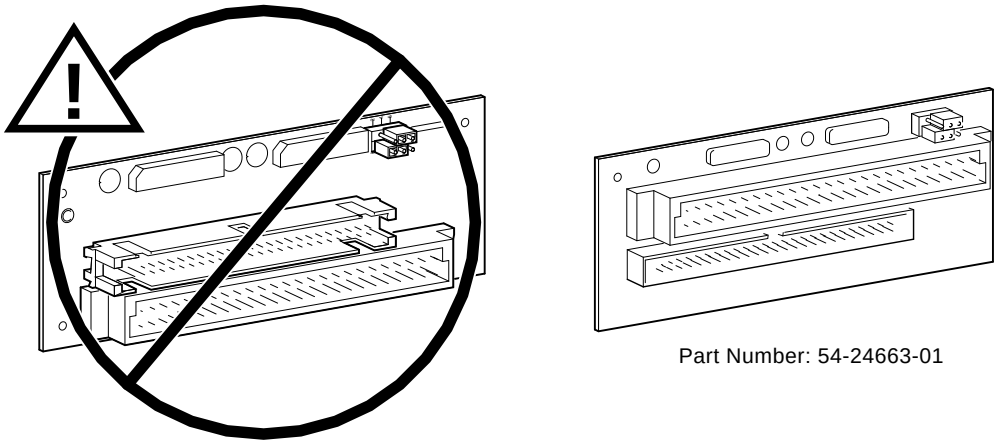
Figure 2–6 Installing the Digital Alpha VME 4 Module



Caution

You must install the primary breakout module (54-24663-01) included in your hardware kit (see Figure 2–7). Applying power to the Digital Alpha VME 4 module **WITHOUT** that primary breakout module in place, or **WITH** the breakout module included with the AXPvme 160, 166, or 230 (P/N 54–22605–01) in place may damage your backplane, the Digital Alpha VME 4 module, or both. Also, do not press on the LED window when you install the module.

Figure 2–7 Alpha VME 4 Primary Breakout Module



7. Set the SCSI termination jumper on the breakout module (refer to Figure 2–8).

   The SCSI bus must be terminated at *each* end. In most installations, the breakout module is one end of the SCSI bus and the far end of the SCSI ribbon cable is the other end of the SCSI bus. In this case, enable the SCSI termination by placing the jumper across pins 1 and 3 (default).

   If the breakout module is not at the end of the SCSI bus, disable the SCSI termination by placing the jumper across pins 3 and 5.

8. Set the watchdog signal jumper on the breakout module (refer to Figure 2–8).

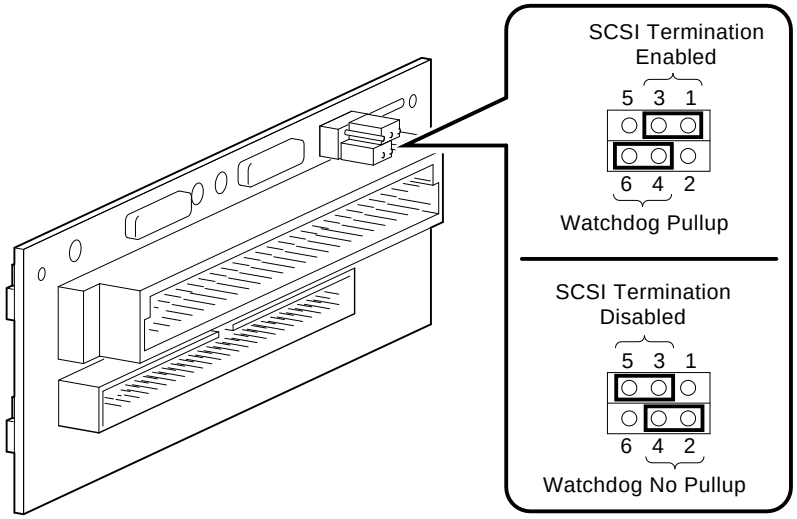
   The Digital Alpha VME 4 module supplies an external watchdog reset signal that you can connect to a monitoring device. If you make no connection to this external signal, the setting of the jumper makes no difference.

   Setting the jumper across pins 4 and 6 (default) provides an internal 2 kOhm to +5 V pullup for this signal. Setting the jumper across pins 2 and 4 provides no pullup. This allows you to attach a monitoring device that operates at a different voltage level. The monitoring device must provide voltage and a pullup resistor that do not exceed the output specifications of a 74LS05

component. The monitoring device must also be connected to the same ground reference as the Digital Alpha VME 4 module.

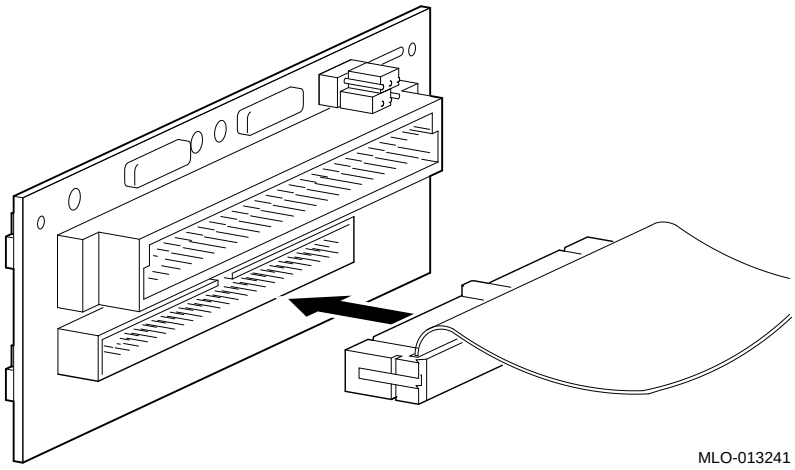
The external watchdog reset signal is on pin C10 of the VMEbus J3 (P2) connector on the breakout module. This signal is low during normal operation and high during a watchdog timer reset (provided that pullup power is connected).

Figure 2–8 Primary Breakout Module Jumpers



9. If your Digital Alpha VME 4 system has SCSI devices, connect the SCSI cable to the primary breakout module (refer to Figure 2–9).

Figure 2–9 Connecting the SCSI Cable to the Primary Breakout Module



10. Install the primary breakout module (refer to Figure 2–10). Ensure that the breakout module is installed behind the slots occupied by the Digital Alpha VME 4 module (as shown).

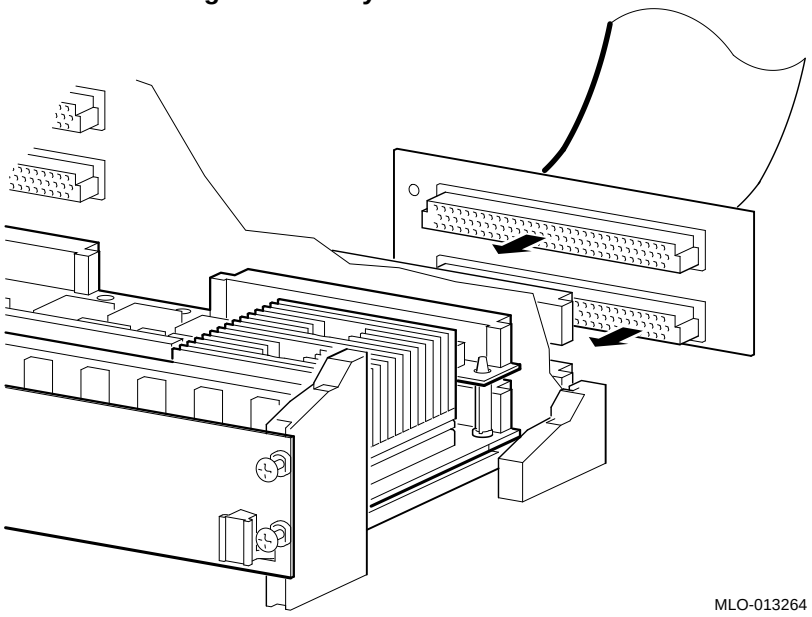
Caution

Running the Digital Alpha VME 4 module when it is not in the same slots as the correct breakout module (refer to Figure 2–10) may damage your backplane, the Digital Alpha VME 4 module, or both.

Never insert a module other than an Digital Alpha VME 4 module into a slot opposite the breakout module. The breakout module feeds power to several of the user-defined pins on the P2 backplane connector. This may damage another VME module.

It is recommended that the slot number and type of breakout module be recorded to ensure that the Digital Alpha VME 4 modules are always installed into a slot with the appropriate breakout module.

Figure 2–10 Installing the Primary Breakout Module

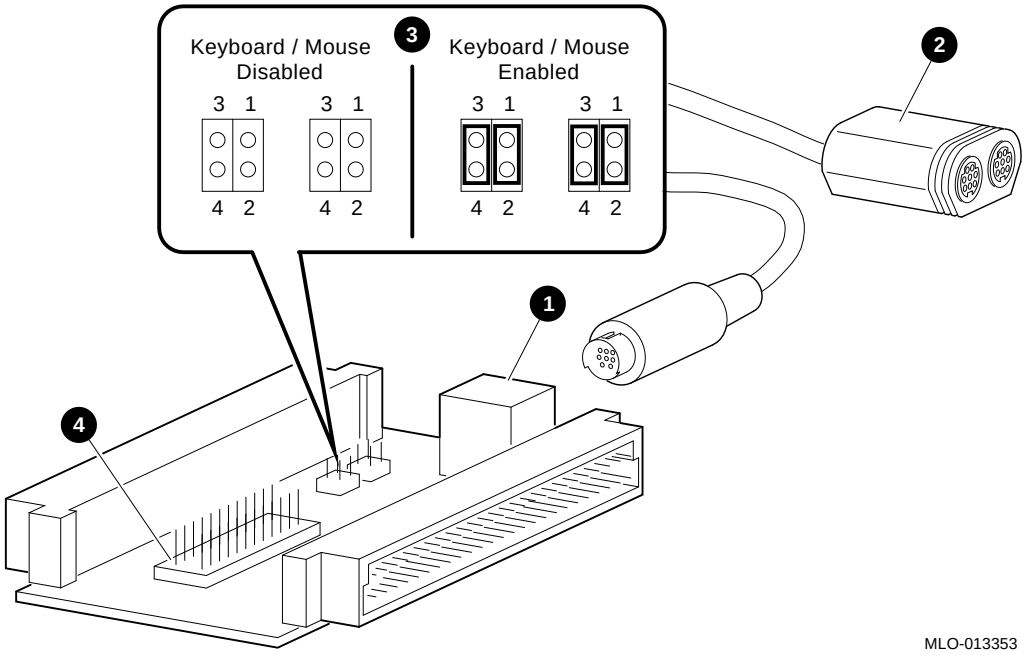


11. A secondary breakout module is included in the hardware kit, which you can connect to the primary breakout module. If you use the secondary breakout module, set the jumpers on that module as shown in Figure 2–11.

Note

An incremental clearance of at least 56.25 mm (2.25 inches) is required to install the secondary breakout module.

Figure 2–11 Secondary Breakout Module Jumpers



❶ Mouse and keyboard connector

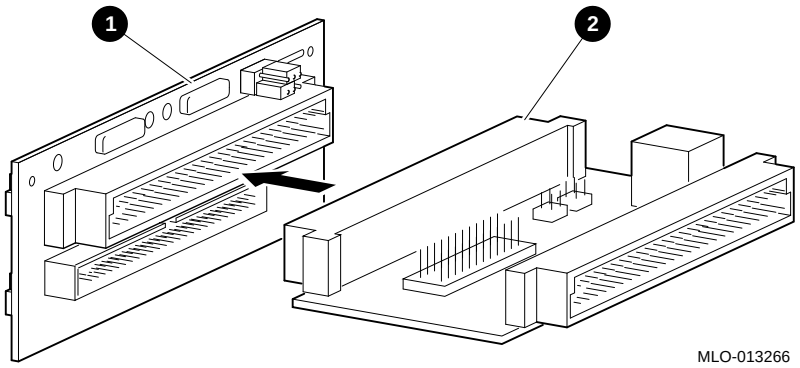
❷ Mouse and keyboard Y cable (17-04230-01)

❸ Keyboard and mouse jumper configurations

❹ Parallel port (see Appendix A for pinouts)

12. Connect the secondary breakout module to the primary breakout module as shown in Figure 2–12.

Figure 2–12 Connecting the Secondary Breakout Module to the Primary Breakout Module

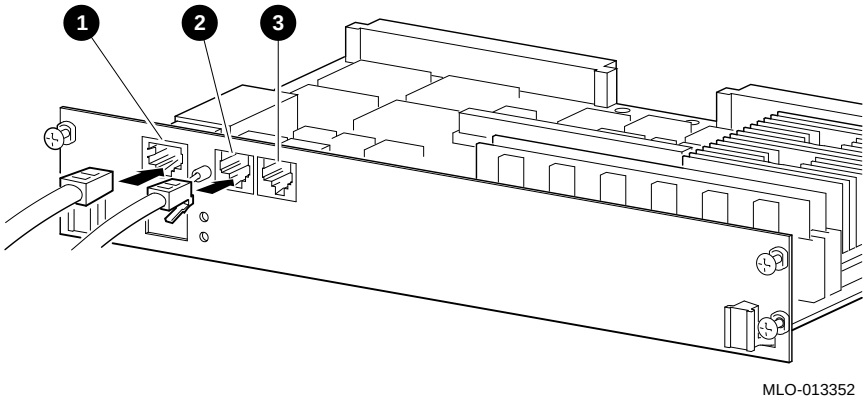


❶ Primary breakout module (54-24663-01)

❷ Secondary breakout module (54-24729-01)

13. Connect the network cable (if any) to the twisted-pair Ethernet connector. See Figure 2–13. Associated with the Ethernet connector are devices to convert from twisted pair to ThinWire (P/N DETTR–AA). See Table 2–4.
14. Connect the console terminal cable to the Digital Alpha VME 4 module (refer to Figure 2–13).
15. If you have an auxiliary terminal, connect it now. Set your console terminal to a speed of 9600 bits/second, an 8-bit data word, and no parity.

Figure 2–13 Connecting Network and Console Terminal Cables



❶ Network

❷ Console

❸ Auxiliary

16. Insert blank panels into the vacant slots of the VME chassis. This improves airflow and reduces electromagnetic interference (EMI) radiation.

17. Your installation is complete and power can be turned on.

18. When you turn power on, the Power LED lights (refer to Figure 3–1) and the Digital Alpha VME 4 module runs its power-up self-test display (POST). This takes about 30 seconds.

    The POST runs a number of tests that show their status on the LED display. These tests complete successfully when the display counts down to zero.

    The POST then runs a number of additional tests that display their status on the console terminal. These tests have completed successfully when the console prompt appears (>>>) and the LED displays a rotating bar. For more information on the POST, refer to the diagnostics chapter.

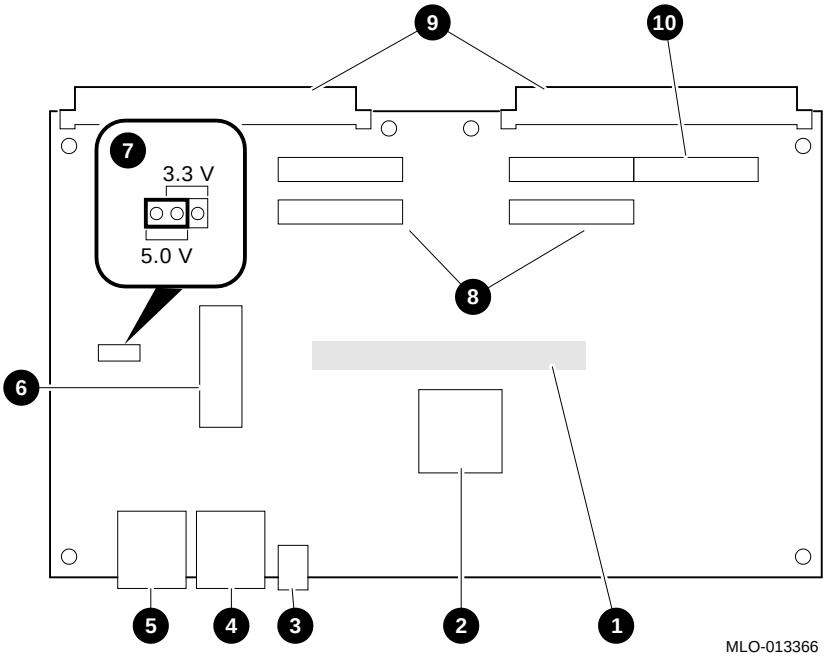
2.2.1 Installing the PMC I/O Companion Card

Figure 2–14 shows the layout of the PMC I/O companion card.

Note

To install the PMC I/O companion card with the Digital Alpha VME 4, you must have three adjacent slots available.

Figure 2–14 PMC I/O Companion Card Layout



❶ I/O module connector (on back of PMC I/O companion card)

❷ PCI-to-PCI bridge chip

❸ Power LED

❹ Keyboard connector

❺ Mouse connector

❻ Debug socket

❼ Signaling level jumper (jumper MUST be set to 5.0 V)

❽ PMC option slots

❾ VME connectors

❿ I/O-to-P2 signal connector

Caution

Perform the following steps gently to avoid damage to the modules.

1. Make sure the signaling-level jumper on the PMC I/O companion card is set for 5.0 V, as show in Figure 2–14.
2. Install any user-supplied PMC options.
3. Carefully, align the ball connector on the bottom edge of the PMC I/O companion card handle into the slot on the top edge of the Digital Alpha VME 4 handle as shown in Figure 2–15. Note the orientation of the heat sink.
4. Raise the PMC I/O companion card up at a slight angle from the I/O module and slide the connecting edges together until the connector on the bottom of the PMC I/O companion card is aligned with its mating connector on the top side of the I/O module as shown in Figure 2–15.

Caution

You must align the connector precisely. If the alignment is not precise, the force required for normal connector mating is sufficient to damage the connector housing and pins.

5. Carefully press down on the module causing the two connectors to mate and four standoffs to anchor as shown in Figure 2–15.
6. Install the Digital Alpha VME 4 module into three adjacent slots in the VME chassis as shown in Figure 2–16.

Caution

Digital recommends that you back out the captive screws on the front panel until they are fully engaged by the press-fit shoulder washer before

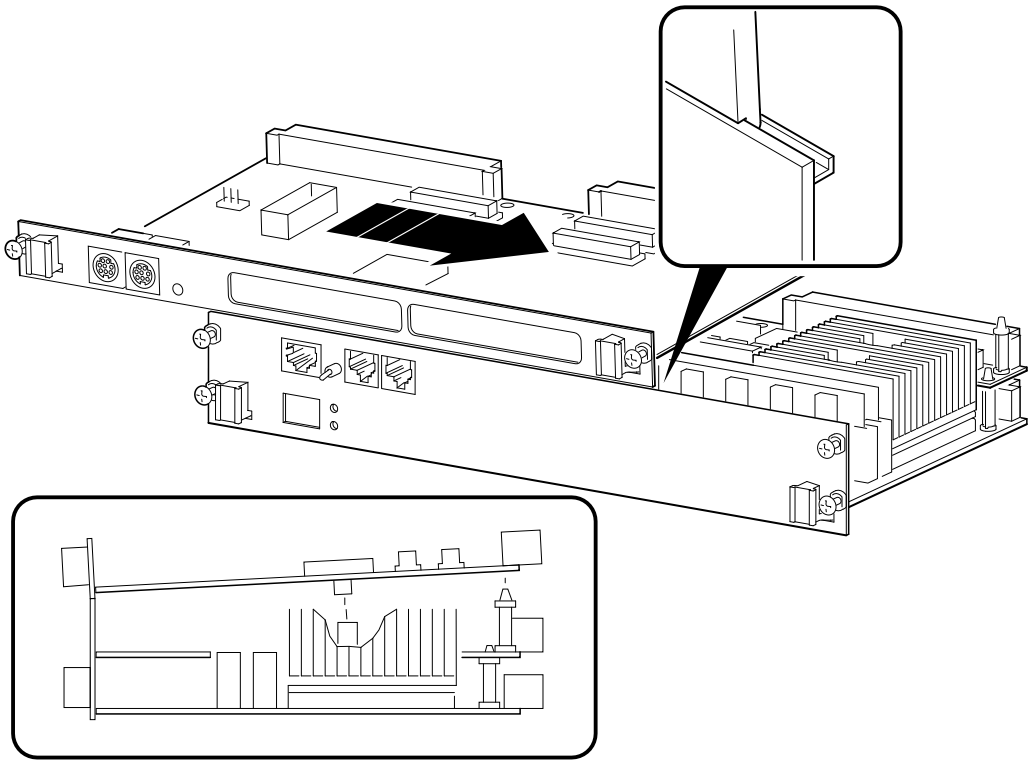
seating the Alpha VME module in the VME chassis. If you do not retract the screws completely:

- The Alpha VME module might not seat properly.
- The press-fit shoulder washer that holds the screw washer in place might become disengaged if you apply excessive pressure to the front panel.

---

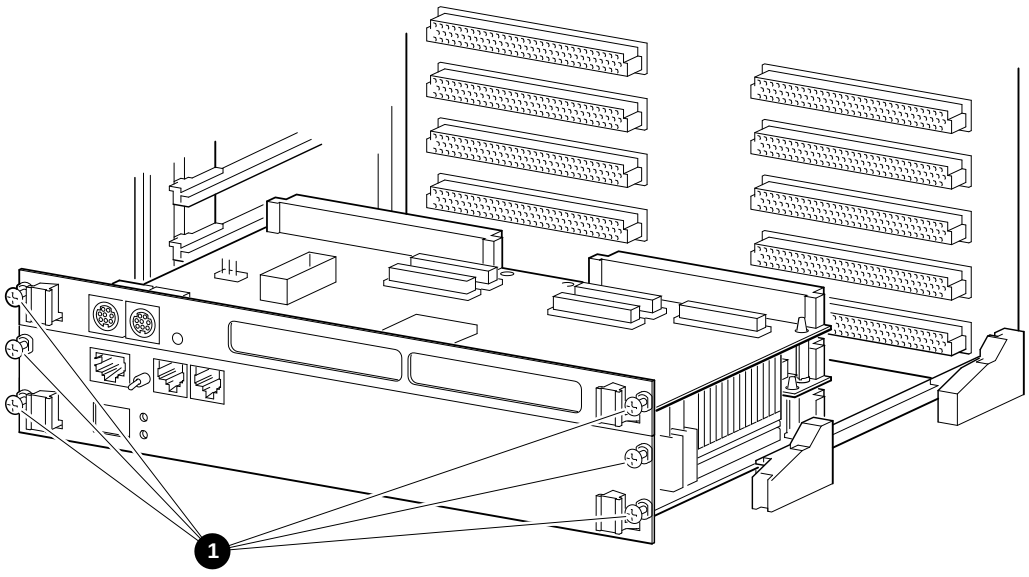
7. Tighten the six screws on the handles as shown in Figure 2–16.
8. If being used, connect the mouse and keyboard cables at the locations shown in Figure 2–14.

Figure 2–15 Connecting the PMC I/O Companion Card



MLO-013265

Figure 2–16 Installing the PMC I/O Companion Card



9. Return to step 6 in Section 2.2 for instructions on installing the Digital Alpha VME 4 module into the VME chassis and setting up and installing the breakout modules.

2.3 Diagnostics

When you turn on the power or toggle the Reset switch, the Digital Alpha VME 4 module runs its POST. The module runs a series of tests stored in the serial read-only memory (SROM) and then runs a series of console code tests stored in the flash ROMs. The SROM tests display their test number on the LED display during execution. If an SROM test fails, the LED display flashes the failing test number. Refer to Table 2–11 for a list of SROM test numbers and functions.

Table 2–11 SROM Test Numbers and Descriptions

LED Display	COM1	Meaning
8	-	Nbus bus has been reset and SIO configured.
7	7..	COM1 port has been initialized (9600 baud).
6	6..	BIU_CTL register has been programmed according to the cache configuration jumpers, but Bcache is not on line.
5	5..	Main memory DIMMs have been configured according to PD bits. Memory is alive but not scrubbed.
4	4..	Bcache has been initialized and put on line.
3	3..	Bcache and all memory has been scrubbed to valid error checking/correction (ECC).
2	2..	Firmware image has been loaded from the flash ROM. Image starts at 0X8000.
1	1..	The debug jumper is about to be checked. If the jumper is IN, then the initialization process traps to the minidebugger.
0	0	Written by the PAL reset entry point. This indicates that the firmware has been decompressed and is starting.

Note

Use of a graphic mode console option may preclude the display of initial POSTs. See the documentation supplied with your graphics option for details.

The console code tests display their test names and results on the console terminal. The console code tests also display their test letter on the LED display as they are being executed. If a console code test fails, the LED display flashes the letter of the failing test. Table 2–12 lists console code test letters and test names.

Table 2–12 Console Code Test Letters and Names

Test Letter	Test Name
A	SCSI control and status register (CSR) test
B	Heartbeat timer test
C	Interval timer test
D	DS1386 nonvolatile RAM tests
E	Auxiliary Universal Asynchronous Receiver/Transmitter (UART) test
F	Ethernet address ROM test
G	Ethernet internal and external loopback tests
H	Watchdog timer test
I	VME interface processor/VIC64 test

After the POST completes and the system is idle, the console outputs a "rotating bar" to the LED display.

Refer to Chapter 4 for more information about these tests.

2.4 Troubleshooting

The Digital Alpha VME 4 modules include extensive diagnostic (POST) capabilities that are normally executed on power-up. These include both SROM and flash ROM-based code.

SROM-based diagnostics are always executed on power-up and use decreasing numeric codes (8, 7, ...1) to indicate status on the dot matrix display. All SROM-based tests must pass successfully before the flash ROM-based diagnostics and console diagnostics are run. If one or more SROM diagnostics fail, the flash ROM-based diagnostics and the console diagnostics will not be loaded and a single > prompt will be displayed on the console terminal. The code of the failing diagnostic will be on the dot matrix display. Additional information appears on the console terminal if present.

Once the SROM diagnostics complete successfully, the flash ROM diagnostics will be loaded, decompressed and executed. Flash ROM diagnostics use an ascending (A, B, ..., I) character-based code to indicate progress. If one or more flash ROM-based diagnostics fail, the code representing the FIRST error will remain on the dot matrix display and alternate between dim and bright intensity.

If all SROM and flash ROM-based diagnostics pass, and an *auto_action*[1] boot command has been set, the >>> console prompt appears on the console terminal and the dot matrix display will display a "rotating bar."

Note that a problem in the PMC I/O companion card that hangs the PCI bus signal lines could cause diagnostics to report problems throughout the I/O subsystem and in the PCI controller of the processor chip. If you have a PMC I/O companion card installed and you are experiencing diagnostic failures, remove it and repeat the POST.

It is important to remember that the dot matrix display is useable by operating system software and by user applications as well. Once the system is booted, the dot matrix display is no longer under control of the console code and may change. The console will automatically clear the display before booting any image.

Table 2–13 lists symptoms and corrective actions that can be used for troubleshooting the Digital Alpha VME 4 modules. Refer to the Troubleshooting chapter of this manual for more information about troubleshooting procedures.

[1] See Table 3–2

Table 2–13 Troubleshooting

Symptom	Corrective Action
No LEDs lit, no console prompts.	Check power. If 5 V power is out of specification, the module will be held in reset.
Green LED on, blank dot matrix display, and no console prompts	Check the seating of SROM (8-pin socketed device near PCI port). See Figure 2–2.
Green LED on, dot matrix displays the number 5 on power-up.	Check the seating of the memory modules.
Green LED on, dot matrix displays the number 0 on power-up.	Ensure that the console terminal is not in "hold screen" mode.
Green LED on, dot matrix displays a flashing letter A on power-up.	Check the SCSI termination, the seating of the Digital Alpha VME 4 module, the seating of the breakout module, the seating of the SCSI cable, and the seating of other SCSI devices.
Green LED on, dot matrix displays a flashing letter D on power-up.	Check that the TOY/NVRAM device is seated properly (see Figure 2–3).
Green LED on, dot matrix displays a flashing letter F on power-up.	Check the seating of the Network Address ROM (see Figure 2–3).
Green LED on, dot matrix displays a flashing letter G on power-up.	Check the seating of the twisted pair cable and the nearest network transceiver.
Green LED on, dot matrix displays a flashing letter I on power-up.	Check the seating of the Digital Alpha VME 4 module, the seating of the breakout module, and the seating of other VME devices.
Diagnostics pass but the SCSI tests take an inordinate amount of time (greater than 10 seconds).	Check the SCSI termination, the seating of the Digital Alpha VME 4 module, the seating of the breakout module, the seating of the SCSI cable, and the seating of other SCSI devices.
Diagnostics pass but there are no (or unreadable) characters displayed on the console.	Check the console terminal connections, and settings (9600 baud, 8-bits, no parity). The terminal should be plugged into the (CON) port.

2.5 Repair and Warranty Information

2.5.1 Return to Digital Hardware Maintenance

The following products come with a 1 year Return to Digital warranty as described in the following sections:

Table 2–14 Products With a 1 Year Return to Digital Warranty

Product	Order Number
Alpha VME 4/224, SBC	EBV14-AA
Alpha VME 4/224, UNIX Development	EBV14-ZA
Alpha VME 4/224, UNIX Runtime	EBV14-RA
Alpha VME 4/224, VxWorks Runtime	EBV14-XA
Alpha VME 4/288, SBC	EBV14-AE
Alpha VME 4/288, UNIX Development	EBV14-ZE
Alpha VME 4/288, UNIX Runtime	EBV14-RE
Alpha VME 4/288, VxWorks Runtime	EBV14-XE
16 MB Memory DIMM, 80-bits, 70 ns	EBMXM-DB
32 MB Memory DIMM, 80-bits, 70 ns	EBMXM-EB
64 MB Memory DIMM, 80-bits, 70 ns	EBMXM-FB
PMC I/O Companion Card	EBV1P-AA

2.5.2 Hardware Warranty

Your Digital Alpha VME 4 system comes with a limited warranty, consisting of Return to Digital hardware support. The warranty provides free repair or replacement of the system or option field replaceable unit through the Digital Customer Support Center.

2.5.2.1 Availability

Warranty support is available worldwide. Proof of purchase or ownership of equipment, including serial numbers, may be required.

2.5.2.2 Return-to-Digital Process

To return products under warranty, contact the Digital Customer Support Center in your particular geography. The Customer Support Center provides you with a Return Material Authorization (RMA#) and an address to which to send the defective material. You are responsible for sending the product to the address provided and for prepaying transportation costs associated with returning the product to the nearest Digital return center. Digital pays transportation costs when the product is returned to you.

In the U.S., call 1-800-354-9000 to get information on returning the product. Elsewhere in the world, contact the nearest Digital Customer Support Center.

2.5.2.3 Response Time

Digital uses an advanced exchange replacement process through the Customer Support Center. Turnaround is two days from receipt at the Customer Support Center.

A defective field replaceable unit must be received by the Digital Support Center within 10 days of shipment of the unit. If the unit is not received within 10 days, you will be billed for the replacement part at full country list price.

2.5.2.4 Eligible Parts

Field replaceable units, as defined by Digital, are the only parts eligible for coverage. Field replaceable units in need of repair due to improper treatment or use are not eligible for return. Improper treatment includes, *but is not limited to*, lifted or burnt etches or delamination due to non-Digital repair or modification.

If you return a field replaceable unit that is not eligible for repair, Digital may demand return of any replacement unit or charge you for full list price value of the replacement unit. Digital will return the ineligible field replaceable unit to you upon receipt of payment or the replacement unit.

Replacement field replaceable units will be at the current revision level and may be refurbished. In the event that newly installed field engineering change orders cause an incompatibility or other interference within your system, you accept responsibility of such incompatibility or interference.

2.5.2.5 Purchaser Responsibility

It is your responsibility to:

- Install the equipment.
- Diagnose faults and disassemble equipment on returns of field replaceable units.
- Properly package and prepay transportation costs of field replaceable units sent to Digital.

- Assume all risk of loss or damage to field replaceable units in transit to Digital.

2.5.2.6 Pre-Call Checklist

To allow Digital to assist you quickly and efficiently, consult the following checklist before calling Digital or your authorized reseller:

1. Consult your product user documentation to assure that your system features are properly configured.
2. Execute the customer diagnostics provided with the product, if applicable, and record the information.
3. Consult your user documentation for more details on operation of the product.
4. Determine the product model number and serial number to enable processing of warranty support.

2.5.3 Software Maintenance

Digital software products are warranted to conform to the applicable Software Product Description. This means that Digital will remedy any conformance that you report during the warranty period.

Warranty of third party software products sold by Digital is as designated in the Software Product Description. The term of the warranty, and the manner in which Digital will remedy any non-conformance is specified in the Software Product Description or the price list. All other software is provided "as is". Digital does not warranty that the execution of the software shall be uninterrupted or error free. Digital does not warranty the form or content of third party distributed software or documentation, both of which Digital provides "as is". Certain third party distributed software is warranted by the third party.

2.5.4 Field Replaceable Units and Order Numbers

Table 2–15 lists the available field replacable units and their associated order numbers.

Table 2–15 Field Replaceable Units and Order Numbers

Saleable Number[1]	Order Number	Description
EBV14-*A		
	70-32976-04	224 MHz Single Board Computer — 2 board set, 512 KB cache
	54-24729-01	VME Secondary Breakout Module
	54-24663-01	VME Primary Breakout Module
EBV14-*E		
	70-32976-02	288 MHz Single Board Computer — 2 board set, 2 MB cache
	54-24729-01	VME Secondary Breakout Module
	54-24663-01	VME Primary Breakout Module
EBV1P-AA		
	54-24665-01	PMC I/O Companion Card
	17-04230-01	Cable, Y-Adapter, IBM ThinkPAD
EBMXM-DB	54-24659-AB	16 MB (2x8) DIMM Set
EBMXM-EB	54-24659-AA	32 MB (2x16) DIMM Set
EBMXM-FB	54-24645-AA	64 MB (2x32) DIMM Set

[1] An asterisk (*) indicates any of the four possible letters (A, Z, R, or X).

3

Operating the Digital Alpha VME 4 Computer

3.1 Controls and Indicators

Figure 3–1 shows the front panel controls and indicators of the Digital Alpha VME 4 module and Table 3–1 describes their function.

Figure 3–1 Controls and Indicators

Table 3–1 Controls and Indicators

	Control or Indicator	Description
❶	Reset/Halt switch	A switch that resets the Digital Alpha VME 4 system when pressed in the Reset (up) direction. When pressed in the Halt (down) direction this switch halts the operating system and the module enters console mode.
❷	Status display	A display that shows which test is running during the POST. After that, the display is under the software control of the operating system or an application program.
❸	VME Slave Activity /Watchdog Timeout LED	An amber LED with two functions. The LED flashes when the Digital Alpha VME 4 module is accessed as a slave by another device on the VMEbus. The LED lights continuously when the watchdog timer has timed out. **Note:** The LED can appear to light continuously when the module is receiving slave accesses. Since the LED glows for 1/3 of a second each time it flashes, three slave accesses per second could make the LED light continuously.
❹	Power LED	A green LED that is lit when the power is on.

3.2 Console Mode

Sections 3.2.1 and 3.2.2 explain how a Digital Alpha VME 4 system enters and exits console mode.

3.2.1 Entering Console Mode

A Digital Alpha VME 4 module enters console mode automatically when the POST is finished. A Digital Alpha VME 4 module also enters console mode when:

- You press the Reset/Halt switch on the front panel.

  Caution

  Depending on the operating system and applications running at the time, this could damage application files that are open and have not been saved.

- The module receives a VMEbus Reset signal and configuration switch 3 on the module is enabled.

  Caution

  Depending on the operating system and applications running at the time, this could damage application files.

- You use the operating system command to enter console mode.
- The operating system executes a HALT instruction.
- The operating system encounters a fatal error.

3.2.2 Exiting Console Mode

You can exit console mode by issuing the **boot**, **start**, or **continue** command. For more information, use the **help** command or see Chapter 13.

3.3 Environment Variables

From the console, you can configure your Digital Alpha VME 4 system by setting the values of environment variables. You set the values of environment variables by using the console command **set**. You can also display the current settings of environment variables by using the **show** command.

Note

Do not change the settings of the environment variables without understanding the implications of the changes.

Table 3–2 lists the environment variables with descriptions.

Table 3–2 Environment Variable Summary

Variable	Description
AUTO_ACTION	Defines the action of the console following an error, halt, or power-up.
BOOT_DEV	Specifies the device list to be used by the last, or currently in progress, bootstrap attempt.
BOOT_FILE	Specifies the file name to be used when a bootstrap requires a file name, when the bootstrap is not the result of a **boot** command, or when no file name is specified with the **boot** command.
BOOT_OSFLAGS	Specifies arguments to be passed to system software when the bootstrap is not the result of a **boot** command or when no arguments are specified with the **boot** command.
BOOTDEF_DEV	Specifies the device list from which bootstrapping is to be attempted when no path is specified with the **boot** command.
BOOTED_DEV	Specifies devices to be used by the last or currently in progress bootstrap attempt.
BOOTED_FILE	Specifies the file name to be used by the last or currently in progress bootstrap attempt.
BOOTED_OSFLAGS	Specifies arguments to be passed to system software during the last or currently in progress bootstrap attempt.
CHAR_SET	Specifies current console terminal character-set encoding.
CONSOLE	Specifies whether console input and output are to use the console serial line or a graphics console, if present.
D_BELL	Specifies whether the bell is to sound on error.
D_CLEANUP	Specifies whether cleanup code is to be executed at the end of diagnostics.
D_COMPLETE	Specifies whether a diagnostic completion message is to be displayed.

(continued on next page)

Table 3–2 (Cont.) Environment Variable Summary

Variable	Description
D_EOP	Specifies whether end-of-pass messages are to be displayed.
D_GROUP	Specifies the diagnostic group to be executed.
D_HARDERR	Defines the action that is to be taken following a hard error detection.
D_OPER	Specifies whether an operator is present.
D_PASSES	Specifies the diagnostic pass count.
D_REPORT	Specifies the level of information to be provided by diagnostic error reports.
D_SOFTERR	Defines the action that is to be taken following soft error detection.
D_STARTUP	Specifies whether a diagnostic startup message is to be displayed.
D_TRACE	Specifies whether trace messages are to be displayed.
DUMP_DEV	Specifies that a device is to write operating system crash dumps.
ENABLE_AUDIT	Specifies whether audit trail messages are to be generated during bootstrap.
EWA0_ARP_TRIES	Specifies the number of transmissions to be attempted before the Internet Address Resolution Protocol (ARP) fails.
EWA0_BOOTP_FILE	Specifies a generic file name to be included in an Internet Boot Protocol (BOOTP) request.
EWA0_BOOTP_ SERVER	Specifies a server name to be included in a BOOTP request.
EWA0_BOOTP_TRIES	Specifies the number of transmissions that are to be attempted before BOOTP fails.
EWA0_DEF_GINETADDR	Specifies the initial value for EWA0_GINETADDR when the interface's internal Internet database is initialized from BOOTP (EWA0_INET_INIT is set to BOOTP).
EWA0_DEF_INETADDR	Specifies the initial value for EWA0_INETADDR when the interface's internal Internet database is initialized from BOOTP (EWA0_INET_INIT is set to BOOTP).
EWA0_DEF_INETFILE	Specifies the initial value for EWA0_INETFILE when the interface's internal Internet database is initialized from BOOTP (EWA0_INET_INIT is set to BOOTP).

(continued on next page)

Table 3–2 (Cont.) Environment Variable Summary

Variable	Description
EWA0_DEF_SINETADDR	Specifies the initial value for EWA0_SINETADDR when the interface's internal Internet database is initialized from BOOTP (EWA0_INET_INIT is set to BOOTP).
EWA0_INET_INIT	Specifies whether the interface's internal Internet database is to be initialized from non-volatile RAM (NVRAM) or from a network server (by way of BOOTP).
EWA0_LOOP_COUNT	Specifies the number of times each message is looped.
EWA0_LOOP_INC	Specifies the amount the message size is to be increased from message to message.
EWA0_LOOP_PATT	Specifies the type of data pattern that is to be used for loopback.
EWA0_LOOP_SIZE	Specifies the size of the loop data to be used.
EWA0_LP_MSG_NODE	Specifies the number of messages to be sent to each node originally.
EWA0_MODE	Specifies the operating mode of the embedded Ethernet controller. Valid settings include TWISTED-PAIR and FULL (full-duplex twisted pair).
EWA0_PROTOCOLS	Specifies the network protocol to be enabled for booting and other functions.
EWA0_TFTP_TRIES	Specifies the number of transmissions that are to be attempted before the Trivial File Transfer Protocol (TFTP) fails.
LANGUAGE	Specifies the current console terminal language (integer ID).
LANGUAGE_NAME	Specifies the current console terminal language.
LICENSE	Specifies whether a software license is in effect.
MODE	Specifies whether diagnostics are to be run when the firmware is initialized. Set to FASTBOOT or NOFASTBOOT.
PAL	Specifies versions of VMS and OSF PALcode in the firmware.
TGA_SYNC_GREEN	Specifies a hexadecimal byte indicating whether video synchronization should be driven on the green channel for up to eight TGA video cards. Video card 0 corresponds to bit 0, card 1 to bit 1, and so on. Used with the CONSOLE environment variable.
TTY_DEV	Specifies the current console terminal unit.
VERSION	Specifies the version of the console code firmware.

(continued on next page)

Table 3–2 (Cont.) Environment Variable Summary

Variable	Description
VME_A32_BASE	Specifies the base address of VMEbus A32 space.
VME_A32_SIZE	Specifies the size of VMEbus A32 space.
VME_A24_BASE	Specifies the base address of VMEbus A24 space.
VME_A24_SIZE	Specifies the size of VMEbus A24 space.
VME_A16_BASE	Specifies the base address of VMEbus A16 space.
VME_CONFIG	Specifies the VME setup mode.
VX_BOOTLINE	Specifies the name of the file to be used for the VxWorks bootstrap.

3.4 Booting an Operating System

For information on booting the Digital UNIX operating system or VxWorks for Alpha kernel, see the operating system documentation. If you are booting the Digital UNIX operating sytem, see the *Digital UNIX Installation Guide.* If you are booting the VxWorks for Alpha kernel, see the *VxWorks: Digital Alpha VME Single-Board Computers Hardware Supplement* and the *VxWorks Programmer's Guide.*

3.5 Updating Firmware

For information on updating the Digital Alpha VME 4 firmware, see the *Digital Alpha VME 4/244 and 4/288 Single-Board Computer Firmware Update Procedures* shipped with the firmware release and either the *VxWorks Digital Alpha VME Single-Board Computers Hardware Supplement* or the *Digital UNIX Installation Guide.*

4
Diagnostics

4.1 Overview

This chapter describes the Digital Alpha VME 4 power-on self-test (POST) diagnostics and additional ROM-based diagnostics (RBDs).

Diagnostics for the Digital Alpha VME 4 system provide a fast, high coverage suite of POSTs to be invoked automatically at power-on and system reset. In addition to the POSTs, there are RBDs that provide additional testing and fault isolation. You invoke RBDs at the console prompt from the console terminal. You can use diagnostic environment variables to gain more control of the test environment.

4.2 Operating Environments

The Digital Alpha VME 4 diagnostics are invoked under two distinct mechanisms:

- Power-on and/or system reset
- By an operator at the console prompt

4.2.1 POST Diagnostics

The diagnostic reset environment is entered as a result of power being applied to the system or, reset being applied to a previously running system. In this mode, a sequence of RBDs is executed without user intervention.

Once the SROM code has been loaded into the 8 KB internal instruction cache, a very basic system initialization is performed in preparation for starting the console firmware. After enough of the system has been initialized, the flash ROM-based console is loaded into system memory and execution is transferred to it. During this phase of console startup, several more diagnostics are automatically invoked and executed without operator intervention.

The system LED display indicates progress of the SROM initialization. The display counts down from 8 to 1.

Failures detected by the SROM-based tests are indicated by the test sequence halting and the LED display permanently showing the failing test number. A detailed dump of internal registers, program counter, expected and actual data is performed either through the serial port of the 21064 or through the console Universal Asynchronous Receiver/Transmitter (UART). If the Intel SIO is successfully configured and the console UART test passes, the SROM does all I/O through the console UART; otherwise, it is through the 21064 serial port/pin.

Failures detected beyond the SROM do not halt the reset sequence, but rather, the display freezes at the first failing test, and the sequence attempts to continue to console mode. An attempt is also made to write the diagnostic log to the console terminal.

You can affect the POST sequence by using certain user-selectable, control parameters (implemented as environment variables) that allow the initialization to continue, despite the existence of some errors that you may not wish to treat as fatal.

4.2.2 Console Prompt Diagnostics

You can invoke some diagnostics directly from the console terminal, and you can control them by using command options and diagnostic environment variables. These tests may require operator intervention.

4.3 Diagnostic Test Descriptions

4.3.1 Available Console Diagnostics

Table 4–1 shows the console diagnostic tests and the commands you can use to invoke them. You can invoke the majority of these tests at the console prompt.

Table 4–1 Console Diagnostic Tests

HW Under Test	Command
Memory and Cache	
- Memory exerciser test	**memtest** or **mem_ex**
Network Interface	
- DECchip 21040 network interface internal loopback test	**niil_diag -t 1**
- DECchip 21040 network interface external loopback test	**niil_diag -t 2**
- DECchip 21040 network interface control /status register (CSR) test	**nicsr_diag -t 1**
- DECchip 21040 network interface CSR test	**nicsr_diag -t 2**
- DECchip 21040 network interface CSR test	**nicsr_diag -t 3**
NVRAM + TOY Clock	
- NVRAM test	**ds1386_diag -t 1**
- NVRAM test	**ds1386_diag -t 2**
- NVRAM test	**ds1386_diag -t 3**
- Time-of-year (TOY) clock register test	**ds1386_diag -t 4**
- TOY clock register test	**ds1386_diag -t 5**
SCSI	
- SCSI device test	**ncr810 -t 1**
- SCSI device test	**ncr810 -t 2**
- SCSI device test	**ncr810 -t 3**
- SCSI device test	**ncr810 -t 4**
- SCSI device test	**ncr810 -t 5**
- SCSI device test	**ncr810 -t 6**
- SCSI device test	**ncr810 -t 7**

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Table 4–1 (Cont.) Console Diagnostic Tests

HW Under Test	Command
- SCSI device exer	**exer dk**
Timers	
- Heartbeat timer test	**hbeat_diag -t 1**
- Interval timer test	**i8254 -t 1**
- Interval timer test	**i8254 -t 2**
- Interval timer test	**i8254 -t 3***
- Interval timer test	**i8254 -t 4***
- Interval timer test	**i8254 -t 5**
- Interval timer test	**i8254 -t 6**
- Watchdog timer test	**wdog_diag -t 1**
* Requires external loopback connector configured as shown in Figure 4–1.	
VMEbus Interface Tests	
- VIP PCI configuration register test	**vip_diag -t 1**
- VIP register write/read test	**vip_diag -t 2**
- VIC register write/read test	**vip_diag -t 3**
- Scatter-gather RAM test	**vip_diag -t 4**
MISC	
- Ethernet hardware address test	**enet_diag -t 1**
- Ethernet hardware address test	**enet_diag -t 2**

4.3.2 SROM Initialization Countdown

During SROM initialization, the LED ASCII display executes a countdown that indicates the progress of the initialization. The console serial output also reports this countdown if the CONSOLE environment variable is set to SERIAL. The countdown is structured as follows:

LED Display	Output on Console	Meaning
8	–	Nbus bus has been reset and system I/O (SIO) configured.
7	7..	COM1 port has been initialized (9600 baud).
6	6..	BIU_CTL register has been programmed according to the cache configuration jumpers, but Bcache was not enabled.
5	5..	Main memory controller has been configured according to the DIMM PD/ID bits. Memory is alive but was not scrubbed.
4	4..	Bcache has been initialized and enabled.
3	3..	Bcache and main memory have been scrubbed to valid error checking/correction (ECC).
2	2..	Firmware image has been loaded from the flash ROM. Image starts at 0x8000.
1	1..	Debug jumper is about to be checked. If jumper is IN, then trap to the mini-debugger.
0	0	Written by the console firmware in PAL reset entry point. Indicates that the firmware has been decompressed and is starting.

4.3.3 Console POST Descriptions

This section provides details on the POST that are run during system initialization.

POST Non-Volatile RAM Diagnostic

The POST Non-Volatile RAM (NVRAM) diagnostic test verifies the module's NVRAM. It performs a data integrity test, through power cycles, and a write /read/compare of specific NVRAM locations used for diagnostics. It also checks for uninitialized NVRAM by comparing the stored checksum with the calculated checksum.

Description

This test executes at the beginning of console boot before the console drivers and devices have been initialized.

Test Name: None; executes on power-on

POST Memory Diagnostic

The POST memory diagnostic test verifies system memory. It runs with ECC enabled. If the test detects a memory error that cannot be corrected with ECC, it logs the error in the error logging area of NVRAM.

Description

See also **memtest** in Chapter 13.

Note

This test is dependent upon the setting of the console MODE environment variable. Setting mode to FASTBOOT evokes a quick verify test of the memory, and NOFASTBOOT evokes a full test of memory.

This test executes at the beginning of console boot before the console drivers and devices have been initialized.

This test provides the following coverage:

Memory bits	Stuck bits, bit transition fault, or bit coupling fault.
Decoder logic	An address selects no memory, two or more addresses select the same memory cell, or one address selects more than one cell.
Sense amplifier logic	Stuck fault or coupling fault.
Component and path coverage	The CPU memory control logic, etch from the CPU to the daughter card connectors, etch from the CPU backup cache control to the backup cache and from backup cache to the memory bus. The daughter card is assumed good since it is tested separately in manufacturing.

Test Name: None; executes on power-on.

4.3.4 Console Diagnostic Test Descriptions

This section provides details on the tests, which are available to the console, that you might run during system initialization testing or run from the console.

Heartbeat Timer Test

The heartbeat timer diagnostic test verifies that a heartbeat interrupt is generated at the correct interval (1024 Hz) and is properly dismissed by way of the module clear heartbeat register.

This test checks the following logic:

- Heartbeat timer and interrupt delivery mechanism
- Module clear heartbeat register

Heartbeat Timer Test

Console Command: hbeat_diag -t 1

Command Option:

-dd: print detailed test information on each pass.

Miscellaneous Notes

- This is a POST diagnostic.
- The test expects timer interrupts to be enabled. If they are not enabled, an interrupt count of zero results.
- You cannot run this test concurrently with other tests.

Interval Timer Tests

The interval timer tests test the functionality of the 8254 interval timer chip and surrounding external circuitry, including latches, programmable-array logic (PAL) devices and printed circuit board module etch.

Since all three interval timers of the 8254 chip have different external configurations, several tests are required for complete test coverage.

The intent of the tests is to verify that timers 0, 1, and 2 can generate a CPU interrupt, if properly enabled, at the programmed frequency.

These tests require that you properly program *both* timer 0 and 1 and connect them externally for successful operation.

Timer 2 Terminal Count Test

This test exercises Timer 2 with the timer interrupts enabled. In the Digital Alpha VME 4 design, the gate input for Timer 2 is always enabled and the clock input is connected to a 10 MHz (100 ns period) clock source.

Timer 2 is programmed to mode 0, interrupt on terminal count. After the timer is initially programmed to mode 0 and loaded with a count value, the OUT output is low and remains low until the internal count value reaches zero. When the count value reaches zero, OUT output is asserted high and remains high until timer 2 is reprogrammed. The event of OUT transitioning from low to high should generate a CPU interrupt.

The interrupt service routine (ISR) invoked due to the timer generated interrupt sets a global flag indicating the interrupt took place and that software was dispatched to the correct point.

Console Command: i8254_diag -t 1

Miscellaneous Notes

- The interrupt enable bits for timers 0 and 2 (bits 4 and 5 of the interrupt status register at address 0x4010) are not writable directly. Bit 4 is toggled by writing to address 0x4010; bit 5 is toggled by writing to address 0x4014. In both cases, the data written is Don't Care.
- A read of the interrupt status register at address 0x4014 causes both interrupt status bits (bits 0 and 1) to be cleared.
- Due to hardware limitations on interrupt detection, the value programmed into timer 2 must be greater than 2.

- See the Intel 8254 interval timer sheet for more details.

Timer 2 Square Wave Test

This test exercises timer 2. In the Digital Alpha VME 4 design, the gate input for timer 2 is always enabled and the clock input is connected to a 10 MHz (100 ns period) clock source.

Timer 2 is programmed to mode 3, square wave mode. After the timer is initially programmed for mode 3 and then loaded with a count value, the OUT output produces a continuous, square wave output whose period is equal to the count value multiplied by the period of the clock input. The count values are chosen such that they check stuck NDATA lines.

The event of OUT transitioning from low to high should generate a CPU interrupt, provided the timer 2 interrupt enable bit is set.

The ISR invoked due to the timer generated interrupt increments an interrupt counter and sets a global flag indicating the interrupt took place and that software was dispatched to the correct point. The test verifies that the interrupt count is within a certain range, based on the count value the timer was programmed with and the duration of time that interrupts were enabled.

Console Command: i8254_diag -t 2

Miscellaneous Notes

- The interrupt enable bits for timers 0 and 2 (bits 4 and 5 of the interrupt status register at address 0x4010) are not directly writable. Bit 4 is toggled by writing to address 0x4010; bit 5 is toggled by writing to address 0x4014. In both cases, the data written is Don't Care.
- A read of the interrupt status register at address 0x4014 causes both interrupt status bits (bits 0 and 1) to be cleared.
- Due to hardware limitations on interrupt detection, the value programmed into timer 2 must be greater than 2.
- See the Intel 8254 interval timer sheet for more details.

3 Timers Loopback Test

This test exercises timer 2, timer 1, and timer 0. In the Digital Alpha VME 4 design, the gate input for timer 2 and timer 1 is always enabled and the clock input is connected to a 10 MHz (100 ns period) clock source. Timer 0 accepts its input through a P2 loopback connector to which the outputs of timers 1 and 2 are tied. Timer 2 is the gate input and timer 1 provides the clock.

Interval Timer Tests

This test essentially emulates the realtime time provider and slave scheme found in the Realtime Clock and Interval Device Driver functional specification.

Note

A VMEbus P2 loopback connector is required. See Figure 4–1 for a description of the loopback connections.

Using the **-lp** option enables the timers indefinitely, making the module the master time provider for test #4.

Timer 2 and timer 1 are programmed to mode 3, square wave mode. Timer 0 is programmed to mode 1. After the timers are initially programmed with the appropriate mode and then loaded with a count value, the OUT output produces a continuous, square wave output whose period is equal to the count value multiplied by the period of the clock input. In this test timer 2 provides a major clock which basically provides the start time of timer 0, and timer 1 produces a much faster clock called the minor clock, which controls the rate that timer 0 counts down.

Timer 0 is the only interrupt that is enabled during this test. The event of OUT transitioning from low to high should generate a CPU interrupt.

The ISR invoked due to the timer generated interrupt increments an interrupt counter and sets a global flag indicating the interrupt took place and that software was dispatched to the correct point. The test verifies that the interrupt occurs, and that no more than one interrupt occurs per major clock cycle.

Console Command: i8254_diag -t 3

Command Options:

- **-np**: no print option; if specified no P2 connector message is printed
- **-lp**: prevents timers from being stopped at the end of the test; required before invoking Test #4.

Timer 0 Loopback Test

This test exercises only timer 0. Timer 0 accepts its clock and gate input from the P2 loopback connector. In this test, the Timer 0 inputs on the P2 connector can be driven by a master Alpha VME board running test 3 with **-lp** specified on the command line. See Figure 4–1.

This test essentially emulates the slave system found in the Realtime Clock and Interval Device Driver functional specification.

This test enables only timer 0 as done in test 3 but does not use timer 1 or timer 2. The clock and gate come from the timers on the master Digital Alpha VME 4 module. Timer 0 interrupts when the gate is received and its count is decremented to 0.

Note

A VMEbus P2 loopback connector is required. See Figure 4–1 for a description of the loopback connections.

Console Command: i8254_diag -t 4

Command Option:

-np: no print option; if specified no P2 connector message is printed

Miscellaneous Note

Test #3 must be invoked, with the **-lp** option, on the master module prior to invoking this test.

Timer 2 Interrupt Test

This test exercises timer 2 with the timer interrupt disabled. In the Digital Alpha VME 4 design, the gate input for timer 2 is always enabled and the clock input is connected to a 10 MHz (100 ns period) clock source.

Timer 2 is programmed to mode 0, interrupt on terminal count. After the timer is initially programmed to mode 0 and loaded with a count value, the OUT output is low and remains low until the internal count value reaches zero. When the count value reaches zero, OUT output is asserted high and remains high until timer 2 is reprogrammed. The event of OUT transitioning from low to high should set the timer 2 status bit and not generate a CPU interrupt.

The ISR global flag is checked verifying that the ISR was not invoked. The timer 2 status bit is checked to indicate the interrupt took place.

Console Command: i8254_diag -t 5

Miscellaneous Notes

- The interrupt enable bits for timers 0 and 2 (bits 4 and 5 of the interrupt status register at address 0x4010) are not directly writable. Bit 4 is toggled by writing to address 0x4010; bit 5 is toggled by writing to address 0x4014. In both cases, the data written is Don't Care.
- A read of the interrupt status register at address 0x4014 causes both interrupt status bits (bits 0 and 1) to be cleared.

- Due to hardware limitations on interrupt detection, the value programmed into timer 2 must be greater than 2.
- See the Intel 8254 interval timer sheet for more details.

Timer 1 Interrupt Test

This test verifies the interrupt path of timer 1 (periodic RT timer).

Timer 1 is programmed to mode 3, square wave mode. After the timer is initially programmed to mode 3 and loaded with a count value, the OUT output is low and remains low until the internal count value reaches zero. When the count value reaches zero, OUT output is asserted high and remains high until timer 1 is reprogrammed.

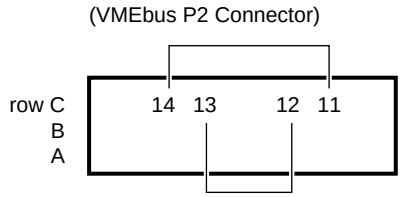
A global interrupt count flag is checked verifying whether the interrupt service routine was invoked.

Console Command: i8254_diag -t 6

Figure 4–1 Loopback Descriptions for Interval Timer Test 3 and 4

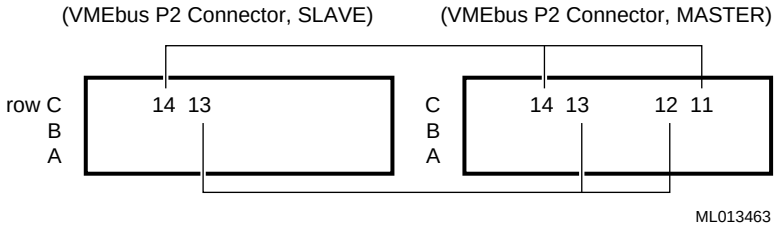
Configuration for Interval Timer test 3

To make a loopback for test 3 connect pin C11 to C14. With a second jumper, connect C12 to C13.



Configuration for Interval Timer test 4 (MASTER/SLAVE Alpha VME)

For test 4, the MASTER signals must be the input for the second Alpha VME module. Connect pins C11 and C14 of the MASTER to C14 of the SLAVE. With a second jumper, connect C12 and C13 of the MASTER to C13 of the SLAVE.



DECchip 21040 Ethernet Controller Tests

These diagnostics verify that the internal and external loopback mechanisms are properly operating in the DECchip 21040 Ethernet controller chip as well as performing writes and reads to all configuration registers.

Ethernet Internal Loopback Test

The NI internal loopback test transmits Ethernet packets from the transmit ring in main memory, loops them back at the MAC layer and returns them to the receive ring in main memory. No traffic is put on the network cable.

The NI external loopback test transmits Ethernet packets from the transmit ring in main memory and places them on the network medium (twisted pair cable). It concurrently listens to the line which carries its own transmissions and returns them to the receive ring in main memory. Received packets not identified as test packets are discarded for the duration of the test.

Note

To run the external loopback test, you must use a 10baseT loopback connector (H4082-AA). The external loopback test does not run if the device is connected to an open network.

These two tests check the following logic respectively:

- The device's internal logic up to but not including the Ethernet transmission logic.
- The on-chip transmit/receive circuitry and the passive external components that connect to the twisted pair interface.

Console Command

- **For internal loopback: niil_diag -t 1**
- **For external loopback: niil_diag -t 2**

Command Option:

-dd: print detailed test information on each pass.

DECchip 21040 PCI Configuration Register Dump

This test reads the PCI configuration registers of the DECchip 21040 and prints them to the standard output.

Console Command: nicsr_diag -t 1

DECchip 21040 Control/Status Register Dump

This test reads the CSRs of the DECchip 21040 and prints them to the standard output.

Console Command: nicsr_diag -t 2

DECchip 21040 Configuration Register Test

This test performs writes and reads to the chip's configuration registers with data patterns of all 1s, all 0s, and alternating 1s and 0s. Upon exiting, the test returns the configuration registers to their initial values.

Console Command: nicsr_diag -t 3

Command Option:

-dd: print detailed test information on each pass.

Miscellaneous Note

This test runs only on power-on.

DALLAS DS1386 RAMified Watchdog Timekeeper Tests

The DS1386 consists of 32 KB of NVRAM and a realtime clock. This diagnostic tests each of these features on an individual basis. The diagnostic tests the DS1386, decoders, and printed circuit board module etch.

The functionality of the watchdog feature is to be tested in a separate diagnostic. No alarm features are tested, since the alarms are not used.

Tests 1 through 3 exercise the NVRAM. Tests 4 and 5 exercise the realtime clock.

The NVRAM is tested on a page basis; there are 128 pages each containing 256 bytes. The NVRAM, therefore, contains 128 pages. However, the first page has reserved addresses for the realtime clock registers.

NVRAM March I Test

This test writes, reads, and compares all 32 KB of NVRAM with data patterns of all 1s, all 0s, alternating 1s and 0s, and shifting 1s and 0s. If the quick verify option is set (default) only the first location of each page is tested. The no quick verify option tests every location (32 KB) of the NVRAM.

Note

The contents of the NVRAM are overwritten by this diagnostic and restored on test completion. If the module is reset during this test, the NVRAM contents are undefined.

Console Command: ds1386_diag -t 1

Command Options:

- **-dd**: print detailed test information on each pass.
- **-nqv**: test every location in NVRAM, default is to test 1 location per 256 byte page.

Miscellaneous Note

This diagnostic is an extended test.

DALLAS DS1386 RAMified Watchdog Timekeeper Tests

NVRAM Address-On-Address Test

The NVRAM locations in the DS1386 are byte wide. Therefore, you do not have enough room to write the unique address into each corresponding location. However, this test writes the unique page offset to its corresponding location in NVRAM.

This test writes, reads, and compares all 32 KB of NVRAM using this unique page offset for test data. If the quick verify option is set (default) only the first location of each page is tested. The no quick verify option tests every location (32 KB) of the NVRAM.

Note

The contents of the NVRAM are overwritten by this diagnostic and restored on test completion. If the module is reset during this test the NVRAM contents are undefined.

Console Command: ds1386_diag -t 2

Command Options:

- **-dd**: print detailed test information on each pass.
- **-nqv**: test every location in NVRAM, default is to test 1 location per 256 byte page.

Miscellaneous Note

This diagnostic is an extended test.

NVRAM March II Test

This test verifies NVRAM addressing by marching (write, read, and compare) a 0x00 byte value through a field of 0xFF. Each iteration reads the entire 32 KB for background pattern of 0xFF. If the quick verify option is set (default) only the first location of each page is tested. The no quick verify, **-nqv**, option tests every location (32 KB) of the NVRAM.

Note

The contents of the NVRAM are overwritten by this diagnostic and restored on test completion. If the module is reset during this test the NVRAM contents are undefined.

DALLAS DS1386 RAMified Watchdog Timekeeper Tests

Console Command: ds1386_diag -t 3

Command Options:

- **-dd**: print detailed test information on each pass.
- **-nqv**: test every location in NVRAM, default is to test 1 location per 256 byte page.

Miscellaneous Note

This diagnostic is an extended test.

TOY Clock Bitwalk Test

This diagnostic does a walking 1, walking 0, and A5 register test on the time-of-year (TOY) clock registers. It also tests the rollover cases associated with keeping time.

The watchdog reset enable bit in the module control register is set to zero to ensure that a watchdog expiration does not cause a hardware reset to occur. Secondly, the contents of the command register is saved and the transfer enable bit is set to 0 to disable updates to the registers while the diagnostic is in progress.

The diagnostic bit patterns are then walked through all 14 registers. Next, the seconds, minutes, hours, day, month, and year registers are programmed such that the next clock tick rolls over for each of these parameters. The updates to the registers are started and updated for a three second time period. After the three second update period, the registers are then examined to verify that each parameter did indeed roll over to the appropriate value.

The diagnostic cleans up by reenabling the watchdog reset bit in the module control register and restoring the original contents of the TOY clock command register.

Note

The current date and time has to be reset after invoking this diagnostic test since approximately 3 seconds of time is lost for each pass.

DALLAS DS1386 RAMified Watchdog Timekeeper Tests

Console Command: ds1386_diag -t 4

Command Option:

-dd: print detailed test information on each pass.

Miscellaneous Note

This diagnostic is an extended test.

TOY Clock Time Advancement Test

This diagnostic is a power-on diagnostic. It verifies that the TOY clock registers are advancing with clock ticks.

The test reads the current value of the seconds register. Then the test sleeps for 1.2 seconds and reads the seconds register again expecting it to have incremented with the exception of the rollover case. The rollover case is where the seconds register advanced from 59 to 0. If the rollover case is encountered, the test sleeps for another second and reads the register again. This is repeated four times.

Console Command: ds1386_diag -t 5

Command Option:

-dd: print detailed test information on each pass.

Miscellaneous Note

This diagnostic is a POST diagnostic.

Local Area Network Address ROM Test

This diagnostic tests the integrity of the Local Area Network (LAN) address ROM, decoders, and printed circuit board module etch. The LAN address ROM contains the Ethernet station address of the module.

LAN Address ROM Dump

This diagnostic dumps the contents of the 32 octets within the LAN address ROM to the screen. No verification of the data is performed.

Console Command: enet_diag -t 1

Command Options:

- **-dd**: enables printing LAN address ROM to screen
- **-np**: no print, if specified, LAN address ROM is not printed to screen

Miscellaneous Notes

- The LAN address ROM octets must be read by using longword aligned byte accesses.
- This diagnostic is an extended test.

LAN Address ROM Verification Test

This test verifies the format of the data in the LAN address ROM. It verifies that the octets are ordered appropriately and that the checksums are correctly calculated based on the LAN address.

Console Command: enet_diag -t 2

Command Option:

-dd: enables printing LAN ROM address to screen

Miscellaneous Notes

- The LAN address ROM octets must be read by using longword aligned byte accesses.
- This test is considered a POST diagnostic.

Figure 4–2 LAN Address ROM Format

NCR 53C810 PCI-SCSI I/O Processor Tests

These tests check the NCR810 SCSI controller chip. The tests do not require a drive to be attached to the SCSI port and are meant to be a power-on check of the NCR810 chip's low-level modes through programmed I/O issued from the CPU. There are no NCR810 scripts executing during these tests.

All tests set up the diagnostic support environment, allocate memory, set up the PCI configuration registers, and check for the default values in the command /status registers as defined by the NCR810 53C810 chip specification (SW Fail point 1,2).

Note

If any of these tests fail, the console SCSI driver does not restart after the test. This causes SCSI devices connected to the system to be removed from the device list, and any attempts to run the disk exerciser or boot from a disk fails. (The command **show device** lists the currently installed devices.)

NCR810 PCI Configuration Register Test

This test prints the current setting of the NCR810 PCI configuration registers to the console screen using a formatted output.

Console Command: ncr810_diag -t 1

Command Option:

Print the config register if **-np** option is NOT specified.

NCR810 Command/Status Register Dump

This test displays the contents of all of the command/status registers on your screen. No test of the contents is performed.

Console Command: ncr810_diag -t 2

Command Option:

Print the config register if **-np** option is NOT specified.

NCR810 Command/Status Register Test

This test writes, reads, and compares all of the NCR810 command/status registers that are feasible to test. When the test finishes, it returns the registers to their initialized values.

Console Command: ncr810_diag -t 3

Command Option:

-lp: loop on write/read if the **-lp** option is specified.

NCR810 Command/Status Register Reset Value Test

This test checks that a reset of the NCR810 sets the command/status registers to their default values as defined by the NCR810 53C810 chip specification.

Console Command: ncr810_diag -t 4

NCR810 Internal Loopback Test

This test performs a SCSI loopback internal to the NCR810 chip. The following data patterns are used: all 1s, all 0s, alternating 1s and 0s. The test also verifies parity checking and that the SCSI reset control lines can be toggled internally.

Console Command: ncr810_diag -t 5

NCR810 Internal Live Bus Loopback Test

This test performs an internal SCSI loopback that also drives the signal lines on the SCSI bus.

All devices must be removed from the SCSI bus before running this test. Devices on the bus interfere with the test and cause false error reports. Also, the test data may produce illegal device instructions and cause the devices to hang.

First the SCSI bus is placed in a high impedance state by loading a data pattern that causes the output drivers to draw no current. Then the output latches are checked for the correct data. The test also verifies parity checking and that the SCSI reset control lines can be toggled internally. The following data patterns are used: all 1s, all 0s, alternating 1s and 0s.

Console Command: ncr810_diag -t 6

NCR810 Interrupt Test

This test verifies the interrupt connection between the NCR810 and the SIO controller to the CPU. A general purpose timer is enabled which generates an interrupt that is dispatched to the CPU through the SIO controller. The console PALcode dispatches to the NCR810_diag ISR, which clears the interrupt.

Console Command: ncr810_diag -t 7

Miscellaneous Notes

- These tests do not run in parallel with the SCSI exerciser tests.
- No external loopback connectors are needed for the loopback tests.
- References - NCR 53C810 PCI-SCSI I/O Processor specification Revision 2.1

Watchdog Timer Interrupt Test

This test verifies the functionality of the watchdog timeout by its ability to handle a user programmed watchdog reset.

This test checks the following logic:

- Watchdog timer
- Some reset logic
- DS1386 TOY clock

Watchdog Timer Interrupt Test

The diagnostic-in-progress bit is set and a watchdog timeout is invoked by loading a short time value into the watchdog timeout register. The user is queried to be sure the watchdog LED is off. Upon expiration of the watchdog, a HALT interrupt is expected. After the expected time, the reset reason register is evaluated. If the HALT interrupt did not occur, or the watchdog reason was not set, an error callout is made. Also, the user is asked to verify the watchdog LED is now on. At the end of the test, the watchdog timer and diagnostic-in-progress bit are disabled.

Console Command: wdog_diag -t 1

Command Options:

- **-dd**: print detailed test information on each pass.
- **-nc**: no confirmation; user is not prompted to verify state of LED
- **-np**: no print; overrides the **-nc** option, no user prompts

Miscellaneous Note

The purpose of setting the diagnostic-in-progress bit is to avoid an actual system reset when the watchdog timer expires. The watchdog expiration first causes a HALT interrupt. Approximately 300 ms later an actual system reset occurs, unless the diagnostic-in-progress bit is set. The reset reason register shows a watchdog reset reason whether or not the diagnostic-in-progress bit is set. The HALT interrupt and the reset reason are used for this diagnostic. User interaction can be suppressed with the **-nc** option (no confirmation).

VME Interface Tests

These tests verify the VME interface logic on the Digital Alpha VME 4 module, including the VME interface processor (VIP), the Cypress VIC064, the scatter/gather RAMs, and some of the interrupt paths from the VME corner to the Alpha processor. No VMEbus transactions are performed by these tests and therefore require no additional VMEbus modules.

VIP PCI Configuration Register Test

This test reads the first 8 longwords of VIP PCI configuration space. Only the device and vendor ID, and base address 0, 1, 2, and 3 are compared to an expected value. The remaining longwords are always read and displayed only if the **-dd** option is present.

Console Command: vip_diag -t 1

Command Option:

-dd: print detailed test information.

VIP Register Write/Read Test

This test ensures that the bits of a VIP register can be written and read correctly; verifying the data path and internal access.

Console Command: vip_diag -t 2

Command Option:

-dd: print detailed test information.

VIC Register Write/Read Test

This test ensures that the bits of a VIC register can be written and read correctly; verifying the data path and internal access.

Console Command: vip_diag -t 3

Command Option:

-dd: print detailed test information.

VME Scatter-Gather RAM Test

This test verifies the integrity of the scatter/gather RAM by performing write, read, and verify of various patterns to the entire scatter/gather RAM.

Console Command: vip_diag -t 4

Command Option:

-dd: print detailed test information on each pass.

4.4 Initialization Sequence

The diagnostic test sequence for a full power-on reset and initialization is shown in Figures 4–3, 4–4, and 4–5.

Figure 4–3 SROM Test Flows

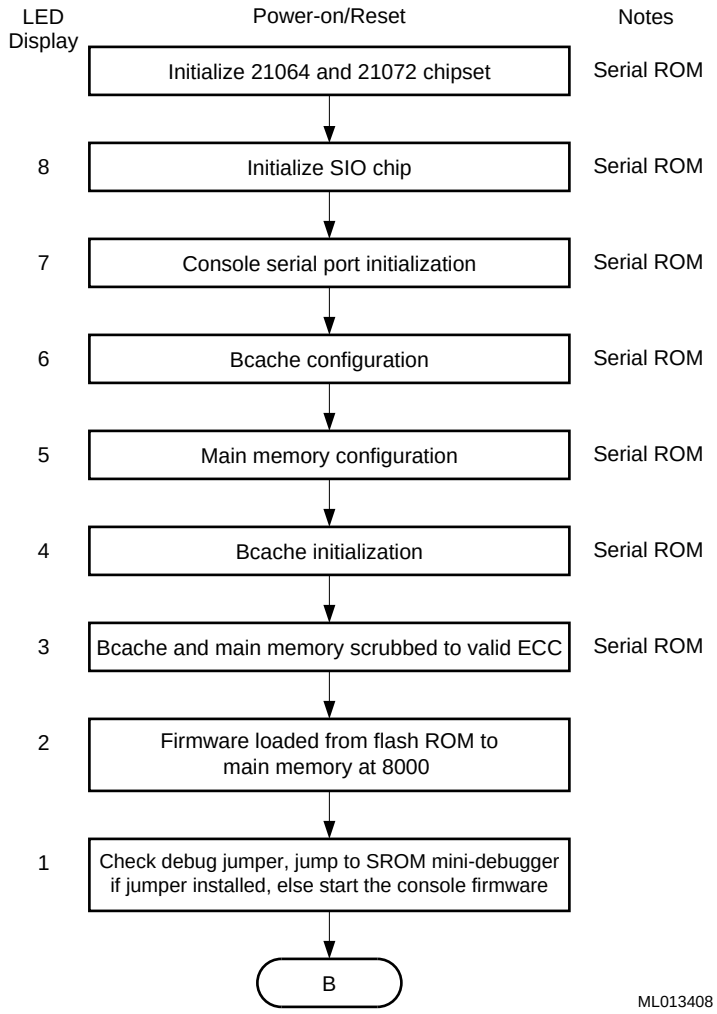


Figure 4–4 Console POST Flows

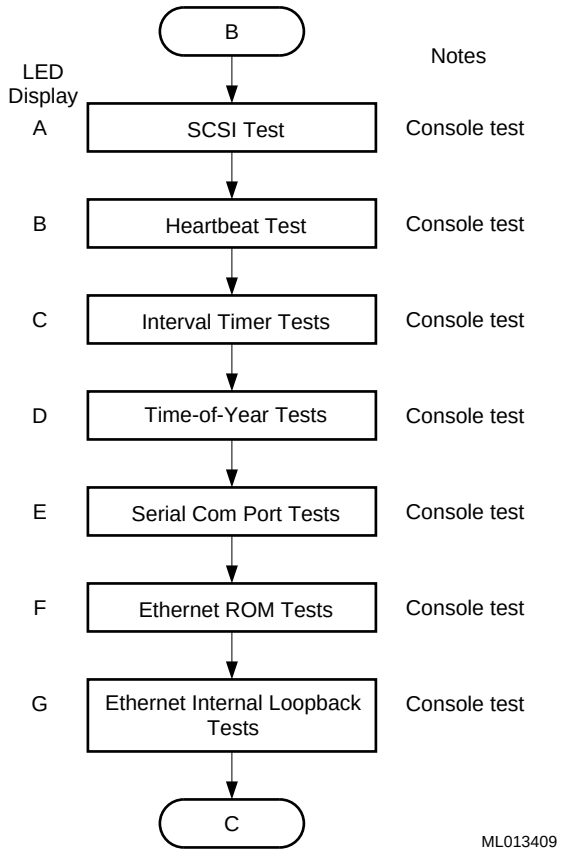
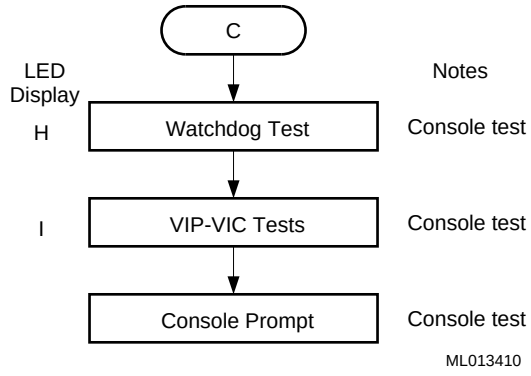


Figure 4–5 Console POST Flows



5
System Address Mapping

This chapter describes the mapping of the 34-bit processor physical address space into memory and I/O space addresses. It also includes the translations of the processor-initiated address into a PCI address, and PCI-initiated addresses into physical memory addresses.

5.1 CPU Address Mapping to PCI Space

The 34-bit physical system bus (sysBus) address space is composed of the following:

- Memory address space
- Local I/O space, for registers residing on the system bus (that is, registers in the 21071-CA and 21071-DA chips)
- PCI space

Note

The system bus represents the 21064A pin bus as well as control signals between the 21071-CA and 21071-DA chips.

The PCI defines three physical address spaces:

- PCI memory space (for memory residing on the PCI)
- PCI I/O space
- PCI configuration space

In addition to these address spaces, the system bus I/O space is also used to generate PCI interrupt acknowledge cycles and PCI special cycles. Figure 5–1 shows the address space. Table 5–1 provides a summary description of the spaces.

Figure 5–1 System Bus Address Map

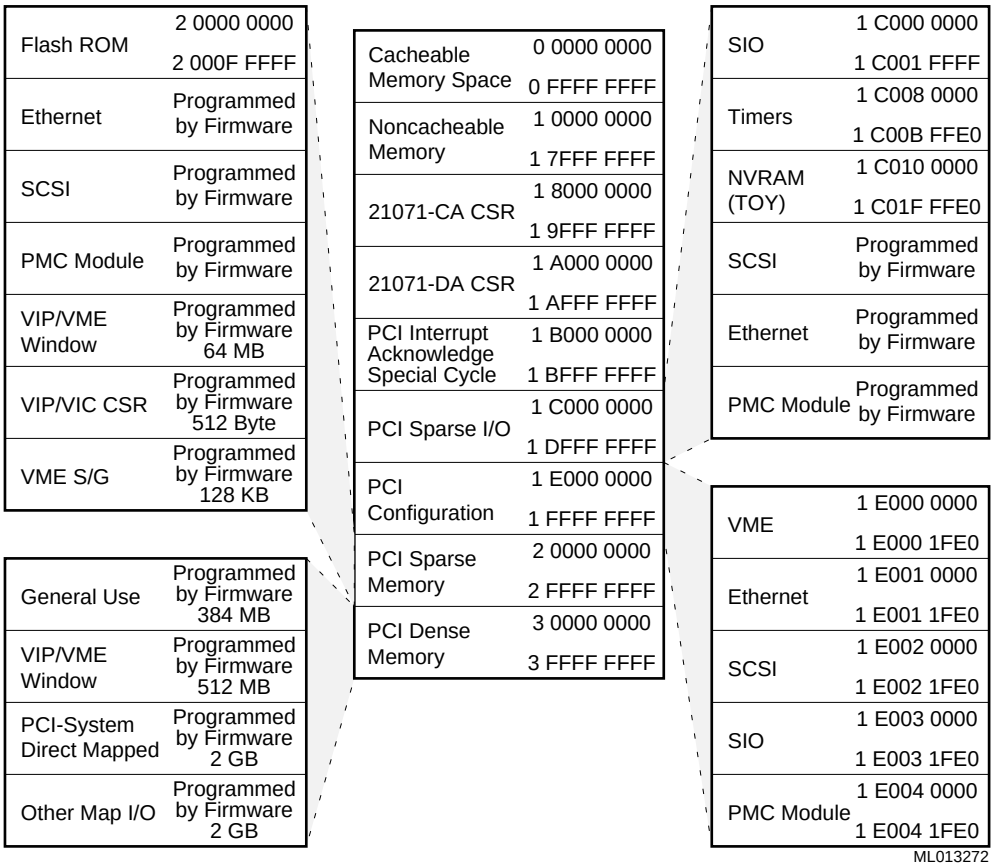


Table 5–1 System Bus Address Space Description

sysAdr <33:32>	sysAdr <31:28>	Address Space	Description
00	xxxx	Cacheable memory space	Accessed by the CPU instruction stream (Istream) or data stream (Dstream). Accessed by direct memory access (DMA).
01	0xxx	Noncacheable memory space	Accessed by the CPU (Istream or Dstream). Accessed by DMA. Can be used for a frame buffer on the DRAM bus.
01	100x	21071-CA CSRs	The 21071-CA responds to all addresses in this space. Dstream access only.
01	1010	21071-DA CSRs	The 21071-DA responds to all addresses in this space. Dstream access only.
01	1011	PCI interrupt acknowledge or PCI special cycle	The 21071-CA expects the 21071-DA to respond to all addresses in this space. A read transaction causes a PCI interrupt acknowledge; a write transaction causes a special cycle. Dstream access only.
01	110x	I/O space	16 MB of PCI space. The lower 256 KB of this space must be used for addressing the PCI bus and Nbus devices. The remainder of the space can be used for other devices. Dstream access only.
01	111x	PCI configuration space	A read or write transaction to this address space causes a configuration read or write cycle on the PCI. Dstream access only.

(continued on next page)

Table 5–1 (Cont.) System Bus Address Space Description

sysAdr <33:32>	sysAdr <31:28>	Address Space	Description
10	xxxx	PCI sparse memory space	128 MB addressable PCI space. The lower address bits are used to determine byte masks and transaction length information. The 4 GB space is reduced to a 128 MB sparse space. Use this space when byte or word granularity is required. Read or write length is no more than a quadword. Reading other than the requested data is harmful. Prefetching read data is prohibited. Dstream access only.
11	xxxx	PCI dense memory space	4 GB of PCI space. Used for devices with access granularity greater than one longword. Read transactions do not have side effects; prefetching data from PCI devices is allowed. Typically used for data buffers. Dstream access only.

5.1.1 Cacheable Memory Space (0x000000000 to 0x0FFFFFFFF)

The 21071-CA recognizes the 4 GB of quadrant 0 (corresponding to **sysBus<33:32>** = 00) as cacheable memory space. The 21071-CA responds to all read and write accesses in this space. Some or all of main memory can be programmed to be in cacheable space.

5.1.2 Noncacheable Memory Space (0x100000000 to 0x17FFFFFFF)

The 21071-CA recognizes the lower 2 GB of quadrant 1 (corresponding to **sysBus<33:32>** = 01) as noncacheable memory space. The L2 cache is bypassed by the 21071-CA on accesses to this space. Some or all of main memory can be programmed to be in this space. If a frame buffer is supported in system memory, it should be addressed in this space.

5.1.3 DECchip 21071-CA CSR Space (0x180000000 to 0x19FFFFFFF)

The DECchip 21071-CA responds to all CSR accesses in this space. Section 6.5 specifies the registers and associated register addresses.

5.1.4 DECchip 21071-DA CSR Space (0x1A0000000 to 0x1AFFFFFFF)

The DECchip 21071-DA responds to all accesses in this space. Section 7.4 specifies the registers and associated register addresses. Section 7.5 contains the register descriptions.

5.1.5 PCI Interrupt Acknowledge/Special Cycle Space (0x1B0000000 to 0x1BFFFFFFF)

A read access to this space causes an interrupt acknowledge cycle on the PCI. Bits **sysBus<6:3>** are used to generate the byte enables on the PCI as specified in Table 5–2. Bits **sysBus<26:7>** are in a don't care state during this transaction.

A write access to this space causes a special cycle on the PCI. The address and byte enables are in a don't care state during this transaction.

Note

Software must use an STL instruction to initiate these transactions.

5.1.6 PCI Sparse I/O Space (0x1C0000000 to 0x1DFFFFFFF)

The PCI sparse I/O space is a 512 MB system bus address space that maps to 16 MB of PCI I/O address space. A read or write transaction to this space causes a PCI I/O read or PCI I/O write command respectively.

Bits **sysBus<33:29>** identify the various address spaces on the system bus. Bits **sysBus<6:3>** generate the length of the PCI transaction in bytes, the byte enables, and **ad<2:0>** on the PCI bus (see Table 5–2).

Bits **sysBus<28:8>** correspond to the quadword PCI addresses and are sent out on **ad<23:3>** during the address phase on the PCI. Bits **ad<31:24>** are obtained from one of two host address extension registers (HAXR0 and HAXR2). The HAXR0 register (which is hardcoded as 0) is used for system bus addresses between 0x1C0000000 and 0x1C07FFFFF (that is, when bits **sysBus<28:23>** are 0).

The HAXR2 register maps system bus addresses between 0x1C0800000 and 0x1DFFFFFFF (that is, when bits **sysBus<28:23>** are nonzero anywhere in the PCI address space). The HAXR2 register is a CSR in the 21071-DA chip and is fully programmable. This allows Nbus devices that require their I/O space to be in the lower 256 KB to coexist with other devices that do not have that restriction. The lower 256 KB of I/O space have fixed mapping (HAXR0 to 0), and the remaining I/O space (64 MB minus 64 KB) can be programmed anywhere in PCI space.

Figure 5–2 shows the translation of system bus addresses to PCI bus I/O addresses. Table 5–2 shows how the byte enable bits and PCI **ad<2:0>** are generated from bits **sysBus<6:3>**.

Figure 5–2 PCI Sparse I/O Space Address Translation

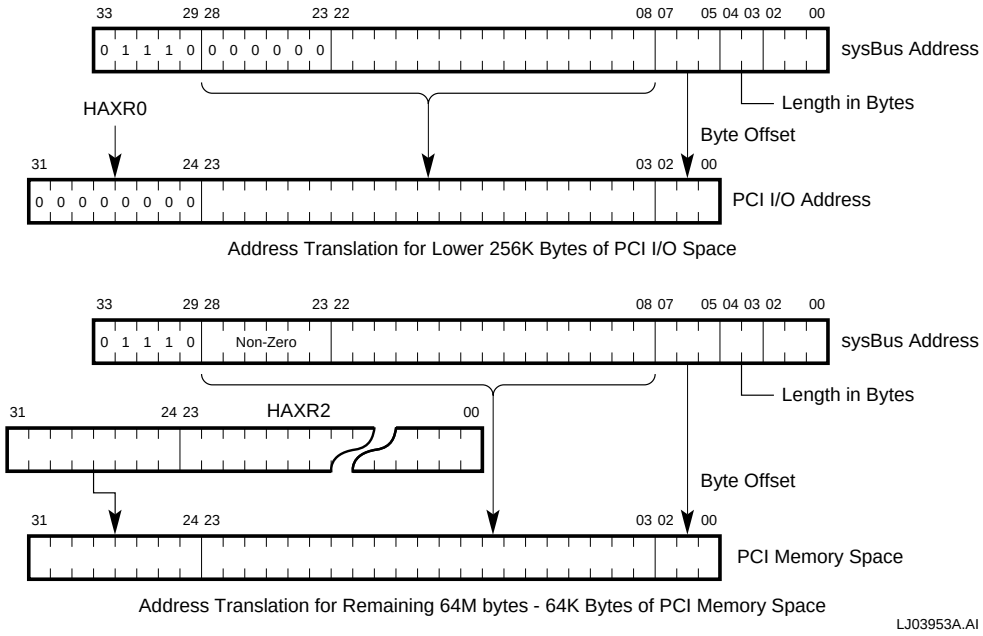


Table 5–2 PCI Sparse I/O Space Byte Enable Generation

Length	CPU Address <6:5>	CPU Address <4:3>	PCI Byte Enable[1]	PCI ad<2:0>
Byte	00	00	1110	CPU **address<7>**, 00
	01	00	1101	CPU **address<7>**, 01
	10	00	1011	CPU **address<7>**, 10
	11	00	0111	CPU **address<7>**, 11
Word	00	01	1100	CPU **address<7>**, 00
	01	01	1001	CPU **address<7>**, 01
	10	01	0011	CPU **address<7>**, 10
	11	01	Illegal[2]	—
Tribyte	00	10	1000	CPU **address<7>**, 00
	01	10	0001	CPU **address<7>**, 01
	10	10	Illegal[2]	—
	11	10	Illegal[2]	—
Longword	00	11	0000	CPU **address<7>**, 00
Longword	01	11	Illegal[2]	—
Longword	10	11	Illegal[2]	—
Quadword	11	11	0000	000

[1]Byte enable set to 0 indicates that byte lane carries meaningful data.

[2]These combinations are architecturally illegal. If there is an access with this combination of **address<6:3>**, the 21071-DA responds to the transactions but the results are UNPREDICTABLE.

Caution

Quadword accesses to this PCI sparse I/O space cause a 2-longword burst on the PCI. PCI devices cannot support bursting in I/O space.

5.1.7 PCI Configuration Space (0x1E0000000 to 0x1FFFFFFFF)

A read or write access to this space causes a configuration read or write cycle on the PCI. There are two classes of targets: devices on the primary PCI bus and devices on the secondary PCI buses that are accessed through PCI-to-PCI bridge chips.

During PCI configuration cycles, the meanings of the address fields vary depending on the intended target of the configuration cycle. Bits **ad<1:0>**, which are supplied by the HAXR2 register, indicate the target bus:

Bits **ad<1:0>** equal to 00 indicate the primary PCI bus.
Bits **ad<1:0>** equal to 01 indicate a secondary PCI bus.

Table 5–3 defines the various fields of PCI **ad<31:0>** during the address phase of a configuration read or write cycle.

Table 5–3 PCI Configuration Space Definition

Target Bus	ad Bits	Definition
Primary PCI Bus		
	<31:11>	Decoded from **sysAdr<20:16>** according to Table 5–4.
		Can be used for IDSEL# or don't care states. Typically, the IDSEL# pin of each device is connected to a unique **ad** line.
	<10:8>	Function select (1 of 8) from **sysAdr<15:13>**
	<7:2>	Register select from **sysAdr<12:7>**
	<1:0>	00 from **HAXR2<1:0>**
Secondary PCI Buses (Must pass through a PCI-to-PCI bridge)		
	<31:24>	Forced to 0 by the 21071-DA chip
	<23:16>	Secondary bus number from **sysAdr<28:21>**
	<15:11>	Device number from **sysAdr<20:16>**
	<10:8>	Function select (1 of 8) from **sysAdr<15:13>**
	<7:2>	Register select from **sysAdr<12:7>**
	<1:0>	01 from **HAXR2<1:0>**

Table 5–4 translates bits **sysAdr<20:16>** to PCI primary bus addresses.

Table 5–4 PCI Address Decoding for Primary Bus Configuration Accesses

Device Number (sysAdr<20:16>)	PCI ad<31:11>
00000	0000 0000 0000 0000 0000 1
00001	0000 0000 0000 0000 0001 0
00010	0000 0000 0000 0000 0010 0
00011	0000 0000 0000 0000 0100 0
00100	0000 0000 0000 0000 1000 0
00101	0000 0000 0000 0001 0000 0
00110	0000 0000 0000 0010 0000 0
00111	0000 0000 0000 0100 0000 0
01000	0000 0000 0000 1000 0000 0
01001	0000 0000 0001 0000 0000 0
01010	0000 0000 0010 0000 0000 0
01011	0000 0000 0100 0000 0000 0
01100	0000 0000 1000 0000 0000 0
01101	0000 0001 0000 0000 0000 0
01110	0000 0010 0000 0000 0000 0
01111	0000 0100 0000 0000 0000 0
10000	0000 1000 0000 0000 0000 0
10001	0001 0000 0000 0000 0000 0
10010	0010 0000 0000 0000 0000 0
10011	0100 0000 0000 0000 0000 0
10100	1000 0000 0000 0000 0000 0
10101 to 11111	0000 0000 0000 0000 0000 0

5.1.7.1 PCI Configuration Cycles to Primary Bus Targets

Primary PCI bus devices are selected during a PCI configuration cycle if:

- Their IDSEL# pin is asserted
- The PCI bus command indicates a configuration read or write transaction
- Bits **ad<1:0>** are 00

Bits **ad<7:2>**, which are taken from bits **sysAdr<12:7>**, select a longword register in the device's 256-byte configuration address space. Configuration accesses can use byte masks, which may be derived by following the method shown in Table 5–2.

Peripherals that integrate multiple functional units (for example, SCSI, Ethernet, and so on) can provide configuration spaces for each function. Bits **ad<10:8>**, which are taken from bits **sysAdr<15:13>**, can be decoded by the peripheral to select one of eight functional units.

Bits <31:11> are used to generate the IDSEL signals. Typically, the IDSEL# pin of each PCI peripheral is connected to a unique address line. Bits **ad<31:11>**, are decoded from bits **sysAdr<20:16>** according to Table 5–4, ensuring that only one bit of **ad<31:11>** is asserted for any given configuration space transaction on the primary PCI bus. Bits **sysAdr<28:21>** are ignored.

5.1.7.2 PCI Configuration Cycles to Secondary Bus Targets

If the PCI cycle is a configuration read or write cycle but bits **ad<1:0>** are 01, a device on a secondary PCI bus is being selected across a PCI-to-PCI bridge. This cycle will be accepted by a PCI-to-PCI bridge for propagation to its secondary PCI bus. During this cycle, bits **sysAdr<28:7>** generate PCI **ad<23:2>**, which has four fields, as listed here:

Bits	Taken From	Operation
ad<23:16>	**sysAdr<28:21>**	Select a unique bus number.
ad<15:11>	**sysAdr<20:16>**	Select a device on the PCI (typically decoded by the target bridge to generate IDSEL# signals).
ad<10:8>	**sysAdr<15:13>**	Select one of eight functional units per device.
ad<7:2>	**sysAdr<12:7>**	Select a longword in the device's configuration register space.

Each PCI-to-PCI bridge device can be configured using PCI configuration cycles on its primary PCI interface. Configuration parameters in the PCI-to-PCI bridge will identify the bus number for its secondary PCI interface and a range of bus numbers that may exist hierarchically behind it.

If the bus number of the configuration cycle matches the bus number of the bridge chip secondary PCI interface, it will intercept the configuration cycle, decode it, and generate a PCI configuration cycle with **ad<1:0>** equal to 01 on its secondary PCI interface. If the bus number is within the range of bus numbers that may exist hierarchically behind its secondary PCI interface, the PCI configuration cycle passes, unmodified (leaving **ad<1:0>** = 01), through the bridge. The configuration cycle will be intercepted and decoded by a downstream bridge.

5.1.8 PCI Sparse Memory Space (0x200000000 to 0x2FFFFFFFF)

Access to PCI sparse memory space can have byte, word, tribyte, longword, or quadword granularity. The Alpha architecture does not provide byte, word, or tribyte granularity, which the PCI requires. To provide this granularity, the byte enable and byte length information is encoded in the lower address bits of this space (**ad<7:3>**).

Bits **sysBus<31:8>** generate quadword addresses on the PCI, resulting in a sparse 4 GB space that maps to 128 MB of PCI address space. An access to this space causes a memory read or write access on the PCI.

Bits **sysBus<33:32>** identify the various address spaces on the system bus. Bits **sysBus<7:3>** generate the length of the PCI transaction in bytes, the byte enables, and **ad<2:0>** (see Table 5–5). Bits **sysBus<31:8>** correspond to the quadword PCI addresses and are sent out on **ad<26:3>** during the address phase on the PCI.

Bits **ad<31:27>** are obtained from one of two host address extension registers (HAXR0 and HAXR1). HAXR0 (which is hardcoded as 0) is used for system bus addresses 0x200000000 to 0x21FFFFFFF (that is, when bits **sysBus<31:29>** are 0). The HAXR1 register maps system bus addresses 0x220000000 to 0x2FFFFFFFF (that is, when bits **sysBus<31:29>** are nonzero anywhere in the PCI address space).

HAXR1 is a CSR in the 21071-DA and is fully programmable. This allows Nbus devices that require memory to be mapped in the lower 16 MB to coexist with other devices that do not have that restriction. The lower 16 MB have a fixed mapping (HAXR0) to 0, and the remaining 112 MB can be programmed anywhere in PCI space.

Figure 5–3 shows the translation of system bus addresses to PCI memory addresses. Table 5–5 shows the generation of the byte enables and PCI address **ad<2:0>** from bits **sysBus<6:3>**.

Figure 5–3 PCI Memory Space Address Translation

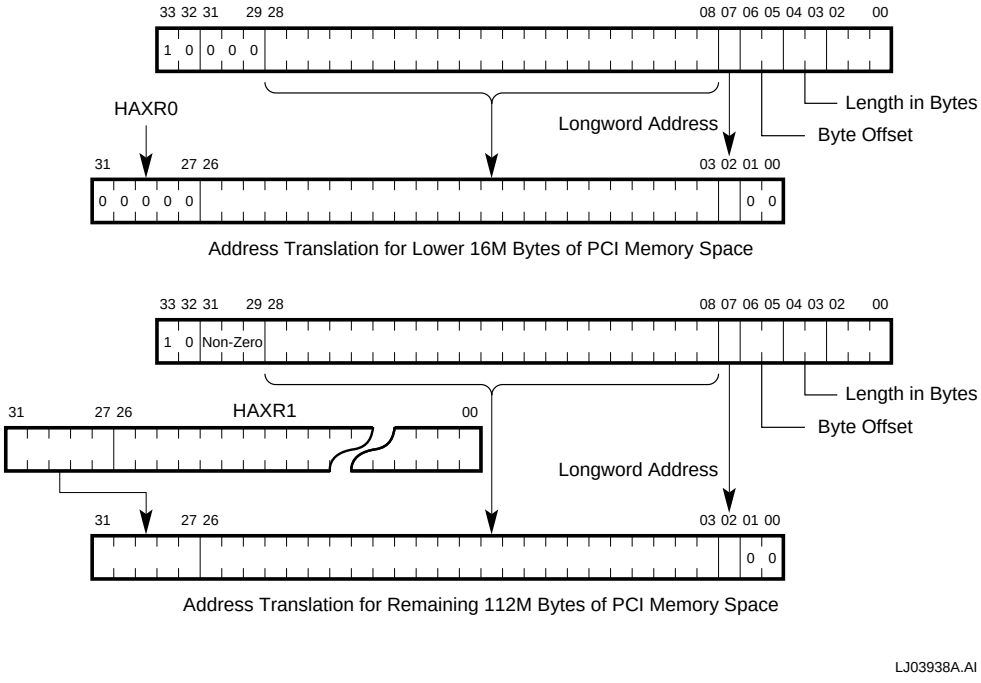


Table 5–5 shows the generation of the byte enables and PCI address **ad<2:0>** from bits **sysBus<6:3>**.

Bits **sysBus<33:5>** are directly available from the CPU. Bits **sysBus<4:3>** are derived from the longword masks (**cpucwmask<7:0>**). On read transactions, the CPU sends out **sysBus<4:3>** on **cpucwmask<1:0>**.

Table 5–5 PCI Sparse Memory Space Byte Enable Generation

Length	CPU Address<6:5>	CPU Address<4:3>	PCI Byte Enable[1]	PCI ad<2:0>[2]
Byte	00	00	1110	CPU **address<7>**, 00
	01	00	1101	CPU **address<7>**, 00
	10	00	1011	CPU **address<7>**, 00
	11	00	0111	CPU **address<7>**, 00
Word	00	01	1100	CPU **address<7>**, 00
	01	01	1001	CPU **address<7>**, 00
	10	01	0011	CPU **address<7>**, 00
	11	01	Illegal[3]	—
Tribyte	00	10	1000	CPU **address<7>**, 00
	01	10	0001	CPU **address<7>**, 00
	10	10	Illegal[3]	—
	11	10	Illegal[3]	—
Longword	00	11	0000	CPU **address<7>**, 00
Longword	01	11	Illegal[3]	—
Longword	10	11	Illegal[3]	—
Quadword	11	11	0000	000

[1]Byte enable set to 0 indicates that byte lane carries meaningful data.

[2]In PCI sparse memory space, PCI **ad<1:0>** are always 00.

[3]These combinations are architecturally illegal. If there is an access with this combination of **address<6:3>**, the 21071-DA will respond to the transactions but the results are UNPREDICTABLE.

On write transactions, the relationship between **cpucwmask<7:0>** and **sysBus<4:3>** is as follows:

If **cpucwmask<1:0>** is nonzero, **sysBus<4:3>** is 00.
If **cpucwmask<3:2>** is nonzero, **sysBus<4:3>** is 01.
If **cpucwmask<5:4>** is nonzero, **sysBus<4:3>** is 10.
If **cpucwmask<7:6>** is nonzero, **sysBus<4:3>** is 11.

Accesses in this space are no more than a quadword. Software must ensure that the processor does not merge consecutive write transactions in its write buffers by using memory barriers after each write transaction. Architecturally, if a byte, word, tribyte, or longword is written on the PCI, an STL instruction must be executed to the lower longword in the corresponding quadword address. An STQ or STL instruction to the upper longword is not allowed.

One bit pair of **cpucwmask<1:0>**, **<3:2>**, **<5:4>**, and **<7:6>** must have a value of 01 (binary). The other fields must be 00. The location of the 01 field indicates whether the data reference is byte, word, tribyte, or longword (respectively).

Similarly, if a quadword is written to the PCI, software must execute an STQ instruction to the corresponding address. The only legal value on **cpucwmask<7:6>** in sparse space is 11000000.

If a byte, word, tribyte, or longword is read from the PCI, an LDL instruction must be executed to the lower longword in the corresponding quadword address. An LDL instruction to the upper longword or LDQ instruction returns the wrong data. If a quadword is read from the PCI, software must use an LDQ instruction. An LDL instruction returns wrong data.

5.1.9 PCI Dense Memory Space (0x300000000 to 0x3FFFFFFFF)

PCI dense memory space is typically used for data buffers on the PCI and has the following characteristics:

- There is a one-to-one mapping between CPU addresses and PCI addresses. A longword address from the CPU maps to a longword on the PCI (thus, the name *dense space* as opposed to PCI sparse memory space).
- Byte or word accesses are not allowed in this space. Minimum access granularity is a longword. The maximum transfer length implemented by the 21072 chipset is a cache line (32 bytes) on write transactions, and a quadword on read transactions.
- Read prefetching is allowed in this space; additional read transactions have no side effects. The 21064A does not specify a longword address on read transactions; it only specifies a quadword address. Therefore, read transactions in this space are always performed as a quadword read transaction with a burst length of two on the PCI.
- Write transactions to addresses in this space can be buffered in the 21064A. The 21072 chipset supports a maximum burst length of 8 on the PCI corresponding to a cache line of data.

The address generation in dense space is as follows:

- Bits **sysBus<31:5>** are sent out on **ad<31:5>**.
- On read transactions, **ad<4:3>** is generated from **cpucwmask<1:0>**; **ad<2>** is always 0.

- On write transactions, **ad<4:2>** is generated from **cpucwmask<7:0>**. If the lower longword is to be written, **ad<2>** is 0; if the lower longword is masked out and the upper longword is to be written, **ad<2>** is 1. The number of longwords written on the PCI is directly obtained from **cpucwmask<7:0>**. Any combination of **cpucwmask<7:0>** is allowed by the 21072 chipset.

  Note

  If the cache line written by the processor has holes, that is, if some of the longwords are masked out, the corresponding transfer is still performed on the PCI bus with disabled byte enables. Downstream bridges must be able to deal with disabled byte enables on the PCI bus during write transactions.

5.2 PCI-to-Physical Memory Addressing

Incoming 32-bit memory addresses are mapped to the 34-bit physical memory addresses. The 21071-DA allows two regions in PCI memory space to be mapped to system memory with two programmable address windows. The mapping from the PCI address to the physical address can be direct (physical mapping with an extension register) or scatter-gather mapped (virtual). These two address windows are referred to as the PCI target windows.

Each window has three registers associated with it:

- PCI base register
- PCI mask register
- Translated base register

The PCI mask register provides a mask corresponding to **ad<31:20>** of an incoming PCI address. The size of each window can be programmed from 1 MB to 4 GB (in powers of 2) by masking bits of the incoming PCI address, using the PCI mask register as specified in Table 5–6.

Table 5–6 PCI Target Window Enables

PCI_MASK<31:20>[1]	Window Size	Value of *n*[2]
0000 0000 0000	1 MB	20
0000 0000 0001	2 MB	21
0000 0000 0011	4 MB	22
0000 0000 0111	8 MB	23
0000 0000 1111	16 MB	24
0000 0001 1111	32 MB	25
0000 0011 1111	64 MB	26
0000 0111 1111	128 MB	27
0000 1111 1111	256 MB	28
0001 1111 1111	512 MB	29
0011 1111 1111	1 GB	30
0111 1111 1111	2 GB	31
1111 1111 1111	4 GB[3]	32

[1]Combinations of bits not shown in **PCI_MASK<31:20>** are not supported.

[2]Depending on the target window size, only the incoming address bits <31:*n*> are compared with bits <31:*n*> of the PCI base registers as shown in Figure 5–4. If *n* = 20 to 32, no comparison is performed; *n* is also used in Figure 5–6.

[3]When this combination is chosen, the WENB bit in the other PCI base register must be cleared; otherwise, the two windows will overlap.

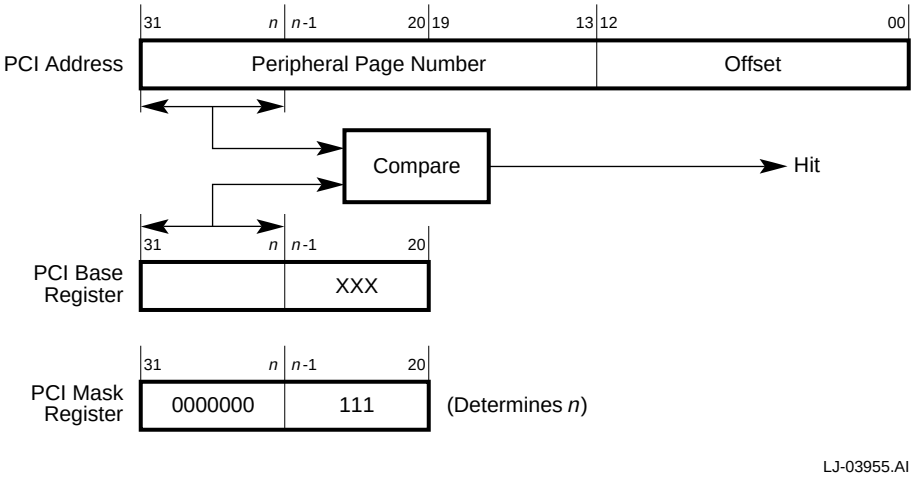
Based on the value of the PCI mask register, the unmasked bits of the incoming PCI address are compared with the corresponding bit of each window's PCI base register. If the base registers and the incoming PCI address match, the incoming PCI address has hit that target window; otherwise, it missed that window. A window enable bit (WENB) is provided in the PCI base register of each window to allow them to be independently enabled and disabled.

The PCI target windows must be programmed such that the PCI address ranges do not overlap. The compare scheme between the incoming PCI address and the PCI base register (together with the PCI mask register) is shown in Figure 5–4.

Note

The window base addresses must be on naturally aligned address boundaries, depending on the size of the window.

Figure 5–4 PCI Target Window Compare Scheme



When an address match occurs with a PCI target window, the 21071-DA translates the 32-bit PCI address **ad<31:0>** to a 34-bit processor byte address (actually a 29-bit hexword address). The translated address is generated in one of two ways as determined by the scatter-gather enable (SGEN) bit of the PCI base register of the associated window.

If SGEN is cleared, the DMA address is direct mapped. The translated address is generated by concatenating bits from the matching window translated base register with bits from the incoming PCI address. The PCI mask register determines which bits of the translated base register and PCI address are used to generate the translated address as shown in Table 5–7.

The unused bits of the translated base register must be cleared for correct operation. Because system memory is located in the lower half of the CPU address space, bit **sysBus<33>** is always zero. Bits **sysBus<32:5>** are obtained from the translated base register.

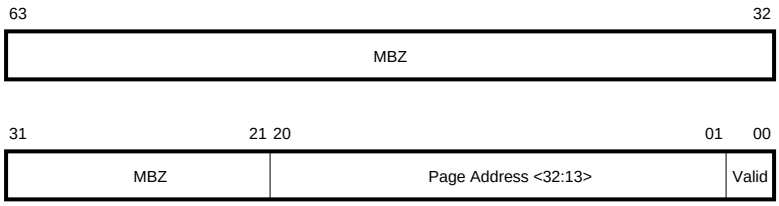
Table 5–7 PCI Target Address Translation—Direct Mapped

PCI_MASK<31:20>	Translated Base <32:5>
0000 0000 0000	**T_BASE<32:20>**:PCI **ad<19:5>**
0000 0000 0001	**T_BASE<32:21>**:PCI **ad<20:5>**
0000 0000 0011	**T_BASE<32:22>**:PCI **ad<21:5>**
0000 0000 0111	**T_BASE<32:23>**:PCI **ad<22:5>**
0000 0000 1111	**T_BASE<32:24>**:PCI **ad<23:5>**
0000 0001 1111	**T_BASE<32:25>**:PCI **ad<24:5>**
0000 0011 1111	**T_BASE<32:26>**:PCI **ad<25:5>**
0000 0111 1111	**T_BASE<32:27>**:PCI **ad<26:5>**
0000 1111 1111	**T_BASE<32:28>**:PCI **ad<27:5>**
0001 1111 1111	**T_BASE<32:29>**:PCI **ad<28:5>**
0011 1111 1111	**T_BASE<32:30>**:PCI **ad<29:5>**
0111 1111 1111	**T_BASE<32:31>**:PCI **ad<30:5>**
1111 1111 1111	**T_BASE<32>**:PCI **ad<31:5>**

If the SGEN bit is set, the translated address is generated by a table lookup. The incoming PCI address indexes a table stored in system memory. The table is referred to as a scatter-gather map. The translated base register specifies the starting address of the scatter-gather map. Bits of the incoming PCI address are used as an offset from the base of the map. The map entry provides the physical address of the page.

Each scatter-gather map entry maps an 8 KB page of PCI address space into an 8 KB page of processor address space. Each scatter-gather map entry is a quadword. Each entry has a valid bit in position 0. Address bit **ad<13>** is at bit position 1 of the map entry. Because the 21072 implements only valid memory addresses up to 6 GB, bits **ad<63:21>** of the scatter-gather map entry must be programmed to 0. Bits **ad<21:1>** of the scatter-gather entry generate the physical page address. This is appended to bits **ad<12:5>** of the incoming PCI address to generate the memory address placed on the system bus. Figure 5–5 shows the scatter-gather map entry.

Figure 5–5 Scatter-Gather Map Page Table Entry in Memory



The size of the scatter-gather map table is determined by the size of the PCI target window as defined by the PCI mask register (see Table 5–8). Because the scatter-gather map is located in system memory, bit **sysBus<33>** is always zero. Bits **sysBus<32:2>** are obtained from the translated base register and the PCI address.

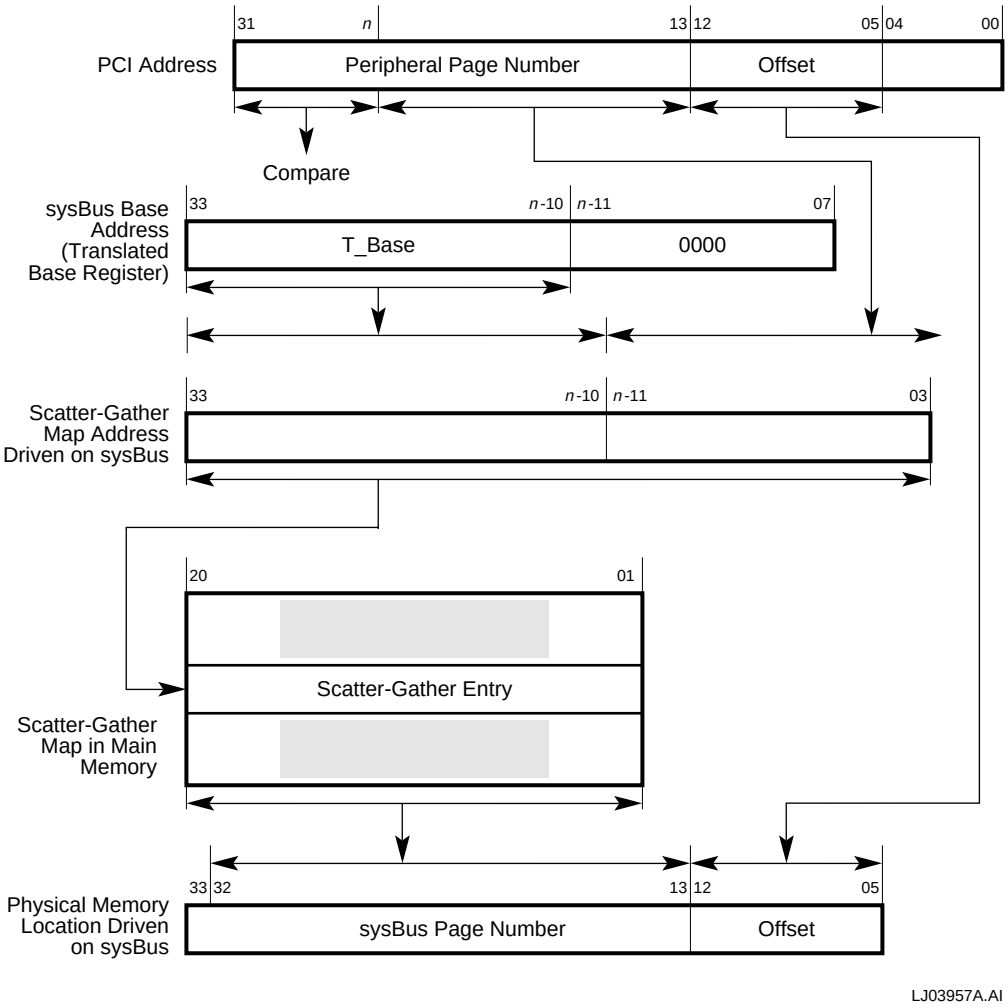
Table 5–8 Scatter-Gather Map Address

PCI_MASK<31:20>	Scatter-Gather Map Table Size	Scatter-Gather Map Address<32:3>
0000 0000 0000	1 KB	**T_BASE<32:10>**:PCI **ad<19:13>**
0000 0000 0001	2 KB	**T_BASE<32:11>**:PCI **ad<20:13>**
0000 0000 0011	4 KB	**T_BASE<32:12>**:PCI **ad<21:13>**
0000 0000 0111	8 KB	**T_BASE<32:13>**:PCI **ad<22:13>**
0000 0000 1111	16 KB	**T_BASE<32:14>**:PCI **ad<23:13>**
0000 0001 1111	32 KB	**T_BASE<32:15>**:PCI **ad<24:13>**
0000 0011 1111	6 KB	**T_BASE<32:16>**:PCI **ad<25:13>**
0000 0111 1111	128 KB	**T_BASE<32:17>**:PCI **ad<26:13>**
0000 1111 1111	256 KB	**T_BASE<32:18>**:PCI **ad<27:13>**
0001 1111 1111	512 KB	**T_BASE<32:19>**:PCI **ad<28:13>**
0011 1111 1111	1 MB	**T_BASE<32:20>**:PCI **ad<29:13>**
0111 1111 1111	2 MB	**T_BASE<32:21>**:PCI **ad<30:13>**
1111 1111 1111	4 MB	**T_BASE<32:22>**:PCI **ad<31:13>**

Figure 5–6 shows the entire translation process from the PCI address to the physical address on a window implementing scatter-gather mapping. The following list describes the translation operation:

1. Bits **ad<12:5>** of the PCI address directly generate the page offset.
2. The relevant bits of the PCI address (as specified by the window mask register, depending on the size of the window) generate the offset into the scatter-gather map.
3. The relevant bits of the translated base register indicate the base address of the scatter-gather map.
4. The map base is appended to the map offset to generate the address of the corresponding scatter-gather entry.
5. Bits <20:1> of the map are used to generate the physical page address, which is appended to the page offset to generate the PCI address.

Figure 5–6 Scatter-Gather Map Translation of PCI Bus Address to System Bus Address



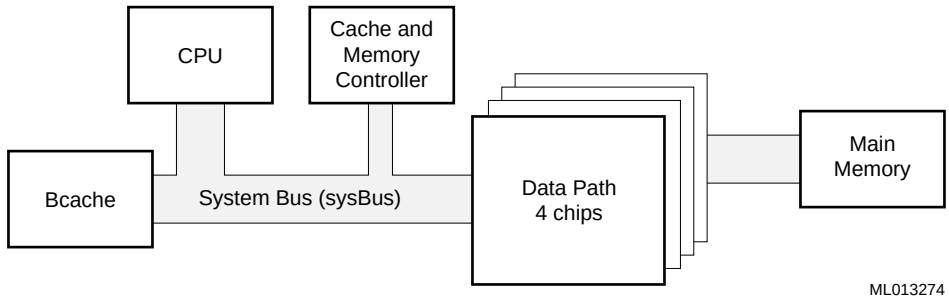
6. Bit <0> is the valid bit for the page table entry.

6

Cache and Memory Subsystem

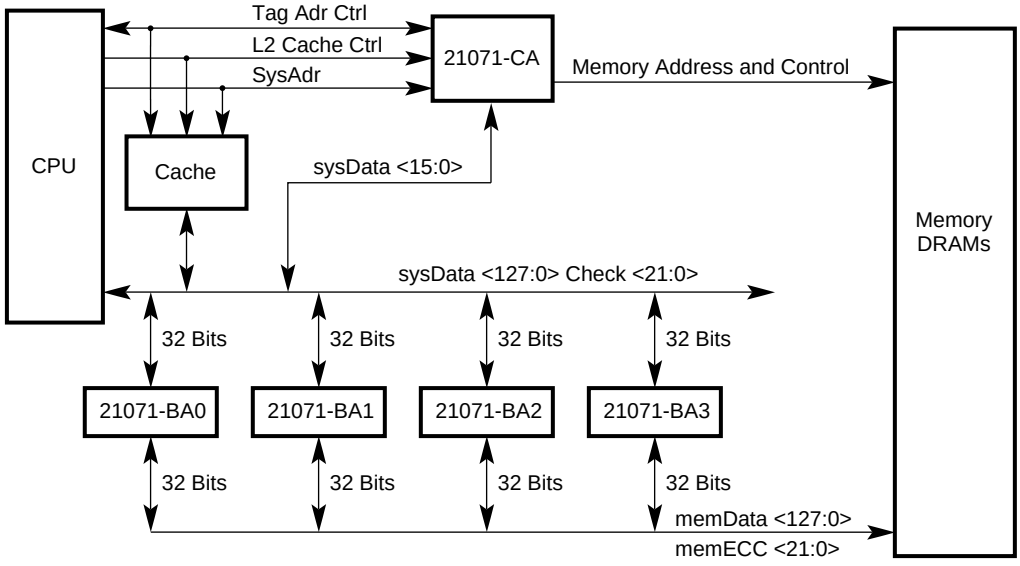
The cache and memory subsystem serves as the memory controller and the system bus (sysBus) controller.

Figure 6–1 Cache and Memory Subsystem



The components of the cache and memory subsystem are distributed between the DECchip 21071-CA and the DECchip 21071-BA. Together, the chips are the interface between the system bus, main memory, and the Bcache (see Figure 6–2).

Figure 6–2 Address and Data Paths of Cache and Memory



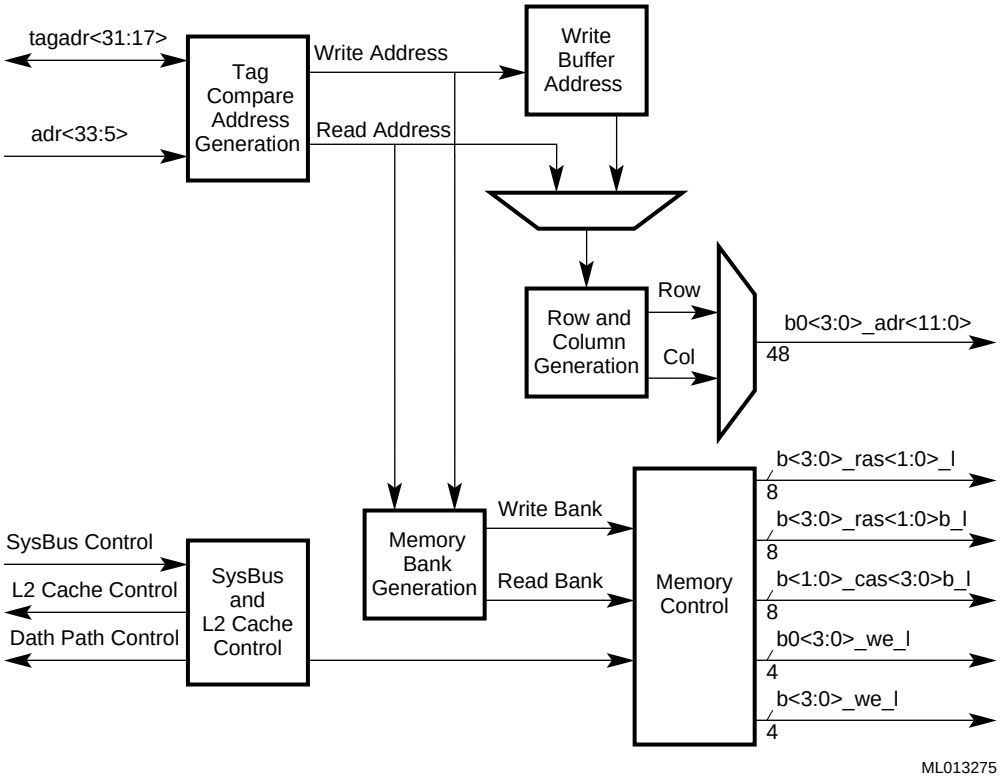
21071-DA Data Path Bit Assignments

sysData Lines	memData Lines
21071-BA0 <31:0>	memData <31:0>
21071-BA1 <63:32>	memData <63:32>
21071-BA2 <95:64>	memData <95:64>
21071-BA3 <127:96>	memData <127:96>

The DECchip 21071-CA provides Bcache and memory control functions and also controls the data paths located in the 21071-BA chips. The DECchip 21071-CA arbitrates between the CPU and the PCI host bridge when they request use of the system bus and Bcache.

Figure 6–3 shows a block diagram of the DECchip 21071-CA.

Figure 6–3 21071-CA Block Diagram



The following list summarizes the functions of the DECchip 21071-CA:

- Arbitrates between the CPU and the 21071-DA for control of the system bus.
- Controls filling the Bcache and extracting victims on CPU-initiated transactions.
- Controls probing the Bcache on direct-memory access (DMA) transactions and invalidating the Bcache on DMA write hits.
- Controls the loading of the I/O write buffer and the DMA read buffer.
- Uses fast-page mode on the DRAMs to improve performance on DMA burst reads and memory write transactions.

6.1 System Bus Interface

The CPU, DECchip 21071-CA, PCI host bridge, cache, and memory communicate with each other through the system bus. The system bus is the processor pin bus with additional signals for DMA transaction control, arbitration, and cache control.

6.1.1 Arbitration on the System Bus

The DECchip 21071-CA arbitrates between the CPU and 21071-DA chip when these components request use of the system bus or the Bcache. The CPU owns the system bus by default so it has access to the Bcache whenever the 21071-DA (PCI Host Bridge) is not requesting the system bus.

6.1.2 System Bus Controller

The system bus controller consists of:

- A sequencer that receives CPU and DMA command fields for decode
- Results from the system bus arbiter logic
- Status from the memory controller logic

The sequencer then supplies machine state signals that are used to:

- Generate requests for Bcache control and read to the memory controller
- Load data from the system bus into the read, merge, and write buffers
- Acknowledge cycles to the CPU and 21071-DA chip

The system bus controller supports wrapping on the system bus.

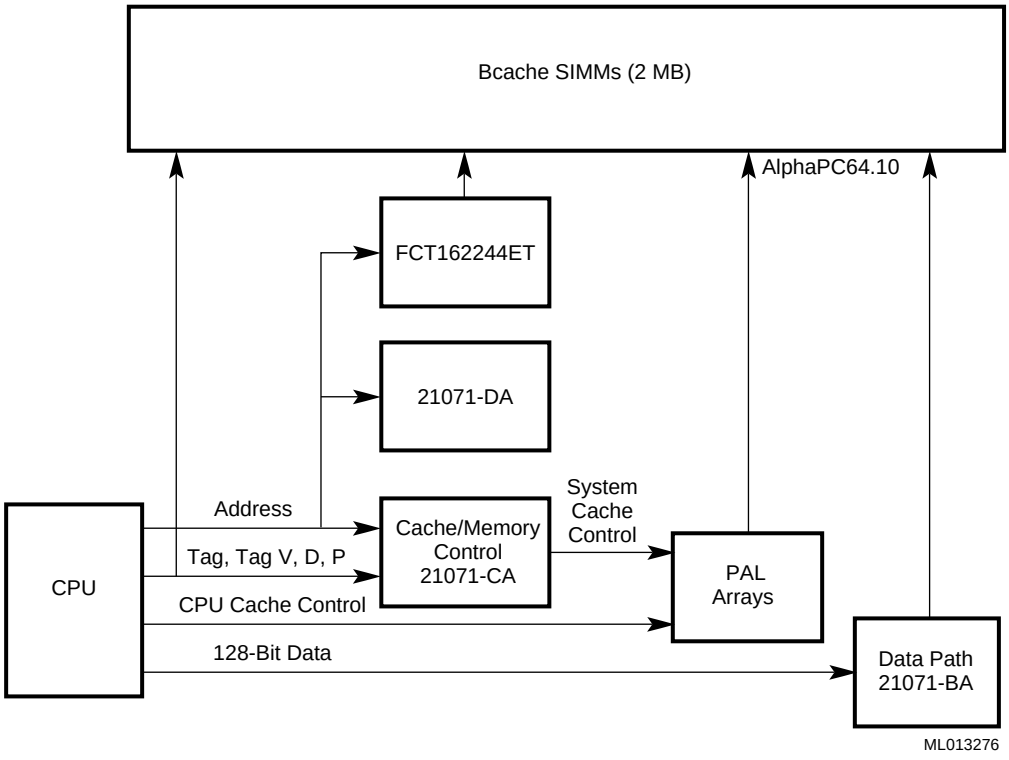
6.1.3 Decoding Addresses

The system bus interface logic decodes the system bus address for both CPU and DMA requests to determine the action to take. It supports cacheable and noncacheable memory accesses as well as accesses to its control/status register (CSR) space.

6.2 Bcache Control

Figure 6–4 shows the implementation of a cache subsystem with a 2 MB cache.

Figure 6–4 Cache Subsystem for a 2 MB Cache



The Bcache controller provides control for the secondary cache on CPU-initiated memory read and write transactions that miss, and on all CPU-initiated memory LD*x*_L and ST*x*_C transactions (hits and misses).

On DMA-initiated transactions, the Bcache controller probes the cache and extracts or invalidates the cache line. The 21071-CA supports a write-back cache.

6.3 Memory Controller

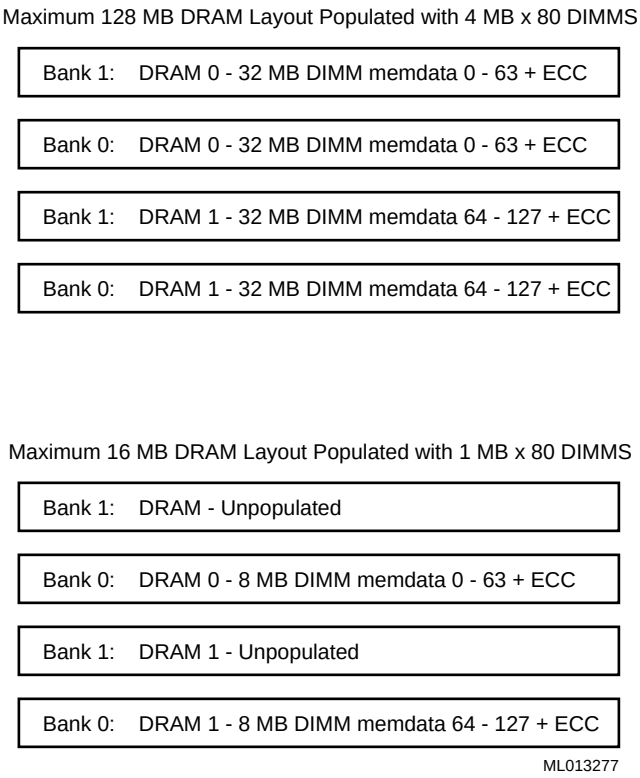
This section summarizes memory organization and memory controller features.

6.3.1 Memory Organization

A bank of memory is one width of DRAMs, 128 bits, implemented with DIMMs. The DECchip 21071-CA supports one or two banks of DRAM where each bank consists of two DIMMs of the same size and speed.

The 21071-CA supports 16 MB to 128 MB of main memory. The chip controls two banks of DRAM DIMMs. Each bank contains two 80-bit DIMMs to support the 128-bit data path and longword error checking/correction (ECC). The DIMM sizes are 1 MB x 80 (8 MB), 2 MB x 80 (16 MB), and 4 MB x 80 (32 MB). This provides for 16, 32, 48, 64, 80, 96 or 128 MB of total system memory. Figure 6–5 shows the maximum and minimum DIMM bank layouts.

Figure 6–5 Maximum and Minimum DIMM Bank Layouts



6.3.2 Memory Address Generation

Each bank has a programmable base address and size. The incoming physical address is compared with the memory ranges of all banks. The number of bits that are compared depends on the size of the bank.

The programmable base address of a bank set must be aligned to the natural size boundary. For example, an 8 MB bank set must start on an 8 MB boundary.

6.3.3 Support for Memory Page Mode

The DECchip 21071-CA supports page mode optimization on the memory banks within a transaction. Between transactions, page mode is supported on DMA read burst transactions and on memory write transactions.

6.3.4 Minimizing Read Latency

To minimize the read latency seen by devices on the system bus, the memory controller optimizes the way it selects transactions. In general, the memory controller gives priority to read transactions over write transactions because write transactions can go into a deep write buffer. In some cases, this priority means the memory controller waits for a read transaction to execute even if there are write transactions queued in the write buffer.

6.3.5 Transaction Scheduler

The memory interface does memory refresh, cache-line read and write transactions. The memory controller has a scheduler that prioritizes all transactions and selects one to be serviced. If the selected transaction is waiting for row address strobe (RAS) precharge, and another higher priority transaction is initiated, the scheduler deselects the current transaction and selects the higher priority transaction.

6.3.6 Programmable Memory Timing

The memory control state machine performs its sequence of steps through all memory transactions. On memory read and write transactions, it communicates with the 21071-BA chips so that data may be latched from the memory data (memData) bus or driven onto the memory data bus, respectively.

The memory control state machine is actually two state machines (master, and read and write). The master state machine performs the RAS and column address strobe (CAS) assertions, and controls when the other state machine starts. The read and write state machine performs the sequencing for generating the memory command to read or write memory data. The read and write state machine is started by the master and runs through its sequence independently.

6.3.7 Presence Detect Logic

The DECchip 21071-CA supports loading the status of 32 presence detect bits from the memory configuration registers 0 to 3 and the memory identification register after reset.

6.4 Error Handling

During CPU and DMA transactions, the DECchip 21071-CA detects the following errors:

- Bcache tag address parity error
- Bcache tag control parity error
- Nonexistent memory error

When an error is detected, the DECchip 21071-CA acknowledges a hard error condition on the **cack<2:0>** or **iocack<1:0>** signal lines at the end of the transaction to signal the error to the CPU or the 21071-DA. The current **sysadr<33:5>** is logged in the error address register, and the error status is logged in the error and diagnostic status register. These CSRs are locked until the CPU clears all the error status bits by writing to the error register.

If errors occur on a transaction while the error address and status are locked, the following occurs:

- The transaction is acknowledged with a hard error condition on the **cack<2:0>** or **iocack<1:0>** fields.
- The **LOSTERR** bit in the error and diagnostics status register is set.
- The lost error address and status are not recorded.

The hard error condition overrides ST*x*_C transaction fail. The lock bit is UNPREDICTABLE after LD*x*_L transactions complete with errors.

6.5 Address Space of Control/Status Registers

CPU address: 0x180000000 - 0x19FFFFFFF

This section describes the control/status registers (CSRs) of the DECchip 21071-CA. The DECchip 21071-CA responds to all CSR accesses in this space.

The CSRs are 16 bits wide and are addressed on cache-line boundaries. Write transactions to read-only registers could result in UNPREDICTABLE behavior; read transactions are nondestructive. Only bits <15:0> of each register are defined. Zeros must be written to unspecified bits within a CSR. CSRs are initialized as shown in the Type column of the register tables.

Table 6–1 identifies all banks; only Bank 0 and 1 are used.

Table 6–1 CSR Register Addresses for DECchip 21071-CA

$Address_{16}$	Register Name
1 8000 0000	General control register
1 8000 0020	Reserved
1 8000 0040	Error and diagnostic status register
1 8000 0060	Tag enable register
1 8000 0080	Error low address register
1 8000 00A0	Error high address register
1 8000 00C0	LD*x*_L low address register
1 8000 00E0	LD*x*_L high address register
1 8000 0200	Global timing register
1 8000 0220	Refresh timing register
1 8000 0240	Video frame pointer register
1 8000 0260	Presence detect low-data register
1 8000 0280	Presence detect high-data register
1 8000 0800	Bank 0 base address register
1 8000 0820	Bank 1 base address register
1 8000 0840	Bank 2 base address register
1 8000 0860	Bank 3 base address register
1 8000 0880	Bank 4 base address register
1 8000 08A0	Bank 5 base address register
1 8000 08C0	Bank 6 base address register
1 8000 08E0	Bank 7 base address register
1 8000 0900	Bank 8 base address register
1 8000 0A00	Bank 0 configuration register
1 8000 0A20	Bank 1 configuration register

(continued on next page)

Table 6–1 (Cont.) CSR Register Addresses for DECchip 21071-CA

Address$_{16}$	Register Name
1 8000 0A40	Bank 2 configuration register
1 8000 0A60	Bank 3 configuration register
1 8000 0A80	Bank 4 configuration register
1 8000 0AA0	Bank 5 configuration register
1 8000 0AC0	Bank 6 configuration register
1 8000 0AE0	Bank 7 configuration register
1 8000 0B00	Bank 8 configuration register
1 8000 0C00	Bank 0 timing register A
1 8000 0C20	Bank 1 timing register A
1 8000 0C40	Bank 2 timing register A
1 8000 0C60	Bank 3 timing register A
1 8000 0C80	Bank 4 timing register A
1 8000 0CA0	Bank 5 timing register A
1 8000 0CC0	Bank 6 timing register A
1 8000 0CE0	Bank 7 timing register A
1 8000 0D00	Bank 8 timing register A
1 8000 0E00	Bank 0 timing register B
1 8000 0E20	Bank 1 timing register B
1 8000 0E40	Bank 2 timing register B
1 8000 0E60	Bank 3 timing register B
1 8000 0E80	Bank 4 timing register B
1 8000 0EA0	Bank 5 timing register B
1 8000 0EC0	Bank 6 timing register B
1 8000 0EE0	Bank 7 timing register B
1 8000 0F00	Bank 8 timing register B

6.6 Description of CSRs

6.6.1 General Control Register

The general control register contains status information that affects the memory, cache, and system bus controllers. The register is shown in Figure 6–6 and is defined in Table 6–2.

Figure 6–6 General Control Register: 0x180000000

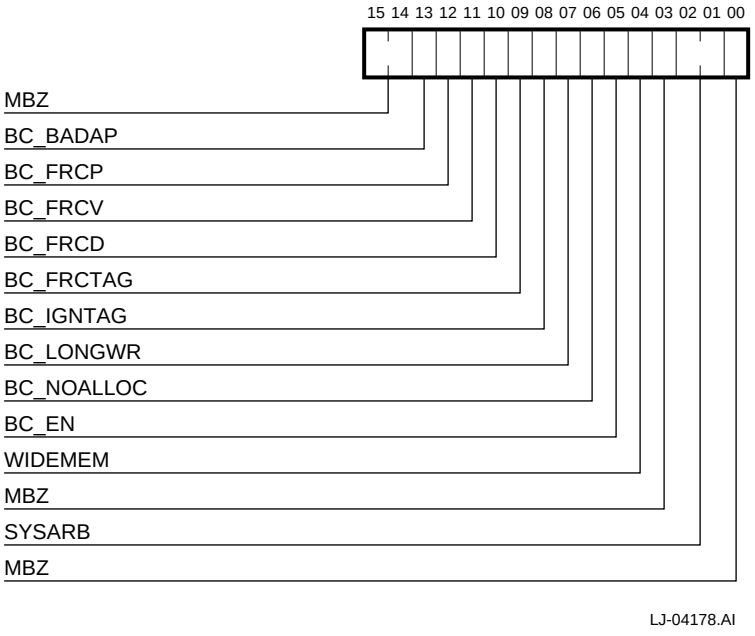


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Table 6–2 General Control Register

Field	Name	Type	Description
<15:14>	Reserved	MBZ	—
<13>	BC_BADAP	RW, 0[1]	Bcache force bad address parity. When set, the tag address parity is loaded as an invalid address, independent of the value of the BC_ FRCTAG bit.
<12>	BC_FRCP	RW, 0	Bcache force parity. Sets the parity bit on the next cache fill.
<11>	BC_FRCV	RW, 0	Bcache force valid. Sets the valid bit on the next cache fill.
<10>	BC_FRCD	RW, 0	Bcache force dirty. Sets the dirty bit on the next cache fill.
<9>	BC_FRCTAG	RW, 0	Bcache force tag. When set, the Bcache is probed for victims, and the line is invalidated using the values in the BC_FRCD, BC_FRCV, and BC_FRCP fields. CSRs are used as the tag controls. Although the line is invalidated (assuming BC_FRCV is reset), the data is loaded into the cache, and is returned to the CPU as cacheable. Used for diagnostic testing of the cache RAM and for flushing the cache, clearing BC_FRCV, and cycling through the address range in the cache.
<8>	BC_IGNTAG	RW, 0	Bcache ignore tag. When set, the probes of the Bcache act as if the valid bit was invalid. All tag results are ignored and any victims are lost. Tag and address parity are ignored. This field can be used to fill the cache with valid data.
<7>	BC_LONGWR	RW, 0	Bcache long write transactions. When set, write transactions to the cache data RAMs require two system bus cycles.
<6>	BC_NOALLOC	RW, 0	Bcache no allocate mode. When set, CPU write transactions to cacheable memory space are not allocated into the cache.

[1]Content of register field after a reset operation.

(continued on next page)

Table 6–2 (Cont.) General Control Register

Field	Name	Type	Description
<5>	BC_EN	RW, 0	Bcache enable. When clear, the L2 cache is disabled and the cache state machine does not probe the cache.
<4>	WIDEMEM	RO	Wide memory size. Reads the status of the widemem input pin. Returns 1 for the 128-bit memory interface.
<3>	Reserved	MBZ	—
<2:1>	SYSARB	RW, 0	DMA arbitration mode. Determines arbitration scheme for system bus transactions.

Value	Meaning
0X	CPU priority
10	DMA priority
11	DMA strong priority

<0>	Reserved	MBZ	—

6.6.2 Error and Diagnostic Status Register

The error and diagnostic register contains read-only status information for diagnostics and error analysis. The register is shown in Figure 6–7 and is defined in Table 6–3.

When an error occurs, it sets one or more error bits (BC_TAPERR, BC_TCPERR, NXMERR) and locks the address of the error. After the address is locked, any additional error sets LOSTERR and does not affect the address or other error bits. Clearing all of the error bits except the LOSTERR bit unlocks the address.

Figure 6–7 Error and Diagnostic Status Register: 0x180000020

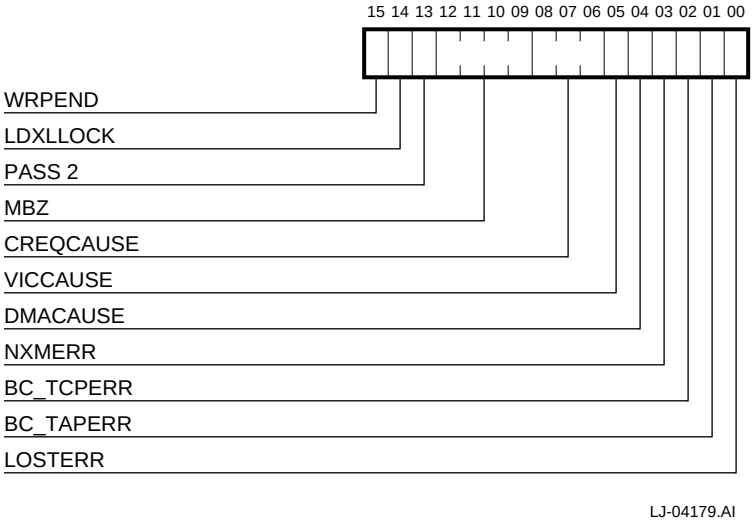


Table 6–3 Error and Diagnostic Status Register

Field	Name	Type	Description
<15>	WRPEND	RO, O	Write pending. When set, indicates that valid write data is stored in the write buffer.
<14>	LDXLLOCK	—	LD*x*_L locked. When set, indicates that the lock bit for LD*x*_L is set and that the next ST*x*_C may succeed. Writing to any CSR or I/O space location clears this lock bit.
<13>	PASS 2	RO	Chip version reads low on pass 1 and high on pass 2.
<12:9>	Reserved	MBZ	—

(continued on next page)

Table 6–3 (Cont.) Error and Diagnostic Status Register

Field	Name	Type	Description
<8:6>	CREQCAUSE	RO	Cycle request caused error. Indicates the DMA or CPU cycle request type that caused the error. Contains a copy of either the cpucreq or iocmd signal lines, depending on **DMACAUSE<4>**. Locked with the error address. Only valid when an error is indicated on BC_TAPERR, BC_TCPERR, or MEMERR.
<5>	VICCAUSE	RO	Victim write caused error. When set, indicates that a victim write transaction caused an NXMERR error. Undefined for other types of errors. Locked with the error address. Valid only when an error is indicated on BC_TAPERR, BC_TCPERR, or MEMERR.
<4>	DMACAUSE	RO	DMA transaction caused error. When set, indicates that a DMA transaction caused a BC_TAPERR, BC_TCPERR, or NXMERR error. Locked with the error address. Valid only when an error is indicated on BC_ TAPERR, BC_TCPERR, or MEMERR.
<3>	NXMERR	RW1C, 0	Nonexistent memory error. When set, indicates that a read or write transaction occurred for an address that does not map to any memory bank, CSR, or I/O quadrant. Set only when address is unlocked.
<2>	BC_TCPERR	RW1C, 0	Bcache tag control parity. When set, indicates that a tag probe encountered bad parity in the tag control RAM. Set only when address is unlocked.
<1>	BC_TAPERR	RW1C, 0	Bcache tag address parity. When set, indicates that a tag probe encountered bad parity in the tag address RAM. Set only when address is unlocked.
<0>	LOSTERR	RW1C, 0	Lost error, multiple errors. When set, indicates that additional errors occurred after an error address was locked. No address or cause information is latched for the error.

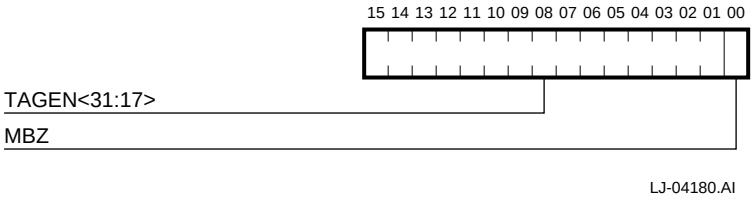
6.6.3 Tag Enable Register

The tag enable register (TAGEN), shown in Figure 6–8, indicates which bits of the cache tag are compared to **sysadr<33:5>**:

- If a bit is 1, the bits in **sysadr<33:5>** and **systag<31:17>** are compared. Bits **<15:1>** in the register represent **systag<31:17>**.
- If a bit is 0, no comparison is made, and the systag bit is assumed to be tied low on the module through a resistor.

This register is not initialized.

Figure 6–8 Tag Enable Register: 0x180000060



The upper bits of **TAGEN<31:17>** are not required to be set. Therefore, an implementation that does not allow the full 4 GB cacheable memory to be installed has the option to mask the upper bits of **TAGEN<31:17>** and so is not required to store a bit of the tag address in the tag address RAM.

To construct **TAGEN<31:17>**, refer to Tables 6–4 and 6–5. The value shown in Table 6–4 (based on the cache size) is ANDed with the value in Table 6–5 (based on the maximum cacheable system memory). For example, a system with a 16 MB cache, and a maximum of 1 GB cacheable memory would program:

1111 1111 0000 000X
ANDed with
0011 1111 1111 111X
gives
0011 1111 0000 000X
which is put into TAGEN.

Table 6–4 Cache Size Tag Enable Values

TAGEN<15:0>	Compared Bits	Cache Size
0000 0000 0000 0000[1]	None	4 GB
1000 0000 0000 0000	<31>	2 GB
1100 0000 0000 0000	<31:30>	1 GB
1110 0000 0000 0000	<31:29>	512 MB
1111 0000 0000 0000	<31:28>	256 MB
1111 1000 0000 0000	<31:27>	128 MB
1111 1100 0000 0000	<31:26>	64 MB
1111 1110 0000 0000	<31:25>	32 MB
1111 1111 0000 0000	<31:24>	16 MB
1111 1111 1000 0000	<31:23>	8 MB
1111 1111 1100 0000	<31:22>	4 MB
1111 1111 1110 0000	<31:21>	2 MB
1111 1111 1111 0000	<31:20>	1 MB
1111 1111 1111 1000	<31:19>	512 KB
1111 1111 1111 1100	<31:18>	256 KB
1111 1111 1111 1110	<31:17>	128 KB

[1] **TAGEN<0>** is reserved and must be zero.

Table 6–5 Maximum Memory Tag Enable Values

TAGEN<15:0>	Compared Bits	Memory Size
1111 1111 1111 1110[1]	<31:17>	4 GB
0111 1111 1111 1110	<30:17>	2 GB
0011 1111 1111 1110	<29:17>	1 GB
0001 1111 1111 1110	<28:17>	512 MB
0000 1111 1111 1110	<27:17>	256 MB
0000 0111 1111 1110	<26:17>	128 MB
0000 0011 1111 1110	<25:17>	64 MB
0000 0001 1111 1110	<24:17>	32 MB
0000 0000 1111 1110	<23:17>	16 MB
0000 0000 0111 1110	<22:17>	8 MB
0000 0000 0011 1110	<21:17>	4 MB
0000 0000 0000 1110	<19:17>	1 MB
0000 0000 0000 0110	<18:17>	512 KB
0000 0000 0000 0010	<17>	256 KB
0000 0000 0000 0000	None	128 KB

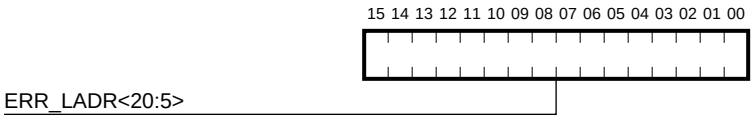
[1] **TAGEN<0>** is reserved and must be zero.

6.6.4 Error Low Address Register

When an error sets the BC_TAPERR, BC_TCPERR, or NXMERR bit in the error and diagnostic status register, the error low address register latches the low-order bits of the **sysadr<20:5>** address that caused the error. If a victim read caused the error, the victim address is not latched. Instead, the address of the transaction is latched.

The register is shown in Figure 6–9. Bits <15:0> represent **sysadr<20:5>**. This register is read-only. It is not initialized and is valid only when an error is indicated.

Figure 6–9 Error Low Address Register: 0x180000080

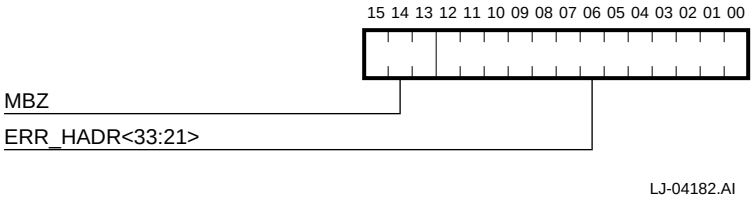


6.6.5 Error High Address Register

When an error sets the BC_TAPERR, BC_TCPERR, or NXMERR bit in the error and diagnostic status register, the error high address register latches the high-order bits of the **sysadr<33:21>** address that caused the error. If a victim read caused the error, the victim address is not latched. Instead, the address of the transaction is latched.

The register is shown in Figure 6–10. Bits <12:0> represent **sysadr<33:21>**. Bits <15:13> are reserved and must be zero. This register is read-only. It is not initialized and is only valid when an error is indicated.

Figure 6–10 Error High Address Register: 0x1800000A0

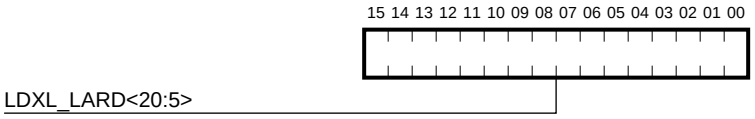


6.6.6 LD*x*_L Low Address Register

The LD*x*_L low address register stores the low-order bits of the last latched address.

The register is shown in Figure 6–11. Bits <15:0> represent **sysadr<20:5>**. This register is read-only and is not initialized.

Figure 6–11 LD*x*_L Low Address Register: 0x1800000C0

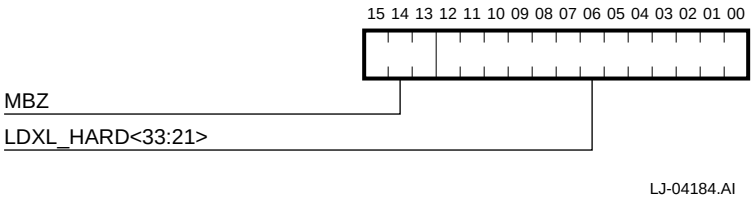


6.6.7 LD*x*_L High Address Register

The LD*x*_L high address register stores the high-order bits of the latched address.

The register is shown in Figure 6–12. Bits <12:0> represent **sysadr<33:21>**. This register is read-only and is not initialized.

Figure 6–12 LD*x*_L High Address Register: 0x1800000E0



6.6.8 Memory Control Registers

The registers described in this section control memory configuration and timing. Each bank of memory has one configuration register, one base register, and two timing registers. The global timing register and refresh timing register apply to all banks.

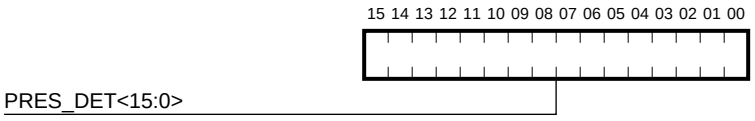
6.6.8.1 Presence Detect Low-Data Register

After a reset operation, presence detect data is shifted from the memory configuration and memory ID. The presence detect low-data register stores the low-order bits of the presence detect data. The register is shown in Figure 6–13.

Note

After reset, the data becomes valid after 148 system clock cycles.

Figure 6–13 Presence Detect Low-Data Register: 0x180000280



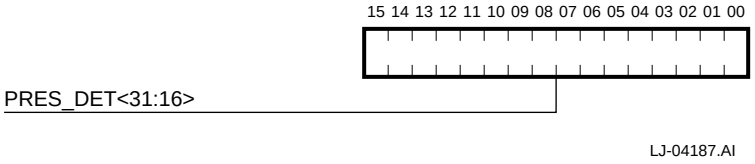
6.6.8.2 Presence Detect High-Data Register

After a reset operation, presence detect data are shifted from the memory configuration and memory ID. The presence detect high-data register stores the high-order bits of the presence detect data. Bits <15:0> in the register represent the shifted data bits <31:16>. The register is shown in Figure 6–14.

Note

After reset, the data becomes valid after 148 system clock cycles.

Figure 6–14 Presence Detect High-Data Register: 0x180000260

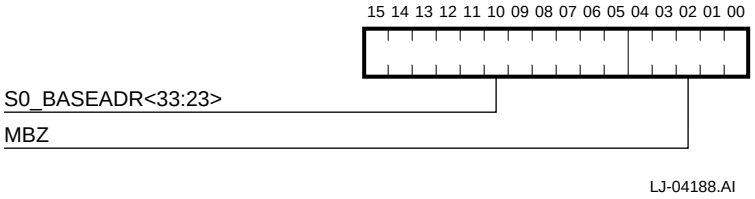


6.6.8.3 Base Address Registers

Each memory bank set has a base address register, as shown in Figure 6–15. The bits in the base address register are compared with the incoming address **sysadr<33:23>** to determine which bank is being addressed. The contents of this register are validated by setting the valid bit in the configuration register of that bank.

Each bank, which has a minimum size of 2 MB and an 11-bit field, compares bits <15:5> in the register to **sysadr<33:23>**.

Figure 6–15 Bank 0 Base Address Register: 0x180000800



The base address of each bank must begin on a naturally aligned boundary. For example, for a bank with 2^n addresses, the *n* least significant bits must be zero.

Register bits <4:0> are reserved and must be zero.

6.6.8.4 Configuration Registers

Each memory bank set has a configuration register that contains mode bits, memory address generation bits, and bank decoding bits. The configuration registers for banks 0 and 1 have the same format and the same limits for size and type of DRAMs used. The registers are shown in Figure 6–16 and are defined in Table 6–6.

Figure 6–16 Configuration Registers for Bank Set 0: 0x180000A00

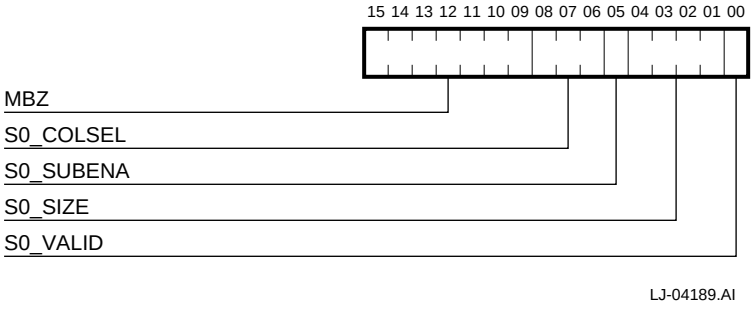


Table 6–6 Configuration Register for Banks 0 and 1

Field	Name[1]	Type	Description
<15:9>	Reserved	MBZ	—
<8:6>	S0_COLSEL	RW	Column address selection. Indicates the number of valid column bits expected at the DRAMs. Used with memory width information to generate row or column addresses. Memory interface width is set at 128 bits. The field codes for **S0_COLSEL<2:0>** are:

S0_COLSEL<2:0>	Row, Column Bits
000	12, 12
001	12, 10 or 11, 11
010	Reserved
011	10, 10
1XX	Reserved

<5>	S0_SUBENA	RW, 0	Enables subbanks, defined by S0_SIZE. When clear, subbanks are disabled and the <3:0>_rasb0_l pins are asserted only during refreshes.

[1] Field names are for Bank 0.

(continued on next page)

Table 6–6 (Cont.) Configuration Register for Banks 0 and 1

Field	Name[1]	Type	Description
<4:1>	S0_SIZE	RW	Bank size in Mbytes. Indicates the size of the bank and any subbanks. The size defines which bits are used in comparing the base address with the physical address (PA) and for generating the subset. **S0_SIZE<3>** must be set to 0. The field codes for **S0_SIZE<3:0>** are:
<0>	S0_VALID	RW, 0	Bank valid. When set, all timing and configuration parameters for the bank are valid, and access to the bank is allowed.

S0_SIZE <3:0>	Compared	Subset	Set Size
0000	—	—	Reserved
0001	**PA<33:29>**	**PA<28>**	512 MB
0010	**PA<33:28>**	**PA<27>**	256 MB
0011	**PA<33:27>**	**PA<26>**	128 MB
0100	**PA<33:26>**	**PA<25>**	64 MB
0101	**PA<33:25>**	**PA<24>**	32 MB
0110	**PA<33:24>**	**PA<23>**	16 MB
0111	**PA<33:23>**	**PA<22>**	8 MB
1XXX	—	—	Reserved

[1] Field names are for Bank 0.

6.6.8.5 Bank Set Timing Registers

Each bank has two timing registers, A and B. These registers contain the parameters for performing memory read and write transactions. The format of the timing registers is identical for all banks.

A reset operation sets all parameters to their maximum values. However, this can cause incorrect operation. Therefore, the software must program the timing registers before the bank's valid bit is set in the configuration register.

All the timing parameters are in multiples of memory clock (memclk) cycles. Most of the timing parameters have a minimum value that is added to the programmed value. In a program, subtract this minimum value from the desired value and then write the value into the register.

The description of the parameters also indicates the corresponding DRAM parameter. Bank 0's timing register A is shown in Figure 6–17 and is defined in Table 6–7.

Figure 6–17 Bank Set 0 Timing Register A: 0x180000C00

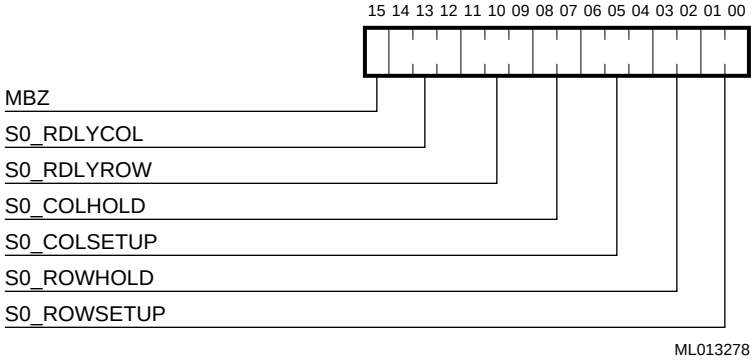


Table 6–7 Timing Register A

Field	Name	Type	Description
<15>	Reserved	MBZ	—
<14:12>	S0_RDLYCOL	RW, 1	Read delay from column address. Used only when starting in page mode. Delay from column address to latching first valid read data. *Programmed value* = *desired value* − 2.
<11:9>	S0_RDLYROW	RW, 1	Read delay from row address. Delay from row address to latching first valid read data. *Programmed value* = *desired value* − 4.
<8:7>	S0_COLHOLD	RW, 1	Column hold (t_{CAH}) from **b0_cas<1:0>_l** assertion. Used to determine when the current column address can be changed to the next column or row address. *Programmed value* = *desired value* − 1.

(continued on next page)

Table 6–7 (Cont.) Timing Register A

Field	Name	Type	Description
<6:4>	S0_COLSETUP	RW, 0	Column address setup (t_{ASC}) to first CAS assertion and write enable setup (t_{CWL}) to CAS assertion. Used to determine first **b0_cas<1:0>_l** assertion after column address and **b<1:0>_cas<1:0>_l** assertion after **b0_l<3:0>_we_l**. The maximum of the two setup values must be programmed. A programmed value of 7 is illegal. *Programmed value = desired value* − 1.
<3:2>	S0_ROWHOLD	—	Row address hold. Used to switch memadr from row to column after **b<1:0>_ras_l** assertion. *Programmed value = desired value* − 1.
<1:0>	S0_ROWSETUP	RW, 1	Row address setup. Used to generate **b<1:0>_ras0_l** assertion from row address. *Programmed value = desired value* − 1.

Timing register B is shown in Figure 6–18 and is defined in Table 6–8.

Figure 6–18 Bank Set 0 Timing Register B: 0x180000E00

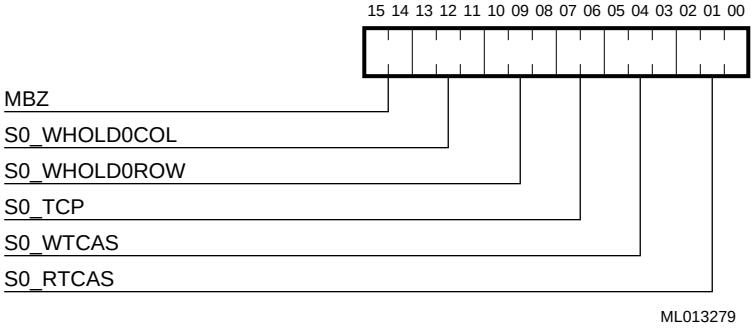


Table 6–8 Timing Register B

Field	Name	Type	Description
<15:14>	Reserved	MBZ	—
<13:11>	S0_WHOLD0COL	RW, 1	Write hold time from column address. Used only for the first data when starting in page mode. Write data is valid with the column address and is held valid for S8_WHOLD0COL + 2 cycles after the column address. *Programmed value = desired value − 2.*
<10:8>	S0_WHOLD0ROW	RW, 1	Write hold time from row address. Hold time of first write data from first row address. Used when not starting in page mode. The first write data is valid with the row address and is held valid for S8_WHOLD0ROW + 2 cycles after the row address. A programmed value of zero is illegal. *Programmed value = desired value − 2.*
<7:6>	S0_TCP	RW, 1	CAS precharge (t_{CP}). Delay from **b0_cas<1:0>_l** deassertion to the next assertion of **b0_cas<1:0>_l** in page mode. *Programmed value = desired value − 1.*
<5:3>	S0_WTCAS	RW, 1	Write CAS width (t_{CAS}). Used on write transactions to generate the **b0_cas<1:0>_l** deassertion from the assertion of **b0_cas<1:0>_l**. The sum of S8_WTCAS and S0_TCP must not be greater than 5. *Programmed value = desired value − 2.*
<2:0>	S0_RTCAS	RW, 1	Read CAS width (t_{CAS}). Used on read transactions to generate the **b0_cas<1:0>_l** deassertion from the assertion of **b0_cas<1:0>_l**. The sum of S8_RTCAS and S0_TCP must not be greater than 5. *Programmed value = desired value − 2.*

6.6.8.6 Global Timing Register

The global timing register contains parameters that are common to all bank sets. Each parameter counts memory clock cycles. All pins on the memory interface refer to memclk rising. The global timing register is shown in Figure 6–19 and is defined in Table 6–9.

Figure 6–19 Global Timing Register: 0x180000200

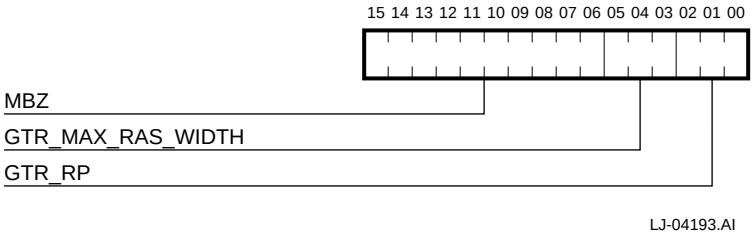


Table 6–9 Global Timing Register

Field	Name	Type	Description
<15:6>	Reserved	MBZ	—
<5:3>	GTR_MAX_RAS_WIDTH	—	Maximum RAS assertion width as a multiple of 128 memory clock cycles. When this count is reached, the signal **b<3:0>_ras0_l** is deasserted at the end of the ongoing transaction. This value must be programmed to allow the timer to overflow during a transaction. Corresponds to DRAM parameter t_{RAS}. When programmed to 0, page mode between transactions is disabled.
<2:0>	GTR_RP	—	Minimum number of RAS precharge cycles. Cycles extend from **b<3:0>_cas0_l** deassertion to next assertion of the same **b<3:0>_cas0_l** pin. Corresponds to DRAM parameter t_{RP}. $Programmed\ value = desired\ value - 2$.

6.6.8.7 Refresh Timing Register

The refresh timing register contains information used to refresh all bank sets simultaneously using CAS-before-RAS refresh. Therefore, these parameters must be programmed to the most conservative values for all bank sets.

All the timing parameters are in multiples of memclk cycles. The parameters have a minimum value that is added to the programmed value. In the program, subtract this minimum value from the desired value before writing the value to the register.

The refresh timing register is shown in Figure 6–20 and is defined in Table 6–10.

Figure 6–20 Refresh Timing Register: 0x180000220

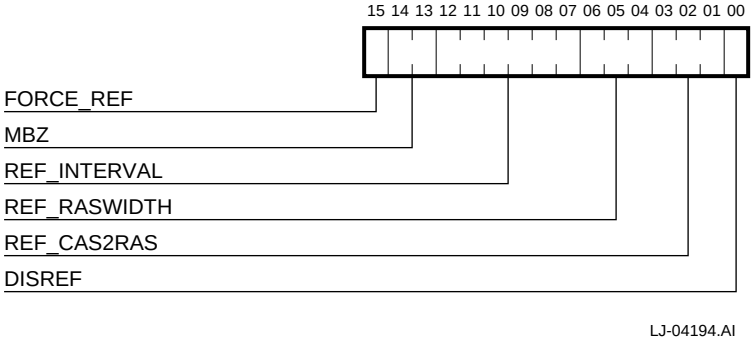


Table 6–10 Refresh Timing Register

Field	Name	Type	Description
<15>	FORCE_REF	RW, 1	Force refresh. Reads as 0. Writing a 1 to this bit causes a single memory refresh. Resets the internal refresh interval counter.
<14:13>	Reserved	MBZ	—
<12:7>	REF_INTERVAL	RW, 000001	Indicates the extent of the refresh interval. Multiplied by 64 to get the number of memclk cycles between refresh requests. A programmed value of zero is illegal.
<6:4>	REF_RASWIDTH	RW, 1	Refresh RAS width. Refresh RAS assertion width from **b<3:0>_ras0_l** assertion to **b<3:0>_ras0_l** deassertion. **b<3:0>_cas0_l** is deasserted with **b<3:0>_ras0_l** for refresh. Corresponds to DRAM parameter t_{RAS}. $Programmed\ value = desired\ value - 3$.
<3:1>	REF_CAS2RAS	RW, 1	Refresh CAS assertion to RAS assertion cycles. Corresponds to DRAM parameter t_{CSR}. $Programmed\ value = desired\ value - 2$.

(continued on next page)

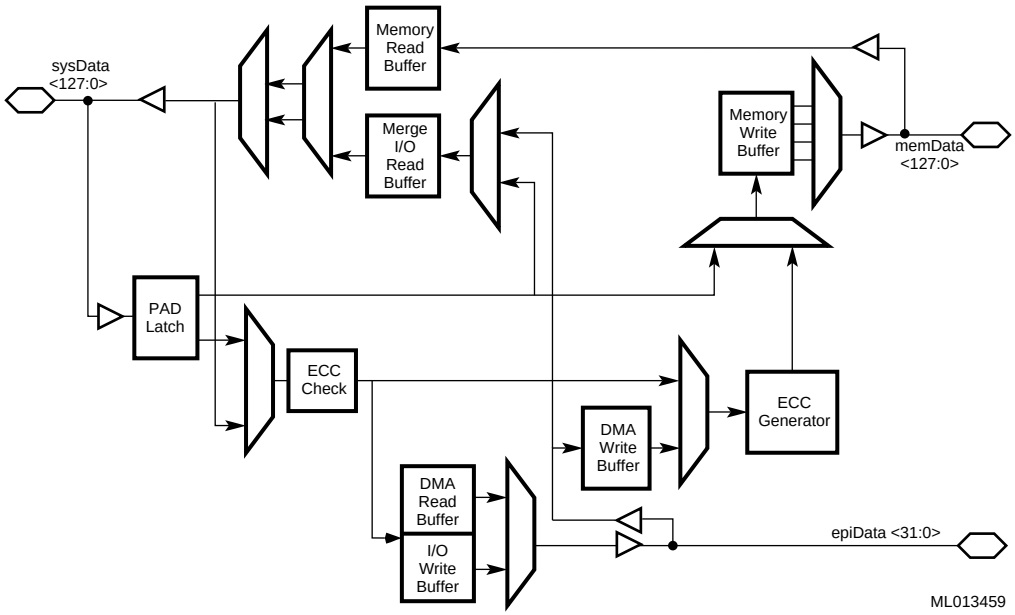
Table 6–10 (Cont.) Refresh Timing Register

Field	Name	Type	Description
<0>	DISREF	RW, 0	Disable refresh. Refresh operations are not performed when DISREF is set. The other timings in this register must not change while this bit is set. FORCE_REF overrides DISREF.

6.7 Data Path

The data path consists of the buffers and their communications buses. This section gives a functional overview of the 21071-BA chips that make up the data bus configuration. Figure 6–21 shows a block diagram of the 21071-BA chip.

Figure 6–21 Block Diagram of the DECchip 21071-BA



6.7.1 Memory Read Buffer

The memory read buffer stores data from memory before the data is sent to the CPU or returned to DMA in the DMA read buffer. Each chip stores 4 longwords of data and the corresponding ECC bits in the memory read buffer.

6.7.2 I/O Read Buffer and Merge Buffer

On CPU-initiated memory transactions, the buffer acts as the merge buffer. On CPU-initiated I/O read transactions addressed to or through the PCI host bridge (the 21071-DA chip), the buffer acts as the I/O read buffer. The memory and cache controller (21071-CA) and the PCI host bridge (21071-DA) control the loading of data into the buffer.

Each chip stores four longwords of data and the corresponding ECC bits. The ECC bits are only meaningful for merge data; the ECC bits are unpredictable for I/O read data.

6.7.3 I/O Write and DMA Read Buffer

This buffer stores up to four entries of data for each chip: two entries for I/O write data and two entries are for read data. Each entry has four longwords but only two longwords are used; the extra storage is not accessible.

The memory and cache controller (21071-CA) handles the loading of the buffer using the address provided on **iolinesel<1:0>** by the PCI host bridge (21071-DA). Each entry can be loaded separately, allowing maximum flexibility in allocating the entries.

The PCI host bridge controls unloading of the buffer. Data from this buffer is sent out on the epiData bus.

6.7.4 DMA Write Buffer

In addition to storing DMA write data, the DMA write buffer stores PCI byte masks. The buffer has four entries for each chip. Each entry has four longwords and their byte mask but only two longwords are used; the extra storage is not accessible. The byte masks are used to merge the valid bytes of data from the buffer with the background data from the cache line, which may be obtained from Bcache or memory.

On DMA write transactions, the PCI host bridge loads the buffer and the memory and cache controller unloads it to the system bus.

6.7.5 Memory Write Buffer

The memory write buffer has four entries for each chip. Each entry has four longwords and corresponding ECC bits. The system bus interface loads the buffer and the memory controller unloads it (both are 21071-CA functions).

6.7.6 Error Handling

The data path chips perform ECC on DMA transactions. The data is checked for ECC errors during a DMA read transaction or a DMA-masked write transaction.

If the data contains a correctable error, the data path chips send corrected data to its destination: DMA read buffer for DMA read transactions, memory write buffer for DMA write transactions.

If the data contains an uncorrectable error (dual-bit ECC error), the data path chips notify the PCI host bridge (21071-DA) and writes the bad ECC error in the memory write buffer.

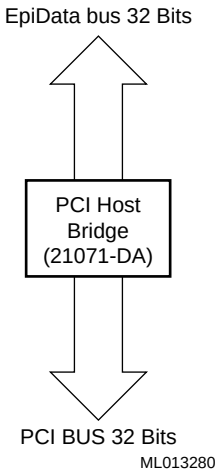
In case of a DMA-masked write transaction, ECC is generated for the merged data going into the memory write buffer.

7

PCI Host Bridge

The 21071-DA chip is the bridge between the PCI local bus and the system bus, as shown in Figure 7–1.

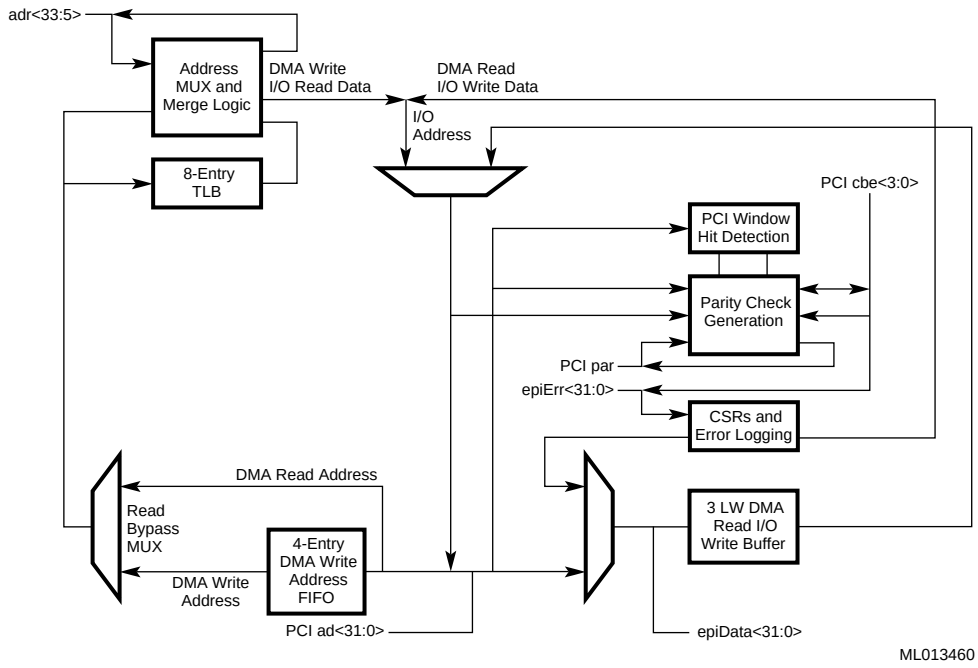
Figure 7–1 PCI Host Bridge



As a PCI host bridge, the 21071-DA chip contains all control functions of the bridge and some data path functions.

Figure 7–2 shows a block diagram of the 21071-DA chip.

Figure 7–2 DECchip 21071-DA Block Diagram



The PCI host bridge serves as the interface between the PCI local bus and the 21064A microprocessor's Bcache and main memory. It acts as a master during the CPU-initiated transactions that use the PCI bus and is a target of transactions initiated by other devices.

The PCI host bridge controls the buffers for various transactions. The address and control mechanism is in the PCI host bridge; the data is stored in the 21071-BA chips.

7.1 Interface to the System Bus

7.1.1 Decoding Physical Addresses

The PCI host bridge provides address decode logic to translate from the CPU's 34-bit physical address space to the 32-bit PCI address space. Chapter 5 shows the address mapping and translation scheme that the address decode logic uses to generate a PCI address. All systems using the 21071-DA are required to follow this address mapping scheme.

7.1.2 Buffering System Bus Transactions

Write-and-run I/O write transactions use a 1-entry write buffer. One I/O read transaction is initiated by the CPU. The I/O read buffer is a temporary buffer and is invalidated at the end of each I/O read transaction.

To function correctly, the CPU must be configured in wrap mode. The PCI host bridge supports wrapped mode only on transactions initiated by the CPU. The requested quadword is the only one that is returned on I/O read transactions.

7.1.3 Burst Length and Prefetching for the System Bus

On write transactions directed toward main memory, the PCI host bridge supports a maximum burst length of 16 longwords. For the maximum burst, the write transaction must start on an even cache-line boundary with PCI **ad<5>** = 0 and PCI **ad<4:2>** = 0. The transaction is terminated using a PCI disconnect after the sixteenth longword has been received. In all other cases, the burst is less than 16 longwords.

On CPU-initiated write transactions, a maximum burst length of two is supported in sparse memory and I/O spaces, and a maximum burst length of eight is supported in dense memory space.

On CPU-initiated read transactions, a maximum burst length of two is supported.

7.2 Interface to the PCI bus

7.2.1 Decoding PCI Addresses

When an entry in the DMA write buffer is unloaded, the PCI host bridge translates the 32-bit PCI address into a 34-bit physical address, using either direct or scatter-gather mapping. The PCI host bridge provides two windows that are mapped to regions within the PCI address space. In a program, each address region can be mapped by either method, independently of each other.

7.2.2 Buffering PCI Transactions

The DMA write buffer consists of four entries. Each entry contains the cache-line address, eight longwords of data, the byte enables for each longword, and a valid bit for the entry.

The DMA read buffer stores up to 16 longwords of data organized as two cache lines. A valid bit is implemented with each longword. When data is loaded into the DMA read buffer, the data's valid bit is set. The PCI host bridge then unloads the data.

7.2.3 Burst Length and Prefetching for PCI bus

On write transactions directed toward main memory, the PCI host bridge supports a maximum burst length of 16 longwords. For the maximum burst, the write transaction must start on an even cache-line boundary with PCI **ad<5>** = 0 and PCI **ad<4:2>** = 0. The transaction is terminated using a PCI disconnect after the sixteenth longword has been received. In all other cases, the burst is less than 16 longwords.

On DMA read transactions, the PCI host bridge supports a maximum burst length of 16 longwords if DMA prefetching is enabled in the 21071-DA and the requesting device uses a PCI read multiple command. If DMA prefetching is not enabled and the requesting device does not use a PCI read multiple command, the maximum burst length is eight longwords.

7.3 Features

7.3.1 Burst Order

In memory transactions, the master specifies the burst order. The PCI host bridge stores the burst order in PCI address bits **ad<1:0>**. When the PCI host bridge is a master of the PCI local bus, it always specifies a linear-incrementing burst order **ad<1:0>** = 0.

On DMA transactions, the PCI host bridge supports burst transfers only if a linear-incrementing burst order is specified. If the master specifies a different burst order, that is, **ad<1:0>** is nonzero, the PCI host bridge disconnects the transaction after one data transfer.

7.3.2 Parity Support

According to the *Local PCI Bus Specification*, all PCI devices generate parity across PCI data and address lines (**ad<31:0>**) and across command and byte enables (**cbe#<3:0>**). The PCI host bridge complies with this specification and, when it is master of the PCI bus, it also checks:

- The incoming parity on I/O read transactions
- Interrupt vector read transactions
- Configuration read transactions during data phases

On memory write transactions, when the PCI host bridge is a target, it checks parity during the address phase and data phases.

7.3.3 Data Coherency

The two agents that must synchronize their data transfers are the CPU and any PCI device. The PCI host bridge maintains data coherency and synchronization between the agents using the following mechanisms:

- Maintains strict ordering of DMA write transactions initiated on the PCI bus.
- Allows DMA read transactions to bypass write transactions that are not to the same address (double cache line) but maintains strict ordering between read and write transactions to the same address.
- Performs I/O transfers from the CPU to the PCI host bridge in order. This policy guarantees a coherent view of PCI I/O space from the CPU.
- Flushes DMA write data to memory before acknowledging a memory barrier command from the CPU. The memory barrier command is used to order CPU and DMA accesses because explicit ordering commands are absent on the PCI bus.
- Flushes the I/O write buffer to the PCI bus before acknowledging a memory barrier command. This policy maintains the order between CPU I/O accesses and CPU memory accesses.
- Clears the system lock flag on read and write transactions to system memory that are exclusive to the PCI bus.

Some data transfers require both the system bus and the PCI bus to complete. For example, CPU I/O transfers require ownership of the system bus followed by ownership of the PCI bus. In the same way, PCI bus masters' DMA transactions with the memory subsystem require ownership of the PCI followed by ownership of the system bus.

During read transfers (I/O or DMA), both buses must be held at the same time for the transfer to complete. During write transfers (I/O or DMA), only one bus must be held because the PCI host bridge features write-and-run style buffering. However, when a write buffer is full, both buses must be held at the same time so that some data from the write buffer can be flushed before new data is accepted.

The PCI host bridge resolves the deadlock by forcing the CPU to give up ownership of the system bus, using a preemption request. Once the system bus is released, the PCI host bridge gives priority to a PCI device for use of the system bus.

The PCI host bridge provides the system designer flexibility in the choice of PCI devices, that is, it supports devices that use the PCI disconnect in handling deadlock situations.

7.3.4 Interrupts

When the PCI host bridge has errors to report, it uses the **int_hw0** signal to interrupt the CPU. It does not distinguish between hard and soft errors when asserting the interrupt signal.

The PCI host bridge does not provide an interval timer interrupt so this functionality must be provided to the CPU by some other device in the system. In addition, interrupts from other PCI devices or from a PCI interrupt controller must be sent directly to the CPU without intervention.

The PCI host bridge participates in the interrupt acknowledge process. When the CPU sends read block commands to the interrupt acknowledge address space, the PCI host bridge performs an interrupt acknowledge transaction on the PCI bus. The interrupt vector from the PCI bus is returned to the CPU through the system bus by the PCI host bridge.

7.3.5 Exclusive Access

The PCI host bridge uses the **lock_l** signal to conform to the PCI Exclusive Access protocol. When the PCI bus detects a latched transaction to main memory, the PCI host bridge locks out all main memory accesses.

The PCI host bridge disconnects the transaction without completing any data transfers. Until the lock is cleared, only the PCI bus master that sent the latched transaction is allowed to complete transactions to main memory (see the *PCI Local Bus Specification*).

In the system bus interface, the lock causes the system lock flag to be cleared by using the **ioclrlock** command encoded on the **iocmd<2:0>**. The system lock flag stays cleared until all latched transactions have been completed and the lock is cleared.

7.3.6 Bus Parking

When no devices are requesting bus mastership, that is, the PCI host bridge is not the target of any transaction, Digital recommends that the PCI host bridge asserts its **iogrant** signal to gain ownership of the PCI local bus. This reduces the latency for CPU-initiated transfers to the PCI bus when the bus is idle. When the PCI host bridge owns the PCI bus, it drives **ad<31:0>**, **cbe_l<3:0>**, and par signals. The *PCI Local Bus Specification* refers to this practice of giving ownership of the PCI bus as bus parking.

The PCI host bridge also supports PCI bus parking during reset. If the **iogrant** signal is asserted by the system arbiter (req_l is always tristated by the 21071-DA chip during reset), the PCI host bridge drives **ad<31:0>**, **cbe<3:0>**, and (one clock cycle later) par. When the **iogrant** signal is deasserted, the 21071-DA chip tristates these signals.

7.3.7 Retry Timeout

The PCI host bridge implements a timeout mechanism to terminate CPU-initiated transactions that do not complete on the PCI bus because of too many disconnects or retries. When it initiates a CPU transaction on the PCI bus, the PCI host bridge counts the number of times it is retried or disconnected. If the number exceeds 2^{24}, it flags an error to the CPU and aborts the transaction.

7.3.8 PCI Master Timeout

The *PCI Local Bus Specification* specifies a mechanism to limit the duration of a PCI bus master's burst sequence. The mechanism requires a PCI master to implement a latency timer that counts the number of cycles since the assertion of a frame#. If the master latency timer has expired, the master is required to surrender the bus. The PCI host bridge implements a programmable master latency timer.

This mechanism is intended to prevent masters from holding bus ownership for extended periods of time, and selects low latency instead of high throughput.

7.3.9 Address Stepping in Configuration Cycles

To provide flexibility and reduce design complexity when using the address-stepping feature, the PCI host bridge performs address stepping on configuration read and write transactions. For these transactions, the PCI host bridge drives the PCI bus for two clock cycles during the address phase for the idsel# pins of all PCI devices to reach a valid logic level. The PCI host bridge does not perform address or data stepping in any other case.

7.4 Address Space of Control/Status Registers

CPU address: 0x1A0000000 through 0x1AFFFFFFF

This section describes the control/status registers (CSRs) of the DECchip 21071-DA. The DECchip 21071-DA responds to all accesses in this space. Table 7–1 specifies the registers and associated register addresses.

Table 7–1 DECchip 21071-DA CSR Addresses

$Address_{16}$	Register Name
1 A000 0000	21071-DA control/status register (DCSR)
1 A000 0020	PCI bus error address register (PEAR)

(continued on next page)

Table 7–1 (Cont.) DECchip 21071-DA CSR Addresses

Address$_{16}$	Register Name
1 A000 0040	System bus error address register (SEAR)
1 A000 0060	Dummy register 1
1 A000 0080	Dummy register 2
1 A000 00A0	Dummy register 3
1 A000 00C0	Translated base 1 register
1 A000 00E0	Translated base 2 register
1 A000 0100	PCI base 1 register
1 A000 0120	PCI base 2 register
1 A000 0140	PCI mask 1 register
1 A000 0160	PCI mask 2 register
1 A000 0180	Host address extension register 0 (HAXR0)
1 A000 01A0	Host address extension register 1 (HAXR1)
1 A000 01C0	Host address extension register 2 (HAXR2)
1 A000 01E0	PCI master latency timer register
1 A000 0200	TLB tag 0 register
1 A000 0220	TLB tag 1 register
1 A000 0240	TLB tag 2 register
1 A000 0260	TLB tag 3 register
1 A000 0280	TLB tag 4 register
1 A000 02A0	TLB tag 5 register
1 A000 02C0	TLB tag 6 register
1 A000 02E0	TLB tag 7 register
1 A000 0300	TLB 0 data register
1 A000 0320	TLB 1 data register
1 A000 0340	TLB 2 data register
1 A000 0360	TLB 3 data register
1 A000 0380	TLB 4 data register
1 A000 03A0	TLB 5 data register
1 A000 03C0	TLB 6 data register

(continued on next page)

Table 7–1 (Cont.) DECchip 21071-DA CSR Addresses

Address$_{16}$	Register Name
1 A000 03E0	TLB 7 data register
1 A000 0400	Translation buffer invalidate all register (TBIA)

7.5 Description of CSRs

The CSRs are 16 bits wide and are addressed on cache-line boundaries. Write transactions to read-only registers could result in UNPREDICTABLE behavior; read transactions are nondestructive. Only bits <15:0> of each register are defined. Only zeros should be written to unspecified bits within a CSR. CSRs are initialized as shown in the Type column.

All CSRs are addressed on cache line boundaries, that is, address bits <4:2> must be zero. In the implementation, address bits <27:11> are treated as a don't care state. Therefore, accesses to addresses with nonzero address bits <27:11> map to the CSR address with address bits <27:11> equal to zero.

7.5.1 Diagnostic Control/Status Register

The diagnostic control/status register (DCSR) controls the operational and diagnostic modes, and reports status and error conditions. The register is shown in Figure 7–3 and is defined in Table 7–2.

Figure 7–3 Diagnostic Control/Status Register: 0x1A0000000

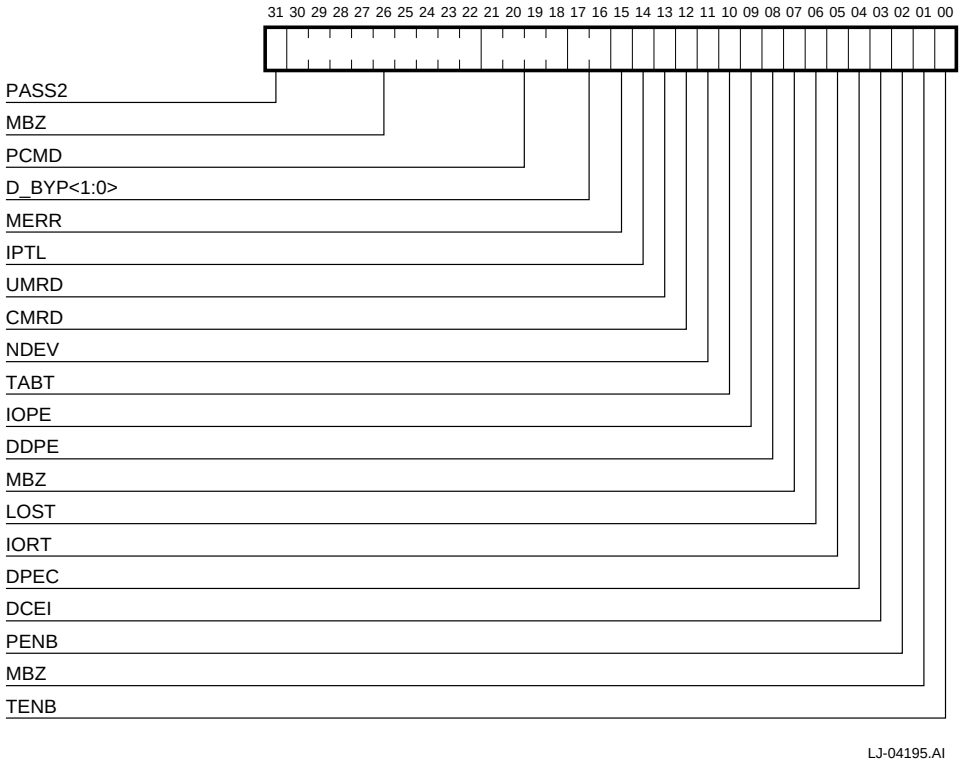


Table 7–2 Diagnostic Control/Status Register

Field	Name	Type	Description
<31>	PASS2	RO	Pass 2. Chip version reads low on pass 1 and high on pass 2.
<30:22>	Reserved	MBZ	—
<21:18>	PCMD	RO	PCI command. Indicates the PCI type when a PCI-initiated error is logged. Valid only when IPTL, NDEV, TABT, and IOPE are set.

(continued on next page)

Table 7–2 (Cont.) Diagnostic Control/Status Register

Field	Name	Type	Description
<17:16>	**D_ BYP<1:0>**	RW, 0	Disable read bypass. Controls the order of PCI-initiated memory read transactions with respect to PCI-initiated memory write transactions. The three modes are shown in the following table.

Value	Mode	Description
00	Full bypass	PCI-initiated memory read transactions bypass buffered DMA write transactions if the double hexword address of the read transaction does not match that of the buffered write transactions. The address comparison is done across address bits <31:6>.
01	—	Reserved
10	Partial bypass	DMA read transactions bypass buffered memory write transactions, if the address within the page does not match that of the buffered DMA write transactions. The address comparison is done across bits <12:6>.
11	No bypass	DMA read bypassing is disabled. DMA read transactions are ordered with respect to DMA write transactions originating on the PCI bus.

<15>	MERR	RW, 0	Memory error. Set when the PCI host bridge receives an error code in the **iocack<1:0>** field in response to a memory access. Bits **sysadr<35:5>** are logged in system bus error address register bits **<31:4>**. This bit is not logged if the system bus error address register is locked by a previous error. In this case, the lost error bit is set.

(continued on next page)

Table 7–2 (Cont.) Diagnostic Control/Status Register

Field	Name	Type	Description
<14>	IPTL	RWC, 0	Invalidate page table lookup. This bit is set when the longword scatter-gather map entry being accessed is invalid. Bits **ad<31:0>** are logged in the PCI error address register, if it is not already locked.
<13>	UMRD	RWC, 0	Uncorrectable memory read data. This bit is set when an uncorrectable error is encountered by the 21071-DA chip in the data read from the DMA read buffer in the 21071-BA chip to the 21071-DA chip on a DMA read or a scatter-gather read transaction. Bits **sysadr<33:6>** are logged in system bus error address register bits <31:4> if it is not locked.
<12>	CMRD	RWC, 0	Correctable memory read data (CMRD) is set when a correctable error is encountered by the 21071-DA chip. The error is encountered when the data read from the DMA read buffer in the 21071-BA reaches the 21071-DA on a DMA read or scatter-gather read transaction.
<11>	NDEV	RWC, 0	No device. This bit is set when devsel# signal is not asserted in response to an I/O read or write transaction initiated on the PCI by the 21071-DA. Bits **ad<31:0>** are logged in the PCI error address register.
<10>	TABT	RWC, 0	Target abort. This bit is set when a PCI slave device ends an I/O read or write transaction using the PCI target abort protocol. Bits **ad<31:0>** are logged in the PCI error address register.
<9>	IOPE	RWC, 0	I/O parity error. This bit is set when a parity error occurs in the data phase of an I/O read or write transaction. Bits **ad<31:0>** are logged in the PCI error address register.
<8>	DDPE	RWC, 0	DMA data parity error. This bit is set when a parity error occurs in the data phase of a DMA transaction. Bits **ad<31:0>** for this transaction are logged in the PCI error address register.
<7>	Reserved	MBZ	—

(continued on next page)

Table 7–2 (Cont.) Diagnostic Control/Status Register

Field	Name	Type	Description
<6>	LOST	RWC, 0	Lost error. This bit is set by a 21071-DA error condition when the address register for that error is locked because of a previous error. In this case, error information for the second error is lost. The logged address information in the system bus Error Address register or the PCI error address register remains valid for the initial error condition.
<5>	IORT	RWC, 0	I/O retry timeout. This bit is set when a retry timeout error occurs on CPU-initiated read or write transactions on the PCI. Bits **ad<31:0>** are logged in the PCI error address register.
<4>	DPEC	RW, 0	Disable parity error checking. When set, parity checking is not performed on the PCI bus (address and data cycles, DMA and I/O transactions). Parity generation is not affected.
<3>	DCEI	RW, 0	Disable correctable error interrupt. When set, correctable errors on DMA read data are not logged in the CMRD bit (DCSR12), and the address is not updated in the system bus error address register. This bit determines only whether the error is logged and if the processor is interrupted.
<2>	PENB	RWC, 0	Prefetch enable bit. When set, the system bus master state machine enables prefetching on DMA read transactions.
<1>	Reserved	MBZ	—
<0>	TENB	RW, 0	TLB enable. When set, the entire TLB is enabled. When cleared, the TLB is turned off and subsequent scatter-gather read transactions do not result in allocation of TLB entries. Entries that were valid when the TENB bit was cleared remain valid. To invalidate entries, software must write to the TBIA register.

7.5.2 PCI Error Address Register

The PCI error address register holds the PCI address **ad<31:0>** that was being used when an error happened. The register is shown in Figure 7–4 and is defined in Table 7–3.

Figure 7–4 PCI Error Address Register: 0x1A0000020

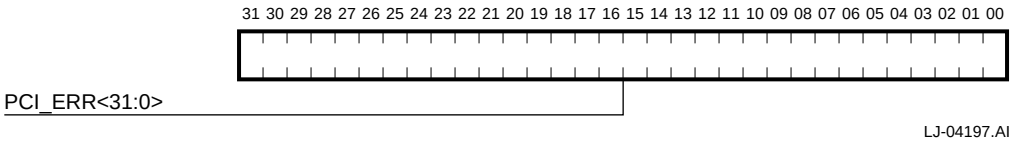


Table 7–3 PCI Error Address Register

Field	Name	Type	Description
<31:0>	**PCI_ERR<31:0>**	RO	PCI error. Stores the address sent out on the PCI bus **ad<1:0>** as a result of an I/O transaction. The field logs the address of the errors indicated by the NDEV, TABT, IOPE, DDPE, IPTL, and IORT bits in the DCSR. The register is valid only when one of these error bits is set. If one of the bits is set, a subsequent error of the same type will not update the address logged in this register and the LOST bit is set in DCSR.

7.5.3 System Bus Error Address Register

The system bus error address register holds the system bus address that was being used when an error happened. The register is shown in Figure 7–5 and is defined in Table 7–4.

Figure 7–5 System Bus Error Address Register: 0x1A0000040

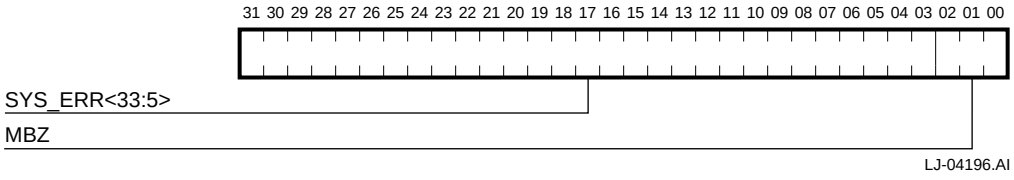


Table 7–4 System Bus Error Address Register

Field	Name	Type	Description
<31:3>	**SYS_ERR<33:5>**	RO	System bus error address. Stores the address sent on system bus **sysadr<33:5>** as a result of a DMA transaction. The field logs errors indicated by the MERR, UMRD, or CMRD bits in the DCSR, and is valid only when one of these bits is set. If an error bit is set, a subsequent error of the same type does not update the address logged in this register and the LOST bit is set in the DCSR.
<2:0>	Reserved	MBZ	—

7.5.4 Dummy Registers 1 Through 3

Dummy registers 1 through 3 have no side effects on write transactions and they return zero on read transactions. Use write transactions to these registers to pack the CPU's write buffers to prevent merging of sparse space I/O write transactions. If this mechanism is used, software is not required to use memory barrier instructions between write transactions.

7.5.5 Translated Base Registers 1 and 2

The translated base registers 1 and 2 provide the base address when mapping is enabled or disabled. The registers are shown in Figure 7–6 and are defined in Table 7–5.

Figure 7–6 Translated Base Registers 1, 2: 0x1A00000C0, 0x1A00000E0

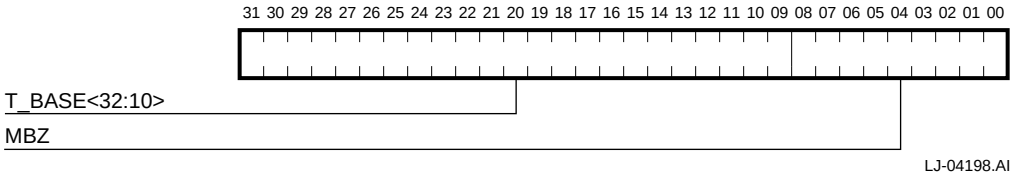


Table 7–5 Translated Base Registers 1 and 2

Field	Name	Type	Description
<31:9>	**T_BASE<32:10>**	RW	Translated base. If scatter-gather mapping is disabled, T_BASE specifies the base CPU address of the translated PCI address for the PCI target window. If scatter-gather mapping is enabled, T_BASE specifies the base CPU address for the scatter-gather map table for the PCI target window.
<8:0>	Reserved	MBZ	—

7.5.6 PCI Base Registers 1 and 2

PCI base registers 1 and 2 provide the base address of the target window. The registers are shown in Figure 7–7 and are defined in Table 7–6.

Figure 7–7 PCI Base Registers 1 and 2: 0x1A0000100, 0x1A0000120

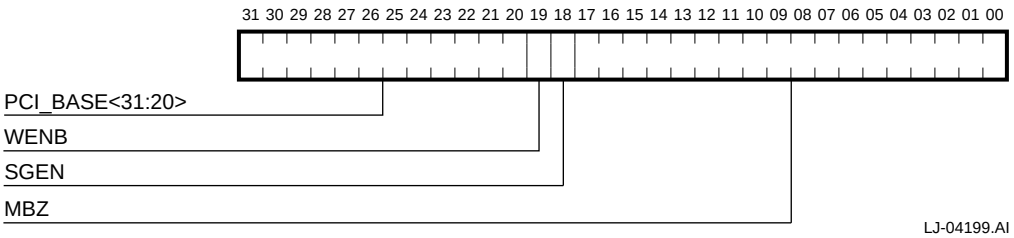


Table 7–6 PCI Base Registers 1 and 2

Field	Name	Type	Description
<31:20>	**PCI_BASE<31:20>**	RW	PCI base. Specifies the base address of the PCI target window.

(continued on next page)

Table 7–6 (Cont.) PCI Base Registers 1 and 2

Field	Name	Type	Description
<19>	WENB	RW, 0	Window enable. When clear, the PCI target window is disabled and does not respond to PCI-initiated transfers. When set, the PCI target window is enabled and responds to PCI-initiated transfers that hit in the address range of the target window. This bit must be disabled by the processor when modifying any of the PCI target window registers (base, mask, or translated base).
<18>	SGEN	RW, 0	Scatter-gather enable. When clear, the PCI target window uses direct mapping to translate a PCI address to a CPU address. When set, the PCI target window uses scatter-gather mapping to translate a PCI address to a CPU address.
<17:0>	Reserved	MBZ	—

7.5.7 PCI Mask Registers 1 and 2

PCI mask registers 1 and 2 define the size of the target window. The registers are shown in Figure 7–8 and are defined in Table 7–7.

Figure 7–8 PCI Mask Registers 1 and 2: 0x1A0000140, 0x1A0000160

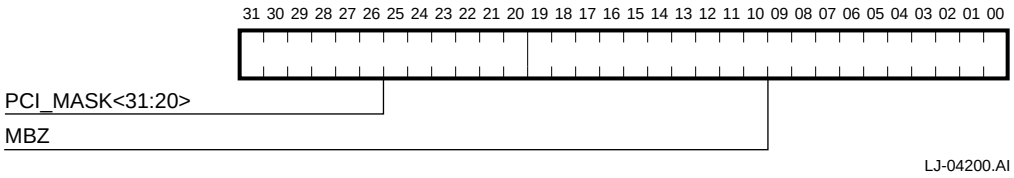


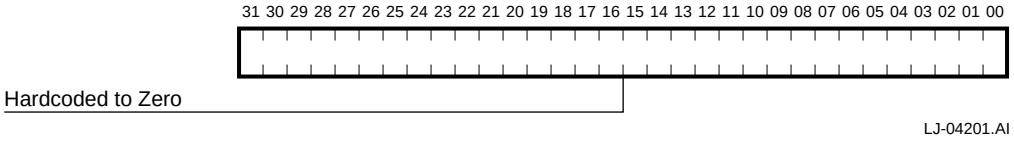
Table 7–7 PCI Mask Registers 1 and 2

Field	Name	Type	Description
<31:20>	**PCI_MASK<31:20>**	RW	PCI mask. This field specifies the size of the PCI target window; it is also used in the PCI-to-CPU address translation.
<19:0>	Reserved	MBZ	—

7.5.8 Host Address Extension Register 0

The host address extension register is hardcoded to zero. A read transaction from this register returns zero; a write transaction has no effect. The register is shown in Figure 7–9.

Figure 7–9 Host Address Extension Register 0: 0x1A0000180



7.5.9 Host Address Extension Register 1

The host address extension register 1 generates **ad<31:27>** on CPU-initiated transactions addressing PCI memory space. The register is shown in Figure 7–10 and is defined in Table 7–8.

Figure 7–10 Host Address Extension Register 1: 0x1A00001A0

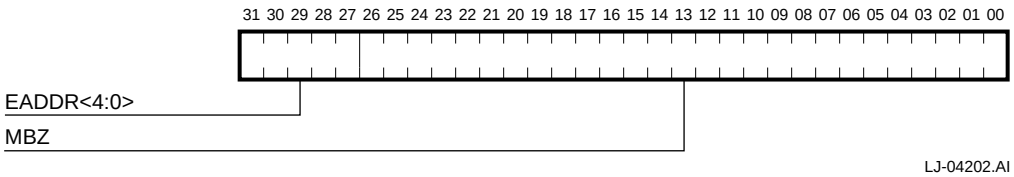


Table 7–8 Host Address Extension Register 1

Field	Name	Type	Description
<31:27>	**EADDR<4:0>**	RW, 0	Extension address. This field is used as the five high-order PCI address bits (**ad<31:27>**) for CPU-initiated transactions to PCI memory.
<26:0>	Reserved	MBZ	—

7.5.10 Host Address Extension Register 2

The host address extension register 2 generates **ad<31:24>** on CPU-initiated transactions addressing PCI I/O space. It also generates **ad<1:0>** during PCI configuration read and write transactions. The register is shown in Figure 7–11 and is defined in Table 7–9.

Figure 7–11 Host Address Extension Register 2: 0x1A00001C0

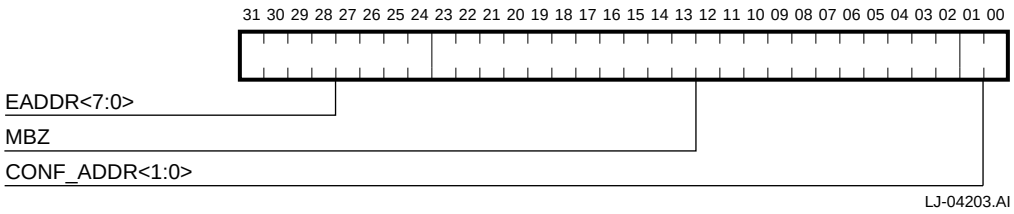


Table 7–9 Host Address Extension Register 2

Field	Name	Type	Description
<31:24>	**EADDR<7:0>**	RW, 0	Extended address. Used as the eight high-order PCI address bits **ad<31:24>** for CPU-initiated transactions to PCI I/O space.
<23:2>	Reserved	MBZ	—
<1:0>	**CONF_ADDR<1:0>**	RW, 0	Configuration address. Used as the two low-order PCI address bits **ad<1:0>** for CPU-initiated transactions to PCI configuration space.

7.5.11 PCI Master Latency Timer Register

The PCI master latency timer register defines the latency timer period. Define a nonzero value during system configuration. The register is shown in Figure 7–12 and is defined in Table 7–10.

Figure 7–12 PCI Master Latency Timer Register: 0x1A00001E0

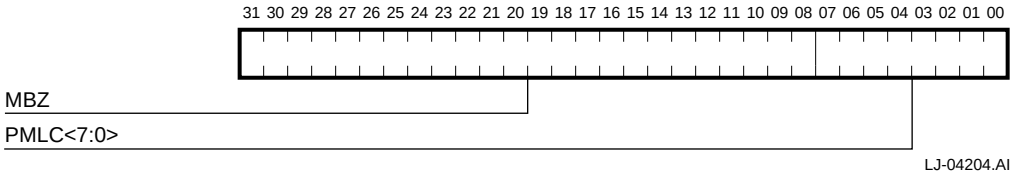


Table 7–10 PCI Master Latency Timer Register

Field	Name	Type	Description
<31:8>	Reserved	MBZ	—
<7:0>	**PMLC<7:0>**	—	PCI master latency time. Loaded into the master latency timer register at the start of a PCI master transaction initiated by the 21071-DA. The register resets to zero.

7.5.12 TLB Tag Registers 0 Through 7

The TLB tag registers contain the PCI page address associated with the CPU page address in the TLB data registers. The registers are shown in Figure 7–13 and are defined in Table 7–11.

Figure 7–13 TLB Tag Registers 0 Through 7: 0x1A0000200 to 0x1A00002E0

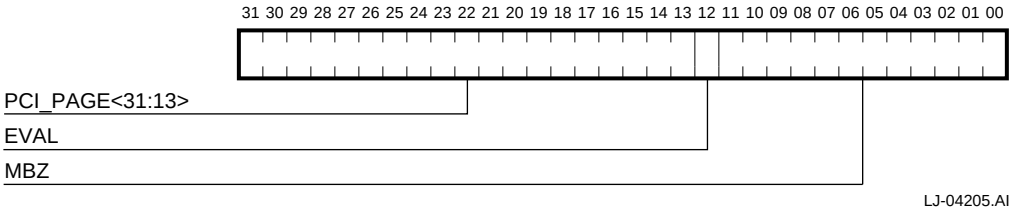


Table 7–11 TLB Tag Registers 0 Through 7

Field	Name	Type	Description
<31:13>	**PCI_PAGE<31:13>**	RO	PCI page. Specifies the PCI page address (tag) for the translated CPU page address in the associated TLB data register.
<12>	EVAL	RO	Entry valid. The entry valid bit can be read and written through this bit. Normally, the invalid bit contains the value read during a page table entry read transaction.
<11:0>	Reserved	MBZ	—

7.5.13 TLB Data Registers 0 Through 7

The TLB data registers contain the CPU page address associated with the PCI page address in the TLB tag registers. The registers are shown in Figure 7–14 and are defined in Table 7–12.

Figure 7–14 TLB Data Registers 0 Through 7: 0x1A0000300 to 0x1A00003E0

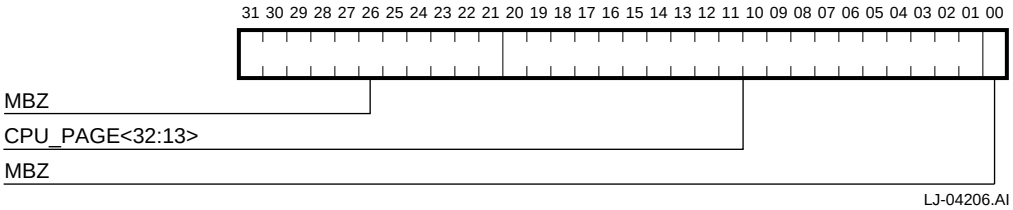


Table 7–12 TLB Data Registers 0 Through 7

Field	Name	Type	Description
<31:21>	Reserved	MBZ	—
<20:1>	**CPU_PAGE<32:13>**	RO	CPU page. Bits <32:13> of the translated CPU address can be read or written through this field.
<0>	Reserved	MBZ	—

7.5.14 Translation Buffer Invalidate All Register: 0x1A0000400

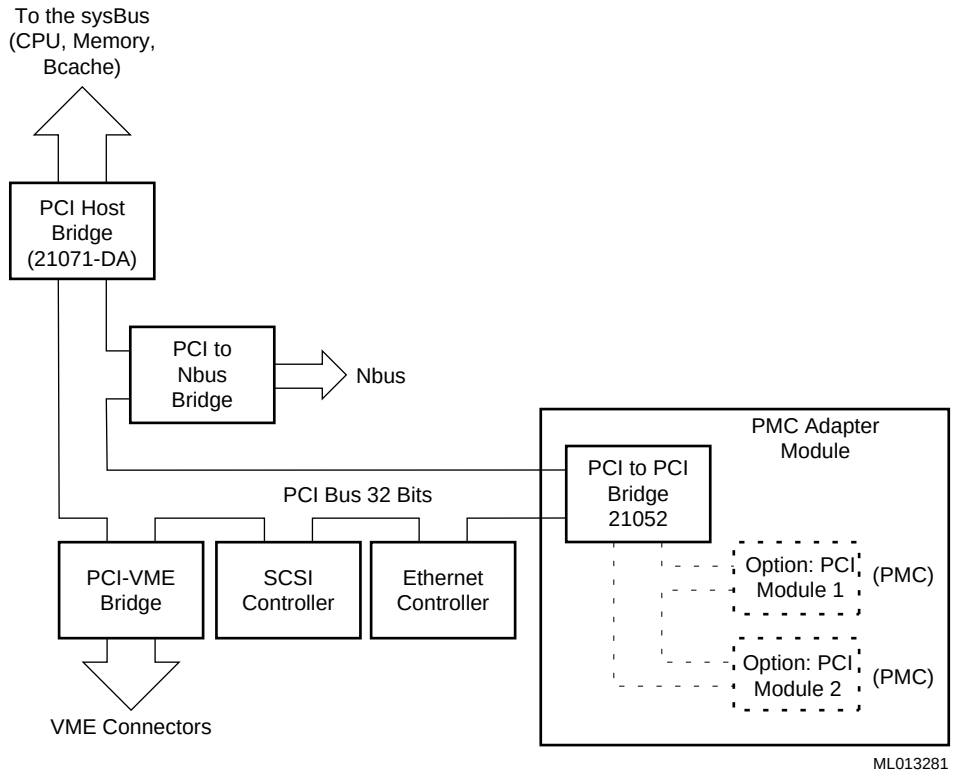
The translation buffer invalidate all register (TBIA) is write-only. A write transaction to this register invalidates all valid entries in the scatter-gather map TLB.

8

PCI bus

The PCI bus is the base for the I/O subsystem. All I/O components are connected by the 32-bit, 5 V only, PCI implementation and are called PCI devices. Figure 8–1 shows a block diagram of the I/O subsystem.

Figure 8–1 PCI Bus and Interfaces to the I/O Subsystem



The base address of each PCI device, except the Nbus interface (SIO), is configured by the Digital Alpha VME 4 firmware. Each base address is initialized by writing configuration registers located in PCI configuration space of the system address map.

The following components make up the I/O subsystem and are PCI devices:

- Ethernet controller: interface to the network
- SCSI controller: interface to SCSI devices
- PCI Expansion card: optional interface to PCI devices
- VMEbus interface: See Chapter 10
- Nbus interface: See Chapter 9

8.1 Ethernet Controller

The physical connection to the network is the Ethernet twisted-pair connector located on the front panel of the module.

The Ethernet controller is based on the DECchip 21040-AA. This chip is a PCI-based Ethernet solution that keeps processor intervention in LAN control to a minimum. The DECchip 21040-AA behaves as a bus slave when communicating with the PCI bus for access to configuration registers and control/status registers (CSRs), and behaves as a bus master when communicating with memory.

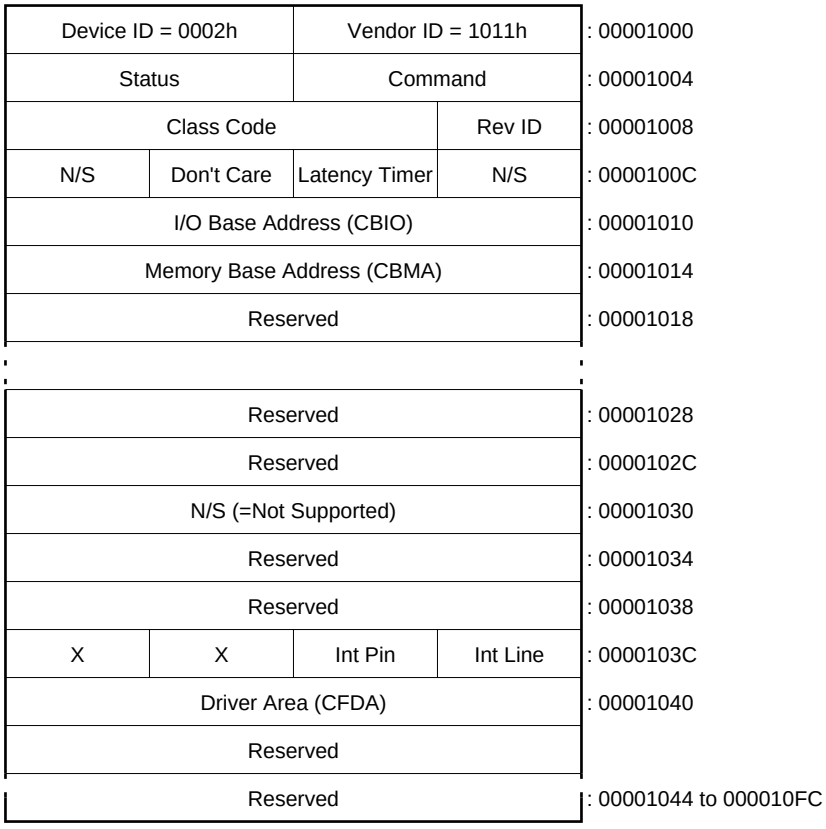
Refer to the DECchip 21040-AA specification for details of programming and use.

8.1.1 PCI Configuration Registers

CPU Address: 0x1E0010000 - 0x1E0011FE0
PCI Address: 0x00001000 - 0x000010FF

The Ethernet controller responds to PCI configuration reads and writes to its configuration registers (see Figure 8–2). For full bit definitions of these registers, refer to the DECchip 21040-AA specification. Figure 8–2 shows the PCI configuration space addresses of each register.

Figure 8–2 PCI Configuration Registers



8.1.2 Ethernet Controller CSRs

The Ethernet controller has 16 CSRs that can be accessed by the PCI host bridge. The address field in Table 8–1 reflects the offset from the CSR base address (CBIO,CBMA). The CSRs are located in PCI I/O or memory space. The CSRs are quadword-aligned and can only be accessed using longword instructions. See the DECchip 21040-AA specifications for more details.

Table 8–1 Ethernet Controller CSRs

Register	Meaning	Address
CSR0	Bus mode register	xxxx xx00H
CSR1	Transmit poll demand	xxxx xx08H
CSR2	Receive poll demand	xxxx xx10H
CSR3	Rx list base address	xxxx xx18H
CSR4	Tx list base address	xxxx xx20H
CSR5	Status register	xxxx xx28H
CSR6	Serial command register	xxxx xx30H
CSR7	Interrupt mask register	xxxx xx38H
CSR8	Missed frame register	xxxx xx40H
CSR9	ENET ROM register	xxxx xx48H
CSR10	Reserved	xxxx xx50H
CSR11	Full-duplex register	xxxx xx58H
CSR12	SIA status register	xxxx xx60H
CSR13	SIA connectivity register	xxxx xx68H
CSR14	SIA Tx Rx register	xxxx xx70H
CSR15	SIA general register	xxxx xx78H

8.1.3 PCI Cycles

As a slave, the Ethernet controller responds to single longword accesses in I/O space and configuration space. Burst writes to I/O space cause target-initiated retry termination of the cycle.

As a master, the Ethernet controller performs DMA operations. Its tenure on the PCI bus can be programmed by the burst length in the bus mode register (CSR0) and by the PCI latency timer value in the configuration latency timer register.

The Ethernet controller handles the following types of cycle termination:

- Target-initiated retry
- Abort
- DEVSEL abort

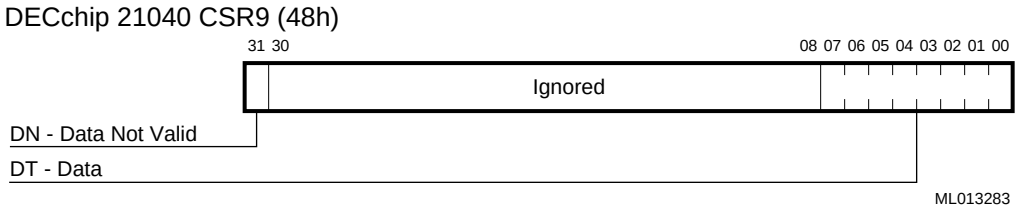
Target-aborted terminations cause an interrupt.

8.1.4 Ethernet Address

The Ethernet ID address for the Digital Alpha VME 4 assembly is stored in an on-board SROM, a 20-pin socketed PLCC. The Ethernet controller's ENET ROM register (CSR9) can read the SROM. Each read access initiates 8-bit serial read cycles from the ENET ROM. Writing to the register resets the pointer of the ENET ROM to its first location.

Figure 8–3 shows the ENET ROM register.

Figure 8–3 DECchip 21040-AA CSR9 (ENET ROM Register)



8.2 SCSI Controller

The SCSI controller is based on the NCR 53C810 chip. For full operational programming details, see the specification for the chip and the NCR 53C720 programming guide.

8.2.1 Connection and Termination

The SCSI bus is routed to the VMEbus P2 connector. The pinning for the user-defined pins of the connector is provided in Appendix A.

An interface to a standard SCSI cable is handled by the primary breakout module. This module brings the SCSI bus to a standard 50-pin SCSI connector pinning for direct connection to an unshielded SCSI A-cable.

Active terminators are controlled by a 6-pin jumper block on the primary breakout module:

- To enable SCSI termination, jumper pins 1 and 3.
- To disable SCSI termination, jumper pins 3 and 5.

8.2.2 SCSI ID

The default SCSI ID is 7. You set the SCSI ID by writing the SCSI controller's SCID register (offset 0x04). To do this, use the following console command:

```
>>> set PKA0_HOST_ID n
```

For example, if you enter **set PKA0_HOST_ID 4**, the embedded SCSI controller assumes a SCSI ID of 4.

8.2.3 Programming

The SCSI controller can affect high-level SCSI operations with very little intervention from the processor. This is accomplished through its low-level register interface or by the NCR chip's SCSI scripts. Once configured in PCI space, the programming of the NCR 53C810 chip is compatible with the NCR 53C720 chip. For information on programming the NCR 53C720 chip, see its programming guide.

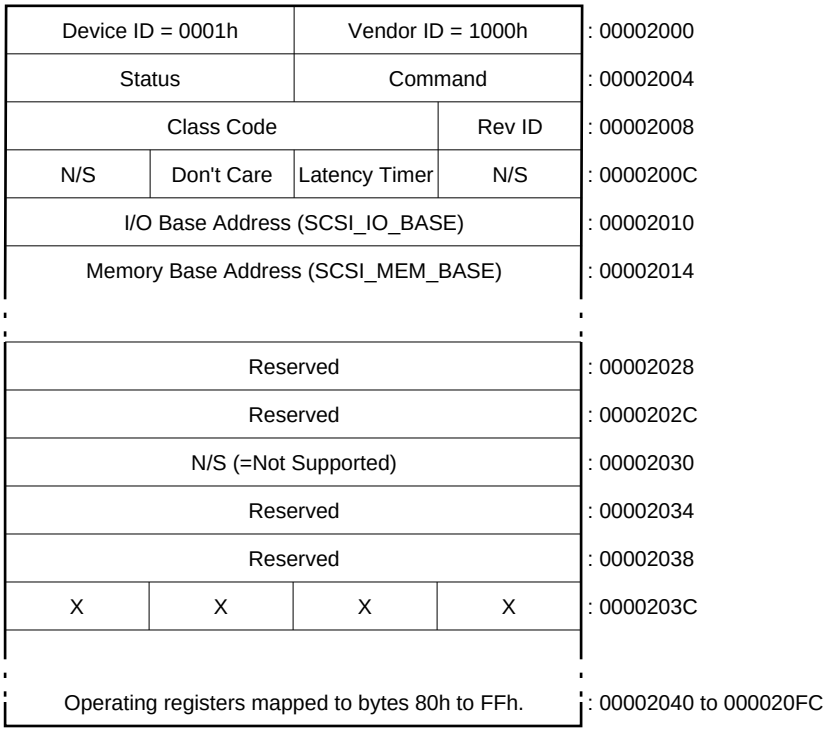
8.2.4 PCI Configuration Registers

CPU Address: 0x1E0020000 - 0x1E0021FE0
PCI Address: 0x00002000 - 0x000020FF

The SCSI controller has two base address registers: one for I/O and one for memory space. This allows the 128 bytes of registers to be accessible in both PCI memory and I/O regions. Figure 8–4 shows the supported fields in the PCI configuration block.

The SCSI controller supports a latency timer and has a programmable data burst size through normal registers (not PCI configuration). See DMODE register, Offset 38h.

Figure 8–4 PCI Configuration Block



8.2.5 SCSI Control Status Registers

The SCSI controller has 128 accessible bytewide CSRs, as shown in Table 8–2. These registers are accessible starting at the following addresses:

- SCSI_IO_BASE in PCI I/O space
- SCSI_MEM_BASE in PCI memory space

For information about how to program these registers, see the PCI local bus specification.

Table 8–2 SCSI Controller CSRs

Label	R/W	Description	Offset
SCNTL0	R/W	SCSI Control 0	00
SCNTL1	R/W	SCSI Control 1	01
SCNTL2	R/W	SCSI Control 2	02
SCNTL3	R/W	SCSI Control 3	03
SCID	R/W	SCSI Chip ID	04
SXFER	R/W	SCSI Transfer	05
SDID	R/W	SCSI Destination ID	06
GPREG	R/W	General Purpose	07
SFBR	R/W	1st Byte Rx'ed	08
SOCL	R/W	Output Cntrl Latch	09
SSID	R	Selector ID	0A
SBCL	R/W	Bus Control Lines	0B
DSTST	R	DMA Status	0C
SSTAT0	R	SCSI Status 0	0D
SSTAT1	R	SCSI Status 1	0E
SSTAT2	R	SCSI Status 2	0F
DSA	R/W	Data Structure Addr	10-13
ISTAT	R/W	Interrupt Status	14
		RESERVED	15-17
CTEST0	R/W	Chip Test 0	18
CTEST1	R	Chip Test 1	19
CTEST2	R	Chip Test 2	1A
CTEST3	R	Chip Test 3	1B
TEMP	R/W	Temporary Stack	1C-1F
			20
CTEST4	R/W	Chip Test 4	21
			22
CTEST6	R/W	Chip Test 5	23
DBC	R/W	DMA Byte Counter	24-26

(continued on next page)

Table 8–2 (Cont.) SCSI Controller CSRs

Label	R/W	Description	Offset
DCD	R/W	DMA Command	27
DNAD	R/W	DMA Next Add for Data	28-2B
DSP	R/W	DMA SCRIPTS Pointer	2C-2F
			30-33
ScratchA	R/W	General Purpose Scratch Pad	34-37
DMODE	R/W	DMA Mode	38
DIEN	R/W	DMA Interrupt Enable	39
DWT	R/W	DMA Watchdog Timer	3A
DCNTL	R/W	DMA Control	3B
ADDER	R	Sum o/p of internal adder	3C-3F
SIEN0	R/W	SCSI Interrupt Enable 0	40
SIEN1	R/W	SCSI Interrupt Enable 1	41
SIST0	R	SCSI Interrupt Status 0	42
SIST1	R	SCSI Interrupt Status 1	43
SLPAR	R/W	SCSI Longitudinal Parity	44
SWIDE	R	SCSI Wide Residue Data	45
			46-47
STIME0	R/W	SCSI Timer 0	48
STIME1	R/W	SCSI Timer 1	49
STEST0	R	SCSI Test 0	4C
STEST1	R	SCSI Test 1	4D
STEST2	R/W	SCSI Test 2	4E
STEST3	R/W	SCSI Test 3	4F
SIDL	R	SCSI Input Data Latch	50-51
SODL	R/W	SCSI Output Data Latch	54-55
SBDL	R	SCSI Bus Data Lines	58-59
ScratchB	R/W	General Purpose Scratch Pad	5C-5F

8.3 PCI I/O Companion Card

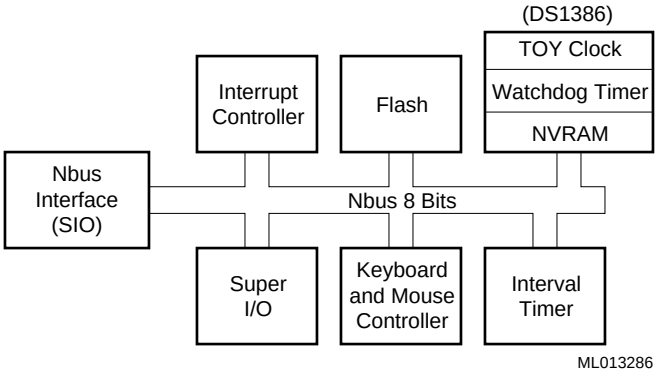
You can connect an optional PMC I/O companion card to the I/O module. This card contains a 21052 PCI-to-PCI bridge chip and two sets of PCI mezzanine card (PMC) connectors that allow you to add one double-width or two single-width PCI PMC modules. One of the PMC connector sets includes a third connector that allows I/O access through the P2 connector.

PCI bus arbitration supports two PCI devices with up to four interrupt request lines each. The PCI clock is driven from the Digital Alpha VME 4 assembly at a frequency of 32 MHz. The card connectors provide 3 V and 5 V supply voltages. Although you can have mixed supply voltages between cards, the PCI bus signaling voltage must be 5 V. The voltage selector jumper is located on the PMC I/O companion card and must be configured by the installer.

9
Nbus

The Nbus is a special case of an ISA bus. The Nbus is a simple 8-bit data, 16-bit address, nonmultiplexed resource bus that interfaces with the PCI bus through the Super I/O (SIO) chip (Intel 82378IB). The interface translates PCI I/O references to the Nbus into simple read and write cycles to the resources hanging off the Nbus lines, as shown in Figure 9–1.

Figure 9–1 Nbus and Nbus Resources



9.1 Nbus Address Space

The bottom 64K of PCI sparse I/O address space is mapped onto the Nbus for use by the:

- Keyboard and mouse controller
- Super I/O
- Module registers

- NVRAM
- Interval timers

The bottom 1 MB in PCI sparse memory space is mapped onto the Nbus for use by the flash ROM.

These address regions are negatively decoded and are not affected by any other PCI device that is programmed to positively decode PCI addresses.

The CPU can access the Nbus devices in I/O space on a byte-by-byte basis. Digital Alpha VME 4 only supports single-byte accesses to all Nbus locations.

Most resources of the Nbus are accessed as the least-significant byte of aligned longwords. The exceptions are the time-of-year (TOY) clock and the ROM. Both of these regions are contiguous bytes. When accessing the Nbus, only one PCI byte enable is asserted.

9.1.1 SIO Chip PCI Configuration Space

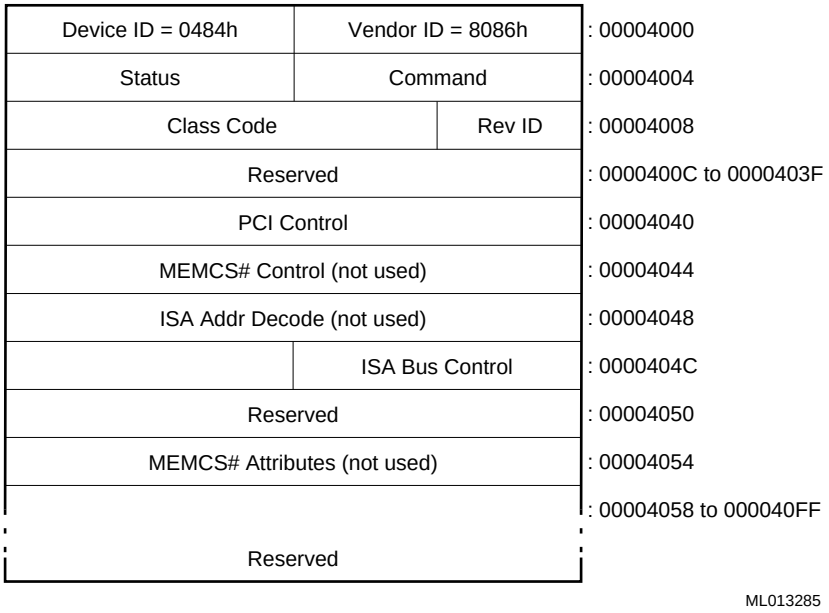
CPU Address: 0x1E0030000 - 0x1E0031FE0
PCI Configuration: 0x00004000 - 0x000040FF

The SIO chip does not have any base address registers. Instead, the SIO chip negatively decodes fixed regions in both PCI I/O and PCI memory space. However, the following registers are used in PCI bus and Nbus control:

- PCI control register
- ISA controller recovery timer register
- ISA clock divisor register

Figure 9–2 shows the layout of the SIO chip configuration space with these registers. For more detail, see Intel's *SIO82378 Chip Specification*.

Figure 9–2 SIO Configuration Block



9.1.1.1 PCI Control Register

The PCI control register enables the SIO chip to respond to PCI IACK cycles and to set the expected assertion speed of the DEVSEL# signal so that the subtractive decode sample point can be set. The PCI posted write buffer is also enabled.

Table 9–1 lists the fields of the PCI control register.

Table 9–1 PCI Control Register

Field	Name	Description
<5>		Must be set to a 1 (default)
<4:3>		Must be set to <00> to allow slow sample point timing for negative decode.
<2>	PCI Posted Write Buffer Enable	Must be set to 1.

All other bits must be 0.

9.1.1.2 ISA Controller Recovery Timer Register

The ISA controller recovery timer register (offset +4Ch) is one of two bytewide registers used as the Nbus control word.

The I/O recovery mechanism in the SIO chip is used to add recovery delay between the I/O cycles originating in the PCI bus and directed to the Nbus. Since only 8-bit cycles are supported, only bits <6:3> of the register are significant. Bits <6:3> define the number of system-clock ticks inserted between back-to-back cycles. The required value for Digital Alpha VME 4 is 1001, representing one additional system-clock tick.

9.1.1.3 ISA Clock Divisor Register

The ISA clock divisor register (offset +4Dh) is one of two bytewide registers used as the Nbus control word. This register enables positive decode for BIOS ROM and the PCI-to-ISA clock divisor. For Digital Alpha VME 4, the BIOS ROM region must not be positively decoded.

Bit <6> must be cleared and bits <2:0> must be 000 for a 32 MHz PCI system. All other bits must be 0.

9.2 Module Registers

There are 17 miscellaneous registers implemented in module logic for a variety of read/write functions. These registers are located in PCI Sparse I/O space within the SIO chip address block and are listed in the following table.

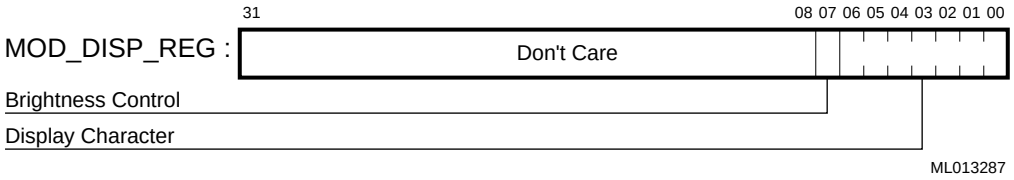
Register	CPU Address	Nbus Offset
Module display control	1 C001 0000	800
Module configuration	1 C001 0020	801
Interrupt register 1	1 C001 0040	802
Interrupt register 2	1 C001 0060	803
Interrupt register 3	1 C001 0080	804
Interrupt register 4	1 C001 00A0	805
Memory configuration 0	1 C001 00C0	806
Memory configuration 1	1 C001 00E0	807
Memory configuration 2	1 C001 0100	808
Memory configuration 3	1 C001 0120	809
Reset reason 1	1 C001 0140	80A
Memory identification	1 C001 0160	80B
Heartbeat (clear-interrupt)	1 C001 0180	80C
Module control	1 C001 01A0	80D
Reset reason 2	1 C001 01C0	80E
Bcache configuration	1 C001 01E0	80F
Reset reason 3	1 C001 05C0	82E

9.2.1 Module Display Control Register

CPU address: 0x1C0010000
Nbus offset: 0x800

The display is a 5x7 dot-matrix intelligent display device, with 96 characters. The unit is read/writable by the display control register (MOD_DISP_REG), shown in Figure 9–3.

Figure 9–3 Module Display Control Register



The display character is stored in bits <6:0>. The most significant bit (bit <7>) can be set to increase the brightness of the display.

Figure 9–4 shows the character set of the display. The numbers along the left-hand edge are the most-significant hexadecimal digit of the character number, while the least-significant is along the top. For example, the character "W" is displayed by writing a value of 0x57 to the display register. A value of 0xD7 displays "W" with full brightness.

After a system reset, the display defaults to character 0x7F (":::") at full brightness. During a system reset, all dots in the matrix are lit.

Figure 9–4 Display Character Set

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**A**	**B**	**C**	**D**	**E**	**F**
0,1					B	L	A	N	K							
2		!	"	#	$	%	&	’	(	)	*	+	,	-	.	/
3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
6	‘	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
7	p	q	r	s	t	u	v	w	x	y	z	{	|	}	~	:::

9.2.2 Module Configuration Register

CPU address: 0x1C0010020
Nbus offset: 0x801

This read-only register contains information relating to module revision, CPU speed, and SCSI options. The information read from this register is hardwired on the module and is unaffected by resets. A write of 1 to bit 0 of this register clears the Periodic Real-Time timer. Figure 9–5 shows the module configuration register.

Figure 9–5 Module Configuration Register

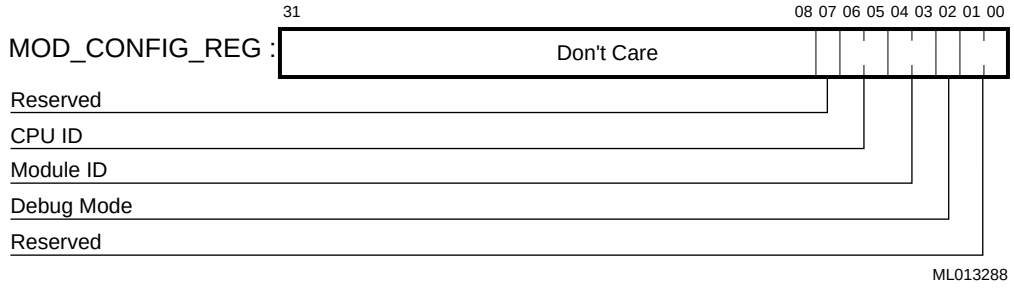


Table 9–2 Module Configuration Register

Field	Name	Type	Description
<1:0>	Reserved		
<2>	Debug	RO	If 0, the SROM starts the mini-debugger. If 1, the SROM starts the console.
<4:3>	Module ID	RO	Identifies the I/O module that is installed according to the following definitions:

<4:3>	Module
00	Type I
01	Type II
10	Reserved
11	Reserved

(continued on next page)

Table 9–2 (Cont.) Module Configuration Register

Field	Name	Type	Description
<6:5>	CPU ID	RO	Determine the speed of the CPU according to the following table:

<6:5>	Definition
00	224 MHz
01	288 MHz
10	Reserved
11	Reserved

9.2.3 Interrupt and Interrupt Mask Registers 1, 2, 3, 4

See Chapter 11 for descriptions of these registers.

9.2.4 Memory Configuration Registers 0, 1, 2, 3 and Memory Identification Register

- Memory configuration 0

  CPU address: 0x1C00100C0
  Nbus offset: 0x806

- Memory configuration 1

  CPU address: 0x1C00100E0
  Nbus offset: 0x807

- Memory configuration 2

  CPU address: 0x1C0010100
  Nbus offset: 0x808

- Memory configuration 3

  CPU address: 0x1C0010120
  Nbus offset: 0x809

  0x1C0010160
  0x80B

The memory configuration and memory identification registers store the presence detect (PD) bits and the ID bits of the main memory DIMMs as shown in Figures 9–6 and 9–7.

These registers are read-only. The values are loaded from memory DIMMs, identified in Table 2–8 at power-up. A complete description of the memory DIMMs is in Chapter 6.

Table 9–3 DIMM Identification

DIMM J#	DRAM#	Bank#	Memory Configuration Register
2	0	0	0
3	1	0	1
4	1	1	3
5	0	1	2

DRAM0 refers to the DIMM array containing memory data lines 0 - 63.
DRAM1 refers to the DIMM array containing memory data lines 64 - 127.

Tables 9–4 and 9–5 show the decode of the presence detect and ID bits stored in these registers.

Figure 9–6 Memory Configuration Registers 0-3

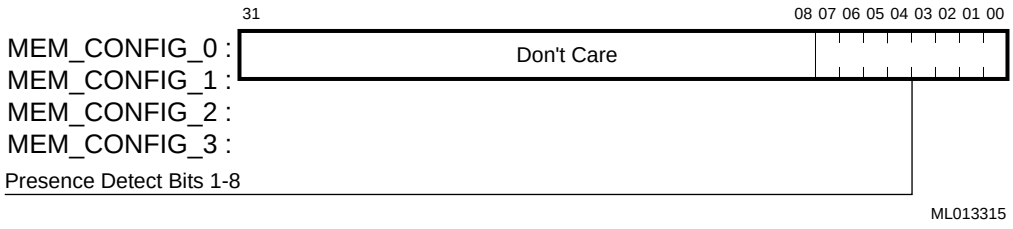


Figure 9–7 Memory Identification Register

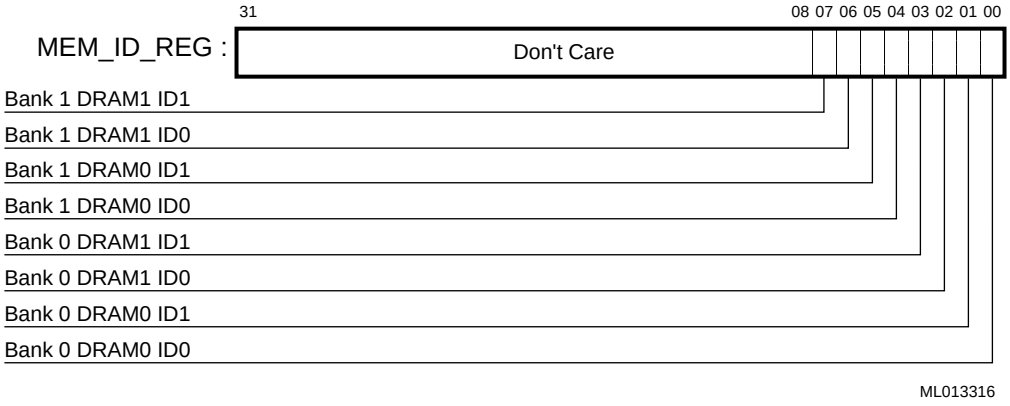


Table 9–4 Presence Detect

Bit	PD Bit	Description
<3:0>	PD 4-1	

PD Bits 4 3 2 1	Configuration (Parity/ECC)	DRAM Organization	RE Address	CE Address	Refresh Periods (ms)	
					Normal	Slow
0 1 0 0	1M x 72/80	1M x 4/16	10	10	16	128
0 1 0 1	2M x 72/80	1M x 4/16	10	10	16	128
1 0 1 1	4M x 72	4M x 4	12	11	64	256
1 0 1 1	4M x 80	4M x 4	12	10	64	256

<4> PD 5 Controls data mode access, according to the following values:

PD5	Definition
0	Fast page
1	Fast page with EDO

<6:5> PD 7-6 Controls speed, according to the following values:

PD 7	PD 6	Speed
0	1	80 ns
1	0	70 ns
1	1	60 ns
0	0	50 ns
0	1	40 ns

<7> PD 8 Used to define memory DIMM configuration (see Table 9–6).

Table 9–5 ID Bits

Bit	ID Bit	Description
<6,4,2,0>	ID 0	Used to define memory DIMM configuration (see Table 9–6).
<7,5,3,17>	ID 1	Sets the refresh mode, according to the following values:
		0 Normal
		1 Self refresh

Table 9–6 Memory DIMM Configuration Bit

PD8	IDO	Description
1	0	x64
1	1	x72 Parity
0	0	x72 ECC
0	1	x80 ECC

9.2.5 Reset Reason Registers

- Reset reason 1

  CPU address: 0x1C0010140
  Nbus offset: 0x80A

- Reset reason 2

  CPU address: 0x1C00101C0
  Nbus offset: 0x80E

- Reset reason 3

  CPU address: 0x1C00105C0
  Nbus offset: 0x82E

The reset reason registers record the cause of a module reset. The cause can be one of the following:

- Power-up
- VME reset
- Front panel switch
- Watchdog timer

These registers are read/pseudowritable registers located at a fixed address on Nbus in PCI I/O address space. Register 1 is located in Nbus offset 0x80A but is also aliased in two longwords at 0x80E and 0x82E. The register contains four reset status bits and one diagnostics in progress (DIP) bit. In reset reason register 3, at 0x82E, any write operation sets <4:0>. This is for testing only.

Figure 9–8 Reset Reason Registers

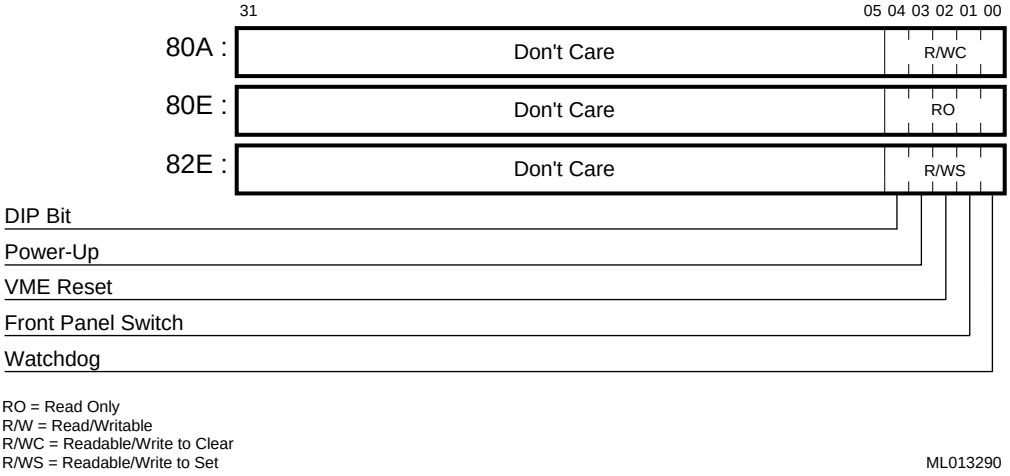


Table 9–7 Reset Reason Registers

Field	Name	Type	Description
<0>	Watchdog timer	0x80A : R/W to clear 0x80E : Read Only 82E : R/W to set	This is set immediately when a watchdog timer timeout occurs. Available to indicate the HALT reason before the system actually resets. In this case, the register forms part of the halt reason information in the system.
<1>	Front Panel Switch	0x80A : R/W to clear 0x80E : Read Only 82E : R/W to set	If set, it indicates that the front panel switch caused a reset.

(continued on next page)

Table 9–7 (Cont.) Reset Reason Registers

Field	Name	Type	Description
<2>	VME reset	0x80A : R/W to clear 0x80E : Read Only 82E : R/W to set	If set, it indicates that the module received a VME reset.
<3>	Power-up	0x80A : R/W to clear 0x80E : Read Only 82E : R/W to set	If set, all other bits are ignored.
<4>	DIP	0x80A : Read Only 0x80E : Read Only 82E : R/W to set	If set, Digital Alpha VME 4 does not reset.

9.2.6 Heartbeat Register

CPU Address: 0x1C0010180
Nbus offset: 0x80C

When the heartbeat clock is enabled in the TOY clock chip, each active (low to high, at a frequency of 1024 Hz) transition sets the heartbeat status bit. This bit is not directly readable but it drives the heartbeat interrupt line into interrupt register 1<5>.

Writing (data independent) to the heartbeat (clear-interrupt) register clears the heartbeat status bit and dismisses the interrupt request.

9.2.7 Module Control Register 1

CPU address: 0x1C00101A0
Nbus offset: 0x80D

The module control register 1 is a read/write register for controlling miscellaneous module functions. This register is reset to 0 on any system reset. Figure 9–9 shows the module control register 1.

Figure 9–9 Module Control Register 1

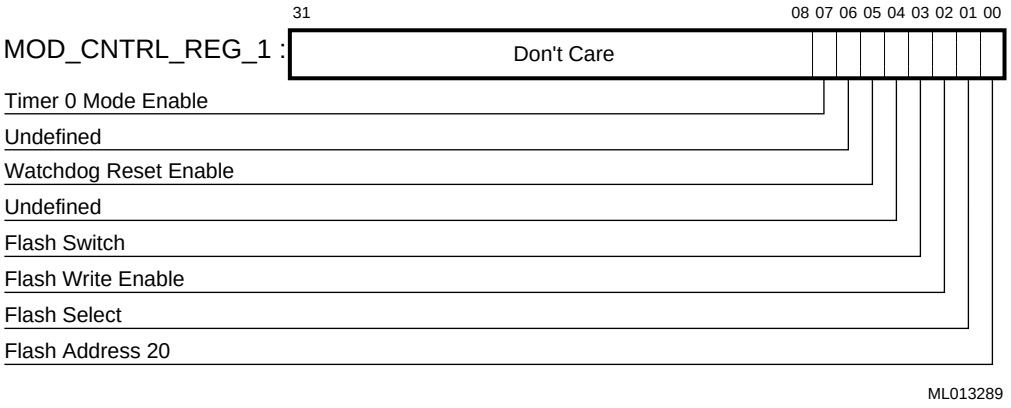


Table 9–8 Module Control Register

Field	Name	Type	Description
<1:0>	Flash Address 20 Flash Select		Divide flash ROM into four 1 MB windows. Flash Select divides the ROM into two 2 MB segments and Flash Address 20 divides the segments in half. These two bits default to <00> at power-up, selecting the device containing the console image in the bottom 512 KB. The remaining 3.5 MB is available for user flash.
<2>	Flash Write Enable		Default at power-up is 0. When set to 1, this bit asserts write enable to the four flash ROMs to allow updates. To avoid corrupting the flash ROMs, keep this bit cleared (0) when not updating.
<3>	Flash Switch	Read only	Indicates the state of the flash ROM update DIP switch. When set, flash ROM updates are enabled. When clear, the flash Write Enable bit is not allowed to enable writes to flash.
<4>			Undefined

(continued on next page)

Table 9–8 (Cont.) Module Control Register

Field	Name	Type	Description
<5>	Watchdog Timer Reset Enable		When 0, watchdog timer expiration has no effect. If set, and the DIP bit of the reset reason register is cleared, a watchdog timer expiration generates a hardware reset of the module. Reset default is disabled.
<6>			Undefined/reserved
<7>	Timer 0 Mode 1 Enable		Default at power-up is 0. When 0, Timer 0 in the 82C54 can only operate in modes 0 and 3. When set, the polarity of the TIMER0 gate input of the 8254 timer chip is inverted, allowing proper operation in modes 1 and 5.

9.2.8 Bcache Configuration Register

CPU address: 0x1C00101E0
Nbus offset: 0x80F

The Bcache configuration register shows the size and speed of the backup cache. The values in this register are determined at installation by setting jumper J10 on the CPU board. This is a read-only register.

Figure 9–10 Bcache Configuration Register

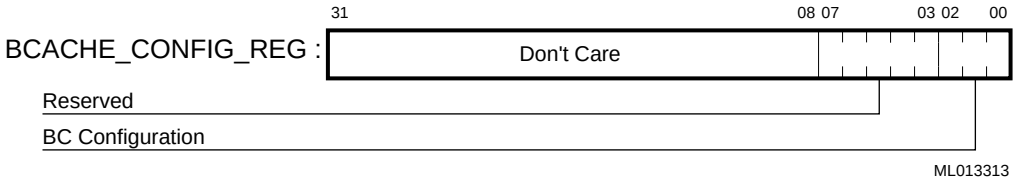


Table 9–9 Bcache Size and Speed Decode

<2>	<1>	<0>	Bcache Size	Bcache Speed
0	0	0	Disables Bcache	
0	0	1	512 KB	15 ns
0	1	0	2 MB	12 ns
0	1	1		Reserved for future use
1	0	0		Reserved for future use
1	0	1		Reserved for future use
1	1	0		Reserved for future use
1	1	1		Reserved for future use

9.3 ROM

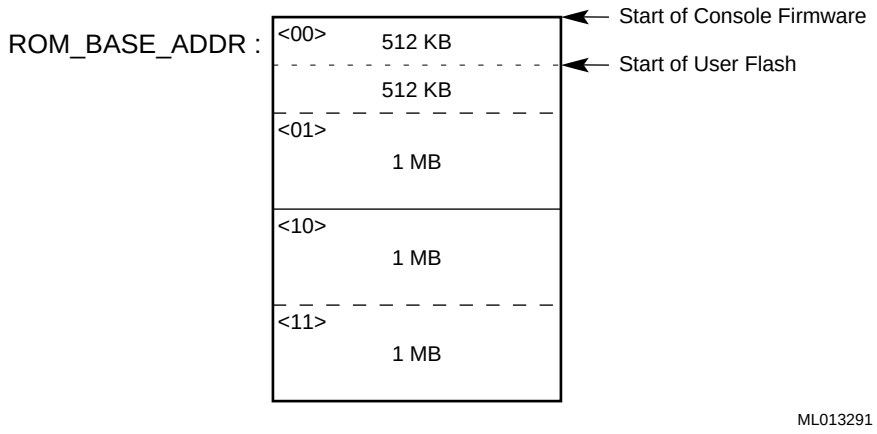
The system has two ROM structures:

- Serial ROM (SROM)
  Contains 8 KB of code serially loaded into the 21064A chip's internal cache (Icache) on power-up. This 8 KB of SROM is copied into the processor instruction cache during a reset. Execution control is passed to this code in PAL mode. The function of the SROM code is as follows:
  - Verify the processor operation
  - Identify the reset type
  - Find 2 MB of good memory
  - Check the ability to read system ROM (checksum)
  - Decompress 512 KB of ROM (initialization code) into memory
  - Transfer control to initialization code

  The SROM is socketed to allow future firmware upgrades.
- System ROM (flash)
  CPU address = 0x200000000
  PCI sparse memory address = ROM_BASE_ADDR = 0x00000000

  The flash ROM is accessible as a contiguous 1 MB in PCI memory space. Only byte accesses to the ROM are supported. The first 512 KB of flash ROM are reserved for console use (Figure 9–11). The remaining space in the flash ROM is reserved for onboard user code. Since the system has a total of 4 MB of flash ROM, the ROM is segmented into 1 MB windows using bits <1:0> of the module control register.

Figure 9–11 Flash ROM Layout/Addressing



The flash ROM can be rewritten. To protect the flash ROM from unauthorized /accidental updates, a hardware switch must be closed before write operations are enabled. The switch, DIP switch 2 on the Digital Alpha VME 4 assembly, must **always** be open unless flash ROM is going to be updated. The state of the switch is stored in the Flash Switch bit <3> of the module control register.

The flash ROM is also protected by a software enable; the Flash Write Enable bit <2> and the Flash Switch bit <3> of the module control register must be set to enable flash updates.

9.4 Super I/O Chip

The FDC37C665GT Super I/O (SIO) chip supports two 16550 UARTS (channel A and channel B) and one parallel port. It provides FIFO for serial ports and EPP/ECP modes for the parallel port.

For more information on the SIO chip and its operation, see SMC's *FDC37C665GT Super I/O Specification*.

9.4.1 Serial Port Channels A and B

The SIO chip supports channels A and B. Channel A is used for the Digital Alpha VME 4 console. It is configured by firmware as an asynchronous line. You can define the configuration by setting the baud rate, parity, data bits, and stop bit values that are stored in NVRAM.

In the absence of valid data in NVRAM on power-up, channel A is programmed with a default of 9600 baud, 8-bits, no parity, and one stop bit.

Channel B is uncommitted and uninitialized by system firmware.

For more information about these serial lines, see Chapter 2.

9.4.2 Super I/O Register Address Space

CPU Address: 0x1C0003E00 - 0x1C0007FE0
Nbus offset: 0x01F0 - 0x03FF

Table 9–10 lists the base address values for the serial port and parallel port controller.

The general registers are located at addresses 398 (index address) and 399 (data address). For example, writing an index value of 1 to address 398 selects the function address register. If a read transaction from address 399 follows, the data associated with the function address register is returned. If a write transaction to address 399 follows, the function address register is updated.

Table 9–10 Super I/O Register Address Space Map

Address Offset Read/Write	Physical Address	Register
General Registers		
398	1 C000 7300	Index address register
399	1 C000 7320	Data address register
	Index	**Register**
	0	Function enable register
	1	Function address register
	2	Power and test register

(continued on next page)

Table 9–10 (Cont.) Super I/O Register Address Space Map

Address Offset Read/Write	Physical Address	Register
COM2 Serial Port Registers		
2F8-R 0DLAB=0	1 C000 5F00	COM2 receiver buffer register
2F8-W 0DLAB=0	1 C000 5F00	COM2 transmitter holding register
2F8 0DLAB=1	1 C000 5F00	COM2 divisor latch register (LSB)
2F9 1DLAB=0	1 C000 5F20	COM2 interrupt enable register
2F9 1DLAB=1	1 C000 5F20	COM2 divisor latch register (MSB)
2FA-R	1 C000 5F40	COM2 interrupt identification register
2FA-W	1 C000 5F40	COM2 FIFO control register
2FB	1 C000 5F60	COM2 line control register
2FC	1 C000 5F80	COM2 modem control register
2FD	1 C000 5FA0	COM2 line status register
2FE	1 C000 5FC0	COM2 modem status register
2FF	1 C000 5FE0	COM2 scratch pad register
COM1 Serial Port Registers		
3F8-R 0DLAB=0	1 C000 7F00	COM1 receiver buffer register
3F8-W 0DLAB=0	1 C000 7F00	COM1 transmitter holding register
3F8 0DLAB=1	1 C000 7F00	COM1 divisor latch register (LSB)
3F9 1DLAB=0	1 C000 7F20	COM1 interrupt enable register
3F9 1DLAB=1	1 C000 7F20	COM1 divisor latch register (MSB)
3FA-R	1 C000 7F40	COM1 interrupt identification register
3FA-W	1 C000 7F40	COM1 FIFO control register
3FB	1 C000 7F60	COM1 line control register
3FC	1 C000 7F80	COM1 modem control register
3FD	1 C000 7FA0	COM1 line status register
3FE	1 C000 7FC0	COM1 modem status register
3FF	1 C000 7FE0	COM1 scratch pad register

(continued on next page)

Table 9–10 (Cont.) Super I/O Register Address Space Map

Address Offset Read/Write	Physical Address	Register
Parallel Port Registers		
3BC-R/W	1 C000 7780	Data register
3BD-R	1 C000 77A0	Status register
3BE-R/W	1 C000 77C0	Control register
3BF	1 C000 77E0	None (tristate bus)

Table 9–11 lists the addresses for the integrated device electronics (IDE) registers.

Table 9–11 Integrated Device Electronics Register Addresses

Address Offset	Physical Address	Read Function	Write Function
1F0	1 C000 3E00	Data	Data
1F1	1 C000 3E20	Error	Features (write precomp)
1F2	1 C000 3E40	Sector count	Sector count
1F3	1 C000 3E60	Sector number	Sector number
1F4	1 C000 3E80	Cylinder low	Cylinder low
1F5	1 C000 3EA0	Cylinder high	Cylinder high
1F6	1 C000 3EC0	Drive/head	Drive/head
1F7	1 C000 3EE0	Status	Command
3F6	1 C000 7EC0	Alternate status	Device control
3F7	1 C000 7EE0	Drive address	Not used

9.5 Keyboard and Mouse Controller

CPU Address: 0x1C0000C00 - 0x1C0000C80
Nbus offset: 0x0060 - 0x0064

The keyboard/mouse controller function is contained in a single-chip microcomputer (Intel 82C42PE) programmed to be IBM PC/AT compatible and can drive DECpc supported keyboards and a PS/2 type mouse. The keyboard and mouse ports are female 6-pin mini-DIN, PS/2 type connectors. The keyboard/mouse controller is programmed to allow either device to operate on either port.

Table 9–12 lists the register and memory addresses for the keyboard/mouse controller.

Table 9–12 Keyboard and Mouse Controller Addresses

Offset	Physical Address	Register
60-R	1 C000 0C00	Auxiliary/keyboard data
60-W	1 C000 0C00	Command data
64-R	1 C000 0C80	Read status
64-W	1 C000 0C80	Command

9.6 TOY Clock

The TOY clock function maintains the timekeeping information: year, month, date, day, hour, minute, second, 1/10th of a second, and 1/100th of a second. The date is corrected for months with fewer than 31 days and for leap years. The time can be maintained in 24-hour format or 12-hour with AM/PM format. The time is stored in binary code decimal (BCD). For example, a time of 29 minutes is stored in location (TOY_BASE_ADDR+02) as 0x29.

A Dallas Semiconductor DS1386 chip is used to implement the TOY clock but does not support the chip's alarm features. This chip also maintains the watchdog timer and SRAM functionality, described in Sections 9.8 and 9.9.

The square wave output of the chip generates a fixed 1024 Hz interval interrupt. Timekeeping accuracy is better than +/-1 minute/month at 25°C.

Timekeeping is maintained in the absence of Vcc by an internal lithium energy cell, which has an active life of at least 10 years. In addition, the device internally protects against spurious accesses during power transitions. Some applications may require the TOY clock (and SRAM) to operate from an external uninterruptable power supply (UPS). Digital Alpha VME 4 has an onboard switch (J3 switch 1) to allow a connection to the 5 V standby connection on the VMEbus (5VSTDBY). When switch 1 is closed, VME 5VSTDBY is connected to the TOY clock supply through isolation diodes.

The chip is socketed to allow:

- Replacement when the internal power source is no longer functional
- Physical removal of the NVRAM

The TOY clock timekeeping registers are updated every 0.01 seconds. Access to the TOY clock, to examine or set current time, is by nine registers: the timekeeping registers and the command register.

9.6.1 TOY Clock Timekeeping Registers

CPU Address: 0x1C0100000 - 0x1C01FFFE0
Nbus offset: 0x8000 - 0xFFFF

Time information is contained in eight 8-bit read/write registers offset from the base address:

Table 9–13 TOY Clock Timekeeping Registers

Field	Register	Description
<0:3>	TOY_BASE_ADDR+00	0.00 sec
<4:7>		0.0 sec
<0:6>	TOY_BASE_ADDR+01	Second
<0:6>	TOY_BASE_ADDR+02	Minute
<0:5>	TOY_BASE_ADDR+04	Hour
<0:3>	TOY_BASE_ADDR+06	Day
<0:5>	TOY_BASE_ADDR+08	Date
<0:4>	TOY_BASE_ADDR+09	Month
<0:7>	TOY_BASE_ADDR+0A	Year

These registers are also used to control the following:

Field	Register	Description
<6>	TOY_BASE_ADDR+04	Specifies the format of the Hour unit. When clear, hours are stored as BCD from 0x00 to 0x23. When set, the format is 12-hour, that is, the hours are 01 to 12.
<5>		Used with <6>=1. When clear, hours are AM. When set, hours are PM.
<6>	TOY_BASE_ADDR+09	Enable Square Wave Enables/disables the fixed-frequency square wave output. When clear, the wave output is enabled and can be used as the heartbeat interval timer interrupt delivered through the interrupt register 2<5>.

Field	Register	Description
<7>	TOY_BASE_ADDR+09	Enable Oscillator bit. Enables/disables the TOY clock chip's internal oscillator. Use it to conserve the lithium source during transport, storage, or during any long period of non-use. When clear, the TOY clock operates. When set, the internal oscillator is disabled (factory default).

These registers are not used:

TOY_BASE_ADDR+03
TOY_BASE_ADDR+05
TOY_BASE_ADDR+07

9.6.2 TOY Clock Command Register

The TOY clock command register, located at TOY_BASE_ADDR+0B, controls the operation of the TOY clock. Figure 9–12 shows this register.

Figure 9–12 TOY Clock Command Register

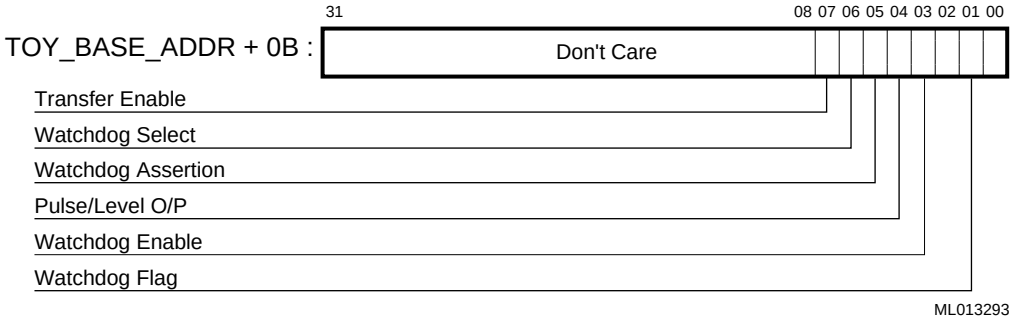


Table 9–14 TOY Clock Command Register

Field	Name	Type	Description
<0>			Not used
<1>	Watchdog Timer Flag	R/W	

(continued on next page)

Table 9–14 (Cont.) TOY Clock Command Register

Field	Name	Type	Description
<2>			Not used
<3>	Watchdog Timer Enable	R/W	
<4>	Pulse/Level O/P	R/W	
<5>	Watchdog Timer Assertion	R/W	
<6>	Watchdog Timer Select	R/W	
<7>	Transfer Enable	R/W	Enables/disables changes to the values in the timekeeping registers. When clear, the current value in the readable registers is frozen even though the internal timing continues. This prevents the update of the registers from changing the values during a read operation or from updating the new value during a write operation.

The 1024 Hz square wave clock output of the TOY clock is fed to interrupt register 2<5>. Everytime the clock makes a low-to-high transition, the interrupt register 2<5> is asserted and held asserted. The interrupt request input is only deasserted by writing to the heartbeat (clear-interrupt) register at address 0x80C on the Nbus.

9.7 Interval Timing Registers

CPU Address: 0x1C0080000 - 0x1C00BFFE0
Nbus offset: 0x4000 - 0x7FFF

Digital Alpha VME 4's timer/counters are based on the 82C54 device. For more detail on the 82C54, see the vendor/DECchip specification.

The 82C54 is made up of three independent but identical 16-bit counter/timers, implemented by some register/interrupt logic. The programming interface is bytewide in the Nbus region of PCI I/O space.

On power-up, the chip is in an undefined state and must be initialized before use.

The timer interface takes up the least significant byte of six adjacent longwords in Nbus space (see Table 9–15). The first four are the standard four bytewide registers of the 82C54 chip, and the other two bytes are an interrupt status register.

Table 9–15 Timer Interface Registers

Field	Register TMR_BASE_ADDR = 4000	Description
<7:0>	TMR_BASE_ADDR+00	Timer#0 Register
	TMR_BASE_ADDR+04	Timer#1 Register
	TMR_BASE_ADDR+08	Timer#2 Register
	TMR_BASE_ADDR+0C	Control Register
	TMR_BASE_ADDR+10	Interrupt Status Register
	TMR_BASE_ADDR+14	Interrupt Status Register

To program the timer device for initialization or during normal operation, the control byte (TMR_BASE_ADDR + 0x0C) is written. To access (read or write) the individual timer count values, the separate timer data registers are used (TMR_BASE_ADDR +0x00 to +0x08).

9.7.1 Interval Timing Control Register

In the interval timing control register, the control byte shown in Figure 9–13, defines the mode of operation of and provides access control to each individual timer.

Because only a single byte in the 82C54 address space is used to access the full 16-bit counter value, two accesses are required to operate on the full 16 bits. The access can use least-significant bit, most-significant bit, or both.

Figure 9–13 82C54 Control Byte

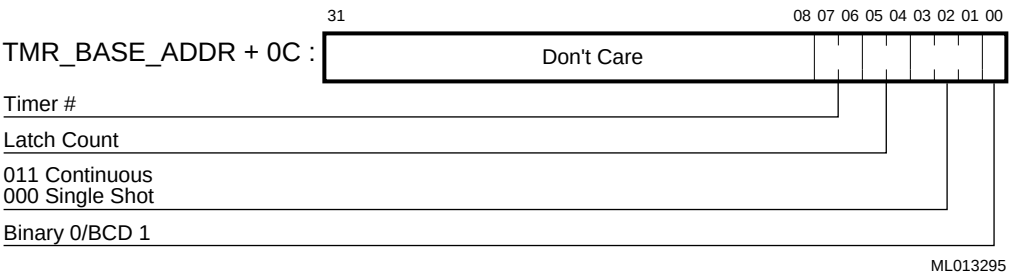


Table 9–16 Interval Timing Control Register

Field	Name	Type	Description
<7:6>			Specifies which timer is to be configured by this control byte. When set to "11", the control byte is a status read command, not a Timer Control operation. As a status read command, the control byte can be used to freeze the state of the timers for read-back. Information pertaining to the assertion state of the output pin, the mode of operation, the read-write access mode, and so forth, is then available by reading the timer data register.
<5:4>			Sets the data interface to accept one or both of the bytes of the timer's 16-bit counter whenever a read or a write operation to that timer occurs. When set, all operations to the timer register are in the format set until a new mode is set by another control byte to the timer, according to the following values:

Value	Description
00	Latch count for read-back
01	LSB-only access mode
10	MSB-only access mode
11	LSB,MSB access mode

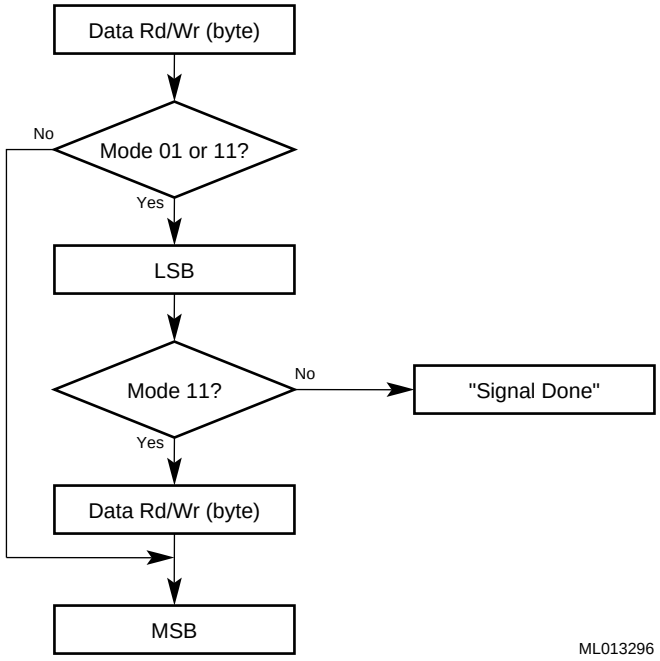
<3:1>			Defines the operational mode of the timer, according to the following values:

Value	Description
011	Continuous
000	Single shot

<0>			Sets the timer's 16-bit counter to either binary or BCD. When clear, the format is binary. When set, the format is BCD.

Figure 9–14 shows a conceptual view of the operation of the timer bytewide data interface. The "signal done" action is important where the completion of a data access becomes an implicit **start**/**go** command to the timer.

Figure 9–14 82C54 Timer Data Access



9.7.2 Timer Registers

Each timer element is a 16-bit synchronous down counter. The device asserts or pulses the corresponding output pin when a counter reaches a 0 count. The following timers are identical in function but are fully independent:

- Timer #0 must be clocked externally by P2 pin C13. Optionally, its gate input can also be driven by P2 pin C14. When Timer #0 makes a low-to-high transition, its output causes the assertion of an interrupt request (IRQ). The IRQ can be dismissed by an access to the timer interrupt status register.
- Timer #1 operates as a rate generator with its output being driven off module by P2 pin C12. This timer is clocked by a fixed 10 MHz. The output is also routed directly to VIC local IRQ input <3>.
- Timer #2 operates as a rate generator with its output connected to P2 pin C11. This timer is clocked with the same fixed 10 MHz. The output can also be used on the module to generate an interrupt request. If enabled, Timer #0's output during a transition from low-to-high causes the assertion of an

interrupt request (IRQ). The IRQ can be dismissed by an access to the timer interrupt status register.

9.7.3 Timer Modes

Of the six timer modes of which the 82C54 chip is capable, Digital Alpha VME 4 implements the following counting modes:

Table 9–17 Timer Modes

Mode	Description	Restrictions	Timers
0	Software retriggerable one-shot timer	N≥3	1, 2
1	Hardware retriggerable one-shot timer	N>=2, CLK<3 MHz	0 only
3	Periodic square wave generator	N>=5	1, 2
5	Hardware triggered strobe	CLK<3 MHz	0 only

Timer #0 Does Not Support Modes 1 and 5

Timer #0 does not function properly in modes 1 and 5. These modes are needed to support the distributed timer functionality across the VME backplane. The circuitry supporting timer #0 will be changing to enable modes 1 and 5. When this change occurs, all modes other than 1 and 5, will be disabled. As a result, this timer should not be used until this problem has been corrected.

For timers #0 and #2, which can cause timer interrupts through the interrupt register 3<3> (reported through the timer interrupt status register), an output low-to-high transition is considered to be the timer expiration that causes a status bit to be set and, if enabled, the interrupt request to be asserted.

Timer #1 can cause an interrupt through the VIC64 chip local IRQ3 only. Even though the VIC64 chip can be programmed to accept either assertion level at its local IRQ input, it is usually configured to generate an interrupt on the rising edge of timer #1 output.

- **Mode 0 - Software Retriggerable One-Shot**

  This mode allows a value to be written to the timer, which then counts down, asserting the output (high) when it reaches 0. In this mode, it takes N+1 clock ticks from the end of the counter value write cycle until the output makes an active transition.

  If a new count value is written during the counting sequence, it is loaded on the next clock pulse and counting continues from the new value. This means the count is software retriggerable.

The timer output is initially high. When the timer value is written, the output is driven low. The counter decrements to 0 where it drives the output high.

- **Mode 1 - Hardware Retriggerable One-Shot**

  This mode allows a value to be written to the timer that can be used when a hardware trigger has been received. TMR_MAJOR_IP L (P2 pin C14) transitions from a high to a low.

  If a new count value is written to the counter during a one-shot pulse, the current one-shot is not affected unless the counter is retriggered. In that case, the counter is loaded with the new count and the one-shot pulse continues until the new count expires.

  The timer output is initially high. A trigger results in loading the counter and setting the output low on the next clock pulse, starting the one-shot. An initial count of *n* results in a one-shot pulse of *n* clock cycles in duration. The output is driven high when the counter reaches 0.

  The one-shot is retriggerable. The output remains low for *n* clocks after any trigger. The one-shot pulse can be repeated without rewriting the same count into the counter.

- **Mode 3 - Continuous, Square Wave Output**

  This mode generates a square wave output of period *n* clock ticks. This output is usually used to generate a rate output or a regular interrupt request to the CPU. For odd count values, the output is high for (*n*+1)/2 and low for (*n*-1)/2 counts. A count value of 1 is illegal.

  For timer #0, the gate input in this mode has a synchronizing or reset effect. If the gate goes low, the counter is reloaded with its original value and the counting restarts.

- **Mode 5 - Hardware Triggered Strobe**

  Placing timer #0 in this mode generates a single clock wide pulse delayed by *n*+1 clock cycles. The output is initially high. Counting is triggered by a high-to-low transition of TMR_MAJOR_IP L (P2 pin C14). The output of timer #0 goes low for one clock period after *n*+1 clock pulses. The counting sequence is retriggerable. Timer #0's output does not strobe low for *n*+1 clocks after any strobe.

9.7.4 Interrupts

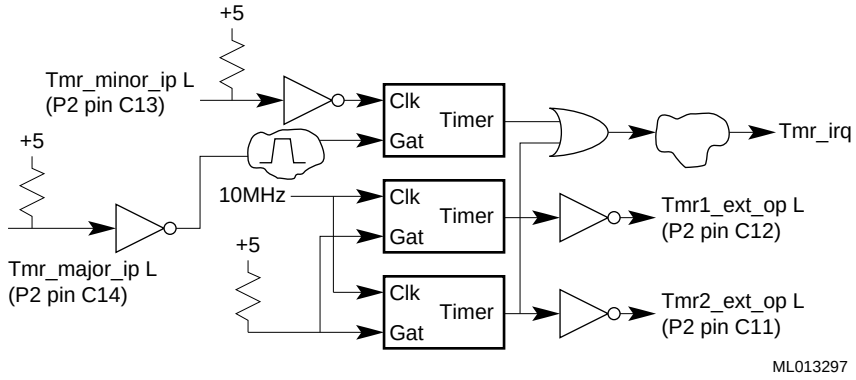
The expiration of timers #0 and #2 are recorded in a timer status register. The asserted state of either or both of the timer status bits can be enabled to assert an interrupt request.

The active low outputs of timer #1 and #2 are routed to P2 connector pins. The active low clock and gate inputs of timer #0 are also tied to P2 connector pins.

TMR1_EXT_OP L = P2 pin C12 (timer #1 output)
TMR2_EXT_OP L = P2 pin C11 (timer #2 output)
TMR_MINOR_IP L = P2 pin C13 (timer #0 clock input)
TMR_MAJOR_IP L = P2 pin C14 (timer #0 gate input)

Figure 9–15 shows the timer inputs and outputs.

Figure 9–15 Timer Clocking



The clock inputs to timer #1 and #2 are a fixed 10 MHz source. The clock input of timer #0 is from a P2 pin (TMR_MINOR_IP L) only.

The gate inputs for timers #1 and #2 are permanently asserted. This means that 82C54 modes 1 and 5 are disabled on timers #1 and #2.

The timer #0 gate input is driven from P2 pin C13 through synchronization and edge detect logic. This signal conditioning means that when the gate input to the module makes a high-to-low transition, a synchronized single clock-tick pulse is presented to the gate input of the 82C54 (see details of the 26V12 PAL for exact timing information associated with this gate function).

The main timer interrupt request line from timers #0 and #2 through the timer interrupt status register logic is routed to interrupt register 2<5>.

The Timer IRQ line is asserted for a low-to-high transition of a timer's output pin when that timer is enabled in the CSR to cause an interrupt. The interrupt is held asserted until the timer status summary register is read (clear on read). The corresponding timer expiration status bit is always set by a low-to-high on the timer output but this only causes the IRQ line to be asserted if the corresponding interrupt enable bit is set.

In addition, the output of timer #1 is brought to the VIC IRQ <3>. As this is the straight output from the 82C54 chip, the VIC should be programmed for an edge-sensitive input for this interrupt (all other interrupts in the system are level).

9.7.5 Timer Interrupt Status Registers

The timer interrupt status register is aliased as the bottom byte in two contiguous longwords (as shown in Table 9–15). The action of the register is slightly different, depending on the address at which it is accessed and whether the access is a read or a write. Figure 9–16 shows the timer interrupt status register.

Figure 9–16 Timer Interrupt Status Register

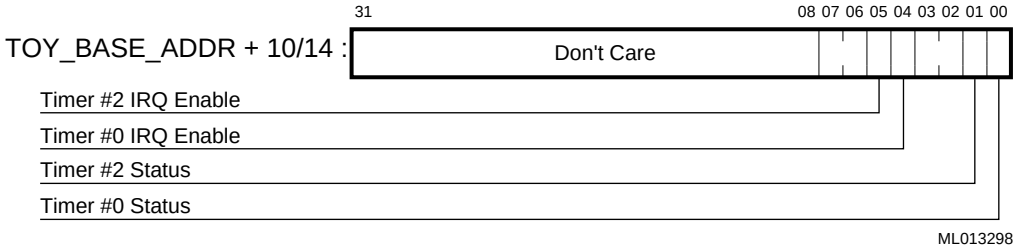


Table 9–18 Timer Interrupt Status Register

Field	Name	Type	Description
<0>			Timer #0 status When clear, the IRQ is dismissed. The bit is cleared at the end of the read cycle of a read operation originating from TMR_BASE_ ADDR+14. A read operation from TMR_BASE_ ADDR+10 has no effect.

(continued on next page)

Table 9–18 (Cont.) Timer Interrupt Status Register

Field	Name	Type	Description
<1>			Timer #2 status When clear, the IRQ is dismissed. The bit is cleared at the end of the read cycle of a read operation originating from TMR_BASE_ ADDR+14. A read operation from TMR_BASE_ ADDR+10 has no effect.
<2:3>	Not used		
<4>		Read	Status of Timer #0 IRQ Enable. When set, the timer output line has made an active transition.
<5>		Read	Status of Timer #2 IRQ Enable. When set, the timer output line has made an active transition.

Bits <1:0> dismiss the interrupt according to the following combination:

```
IRQ = (BIT <0> and BIT <4>) or (BIT <1> and BIT <5>)
```

Bits <5:4> are not writable. However, a write operation to address TMR_BASE_ ADDR+10 toggles bit <4> only and a write operation to TMR_BASE_ADDR+14 toggles bit <5> only. All other bits in the register are unaffected.

9.8 Watchdog Timer

The watchdog timer is included to allow hardware to bring the system back to some known state when software fails to function correctly. This timer is located on the same chip as the TOY clock.

The watchdog timer is initialized with some time value (in the range 0.01 to 99.9 seconds). If left unaccessed, the timer decrements towards 0. If allowed to reach 0, the watchdog timer first halts the system (jump to Halt entry firmware) and then forces the module into hardware reset (some 300 ms later). The module can be maintained by periodically accessing the watchdog timer registers. Any access to these registers resets the time back to the initialized value. Therefore, as long as the worst-case time between watchdog timer access is less than the programmed timeout value, the module functions normally.

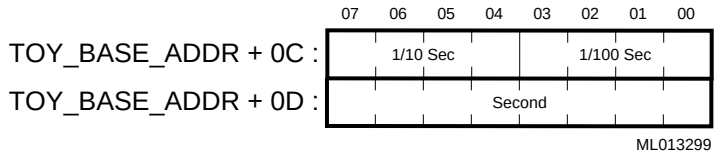
In addition to the hardware support for the watchdog timer operation, console firmware can be configured to dispatch to user code or continue with its default reset action on watchdog timer timeout. Firmware can detect the expiration of the watchdog timer during reset code by examining the hardware reset reason register (see Section 9.2.5). The “jump to halt” code just before causing a hardware reset enables firmware to take a snap-shot of the processor state

(general-purpose registers (GPRs), and so forth) at the time the watchdog timer expires before the full hardware reset.

Watchdog timer operation is controlled by four registers - three in the DS1386 chip and a single enable bit in the module control register. Operation of the watchdog timer must be configured in the TOY clock command register (TOY_BASE_ADDR+0x0B) and enabled in the module control register (MOD_CNTRL_REG).

The watchdog timer timeout time is set in BCD in two bytewide registers in the TOY clock's address space, as shown in Figure 9–17.

Figure 9–17 Watchdog Timer Registers



Within the TOY clock chip, the interrupt line and the pulse/level assertion of that interrupt line for the watchdog timer are selectable. In addition, the watchdog function can be enabled or disabled by the TOY clock command byte, bit <4>. Figure 9–18 shows the required setup of the watchdog timer.

Figure 9–18 Watchdog Timer TOY Clock Command Register

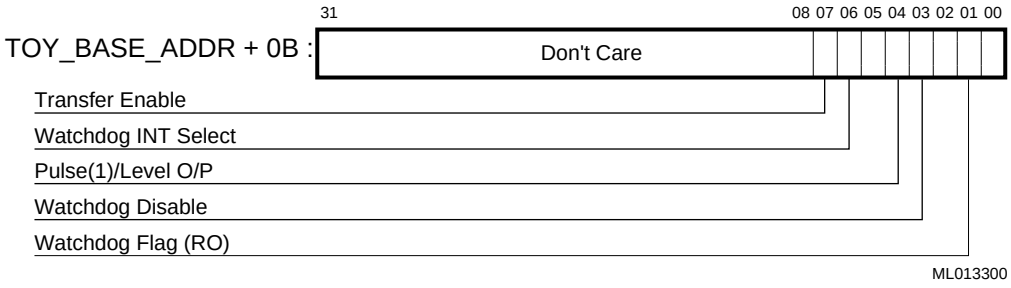
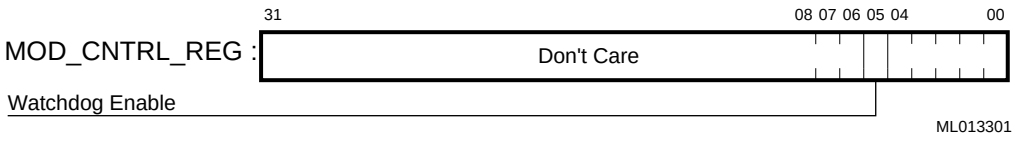


Table 9–19 Watchdog Timer TOY Clock Command Register

Field	Name	Type	Description
<0>			Not used
<1>	Watchdog timer flag	R/W	
<2>			Not used
<3>	Watchdog timer enable	R/W	
<4>	Pulse/level O/P	R/W	
<5>	Watchdog timer assertion	R/W	
<6>	Watchdog timer select	R/W	
<7>	Transfer enable	R/W	See description of TOY clock.

Because there exists the possibility to set up the watchdog timer in such a way that it would constantly drive the module into reset (by setting the watchdog timer output to level rather than pulse, for example), an external enable, which defaults to disabled on power-up, is included. This bit is in the module control register (see Figure 9–19), and described in Section 9.2.7. When the watchdog timer has been fully and correctly initialized, this bit should be set to allow normal watchdog timer operation.

Figure 9–19 Watchdog Timer Module Control Register



The reset generated by the watchdog timer is "one-shot," because the module control register is cleared, disabling the watchdog timer reset, when the hardware reset is asserted.

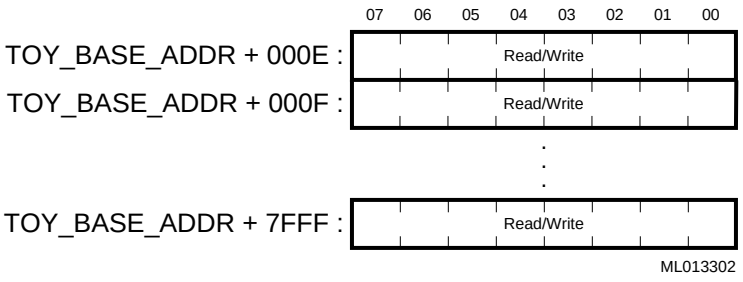
9.9 Nonvolatile RAM

Digital Alpha VME 4 offers just under 32 KB of battery backed-up on-board SRAM. The RAM is provided by the DS1386 chip and is held nonvolatile by the built-in lithium battery source.

The memory is read/write accessible in Nbus space. In effect, the DS1386 chip (TOY clock, watchdog timer, and NVRAM) contains 32 KB read/write byte elements. The lowest 14 of these bytes have special register functions for operation of the TOY clock and watchdog timer. The remaining bytes, 32 KB-14, are usable as general-purpose bytewide read/write RAM.

This RAM is organized as contiguous bytes starting at TOY_BASE_ADDR+0x0E through TOY_BASE_ADDR+7FFF, as shown in Figure 9–20.

Figure 9–20 NVRAM Access



As for the TOY clock operation, module switch 1 allows the VMEbus 5VSTDBY to be connected to the DS1386 giving RAM backup that is independent of both the normal 5 V supply and the internal lithium battery.

The firmware uses NVRAM for module parameters and settings, and error and failure information.

The lowest 16 KB of the battery backed-up RAM is reserved for firmware usage. Thus, user and O/S code should not access NVRAM below the address of TOY_ BASE_ADDR+0x4000.

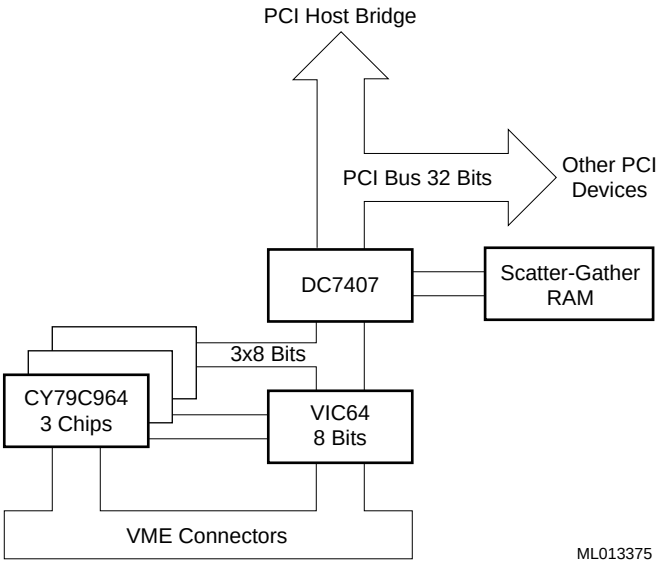
10

VME Interface

The VME interface handles the VMEbus and its interactions with the PCI bus. This chapter describes the functions of the VME interface, which are controlled by the operating system. See the documentation for the operating system for instructions on configuring the VME interface.

The VME interface consists of the DC7407 chip, the VIC64 chip, the CY7C964 bus interfaces, and the connectors to the VMEbus on the backplane. Figure 10–1 shows a block diagram of the VME interface.

Figure 10–1 VME Interface Block Diagram



The VME interface serves the following purposes:

- As a VMEbus master, it controls PCI bus-to-VMEbus, or outbound, transactions
- As a VMEbus slave, it handles VMEbus-to-PCI bus, or inbound, transactions and interprocessor communication.
- It can be configured as the VME system controller, handling functions such as arbitration of bus ownership.
- It handles interrupts to the VMEbus, as an interrupter and an interrupt servicing agent.

The VME interface conforms to the IEC 821, IEEE1014-1987, and D64 sections of IEEE1014 Rev.D (draft) standards.

This chapter:

- Describes VME master and slave operation as well as its other roles
- Describes the procedures for initalizing the VME interface
- Summarizes all the VME interface registers

10.1 VMEbus Master

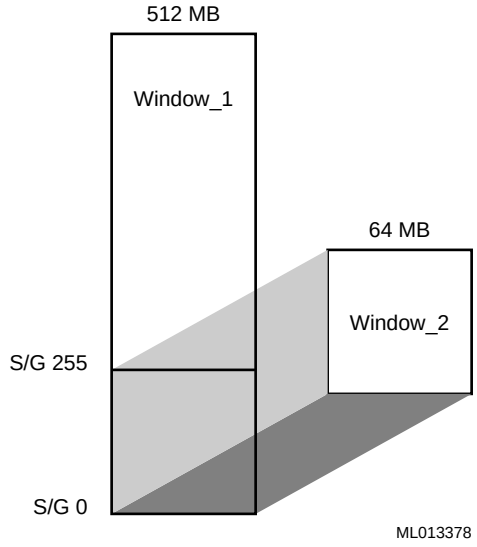
Digital Alpha VME 4 supports VME address spaces A16, A24, and A32, using two address windows to map from PCI memory space to VME address space:

- VME_WINDOW_1 is a 512 MB address window positioned in PCI memory space, divided into 2048 KB x 256 KB pages. Each page is mapped to VME address space by its own scatter-gather entry. The scatter-gather entries of the first 256 pages are also used to map the VME_WINDOW_2 pages.
- VME_WINDOW_2 is a 64 MB address window positioned in PCI memory space, divided into 256 KB x 256 KB pages. These pages are mapped by the same scatter-gather entries that mapped the first 256 pages in VME_ WINDOW_1. The VME_WINDOW_2 address allows support of "sparse space" access to the VMEbus.

Each of the first 256 scatter-gather entries maps two pages to the same VME address: a unique page within the VME_WINDOW_1 address window and an overlapped page within the VME_WINDOW_2 address window. For example, Entry 5 of the outbound scatter-gather RAM maps both page 5 of VME_ WINDOW_1 and page 5 of VME_WINDOW_2 to exactly the same VME address.

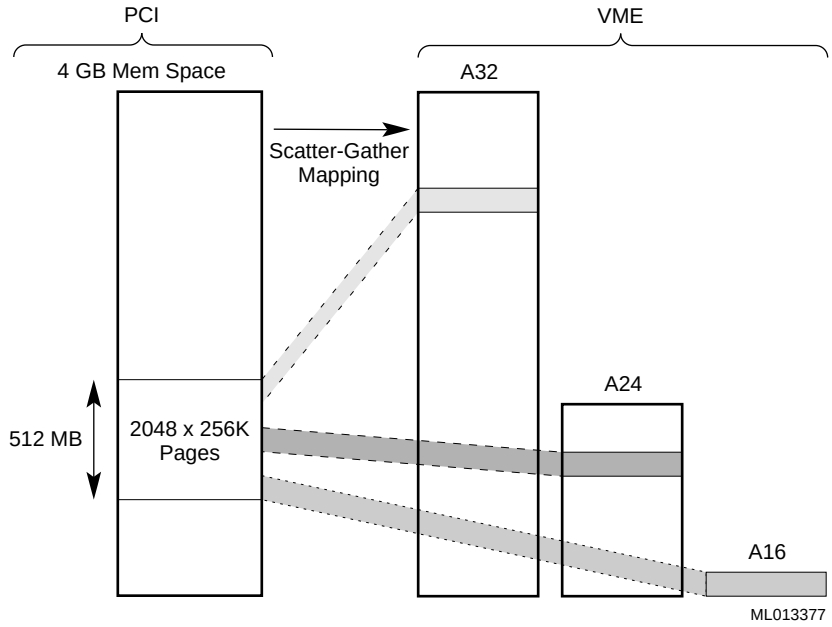
Figure 10–2 shows a mapping of Window_1 and Window_2.

Figure 10–2 Mapping Window_1 and Window_2



Each page can be mapped to any one of the three VMEbus address spaces: A32, A24, or A16. As shown in Figure 10–3, numerous pages can be mapped to the same VMEbus address to allow access to the same location with different modes. The address modifier code is fully programmable for each page.

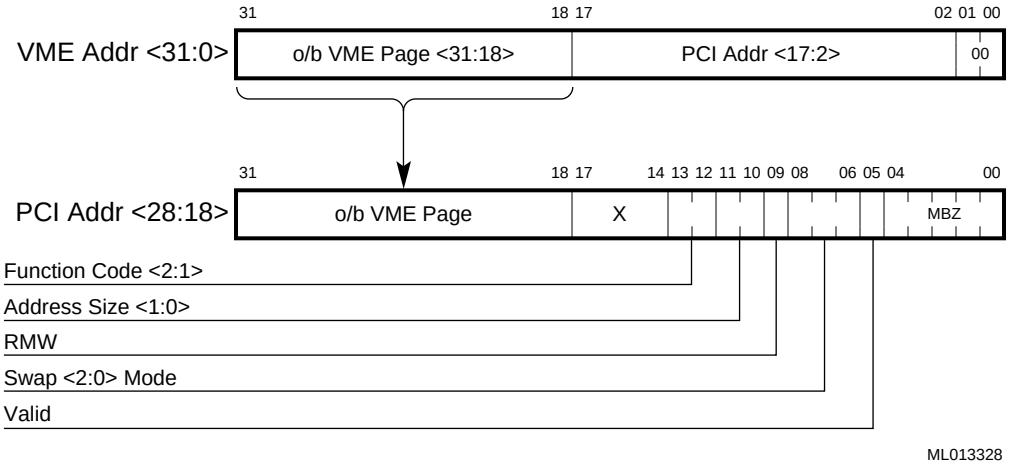
Figure 10–3 Mapping Pages From PCI to VME



10.1.1 Outbound Scatter-Gather Mapping

The outbound scatter-gather entries control and map all master accesses from Digital Alpha VME 4 to the VMEbus. Figure 10–4 shows an outbound scatter-gather entry and how the VMEbus address is formed from the VME page and the PCI address.

Figure 10–4 Outbound Scatter-Gather Entry



A PCI memory access in either VME WINDOW_1 or VME WINDOW_2 address windows causes a lookup for the corresponding scatter-gather entry. That is, if PCI Address bits <31:29> match the VME_WINDOW_1_BASE register or if PCI Address bits <31:26> match the VME_WINDOW_2_BASE register, a scatter-gather lookup occurs.

The scatter-gather entry is identified using either PCI address bits <28:18> or PCI address bits <25:15>. If the PCI memory cycle addresses VME_WINDOW_1, the scatter-gather entry is identified by PCI address bits <28:18>. If the PCI memory cycle addresses VME_WINDOW_2, the scatter-gather entry is identified by PCI address bits <25:18>.

Bits <31:18> of the scatter-gather entry provide the page address (VME address bits <31:18>) of the corresponding VMEbus page. PCI address bits <17:2>, together with the PCI byte enables, specify the byte address within that page.

Once the correct scatter-gather entry is identified, its valid bit, <5>, is checked. If the valid bit is set, the VME interface forms the VMEbus address from the scatter-gather entry. If the bit is not set, the scatter-gather entry is invalid and no VMEbus transaction can occur. Instead, the outbound Error bit in the VME Interface Processor Bus error/status register (VIP_BESR) is set. If the corresponding bit is also set in the VME interface processor interrupt control register (VIP_ICR), this event causes a DC7407 interrupt assertion.

The following sections describe the other fields of the scatter-gather entry.

10.1.1.1 Address Modifier

The scatter-gather entry has two fields that provide the address modifier used in the master VMEbus transfer. The address size (ASIZ) and function code (FC) fields map directly to the VME interface controller's input for ASIZ and FC. Table 10–1 shows the use of these fields.

Table 10–1 Formation of Address Modifier Codes from Scatter-Gather Entry

ASIZ1/0	FC2/1	Block Mode	Operation	AM<5:0>
01 (A32)	00	No	User Data	09h
	01	No	User Program	0Ah
	10	No	Supervisory Data	0Dh
	11	No	Supervisory Program	0Eh
	0x	Yes	User Page	0Bh (D64 08h)
	1x	Yes	Supervisory Page	0Fh (D64 0Ch)
11 (A24)	00	No	User Data	39h
	01	No	User Program	3Ah
	10	No	Supervisory Data	3Dh
	11	No	Supervisory Program	3Eh
	0x	Yes	User Page	3Bh (D64 38h)
	1x	Yes	Supervisory Page	3Fh (D64 3Ch)
10 (A16)	0x	No	User Access	29h
	1x	No	Supervisory Access	2Dh
00	User	Defined	AM codes	VIC_AMSR

10.1.1.2 Read-Modify-Write

When a scatter-gather entry's read-modify-write (RMW) bit is set, any master access to that page causes the VME interface to perform the next two accesses as a single sequence of VMEbus cycles. The two accesses are:

- The one whose scatter-gather entry has RMW bit set
- The next PCI cycle that addresses the VMEbus

The two accesses are handled as an indivisible sequence on the VMEbus by acquiring VMEbus ownership for the current access and holding it until another master operation is done by the processor. This is designed for doing atomic VMEbus RMW cycles.

The VIC interface configuration register must be programmed with **VIC_ICR**<7:5> = 001. A value of **VIC_ICR**<7:5> = 000 disables the RMW mode regardless of the setting in the scatter-gather map, while any other **VIC_ICR**<7:5> value gives UNPREDICTABLE results.

To use the RMW mechanism, software must be able to guarantee sequential execution of the two PCI cycles to the VMEbus on the PCI bus.

An alternate way of defining a divisible sequence is to use the VIC64 "bus capture and hold" mechanism, described in Section 10.3.1.

10.1.2 Data Transfers

As a master, data transfers are supported in two ways:

Single transfers: D08, D16, D32 data size
Block transfers: D16, D32, D64 data size

10.1.2.1 Single Mode Transfers

Single D08, D16, and D32 data transfers are executed by individual accesses to either of the two VME address windows in PCI memory space. The data size for the VME transfers are derived from the byte-enabling of the corresponding PCI cycle.

10.1.2.2 Block Mode Transfers

A block-mode DMA engine in the VME interface can be programmed to transfer up to 64 KB without processor intervention in D16, D32, or D64. The interface handles the segmentation of the transfer so as not to violate the VMEbus specification for crossing VME address boundaries.

The following restrictions apply to master block-mode transfers:

- Master block mode D64 transfers that do not start on naturally-aligned 2K boundaries on the VMEbus require some special care. If a 2 KB boundary crossing is enabled (**VIC_BTDR**<7> = 1), the VME starting address must be aligned to a 2 KB boundary.
- The PCI address must not cross a 64 KB aligned boundary. Usually, the operating system's DMA interface handles this restriction.

Because the VMEbus specification prohibits crossing any 256/2 KB boundaries, any DMA must split into a number of bus transfers. At the interval between these transfers, the VME interface can be programmed to wait a period of time before arbitrating again for the VMEbus and proceeding. This delay gives slave accesses to the Digital Alpha VME 4 the opportunity to complete during a block-mode transfer. This interleave period is programmable in the VIC block transfer control register, shown in Figure 10–5. Table 10–2 describes the register fields.

Figure 10–5 VIC Block Transfer Control Register

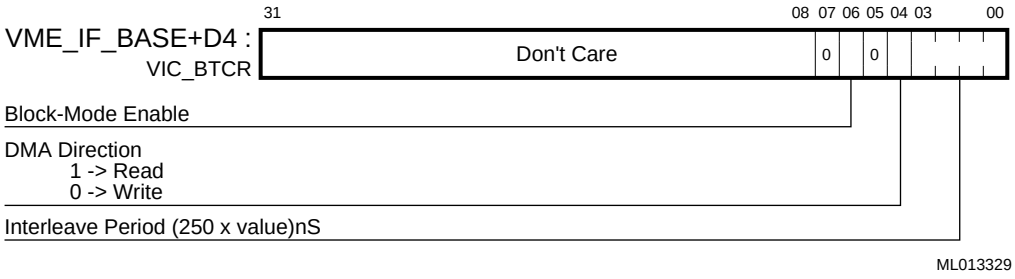


Table 10–2 VIC Block Transfer Control Register

Field	Name	Description
<3:0>	Interleave period	250xValue nanoseconds. Specifies a delay between bus transfers of blocks to allow arbitration of the bus.
<4>	DMA direction	When set, the direction is Read. When clear, the direction is Write.
<5>	Not used.	
<6>	Block-mode enable	When set, block mode is enabled. When clear, block mode is disabled.

The transfer burst length on the VMEbus can be programmed to be less than the maximum 256/2K burst, using the DMA burst length field of the VIC release control register (see Figure 10–12).

A block transfer setup consists of defining the:

- Data size
- Transfer direction
- Transfer length in bytes (must be even as D08 block mode is not supported)

- Source address
- Destination address

The mapping of PCI memory to VMEbus addresses is handled as usual through the scatter-gather mapping mechanism, however, the address modifiers in the mapping entry are automatically transformed to generate the block-mode version of the specified address modifier code (except for user-defined address modifier codes).

The following sequence of steps set up a master DMA:

1. Write the DMA transfer length to the VME byte length registers, VIC_ BTLR0, VIC_BTLR1. PCI deferred writes can be enabled to decouple the CPU from the holdups on the "local-bus" when setting up DMAs. D64 block mode operations are distinguished by a write to bit 4 of the VIC64's block transfer definition register (BTDR).
2. Write the DMA direction bit (read/write) and DMA enable bit to the VIC block transfer control register (VIC_BTCR).
3. Write to the desired PCI memory address (that will map to the target VMEbus address) with the required PCI start address as the write data.
4. Clear the DMA enable bit in the VIC_BTCR.
5. Wait for completion notification. The completion interrupt is enabled in the VIC status register (VIC_DMAICR) and its vector is generated by the VIC error group interrupt vector address register (VIC_EGIVBR).

10.1.3 Requesting the VMEbus

When Digital Alpha VME 4 acts as the VMEbus master, the VME interface must request ownership of the bus. Controlling the manner and level of the bus request is achieved using the VIC arbiter/requester configuration register (VIC_ARCR), shown in Figure 10–11. See Section 10.3.1 for information about this register and VMEbus arbitration.

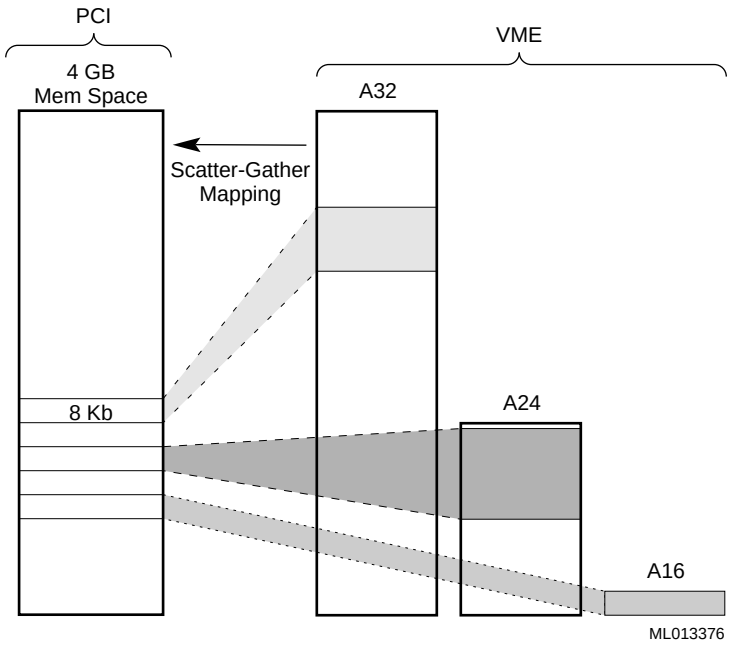
10.2 VMEbus Slave

The VME interface responds to A32, A24, and A16 accesses. A32 and A24 cycles are used to access the memory of a Digital Alpha VME 4 system's memory. Incoming A32 and A24 transactions are mapped to 8 KB pages by the VME interface's inbound scatter-gather maps. A16 cycles provide access to a small number of byte-wide interprocessor communication registers.

Incoming slave accesses are mapped and controlled by two incoming scatter-gather maps:

- For A32 accesses, a Digital Alpha VME 4 system occupies up to 128 MB of memory mapped by 16384 scatter-gather entries, each mapping an 8 KB page.
- For A24 accesses, a Digital Alpha VME 4 system occupies up to 16 MB mapped by 2048 scatter-gather entries, each mapping an 8 KB page.

Figure 10–6 Mapping Pages of Memory from VMEbus to PCI Bus

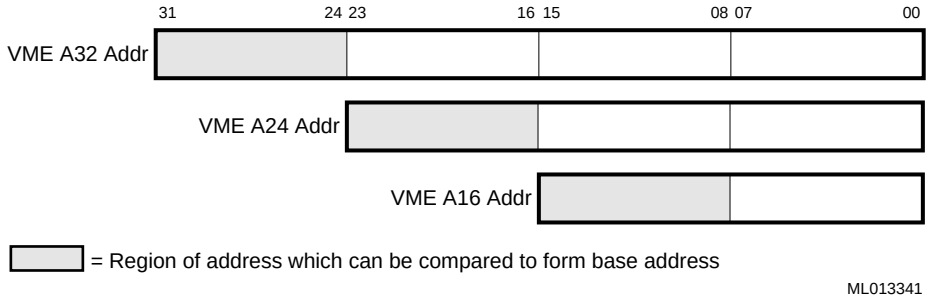


10.2.1 Decoding Addresses

The VME-to-PCI address decoding is implemented using CY7C964 bus interfaces within the VME interface. Three CY7C964 bus interfaces are accessed together in the VMEbus i/f address base (VIF_ABR) and VMEbus i/f address base mask (VIF_MASK) registers. The registers must be accessed as longwords even though the individual bytes represent address match data for separate VME address spaces.

VIF_ABR (VME_IF_BASE + 184) defines the base address of the Alpha VME 4 system in each VMEbus address space as shown in Figures 10–7 and 10–8.

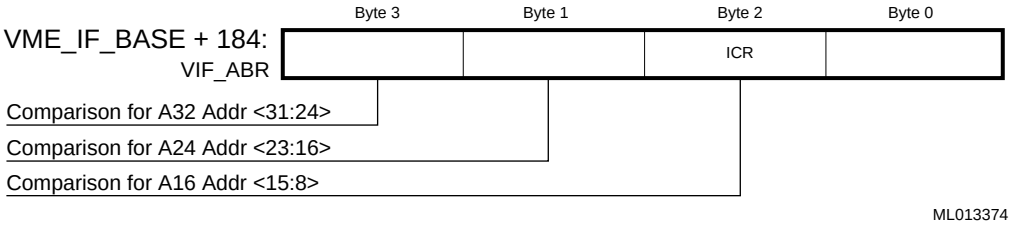
Figure 10–7 Address Decoding



Associated with each of the top three comparison bytes is a bit mask to control the number of bits that are checked during a VMEbus address match. These bits are contained in VIF_MASK at VME_IF_BASE + 0x180. If a bit is set, the address-to-base register bit is not used in the address comparison. At least the top five bits of the A32 address match byte must be used for matching.

Bytes 1 through 3 of VIF_ABR and VIF_MASK are contained in CY7C964 elements. These three bytes must be written simultaneously. Byte 0 is not used and does not affect address recognition. See the CY7C964 specification for more detail on the comparison and mask registers.

Figure 10–8 Base and Mask Register



10.2.2 Inbound Scatter-Gather Entries

The inbound scatter-gather RAM format is shown in Figure 10–9 and described in Table 10–3.

Figure 10–9 Inbound Scatter-Gather Entry With A32 Address Mapping

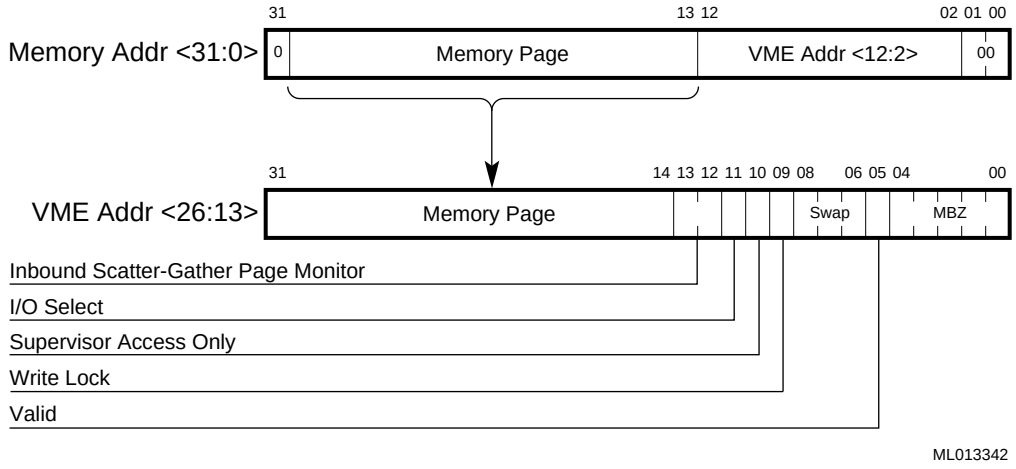


Table 10–3 VME Address

Field	Name	Description
<4:0>	MBZ	
<5>	Valid	
<8:6>	Swap	
<9>	Write Lock	Limits slave accesses to read-only, that is, a page can be write-locked.
<10>	Supervisor Access Only	Restricts access to supervisory cycles only.
<11>	PCI I/O Mem Select	When clear (the default), the VME master uses a PCI memory cycle to transfer VME data to the mapped main memory address. When set, it forces a PCI I/O cycle to allow a VME device access to one of Digital Alpha VME 4 system's I/O resources.

(continued on next page)

Table 10–3 (Cont.) VME Address

Field	Name	Description
<13:12>	Page Monitor	Specifies how a Digital Alpha VME 4 system checks the scatter-gather entry for access, according to the following values: 0 No monitoring of the page. 1 Each time the page is accessed, Monitor 1 is incremented. 2 Each time the page is accessed, Monitor 2 is incremented. 3 Each time the page is accessed, Monitor 3 is incremented. The counters are readable in the VME Interface Processor Page Monitor CSR, (VIP_PMCSR) shown in Figure 10–10.
<31:14>	Memory Page	

PCI uses C/BE<3:0> signals to specify which bytes are being accessed.

Table 10–4 PCI Address

Field	Description
<1:0>	Set to 00 to pad.
<12:2>	VME Address
<30:13>	Memory Page, that is, bits <31:14> of the VME address.
<31>	Set to 0 to force access to the lower 2GB of PCI memory space. Configuration cycles are never initiated by the VME interface.

Figure 10–10 VME Interface Processor Page Monitor CSR

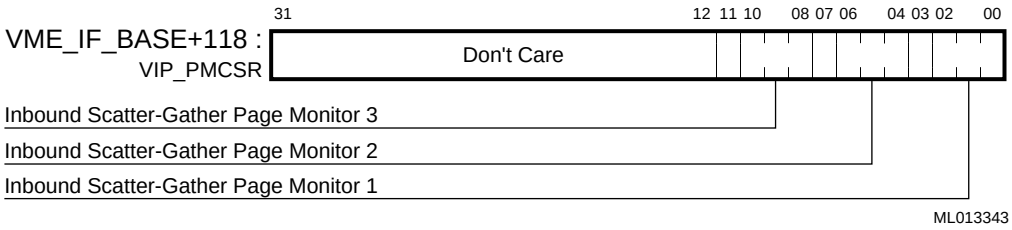


Table 10–5 VME Interface Processor Page Monitor CSR

Field	Name	Description
<2:0>	Monitor 1	Number of access to page.
<3>	Overflow	Overflow for Monitor 1. When a counter overflows, it sets a bit in VIP_BESR register. If enabled by the VIP_ICR register, the overflow causes **VIP_LIRQ**<0> interrupt to be asserted at **VIC_LIRQ**<2>.
<6:4>	Monitor 1	Number of access to page.
<7>	Overflow	Overflow for Monitor 1
<10:8>	Monitor 1	Number of access to page.
<11>	Overflow	Overflow for Monitor 1

10.2.3 Interprocessor Communication

Digital Alpha VME 4 system's VIC64 chip has two sets of registers, communication registers and software switches, which allow communication between processors. The use of these register sets are restricted to only one set at a time.

The registers are accessible in the VME interface register space mapped in PCI memory space. When accessed over the VMEbus, they are located in A16 space by Byte 1 of the VMEbus i/f address base register (VIF_ABR). They are also accessible from PCI memory space starting at address VME_IF_BASE + 0x60.

The interprocessor communication register map is shown in Table 10–6.

10.2.3.1 Interprocessor Communication Registers

Five of the general-purpose registers, the interprocessor communication registers (ICRs), are simply 8-bit read/write registers accessible over the VMEbus and in local PCI memory space. Two others allow VIC64 status and hardware revision information to be read over the VMEbus.

Bits <4:0> in the final register are set when there is a write access to the corresponding ICR. See the VIC64 specification for more detail.

10.2.3.2 Interprocessor Communication Global Switches

The Interprocessor Communication Global Switches (ICGSs) are software switches that may be set over the VMEbus (not locally accessible over the PCI bus) to interrupt a group of VMEbus modules that share an A16 base address.

Because the global switches are meant to be issued to several modules, the slave targets of a global switch access do not acknowledge the cycle, but rather the master driving the write data transfer acknowledgements (DTACKs) the cycle itself (the VIF_ABR should be set to generate a self-access by the global-switch write).

A write to an even address clears the selected switch and a write to an odd address sets the switch.

If global-switch interrupts are enabled in the VIC64 interprocessor communication global switch interface configuration register (ICGSICR), an interrupt is generated to the local processor by way of the system interrupt controller. The vector for the interrupt is generated from the VIC64 interprocessor communication global switch interface vector base register (ICGSVBR).

Bits <4:0> in the final register are set when there is a write access to the corresponding interprocessor communication group processor register (ICGPR). See the VIC64 specification for more complete details.

10.2.3.3 Interprocessor Communication Module Switches

The Interprocessor Communication Module Switches (ICMSs) are software-writable switches that can be set over the VMEbus to interrupt a processor. The module switches, however, are meant to be issued to a specific module.

Because the module switches are meant for a specific module, the cycle is just like a normal write on the bus (unlike for the global switch interface).

If interprocessor communication module-switch interrupts are enabled in the VIC64 interprocessor communication module switch interface configuration register (ICMSICR), an interrupt is generated. The vector for the interrupt is generated from the VIC64 interprocessor communication module switch vector base register (ICMSVBR).

Table 10–6 Interprocessor Communication Register Map Through VIF_ABR

<byte 1>+	Register	
Interprocessor communication registers (ICR)		
01	8-bit general-purpose register 0	R/W
03	8-bit general-purpose register 1	R/W
05	8-bit general-purpose register 2	R/W

(continued on next page)

Table 10–6 (Cont.) Interprocessor Communication Register Map Through VIF_ABR

<byte 1>+	Register	
Interprocessor communication registers (ICR)		
07	8-bit general-purpose register 3	R/W
09	8-bit general-purpose register 4	R/W
0B	VIC revision register	Read-only. Provides VIC64 hardware revision.
0D	VIC status register	Read-only. Provides VIC64 status revision.
0F	Intercommunication register status	Bits <4:0> are set when there is a write access to the corresponding ICR. See the VIC64 specification for more complete details.
Interprocessor communication global switches (ICGS)		
	Write Only. A write to an odd address sets the switch; a Write to an even address clears that switch.	
010	Clear global switch 0	
011	Set global switch 0	
012	Clear global switch 1	
013	Set global switch 1	
014	Clear global switch 2	
015	Set global switch 2	
016	Clear global switch 3	
017	Set global switch 3	

(continued on next page)

Table 10–6 (Cont.) Interprocessor Communication Register Map Through VIF_ABR

<byte 1>+	Register
Interprocessor communication module switches (ICMS)	
	Write-only. A write to an odd address sets the switch; a Write to an even address clears that switch.
020	Clear module switch 0
021	Set module switch 0
022	Clear module switch 1
023	Set module switch 1
024	Clear module switch 2
025	Set module switch 2
026	Clear module switch 3
027	Set module switch 3

10.3 System Controller Operation

A Digital Alpha VME 4 system can operate as a full VMEbus system controller (in slot 1). The Digital Alpha VME 4 system is selected as a system controller at power-up by the state of the module diagnostic-in-progress switch (position 4 closed).

As a system controller, the Digital Alpha VME 4 system provides the following functions:

- Causes a global reset to the VME interface logic.
- Controls VMEbus arbitration (driving BGIOUT*)
  - Priority (PRI)
  - Round-Robin (RRS)
  - Single-level (SGL)
- Drives the system clock (SYSCLK)
- Controls timeout timers for data transfers and arbitration
- Handles VMEbus interrupt control (driving IACK*)

The system controller functions are controlled through byte registers that are mapped into the lowest byte of an aligned longword in PCI memory space.

10.3.1 Arbitrating the VMEbus

10.3.1.1 Requesting the VMEbus

Three arbitration schemes — priority, round-robin, and single-level — are achieved by a combination of setting the arbiter/requester configuration register (VIC_ABR, offset 0xB0) and using the VMEbus request lines. See Table 10–7 and Figure 10–11.

The granting of ownership of the VMEbus to a master is passed down the VMEbus along a daisy-chain. Because of this arrangement, the masters further down the daisy-chain may be blocked by masters higher up the chain. This problem (bus starvation) can be minimized if the masters all implement a Fair Request scheme. If any master does not obey the fairness scheme, it can starve the masters further along the daisy-chain.

Under the Fair Request scheme, the Digital Alpha VME 4 system does not request the VMEbus for the duration of a fairness timeout period, if any other master is requesting the VMEbus. When the timeout period expires, the Digital Alpha VME 4 system asserts its request regardless of other requests. The fairness timeout period gives any other masters along the daisy-chain the opportunity to win the VMEbus.

Figure 10–11 VIC Arbiter/Requester Configuration Register

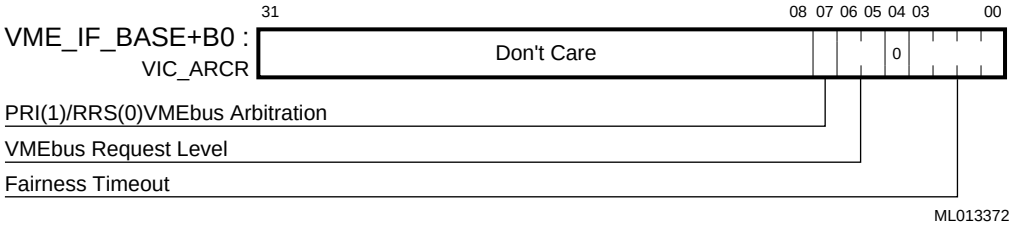


Table 10–7 Arbiter/Requester Configuration Register

Field	Name	Description
<3:0>	Fairness timeout	The fairness timeout field accepts the following values: 0 — Fair request is not enabled. Non-zero — Number of 2-microsecond intervals that make up the fairness timeout period. F — Fairness timeout period is not enabled, that is, the Digital Alpha VME 4 system can only request the VMEbus if no other requests for the VMEbus are being asserted.
<4>	Not used	
<6:5>	Request level	Sets the request level of each device to 0, 1, 2, or 3. The setting works with the value in <7> to specify the arbitration scheme according to the following table:
<7>		Works with a device's request level to specify the arbitration scheme. When clear, the arbitration scheme is round-robin. When set, other arbitration types are possible.

Scheme	Bit 7	Bus request level
Priority (PRI)	<7>= 1	Level 3 has the highest priority; level 0 has the lowest priority.
Round-robin (RRS)	<7>= 0	When a request is being handled on a bus request level *n*, the next request to be handled is on level *n*-1. If a request is being handled on level 0, the next request to be handled is on level 3.
Single-level (SGL)	<7>= 1	All bus requests are set to the same level.

10.3.1.2 Releasing the VMEbus

Once a Digital Alpha VME 4 system has acquired ownership of the VMEbus, it is important to control the manner in which it is relinquished. Four release modes are supported: release-on-request (ROR), release-when-done (RWD), release-on-clear (ROC), and bus capture and hold (BCAP). The release mode is configured in the VIC release control register (VIC_RCR, offset D0), shown in Figure 10–12 and Table 10–8.

In addition to these four bus release modes, the scatter-gather RMW bit (RMC) can be used to force Digital Alpha VME 4 to hold ownership of the VMEbus for two accesses before releasing in the programmed ROR, RWD, or ROC fashion. See Section 10.1.2 for details.

Figure 10–12 VIC Release Control Register

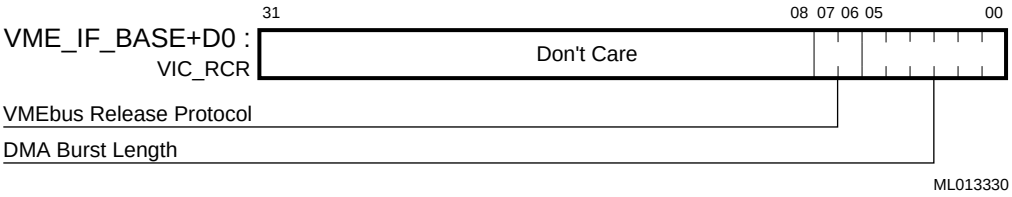


Table 10–8 VIC Release Control Register

Field	Name	Description
<5:0>	DMA burst length	Specifies the number of data transfers during a burst on the VMEbus. For example, a value of 4 means that 4 words are transferred in D16, or, in D32, it means 4 longwords. For D64 block-mode operation, the burst-length value is multiplied by four to give the maximum number of data transfers before giving up the bus. This means a maximum burst length value of 64 allows 256 (64x4) transfers of D64 data, which is 2048 bytes.

(continued on next page)

Table 10–8 (Cont.) VIC Release Control Register

Field	Name	Description
<7:6>	Release protocol	Specifies the release mode, according to the following values: 00 Release-on request (ROR) the Digital Alpha VME 4 system keeps ownership until another device requests the bus. 01 Release-when-done (RWD) the Digital Alpha VME 4 system releases the bus immediately after completion of the cycles for which it requested ownership. 10 Release-on-clear (ROC) the Digital Alpha VME 4 system retains ownership of the bus after completion of the cycles for which it requested ownership, until the system controller asserts the Bus Clear signal. 11 Capture and hold (BCAP) the Digital Alpha VME 4 system claims ownership of the VMEbus for as long as the BCAP mode is selected. The VMEbus is only released when the Digital Alpha VME 4 system is reprogrammed to another release mode.

10.3.2 System Clock Output

As the system controller, the Digital Alpha VME 4 system drives the system clock (SYSCLK) for the VMEbus. The clock is a fixed 16 MHz clock with a nominal 50% (+/- 10%) duty cycle. This 16 MHz timing has no fixed phase relationship with other bus timings.

10.3.3 Timeout Timers

10.3.3.1 Arbitration Timers

By default, the Digital Alpha VME 4 system operates as an arbitration watchdog when configured as VMEbus system controller. After issuing a VMEbus grant to the winning requester, the VME interface monitors the bus and, if it does not detect activity (BBSY* asserting) within 8 µs, it asserts the BBSY* signal to terminate the bus ownership and to allow rearbitration of the VMEbus. This arbitration timeout cannot be disabled. However, the condition can be used to generate a local interrupt to the processor. Control of this interrupt is through the VIC error group interrupt control register (VIC_EGICR). For more information, see Chapter 11.

10.3.3.2 VMEbus Transfer Timers

When enabled, the VME interface starts the transfer timer whenever the data phase of a cycle is signaled (DSx* asserting). If the timer expires before the data cycle is acknowledged or completes in error, the VME interface, as the system controller, flags a VMEbus error (asserting BERR*). This condition sets a status bit in the VMEbus error status register (VIC_BESR).

The transfer timeout is configured in the VMEbus transfer timeout register (VIC_TTR, offset 0xA0), shown in Figure 10–13.

Figure 10–13 VMEbus Transfer Timeout Register

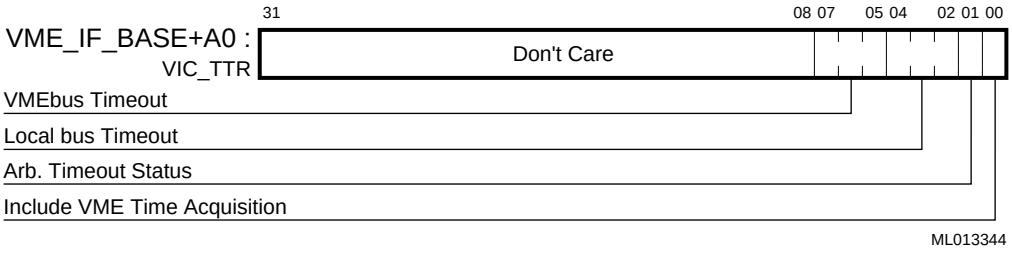


Table 10–9 VMEbus Transfer Timeout Register

Field	Name	Description
<0>		When set, the local bus timer includes the time for VMEbus acquisition
<1>	Arbitration timeout status	This bit is set when the arbitration timer expires.
<4:2>	Local bus timeout	Specifies the timeout, according to the following values: 000 4 microseconds 001 16 microseconds 010 32 microseconds 011 128 microseconds 100 256 microseconds 101 512 microseconds 111 Disabled

(continued on next page)

Table 10–9 (Cont.) VMEbus Transfer Timeout Register

Field	Name	Description
<7:5>	VMEbus timeout	Specifies the timeout, according to the following values: 000 4 microseconds 001 16 microseconds 010 32 microseconds 011 128 microseconds 100 256 microseconds 101 512 microseconds 111 Disabled

10.3.3.3 Local Bus Transfer Timer

When enabled, the local bus transfer timer starts whenever a data phase is initiated on the local bus (the bus between the VIC64 and DC7407). If the timer expires before the data cycle is acknowledged or terminated by an error, the VME interface signals a local bus timeout. This condition sets a status bit in the VMEbus error status register (VIC_BESR).

10.3.4 VMEbus Interrupt Handling

A Digital Alpha VME 4 system can act as a VMEbus interrupter as well as a VMEbus interrupt servicing agent (as described in Chapter 11). As system controller, the Digital Alpha VME 4 system drives the IACK daisy-chain if the VIC64 has no VME interrupt pending.

The VIC interrupt request/status register (VME_IF_BASE + 0x80) is used to control the state of the Digital Alpha VME 4 system's IRQ1*-7* lines driven out onto the VMEbus. This register provides the current state of the IRQ lines. Figure 10–14 shows the form of this register.

Figure 10–14 VIC Interrupt Request/Status Register

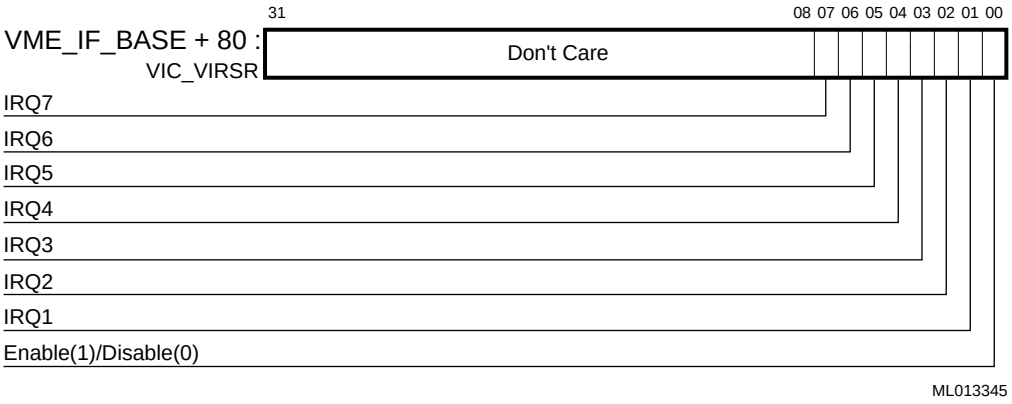
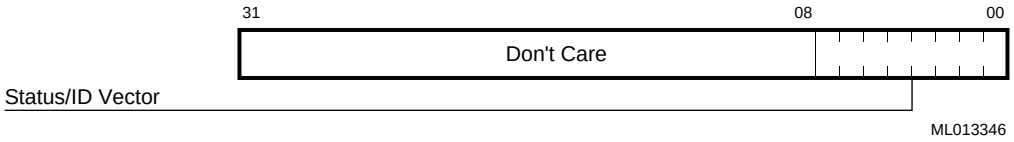


Table 10–10 VIC Interrupt Request/Status Register

Field	Name	Description
<0>		Controls whether the IRQs are reset or asserted. When <0> = 1, setting any of the bits <7:1> asserts the corresponding IRQ. When <0> = 0, setting any of the bits <7:1> clears the corresponding IRQ. For example, when <0> is set, setting <4> asserts IRQ4.
<1>	IRQ1	
<2>	IRQ2	
<3>	IRQ3	
<4>	IRQ4	
<5>	IRQ5	
<6>	IRQ6	
<7>	IRQ7	

A Digital Alpha VME 4 system uses the Release-On-Acknowledge method for removal of its interrupt requests. As an alternative, the interrupt requests can be deasserted by writing to the same VMEbus interrupt request/status register that is used to assert the IRQ* lines. When a Digital Alpha VME 4 system detects an IACK cycle on the VMEbus for one of its interrupt requests, it responds with a vector that is programmable in the VMEbus interrupt vector base registers (see Figure 10–15), starting at PCI memory address VIF_ABR+0x84.

Figure 10–15 VMEbus Interrupt Vector Base Registers



A local interrupt can be generated to the CPU by the VME interface when it detects a VMEbus IACK cycle for a VME interrupt that is pending. This interrupt can be used to inform system software that the VMEbus interrupt request has been serviced. The VIC interrupter interrupt control register (VME_IF_BASE + 0x00) provides enabling of priority encoding for this interrupt (Figure 10–16).

Figure 10–16 VMEbus Interrupter Interrupt Control Register

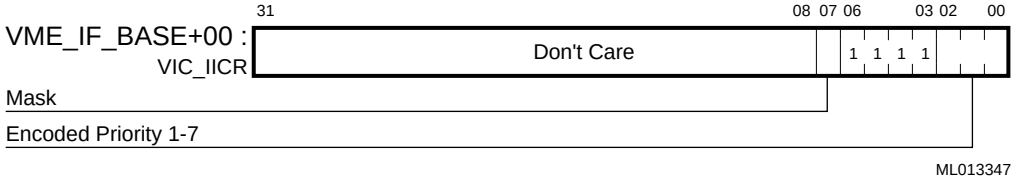


Table 10–11 VMEbus Interrupter Interrupt Control Register

Field	Name	Description
<2:0>	Priority	Priority 1-7
<6:3>	1111	
<7>	Mask	When set, no interrupt is generated.

The vector that is returned when the processor locally IACKs this interrupt comes from the VIC error group interrupt vector register (VIC_EGIVBR) described in Chapter 11.

10.4 Byte Swapping

The Digital Alpha VME 4 interface provides hardware to support byte-swapping for transfers to and from the VMEbus. Four modes of swapping are supported. The swap mode is defined for each inbound or outbound page by the related scatter-gather entry.

10.4.1 DC7407 Byte Swapping

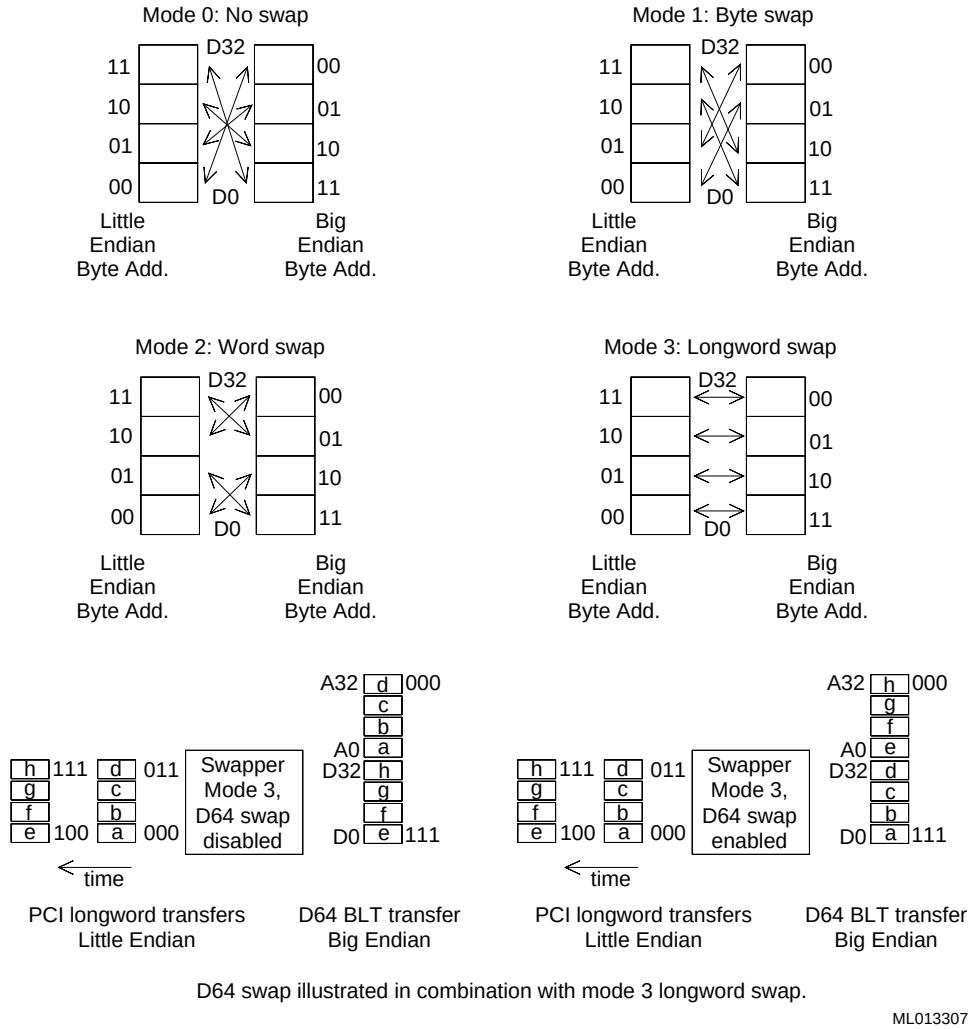
The swap mode for each scatter-gather entry is defined by 3 bits, SWP<2:0>. Bits <1:0> define mode 0 through 3 and **SWP**<2> enables D64 swapping, which is only used in D64 block mode data transfers.

The four swap modes are described in Figure 10–17 with the D64 swap cases illustrated with mode 3. The following table defines the swap modes.

Table 10–12 Swap Modes

Mode	Type of Swap	Description
0	No Swap	No bytes are swapped, and in transferring bytes from the little endian PCI to the big endian VMEbus, the address of any byte as seen on the two buses remains the same.
1	Byte Swap	The bytes within words are swapped.
2	Word Swap	The words within longwords are swapped.
3	Longword Swap	Combination of modes 1 and 2. Byte 11 in a longword becomes byte 00, 10 becomes 01, 01 becomes 10, and 00 becomes 11.
	D64 Swap	Used only in D64 block mode transfers. Swaps the order that the longwords are taken from or put into memory over the PCI bus. For example, when enabled with a mode 3 swap, byte 000 in a quadword becomes byte 111, that is, the binary byte address is inverted.

Figure 10–17 Swap Modes



D64 swap illustrated in combination with mode 3 longword swap.

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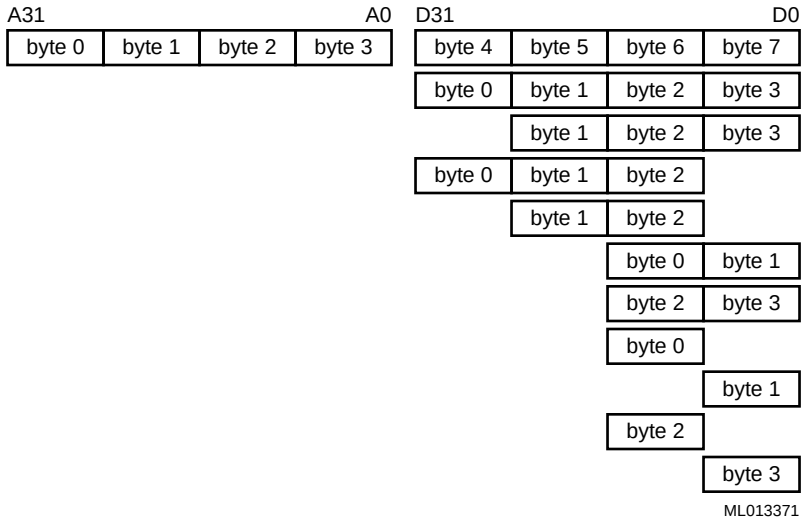
10.4.2 VIC64 Byte Swapping

When transfers of less than complete longwords are done to or from the VMEbus, the VIC64, as a VMEbus master, drives the data to/from the VMEbus. The data must be driven to certain VMEbus lanes depending on the data width. This is shown in Figure 10–18.

Figure 10–18 Big Endian VME Byte Lane Formats



The longword transfers, tribyte transfers, and unaligned word transfers all use the byte lanes in the same way. However, when the low word in a longword is transferred, the data is switched to or from its usual lanes **D**<31:16> to or from **D**<15:0>. Byte transfers in the low word of a longword are swapped in a similar way.

The single data transfers, D64, are a special case. The VIC64 chip packs the data to form quadwords in the CY7C964s and on the VMEbus. Only full quadword block mode transfers are allowed in D64 mode.

Table 10–13 shows the local bus address and size signals used for the DC7407's swap modes when the DC7407 is master of the local bus. When consulting the table, keep the following in mind:

- Cycles in which data moves to or from the D0-16 lane are marked with "L".
- Cycles that would cause a noncontiguous arrangement of bytes on the VMEbus are not allowed and are aborted on the PCI bus.
- No cycles are generated for PCI transfers with noncontiguous PCI byte enables, but these cycles are included in the table for completeness.

Table 10–13 PCI BE# to Local A1,0 and SIZ1,0 Translation for Various Swap Modes

PCI BE# <3:0>	Mode 0 No Swap A1,0	SIZ1,0		Mode 1 Byte Swap A1,0	SIZ1,0		Mode 2 Word Swap A1,0	SIZ1,0		Mode 3 Longword Swap A1,0	SIZ1,0	
1111	No cycle			No cycle			No cycle			No cycle		
1110	00	01	L	01	01	L	10	01		11	01	
1101	01	01	L	00	01	L	11	01		10	01	
1011	10	01		11	01		00	01	L	01	01	L
0111	11	01		10	01		01	01	L	00	01	L
1100	00	10	L	00	10	L	10	10		10	10	
1001	01	10		Noncontig			Noncontig			01	10	
0011	10	10		10	10		00	10	L	00	10	L
1000	00	11		Noncontig			Noncontig			01	11	
0001	01	11		Noncontig			Noncontig			00	11	
0000	00	00		00	00		00	00		00	00	
0101	Noncontig			Noncontig			Noncontig			Noncontig		
1010	Noncontig			Noncontig			Noncontig			Noncontig		
0110	Noncontig			01	10		01	10		Noncontig		
0010	Noncontig			01	11		00	11		Noncontig		
0100	Noncontig			00	11		01	11		Noncontig		

As a VMEbus slave or during DMA-driven block mode transfers, the VIC64 drives the local bus address lines and the DC7407 generates the byte-enable combinations to drive onto the PCI bus. In some cases, the translations may result in noncontiguous byte-enable arrangements on the PCI bus. These are passed to the PCI bus with the corresponding byte enables asserted. As shown in Table 10–14, the data for byte and aligned words is always received on the data lines D[15:0].

Table 10–14 Local Bus A1,0 and SIZ1,0 to PCI BE# Translation

Local Bus A1,0	SIZ1,0	Data		Mode 0 BE#	Mode 1 BE#	Mode 2 BE#	Mode 3 BE#
00	00	D[31:0]		0000	0000	0000	0000
00	11	D[31:8]		1000	0100	0010	0001
01	11	D[23:0]		0001	0010	0100	1000
00	10	D[15:0]	L	1100	1100	0011	0011
01	10	D[23:8]		1001	0110	0110	1001
10	10	D[15:0]		0011	0011	1100	1100
00	01	D[15:8]	L	1110	1101	1011	0111
01	01	D[7:0]	L	1101	1110	0111	1011
10	01	D[15:8]		1011	0111	1110	1101
11	01	D[7:0]		0111	1011	1101	1110

10.5 Initializing the VME Interface

The Digital Alpha VME 4 firmware must set up some registers in the VME interface as fixed configuration values. This section describes these registers and other VME interface initialization.

The firmware uses the following procedure to set up the VME interface for use with the default values for the DC7407 registers:

1. Set up the three PCI base registers in the VME interface.
2. Program scatter-gather RAM as needed.
3. Configure the VIC64 for initialization. Some timing control register values are defined.
4. Operate the VME interface.

10.5.1 VME PCI Configuration Registers

CPU Address: 0x1E0000000 - 0x1E0001FE0
PCI Configuration: 0x00000800 - 0x000008FF

The PCI bus interface to VMEbus must be configured at startup by writing three base address registers within the DC7407. A fourth register can be used to read the hardware setting for the second VME window if required. These registers are accessible only through PCI configuration address space. Once these registers are initialized, PCI memory space can be used to set up the remainder of the VME subsystem for access to VME devices.

The windows defined by these registers must not overlap each other. The following sections describe these registers and the region of address space they define.

Table 10–15 Access to PCI Memory Addresses

Register	PCI Configuration Address Space	Purpose
VME_CSR_BASE	00000810	This register gives access to the DC7407, VIC64, and CY7C964 registers when the base address of a window in PCI memory space is written into the register. The window is a 512-byte address region in PCI memory space, aligned on a 512-byte boundary. <31:9> are writeable. The locations of the VME interface registers are identified as VME_CSR_ BASE + xxxx, representing their address in PCI memory space.
VME_WINDOW_1_BASE	00000814	This register gives access to VME address space when the base address of a window in PCI memory space is written into the register. Only bits <31:29> are writable because the 512 MB window must be aligned on a natural boundary.
VME_SG_BASE	00000818	This register gives access to scatter-gather RAM when the base address of a 128 KB window in PCI memory space is written into the register.
VME_WINDOW_2_BASE	0000081C	This register gives access to VME address space when the base address of a second window in PCI memory space is written into the register. Only bits <31:26> are writable because the 64 MB window must be aligned on a natural boundary.

10.5.2 Programming Scatter-Gather RAM

To configure the VME interface for both master and slave operation, the scatter-gather entries for both inbound and outbound accesses must be programmed to provide address translation between the VMEbus and the PCI bus. The scatter-gather RAM can be programmed independently of master or slave VMEbus activity.

The scatter-gather RAM is an 32K *n* longword page in memory space. The top 27 bits are read/write; the remaining 5 bits are MBZ. Scatter-gather RAM is not initialized by hardware and starts up in a random state. Firmware must initialize this area to a default state before using the VME subsystem.

The scatter-gather RAM is fully programmable over the PCI bus. The mapping of the scatter-gather RAM takes up 128 KB of PCI memory space and has its own base address.

The 8K scatter-gather longword entries are in three regions:

Entry	Address	Each Entry Maps:	Index Formed By:
2048 A24 inbound	VME_SG_BASE + 10000h	8K page of A24 VME address space into PCI address space	VME A24 <23:13>
16384 A32 inbound	VME_SG_BASE	8K page of A32 VME address space into PCI address space	VME A32 <26:13>
2048 outbound	VME_SG_BASE + 1E000h	256K page of PCI memory into VMEbus	Depends on region used for master access: VME_WINDOW : PCI <28:18> VME_SUB_ WINDOW (64 MB) : PCI <25:18>

10.5.3 Configuring the VIC64

The address map for the VIC64 places the VIC registers in byte 3 of a particular longword address. As used by a Digital Alpha VME 4 system, the VIC registers are seen at byte zero in each longword, when accessed over the PCI bus.

VIICR

Bits 2-0	Local interrupt priority level (IPL) setting for VMEbus interrupter acknowledge received interrupt.
Bits 6-3	Reserved, must read as 1s.
Bit 7	Interrupt mask bit.

VICR1-7

Bits 2-0	Local IPL setting for VMEbus interrupt.
Bits 6-3	Reserved, must read as 1s.
Bit 7	Interrupt mask bit.

DMASICR

Bits 2-0	Local IPL setting for end of DMA interrupt.
Bits 6-3	Reserved, must read as 1s.
Bit 7	End of DMA interrupt mask bit.

LICR1-7

Bits 2-0	Local IPL setting for LIRQ interrupt line.
Bit 3	Indicates voltage level at LIRQ pin.
Bit 4	Autovector enable. Must be set in the Digital Alpha VME 4 system.
Bit 5	Edge/level enable for LICR2 and LICR7. Must be clear in the Digital Alpha VME 4 system.
Bit 6	Polarity set for LICR2 and LICR7. Must be clear in Digital Alpha VME 4.
Bit 7	Local interrupt mask bit.

ICGSICR

Bits 2-0	Local IPL for global switch interrupts.
Bit 3	Reserved, must read as 1.
Bits 7-4	Interrupt mask bit for ICGS <3:0>.

ICMSICR

Bits 2-0	Local IPL for module switch interrupts.
Bit 3	Reserved, must read as 1.
Bits 7-4	Interrupt mask bit for ICMS <3:0>.

EGICR

Bits 2-0	Local IPL for error group interrupts.
Bit 3	SYSFAIL asserted (read only).
Bit 4	SYSFAIL interrupt mask.
Bit 5	Arbitration timeout interrupt mask.
Bit 6	VIC/CY write post fail interrupt mask.
Bit 7	AC fail interrupt mask.

ICGSIVBR

Bits 1-0	Read only.
Bits 7-2	User defined. Combines with ICGS switch number to provide vector.

ICMSIVBR

Bits 1-0	Read only.

Bits 7-2	User defined. Combines with ICMS switch number to provide vector.
LIVBR	
Bits 1-0	Read only.
Bits 7-2	User defined. Combines with LIRQ number to provide vector.
EGIVBR	
Bits 1-0	Read only.
Bits 7-2	User defined. Combines with fixed codes to provide vector.
ICFSR	
Bits 3-0	Module switches.
Bits 7-4	Global switches.
ICR0-4	General-purpose registers. Accessible over the VMEbus or local bus.
ICR5	Read-only register containing the VIC64 revision. Accessible over VMEbus or local bus.
ICR6	
Bits 1-0	Read only from the VMEbus. Must be cleared by the processor after reset.
Bits 5-2	Reserved, must read as 1s.
Bit 6	Must be cleared by the processor after reset. If enabled by LICR7, this bit being set asserts SYSFAIL* on the VMEbus.
Bit 7	Read only.
ICR7	
Bits 4-0	Read and write from the VMEbus or local bus. These bits are set if the corresponding ICR is written.
Bit 5	Read only.
Bit 6	HALT and RESET control.
Bit 7	VME SYSFAIL* mask, must be set after reset if resets are not to be translated into SYSFAIL* assertion.
VIRSR	
Bit 0	Enable VMEbus interrupter.
Bits 7-1	If bit 0 is set during the write that sets a bit, the corresponding VMEbus interrupt is asserted. These bits are cleared if bit 0 is cleared during the write that sets a bit.
VIVBR1-7	Each register sets the vector returned on VMEbus interrupt acknowledge cycles at that interrupt level.
TTR	

Bit 0	Set to include VMEbus acquisition time in local bus timeout.
Bit 1	When VME interface is used as system controller, this bit is set to indicate arbitration timeout.
Bits 4-2	Recommended timeout period for local bus is 64 µs (011).
Bits 7-5	Recommended timeout period for VMEbus is 128 µs (100).
	The use of timeout periods depends on the VME environment. When the Digital Alpha VME 4 system is a system controller and a cycle times out on the local bus after timing out on the VMEbus, the cycle hangs. To avoid this condition, set the timeout period for the local bus first or not at all.

LBTR

Bits 3-0	Minimum PAS assertion time. Keep the default of zero.
Bit 4	Minimum DS deasserted time. Must be set in the Digital Alpha VME 4 system.
Bits 7-5	Minimum PAS deasserted time. Must be binary 110.

BTDR

Bit 0	Dual Path enable. Must be set.
Bit 1	AMSR register. Sets up user-defined address modifier codes for block mode transfers.
Bit 2	Local bus 256 bus byte boundary. Recommend this be set.
Bit 3	VME 256 bus crossing enabled. Recommend this be set.
Bit 4	Enables D64 master operation.
Bit 5	Enable enhanced turbo mode. Must be clear.
Bit 6	Enables D64 slave operation. Recommend this be set.
Bit 7	Enable 2 KB boundary crossing for D64. If set, software must check that the D64 block mode transfer start address is 2 KB aligned and that the transfer does not cross a 64 KB boundary.

ICR

Bit 0	Read-only system controller pin.
Bit 1	Turbo enable. Must be clear.
Bit 2	Metastability delay. Recommend this be clear.
Bits 4,3	Deadlock signaling. Must be clear.
Bits 5-7	RMC Control bits 1 to 3.

ARCR

Bits 3-0	VMEbus fairness timer enable.
Bit 4	DRAM refresh enable. Must be clear.

Bits 6,5	VMEbus request level.
Bit 7	Arbitration mode.
AMSR	Defines response top and generation of user-defined address modifier codes.
BESR	All 8 bits are flags set by the VIC after status conditions that must be cleared by the processor.
DMASR	
Bit 0	Block transfer in progress. Once set, must be cleared by processor.
Bit 1	LBERR during DMA transfer.
Bit 2	BERR during DMA transfer.
Bit 3	Local bus error.
Bit 4	VMEbus BERR.
Bits 5,6	Reserved, read as 1s.
Bit 7	Master write post information stored in CYs.
SS0CR0	
Bits 1-0	Accelerated transfer mode. Must be set to binary 10.
Bits 3,2	Must be binary 01 for A24 slave selection.
Bit 4	D32 enable. Must be set in the Digital Alpha VME 4 system.
Bit 5	Supervisor access.
Bits 7,6	Periodic timer enable. Must be binary 00.
SS0CR1	Local bus timing values. Must be 0x00.
SS1CR0	
Bits 1-0	Must be set to binary 10, accelerated transfer mode.
Bits 3,2	Must be binary 00 for A32 slave selection.
Bit 4	D32 enable. Must be set.
Bit 5	Supervisor access.
Bit 6	VIC/CY master write posting enable. Recommend this be clear.
Bit 7	Slave write post enable. Must be clear.
SS1CR1	Local bus timing values. Must be 0x00.
RCR	
Bits 5-0	Block transfer burst length.
Bits 7,6	VMEbus release mode.
BTCR	

Bits 3-0	Interleave period. Recommend a value of 0xF.
Bit 4	Data direction bit: 0=write, 1=read.
Bit 5	MOVEM enable. Recommend this be clear.
Bit 6	BLT with local DMA enable.
Bit 7	Module based DMA transfer enable.
BTLR1-0	Registers for block transfer length for local DMA block mode transfers.
SRR	System reset register.

10.6 Summary of VME Interface Registers

Table 10–16 VME_IF_BASE +

00	VIC_IICR	VMEbus interrupter interrupt control register
04-1C	VIC_ICPR1-7	VMEbus interrupt control registers 1-7
20	VIC_DMASICR	DMA status register
24-3C	VIC_LICR1-7	Local interrupt status register
40	VIC_ICGISR	ICGS interrupt control register
44	VIC_ICMSICR	ICMS interrupt control register
48	VIC_EGICR	Error group interrupt control register
4C	VIC_ICGSIVBR	ICGS vector base register
50	VIC_ICMSVBR	ICMS vector base register
54	VIC_LIVBR	Local interrupt vector base register
58	VIC_EGIVBR	Error group interrupt vector base register
5C	VIC_ICSR	Interprocessor communications switch register
60-70	VIC_ICR0-4	Interprocessor communications registers 0-4
74	VIC_ICR5	Interprocessor communications register 5
78	VIC_ICR6	Interprocessor communications register 6
7C	VIC_ICR7	Interprocessor communications register 7
80	VIC_VIRSR	VMEbus interrupt request/status register
84-9C	VIC_VIVBR1-7	VMEbus interrupt vector base registers 1-7
A0	VIC_TTR	Transfer timeout register
A4	VIC_LBTR	Local bus timing register

(continued on next page)

Table 10–16 (Cont.) VME_IF_BASE +

A8	VIC_BTDR	Block transfer definition register
AC	VIC_ICR	Interface configuration register
B0	VIC_ARCR	Arbiter/requester configuration register
B4	VIC_AMSR	Address modifier source register
B8	VIC_BESR	Bus error status register
BC	VIC_DMASR	DMA status register
C0	VIC_SS0CR0	Slave select 0/control register 0 The D32 enable must be set in VIC_SS0CR0.
C4	VIC_SS0CR1	Slave select 0/control register 1
C8	VIC_SS1CR0	Slave select 1/control register 0
CC	VIC_SS1CR1	Slave select 1/control register 1
D0	VIC_RCR	Release control register
D4	VIC_BTCR	Block transfer control register
D8	VIC_BTLR1	Block transfer length register 1
DC	VIC_BTLR0	Block transfer length register 0
E0	VIC_SRR	System reset register
E4	BTLR2	Block transfer length register 2
E8-FC		Reserved locations
100	VIP_CR	VME interface processor control register
104	VIP_BESR	VME interface processor bus error/status register
108	VIP_ICR	VME interface processor interrupt control register
10C	VIP_IRR	VME interface processor interrupt reason register
110	VIP_HWIPL	VME interface processor hardware IPL mask register
114	VIP_DIAG CSR	VME interface processor diagnostic register
118	VIP_PMCSR	VME interface processor page monitor CSR
11C	VIP_OBISGABR	VME interface processor outbound internal scatter-gather entry ABR
120	VIP_OBISGMSK	VME interface processor outbound internal scatter-gather entry mask
124	VIP_OBISGWORD	VME interface processor outbound internal scatter-gather entry control word

(continued on next page)

Table 10–16 (Cont.) VME_IF_BASE +

128	VIP_IBISGMSK	VME interface processor inbound internal scatter-gather entry mask
12C	VIP_IBISGWORD	VME interface processor inbound internal scatter-gather entry control word
130	VIP_SGCCHIX	VME interface processor scatter-gather cached index
134	VIP_SGCWRD	VME interface processor scatter-gather cached control word
138	VIP_PCIERTADR	VME interface processor PCI error target address register
13C	VIP_PCIERTCBE	VME interface processor PCI error target command/byte enables register
140	VIP_PCIERIADR	VME interface processor PCI error initiator address register
144	VIP_LERADR	VME interface processor VME/local bus error address register
148-17C		Reserved locations
180	VIFMASK	VMEbus i/f address base mask register
184	VIFABR	VMEbus i/f address base register
188-3FC		Reserved

10.7 VME Subsystem Restrictions (as of 03-Jun-94)

This section describes limitations on the use of the VME subsystem due to outstanding hardware constraints. The intention is that these will be eliminated as new revision hardware components become available. This section will be updated as restrictions change. Please contact your field application engineer for the latest status on these constraints.

10.7.1 Collision of VIC64 Master Write Posting with Master Block Transfers

Write Posting in the VIC64 should not be enabled. Collisions of outbound cycles, cycles posted in the VIC64, and incoming VME slave cycles may cause a deadlock condition that is not detected by the VIC64.

If the VIC64 Local Bus timer is enabled, this deadlock condition will generate a Local Bus timeout error. If the VIC64 Local Bus timer is not enabled, this deadlock condition will persist, causing the Local Bus and possibly the VMEbus to hang.

A collision of the following three cycles will cause a bus timeout error:

- Posted master Write in the VIC64/CY964
- Alpha VME CPU is being accessed as a VME slave
- Master block transfer is being initiated by a "pseudo write" to the VIC64 over the Local bus

10.7.2 VIC64 Errata: A16 Master Cycles During Interleave

The Cypress VIC64-00 Design Considerations document (dated 22 February 1994) lists the following errata:

" A16 master cycles during an interleave period with dual path enabled will cause BERR* and LBERR* to be asserted. "

Followup conversations with Cypress (and testing) have determined that a further statement must be added. Apparently, the problem only occurs if the DMA enable bit is set (**BTCR**<6>). The DMA drivers used with the Alpha VME systems always clear this bit immediately after the "pseudo-write" to avoid any PIO being taken as another "pseudo-write." Therefore, **BTCR**<6> is always clear by the time an A16 access could get through in an interleave gap.

While this is not a problem for customers using driver software supplied by Digital, anyone writing their own interface to the VIC64s DMA engine must use the same sequence to ensure this problem is not encountered.

11

System Interrupts

11.1 System Interrupts

Figure 11–1 shows a schematic overview of the interrupt structure in the Digital Alpha VME 4 system. Most interrupts are routed through the VIC64 chip, the Digital Alpha VME 4 interrupt controller, and the SIO chip.

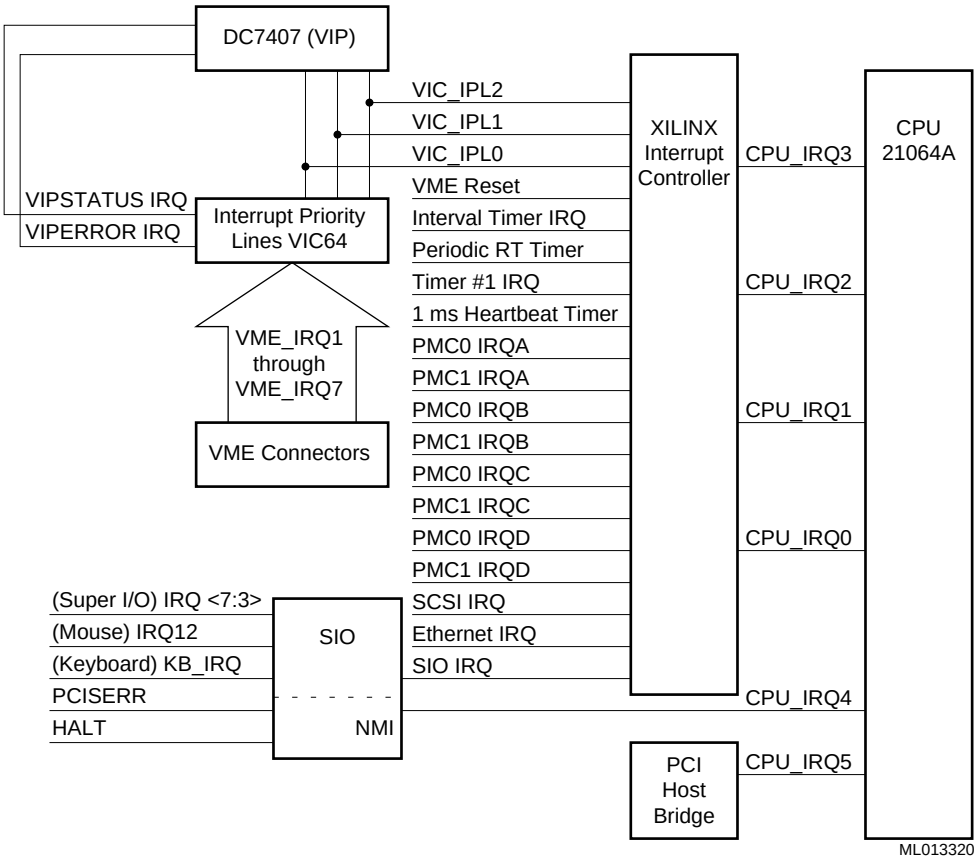
The 21064A receives six interrupts (CPU_IRQ[5:0]). The six interrupts are identical, asynchronous, level sensitive, and can be masked by PALcode individually.

Table 11–1 lists the CPU interrupt assignments during normal operation. Figure 11–1 shows a block diagram of the interrupt logic.

Table 11–1 Table of CPU Interrupt Assignments

CPU Interrupt	Interrupt Source	Description
cpu_irq0	Interrupt registers 3 & 4	PCI device interrupts from SCSI, Ethernet, multifunction PMC options, SIO chip, and VME interrupts [3:1]
cpu_irq1	Interrupt register 2	PCI device INTA from PMC options and VME interrupts [6:4]
cpu_irq2	Interrupt register 1	VIP location monitor status and the 1 ms heartbeat timer
cpu_irq3	Interrupt register 1	Interval timer, VMEbus reset, and VMEbus interrupt 7, VIP/VIC error and status, and periodic real-time timer
cpu_irq4	82378	SIO chip nonmaskable interrupt
cpu_irq5	DC7277	APECS PCI bridge

Figure 11–1 Block Diagram of the Interrupt Logic



11.1.1 Xilinx Interrupt Controller

The cpu_irq[3:0] are generated by four interrupt/mask registers contained in a Xilinx FPGA, as shown in Figures 11–2 through 11–5.

- cpu_irq3 is controlled by bits [3:0] in interrupt/mask register 1
- cpu_irq2 is controlled by bits [5:4] in interrupt/mask register 1
- cpu_irq1 is controlled by bits [2:0] in interrupt/mask register 2
- cpu_irq0 is controlled by bits [7:0] in interrupt/mask register 3 and bits [1:0] in the interrupt/mask register 4

Each interrupt can be individually masked by setting the appropriate bit in the interrupt/mask register. Interrupts generated by the VMEbus subsystem also need to be masked in the VIC64 chip (see Section 11.1.2). An interrupt is disabled by writing a 1 to the desired position in the interrupt/mask register. An interrupt is enabled by writing a 0. The interrupt/mask register is write only.

A read of the interrupt/mask register returns the state of the interrupts regardless of which mask bits are set. A 1 means that the interrupt source has asserted an interrupt.

Figure 11–2 Interrupt/Mask Register #1

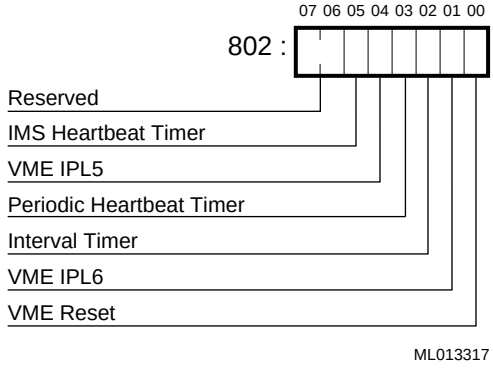


Figure 11–3 Interrupt/Mask Register #2

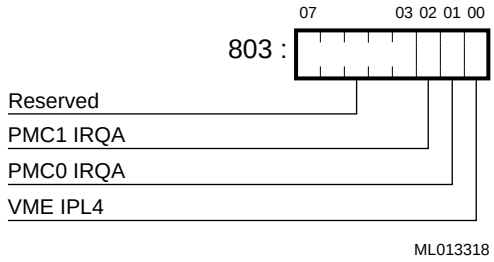


Figure 11–4 Interrupt/Mask Register #3

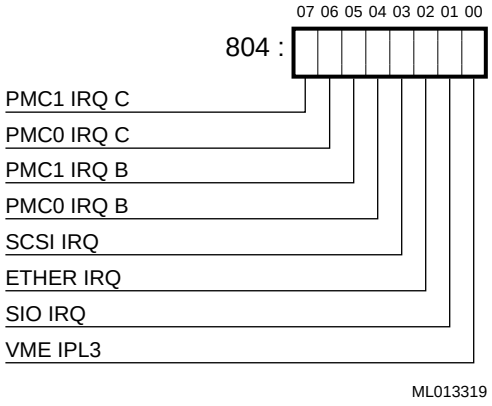
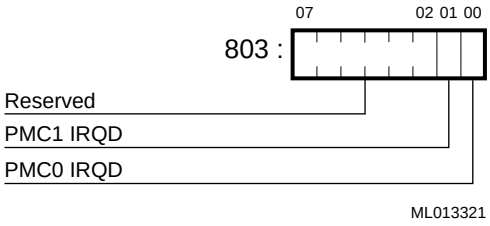


Figure 11–5 Interrupt/Mask Register #4



11.1.2 VIC64 Chip System Interrupt Controller

The Digital Alpha VME 4 system's use of the VIC64 chip as an interrupt controller is modified slightly by the operation of the DC7407, the SIO chip, and the interrupt/mask registers. VMEbus interrupts are passed to the interrupt /mask registers by the VIC64 interrupt priority lines.

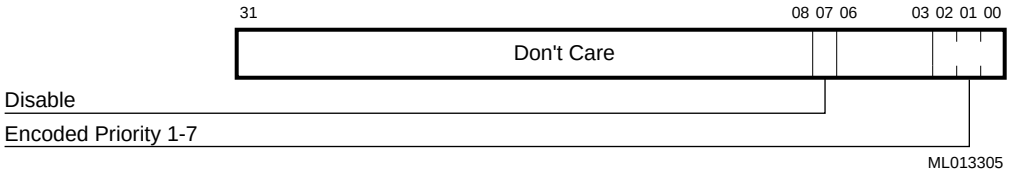
Vectors returned from the VIC as system interrupt controller are "pre-pended" (using bits <10:8>) with the interrupting IPL.

The VIC64 chip system interrupt controller operation is described in the VIC64 chip documentation.

11.1.2.1 Basic Operation

The VIC64 chip handles 19 interrupt sources. Each of these can be individually programmed to any of the seven IPLs in the controller's interrupt control registers (ICRs). The generic form of the ICR is shown in Figure 11–6.

Figure 11–6 Generic ICR



A fixed relative ranking for requests is defined. This ranking is shown in Table 11–2, and is used to decide which interrupt is reported if many interrupts are pending.

When a VME interrupt is identified, the CPU initiates a read of the VMEbus interface processor interrupt reason register (VIP_IRR), which is read to retrieve the vector from the VIC/DC7407. The read of the VIP_IRR generates a local bus IACK cycle at the pins of the VIC64 chip. When the VIC64 chip detects the IACK cycle, it responds with the vector and IPL of the winning interrupter. The controller determines the highest ranking active interrupt request to be the winning interrupt. The vector returned from the VIC64 chip and the current IPL are concatenated and returned to the processor.

Table 11–2 VIC64 Chip Interrupt Ranking

RANK	Interrupt Description	CSRs
19	DC7407 Error	VIC_LICR7, VIC_LIVBR
18	VME Interface Status/Error	VIC_EGICR, VIC_EGIVBR
17	not used	
16	not used	
15	not used	
14	not used	
13	DC7407 Status	VIC_LICR2, VIC_LIVBR
12	not used	
11	Interprocessor Communications Global Switch	VIC_ICGSICR, VIC_ICGSIVBR
10	Interprocessor Communications Module Switch	VIC_ICMSICR, VIC_ICMSIVBR
9	VMEbus IRQ7*	VIC_IRQ7ICR
8	VMEbus IRQ6*	VIC_IRQ6ICR
7	VMEbus IRQ5*	VIC_IRQ6ICR
6	VMEbus IRQ4*	VIC_IRQ6ICR
5	VMEbus IRQ3*	VIC_IRQ6ICR
4	VMEbus IRQ2*	VIC_IRQ6ICR
3	VMEbus IRQ1*	VIC_IRQ6ICR
2	DMS status	VIC_DSICR, VIC_EGIVBR
1	VME IACK	VIC_IICR, VIC_EGIVBR

11.1.3 VIC64 Chip Interrupt Sources

The following sections describe the VIC64 chip interrupt sources.

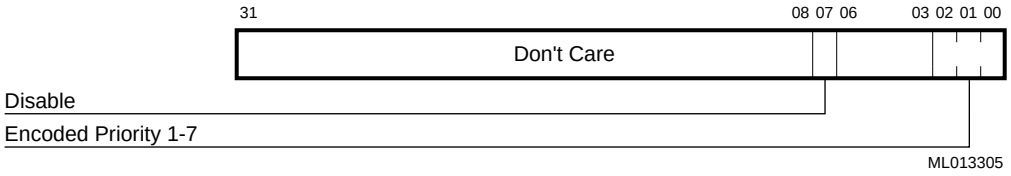
11.1.3.1 Local Device Interrupts

There are two external/system interrupt sources controlled by the VIC64 chip interrupt controller (the VIC64 can support up to seven).

- DC7407 status
- DC7407 errors

Each of the these interrupt sources has an associated ICR that allows the interrupt to be programmed with an individual IPL or to be disabled. Figure 11–7 shows these ICRs.

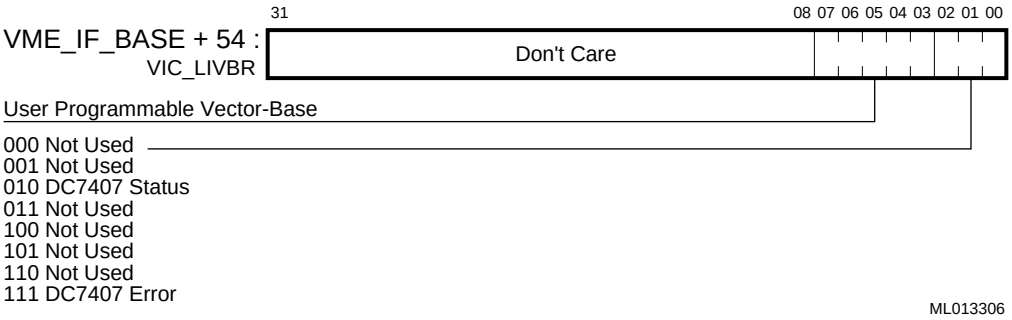
Figure 11–7 Device ICRs



The vectors associated with these seven interrupt inputs have a single common root that is modified to give a unique vector for each device. Bits <7:3> of this common 8-bit vector are programmable while bits <2:0> uniquely identify the winning interrupt.

Figure 11–8 shows the local interrupt vector base register.

Figure 11–8 VIC Local Interrupt Vector Base Register



11.1.3.2 VMEbus Interrupt Requests

The VIC64 chip handles the standard seven-level prioritized interrupt scheme of the VMEbus when configured as system controller.

As for the module-based interrupt sources described above, each of the seven VMEbus interrupt request (IRQ) lines has its own ICR to allow individual disable and priority assignments (see Figure 11–9 and Table 11–3).

Figure 11–9 VME IRQ* ICRs

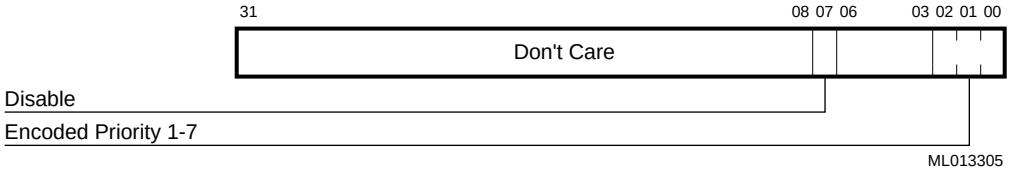


Table 11–3 VME IRQ ICR Priority Assignments

Address	Register	Line
:VME_IF_BASE+04	VIC_ICR1	1RQ1
:VME_IF_BASE+08	VIC_ICR2	IRQ2
:VME_IF_BASE+0C	VIC_ICR3	IRQ3
:VME_IF_BASE+10	VIC_ICR4	IRQ4
:VME_IF_BASE+14	VIC_ICR5	IRQ5
:VME_IF_BASE+18	VIC_ICR6	IRQ6
:VME_IF_BASE+1C	VIC_ICR7	IRQ7

Within the system, VMEbus interrupts compete (based on IPL and ranking) with other system interrupts. If, during a local bus IACK, a VMEbus source is the IRQ winner, the VIC64 chip initiates a VMEbus IACK cycle to retrieve the bus interrupter's vector. The VMEbus vector response is passed back to the DECchip 21064A in response to the system read of the VIP_IRR register.

It is assumed that the VMEbus interrupter releases the IRQ line either on seeing the VME IACK or because of the action (register write, and so forth) of the interrupt service routines (ISRs).

11.1.3.3 Status/Error Interrupts

Internal to the VIC itself are a number of conditions and errors that can be reported by an interrupt request.

The conditions that can be enabled to cause system interrupts are:

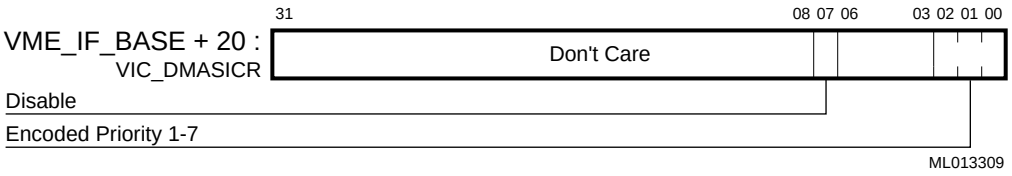
- VMEbus SYSFAIL* assertion
- VMEbus ACFAIL* assertion
- VMEbus arbitration timeout
- VIC write post failure

- DMA completion
- VMEbus IACK cycle in response to a VMEbus interrupt generated by an Alpha VME system

These conditions are divided into three cases.

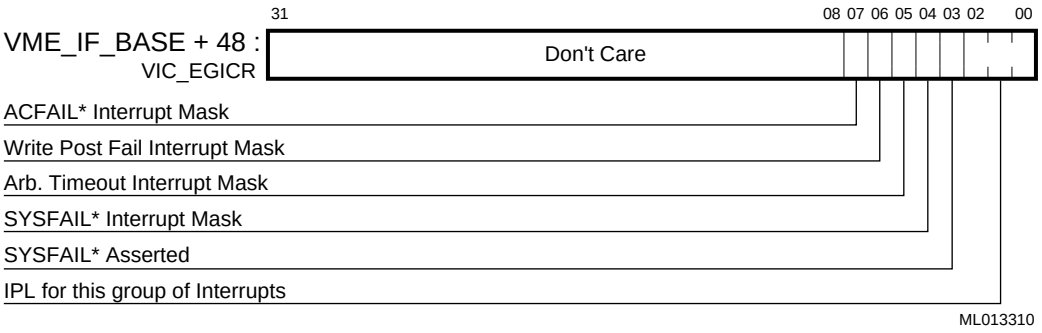
The first "case" is DMA completion. There is an ICR associated with this event, VIC_DMASICR (see Figure 11–10), which allows the signaling of DMA completion. If enabled, an interrupt is generated at the programmed IPL upon DMA completion.

Figure 11–10 DMA Status ICR



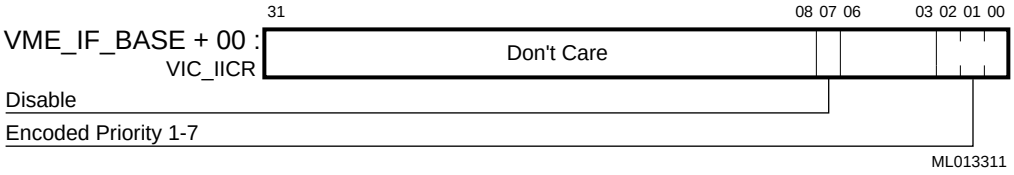
The second case is a grouping that encompasses the SYSFAIL assertion, arbitration timeout, write posting failure, and ACFAIL conditions. The ICR (VIC_EGICR) associated with this group (see Figure 11–11) is different than the ICRs already discussed. Here, a single IPL is assigned for all of the events, while the higher order register bits (<7:4>) allow individual conditions to be selectively disabled.

Figure 11–11 VIC Error Group ICR



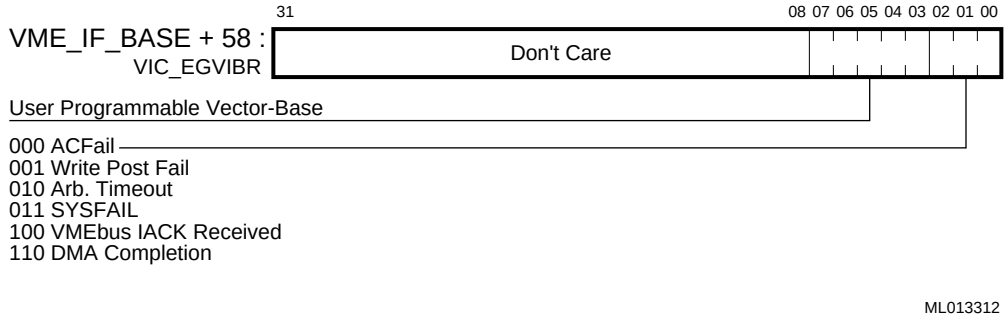
Finally, a local (on-board) interrupt is generated by the VIC64 chip when the VME interface detects a VMEbus IACK cycle to itself. The VIC64 chip can notify the CPU when the VME interface, as a VMEbus interrupter, has its interrupt acknowledged. Once again there is an associated ICR, VIC_VIICR (see Figure 11–12), to set the IPL and allow the condition to be disabled from generating its local interrupt.

Figure 11–12 VMEbus Interrupter ICR



There is a single interrupt vector base register for the error-group DMA and "interrupter-sees-IACK" interrupts (see Figure 11–13). In a similar way to the device interrupts outlined above, the vector root (vector bits <7:3>) is user programmable while the least significant 3 bits are different for each condition. In this way, there is a unique interrupt vector for each of these error/status events.

Figure 11–13 VIC Error Group Interrupt Vector Base Register



11.1.4 SIO Chip Programmable Interrupt Controller

The 82378 chip is used to deliver interrupts from the mouse, keyboard, and Super I/O chip (37C665) to the interrupt/mask register.

For programming details of the 8259, see the SIO chip (82378ZB) and 8259 data sheets.

11.1.4.1 Nonmaskable System Events

In addition to the Nbus device interupts, the SIO chip also sends a nonmaskable interrupt (NMI) to CPU IRQ line 0.

The front panel HALT button, the watchdog HALT, and a PCI SERR are the only such nonmaskable events. The two categories of Digital Alpha VME 4 nonmaskable events (halt and SERR) are handled through the SIO chip, which contains a status register that can be polled to determine the NMI reason. This register is the NMI status and control register at PCI I/O address 0x00000061.

All NMI events should cause a jump to the console entry point without destroying the software context, and SERR should report an error. If the interrupt reason is a HALT, the firmware should also read the reset reason register (PCI I/O 0x80A) to see if the watchdog bit is set. If set, the HALT must be treated as a "save-software-context" watchdog HALT.

The nonmaskable description refers to the processor's operation. PALcode never masks the NMI input pin and the events are considered highest priority. However, the SIO chip, by default, disables the generation of the interrupt to the processor so they must be enabled by initialization code. Also, firmware can operate in "HALT-protected" space by disabling the NMI delivery either at the HIER or SIO chip level.

11.1.4.2 NMI Status and Control Register

Figure 11–14 shows the NMI status and control register.

Figure 11–14 NMI Status and Control Register

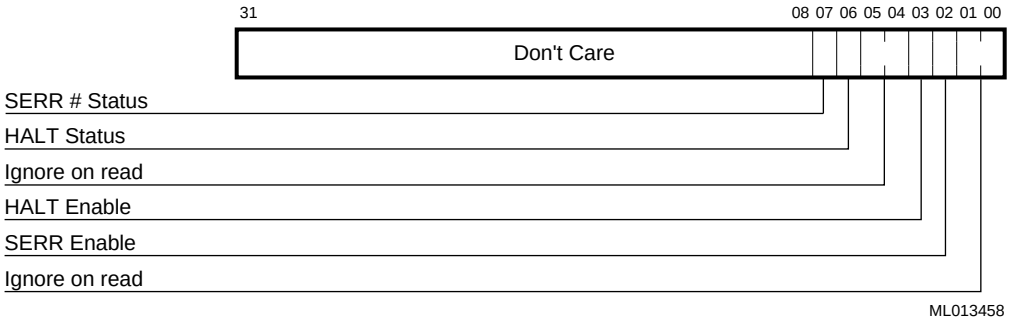


Table 11–4 contains more details about the settings in the NMI status and control register.

Table 11–4 NMI Status and Control Register Bits

Field	Name	Type	Description
<7>	SERR# Status	RO	Bit <7> is set if a system SERR has occurred. The interrupt in response to this event is enabled by clearing bit <2> of this register to a 0. Bit <7> can be cleared only by setting the SERR enable bit (bit <2>) to a 1 and then back to a 0. Always write this bit as a 0.
<6>	HALT Status	RO	Bit <6> is set when either the watchdog timer expires (and is enabled) or the HALT switch is toggled. This interrupt is enabled by clearing bit <3> of this register to 0. Bit <6> should always be written as a 0. To clear this status bit, set bit <3>, and then clear it again to reenable this NMI event reporting.
<5:4>	-	R/W	Ignore on read. Writes must be 0.

(continued on next page)

Table 11–4 (Cont.) NMI Status and Control Register Bits

Field	Name	Type	Description
<3>	HALT Enable	R/W	When set to a one, HALTs are disabled and the halt status bit in this register is cleared. When cleared (reset default), HALTs are enabled as NMI events.
<2>	SERR Enable	R/W	When set to a 1, SERR reporting is disabled and the SERR status bit in this register is cleared. When cleared (reset default), SERRs are enabled as NMI events.
<1:0>	-	R/W	Ignore on read. Writes must be 0.

Note

The SIO chip specification specifies that HALT events are reported by the SIO chip's IOCHK# pin.

11.1.4.3 EPIC Interrupt

The 21071-DA interrupts the CPU using the **int_hw0** signal when there are errors to report. The 21071-DA chip does not distinguish between hard and soft errors when asserting the interrupt signal.

The 21071-DA chip responds to CPU read block commands directly to the interrupt acknowledge address space, which triggers the 21071-DA chip to perform an interrupt acknowledge transaction on the PCI bus. The interrupt vector returned on the PCI bus is returned to the CPU through the sysBus by the 21071-DA chip.

11.2 Module Reset

The Digital Alpha VME 4 module can be reset by four distinct events:

- Power-up
- Front panel switch
- Watchdog timeout
- VMEbus SYSRESET* assertion (if enabled)

All on-board logic, except the module-level reset reason register, are hardware reset by all of these reset events.

The VMEbus SYSRESET* assertion generates a module reset only if Switch 3 is closed. This prevents a module configured as a VME system controller from locking into a reset state when it issues a VME SYSRESET* under software control.

If Switch 3 is open, the VIC64 chip still resets (all internal registers return to their default state, current transactions are aborted) but the module reset is not generated. To allow detection of this condition (VIC64 chip only reset), the VME **SYSRESET*** signal is tied to interrupt and interrupt mask register 3<0>.

12

Console Primer

This chapter describes the Digital Alpha VME 4 console and explains how to use basic commands to perform console tasks.

The console achieves much of its power and flexibility from its traditional UNIX functionality. This chapter gives you an understanding of the basic functions of the UNIX like kernel, various utilities and tools, the user interface, and how these compare with the structure of the OpenVMS operating system. If you have a good working knowledge of the OpenVMS operating system, this primer will help you make a smooth transition from using that operating system to using the UNIX operating system. Read this chapter and practice some of the examples before attempting an actual terminal session. If you are already proficient in using the UNIX operating system, you can start using the console commands described in Chapter 13.

12.1 About the Console

The Digital Alpha VME 4 console is a hybrid of an OpenVMS console and a UNIX shell. A *shell* is a command line interpreter, the interface between the operator and the firmware. The Digital Alpha VME 4 console's firmware includes three OpenVMS components: console, diagnostics, and the virtual monitor boot (VMB). By cloning some UNIX functions and carrying over some OpenVMS console functions, the Digital Alpha VME 4 console takes advantage of familiar commands and avoids, when possible, creating new commands for existing functions.

12.1.1 Console Features

The console firmware is an extremely powerful, yet simple, environment. It is a platform of simple tools that handle common services like the following:

- Operator interface
- Operating system bootstrap
- Operating system restarts

- Self-test diagnostics and extended functional diagnostics.

You use UNIX command methods to combine these tools to solve complex problems. The UNIX command methods are piping, I/O redirection, command-level scripting, and control functions. Because the console is built around a multitasking kernel, it can support more complex functions, such as systems exercisers, the Maintenance Operations Protocol (MOP) listener, and remote console operations.

All components of the firmware use the same kernel services and I/O drivers. For example, you use the same drivers when performing diagnostics as when you perform bootstrap or normal console operations.

12.1.2 Command Overview

The Digital Alpha VME 4 console prompt is a familiar one to OpenVMS users: the triple angle prompt, >>>.

The set of commands consists of many UNIX like commands, several OpenVMS like commands, and a unique set of commands specifically developed for diagnostics and design verification environments. Chapter 13 describes each of the commands. Table 12–1 shows the most frequently-used commands.

Table 12–1 Commonly Used Commands

OpenVMS like Commands	UNIX like Commands	Unique Commands
boot	**cat**	**edit**
examine	**echo**	**exer**
deposit	**eval**	**memexer**
help	**grep**	**memtest**
set	**hd**	**nettest**
show	**ls**	**sa**
	man	
	ps	
	sleep	

Just as OpenVMS commands use /qualifier syntax to direct a command, the Digital Alpha VME 4 console commands use the UNIX like -option syntax. For example, the OpenVMS console command **e/b 0** is **e -b 0**. Notice that a space separates the option from the command. If you type **e-b 0**, the console issues an error message.

12.1.3 Shell Operators

The UNIX command line makes use of some Bourne shell operators to complete a command. In OpenVMS, some commands take parameters. The shell operators are similar but are much more powerful because you can use them to combine commands. These operators are described in Table 12–2.

Table 12–2 Console Shell Operators

Operator	Name	Description
>	Output creation	Writes output to a specified destination, such as a file. **Form:** > *destination*
>>	Output append	Adds output to the destination. **Form:** >> *destination*
<	Input redirection	Reads input from the source. **Form:** < *source*
<<	Here document	Reads input from standard input until the specified string is found at the beginning of a line. **Form:** << *string*
|	Pipe	Uses output of the first command as the input for the second command. **Form:** *cmd1* | *cmd2*
;	Sequence	Runs the first command to completion before running second command. **Form:** *cmd1* ; *cmd2*
\	Line continuation	Continues the command on the next line. The prompt changes to _> until the command is completed. **Form:** `cmd1 \ _> cmd2`
#	Line comment	Ignores the text that follows the operator. Used for embedding comments in command scripts or logs. **Form:** # text
&	Background	Runs the command in a background process. The command line remains available for a new command. **Form:** *cmd* &
&a	Affinity	Runs the process on the CPU allowed by the processor affinity mask, *m*. Multiple processors can be specified using a list or range. **Form:** &a m

(continued on next page)

Table 12–2 (Cont.) Console Shell Operators

Operator	Name	Description
(),{}	Grouping	Shows which commands are grouped together in complex command lines. These operators override the [precedence] of pipe, sequence, and background operators. **Form:** {cmd1 ; cmd2} | cmd3
*,?,[...]	Pattern specifiers	Like OpenVMS wildcard characters. Used for matching patterns in character strings. * matches any character or characters or none ? matches any single character [...] matches any of the enclosed characters
$string	Environment variable substitution	Treats the string as a legal environment variable and translates it.
"xxx"	String with no substitution	Passes the string without effect.
"String"	String with substitution	Passes the string after expanding wildcards and environment variables.
"cmd"	Command substitution	Treats the string as a command, executes it, and substitutes it in the resulting output.

12.1.4 Using Flow Control

The console uses the following reserved words: **if**, **then**, **else**, **elif**, **fi**, **case**, **in**, **esac**, **for**, **while**, **until**, **do**, and **done**. These words provide a limited number of flow control structures at the shell command level. The syntax for these constructions is as follows:

- **while** *command_sequence* **done**
- **while** *command_sequence* **do** *command_sequence* **done**
- **until** *command_sequence* **done**
- **until** *command_sequence* **do** *command_sequence* **done**
- **for** *name* **do** *command_sequence* **done**
- **for** *name* **in** *list* **do** *command_sequence* **done**
- **case** *word* **in** *case_part_list*
  pattern **)** *command_sequence* **;;**
  [*pattern* **)** *command_sequence* **;;**]
  esac

- **if** *command_sequence*
  then *command_sequence*
  [**elif** *command_sequence* **then** *command_sequence*]
  [**else** *command_sequence*]
  fi

Conditional branching in **if**, **while**, and **until** loops is determined by the exit status of the command sequence following the control structure. In general, an exit status of zero indicates success and results in the execution of the true path.

In the following example, the **eval** command is used to extract an exit status from variable *junk*. The variable is initialized with the console **set** command.

```
>>>  set junk 0
>>>  show junk
junk                    0
>>>  eval junk
0
>>>  if (eval junk) then (echo true) else (echo false) fi
0
true
>>>  set junk 1
>>>  if (eval junk) then (echo true) else (echo false) fi
1
false
>>>  set junk 2
>>>  if (eval junk)
_>  then (echo true)
_>  else (echo false) fi
2
false
>>>
```

12.2 Getting Information About the System

The following commands are used to display information about software and hardware resident in the system:

Command	Description	Example
show version	Displays version number of console firmware	V1.1-0 Jul 1 1996 10:16:59

Command	Description	Example		
show pal	Displays version number of PALcode	VMS PALcode V5.56-4, OSF PALcode X1.45-8		
show device	Displays known devices on system	dkb0.0.0.1.0	DKB0	RZ57
		mke0.0.0.4.0	MKE0	TZ85
		eza0.0.0.6.0	EZA0	08-00-2B-19-60-31
		ezb0.0.0.7.0	EZB0	08-00-2B-1A-2C-06
		p_a0.7.0.0.0		Bus ID 7
		p_c0.7.0.2.0		Bus ID 7
		pkb0.7.0.1.0	PKB0	SCSI Bus ID 7
		pke0.7.0.4.0	PKE0	SCSI Bus ID 7

The command **show config** displays all of this information.

12.3 Getting Help

The Digital Alpha VME 4 console provides online Help in the form of brief help text in ROM-based images of the console and full help in loadable versions of the console. The brief help for a command is a one-line description of the command's function and all possible options and arguments for the command. With full help, all the information provided in Chapter 13 for a command is displayed on the console. However, due to space restrictions in the firmware ROMs, only brief help is available by default.

To display help text, use either the **help** or the **man** command followed by the command on which you are seeking help. If you do not specify a command after **help** or **man**, the console displays a list of all commands.

You can specify multiple help topics with one command. Separate the topics with a space, as shown in the following example:

```
>>> help examine deposit
NAME
        examine
FUNCTION
        Display data at a specified address.
SYNOPSIS
        examine [-{b,w,l,q,o,h,d}] [-{physical,virtual,gpr,fpr,ipr}]
                [-n <count>] [-s <step>]
                [<device>:]<address>

NAME
        deposit
FUNCTION
        Write data to a specified address.
SYNOPSIS
        deposit [-{b,w,l,q,o,h}] [-{physical,virtual,gpr,fpr,ipr}]
                [-n <count>] [-s <step>]
                [<device>:]<address> <data>
```

The **help** command supports a type of wildcarding. For example, the command **help st** displays any commands that begin with "st", such as **start** and **stop**.

If full help is available, the **help *** command displays all of the information on all of the commands. However, to control the display of the text, combine the command with the **more** command, as shown in the following example:

```
>>> help * | more
```

This command sequence causes a screen of text to be displayed. Press the spacebar to continue the display and press Ctrl/C to terminate the display.

For an explanation of the symbols used to represent syntax, get help on the **help** command itself, using the following command:

```
>>> help help
```

12.4 Examining and Depositing to Memory or System Registers

A byte stream is similar in concept to an OpenVMS console address space. It can represent an extent of memory, a set of registers, a device, or a file. The console commands manipulate these byte streams by performing typical device operations: open, read, write, close. Therefore, in this discussion, the term *device* refers to any byte stream or address space regardless of its actual physical implementation. For example, the address space, /P, can be accessed as a device, PMEM.

The **examine** and **deposit** commands manipulate devices to get access to data within the system. The default device is physical memory. When another device is specified, that device becomes the default. A default device is *sticky*, that is, all subsequent commands affect that device until another device is explicitly specified and becomes the new default.

The console uses drivers as the mechanism for referring to various devices. The console provides drivers for the following Alpha devices:

Device	Description
pmem:	Physical memory
vmem:	Virtual memory
gpr:	General-purpose registers
fpr:	Floating-point registers
ipr:	Internal processor registers

Because Digital Alpha VME 4 is treating address space as a device, the address argument of an OpenVMS console command becomes a byte offset within a device in a Digital Alpha VME 4 console command.

For example, **pmem:0** refers to the location in physical memory at offset zero, that is, physical address 0. If no device name is supplied, the offset applies to the last device referenced (**pmem** by default). However, in the remaining discussions, the terms *address* and *offset* are used synonymously.

The **examine** and **deposit** commands act on a physical address. You can specify the actual address or use the following symbols to point to the address:

Symbols	Description
+	Next address
*	Current address
-	Previous address

These symbols work because the console keeps track of the last referenced address. If you issue an **examine** or a **deposit** command without an address, the console firmware uses the next address. The console computes the next address as the last referenced address plus the current data size.

The options for specifying the size of the accessed data are analogous to those used for OpenVMS qualifiers, that is, options **-b**, **-w**, **-l**, and **-q** indicate byte, word, longword, and quadword, respectively.

12.4.1 Accessing Memory

Commands are available for gaining access to memory.

Note

Because the console itself and other critical data structures reside in memory, be careful not to alter them.

Use the **alloc** command to find an unused 1000-byte block of memory, as shown in the following example:

```
>>> alloc 1000
03FFF000
```

The address of the allocated block is, in this case, 0x03FFF000. Use your allocated block to test the procedures in this section.

Use the **deposit** command to add a value of 1 to physical memory:

```
>>> deposit pmem:3fff000 1
```

To check the contents of the address, use the **examine** command:

```
>>> examine pmem:3fff000
pmem:          3FFF000 00000001
```

You can abbreviate commands and you do not need to specify the device if you are referring to the default device. The following example shows the **deposit** and **examine** in an abbreviated form. The current device is still physical memory.

```
>>> d 3fff000 abcdef12                    # Deposit new data there.
>>> e 3fff000                             # Check it out.
pmem:          3FFF000 ABCDEF12
```

The console commands can be qualified, using the UNIX like options. You must leave a space between the command and each option. The following example shows how to use the **-n** option to specify a repeat count. The command is executed over n+1 successive addresses.

```
>>> d 3fff000 aaaa5555 -n 3               # Write to 4 locations, yes 4!
>>> e 3fff000 -n 3                        # Notice that -n 3 yields n+1 or 4!
pmem:          3FFF000 AAAA5555
pmem:          3FFF004 AAAA5555
pmem:          3FFF008 AAAA5555
pmem:          3FFF00C AAAA5555
```

An alternate method for dumping memory (or other devices or files) is the **hex dump** command, **hd**. The **-l** option specifies the number of bytes to display.

Note

Both **-l** and **-n** have the same result, but **-l** only works with **hd** and **-n** only works with **examine**. The distinction is caused by the commands; **examine** is a VMS like command and **hd** is a UNIX cloned command.

```
>>>  hd pmem:3fff000 -l 10                    # Dump the allocated memory.
00000000  55 55 aa aa 55 55 aa aa 55 55 aa aa 55 55 aa aa UUaaUUaaUUaaUUaa

>>> hd -l 20 show_status                     # Dump part of SHOW_STATUS script.
00000000  65 63 68 6f 20 27 64 2f 53 27 20 3e 24 24 73 73 echo 'd/S' >$$ss
00000010  0a 65 63 68 6f 20 27 2d 2d 2d 27 20 3e 3e 24 24 .echo '---' >>$$
```

12.4.2 Examining Registers

You can use the **examine** and **deposit** commands to refer to registers. You must include the address for the registers in one of the following ways:

- Symbolically, for example, **r0** or **ksp**
- Explicitly, as offsets within device address space, for example, **gpr:0** or **ipr:0**
- Implicitly, as offsets within the current device address space, for example, **0**

You can also use the symbolic addresses **+**, *****, **-**, and the implied address increment (no address specified). The following examples show the ways to include an address, as described in each command's comment.

```
>>> e r0                          # Examine R0 symbolically,...
gpr:                0 (    R0) 0000000000000002

>>> e gpr:0                       #...explicitly as device offset,...
gpr:                0 (    R0) 0000000000000002

>>> e 0                           #         ...or implicitly as device offset.
gpr:                0 (    R0) 0000000000000002

>>> e 8                           # Examine R1...
gpr:                8 (    R1) 000000000000C408

>>> e                             #           ...and the next R2.
gpr:               10 (    R2) 0000000000000000

>>> e ipr:0                       # Examine an IPR...
ipr:                0 (   ASN) 0000000000000000

>>> e                             #               ...and the next...
ipr:                1 ( ASTEN) 0000000000000000

>>> e +                           #               ...and the next...
ipr:                2 ( ASTSR) 0000000000000000

>>> e *                           #               ...and the current...
ipr:                2 ( ASTSR) 0000000000000000

>>> e -                           #               ...and the previous one.
ipr:                1 ( ASTEN) 0000000000000000

>>> e ksp                         # Examine an IPR by name...
ipr:               12 (   KSP) 0000000000000F30

>>> e                             # ...and the next one.
ipr:               13 (   ESP) 0000000000000000
```

The **examine** and **deposit** commands support symbolic representation of the following processor registers:

Register	Meaning
pc	Program counter
sp	Stack pointer
ps	Process status longword

```
>>> e pc                          # Program Counter
PC psr:                0 (    PC) 0000000000000D30

>>> e ps                          # Process Status
ipr:               17 (    PS) 0000000000001F00

>>> e sp                          # Stack Pointer
gpr:               F0 (   R30) 0000000000000F30
```

12.5 Using Pipes and grep to Filter Output

To search for specific values in a device, use a pipe with the **grep** command. A *pipe* (|) enables the output of one command to be the input for the next command without creating an intermediate file. The **grep** command filters its input according to the command argument. Because the **grep** command requires input, a pipe is used to channel the output of the **examine** command into the **grep** command.

The following example uses **grep** to search for a pattern in memory. In this case, **grep** parses all the output lines from the **examine** command, but only permits lines that contain *abcdef12* to reach the display. The **grep** command also can be used to search for patterns that do not match the model provided; that is, it searches for every line that does **not** contain the input pattern. The following example sets up the memory and then uses **grep** to filter the output.

```
>>>  d pmem:3fff000 0 -n 8                  # Clear some memory.
>>>  d 3fff020 abcdef12                     # Drop in a target.
>>>  e 3fff000 -n 8                         # Display memory.
pmem:          3FFF000 0000000000000000
pmem:          3FFF008 0000000000000000
pmem:          3FFF010 0000000000000000
pmem:          3FFF018 0000000000000000
pmem:          3FFF020 00000000ABCDEF12
pmem:          3FFF028 0000000000000000
pmem:          3FFF030 0000000000000000
pmem:          3FFF038 0000000000000000
pmem:          3FFF040 0000000000000000

>>>  e 3fff000 -n 8  | grep ABCDEF12       # Display only lines with ABCDEF12.
pmem:          3FFF020 00000000ABCDEF12
```

12.6 Using I/O Redirection (>)

By default, output goes to the console. You can redirect output to other devices or files by using the redirection operator, >. In the following example, the output of an **examine** command is redirected to file *foo*, which is created dynamically out of the console's memory heap. The console **cat** command, similar to the OpenVMS **copy** command, is used in this example to display the contents of the new file. The **rm** command, similar to the OpenVMS **delete** command, is used to remove the *foo* file.

```
>>> ls foo                              # Check to see if foo exists.
foo no such file

>>> e 3fff000 -n 1 > foo                # Redirect examine output to file foo.
>>> ls foo                              # Check to see if foo exists.
foo

>>> cat foo                             # Display foo.
pmem:          3FFF000 0000000000000000
pmem:          3FFF008 0000000000000000
>>> rm foo                              # Delete (remove) file foo.
>>> ls foo                              # Check to see if foo exists.
foo no such file
```

12.7 Running Commands in Background

"Running a command in background" means that the console creates a subprocess to execute the command, leaving the main process available for you to enter a new command. You can execute any command in the background by placing the background operator **&** at the end of the command.

In the following example, three processes are started in the background. The first process, invoked with the console **exer** command, reads data from block 0 of a disk. Then, two processes of the console memory test are created, using the **memtest** command. In all three cases, the console immediately returns with the console prompt and awaits further commands.

```
>>> show device                              # See what devices are available.
dka0.2.0.1.0              dka0              dka0
eza0.0.0.0.0              EZA0              08-00-2B-1D-02-91
ezb0.0.0.1.0              EZB0              08-00-2B-1D-02-92
pka0.7.0.2.0              PKA0              SCSI Bus ID 7

>>> exer dka0 -sb 0 -p 0 &                # Read block 0 forever.
>>> memtest -p 0 &                        # Start up the memory test forever.
>>> memtest -p 0 &                        # Start up another memory test task.
>>>
```

12.7.1 Monitoring Status

The console monitors all the processes while they are executing. To see the status of all the processes, use the **ps** command, similar to the OpenVMS **show system** command.

To see the status of a specific process, use the **grep** command with a pipe to filter the output, as shown at the end of the following example:

```
>>> ps                                    # Display complete process status.
ID       PCB     Pri CPU Time Affinity CPU  Program    State
-------- -------- --- -------- -------- --- ---------- --------------------
0000006c 001423a0 3          2 00000001 0          ps running
0000005c 00144b40 2      19253 00000001 0      memtest ready
0000005b 00147a60 2          9 00000001 0        sh_bg waiting on 00144B40
00000059 0014c060 2      21750 00000001 0      memtest ready
00000058 0014edc0 2          5 00000001 0        sh_bg waiting on 0014C060
00000056 00152860 2          3 00000001 0     exer_kid waiting on mscp_rsp
00000055 00153ae0 2          2 00000001 0         exer waiting on exer_tqe
00000054 00181580 2          6 00000001 0        sh_bg waiting on 00153AE0
0000004f 00154d60 5         38 ffffffff 0    pke0_poll waiting on tqe
   .
   .
   .
>>> ps | grep exer                       # Check exer.
00000056 00152860 2          6 00000001 0     exer_kid waiting on mscp_rsp
00000055 00153ae0 2          2 00000001 0         exer waiting on exer_tqe
```

12.7.2 Killing a Process

To stop a process, use the process ID that you get from using the **ps** command as the argument of the **kill** command.

```
>>> ps | grep memtest                    # Find a process to kill.
0000005c 00144b40 2     135733 00000001 0      memtest ready
00000059 0014c060 2     138258 00000001 0      memtest ready

>>> kill 59                              # Kill one of the memtests.

>>> ps | grep memtest                    # Display our background tasks.
0000005c 00144b40 2     135733 00000001 0      memtest ready
```

12.8 Creating Scripts

A script is a file that contains console commands, similar to an OpenVMS command file. The console firmware contains many scripts, such as the powerup script, that you can run by typing the name of the script file.

If you have a complex command or a series of commands that you have to use frequently, you can write a script for your convenience. Use the **echo** command and the output creation operator, **>**, to write characters to a file. The file is the script. The following example creates the **foo** script, containing the **examine** command.

```
>>> echo e pmem:3fff000 > foo            # Write "e 0" to file foo.

>>> cat foo                              # List foo.
e pmem:3fff000

>>> foo                                  # Execute script foo.
pmem:          3FFF000 0000000000000000
```

To add another command to the script, use the append operator, >>. If the command you are appending contains characters that could be interpreted by the **echo** command, use a grouping character to enclose the appended command. The following example uses the single quote ' grouping character to prevent the command-separator character (;) in the appended command from terminating the **echo** command.

```
>>> echo 'd 3fff000 5 ; e 3fff000' >> foo   # Append "d 0 5 ; e 0" to foo.
>>> cat foo                                 # List foo.
e pmem:3fff000
d 3fff000 5 ; e 3fff000

>>> foo                                     # Execute foo.
pmem:          3FFF000 0000000000000000
pmem:          3FFF000 0000000000000005
```

You can also use the grouping character to help you create a script that contains many commands. You have to rearrange the **echo** command so that the appended characters are at the end. Then you use the first grouping character to open the character string and take as many lines as needed to create the script before entering the closing grouping character. The following example shows how to create a long script using grouping characters:

```
>>> echo > foo 'ex 3fff000
_> d 3fff000 7
_> e 3fff000
_> d 3fff000 5
_> e 3fff000'

>>> cat foo
ex 3fff000
d 3fff000 7
e 3fff000
d 3fff000 5
e 3fff000

>>> foo
pmem:          3FFF000 0000000000000000
pmem:          3FFF000 0000000000000007
pmem:          3FFF000 0000000000000005
```

12.9 Copying Scripts Over the Network

The console provides a mechanism for transferring command scripts over the network. You can create scripts on an OpenVMS system and then fetch them from the console of an Digital Alpha VME 4 system. Use the following procedure:

1. Create a file of console commands in the familiar OpenVMS environment, using your favorite editor to create the script. In this simple example, the OpenVMS **create** command makes a file called **sample.**.

```
$  create sample.
show version
ls -l sample
(Control-Z exit)
$
```

2. Make the file compatible with the MOP load protocol. To accomplish this, run the **add_header.exe** program to append a one-block header to the file, making it compatible with the MOP load server. This executable program is on the Firmware Update CD at *[ALPHAVME]ADD_HEADER.EXE*. If you prefer, copy the file to the SYS$LOGIN area and define it as a foreign command, for example, **addhead**. To run the program, invoke **addhead,** and supply the file name as input and a name for the resulting output file.

   Note

   The current MOP load protocol only supports 15-character file names. To make use of all 15 characters in the name, do not specify a file extension. The MOP server defaults to a file extension of **.sys**.

3. Place the output file in the MOP server's load file directory, MOP$LOAD. Whenever MOP gets a request for the script, it searches in its service area.

At this point, the script file is available on the Ethernet segment of the MOP server. If the Digital Alpha VME 4 system is on the same Ethernet segment as the MOP server, the following example copies the script file over the network. The string, **mopdl:sample.sys/eza0**, specifies that the file, **sample.sys**, can be accessed over the Ethernet device, **eza0**, using the MOP download protocol driver, **mopdl:**.

```
>>>  cat mopdl:sample.sys/eza0          # Be patient! The MOP protocol is slow.
show version
ls -l sample
>>>
```

The redirection (>) operator may be used to redirect the output of the **cat** command into a local file. In this case, the output is redirected to **sample**.

```
>>>  cat mopdl:sample/eza0 > sample      # Remember be patient!
```

Once the >>> prompt returns, the file copy has completed. The resident script file, **sample** can then be displayed and executed using the following sequence of console commands:

```
>>>  cat sample
show version
ls -l sample
>>>  sample
version             V1.1-0 Jul 1 1996 10:16:59

rwx-   rd                512/2048           0   sample
```

Table 12–3 Digital Alpha VME 4 Console Command Summary

Command	Options	Parameters
	VMS like Console Commands	
boot	[-file filename] [-flags root,bitmap] [-halt]	[boot_device]
deposit	[-{b,w,l,q,o,h}] [-n val] [-s val]	[*device:*]address data
examine	[-{b,w,l,q,o,h,d}] [-n val] [-s val]	[*device:*]address
help		[command]
initialize	[-c] [-d device_path]	[slot-id]
show		{ *envar*, config, device, error, hwrpb, memory}
start		address
	UNIX like Console Commands	
cat		file...
chmod	[{- | + | =}{r | w | x | b | z}]	file...
clear		***envar***
dynamic	[-h] [-v] [-c] [-z ha]	
echo	[-n]	args...
eval		postfix_expression
exit		exit_value
grep	[-{v | c | n | y | x}] [-f filename]	expression [file...]
kill		pid...
ls	[-l]	[file...]
more	[-n pagesize]	file...
ps		

In this summary, the following conventions are used:

[*item*] - indicates the *item* is optional.
{*a*,*b*,*c*} - indicates any one of *a*, *b*, or *c*.
{*a* | *b* | *c*} - indicates any combination of *a*, *b*, or *c*.
device: specifies the name of the driver for a device address space and is one of:
pmem:, vmem:, gpr:, fpr:, ipr:, pio:,
eerom:, enet:, ferom:, iic:, ncr0(1,2,3,4):, scram:, tgec0(1): toy:, uart:
envar: specifies the name of an environment variable, for example, BOOT_DEVICE.

(continued on next page)

Table 12–3 (Cont.) Digital Alpha VME 4 Console Command Summary

Command	Options	Parameters
	UNIX like Console Commands	
rm		file...
set		***envar*** value
sleep		time
sort		file...
tr	[-{c | d | s}]	string1 [string2]
uniq		file...
wc	[-{l | w | c}]	file...
	Unique Console Commands	
alloc	[-z heap_address]	size [modulus] [remainder]
exer	[-sb startblock] [-eb endblock] [-p passcount] [-l blocks] [-bs blocksize] [-bc block_per_io] [-d1 buf1_string] [-d2 buf2_string] [-a action_string] [-sec seconds] [-m] [-v]	[device]...
free		address...
memtest	[-sa address] [-ea address] [-l length] [-bs block size] [-i inc] [-p n] [-f] [-m] [-z] [-h] [-rs n] [-rb] [-mb]	
net	[-sa] [-s] [-i] [-ri] [-ic] [-se] [-re] [-rc] [-l1] [-l2] [-els] [-kls] [-l file_name] [-id node_address] [-lc number] [-l0 node_address] [-bd burst_interval] [-cm mode_string] [-sv mop_version]	[port]
nettest	[-f filename] [-mode string] [-p n] [-sv mop_version] [-to loop_time] [-w number]	[port]
sa		process_id affinity_ mask
semaphore		
show_ status		

(continued on next page)

Table 12–3 (Cont.) Digital Alpha VME 4 Console Command Summary

Command	Options	Parameters
	Unique Console Commands	
sp		process_id new_ priority
stop		device_path

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Console Commands

Console mode provides the user interface that you enter when the power-on self-test (POST) completes. The console prompt is:

>>>

Console mode is entered in any of the following ways:

- You press the Halt/Reset switch on the front panel. Depending on your operating system and applications running at the time, this could damage application files.
- The module receives a VMEbus reset signal and switch 3 of the configuration switches on the Digital Alpha VME 4 module is enabled. Depending on your operating system and applications running at the time, this could damage application files.
- You enter the operating system command to go to console mode.
- The operating system executes a HALT instruction.
- The operating system encounters a fatal error.
- The watchdog timer is enabled, and the system software allows the timer to time out.

To leave console mode, use the **boot** or **start** commands.

The code that supports console mode is built into the Digital Alpha VME 4 module and stored in the flash ROMs.

13.1 Console Commands

13.1.1 Special Keys

The following keys perform special functions:

- Ctrl/U—Ignores the current command line
- Backspace/Delete—Deletes a character within the command line

- Ctrl/S—Suspends output to the console terminal
- Ctrl/Q—Resumes output to the console
- Ctrl/C—Aborts the current command, if possible

  The console program has no control over this once control has been passed to another program such as an operating system or loadable diagnostic.
- Ctrl/R—Retypes the current command line
- Ctrl/O—Causes the console code to throw away output characters rather than send them to the terminal

  Entering another Ctrl/O resumes sending output characters.
- Up and Down Arrow—Used for command-line recall

13.1.2 Command Line Characteristics

The character sequence used for the prompt >>> is:

```
0Dh 0Ah 0Dh 3Eh 3Eh 3Eh 20h
```

This sequence is <CR>, <LF>, <CR>, >>>, <SP>. Host software executing a binary load on the console terminal port can look for this character string to determine when to respond.

Commands are limited to 80 characters. Characters entered after the 80th character replace the last character in the buffer. Depending on your terminal, these lost characters may be displayed but they are not included in the actual command line.

The command interpreter is not case-sensitive. Lowercase ASCII characters a through z are treated as uppercase characters.

Characters with codes greater than 7Fh are rejected by the parser. These characters are acceptable in comments.

Type-ahead is not supported. Characters received before the console prompt are checked for special characters (Ctrl/S, Ctrl/Q, Ctrl/C) but are otherwise discarded.

13.1.3 Radix Control

Numbers that you enter are, by default, interpreted as hexadecimal. You can change the radix of input by entering %x before a number to specify hexadecimal or %d for decimal.

13.1.4 Console Command Dictionary

The following commands are supported by the Digital Alpha VME 4 console program.

alloc — allocate a block of memory

Exports the malloc routine out to the shell so you can allocate a block of memory from heap. You can then use the block simultaneously with several test routines (there can be several readers but only one writer).

Syntax

alloc ***size*** **[***modulus***] [***remainder***] [-flood] [-z** ***heap_address***]

Arguments

size
Specifies the size (hexadecimal) in bytes of the requested block.

modulus
Specifies the modulus (hexadecimal) for the beginning address of the requested block.

remainder
Specifies the remainder (hexadecimal) used in conjunction with the modulus for computing the beginning address of the requested block.

Options

-flood
Flood memory with 0s. By default, the **alloc** command does not flood memory.

-z heap_address
Allocate memory from the memory zone starting at address *heap_address*. You can get this address from the output of the **dynamic** command.

Example

```
>>> alloc 200
00FFFE00
>>> free fffe00
>>> set base 'alloc 400'
>>> show base
base                    00FFFC00
>>> memtest $base
>>> free $base
>>> clear base
```

See Also

dynamic, **free**

boot — bootstrap the system

Initializes the processor, loads a program image from the specified boot device, and transfers control to that image. If you do not specify a boot device, the default boot device, defined by the value of the BOOTDEF_DEV environment variable, is used.

You can specify a list of devices so that a bootstrap is attempted from each device in order. When one of the devices boots successfully, control passes to that booted image. Be sure to put network devices at the end of the list because network bootstraps only terminate if a fatal error occurs or an image is successfully loaded.

The **flags** option can pass additional information to the operating system about the boot that you are requesting.

Use the **-protocol** option to specify either the DECNET MOP or the TCP/IP BOOTP network bootstraps. Use the environment variable, EWA0_PROTOCOLS to set the default protocol for a given port.

Note

Explicitly stating the boot flags or the boot device overrides the current default value for the current boot request, but does not change the setting of the corresponding environment variable.

TFTP and BOOTP

For the Internet environment, the console implements Boot Protocol (BOOTP) and Trivial File Transfer Protocol (TFTP) clients to support network bootstrapping and file transfers.

BOOTP is a standard protocol in the TCP/IP suite. It operates in the client-server paradigm and requires only a single packet exchange. The machine that sends the BOOTP request is the client; any machine that replies is the server. The first packet sent requests a file transfer and establishes the connection between client and server.

The packet specifies a file name and whether the file is to be read (transferred to the client) or written (not currently supported). TFTP performs this operation. Internet booting is a two-stage operation:

1. BOOTP provides the client with information needed to obtain an image.

A 300-byte database in the same format as the BOOTP message is used to store the received packet. Once a BOOTP packet is broadcasted and received, the database is marked as initialized, ending the first stage of the operation.

2. The client uses TFTP to obtain the image.

   TFTP takes the information in the BOOTP packet (or uses a file name specified in the command string or the environment variable BOOT_FILE and gets the file from the server. TFTP accepts one parameter: the host address concatenated to the file name of the remote file to be read.

Both BOOTP and TFTP use UDP (User Datagram Protocol) as the primary transport mechanism to send datagrams to other application programs. TFTP depends on UDP, which is an unreliable, connectionless Internet protocol.

Internet Booting Hierarchy

A complete description of Internet protocols is in Douglas Comer's *Internetworking with TCP/IP, Vol I, Principles, Protocols and Architecture*, Second edition, Prentice Hall.

The following list shows the priority of the different ways of Internet booting from an initialized system:

1. Specify the file name as the named boot:

   ```
   >>> boot -file filename ewa0
   ```

   If the pathname includes a slash (/), it must be specified as a double slash (//). For example:

   ```
   >>> boot -file //var//adm//ris//ris0.alpha//vmunix ewa0
   ```

   Use this method only when using the **-file** option to specify the named boot or to load the file name into the environment variable, BOOT_FILE.

2. Assign the file name to the environment variable BOOT_FILE.

   This is the same method as the first one but the file name is taken from BOOT_FILE. For example:

   ```
   >>> set boot_file //var//adm//ris//ris0.alpha//vmunix
   >>> boot ewa0
   ```

3. Assign the file name to the environment variable EWA0_INETFILE.

   This method uses only the TFTP protocol. The BOOTP packet must already be initialized. All other fields of the BOOTP packet must contain valid information from a previous Internet boot.

4. Assign the file name to the environment variable EWA0_BOOTP_FILE.

The file name defined by this environment variable becomes the file name in the outgoing BOOTP request packet. For example:

```
>>> set ewa0_bootp_file /var/adm/ris/ris0.alpha/vmunix.old
```

5. Do not specify a file name:

   ```
   >>> boot ewa0
   ```

   With this method, because none of the environment variables are written, the boot process runs through both stages. Any server that receives the request replies.

In the client-server paradigm, the way the firmware acts is affected by the software running on the server. For example, the format of the file specification used with TFTP depends on the server: the UNIX server requires a complete path name. See the operating system documentation for details about server software.

For BOOTP and TFTP to operate reliably, several network parameters, defined as environment variables, must be configured properly. If the parameters are misconfigured, the Internet protocols are robust enough to work intermittently, making it hard to debug the failures. Use the following procedure to get the software running. Note that each network interface has a complete set of variables of its own, prefixed with the name of the interface.

The examples shown here use boot device EWA0.

1. Define the environment variable EWA0_PROTOCOLS with the name of the boot protocol you want to enable.

   You can use BOOTP (TFTP) and MOP. If this variable is not defined, all protocols are enabled. If both strings are defined, the system tries the first one, and if that does not work, uses the second one. For example, the following command enables BOOTP if available, and then MOP if BOOTP is not available:

   ```
   >>> set ewa0_protocols bootp,mop
   ```

   When specifying both protocols, do not use spaces between names.

2. Define the fields of the database.

   Each network interface has a small database of information that is required to operate as is on that network. The database is stored in a 300-byte structure with the same format as a BOOTP packet. This database can be directly read and written in binary form through the BOOTP protocol driver. The four most important fields of the database are accessed through the following environment variables:

Environment Variable	Field	Description
EWA0_INETADDR	Internet address of the network interface (EWA0)	Local address. TFTP and the Address Resolution Protocol (ARP) do not operate properly without the correct address.
EWA0_SINETADDR	Internet address of the remote server	The address of a server, which may or may not be on the local network. Usually, this is the server from which to boot. This is the default remote host contacted by TFTP.
EWA0_GINETADDR	Internet address of the remote gateway	The address of an Internet gateway on the local network. TFTP cannot communicate beyond the local network if this gateway address is not correct.
EWA0_INETFILE	A file to be booted, formatted as a string	Use a fully qualified file name, according to whatever rules are specified by the TFTP server on the remote host. This is the default file name requested by TFTP.

The Internet addresses use Internet standard dotted decimal notation, for example, 16.123.16.53.

3. Initialize the database. The database is marked as initialized on the first occurrence of any of the following:

   - Invoking BOOTP
   - Invoking TFTP

   The most common way for initializing the database is the invocation of TFTP. When TFTP is invoked and the database has not been marked as initialized, the initialization occurs automatically, based on the definition of the environment variable EWA0_INET_INIT. If EWA0_INET_INIT is set to BOOTP (the default), the BOOTP driver broadcasts a BOOTP request and stores the response in the database, initializing the database. If EWA0_INET_INIT is set to NVRAM, the database is initialized by copying the contents of five nonvolatile default variables into the five database fields. However, these five nonvolatile default variables must be set in advance.

   The five nonvolatile default variables are:

   EWA0_DEF_INETADDR

EWA0_DEF_SINETADDR
EWA0_DEF_GINETADDR
EWA0_DEF_SUBNETMASK
EWA0_DEF_INETFILE

These variables are defined in the following example:

```
>>> set EWA0_DEF_INETADDR 16.123.16.53
>>> set EWA0_DEF_SINETADDR 16.123.16.242
>>> set EWA0_DEF_GINETADDR 16.123.16.242
>>> set EWA0_DEF_SUBNETMASK 255.255.255.0
>>> set EWA0_DEF_INETFILE bootfiles/vmunix
>>> set EWA0_INET_INIT nvram
```

Another way for the database to be initialized is when BOOTP is invoked, either explicitly or as a consequence of invoking TFTP. In the usual case, BOOTP copies the received reply packet into the database, initializing it. However, if the *nobroadcast* argument is specified, that is, `bootp:nobroadcast /ewa0`, no request is broadcast, no reply can be received, and so nothing is copied into the database.

The BOOTP database is initialized every time a BOOTP/TFTP boot is performed. Whether the database is initialized from the response to a BOOTP broadcast or from the NVRAM environment variables depends on whether the EWA0_INET_INIT environment variable is set to BOOTP or NVRAM, respectively.

TFTP, BOOTP, and ARP all use retransmission to improve robustness. If an initial transmission is not answered appropriately, the protocol software retransmits. Each protocol has an environment variable to control the number of retries. The variables are named EWA0_ARP_TRIES, EWA0_BOOTP_TRIES, and EWA0_TFTP_TRIES. The default value of these is 3. If the value of one of these variables is less than 1, the protocol fails immediately. Machines located on very busy networks or associated with heavily-loaded servers may need these variables set higher.

Three retries translates to an average of 12 seconds before failing. The retransmission algorithms use a randomized exponential backoff delay. If the first try fails, a second try occurs about 4 seconds later. A third try occurs after another 8 seconds, a fourth after 16 seconds, and so on, up to 64 seconds. These times are averages since random jitter of about +/- 50% is added to each delay. For example, if EWA0_ARP_TRIES is set to 3, ARP fails if it does not get a response within 12 seconds on average; the actual timeout is between 6 and 18 seconds.

Protocol Drivers

You normally use BOOTP and TFTP to bootstrap across a network. However, you can invoke the protocols as protocol drivers. The BOOTP and TFTP protocols must be followed by a network in the protocol tower.

When a BOOTP request is broadcast, the environment variable EWA0_BOOTP_SERVER is copied into the *sname* field of the request packet and the variable EWA0_BOOTP_FILE is copied into the *file* field of the request packet. The exact interpretation of these fields depends on the BOOTP server. The *sname* field must be the name of a specific host from which the local machine wants to boot. If it does not matter which server answers, the variable EWA0_BOOTP_SERVER must be left empty. The server must use the *file* field in the request to define which boot file to specify in the response. For example, the client could supply a generic name like UNIX or LAT, and the server would respond with the fully qualified file path to be used with TFTP. If a machine always boots the same file, EWA0_BOOTP_FILE can be left empty.

Use the TFTP protocol driver to read files across the network. TFTP accepts one parameter, the host address concatenated to the file name of the remote file to be read. Specify the host address in dotted decimal notation. Separate the address from the file with a colon (:). A slash (/) in a file name must be doubled (//). The following example displays the file /usr/foo/bar on a host with the address of 16.123.16.242:

```
>>> cat tftp:16.123.16.242://usr//foo//bar/ewa0
```

For convenience, you can save an address in an environment variable:

```
>>> set ktrose 16.123.16.242
>>> cat tftp:$ktrose://usr//foo//bar/ewa0
```

If you do not specify a parameter, TFTP uses the file name and server address defined in EWA0_INETFILE and EWA0_SINETADDR.

When booting with TFTP, the **boot** command passes the contents of the environment variable BOOT_FILE as the parameter for TFTP. If BOOT_FILE does not have the correct format, TFTP fails. A common practice is to leave BOOT_FILE undefined so that TFTP defaults to using EWA0_SINETADDR and EWA0_INETFILE.

Syntax

boot **[-file *filename*]** [-flags *longword*[, *longword*]] [-protocols *enet_protocol*] [-halt] [*boot_device*]

Arguments

boot_device
A device path or list of devices from which the firmware attempts to boot, or a saved boot specification in the form of an environment variable. Use the **set** command with the environment variable BOOTDEF_DEV to define the default boot device. You can specify a list of devices by using commas without spaces. For example:

```
>>> set BOOTDEF_DEV ewa0,dka0
```

Options

-file *filename*
Specifies the name of a file to load into the system. Use the **set** command with the environment variable BOOT_FILE to specify a default boot file.

-flags *longword*[, *longword*]
Specifies additional information to the operating system.

-protocols *enet_protocol*
Specifies the Ethernet protocols to be used for the network boot. You can specify either MOP or BOOTP. If you specify both, the firmware attempts to use each protocol to solicit a boot server.

-halt
Forces the bootstrap operation to halt and invoke the console program once the image is loaded and page tables and other data structures are set up. Console device drivers are not shut down when you specify this option.

Examples

1. `>>> boot`

   The system boots from the default boot device. The console program returns an error message if you have not set a default boot device.

2. `>>> boot ewa0`

   The system boots from the Ethernet port EWA0.

3. `>>> boot -file avme.sys ewa0`

   The system boots the file `avme.sys` from Ethernet port EWA0.

4. >>> **boot -fi //usr//local//bootfile//alphavme_v1_1-0 -protocol bootp ewa0**

   The system performs a TCP/IP BOOTP network boot from Ethernet port EWA0.

5. >>> **boot -flags 0,1**

   The system boots from the default boot device using boot flag settings 0,1.

6. >>> **boot -halt dka0**

   The system loads the operating system from the SCSI disk, dka0, but remains in console mode.

See Also

set, **show**

break — break from a program loop

Breaks from a for, while, or until loop. Exits the current shell with a status or returns the status of the last command.

Syntax

break [*break_level*]

Arguments

break_level
Specifies the status code to be returned by the shell.

Example

```
>>>  for i in 1 2 3 4 5 ; do  echo $i ; break ; done
1
>>>
```

cat — copy files

Concatenates files that you specify to the standard output. If you do not specify files on the command line, the **cat** command copies standard input to standard output.

You can also copy or append one file to another by specifying I/O redirection.

Syntax

cat [-l *length*] *file1* [*file2 . . .*]

Arguments

***file1* [*file2 . . .*]**
Specifies the name of the input files to be copied.

Options

-l *length*
Specifies the number of bytes (decimal) of each input file to copy.

Examples

1.
```
>>> echo > foo 'this is a test.'
>>> cat foo
this is a test.
>>>
```

   Creates the file `foo` with the **echo** command, and then uses the **cat** command to send the contents of the file to the standard output, the console terminal screen.

2.
```
>>> cat -l 6 foo
this i
>>>
```

   Sends the first 6 bytes of the file `foo` to the standard output, the console terminal screen.

See Also

echo, **ls**, **rm**

chmod — change file attributes

Changes the specified attributes of a file. The **chmod** command is a subset of the equivalent UNIX command.

Syntax

chmod { **-** **+** **=** } **{r,w,x,b,z}** ***file1*** **[*file2 . . .*]**

Arguments

file1 **[*file2 . . .*]**
Specifies the files or inodes to be modified.

Options

–
A minus sign indicates to remove the specified attributes.

+
A plus sign indicates to add the specified attributes.

=
An equals sign indicates to set the specified attributes and clear all other attributes not included in the command.

r
Sets or clears the read attribute.

w
Sets or clears the write attribute.

x
Sets or clears the execute attribute.

b
Sets or clears the binary attribute.

z
Sets or clears the expand attribute.

Examples

1. `>>> chmod +x script`

   Adds the executable attribute to the file, `script`.

2. `>>> chmod =r errlog`

   Sets the file `errlog` to read only.

3. `>>> chmod -w dk*`

   Makes all SCSI disks nonwriteable.

See Also

chown, **ls -l**

chown — change ownership of memory block

Changes the ownership of a memory block to the specified process.

Syntax

chown ***pid address1*** **[*address2 . . .*]**

Arguments

pid
Specifies the hexadecimal process identifier (PID) of the new owner. You can display PIDs with the **ps** command.

address1 **[*address2 . . .*]**
Specifies the hexadecimal address or list of addresses of allocated blocks for which ownership is to be changed.

Example

```
>>> chown 'ps | grep idle | find 0' 'alloc 200'
```

The first argument to the **chown** command uses the **ps** command to display processes and pipes the output to the **grep** command to find the idle process.

The second argument to the **chown** command calls `alloc 200` to return the starting address of the first free block of 200 bytes.

See Also

alloc, **dynamic**, **ps**

clear — delete environment variable

Deletes an environment variable from the name space.

Note

Some environment variables, such as BOOTDEF_DEV, are permanent and cannot be deleted.

Syntax

clear ***variable_name***

Arguments

variable_name
Specifies the name of the environment variable to be deleted.

Example

```
>>> clear foo
>>>
```

Deletes the environment variable *foo*.

See Also

set, **show**

clear_log — clear error log in NVRAM

Clears and initializes the area of NVRAM used for console error logging. The entire area of NVRAM where fault information is stored is cleared to zero. Miscellaneous pointers, counters, and initialization flags used in the error logging process are reset accordingly.

Notes

The current contents of the NVRAM error log area is destroyed and lost forever. If you do not want the console to prompt you before the log areas is cleared, specify the **-nc** command option.

Console error logging is completely independent of the operating system's error logging.

Syntax

clear_log

Options

-nc
No confirmation, when specified; you are not prompted before the NVRAM log area is cleared.

Example

```
>>>  clear_log
Error Log data in NVRAM will be destroyed!!
Continue (y/n)?
y
Initializing NVRAM Error Log...
```

The user is prompted to continue, then the NVRAM error log is initialized.

See Also

show_log

date — display or change time

Displays or modifies the current date and time. If you include no arguments, the command displays the current date and time. If you do include arguments, the command modifies the current date and time stored in the time-of-year (TOY) clock.

Note

The date is not preserved if the TOY clock battery has been disabled with the **set** TOY SLEEP command. On the next power-on of the module, the battery is reenabled and the date might need to be reinitialized.

The format of the date and time registers for the console is as described in the DS1386 specification, except that the year register contains the number of years 1858. This is done to retain compatibility with the openVMS and UNIX operating systems.

Syntax

date ***[[[yyyy]mm]dd]hhmm[.ss]***

Arguments

yyyymmddhhmm.ss
Specifies the new date and time, where:

- *yyyy* (0000-9999) is the year
- *mm* (01-12) is the two digit month
- *dd* (01-31) is the two digit day
- *hh* (00-23) is the two digit hour
- *mm* (00-59) is the two digit minute
- *ss* (00-59) is the two digit second

When you modify the date or time, you must specify at least the hour and minute fields (4 digits). If you include 6 digits, that is interpreted as the day, hour, and minute fields. Omitted fields are inherited.

date

Example

```
>>>  date 199208031029.00
>>>  date
10:29:04  August  3, 1992
>>>
```

deposit — write memory data

Writes data to a memory location, a register, a device, or a file.

After initialization, if you have not specified a data address or size, the default address space is physical memory, the default data size is a quadword, and the default address is zero.

You specify an address or device by concatenating the device name with the address, for example, `pmem:0`, and by specifying the size of the space to which to write.

If you do not specify an address, the data is written to the current address in the current data size (the last previously specified address and data size).

If you specify a conflicting device, address, or data size, the console ignores the command and issues an error response.

Syntax

d[eposit] [**-b** | **-w** | **-l** | **-q** | **-o** | **-h**] [**-physical** | **-virtual** | **-gpr** | **-fpr** | **-ipr**] **[-n** ***count*****]** **[-s** ***step*****]** **[*****device*****:]** ***address data***

Arguments

[*device*:]
Specifies the device name or address space to access. The following devices are supported:

pmem: Physical memory.

vmem: Virtual memory. All access and protection checking occur. If the access would not be allowed to a program running with the current PS, the console issues an error message. If memory mapping is not enabled, virtual addresses are equal to physical addresses.

gpr: General purpose register. The data size defaults to quadword. The following symbols for *address* are recognized: r0, r1, . . . r31, ai, ra, pv, fp, sp, and rz.

fpr:	Floating-point register set. The data size defaults to quadword. The following symbols for *address* are recognized: f0, f1, . . . f31.
ipr:	Internal processor register set. The size defaults to quadword. The following symbols for *address* are recognized: ps, asn, asten, astsr, at, fen, ipir, ipl, mces, pcbb, prbr, ptbr, scbb, sirr, sisr, tbchk, tbia, tbiap, tbis, esp, ssp, usp, and whami.
pt:	PAL Temporary register set, PT:0-PT:31 or PT0:-PT31:. The data size defaults to quadword.
pcicfg:	PCI configuration space.
pcidmem:	PCI dense memory space.
pcismem:	PCI sparse memory space.
pciio:	PCI I/O space.
eerom:	Environment variable and error log NVRAM.
ferom:	Intel 28F020 firmware FEPROM.
toy:	DS1386 registers, clock chip, and NVRAM.

address

Specifies the address into which the data is to be deposited. The address can be any valid hexadecimal offset in the device's address space or it can be a symbolic address.

For hexadecimal addresses that start with "f", you must add a leading zero (0) to prevent recognition as a floating-point register. For example, 0f0 is a valid memory address while f0 is not.

You cannot use a symbolic address if you include the *device:* field. The following are valid symbolic addresses:

gpr	General purpose register 0.
fpr	Floating-point register 1.
ipr	Internal processor register.
pt or **pt0 - pt31**	PAL Temporary registers 0-31. The data size defaults to quadword; the address space defaults to **pt**.
PC	Names the Program Counter (execution address register). The last address, size, and type are unchanged.

+	Names the location immediately following the last location referenced in an examine or deposit. For references to physical or virtual memory, the location is the last address plus the size of the last reference. For other address spaces, the address is the last address referenced plus one.
-	Names the location immediately preceding the last location referenced in an examine or deposit. For references to physical or virtual memory, the location is the last address minus the size of the last reference. For other address spaces, the address is the last address referenced minus one.
*****	Names the location last referenced by an examine or deposit.
@	Uses the data at the last location referenced by an examine or deposit as the address.

data
The data to be deposited. If the specified data is larger than the deposit data size, the console ignores the command and issues an error. If the specified data is smaller than the deposit data size, it is padded with leading zeros before being deposited.

Options

-b
The data type is byte.

-w
The data type is word.

-l
The data type is longword.

-q
The data type is quadword.

-o
The data type is octaword (8 words).

-h
The data type is hexaword (16 words).

-d
The data displayed is the decoded macro instruction. Alpha instruction decode (-d) does not recognize machine-specific PAL instructions.

-physical
The address space is physical memory. Using this option is the same as specifying the `pmem:` device.

-virtual
The address space is virtual memory. Using this option is the same as specifying the `vmem:` device.

-gpr
The address space is general purpose registers. Using this option is the same as specifying the `gpr:` device.

-fpr
The address space is floating-point registers. Using this option is the same as specifying the `fpr:` device.

-ipr
The address space is internal processor registers. Using this option is the same as specifying the `ipr:` device.

-n *count*
Specifies the number (hexadecimal) of consecutive locations to modify. The console deposits to the first address, then to the specified number of succeeding addresses.

-s *step*
Specifies the address increment size (hexadecimal). The address increment size defaults to the data size, but is overridden by the presence of this option. This option is not inherited.

Examples

1. `>>> d -b -n 1FF pmem:0 0`

   Clears the first 512 bytes of physical memory.

2. `>>> d -l -n 3 vmem:1234 5`

   Deposits 5 into four longwords starting at virtual memory address 1234.

3. `>>> d -n 8 R0 FFFFFFFF`

   Loads GPRs R0 through R8 with -1.

4. `>>> d -l -n 10 -s 200 pmem:0 8`

   Deposits 8 into the first longword of each of the first 17 pages in physical memory.

See Also

examine

dynamic — show memory

Shows the state of dynamic memory. Dynamic memory is split into two main heaps: the console's private heap and the remaining memory heap.

Syntax

dynamic [-c [-r]] [-h] [-p] [-v] [-setsize] [-extend *byte_count*] [-z *heap_address*]

Options

-c
Performs a consistency check on the default heap or the heap specified with option **-z**.

-r
Repairs a broken heap by flooding free blocks with DYN$K_FLOOD_FREE if and only if the free blocks have been corrupted. Repairing broken heaps is dangerous at best, as it masks underlying errors. This flag takes effect only if a consistency check is being done.

-h
Displays the headers of the blocks in the default heap or the heap specified with option **-z**.

-p
Displays dynamic memory statistics on a per process basis.

-v
Performs a validation test on the default heap or the heap specified with option **-z**.

-setsize
Sets the total memory in the system to the specified size. Adds the memory to or subtracts the memory from the end of the memory zone.

-extend *byte_count*
Extends the default memory zone by the specified byte count at the expense of the main memory zone. This command assumes that these two zones are physically adjacent.

-z *heap_address*
Operates on the heap at the specified address.

Examples

1.
```
>>> dynamic
zone     zone       used    used       free    free       utili-  high
address  size       blocks  bytes      blocks  bytes      zation  water
-------- ---------- ------- ---------- ------- ---------- ------- ----------
00097740 1048576    389     358944     17      689664      34 %   371872
001D2B80 14805504   1       32         1       14805504     0 %   0
```

2.
```
>>> dynamic -cv -z 97740
zone     zone       used    used       free    free       utili-  high
address  size       blocks  bytes      blocks  bytes      zation  water
-------- ---------- ------- ---------- ------- ---------- ------- ----------
00097740 1048576    398     359520     17      689088      34 %   371872
```

3.
```
>>> dynamic -h
zone     zone       used    used       free    free       utili-  high
address  size       blocks  bytes      blocks  bytes      zation  water
-------- ---------- ------- ---------- ------- ---------- ------- ----------
00097740 1048576    392     359136     17      689472      34 %   389280
a 00097740 000E1600_001E0600 000E1608_001BF628 00000000 00097740 32
f 000E1600 0017E600_00097740 00189E68_00097748 FFFFFFFF 000E1600 643072
a 0017E600 001823C0_000E1600 001BF448_001B0D6C 00000023 0017E600 15808
   .
   .
   .
>>>
```

See Also

alloc, **free**

echo — display text output

Sends a line of text that you enter on the command line to the current output device. The default output device is your console screen. The **echo** command separates arguments (words) in the line with blanks and adds a new line character to the end of the line.

Whenever you specify pipes or I/O redirection, enclose the text within single quotes.

Syntax

echo [-n] ***args...***

Arguments

args...
Specifies the character strings to be displayed.

Options

-n
Suppresses new lines from the command output.

Examples

1.
```
>>> echo this is a test.
this is a test.
>>>
```

   Echo sends the character string to your console screen.

2.
```
>>> echo -n this is a test.
this is a test.>>>
```

   Echo sends the character string to your console screen, but with no new line separating the string from the next console prompt (>>>).

3.
```
>>> echo 'this is a test' > foo
>>> cat foo
this is a test
>>>
```

   The string is piped to the file `foo`. Typing the contents of the file `foo` then shows the string.

4.
```
>>>  echo > foo 'this is the simplest way
_>to create a long file. All characters will be echoed
_>to file foo until the closing single quote.'
>>>  cat foo
this is the simplest way
to create a long file. All characters will be echoed
to file foo until the closing single quote.
>>>
```

   Shows how you can use **echo** to create a file that is several lines long.

See Also

cat

eval — evaluate expression

Evaluates a postfix expression.

Syntax

eval [**-ib** | **-io** | **-id** | **-ix**] [**-b** | **-o** | **-d** | **-x**] ***operand1 operand2 operator***

Arguments

operand1
The first numeric value to be evaluated.

operand2
The second numeric value to be evaluated.

operator
One of the following:

- + Add the operands.
- - Subtract *operand2* from *operand1*.
- * Multiply the operands.
- / Divide *operand1* by *operand2*.

Options

-ib
Indicates that the operands are binary values.

-io
Indicates that the operands are octal values.

-id
Indicates that the operands are decimal values.

-ix
Indicates that the operands are hexadecimal values.

-b
Displays the output as binary values.

-o
Displays the output as octal values.

-d
Displays the output as decimal values.

-x
Displays the output as hexadecimal values.

Examples

1. `>>> eval 5 10 +`
   15

   The sum of 5 plus 10 is 15.

2. `>>> eval -ix -d 5 10 +`
   21

   The sum of 5 plus 0x10 is 21 (decimal).

examine — display memory data

Displays data located at a specified address: a memory location, a register, a device, or a file.

After initialization, if you have not specified a data address or size, the default address space is physical memory, the default data size is a quadword, and the default address is zero.

You specify an address or device by concatenating the device name with the address, for example, PMEM:0, and by specifying the size of the data to be displayed.

If you do not specify an address, the data at the current address is displayed in the current data size (the last previously specified address and data size).

If you specify a conflicting device, address, or data size, the console ignores the command and issues an error response.

The display line consists of the device name, the hexadecimal address (or offset within the device), and the examined data, also in hexadecimal.

The **examine** command uses the same options as the **deposit** command. Additionally, the **examine** command supports instruction decoding, the **-d** option, which disassembles instructions beginning at the current address.

Syntax

e[xamine] [**-b** | **-w** | **-l** | **-q** | **-o** | **-h** | **-d**] [**-physical** | **-virtual** | **-gpr** | **-fpr** | **-ipr**] **[-n** ***count*****]** **[-s** ***step*****]** **[***device***:]** ***address data***

Arguments

[*device*:]
Specifies the device name or address space to access. The following devices are supported:

pmem: Physical memory.

vmem:	Virtual memory. All access and protection checking occur. If the access would not be allowed to a program running with the current PS, the console issues an error message. If memory mapping is not enabled, virtual addresses are equal to physical addresses.
gpr:	General purpose register set, R0-R31. The data size defaults to -q.
fpr:	Floating-point register set, F0-F31. The data size defaults to -q.
ipr:	Internal processor register set.
pt:	PAL Temporary register set, PT0-PT31. The data size defaults to -q.
pcicfg:	PCI configuration space.
pcidmem:	PCI dense memory space.
pcismem:	PCI sparse memory space.
pciio:	PCI I/O space.
eerom:	Environment variable and error log NVRAM.
ferom:	Intel 28F020 firmware FEPROM.
toy:	DS1386 registers, clock chip, and NVRAM.

address

Specifies the address into which the data is to be deposited. The address may be any valid hexadecimal offset in the device's address space or it may be a symbolic address.

For hexadecimal addresses that start with "f," you must add a leading zero (0) to prevent recognition as a floating-point register. For example, 0f0 is a valid memory address while f0 is not.

You cannot use a symbolic address if you include the *device:* field.

The following are valid symbolic addresses:

gpr- *name*	Names a general purpose register. The size defaults to quadword; the address space defaults to **gpr**. The following symbols for *name* are recognized: r0, r1, . . . r31, ai, ra, pv, fp, sp, and rz.
fpr- *name*	Names a floating-point register. The size defaults to quadword; the address space defaults to **fpr**. The following symbols for *name* are recognized: f0, f1, . . . f31.

ipr- *name*	Names an internal processor register. The size defaults to quadword; the address space defaults to **ipr**. The following symbols for *name* are recognized: ps, asn, asten, astsr, at, fen, ipir, ipl, mces, pcbb, prbr, ptbr, scbb, sirr, sisr, tbchk, tbia, tbiap, tbis, esp, ssp, usp, and whami.
pt- *name*	Names a PAL Temporary register. The data size defaults to quadword; the address space defaults to pt. The following symbols for *name* are recognized: pt0, pt1, . . . pt31.
PC	Names the Program Counter (execution address register). The last address, size, and type are unchanged.
+	Names the location immediately following the last location referenced by the **examine** or **deposit** command. For references to physical or virtual memory, the location is the last address plus the size of the last reference. For other address spaces, the address is the last address referenced plus one.
-	Names the location immediately preceding the last location referenced by the **examine** or **deposit** command. For references to physical or virtual memory, the location is the last address minus the size of the last reference. For other address spaces, the address is the last address referenced minus one.
*****	Names the location last referenced by the **examine** or **deposit** command.
@	Uses the data at the last location referenced by the **examine** or **deposit** command as the address.

Options

-b
The data size is byte.

-w
The data size is word.

-l
The data size is longword.

-q
The data size is quadword.

-o
The data size is octaword.

-h
The data size is hexaword.

-d
The data displayed is the decoded macro instruction. Alpha instruction decode (-d) does not recognize machine-specific PAL instructions.

-physical
The address space is physical memory. Using this option is the same as specifying the `pmem:` device.

-virtual
The address space is virtual memory. Using this option is the same as specifying the `vmem:` device.

-gpr
The address space is general purpose registers. Using this option is the same as specifying the `gpr:` device.

-fpr
The address space is floating-point registers. Using this option is the same as specifying the `fpr:` device.

-ipr
The address space is internal processor registers. Using this option is the same as specifying the `ipr:` device.

-n *count*
Specifies the number of consecutive locations to examine.

-s *step*
Specifies the address increment size (hexadecimal). Normally this defaults to the data size, but is overridden by the presence of this option. This option is not inherited.

Examples

1.
```
>>> e r0
gpr:                0 (    R0) 0000000000000002
```

   Examine general purpose register (GPR) R0 by symbolic address.

examine

2.
```
>>> e -g 0
gpr:                0 (    R0) 0000000000000002
```

   Examine GPR register R0 by address space (-gpr option).

3.
```
>>> e gpr:0
gpr:                0 (    R0) 0000000000000002
```

   Examine R0 by device name.

4.
```
>>> examine pc
gpr: 0000000F (    PC) FFFFFFFC
```

   Examine the program counter (PC).

5.
```
>>> examine sp
gpr: 0000000E (    SP) 00000200
```

   Examine the GPR stack pointer (SP) register.

6.
```
>>> examine -n 5 R7
gpr: 00000007 (    R7) 00000000
gpr: 00000008 (    R8) 00000000
gpr: 00000009 (    R9) 801D9000
gpr: 0000000A (   R10) 00000000
gpr: 0000000B (   R11) 00000000
gpr: 0000000C (    AP) 00000000
```

   Examine R7 plus the 5 following GPRs.)

7.
```
>>> examine ipr:11
ipr: 00000011 (  SCBB) 2004A000
```

   Examine the SCBB, internal processor register (IPR) 17 (decimal).

8.
```
>>> examine scbb
ipr: 00000011 (  SCBB) 2004A000
```

   Examine the SCBB using the symbolic name.

9.
```
>>> examine pmem:0
pmem: 00000000 00000000
```

   Examine physical address 0.

10.
```
>>> examine -d 40000
pmem: 00040000      11 BRB     20040019
```

   Examine address 40000 with macro instruction decode.

11. >>> **examine**
    pmem: 20040048   DB MFPR   S^#2B,B^48(R1)

    Look at the next instruction.

See Also

deposit

exer — exercise devices

Exercises one or more devices by performing read, write, and compare operations. Optionally, reports performance statistics.

A read operation reads from a device into a buffer. A write operation writes from a buffer to a device. A comparison operation compares the contents of the two buffers.

The **exer** command uses two buffers, *buffer1* and *buffer2*. A read or write operation can be performed using either buffer. A compare operation uses both buffers.

You can tailor the behavior of the **exer** command by using options to specify the following:

- An address range to test within the devices
- The packet size, also known as the I/O size, which is the number of bytes read or written in each I/O operation
- The number of passes to run
- The number of seconds to run
- A sequence of individual operations performed on the test devices. You specify this with the action string option.

Syntax

exer [-sb *start_block*] [-eb *end_block*] [-p *pass_count*] [-l *blocks*] [-bs *block_size*] [-bc *block_per_io*] [-d1 *buf1_string*] [-d2 *buf2_string*] [-a *action_string*] [-sec *seconds*] [-m] [-v] [-delay *milliseconds*] *device_name1* [*device_name2*]

Arguments

***device_name1* [*device_name2*]**
Specifies the names of the devices or file streams to be exercised.

Options

-sb *start_block*
Specifies the starting block number (hexadecimal) within the file stream. The default is 0.

-eb *end_block*
Specifies the ending block number (hexadecimal) within the file stream. The default is 0.

-p *pass_count*
Specifies the number of passes to run the exerciser. If you specify 0, the exerciser runs forever or until you enter Ctrl/C. The default is 1.

-l *blocks*
Specifies the number of blocks (hexadecimal) to exercise. This option has precedence over the **-eb** option. If only reading, and you specify neither **l** nor **-eb**, the exerciser reads until it reaches the end-of-file (EOF). If writing, and you specify neither **l** nor **-eb**, the exerciser writes for the size of the device. The default is 1.

-bs *block_size*
Specifies the block size (hexadecimal) in bytes. The default is 0x200 except for tape drives, which default to 0x800. The maximum block size allowed with variable length block reads is 0x800 bytes.

-bc *block_per_io*
Specifies the number of blocks (hexadecimal) per I/O operation. The default is 1.

-d1 *buf1_string*
Specifies a character string that is processed by the **eval** command and then loaded into buffer1 to initialize the buffer. By default, the buffer is loaded with alternating 5s and As (hexadecimal).

-d2 *buf2_string*
Specifies a string that is processed by the **eval** command and then loaded into buffer2 to initialize the buffer. By default, the buffer is loaded with alternating 5s and As (hexadecimal).

-a *action_string*
Specifies an exerciser "action string," which determines the sequence of read, write, and compare operations on various buffers. The default action string is "?r." The action string characters are:

r Read into *buffer1*
w Write from *buffer1*
R Read into *buffer2*
W Write from *buffer2*

n Write without lock from *buffer1*

N Write without lock from *buffer2*

c Compare buffer1 with *buffer2*

- Seek to file offset prior to last read or write

? First, seek to a random block offset within the specified range of blocks. Next, call the program `random` to create each of a set of numbers once. Then, choose a set that is a power of two and is greater than or equal to the block range.

Each call to `random` results in a number that is then mapped to the set of numbers in the block range. The **exer** command seeks to that location in the file stream.

Since the **exer** command starts with the same random number seed, the set of random numbers generated is always over the same set of block range numbers.

s Sleep for the number of milliseconds specified by the **delay** option. If the **delay** option is not present, sleep for 1 millisecond.

Note

Times reported in verbose mode are not necessarily accurate when this action character is used.

-sec *seconds*
Terminates the exercise after the specified number of seconds have elapsed. By default, the exerciser continues until the specified number of blocks or *passcount* are processed.

-m
Specifies metrics mode and reports throughput at the end of the exercise.

-v
Specifies verbose mode and data read is written to STDOUT. This is not applicable on write or compare operations.

-delay *millisecs*
Specifies the number of milliseconds to delay when "s" appears in the action string.

Description

Exercises one or more devices. As described in the preceding overview section, the **exer** command uses two buffers, *buffer1* and *buffer2*. The buffers are in main memory in the memory zone heap.

Both *buffer1* and *buffer2* are initialized to a data pattern before any I/O operations occur. These buffers are never reinitialized, even after completing one or more passes.

The data patterns with which the buffers are initialized are 0x5A in every byte of each buffer. Alternatively, you can specify the patterns by using the string arguments to the data pattern options **-d1** and **-d2**.

The **-d1** and **-d2** options use a postfix string argument to initialize a buffer's contents. For each byte in the specified buffer, starting with the first byte, this postfix string is passed to the **eval** command, which returns a byte value that is then written to the specified buffer.

The following options specify the amount of device data to be processed:

-sb Starting block

-eb Ending block

-l Number of blocks

-bs Block size in bytes

-bc Number of blocks in a packet, where a packet is the amount of data transferred in one I/O operation

You can specify reading, writing, comparing buffers, and other operations to occur in various combinations and sequences. These operations are specified by a string of 1-character command codes known as the "action string." Specify the action string as an argument to the action string option, **-a**.

Each command code character in the action string is processed in a sequence from left to right. Each time that the **exer** command completes all of the operations specified by the action string, the command reduces the remaining amount of device data to be processed by the size of the last packet processed by the action string. The **exer** command processes the action string repeatedly until the specified amount of device data has been processed.

Lowercase action string characters *rwn* specify operations that involve *buffer1*. Uppercase action string characters *RWN* specify operations that involve *buffer2*. The action string character *c* involves both buffers. The action string characters -*?* do not involve either buffer.

exer

You can use a random number generator to seek to varying device locations before performing either a read or write operation. Randomization is achieved by calling the function `random`, which uses a linear congruential generator (LCG) to generate the numbers. This algorithm is not truly random, but it comes closest to meeting the needs of the **exer** command. Each time that `random` is called, it returns a number from a specified range. If the range of numbers is a power of two, then each subsequent call to `random` is guaranteed to return a different number from the range until all possible numbers within the range have been chosen. If the range of numbers is not a power of two, then `random` is used with an upper bound that is greater than the actual range size but is a power of two. Then a modulus operation with the range size is performed on the number that `random` returns, thereby ensuring that a random number is generated within the random range size.

The total number of bytes read or written on each pass of the exerciser is specified by the length in blocks or the starting/ending block address option arguments.

If neither the ending address nor the length options are specified, then on each pass the number of bytes processed could vary depending on whether or not the file stream is being written to or just being read.

If the **exer** command does not write to the file stream, the command reads until it reaches the EOF.

If the **exer** command is writing to the file (as specified in the action string), then the number of bytes processed per pass is equal to the allocation size of the file, which is usually larger than the length of the file for RAM disk files, but equal to the length for disk devices.

Note

Disk device I/O fails if the block size is not equal to 1 or a multiple of 512. Partial block read or write operations are not supported; therefore, a length that is not a multiple of the block size results in no errors, but the last partial block I/O of data does not occur.

Any combination of writing, reading, or comparing *buffer1* and *buffer2* can be executed in the sequence as specified in the action string. Depending on the option arguments, one or two of these three operations (read/write/compare) can be omitted without affecting the execution of the other operations.

The **exer** command returns an error code immediately after a read, write, or compare error, if the D_HARDERR environment variable is set to HALT. When an error occurs and continue or loop on error is specified, then subsequent operations specified by the action string option occur except for comparisons. For instance, if a read error occurs, a subsequent comparison is skipped since a read failure preceding a compare operation guarantees that the comparison fails. If subsequent block I/O operations succeed, comparisons of those blocks occur.

When the **exer** command terminates because of completing all passes or by operator termination, the status returned is that of the last failed write, read, or compare operation, regardless of subsequent successful I/O operations.

Examples

1. `>>> exer dk*.* -p 0 -secs 36000`

   Read all SCSI type disks for the entire length of each disk. Repeat this until 36000 seconds (10 hours) have elapsed. All disks are read concurrently. Each block read occurs at a random block number on each disk.

2. `>>> exer -l 2 dka0`

   Read block numbers 0 and 1 from device dka0.

3. `>>> exer -sb 1 -eb 3 -bc 4 -a 'w' -d1 '0x5a' dka0`

   Write 0x5as to every byte of blocks 1, 2, and 3. The packet size is bc * bs, 4 * 512, 2048 for all writes.

4. ```
   >>> ls -l du*.* dk*.*
   d**.* no such file
   r---   dk                  0/0             0   dka0.0.0.0.0
   >>> exer dk*.* -bc 10 -sec 20 -m -a 'r'
   dka0.0.0.0.0 exer completed

   packet                                  IOs            elapsed idle
   size    IOs  bytes read  bytes written   /sec bytes/sec seconds secs
   8192  3325    27238400              0    166   1360288     20    19
   ```
   ```

5. >>> **exer -eb 64 -bc 4 -a '?w-Rc' dka0**

   A destructive write test over block numbers 0 through 100 on disk dka0. The packet size is 2048 bytes. The action string specifies the following sequence of operations:

   1. Set the current block address to a random block number on the disk between 0 and 97. A four block packet starting at block numbers 98, 99, or 100 would access blocks beyond the end of the length to be processed so 97 is the largest possible starting block address of a packet.
   2. Write from buffer1 (contains the previously read data) to the current block address.
   3. Set the current block address to what it was just prior to the previous write operation.
   4. From the current block address read a packet into *buffer2*.
   5. Compare *buffer1* with *buffer2* and report any discrepancies.
   6. Repeat steps 1 through 5 until enough packets have been written to satisfy the length requirement of 101 blocks.

6. >>> **exer -a '?r-w-Rc' dka0**

   A nondestructive write test with packet sizes of 512 bytes. The action string specifies the following sequence of operations:

   1. Set the current block address to a random block number on the disk.
   2. From the current block address on the disk, read a packet into *buffer1*.
   3. Set the current block address to the device address where it was just before the previous read operation occurred.
   4. Write a packet of 0x5as from *buffer1* to the current block address.
   5. Set the current block address to what it was just prior to the previous write operation.
   6. From the current block address on the disk, read a packet into *buffer2*.
   7. Compare *buffer1* with *buffer2* and report any discrepancies.
   8. Repeat the above steps until each block on the disk has been written once and read twice.

7.
```
>>> set myd 0
>>> exer -bs 1 -bc a -l a -a 'w' -d1 'myd myd ~ =' foo
>>> clear myd
>>> hd foo -l a
00000000  ff 00 ff 00 ff 00 ff 00 ff 00 ..........
```

Use an environment variable *myd* as a counter. Write 10 bytes of the pattern ff 00 ff 00... to RAM disk file foo. A packet size of 10 bytes is used. Because the length specified is also 10 bytes, only one write occurs. Delete the environment variable *myd*.

The **hd**, hexadecimal dump of foo shows the contents of foo after the **exer** command is run.

8.
```
>>> set myd 0
>>> exer -bs 1 -bc a -l a -a 'w' -d1 'myd myd 1 + =' foo
>>> hd foo -l a
00000000  01 02 03 04 05 06 07 08 09 0a ..........
```

Write a pattern of 01 02 03 . . . 0a to file foo.

9.
```
>>> set myd 0
>>> exer -bs 1 -bc 4 -l a -a 'w' -d1 'myd myd 1 + =' foo -m
foo exer completed

packet                                  IOs           elapsed idle
size    IOs  bytes read  bytes written   /sec bytes/sec seconds secs
4     3           0             10   3001     10001      0     0
>>> hd foo
00000000  01 02 03 04 01 02 03 04 01 02 ..........
>>> show myd
myd                4
```

10.
```
>>> echo '0123456789abcdefghijklmnopqrstAB' -n > foo3
>>> exer -bs 1 -v -m foo3
b2lkfmp8jatsnA1gri54B69o3qdc7eh0foo3 exer completed

packet                                  IOs           elapsed idle
size    IOs  bytes read  bytes written   /sec bytes/sec seconds secs
1    32          32             0   5333      5333      0     0
```

exer

See Also

memexer

exit — exit current shell

Exits the current shell with the specified status or returns the status of the last command executed.

Syntax

exit ***exit_value***

Arguments

exit_value
Specifies the status code to be returned by the shell.

Examples

1. `>>> exit`

   Exits returning the status of the previously executed command.

2. `>>> exit 0`

   Exits with success status.

3. `>>> test || exit`

   Runs `test` and exits if there is an error.

false — return failure status

Returns a failure status.

Syntax

false

Example

```
>>>  while false ; do echo foo; done
>>>
```

free — deallocate memory

Frees a block of memory that has been allocated from a heap. The block is returned to the appropriate heap.

Syntax

free ***address1*** **[*address2* . . .]**

Arguments

***address1 address2* . . .**
Specifies an address (hexadecimal) or list of addresses of allocated blocks to be returned to the heap.

Example

```
>>>  alloc 200
00FFFE00
>>>  free fffe00
>>>  free 'alloc 10' 'alloc 20' 'alloc 30'
>>>
```

See Also

alloc, **dynamic**

grep — search for regular expressions

Globally searches for regular expressions and prints any lines containing occurrences of the regular expressions. A regular expression is a shorthand way of specifying a wildcard type of string comparison. Since the **grep** command is line oriented, it only works on ASCII files.

Syntax

grep [-c] [-i] [-n] [-v] { ***expression* -f *file*** } **[*file1*] [*file2* . . .]**

Arguments

expression
Specifies the regular expression for which to search. If you include metacharacters, enclose the expression within quotes to avoid interpretation by the shell.

The **grep** command supports the following metacharacters:

^ Matches the beginning of a line.

$ Matches the end of a line.

. Matches any single character.

[ ] Matches a specified set of characters, for example, [ABC] matches A or B or C.

The following rules also apply for these sets:

- A dash other than the first or last character denotes a range of characters: [A-Z] matches any uppercase letter.
- If the first character of the set is ^, then the sense of match is reversed: [^0-9] matches any non-digit.
- The following characters must be preceded with backslash (\ ) if they occur in a set: \,], -, and ^.

***** Repeated matching.

When placed after a pattern, the asterisk indicates that the pattern should match any number of times. For example, [a-z][0-9]* matches a lowercase letter followed by zero or more digits.

+ Repeated matching.

When placed after a pattern, the plus sign indicates that the pattern should match one or more times. For example, [0-9]+ matches any sequence of one or more digits.

? Optional matching.

When placed after a pattern, the question mark indicates that the pattern can match zero or one times. For example, [a-z][0-9]? matches a lowercase letter alone or followed by a single digit.

\ x ' Prevents the character (denoted by x) following the backslash from having special meaning.

file...
Specifies the files to be searched. If you do not specify a file, the command seaches STDIN.

Options

-c
Prints only the number of lines that matched.

-i
Ignores case in the search. By default, the **grep** command is case sensitive.

-n
Prints the line numbers of the matching lines.

-v
Prints all lines that do not contain the expression.

-f *file*
Take the regular expression from a file instead of the command line.

Examples

1.
```
>>>  ps | grep ewa0
0000001f 0019e220 3     2 ffffffff 0   mopcn_ewa0 waiting on mop_ewa0_cnw
00000019 0018e220 2     1 ffffffff 0   mopid_ewa0 waiting on tqe
00000018 0018f900 3     3 ffffffff 0   mopdl_ewa0 waiting on mop_ewa0_dlw
00000015 0019c320 5     0 ffffffff 0      tx_ewa0 waiting on ewa0_isr_tx
00000013 001a2ce0 5     2 ffffffff 0      rx_ewa0 waiting on ewa0_isr_rx
```

   The output of the **ps** command (STDIN) is searched for lines containing EWA0.

grep

2.
```
>>> alloc 20
00FFFFE0
>>> deposit -q pmem:fffff0 0
>>> e -n 3 ffffe0
pmem:           FFFFE0 EFEFEFEFEFEFEFEF
pmem:           FFFFE8 EFEFEFEFEFEFEFEF
pmem:           FFFFF0 0000000000000000
pmem:           FFFFF8 EFEFEFEFEFEFEFEF
>>> e -n 3 ffffe0 | grep -v 0000000000000000
pmem:           FFFFE0 EFEFEFEFEFEFEFEF
pmem:           FFFFE8 EFEFEFEFEFEFEFEF
pmem:           FFFFF8 EFEFEFEFEFEFEFEF
>>> free ffffe0
>>>
```

The **grep** command searches for all quadwords in a range of memory that are non-zero.

hd — dump file contents

Dumps the contents of a file in hexadecimal and ASCII format.

Syntax

hd ***[-{byte|word|long|quad}] file...***

Arguments

file...
Specifies the files to be displayed.

Options

-byte
Prints data in bytes.

-word
Prints data in words.

-long
Prints data in longwords.

-quad
Prints data in quadwords.

Examples

1.
```
>>> echo -n 'the quick brown fox jumped over the lazy dog' >foo
>>> hd foo
00000000 74 68 65 20 71 75 69 63 6B 20 62 72 6P 77 6E 20  the quick brown
00000010 66 6F 78 20 6A 75 6D 70 65 64 20 6F 76 65 72 20  fox jumped over
00000020 74 68 65 20 6C 61 7A 79 20 64 6F 67              the lazy dog
```

2.
```
>>> -byte foo
00000000 74 68 65 20 71 75 69 63 6B 20 62 72 6P 77 6E 20  the quick brown
00000010 66 6F 78 20 6A 75 6D 70 65 64 20 6F 76 65 72 20  fox jumped over
00000020 74 68 65 20 6C 61 7A 79 20 64 6F 67              the lazy dog
```

3.
```
>>>  -word foo
00000000 6874 2065 7571 6369 206B 7262 776F 206E  the quick brown
00000010 6F66 2078 756A 706D 6465 6F20 6576 2072  fox jumped over
00000020 6874 2065 616C 797A 6420 676F            the lazy dog
```

4.
```
>>>  -long foo
00000000 20656874  63697571 7262206B  206E776F    the quick brown
00000010 20786F66  706D756A 6F206465  20726576    fox jumped over
00000020 20656874  797A616C 676F6420              the lazy dog
```

5.
```
>>>  -quad foo
00000000 6369757120656874   206E776F7262206B      the quick brown
00000010 706D756A20786F66   207265766F206465      fox jumped over
00000020 797A616C20656874   00000000676F6420      the lazy dog
>>>
```

help— help on commands

Defines and shows the syntax for each command that you specify on the command line. If you do not specify a command, the **help** command displays information about itself and lists the commands for which additional information is available.

For each argument (or command) on the command line, the **help** command tries to find all topics that match that argument. For example, if there are topics on **exit**, **examine**, and **entry**, the **help ex** command displays the help text for both **exit** and **examine**.

Wildcards are supported. For example, **help *** generates the expected behavior. Topics are treated as regular expressions that have the same rules as regular expressions for the shell. For more information on regular expressions, see the **grep** command. Help topics are case sensitive.

When the **help** command describes command syntax, the following conventions are used:

<item>	Angle brackets denote a variable for which you must specify a value.
[<item>]	Square brackets enclose optional parameters, options, or values.
{a,b,c}	Braces enclosing items separated by commas indicate mutually exclusive items. Choose only one of a, b, or c.
{a | b | c}	Braces enclosing items separated by vertical bars indicate combinatorial items. Choose any combination of a, b, c.

You can use the **help** and **man** commands interchangeably.

Syntax

help or man [*command1*] [*command2 . . .*]

Arguments

command1 command2 . . .
Specifies the commands or topics for which you request help.

Examples

1. `>>> help  # List all topics.`

   Requests a list of topics for which help is available.

2. `>>> help *  # List all topics and associated text.`

   Requests help on all topics.

3. `>>> help ex`

   Requests help on all commands that begin with “ex”.

4. `>>> help boot`

   Requests help on the **boot** command.

init_ev — initialize environment variables

Sets all environment variables to their default values.

Once you issue this command, you need to reset the system or issue the **init** command to set the environment variables to their default values.

Syntax

init_ev

Example

```
>>>  init_ev

Note: A System Reset or init command must be issued immediately
      after this command to set all environment variables to their
      default values!!

>>>
```

A system reset or the **init** command is now required.

initialize — initialize the console, a device, or the processor

Initializes the console, a device, or the processor.

Syntax

init[ialize] [-c] [-d *device*]

Options

-c
Specifies that the console be initialized.

-d *device*
Specifies a device to be initialized.

Examples

1. `>>> init`

   Initializes the processor.

2. `>>> initialize -d ewa0`

   Initializes device EWA0.

kill — delete process

Deletes the processes listed on the command line. Processes are killed by making a call to a kernel function with the process ID (PID) as the argument.

Syntax

kill ***pid1*** **[*pid2 . . .*]**

Arguments

pid1 pid2 . . .
Specifies the PIDs of the processes to be killed. You can display PIDs with the **ps** command.

Example

```
>>> memtest -p 0 &
>>> ps | grep memtest
000000f1 00217920 2       9357 ffffffff 0      memtest ready
>>> kill f1
>>> ps | grep memtest
```

Runs **memtest**. Displays the test's PID (f1) with the **ps** and **grep** commands. Deletes the process with the **kill** command. Displays the memtest process again to show that it is now gone.

See Also

ps

line — read a line

Copies one line (up to a new line) from the standard input channel of the current process to the standard output channel of the current process. This command always writes at least a new line as output.

Use this command in scripts to read from the user's terminal, or to read lines from a pipeline while in a `for/while/until` loop.

Syntax

line

Examples

1.
```
>>> line
 type a line of input followed by carriage return
type a line of input followed by carriage return
```

   The line you typed is copied to your screen.

2.
```
>>> line >foo
 type a line of input followed by carriage return
>>> cat foo
type a line of input followed by carriage return
```

   Shows the **line** command used interactively.

3.
```
>>> echo -n 'continue [Y, (N)]? '
>>> line <tt >tee:foo/nl
>>> if grep <foo '[yY]' >nl; then echo yes; else echo no; fi
>>>
```

   Shows the **line** command used within a script.

ls — list files

Lists files or inodes in the system. Inodes are RAM disk files, open channels, and some drivers. RAM disk files include script files, diagnostics, and executable shell commands.

Syntax

ls [-l] [*file1*] [*file2 . . .*]

Arguments

file1 file2 . . .
Specifies the files or inodes to be listed. If you omit the argument, the command lists all files and inodes on the system.

Options

-l
Lists the files or inodes in long format. Each file or inode is listed on a line with additional information. By default, the command lists just file names.

Examples

1.
```
>>> ls examine
examine
```

   Lists the file named examine.

2.
```
>>> ls d*
d            date         debug1       debug2       decode       deposit
dg_pidlist   dka0.0.0.0.0               dke100.1.0.4.0
dub0.0.0.1.0              dynamic
```

   Lists files and inodes that start with d.

memexer — memory exerciser

Starts a specified number of graycode memory test processes running in the background. Each test randomly allocates and tests blocks of memory twice the size of the Bcache, using all available memory. The pass count is 0 to run the tests forever.

Nothing is displayed unless an error occurs.

Syntax

memexer [*number_of_tests*]

Arguments

number_of_tests
Specifies the number of memory test processes to start. The default is 1.

Example

```
>>> memexer 2 &
>>>
```

Starts two memory tests running in the background. Tests in blocks of 2 times the backup cache size across all available memory.

See Also

memtest

memtest — memory test

Tests memory with any or all of four tests:

Test	Description
Graycode memory test	Writes, reads, and verifies a graycode pattern and an inverse graycode pattern for the specified address range.
March memory test	Writes, reads, and verifies a marching pattern and an inverse marching pattern for the specified address range.
Random memory test	Exercises random addresses within the specified range with random data of random length.
Victim block test	Writes blocks of data to the specified address, victimizes the data, and then reads back and verifies the block.

Detailed Description

When you specify a starting address, the memory is allocated with the `malloc` function beginning at the starting address - 32 bytes for the length specified. The extra 32 bytes that are allocated with `malloc` are reserved for the `malloc` function's header information. Therefore, if you request a starting address of 0xa00000 and a length of 0x100000, the command reserves the area from 0x9fffe0 through 0xb00000. This is transparent to the user, but could be confusing if you begin two `memtest` processes simultaneously with one beginning at 0xa00000 for a length of 0x100000 and the other at 0xb00000 for a length of 0x100000. In this case, the second `memtest` process displays the message:

```
"Unable to allocate memory of length 100000 at starting address b00000."
```

The second process should use the starting address of 0xb00020.

Memtest Test 1 - Graycode Test This test uses a graycode algorithm to test a specified section of memory. The graycode algorithm used is data = (x>>1)^x where *x* is an incrementing value.

Three passes are made of the memory under test.

1. Writes alternating graycode inverse graycode to each longword. This causes all but one data bit to toggle between each longword write. For example, graycode(0)=0x00000000 while inverse graycode(1)=0xFFFFFFFE.

2. Reads each location, verifies the data, and writes the inverse of the data. The read-verify-write is done one longword at a time. This causes the following:
   - All data bits are written as a one and zero.
   - All but one data bit toggle between longword writes.
   - Address shorts are identified.
3. Reads and verifies each location. To verify that sections of the second and third loops are not performed, use the **-f** (fast) option. This option does not catch address shorts but does stress memory with a higher throughput. The ECC/EDC logic is used to detect failures.

Memtest Test 2 - March Test This test uses a marching 1s/0s algorithm to test a specified section of memory. The same range can be tested as in the graycode, test 1. The default data patterns used by this test are 0x55555555 and its inverse 0xAAAAAAAA.

To alter the data pattern, use the **-d** option. In this case, the pattern entered and its compliment are used instead of the default patterns.

Three passes are made of the memory under test.

1. Writes the data pattern entered (or default) beginning at the starting address and marching through for the entire length specified.
2. Begins again at the starting address, reads the previously written data pattern, and writes back its inverse. This is done a longword at a time for the entire specified length.
3. Begins at the end of the testing region and again reads back the previously written inverse pattern and writes back 0s. This is performed a longword at a time, decrementing up through memory until the starting address is reached.

Memtest Test 3 - Random Test This test performs writes with random data to random addresses using random data size, lengths, and alignments. The run time of the random test can be noticeably longer than that of the other tests, because the test requires two calls to the console firmware's random number generator every time data is written.

The random test accesses every memory location within the boundaries specified by the **-sa** and **-l** options (as long as the length is less than 8 MB—with lengths greater than 8 MB a modulo function is required on the seed; therefore, some addresses might repeat and some might not test at all.

The random test:

1. Obtains an address index into the Linear Congruential Generator (LCG) structure that is dependent on the specified length. The test obtains the data index as a function of the entered random data seed and the maximum 32 bit data pattern.
2. Calls the random number generator, using the address index and an initial address seed of 0, to obtain a random address.
3. Calls the random number generator again, using the data index and initial user entered data seed, (**-rs** option), or default of 0, to get the longword of data to use in testing.
4. Determines whether to perform longword or quadword transactions by using the lower bit of the random data returned. (Using the lower bit merely saves another call to the random function to help speed up the test.)
5. Stores the data at the random address, and performs memory barrier to flush the data out to the Bcache.
6. Reads the data back into the random address.
7. Compares the data written and the data read. In the case of quadword write and read operations, the longword of random data is shifted left by 32 and ORd with the original data's compliment to form the quadword.

Memtest test 4 - Victim Eject Test You must first set up a block of data to be used in the test. The address of this block of data is be read as an input to the test using the **-ba** option. (The default is a block of data containing 4 longwords of 0xFs, then 4 longwords of 0s, then 4 longwords of 0xFs, and finally 4 longwords of 0s.)

This test:

1. Writes the block of data to the specified starting address.
2. Adds 4 MB to the starting address.
3. Writes arbitrary data. This causes the original data to be "victimized" to memory.
4. Reads the original starting address and verifies that it is correct.
5. Increments the starting address by a block.
6. Repeats the write/write/read procedure for the specified length of memory.

If the **memtest** command is used to test large sections of memory, it might take a while for testing to complete.

If you issue a Ctrl/C or the **kill** command with a PID in the middle of testing, the memtest process might not abort right away. To increase speed of execution, check for a Ctrl/C or **kill** command done outside of any test loops. If this is not satisfactory, you can run concurrent memtest processes in the background with shorter lengths within the target range.

Syntax

memtest [-sa *start_address*] [-ea *end_address*] [-l *length*]
[-bs *block_size*] [-i *address_inc*] [-p *pass_count*]
[-d *data_pattern*] [-rs *random_seed*] [-rb]
[-f] [-m] [-z] [-h] [-mb] [-t] [-g] [-se]

Options

-sa *start_address*
Specifies the starting address for the test. The default is the first free space in the memory zone.

-ea *end_address*
Specifies the ending address for the test. The default is *start_address* plus *length*.

-l *length*
Specifies the length of the section to test in bytes. The default is BLOCK_SIZE, except with the **-rb** option,which uses the zone size. The **-l** option has precedence over the **-ea** option.

-bs *block_size*
Specifies the block size (hexadecimal) in bytes. The default is 8192 bytes. This is only used for the random block test. For all other tests, the block size equals *length*.

-i *address_inc*
This value is used to increment through the memory to be tested. Default = 0 (no increment). This is only implemented for the graycode test. The increment value is in quadwords (that is, increment of 1 tests every other quadword). The **-z** option must be specified to test an unaligned starting address. This option is useful for multiple CPUs testing the same physical memory.

-d *data_pattern*
This pattern is used as a test pattern. The default is 5s.

-p *pass_count*
Specifies the number of times to execute the test. If you specify 0, the command runs forever or until you enter Ctrl/C. The default is 1.

-rs *random_seed*
Specifies the random seed. Use this option only with the **-rb** option. The default is 0.

-rb
Specifies to randomly allocate and test all of the specified memory address range. Allocations are done of *block_size*.

-f
Specifies fast mode. If you specify **-f**, the data comparison is omitted. Only ECC /EDC errors are detected.

-m
Specifies that the memory test is to be timed. At the end of the test, the elapsed time is displayed. By default, the timer is off.

-z
Specifies that the test is to use the specified memory address without an allocation. This bypasses all checking, but allows testing in addresses outside of the main memory heap. It also allows unaligned testing.

Caution

This flag permits testing and corrupting *any* memory!

-h
Allocates test memory from the firmware heap.

-mb
Uses memory barriers after each memory access. Use this option only in the -f graycode test. When this flag is specified, an Alpha MB instruction is executed after every memory access, which guarantees serial access to memory.

-t
Specifies the tests to run. By default, all the tests in the selected group are run. The individual tests are as follows:

1 Graycode test
2 March test
3 Random test
4 Victim eject test

-g
Specifies a group name. Currently, the only group supported is MFG.

-se
Specifies a soft error threshold.

Examples

1. `>>> memtest -sa 200000 -l 1000`

   Tests memory starting at 0x200000 (-sa) for 0x1000 bytes (-l).

2. `>>> memtest -sa 200000 -l 1000 -f`

   Tests memory from 0x200000 for 0x1000 bytes, but data is not verified (-f).

3. `>>> memtest -sa 300000 -p 10`

   Writes a default block size of 8192 bytes from 0x300000 for 10 passes (-p).

4. `>>> memtest -f -mb`

   Tests memory in arbitrary 8192 byte blocks without verification. After each read and write to memory a memory barrier (MB) instruction is executed (-*mb*).

5. `>>> memtest -sa 200000 -ea 400000 -rb`

   Tests memory from 0x200000 to 0x3fffff. Every block within this range is randomly allocated (-rb).

   Note

   The **memtest** command does not generate an error with the **-rb** option if a block within the range cannot be allocated.

6. `>>> memtest -h -rb -bs 100`

   Tests the console heap (-h) by randomly allocating memory in 0x100-byte blocks (-bs).

7. `>>> memtest -rb -p 0`

   Tests memory across all of memory zone (all memory excluding the HWRPB, the PAL area, the console, and the console heap). It is run in the foreground until you enter Ctrl/C.

See Also

memexer

net — MOP function

Using a specified port, performs basic maintenance operations protocol (MOP) operations.

The **net** command performs basic MOP operations, such as, loopback, request IDs, and remote file loads. The **net** command also provides the means to observe the status of a network port. Specifically, the **net** command with the **-s** option displays the current status of a port including the contents of the MOP counters. This is useful for monitoring port activities and trying to isolate network failures.

To display the Ethernet station address, enter:

```
>>>  net -sa ewa0
```

Syntax

net **[-s] [-sa] [-ri] [-ic] [-id] [-l0] [-l1] [-rb] [-csr]**
[-els] [-kls] [-cm *mode_string*] [-da *node_address*]
[-l *file_name*] [-lw *wait_in_secs*] [-sv *mop_version*]
port_name

Arguments

port_name
Specifies the Ethernet port on which to operate. If you do not specify a port the default port, EWA0, is used.

Options

-s
Displays port status information including MOP counters.

-sa
Displays the port's Ethernet station address.

-ri
Reinitializes the port drivers.

-ic
Initializes the MOP counters.

-id
Sends a MOP request ID to a specified destination node. You specify the address of the destination node with the **-da** option.

-l0
Sends an Ethernet loopback to a specified destination node. You specify the address of the destination node with the **-da** option.

-l1
Requests a MOP loopback.

-rb
Requests to be rebooted by sending a MOP V4 request boot message to a remote boot node. You specify the address of the destination node with the **-da** option.

-csr
Displays the values of the Ethernet port CSRs.

-els
Enables the extended design verification test (DVT) loop service.

-kls
Kills the extended DVT loop service.

-cm *mode_string*
Changes the mode of the port device. The mode string can be one of the following abbreviations:

nm	Normal mode
in	Internal loopback
ex	External loopback
nf	Normal filter
pr	Promiscuous
mc	Multicast
ip	Internal loopback and promiscuous
fc	Force collisions
nofc	Do not force collisions
df	Default

-da *node_address*
Specifies the address of a destination node to be used with the **-l0**, **-id**, or **-rb** option.

-l *file_name*
Broadcasts a MOP load request that requests the specified load file.

-lw *wait_in_secs*
Waits the specified number of seconds for the loop messages from the **-l1** option to return. If the messages do not return in the specified time period, an error message is generated.

-sv *mop_version*
Sets the preferred MOP version number for operations. Valid values are 3 or 4.

Examples

1.
```
>>> net -sa
-ewa0:  08-00-2b-1d-02-91
```

   Displays the local Ethernet port station address.

2.
```
>>> net -s

DEVICE SPECIFIC:
TI: 203 RI: 42237 RU: 4 ME: 0 TW: 0 RW: 0 BO: 0
HF: 0 UF: 0 TN: 0 LE: 0 TO: 0 RWT: 39967 RHF: 39969  TC: 54

PORT INFO:
tx full: 0 tx index in: 10 tx index out: 10
rx index in: 11

MOP BLOCK:
Network list size: 0

MOP COUNTERS:
Time since zeroed (Secs): 2815

TX:
Bytes: 116588 Frames: 204
Deferred: 2 One collision: 52 Multi collisions: 14
TX Failures:
Excessive collisions: 0 Carrier check: 0 Short circuit: 0
Open circuit: 0 Long frame: 0 Remote defer: 0
Collision detect: 0

RX:
Bytes: 116564 Frames: 194
Multicast bytes: 13850637 Multicast frames: 42343
RX Failures:
Block check: 0 Framing error: 0 Long frame: 0
Unknown destination: 42343 Data overrun: 0 No system buffer: 22
No user buffers: 0
>>>
```

   Displays the EWA0 port status, including the MOP counters.

ps — show process

Displays the system state in the form of process status and statistics.

Syntax

ps

Example

```
>>> ps
                    CPU
ID       PCB      Pri Time   Affinity CPU Program   State
-------- -------- --- ------ -------- --- --------- ---------------------
0000008f 0010e8a0 3        0 00000001 0          ps running
00000020 00110160 1        0 ffffffff 0    puc_poll waiting on tqe
0000001f 0013cb60 6        0 ffffffff 0 puc_receive waiting on puu_receive
0000001c 0013ed00 1        0 ffffffff 0    pub_poll waiting on tqe
0000001b 0014fc00 6        0 ffffffff 0 pub_receive waiting on puu_receive
0000001a 00111a20 3        0 00000001 0          sh ready
00000015 001176a0 2        0 ffffffff 0  mopcn_ewa0 waiting on mop_ewa0_cnw
00000014 00119140 2        0 ffffffff 0  mopid_ewa0 waiting on tqe
00000013 0011ac20 2        0 ffffffff 0  mopdl_ewa0 waiting on mop_ewa0_dlw
00000012 0011f6a0 6        0 ffffffff 0     tx_ewa0 waiting on ewa0_isr_tx
00000011 00121140 6        0 ffffffff 0     rx_ewa0 waiting on ewa0_isr_rx
00000010 00122ac0 1        0 ffffffff 0    pua_poll waiting on tqe
0000000f 001244e0 6        0 ffffffff 0 pua_receive waiting on pua_receive
00000009 00147460 5        0 ffffffff 0    lad_poll waiting on tqe
00000008 00148f00 5        0 ffffffff 0    dup_poll waiting on tqe
00000007 0014a9a0 5        0 ffffffff 0   mscp_poll waiting on tqe
00000006 0014e1a0 5        0 00000001 0    entry_00 waiting on entry_00
00000004 001516e0 2        0 ffffffff 0  dead_eater waiting on dead_pcb
00000003 00153140 7 11759330 ffffffff 0       timer waiting on timer
00000002 00158740 6        0 ffffffff 0  tt_control waiting on tt_control
00000001 0005cfd8 0        0 00000001 0        idle ready
>>>
```

See Also

sa, **sp**

pwrup — run power-on diagnostics

Runs the power-on diagnostics script. The **pwrup** command initializes network environment variables and runs memory tests.

Syntax

pwrup

Example

```
>>> pwrup
```

Runs the power-on script.

rm — remove file

Removes the specified files from the file system. Allocated memory is returned to the heap.

Syntax

rm ***file1*** **[*file2 . . .*]**

Arguments

file1 file2 . . .
Specifies the files to be deleted.

Example

```
>>>  ls foo
foo
>>>  rm foo
>>>  ls foo
foo no such file
>>>
```

Lists file foo to show that it exists, removes file foo, lists file foo again to show that it is gone.

See Also

cat, **ls**

sa — set process affinity

Changes the affinity mask of a process. The affinity mask of a process specifies the processors on which the process can run.

Syntax

sa ***process_id affinity_mask***

Arguments

process_id
Specifies the process ID (PID) of the process to be modified.

affinity_mask
Specifies the new affinity mask, which indicates on which processors the process can run. Bits 0 and 1 of the mask correspond to processors 0 and 1, respectively.

Example

```
>>>  memtest -p 0 &
>>>  ps | grep  memtest
00000025 001a9700 2      23691 00000001 0      memtest ready
>>>  sa 25 2
>>>  ps | grep  memtest
00000025 001a9700 2     125955 00000002 1      memtest running
>>>
```

See Also

ps, **sp**

semaphore — show system semaphores

Shows all the semaphores known to the system by traversing the semaphore queue.

Syntax

semaphore

Example

```
>>> semaphore
                Name              Value   Address  First Waiter
------------------------------- -------- -------- ------------------------
                                   dyn_sync 00000001 00050378
                                dyn_release 00000001 000503A0
                               shell_iolock 00000001 0015D684
                                exit_iolock 00000001 0015D770
                                grep_iolock 00000001 0015DB20
                                eval_iolock 00000001 0015DC0C
                               chmod_iolock 00000001 0015DCF8
^C
>>>
```

set — set environment variable

Sets or modifies the value of an environment variable. Some of the environment variables are stored in nonvolatile memory. You use environment variables to pass configuration information between the console and the operating system.

For a listing of predefined environment variables, see Table 3–2.

Syntax

set ***envar_name value*** **[-default] [-integer] [-string]**

Arguments

envar_name
Specifies the name of the environment variable to be assigned a new value. See the listing of predefined environment variables in Table 3–2 and the descriptions of commonly used environment variables below.

value
Specifies the value to be assigned to the environment variable. The value can be a numeric value or an ASCII string.

Options

-default
Restores an environment variable to its default value.

-integer
Creates an environment variable as an integer.

-string
Creates an environment variable as a string.

Commonly Used Environment Variables

auto_action
Sets the console action following an error, halt, or power on, to HALT, BOOT, or RESTART. The default is HALT.

bootdef_dev
Sets the default device or device list from which the system attempts to boot. For systems that ship with factory-installed software, the default device is preset at

the factory to the device that contains the factory-installed software. For systems that do not ship with factory-installed software, the default setting is null.

boot_file
Sets the file name to be used when a bootstrap requires a file name. The default setting is null.

boot_osflags
Sets additional parameters to be passed to system software. The default setting is 0,0.

Examples

1. `>>> set MODE FASTBOOT`

   Sets the mode for controlling the level of testing done at power-on or after console initialization to FASTBOOT. The FASTBOOT value indicates that you want the system to execute minimal console diagnostics.

2.
```
>>> set VME_A16_BASE 0
>>> set VME_A24_BASE a00000
>>> set VME_A24_SIZE 400
>>> set VME_A32_BASE 80000000
>>> set VME_A32_SIZE 4000
```

   Set the following:

   - The base address of the VMEbus A16 address space to be %x0
   - The base address of the VMEbus A24 address space to be %x0xa00000
   - The size of the VMEbus A24 address space to be 1 MB
   - The base address of the VMEbus A32 address space to be %x80000000
   - The size of the VMEbus A32 address space to be 16 MB

3. `>>> set EWA0_PROTOCOLS BOOTP`

   Sets the network protocol for booting and other network functions to be BOOTP.

4. `>>> set BOOTDEF_DEV ewa0`

   Sets the default device from which the system attempts to boot to EWA0.

5. >>> **set AUTO_ACTION BOOT**

   Sets the system's default console action to boot after an error, halt, or power-on.

6. >>> **set BOOT_FILE avme.sys**

   Sets the file name to be used when the system's boot requires a file name to avme.sys.

7. >>> **set BOOT_OSFLAGS 0,1**

   Sets the system's default boot flags to 0,1.

8. >>> **set foo 5**

   Creates environment variable *foo* and sets its value to 5.

See Also

clear, **show**

set led — display char on LED

Displays a character on the front panel light emitting diode (LED).

Syntax

set led *char* **[-b]**

Arguments

char
Specifies the character to display on the front panel LED. Prefix metacharacters with a backslash (\).

Options

-b
Specifies that the character be displayed in bright mode. The default is dim mode.

Examples

1. `>>> set LED "W" -b`

   Displays an uppercase W on the LED panel at full brightness.

See Also

show led

set reboot srom — set reboot mode to Serial ROM Mini-Console

Enters the Serial ROM (SROM) Mini-Console.

The only valid (and necessary) argument is *srom*. When you issue this command, you enter the SROM Mini-Console the next time you reset or power on the system. Once issued, the command prevents you from rebooting from the console until you alter NVRAM bytes using the SROM Mini-Console.

To alter the NVRAM bytes, enter the SROM Mini-Console command **wb**. This command sets either NVRAM location 0x8028 and/or 0x8029 to zero and allows the console to start the next time you reset or power on the system.

Note

If the I/O module's debug jumper is installed, the system displays the SROM Mini-Debugger prompt every time you power on the system. While in the SROM Mini-Debugger, you can start the SRM console by entering the **st** command and then entering address 8000 at the address prompt as follows:

```
SROM>  st
a>  8000
```

Syntax

set reboot srom

Example

```
>>>  set REBOOT SROM
```

Sets the reboot flag to enter Serial ROM Mini-Console on the next reset or power on.

set toy sleep — disable TOY clock's internal oscillator

Disables the DS1386 TOY clock's internal oscillator, lengthening the shelf life of the device. When you execute this command, bit 8 of the MONTH register of the device is set to 1, disabling the TOY clock's oscillator. The TOY clock's time registers cease to advance, and the life of the device's internal lithium battery is lengthened. The next time the system is powered up, the oscillator is automatically reenabled by the console and time is once again counted by the TOY device.

This command is for use by manufacturing at final test or by users who want to put the system into storage.

Note

You must reset the time and date once the module is powered up after disabling the battery.

Syntax

set toy sleep

Example

```
>>> set TOY SLEEP
```

Sets the TOY clock into storage mode. The clock is automatically reenabled on subsequent initialization.

sh — create new shell

Creates another shell process. Each shell process implements most of the functionality of the Bourne shell.

Syntax

sh [**-x** | **-v** | **-d**] **[-l] [-r] [-p] [arg . . .]**

Arguments

arg
Specifies a text string terminated with white space.

Options

-v
Prints lines as they are read.

-x
Shows commands just before they are executed.

-d
Deletes STDIN when the shell is done.

-l
Traces the lexical analyzer (shows tokens as they are recognized).

-r
Traces the parser (shows rules as they execute).

-p
Traces the execution engine (shows routines called).

Example

```
>>>  sh          # start a new shell
>>>              # the new shell's prompt

>>>  sh -v <foo  # execute command file "foo" and show lines as read in
>>>  sh -x <foo  # print out commands as they are executed and after
>>>              # all substitutions have been performed.
```

show — display system information

Displays the current value of an environment variable or other system parameter.

Syntax

show [{config, device, hwrpb, led, map, mode, pal, version}] [*envar_name*]

Arguments

config
Displays the system configuration.

device
Displays devices and controllers in the system.

hwrpb
Displays the Alpha hardware restart parameter block (HWRPB).

led
Displays a character illuminated on the LED panel.

map
Displays system virtual memory map.

mode
Displays the current mode, FASTBOOT or NOFASTBOOT.

pal
Displays the version of PALcode.

version
Displays the version of the console firmware.

envar
Displays the value of the environment variable specified. See the listing of predefined environment variables in Table 3–2 and the descriptions of commonly used environment variables in the description of the **set** command.

Commonly Used Environment Variables

auto_action
Displays the console action following an error halt or power on. The action can be halt, boot, or restart.

bootdef_dev
Displays the device or device list from which bootstrapping is attempted.

boot_file
Displays the file name to be used when a bootstrap requires a file name.

boot_osflags
Displays the additional parameters to be passed to system software.

language
Displays the language in which system software and layered products are displayed.

Examples

1.
```
>>> show version
version                V1.1-0 Jul 1 1996 10:16:59
>>>
```

   Displays the version of the firmware on a system.

2.
```
>>> show auto_action
boot
>>>
```

   Displays the default system power-on action.

3.
```
>>> show bootdef_dev
ewa0
>>>
```

   Displays a system's default boot device. In this example, the default boot device is EXA0.

See Also

set, **show config**, **show device**, **show hwrpb**, **show led**, **show map**, **show mode**

show config — display system configuration

Displays the system configuration.

Syntax

show config

Example

```
>>>  show config

                       Digital Equipment Corporation
                             Alpha VME 4/288

        SRM Console V1.1-0  VMS PALcode V5.56-4, OSF PALcode X1.45-8

                     MEMORY:    16 Meg of system memory
          System Controller:    VIC64 Enabled

Hose 0, PCI
        slot 0  DECchip 7407
        slot 1  DECchip 21040-AA      ewa0.0.0.1.0      08-00-2B-E4-E3-06
        slot 2  NCR 53C810            pka0.7.0.2.0      SCSI Bus ID 7
                                dka0.0.0.2.0          RZ26L
                                dka300.3.0.2.0        RZ26L
                                dka500.5.0.2.0        RRD42
        slot 3  Intel 82378IB
        slot 4  DECchip 21052-AA

>>>
```

Displays the system's configuration.

show device — displays devices

Displays the devices and controllers in the system. By default, all devices and controllers that respond are shown.

The device naming convention is as follows.

```
dka0.0.0.0.0
| || | | | |
| || | | | +-- Hose # : Always zero for Digital Alpha VME 4
| || | | +---- Slot # : On PCI System = <PCI bus * 1000>+<PCI function * 100>+<PCI slot>
| || | +--- Channel # : Always zero.
| || +---- Bus Node # : Device's bus ID (i.e. SCSI node ID plug #).
| |+--- Device Unit # : Device's unique system unit number.
| +---- Controller ID : One letter controller designator.
+---------- Driver ID : Two letter port or class driver designator.
                        PK - SCSI port, DK - SCSI class
                        EW - Ethernet Port
```

The output displays the device name, device ID, device type, and device internal firmware revision information (if available).

Syntax

show device [*device_name*]

Arguments

device_name
Specifies the device name or an abbreviation of a device name. When you use an abbreviation or wildcard, all devices that match are shown.

Examples

1.
```
>>> show device
dkc0.0.0.2.0              DKC0                          RZ57
mke0.0.0.4.0              MKE0                         TLZ04
ewa0.0.0.6.0              EWA0            08-00-2B-1D-27-AA
p_a0.7.0.0.0                                     Bus ID 7
p_b0.7.0.1.0                                     Bus ID 7
pkc0.7.0.2.0              PKC0                SCSI Bus ID 7
pke0.7.0.4.0              PKE0                SCSI Bus ID 7
pud0.7.0.3.0              PID0                DSSI Bus ID 7
>>>
```

   Displays all devices and controllers in the system. The controllers p_a0 and p_b0 are indeterminant. That is, neither SCSI nor DSSI. This occurs when no devices or terminators are present.

show device

2.
```
>>> show device e
ewa0.0.0.6.0                EWA0              08-00-2B-1D-27-AA
```

   Displays devices that start with “e”.

3.
```
>>> show device *k*          # Show SCSI devices.
dkc0.0.0.2.0                DKC0                             RZ57
mke0.0.0.4.0                MKE0                            TLZ04
```

   Displays all devices with “k” in the device name.

4.
```
>>> show device dk           # Show SCSI disks.
dkc0.0.0.2.0                DKC0                             RZ57
```

   Displays all devices starting with “dk” (all SCSI disks).

5.
```
>>> show device mk           # Show SCSI tape drives.
mke0.0.0.4.0                MKE0                            TLZ04
>>>
```

   Displays all devices starting with “mk” (all SCSI tapes).

show hwrpb — display HWRPB

Displays the address of the Alpha hardware restart parameter block (HWRPB).

Syntax

show hwrpb

Example

```
>>>  show hwrpb
HWRPB is at 2000
>>>
```

show led — display LED character

Displays the current character being displayed on the front LED panel.

Syntax

show led [-hex]

Options

-hex
Displays the contents of the LED register. If you do not specify **-hex**, the character being displayed is echoed to the console.

Examples

1. `>>> show led`

   Displays the current character being displayed by the LED panel.

2. `>>> show led -hex`

   Displays the contents of the LED register.

See Also

set led

show map — display memory map

Displays the current system virtual memory map.

Note

The map is empty after all console initialization. To fill in the page table entries, enter the **boot** command with the **-halt** option at the console prompt.

Syntax

show map

Example

```
>>>  show map
pte 00001020 v FFFFFC0902408000 p 00000000 V KR    SR            FR FW
pte 00001028 v FFFFFC090240A000 p 00000000 V KR    SR               FW
pte 00001020 v FFFFFC0902C08000 p 00000000 V KR    SR            FR FW
pte 00001028 v FFFFFC0902C0A000 p 00000000 V KR    SR               FW
pte 00001020 v FFFFFC0B02408000 p 00000000 V KR    SR            FR FW
pte 00001028 v FFFFFC0B0240A000 p 00000000 V KR    SR               FW
pte 00001020 v FFFFFC0B02C08000 p 00000000 V KR    SR            FR FW
pte 00001028 v FFFFFC0B02C0A000 p 00000000 V KR    SR               FW
>>>
```

show_log — display NVRAM error log information

Displays console-detected fault information that was previously stored in the error log area of NVRAM.

If you do not specify command-line options, the command displays the most recent fault.

Console error logging is completely independent of the operating system's error logging.

Syntax

show_log [**-n [count]** | **-all** | **-new**]

Options

-n *count*
Displays the number of most-recent faults indicated by *count* that are logged into the NVRAM error log area. The default value for *count* is 1.

-all
Displays all faults logged into the NVRAM error log area. All faults are marked as seen so that new faults can be easily displayed using the **-new** option. This command always displays all logged faults.

-new
Displays all new faults logged into the NVRAM error log area; displays all faults that have *not* been previously displayed by the **show_log -all** command.

Examples

1. `>>> show_log`

```
============================== F A U L T #1 ==============================

Time of Error: 13:08:39  9-AUG-1994
Diagnostic   : Interval Timer
Pass Count   : 1     Test Number: 4     Failing Point: 18
Error Message: Interrupt not invoked and should have been
>>>
```

   By default, the most-recent fault is displayed.

2. >>> **show_log -n 3**

```
============================== F A U L T #1 ==============================

Time of Error: 13:10:06  9-AUG-1994
Machine Check: IOC Controller
SCB Vector   : 67
IOC Status 0 : 0400031604000316
IOC Status 1 : 0400000004000000
PC           : 0000000000064c40

============================== F A U L T #2 ==============================

Time of Error: 13:08:39  9-AUG-1994
Diagnostic   : Interval Timer
Pass Count   : 1     Test Number: 4     Failing Point: 18
Error Message: Interrupt not invoked and should have been

==========================================================================

No more faults found

==========================================================================

>>>
```

Displays the two most-recent faults since they are the only ones logged into NVRAM.

See Also

clear_log

sleep — suspend execution

Suspends execution of a console process for a specified number of seconds. The console process temporarily wakes up every second to check for and kill pending bits.

Syntax

sleep [-v] ***time_in_secs***

Arguments

time_in_secs
Specifies the number of seconds to sleep. The default is one second.

Options

-v
Specifies that the value supplied is in milliseconds. The default is 1000 (one second).

Examples

1.
```
>>> ((sleep 10; echo hi there)&)
>>>
(10 seconds expire...)
hi there
```

   Sleep for 10 seconds then execute the **echo** command.

2.
```
>>> sleep -v 20
```

   Sleep for 20 milliseconds.

sort — sort a file

Arranges the lines of a file in lexicographic order and writes the results to STDOUT. The size of the file that sort can handle is limited by the size of memory.

Syntax

sort ***file***

Arguments

file
Specifies the file to be sorted.

Examples

1.
```
>>>  echo > foo 'banana
_>pear
_>apple
_>orange'
```

   Create file foo with 4 lines.

2.
```
>>>  sort foo
apple
banana
orange
pear
```

   Sort file foo and send output to the console.

sp — set priority

Modifies the priority of a process. Changing the priority of the process impacts the behavior of the process and the rest of the system.

Syntax

sp ***process_id new_priority***

Arguments

process_id
Specifies the process ID (PID) of the process to be modified.

new_priority
Specifies the new priority for the process. Priority values range from 0 to 7 where 7 is the highest.

Example

```
>>>  memtest -p 0 &
>>>  ps | grep  memtest
00000025 001a9700 2      23691 00000001 0      memtest ready
>>>  sp 25 3
>>>  ps | grep  memtest
00000025 001a9700 3     125955 00000001 0      memtest ready
>>>
```

Raises the priority of process 25 from 2 to 3.

See Also

ps, **sa**

start — start program

Starts program execution at the specified address or starts drivers.

Syntax

start [-drivers [*device_prefix*]] [*address*]

Arguments

address
Specifies the PC address at which to start execution.

Options

-drivers [*device_prefix*]
Specifies the name of the device or device class to stop. If no device prefix is specified, then all drivers are started.

Examples

1. `>>> start 400`

   Starts program execution at address 400.

2. `>>> start -drivers`

   Starts all the drivers in the system.

See Also

continue, **init**, **stop**

stop — stop CPU or device

Stops the CPU or a specified device.

Syntax

stop [-drivers [*device_prefix*]] [*processor_num*]

Arguments

processor_num
Specifies the processor to stop. If you use this argument, specify 0.

Options

-drivers [*device_prefix*]
Specifies the name of the device or the device class to stop. If you do not specify a device prefix, the command stops all drivers.

Example

```
>>> stop
```

Stops the processor.

See Also

continue, **init**, **start**

update — update flash ROMs on the system

Loads new firmware into the flash ROMs (FEPROMs). To modify the flash ROMs, you must close DIP switch #2 on the Digital Alpha VME 4 module.

The update process proceeds as follows:

1. The image is loaded from the specified device into system memory.
2. A prompt appears for confirmation of update continuation.
3. The FEPROMS are reprogrammed.

Each byte of the FEPROM is verified. Each step provides for a certain number of retries to perform the operation successfully on a particular byte of the FEPROM. If a failure occurs in any of the steps, an error message is displayed on the console.

If the programming operation is successful, a success message is displayed on the console.

Notes

You must reset or cycle power on the system to run the new image in the FEPROMs; otherwise, the previous console image executes out of memory.

Be sure to disable FEPROM writing after completing the update process by setting switch #2 to the open position.

Syntax

update [-file *filename*] [-protocol *transport*] [-device *source_device*] [-target *target_name*]

Options

-file *filename*
Specifies the name of the new FEPROM update image.

-protocol *transport*
Specifies the source transport protocol. Valid protocols are MOP and TFTP. See the **boot** command for more information on using the TFTP protocol.

-device
Specifies the device from which to load the new FEPROM update image file. Currently, the only valid device is EWA0.

-target *device*
Specifies the device that contains the FEPROMs to be upgraded. Valid targets are CONSOLE and USERFLASH.

Examples

1.
```
>>>  update -fi alphavme_v1_1-0 -dev ewa0 -prot
mop -tar console
update -path mop:alphavme_v1_1-0/ewa0 -target console
.....
Network load complete.
Host name: OHMY
Host address: aa-00-04-00-00-4b

new: 1.1-0
Note: Module DIP Switch #2 must be CLOSED to enable Updates!

                        FEPROM UPDATE UTILITY
                        -----> CAUTION <-----
        EXECUTING THIS PROGRAM WILL CHANGE YOUR CURRENT ROM!

Do you really want to continue [Y/N] ? : Y

        DO NOT ATTEMPT TO INTERRUPT PROGRAM EXECUTION!
        DOING SO MAY RESULT IN LOSS OF OPERABLE STATE.

The program will take at most several minutes.

Erasing the target flash device...
........
Erasure completed.
Programming...
........
Programming completed.
Verifying...
Update successful
>>>
```

   The example above shows how to do an update using the MOP protocol.

2.
```
>>>  update -fi //usr//local//bootfiles//alphavme_v1_1-0 -dev ewa0 -tar
console -pro tftp
update -path tftp://usr//local//bootfiles//alphavme_v1_1-0/ewa0 -target
console

                        FEPROM UPDATE UTILITY
                        -----> CAUTION <-----
        EXECUTING THIS PROGRAM WILL CHANGE YOUR CURRENT ROM!

Do you really want to continue [Y/N] ? : y

        DO NOT ATTEMPT TO INTERRUPT PROGRAM EXECUTION!
        DOING SO MAY RESULT IN LOSS OF OPERABLE STATE.
```

```
The program will take at most several minutes.

Erasing the target flash device...
........
Erasure completed.
Programming...
........
Programming completed
Verifying...
Update successful
>>>
```

The example above shows how to do an update using the TFTP protocol.

A

Module Connector Pinouts

Sections A.1 through Section A.5 provide pinout information for the Alpha VME 4:

- CPU connector
- I/O Type 1 card connector
- Primary breakout module connector
- Secondary breakout module connector
- PMC I/O Companion card

A.1 CPU Connector Pinouts

The Alpha VME 4 CPU (54-24325-*xx*) J12 (P2) connector has the following power/ground pin assignments:

	Row A	Row B	Row C
Ground	1, 2, 4, 5, 7, 8, 10, 11, 13, 15, 16, 18-23, 28-30	2, 12, 22, 31	3, 4, 7-11, 14-17, 20-22, 24-27, 30
VCC	3, 6, 9, 12, 14, 17, 24-27, 31, 32	1, 13, 32	1, 2, 5, 6, 12, 13, 18, 19, 23, 28, 29, 31, 32

A.2 I/O Type 1 Card Connector Pinouts

Sections A.2.1 through A.2.3 show the pinouts for the VMEbus connector, console and serial connectors, and the Ethernet connector on the Alpha VME I/O Type 1 card (54-24139-01).

A.2.1 VMEbus (J1) Connector Pinouts

Table A–1 lists the pinouts for the VMEbus (J1) connector (P2).

Table A–1 VMEbus (J1) Connector

Pin	Row A	Row B	Row C
1	SCSI_DATA0_L	VCC	MSDATA
2	SCSI_DATA1_L	Ground	MSCLK
3	SCSI_DATA2_L	N/C	Ground
4	SCSI_DATA3_L	VME_A24	KBDATA
5	SCSI_DATA4_L	VME_A25	KBCLK
6	SCSI_DATA5_L	VME_A26	WD_STATUS_OC
7	SCSI_DATA6_L	VME_A27	BREAKOUT0
8	SCSI_DATA7_L	VME_A28	BREAKOUT1
9	SCSI_DP_L	VME_A29	Ground
10	SCSI_ATN_L	VME_A30	EXT_RESET_L
11	SCSI_BSY_L	VME_A31	TMR2_EXT_OP_L
12	SCSI_ACK_L	Ground	TMR1_EXT_OP_L
13	SCSI_RST_L	VCC	TMR_MINOR_IP_L
14	SCSI_MSG_L	VME_D16	TRM_MAJOR_IP_L
15	SCSI_SEL_L	VME_D17	Ground
16	SCSI_CD_L	VME_D18	PP_STB_L
17	SCSI_REQ_L	VME_D19	PP_ERR_L
18	SCSI_IO_L	VME_D20	PP_DATA0
19	Ground	VME_D21	PP_DATA1
20	Ground	VME_D22	PP_DATA2
21	Ground	VME_D23	PP_DATA3
22	Ground	Ground	PP_DATA4
23	VME_MASTER_SW_L	VME_D24	PP_DATA5
24	VCC	VME_D25	PP_DATA6
25	VCC	VME_D26	PP_DATA7
26	VCC	VME_D27	PP_SLCT

(continued on next page)

Table A–1 (Cont.) VMEbus (J1) Connector

Pin	Row A	Row B	Row C
27	VCC	VME_D28	PP_PE
28	Ground	VME_D29	PP_BUSY
29	Ground	VME_D30	PP_ACK_L
30	Ground	VME_D31	PP_AFD_L
31	VCC	Ground	PP_INIT_L
32	VCC	VCC	PP_SLIN_L

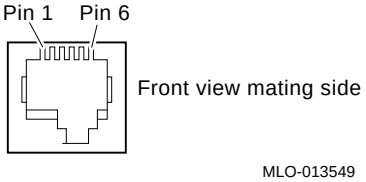
A.2.2 Console (J6) and Serial (J7) Connector Pinouts

Table A–2 lists the pinouts for the console (J6) and serial (J7) connectors. Figure A–1 shows a pinout diagram.

Table A–2 Console (J6) and Serial (J7) Connector Pinouts

Pin	Signal
1	ready out
2	transmit +
3	transmit -
4	receive +
5	receive -
6	ready in

Figure A–1 Console (J6) and Serial (J7) Connector Pinouts



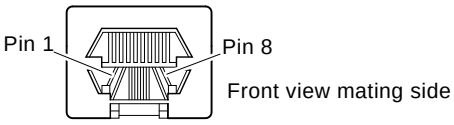
A.2.3 Ethernet (J9) Connector Pinouts

Table A–3 lists the pinouts for the Ethernet (J9) connector. Figure A–2 shows a pinout diagram.

Table A–3 Ethernet (J9) Connector Pinouts

Pin	Signal
1	transmit +
2	transmit -
3	receive +
4	no connection
5	no connection
6	receive -

Figure A–2 Ethernet (J9) Connector Pinouts



A.3 Primary Breakout Module Connector Pinouts

Table A–4 lists the pinouts for the primary breakout module (54-24663-01). Figure A–3 shows a pinout diagram.

Table A–4 Primary Breakout Module Connector Pinouts

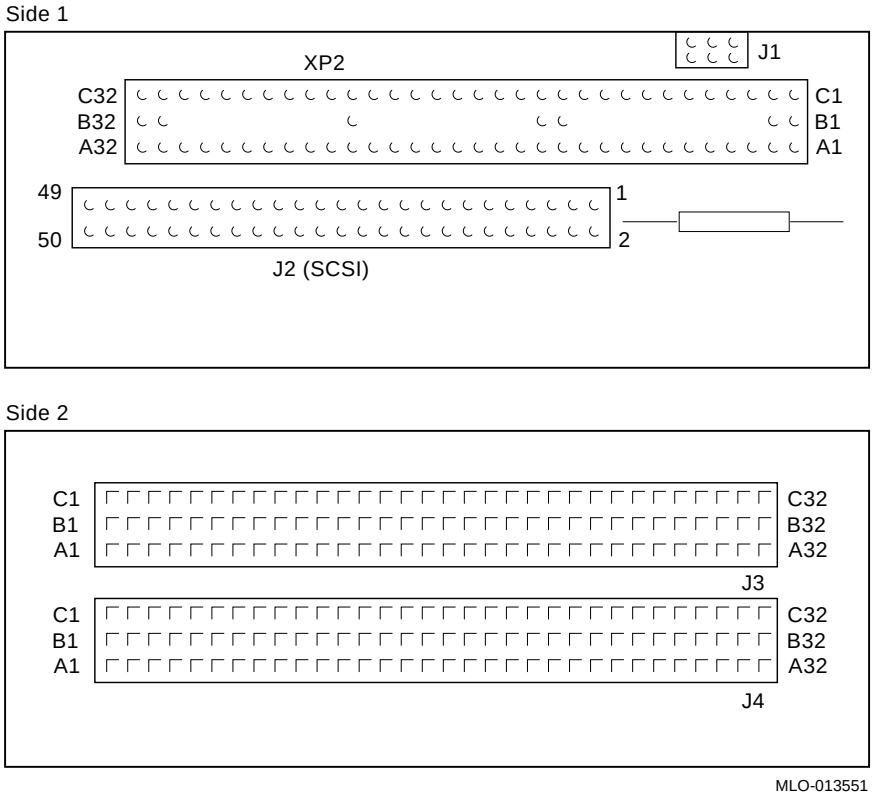
Pin	Row A	Row B	Row C
1	SCSI_DATA0_L	VCC	MSDATA
2	SCSI_DATA1_L	Ground	MSCLK
3	SCSI_DATA2_L	N/C	Ground
4	SCSI_DATA3_L	N/C	KBDATA

(continued on next page)

Table A–4 (Cont.) Primary Breakout Module Connector Pinouts

Pin	Row A	Row B	Row C
5	SCSI_DATA4_L	N/C	KBCLK
6	SCSI_DATA5_L	N/C	WD_STATUS_OC
7	SCSI_DATA6_L	N/C	BREAKOUT0
8	SCSI_DATA7_L	N/C	BREAKOUT1
9	SCSI_DP_L	N/C	Ground
10	SCSI_ATN_L	N/C	EXT_RESET_L
11	SCSI_BSY_L	N/C	TMR2_EXT_OP_L
12	SCSI_ACK_L	Ground	TMR1_EXT_OP_L
13	SCSI_RST_L	VCC	TMR_MINOR_IP_L
14	SCSI_MSG_L	N/C	TRM_MAJOR_IP_L
15	SCSI_SEL_L	N/C	Ground
16	SCSI_CD_L	N/C	PP_STB_L
17	SCSI_REQ_L	N/C	PP_ERR_L
18	SCSI_IO_L	N/C	PP_DATA0
19	Ground	N/C	PP_DATA1
20	Ground	N/C	PP_DATA2
21	Ground	N/C	PP_DATA3
22	Ground	Ground	PP_DATA4
23	VME_MASTER_SW_L	N/C	PP_DATA5
24	VCC	N/C	PP_DATA6
25	VCC	N/C	PP_DATA7
26	VCC	N/C	PP_SLCT
27	VCC	N/C	PP_PE
28	Ground	N/C	PP_BUSY
29	Ground	N/C	PP_ACK_L
30	Ground	N/C	PP_AFD_L
31	VCC	Ground	PP_INIT_L
32	VCC	VCC	PP_SLIN_L

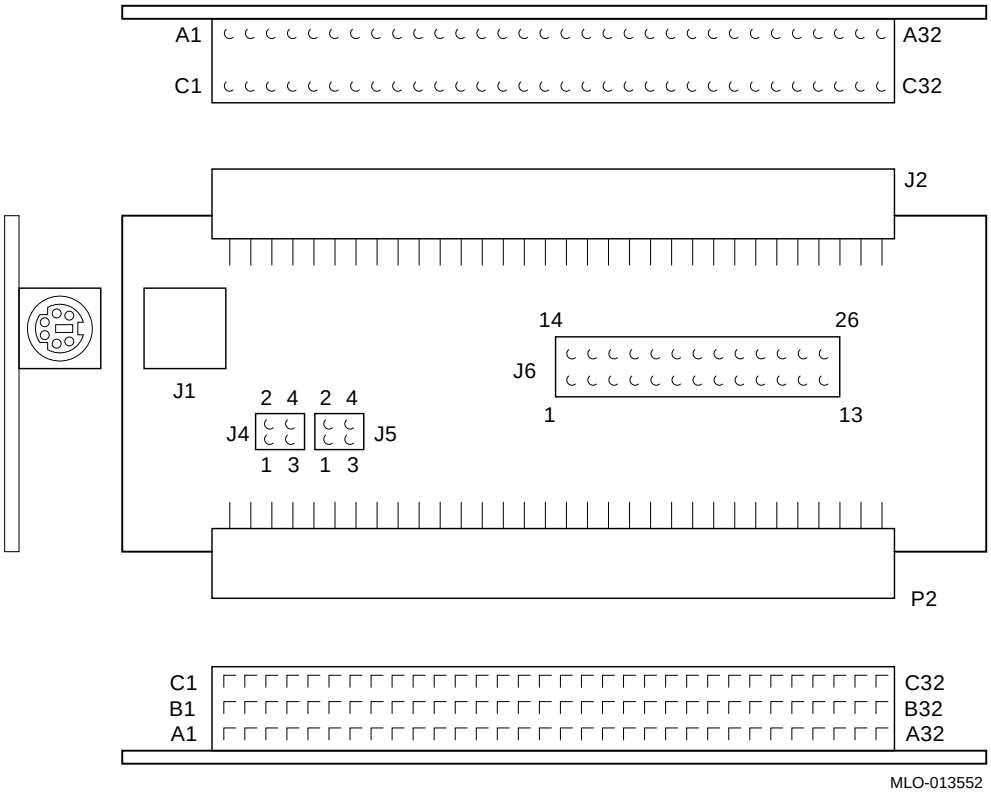
Figure A–3 Primary Breakout Module Connector Pinouts



A.4 Secondary Breakout Module Connector Pinouts

Figure A–4 shows the layout of the pinouts for the secondary breakout module. Note the positions of the J1 (keyboard and mouse) and J6 (parallel port) connectors.

Figure A–4 Secondary Breakout Module Connector Pinouts



Sections A.4.1 and A.4.2 provide more detail on the J1 and J6 connectors, respectively.

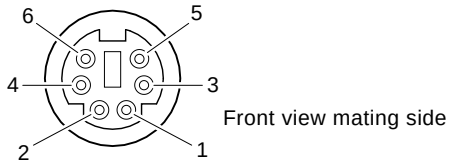
A.4.1 Keyboard and Mouse (J1) Connector Pinouts

Table A–5 lists the pinouts for the keyboard and mouse (J1) connector. Figure A–5 shows a pinout diagram.

Table A–5 Keyboard and Mouse (J1) Connector

Pin	Signal
1	MOUSE_DATA
2	KBRD_DATA
3	Ground
4	VCC
5	MOUSE_CLOCK
6	KBRD_CLOCK

Figure A–5 Keyboard and Mouse (J1) Pinouts



A.4.2 Parallel Port (J6) Connector Pinouts

Table A–6 lists the pinouts for the parallel port (J6) connector. Figure A–6 shows a pinout diagram.

Table A–6 Parallel Port (J6) Connector

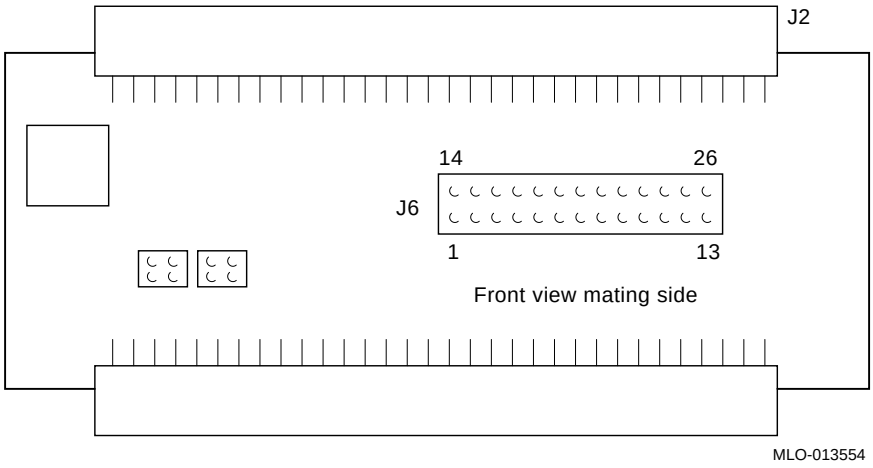
1	PP_STB_L
2	PP_DATA0
3	PP_DATA1
4	PP_DATA2
5	PP_DATA3
6	PP_DATA4
7	PP_DATA5
8	PP_DATA6

(continued on next page)

Table A–6 (Cont.) Parallel Port (J6) Connector

9	PP_DATA7
10	PP_ACK_L
11	PP_BUSY
12	PP_PE
13	PP_SLCT
14	PP_AFD_L
15	PP_ERR_L
16	PP_INIT_L
17	PP_SLIN_L
18-25	Ground
26	N/C

Figure A–6 Parallel Port (J6) Connector Pinouts



A.5 PMC I/O Companion Card Connector Pinouts

Tables A–7 and Table A–8 list the pinouts for the PMC I/O Companion Card (54-24665-01) mouse (J2) and keyboard (J3) connectors, respectively. Figure A–7 shows a pinout diagram for the connectors.

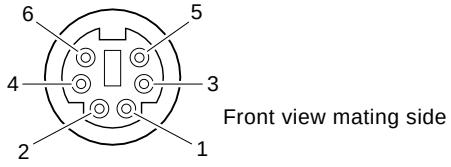
Table A–7 PMC I/O Companion Card Mouse (J2) Connector

Pin	Signal
1	MOUSE_DATA
2	KBRD_DATA
3	Ground
4	VCC
5	MOUSE_CLOCK
6	KBRD_CLOCK

Table A–8 PMC I/O Companion Card Keyboard (J3) Connector

Pin	Signal
1	KBRD_DATA
2	MOUSE_DATA
3	Ground
4	VCC
5	KBRD_CLOCK
6	N/C

Figure A–7 PMC I/O Companion Card Mouse (J2) and Keyboard (J3) Connector Pinouts



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