EK–SCSIS–SP–001

Small Computer System Interface

A Developer's Guide

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digital equipment corporation
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About This Guide

Digital encourages third-party vendors to develop complementary SCSI peripheral devices that are not currently available through Digital. Confirming its commitment to **open systems**, Digital has chosen to provide developers with the technical information they need to interface peripheral devices to Digital's SCSI-based systems.

Purpose of This Guide

This guide defines Digital Equipment Corporation's implementation of the *American National Standard for Information Systems—Small Computer System Interface-2 (SCSI-2)* specification. It defines the mechanical, electrical, and functional requirements for interconnecting small computers and intelligent peripheral devices.

This guide is not intended to replace the SCSI-2 specification, but rather to specify which options of the SCSI-2 specification must be implemented, and to impose additional restrictions when necessary.

Note *At this writing, the Small Computer System Interface (SCSI-2) is under development. The draft SCSI-2 specification (Revision 10b) should be the official guide to what is implemented by a third-party device.*

Table 1 summarizes Digital's implementation of SCSI.

Table 1 Digital's Implementation of SCSI

FEATURE	Currently Not implemented	IMPLEMENTED
Data transfer width	16 and 32 bit-wide SCSI	8-bit SCSI
Transfer mode	Fast data transfer	1.5 MB/s (async), 4+ MB/s (synch)
Drivers	Differential	Single-ended drivers and receivers
Termination	Internal termination	External termination of last peripheral device on bus
Cable	25 meters long	6 meters long
	68-conductor B cable	50-conductor A cable
Initiators	Multiple initiators	Single initiator with multiple targets
Performance	Command queuing (tagged commands)	
		Disconnect and reconnect
	Soft Reset to clear devices from bus	Hard Reset to clear devices from bus. Also, ABORT, BUS DEVICE RESET.
	Dynamic reconfiguration of peripheral devices on bus	
Command set (class driver)		Common Command Set for disks
Operating system support for SCSI devices not supplied by Digital	ULTRIX application level interface. VAXELN application level interface.	VMS Version 5.3 third-party device development support
Operating system support for SCSI disk and tape drives supplied by Digital		ULTRIX Workstations Software V2.1 for MicroVAX 3100, DS2100, DS3100, VS3100, and VS3520/3540 systems
		VMS driver support on MicroVAX 3100, VS3100, and VS3520/3540 systems

Digital computer systems support multiple operating systems. Some operating systems may have a different set of SCSI requirements and restrictions. Restrictions specific to an operating system are indicated by a delta symbol as defined in the Conventions section of this guide.

Who Should Use This Guide

This guide is intended for developers of peripheral devices who need information about Digital's SCSI requirements. The developers should have knowledge of the draft **ANSI** SCSI-2 specification.

VMS Development Considerations

The VMS operating system provides two mechanisms for the attachment of third-party devices to Digital systems. Depending upon the peripheral device to be supported, the requirements of the application programs that will access the device, and programming resources available, a third-party vendor may elect to use either the VMS generic SCSI class driver or to write a device-specific class driver.

To use the VMS generic SCSI class driver, programmers should understand how to use the VMS Queue I/O Request ($QIO) system service interface with a high-level language. To write a third-party SCSI class device driver, programmers should have detailed knowledge of the VMS operating system and the VAX MACRO assembly language. See *Small Computer System Interface: An Overview* for a technical summary of the VMS Version 5.3 SCSI Device Support product, and Appendix A for a list of associated documents.

Structure of This Guide

This guide contains five chapters and two appendixes.

Chapter 1 contains the physical description of Digital's implementation of the Small Computer System Interface (SCSI-2) specification.

Chapter 2 describes the eight bus phases that define the logical characteristics of the SCSI bus.

Chapter 3 defines the SCSI command and status structures.

Chapter 4 describes the characteristics expected of most SCSI devices.

Chapter 5 describes Digital's requirements for system initialization of SCSI devices.

Appendix A lists the manuals associated with Digital's implementation of the Small Computer System Interface.

Appendix B contains a cross-reference between the ANSI specification and this guide. See Table B–1.

The Glossary explains technical terms used in the manual.

ANSI Cross-References

ANSI SCSI-2 specification, Section n.n.n.

Chapters, sections, and paragraphs in this manual are cross-referenced to the *American National Standard for Information Systems—Small Computer System Interface-2 (SCSI-2)* specification (X3T9/89-042), Revision 10b. In the printed version of the manual, the cross-references are adjacent to the text; in the online version they appear above the text.

The format and content of this manual are similar to the referenced specification. However, this guide contains only the information applicable to Digital's implementation of SCSI.

Refer to the ANSI SCSI-2 specification for information about numeric order codes and vendor identification.

Conformance to Standards

The ANSI SCSI-2 specification (revision 10b) should be the official guide to what features should be implemented on the device and how to implement them. Digital's requirements for third-party SCSI devices are based on the evolving SCSI-2 specification. SCSI-2 is compatible with the SCSI-1 standard; SCSI-2 clarifies much of the material in SCSI-1.

Digital has designed its hardware and software so that it adheres to the draft SCSI-2 specification and yet provides as much flexibility as possible. To work with Digital systems, third-party devices must implement all the mandatory features of the SCSI-2 interface. Third-party devices may implement optional features, as long as the implementation follows the SCSI-2 specification. Devices may implement vendor-specific features as long as the features are implemented in areas clearly designated as such by the SCSI-2 specification.

Development Considerations

Products licensed or sold by Digital Equipment Corporation have been tested by Digital. Products should operate with Digital computer systems if they are developed using Digital SCSI documentation and implemented according to Digital requirements as specified in this guide. The proper operation of products that have been developed by third-party vendors cannot be assured by Digital. Many third-party products require additional features that are not part of Digital's software. These products may not be fully functional with Digital's software as licensed and sold. Digital customers who use unsupported products may not qualify for Digital customer service programs.

Third-party peripheral devices may be attached to Digital SCSI-based systems; however:

- Performance and functionality with the operating system may not be optimized.
- Data integrity and reliability are potentially at risk due to loss of data, error rate, data corruption, and disabling of the bus.
- Quality of peripheral devices may not meet Digital standards.

A product that is not supplied by Digital may appear to work in a specific configuration; it may not work with future updates of Digital hardware and software.

Conventions

The following conventions are used in this guide:

boldface	Boldface type represents the introduction of a new term. New terms are defined in the Glossary.
Caution	Cautions provide information to prevent damage to equipment or software. Read these carefully.
Note	Notes provide information about the current topic and are of special interest to vendors of peripherals.
ANSI SCSI-2 specification, Section *n.n.n.*	This notation indicates that the section, paragraph, or table is cross-referenced to a numbered section in the draft ANSI Small Computer System Interface-2 (SCSI-2) specification (X3T9/89-042), Revision 10b.
SCSI	The term SCSI is used wherever it is not necessary to distinguish between SCSI-1 and SCSI-2.
△	The delta symbol flags information in Digital's implementation of SCSI that differs from the draft SCSI-2 specification. In the printed version of the manual, the delta symbols are adjacent to the text; in the online version, they appear above the text.
△ VMS	The delta symbol with the letters VMS below signifies a restriction, selection, or a change from the draft SCSI-2 specification that is specific to the VMS operating system.
UPPERCASE	Uppercase text represents the names of signals, messages, and commands; for example, INQUIRY.
xx	Numbers that are not immediately followed by lowercase ''b'' or ''h'' are decimal values.
xxb	Numbers immediately followed by lowercase ''b'' are binary values.
xxh	Numbers immediately followed by lowercase ''h'' are hexadecimal values.

1

Physical Characteristics

This chapter contains the physical definition of Digital Equipment Corporation's implementation of the draft proposed **ANSI** Small Computer System Interface-2 (SCSI-2) specification. Cables, connectors, terminators, signals, and bus timing are described in the following sections:

- Physical description, Section 1.1
- Cable requirements, Section 1.2
- Connector requirements, Section 1.3
- Electrical description, Section 1.4
- SCSI bus, Section 1.5
- SCSI bus signals, Section 1.6
- SCSI bus timing, Section 1.7

1.1 Physical Description

ANSI SCSI-2 specification, Section 4.1.

SCSI devices are daisy-chained together using 50-pin connectors on the A cable. Both ends of the cable must be terminated. All signals are common between all SCSI devices on the cable.

Single-ended drivers and receivers, with a maximum cable length of 6 meters, are specified.

Single-ended and differential devices are mutually exclusive within a system. They are electrically different and must not be used on the same bus. Digital supports only the single-ended implementation.

The fast synchronous data transfer option is not supported.

Caution ***Devices** cannot be added to the SCSI **bus**, removed from the bus, or re-cabled while equipment is powered on. Failure to meet this requirement may cause loss of user data or system failure.*

1.2 Cable Requirements

ANSI SCSI-2 specification, Section 4.2.

An ideal impedance match with cable terminators implies a cable characteristic impedance of 132 ohms (a lower impedance is satisfactory). A characteristic impedance of 100 ohms ±10 percent is recommended for all cable types.

A minimum conductor size of 0.08042 mm^2 (28 **AWG**) is required for the TERMPWR line. This wire size minimizes the effect of noise and ensures proper distribution of terminator power.

Note *To minimize discontinuities and signal reflections, do not use cables of different impedances on the same bus. Implementations may require trade-offs in shielding effectiveness, cable length, the number of loads, transfer rates, and cost to achieve satisfactory system operation.*

To minimize discontinuities due to local impedance variation, space a flat cable at least 1.27 mm (0.050 in) from other cables, any other conductor, or the cable itself when the cable is folded.

Regulatory agencies may require you to use a larger wire size.

For proper operation of the SCSI bus, use high-quality, properly configured cables and connectors to connect all devices. It is recommended that you use only cable assemblies supplied by Digital intended for interconnecting SCSI devices. This ensures that the impedance characteristics, signal propagation, velocity, inductance, capacitance, cross-talk, grounding, conductor pairing, and shielding meet the requirements for proper operation of the bus.

In addition, it is recommended that all units on the SCSI bus be powered from a common ac power source.

The proper operation of any SCSI bus that uses cable assemblies not supplied by Digital, or not configured in accordance with Digital's recommendations, is not guaranteed.

Section 1.2.1 explains the requirements for single-ended cable. Section 1.2.2 contains ordering information for Digital cables.

1.2.1 Single-Ended Cable

ANSI SCSI-2 specification, Section 4.2.1.

Use a 50-conductor flat cable or 25-signal twisted-pair cable as the A cable. Digital recommends a maximum cable length of 4 meters for the best signal integrity. If you use twisted-pair cable, the twisted pairs in the cable must be wired to opposing **contacts** in the connector. The contact assignments for the shielded connector differ from those of the nonshielded connector:

- For the shielded connector, the order of the twisted pairs is 1/26, 2/27, . . . , 25/50.
- For the nonshielded connector, the order of the twisted pairs is 1/2, 3/4, . . . , 49/50.

See Section 1.3.3 for 50-pin connector pin assignments.

A stub length of no more than 0.1 meters is allowed off the mainline interconnection within any connected equipment or from any connected point.

Note *Do not cluster stubs. Space stubs at least 0.3 meters apart.*

Terminate bus devices externally with a terminator supplied by Digital.

1.2.2 Ordering Information for Digital Cables

Figure 1–1 shows the types of SCSI connector cables available from Digital.

Figure 1–1 Digital SCSI Connector Cables

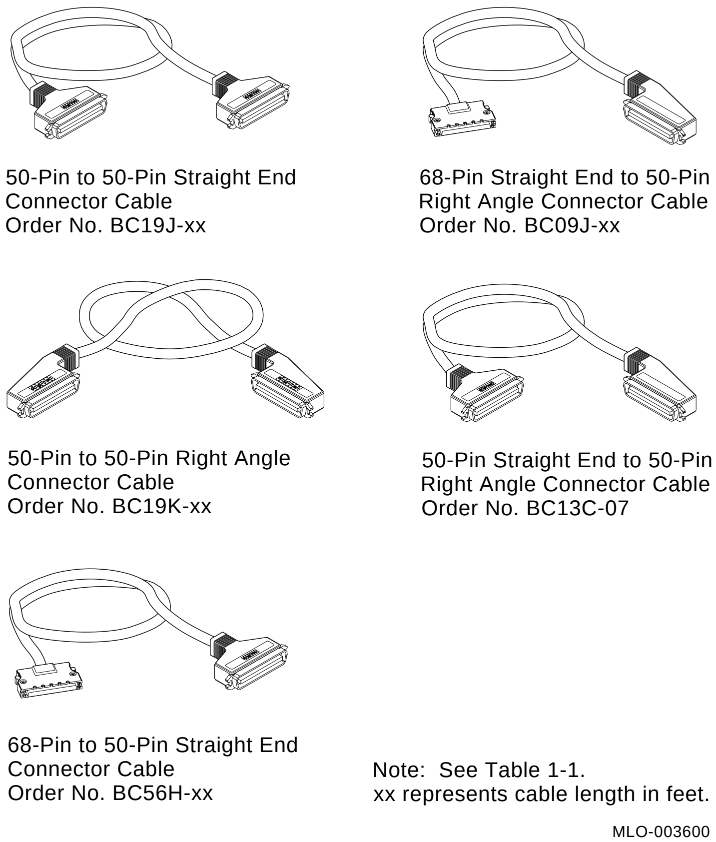


Table 1–1 lists Digital SCSI cable part numbers.

Table 1–1 Cable Ordering Information

System	Digital Part Number	Customer Order Number	Cable Length In Meters	Cable Length In Feet
VAXstation 3520/3540	17–02238–01	BC13C–07	2.14	7.0
DECstation 3100 and VAXstation 3100[1]	17–02008–01	BC56H–03	0.91	3.0
	17–02008–02	BC56H–06	1.83	6.0
	17–02443–03	BC09J–03	0.91	3.0
MicroVAX 3100 or expansion boxes	17–01351–01	BC19J–03	0.91	3.0
	17–01351–02	BC19J–06	1.83	6.0
	17–01351–04	BC19J–1E	0.46	1.5
	17–02446–01	BC19L–01	0.46	1.5
	17–02446–02	BC19K–02	0.61	2.0

[1] If your workstation is shipped with a 68–50 pin adapter, remove the adapter cover before connecting the SCSI cable.

1.3 Connector Requirements

ANSI SCSI-2 specification, Section 4.3.

Nonshielded connectors are typically used for in-cabinet applications. Shielded connectors are used for external applications where electromagnetic compatibility (**EMC**) and protection from electrostatic discharge (**ESD**) are required. You can use either type of connector with single-ended drivers.

In order to support daisy-chain connections, SCSI devices that use shielded connectors must provide two shielded device enclosures on the device. You can wire the two connectors one-to-one with a stub to the SCSI device's drivers and receivers, as long as you do not exceed the maximum stub length. Alternatively, you can run two cables from the two shielded connectors to the drivers and receivers to ensure that the maximum stub length is not exceeded. When you calculate the total cable length of the SCSI bus, be sure to include the length of the cable in the device enclosure.

Nonshielded connectors must be shrouded and keyed in order to protect users from making cabling errors.

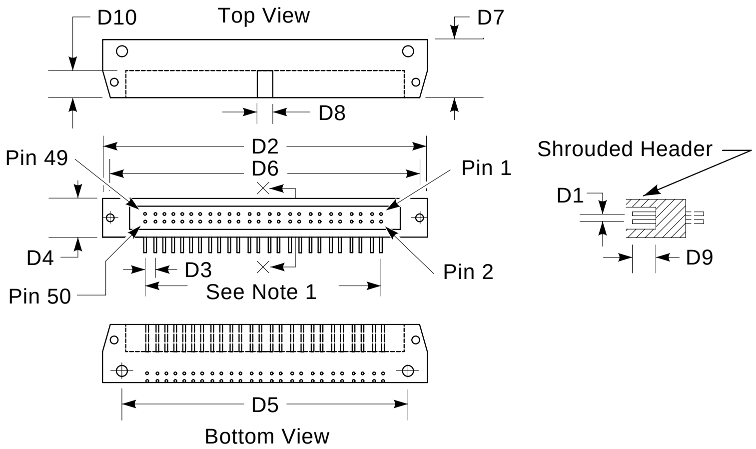
Section 1.3.1 through Section 1.3.5 describe cable and connector requirements in detail.

1.3.1 50-Pin Nonshielded Device and Cable Connector

ANSI SCSI-2 specification, Section 4.3.1.2.

The nonshielded, low-density, PC-board mounted, SCSI device connector for the A cable (Figure 1–2) is a 50-pin connector consisting of two rows of 25 male pins with adjacent pins 2.54 mm (0.1 in) apart. A shroud and header body must be used.

Figure 1–2 50-Pin Nonshielded SCSI Device Connector



Dimension	Millimeters	Inches	Comments
D1	2.54	0.100	
D2	82.80	3.260	Reference only
D3	2.54	0.100	
D4	8.89	0.350	Reference only
D5	72.64	2.860	Reference only
D6	78.74	3.100	Reference only
D7	13.94	0.549	Reference only
D8	4.19 ± 0.25	0.165 ± 0.01	
D9	6.09	0.240	
D10	6.60	0.260	Reference only

Notes:
(1) Two rows of 25 contacts on 2.54-mm (0.100-inch) spacing = 60.96 mm (2.400 inch).
(2) Tolerances ± 0.127 mm (0.005 inch) noncumulative, unless specified otherwise.

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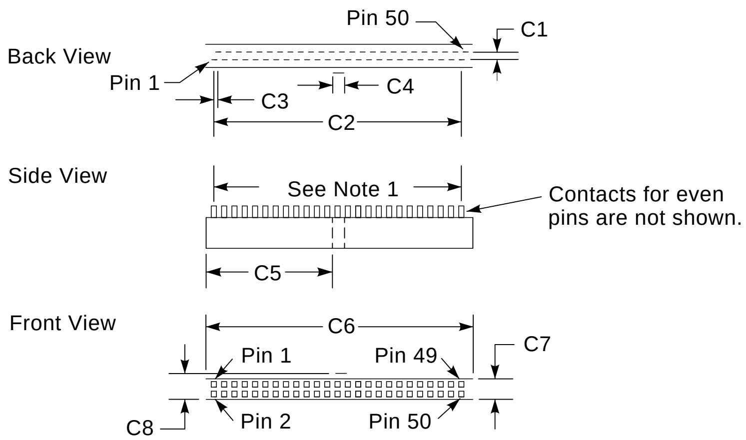
ANSI SCSI-2 specification, Section 4.3.1.2.

The nonshielded, low-density cable connector recommended for attachment to the A cable (Figure 1–3) is a 50-conductor connector consisting of two rows of 25 female contacts with adjacent contacts 2.54 mm (0.1 in) apart. The connector must be shrouded and keyed.

Figure 1–3 50-Pin Nonshielded SCSI Cable Connector



Dimensions	Millimeters	Inches	Comments
C1	2.540	0.100	
C2	60.960	2.400	
C3	2.540	0.100	
C4	3.302	0.130	
C5	32.385	1.275	
C6	68.972	2.680	
C7	6.096	0.240	
C8	7.620	0.300	Maximum

Notes:

(1) Fifty contacts on 1.27 mm (0.05 inch) staggered spacing = 62.23 mm (2.450 inch) [reference only].

(2) Tolerances $\pm$ 0.127 mm (0.005 inch) noncumulative unless specified otherwise.

(3) Connector cover and strain relief are optional.

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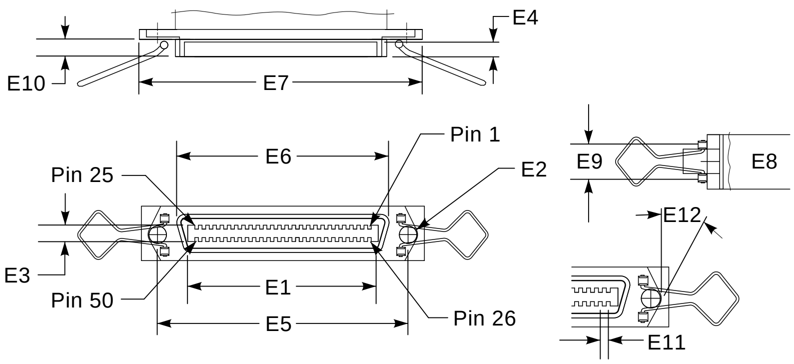
1.3.2 50-Pin Shielded Device and Cable Connector

ANSI SCSI-2 specification, Section 4.3.2.2.

The shielded low-density device connector for the A cable (Figure 1–4) is a 50-pin connector consisting of two rows of ribbon contacts spaced 2.16 mm (0.085 in) apart.

Figure 1–4 50-Pin Shielded SCSI Device Connector



Dimensions	Millimeters	Inches
E1	56.39 Minimum	2.220 Minimum
E2 (3)	2.62 Minimum	0.103 Minimum
E3	3.99 Minimum	0.157 Minimum
E4	5.84 Minimum	0.230 Minimum
E5	74.85	2.947
E6	64.29 Maximum	2.531 Maximum
E7	83.06	3.270
E8	15.24	0.600
E9	12.04 Maximum	0.474 Maximum
E10	9.78 Maximum	0.385 Maximum
E11	2.16	0.085
E12	15° ± 2°	15° ± 2°

Notes:

(1) Tolerances ± 0.127 mm (0.005 inch) noncumulative unless specified otherwise.

(2) Dimensions are shown for reference.

(3) Dimension E2 to accommodate 4-40 or 6-32 threaded screws.

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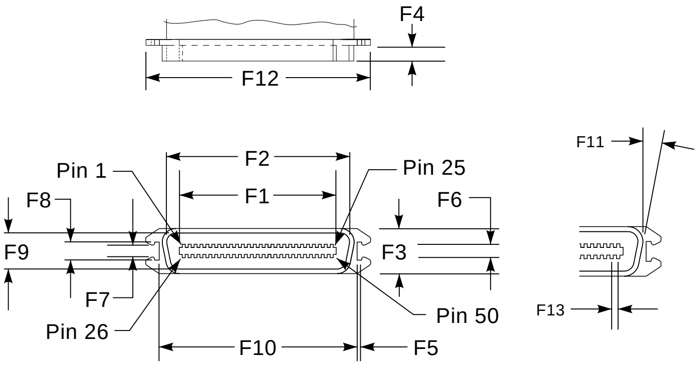
ANSI SCSI-2 specification, Section 4.3.2.2.

The shielded low-density cable connector for the A cable (Figure 1–5) is a 50-conductor connector consisting of two rows of ribbon contacts spaced 2.16 mm (0.085 in) apart.

Figure 1–5 50-Pin Shielded SCSI Cable Connector



Dimensions	Millimeters	Inches
F1	56.26 Maximum	2.215 Maximum
F2	64.29 Minimum	2.531 Minimum
F3	15.24	0.600
F4	7.29 Minimum	0.287 Minimum
F5	1.02	0.040
F6	4.09 Maximum	0.161 Maximum
F7	5.08	0.200
F8	6.10	0.240
F9	12.04 Minimum	0.474 Minimum
F10	68.45	2.695
F11	15° ± 2°	15° ± 2°
F12	76.71	3.020
F13	2.16	0.085

Notes:

(1) Tolerances ± 0.127 mm (0.005 inch) noncumulative unless specified otherwise.

(2) Dimensions are shown for reference.

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1.3.3 50-Pin Connector Pin Assignments

The pin assignments for the single-ended A cable (with nonshielded low-density connector) are listed in Figure 1–6.

Figure 1–6 Nonshielded Pin Assignments

Signal Name	Pin Number	Pin Number	Signal Name
Ground	1	2	-DB(0)
Ground	3	4	-DB(1)
Ground	5	6	-DB(2)
Ground	7	8	-DB(3)
Ground	9	10	-DB(4)
Ground	11	12	-DB(5)
Ground	13	14	-DB(6)
Ground	15	16	-DB(7)
Ground	17	18	-DB(P)
Ground	19	20	Ground
Ground	21	22	Ground
Reserved	23	24	Reserved
Open	25	26	Termpwr
Reserved	27	28	Reserved
Ground	29	30	Ground
Ground	31	32	-ATN
Ground	33	34	Ground
Ground	35	36	-BSY
Ground	37	38	-ACK
Ground	39	40	-RST
Ground	41	42	SMG
Ground	43	44	-SEL
Ground	45	46	-S/D
Ground	47	48	-REQ
Ground	49	50	-I/O

Notes:
Minus sign next to a signal indicates an active low.

Reserved indicates one of the following:
An open signal (recommended)
A signal ground in the end device
A signal ground at the bus terminator

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The pin assignments for the single-ended A cable (with shielded low-density connector) are listed in Figure 1–7.

Figure 1–7 Shielded Pin Assignments

Signal Name	Pin Number	Pin Number	Signal Name
Ground	1	26	-DB(0)
Ground	2	27	-DB(1)
Ground	3	28	-DB(2)
Ground	4	29	-DB(3)
Ground	5	30	-DB(4)
Ground	6	31	-DB(5)
Ground	7	32	-DB(6)
Ground	8	33	-DB(7)
Ground	9	34	-DB(P)
Ground	10	35	Ground
Ground	11	36	Ground
Reserved	12	37	Reserved
Open	13	38	Termpwr
Reserved	14	39	Reserved
Ground	15	40	Ground
Ground	16	41	-ATN
Ground	17	42	Ground
Ground	18	43	-BSY
Ground	19	44	-ACK
Ground	20	45	-RST
Ground	21	46	SMG
Ground	22	47	-SEL
Ground	23	48	-S/D
Ground	24	49	-REQ
Ground	25	50	-I/O

Notes:
Minus sign next to a signal indicates an active low.

Reserved indicates one of the following:
An open signal (recommended)
A signal ground in the end device
A signal ground at the bus terminator

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1.3.4 68-Pin Connector

The **SCSI port** on the VAXstation 3100 and DECstation 3100 and 2100 systems contains a 68-pin device connector. In order to attach expansion boxes to the system unit SCSI port, a 68-pin to 50-pin connector cable is required.

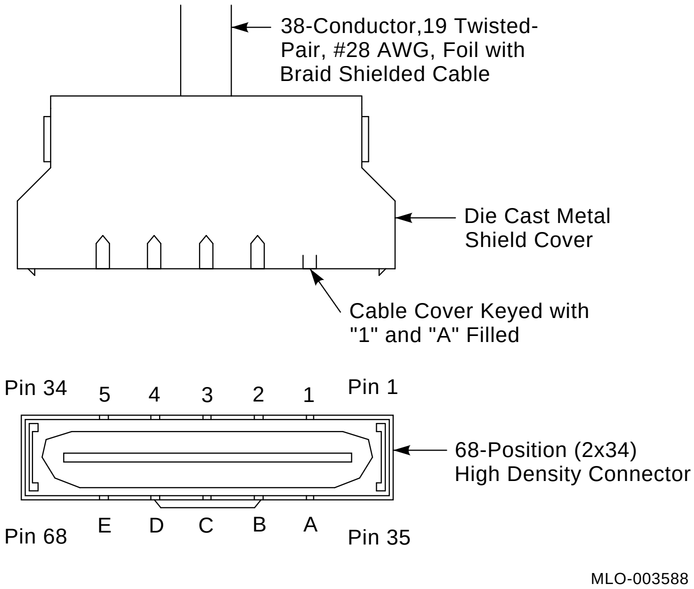
The 68-pin to 50-pin SCSI cable assembly (Figure 1–8) consists of:

- A 68-position (2 x 34) high density connector at one end
- A 38-conductor 19 twisted-pair (#28 AWG) foil with braid shielded cable
- A 50-position shielded low-density SCSI cable connector at the other end

Figure 1–5 illustrates the 50-position shielded cable connector.

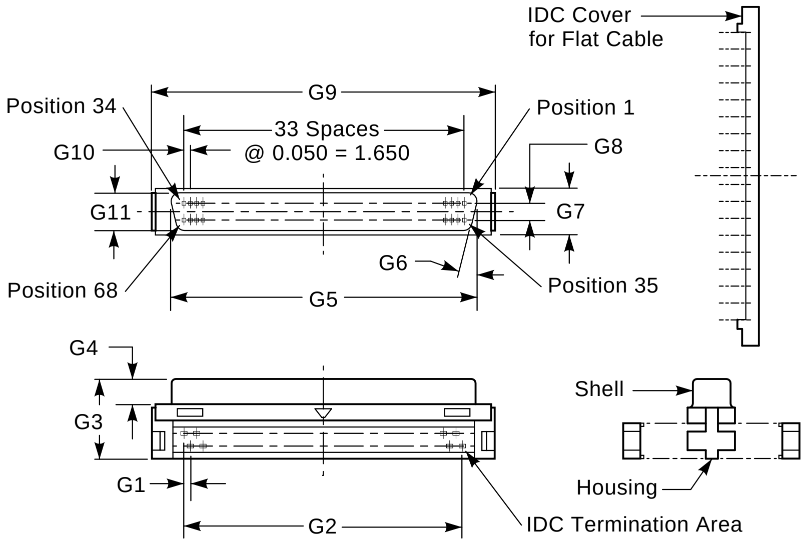
Figure 1–8 through Figure 1–10 illustrate the 68-position cable connector assembly. The 68-pin connector is a micro D, female, IDC type for flat cable, with metal shell.

Figure 1–8 68-Pin Connector Assembly



The shielded 68-pin connector (Figure 1–9) for the 68-pin to 50-pin adapter cable consists of two rows of contacts spaced 5.51 mm (.217 in) apart.

Figure 1–9 Configuration/Dimensions for 68-Pin Connector



Dimension	Millimeters	Inches
G1	1.27	0.050 Typ
G2	41.91	1.650
G3	13.21	0.52
G4	5.00	0.197
G5	46.07	1.814
G6	15° ± 30’	15° ± 30’
G7	7.29	0.287
G8	2.54	0.100
G9	52.09	2.051
G10	1.27	0.050 Typ
G11	5.51	0.217

Notes:
(1) Tolerances ± 0.397 mm (± 0.016 inch) unless specified otherwise.
(2) Dimensions are shown for reference.

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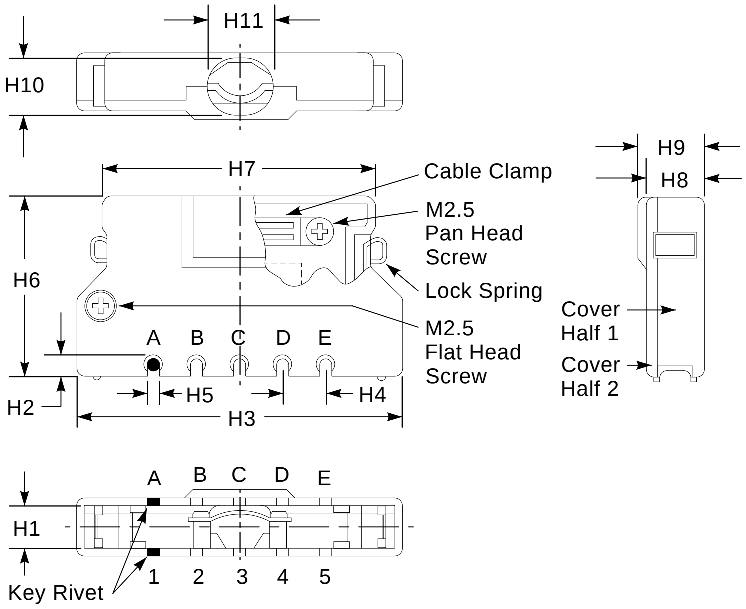
The cover and strain relief for the 68-pin connector are shown in Figure 1–10.

Figure 1–10 Cover and Strain Relief for 68-Pin Connector



Dimensions	Millimeters	Inches
H1	7.29	0.287
H2	4.06	0.160
H3	60.30	2.374
H4	8.00	0.315
H5	2.01	0.079
H6	32.00	1.260
H7	50.59	1.992
H8	10.01	0.394
H9	11.61	0.457
H10	9.98	0.393
H11	13.00	0.512

Notes:

(1) Tolerances ± 0.397 mm (± 0.016 inch) unless specified otherwise.

(2) Dimensions are shown for reference.

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1.3.5 68-Pin Connector Pin Assignments

The pin assignments for the 68-pin connector are listed in Figure 1–11.

Figure 1–11 68-Pin Connector Pin Assignments

Signal Name	Pin Number	Pin Number	Signal Name
	1	35	
-DB(0)	2	36	Ground
Ground	3	37	
-DB(1)	4	38	
Ground	5	39	
-DB(2)	6	40	Ground
Ground	7	41	
-DB(3)	8	42	Ground
Ground	9	43	
-DB(4)	10	44	
Ground	11	45	
-DB(5)	12	46	Ground
Ground	13	47	
-DB(6)	14	48	Ground
Ground	15	49	
-DB(7)	16	50	
Ground	17	51	
-DB(P)	18	52	
-ATN	19	53	
-BSY	20	54	
-ACK	21	55	
Ground	22	56	Ground
-RST	23	57	
-MSG	24	58	
-SEL	25	59	
-C/D	26	60	
-REQ	27	61	
-I/O	28	62	
Termpwr2	29	63	
Ground	30	64	
	31	65	
	32	66	
	33	67	
	34	68	

Note:
Minus sign next to a signal indicates an active low.

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1.4 Electrical Description

ANSI SCSI-2 specification, Section 4.4.

This section contains a description of Digital's implementation of the SCSI electrical specifications, as follows:

- Single-ended signals, Section 1.4.1
- Terminator Power, Section 1.4.2
- Signal Termination, Section 1.4.3
- Reserved Lines, Section 1.4.4

SCSI bus termination is assumed to be external to the SCSI device for all measurements described in Section 1.4.1 and Section 1.4.2.

1.4.1 Single-Ended Signals

ANSI SCSI-2 specification, Section 4.4.1.

It is recommended that Digital terminating connectors be used. See Table 1–2 for ordering information.

Table 1–2 Terminator Ordering Information

System	Part Number	Description
VAXstation 3520/3540 Expansion boxes MicroVAX 3100	12–30552–01	50-pin IEEE terminator
VAXstation 3100 DECstation 2100/3100	12–29635–01	68-pin Micro D-sub terminator

All signals use open-collector or three-state drivers.

SCSI devices (with power off) must have the low-level electrical characteristics and high-level electrical characteristics on each signal described in the ANSI specification. The recommended nominal switching threshold is approximately 1.4 volts.

Refer to the ANSI SCSI-2 specification for input and output characteristics.

1.4.2 Terminator Power

ANSI SCSI-2 specification, Section 4.4.3.

Each SCSI device should supply terminator power to a TERMPWR pin that is either fused or protected from a short circuit. This power is supplied through a diode or similar semiconductor that prevents backflow of power to the SCSI device. A 1.5 ampere current limiter is required.

The terminating connector, regardless of its location, must be powered from the TERMPWR pin. The use of keyed connectors is required in SCSI devices that provide terminator power, in order to prevent accidental grounding or misconnection of terminator power. Digital requires that all devices on the SCSI cable be powered on at all times.

SCSI devices must sink no more than 1 milliampere from TERMPWR except to power an optional internal terminator.

Single-ended SCSI devices providing terminator power on cable A have the following characteristics:

> VTerm = 4.25 volts dc to 5.25 volts dc, 900 milliamperes minimum source drive capability

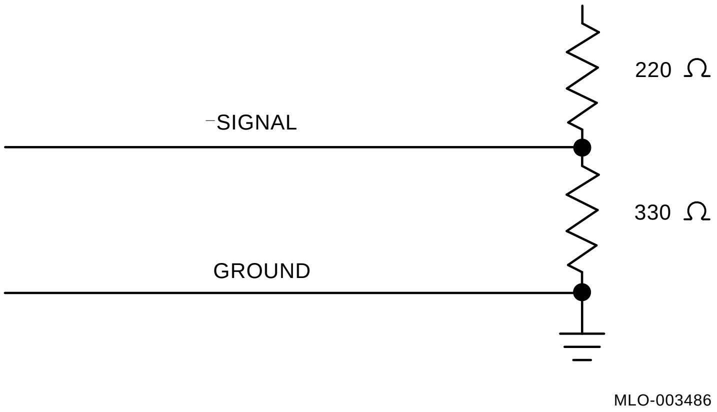
Note *It is recommended that the terminator power lines be decoupled to improve signal quality.*

1.4.3 Signal Termination

Figure 1–12 shows one termination scheme for single-ended buses.

Note *Signal termination for SCSI devices is changing. Refer to the ANSI SCSI-2 specification for information on alternative termination for single-ended buses.*

Figure 1–12 Termination



Near-end termination is provided within the system enclosure. The far-end termination for the external bus is provided by a terminator plugged into the last SCSI device connector. There must be no other terminators on the bus. The bus must be terminated externally. If you follow these rules for all devices, you will be able to configure the bus with proper termination.

Caution *Failure to terminate the bus properly may cause a system crash or data corruption.*

1.4.4 Reserved Lines

ANSI SCSI-2 specification, Section 4.4.4.

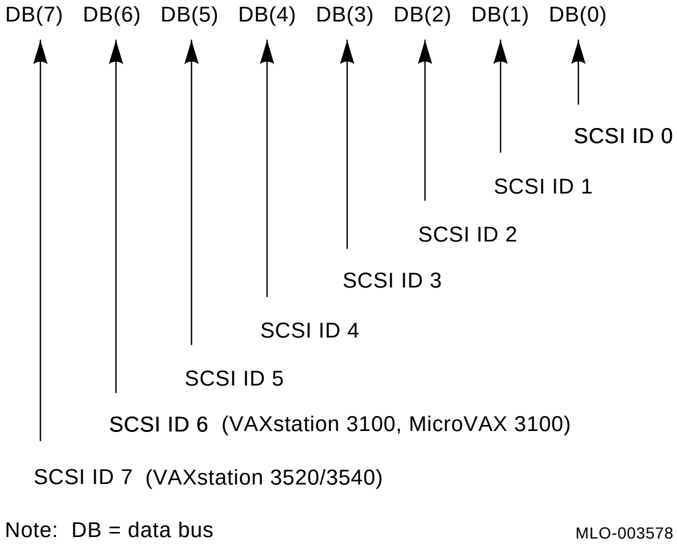
Lines labeled **reserved** in the pin assignments shown in Figure 1–6 and Figure 1–7 must be connected to ground in the bus terminator assemblies. Reserved lines may not be driven by SCSI devices; they should be connected to ground.

1.5 SCSI Bus

ANSI SCSI-2 specification, Section 4.5.

Communication on the SCSI bus can only occur between two SCSI devices at any given time. The SCSI bus can have a maximum of eight SCSI devices; the devices can be any combination of **initiator** and **target**. Each SCSI device has a **SCSI ID** bit assigned, as shown in Figure 1–13.

Figure 1–13 SCSI ID Bits



The SCSI ID is a value in the range 7–0. The SCSI ID determines the logical position of the device **controller** on the SCSI bus. You determine the SCSI ID you wish to use before configuring a SCSI device in a system. Each device must have user-accessible switches or jumpers so that the SCSI ID can be changed easily.

SCSI ID assignments vary from system to system. A third-party device may use any SCSI ID that does not conflict with another SCSI ID on the same bus. Suggested SCSI ID assignments are shown in Table 1–3.

Table 1–3 SCSI ID Assignments

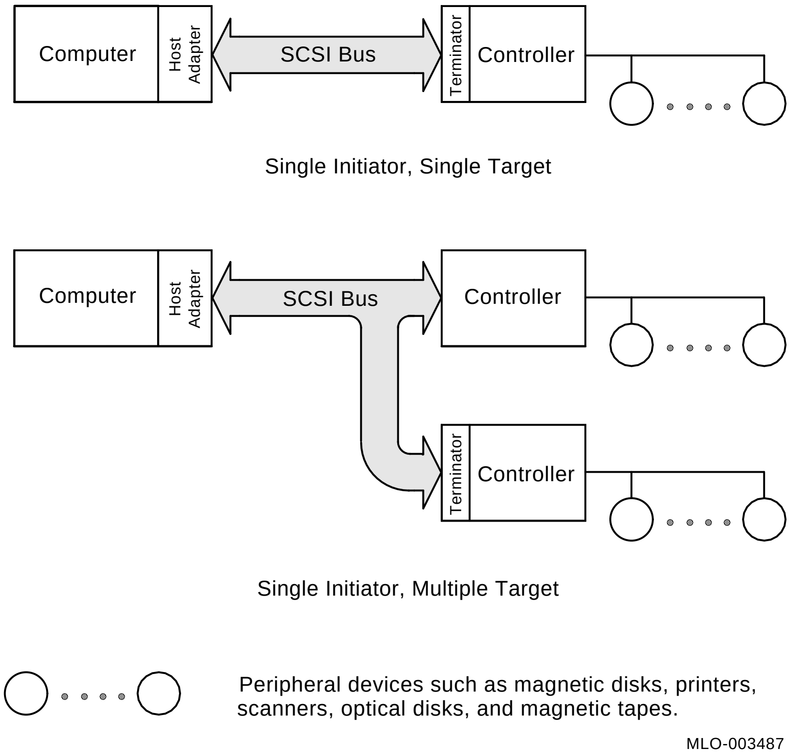
SCSI ID	Assignment
7	VAX CPU on the VAXstation 3520/3540
6	VAX CPU on the VAXstation 3100 and MicroVAX 3100
5	Tape drive
4, 3, 2	Disks
1, 0	Open

Note *The device **logical unit number (LUN)** identifies the different units attached to a single SCSI controller.*

When two SCSI devices communicate on the SCSI bus, one acts as an initiator and the other acts as a target. The initiator originates an operation and the target performs the operation. A SCSI device usually has a fixed role as an initiator or target, but some devices may be able to assume either role.

An initiator may address up to seven **peripheral device**s connected to a target. If the target is physically housed within the peripheral device, then the device is referred to as an embedded SCSI device. Sample system configurations are shown in Figure 1–14.

Figure 1–14 Sample SCSI Configurations



Certain SCSI bus functions are assigned to the initiator and certain SCSI bus functions are assigned to the target. The initiator may **arbitrate** for the SCSI bus and select a particular target. The target may request the transfer of command, data, **status**, or other information on the data bus, and in some cases it may arbitrate for the SCSI bus and reselect an initiator for the purpose of continuing an operation.

Information transfers on the data bus are asynchronous and follow a defined REQ/ACK (Request/Acknowledge) handshake protocol. One **byte** of information can be transferred with each handshake on the A cable. The SCSI-2 specification defines an option for synchronous data transfer.

1.6 SCSI Bus Signals

ANSI SCSI-2 specification, Section 4.6.

Eighteen signals are used on the A cable: nine signals are used for control and nine signals are used for data (messages, commands, status, and data), including parity. Table 1–4 describes the signals. Section 1.6.1 describes signal values, and Section 1.6.2 describes signal sources.

Table 1–4 SCSI Bus Signals

Signal	Description
BSY (BUSY)	An OR-tied signal that indicates that the bus is being used.
SEL (SELECT)[1]	An OR-tied signal used by an initiator to select a target or by a target to reselect an initiator.
C/D (CONTROL/DATA)	A signal driven by a target that indicates whether control or data information is on the data bus. True[2] indicates control.
I/O (INPUT/OUTPUT)	A signal driven by a target that controls the direction of data movement on the data bus with respect to an initiator. True indicates input to the initiator. This signal is also used to distinguish between Selection and Reselection phases.
MSG (MESSAGE)	A signal driven by a target during the Message phase.
REQ (REQUEST)	A signal driven by a target on A cable to indicate a request for a REQ/ACK data transfer handshake.
ACK (ACKNOWLEDGE)	A signal driven by an initiator on A cable to indicate an acknowledgment for a REQ/ACK data transfer handshake.
ATN (ATTENTION)	A signal driven by an initiator to indicate the Attention condition.

[1]Digital's SCSI **System Interface Interconnect (SII)** chip does not have the SEL line OR-tied. The SII chip does not directly drive the SCSI bus. The SII chip together with the NCR 8310 SCSI transceiver chip combine the SII's SELIN and SELOUT lines into the SCSI SEL line.

[2]Signal assertion is the process of driving the signal to the true state (low), 0–.5V. Signal negation is the process of driving the signal to the false state (high), 2.5–5.5V.

(continued on next page)

Table 1–4 (Cont.) SCSI Bus Signals

Signal	Description
RST (RESET)	An OR-tied signal that indicates the reset condition. Only the Digital **host adapter** can assert reset.
DB(7–0,P) (DATA BUS)	Eight data-bit signals, plus a parity-bit signal, that form a data bus. DB(7) is the most significant bit and has the highest **priority** during the Arbitration phase. Bit number, significance, and priority decrease downward to DB(0).

A data bit is defined as **one** when the signal value is true and is defined as **zero** when the signal value is false. A device must generate odd parity during all information transfer phases in which the device writes data to the SCSI bus. The device must check for odd parity during all Information Transfer phases in which it reads data from the bus. Parity is undefined during the Arbitration phase.

1.6.1 Signal Values

ANSI SCSI-2 specification, Section 4.6.1.

Signals can assume true or false values during information transfer. When a value is true, the signal is driven true, or **asserted**. When a value is false, the non-OR-tied signals are driven false, or **negated**, and OR-tied signals are released.

In this guide, whenever the term negated is used, it means that the signal is actively driven false, or simply released at the option of the implementor.

The advantage of actively driving signals false during information transfer is that the transition from true to false occurs more quickly and the noise margin is much higher than if the signal is simply released; this facilitates reliable data transfer at high rates.

See the ANSI SCSI-2 specification for additional information.

1.6.2 Signal Sources

ANSI SCSI-2 specification, Section 4.6.3.

Figure 1–15 indicates which type of SCSI device (target or initiator) is allowed to source each signal. The figure does not show whether the source is driving asserted, driving negated, or passive. All SCSI **device driver**s that are not active sources must be in the passive state. The RST signal may be asserted by any SCSI device at any time.

Figure 1–15 Signal Sources

	A Cable Signals				
Bus Phase	BSY	SEL	C/D, I/O, MSG, REQ	ACK, ATN	DB(7-0) DB(P)
Bus Free	None	None	None	None	None
Arbitration	All	Win	None	None	S ID
Selection	I&T	Init	None	Init	Init
Reselection	I&T	Targ	Targ	Init	Targ
Command	Targ	None	Targ	Init	Init
Data in	Targ	None	Targ	Init	Targ
Data out	Targ	None	Targ	Init	Init
Status	Targ	None	Targ	Init	Targ
Message in	Targ	None	Targ	Init	Targ
Message out	Targ	None	Targ	Init	Init

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The following table describes the signal sources shown in Figure 1–15.

Source	Description
All	The signal must be driven by all SCSI devices that are actively arbitrating.
S ID	A unique data bit (the SCSI ID) must be driven by each SCSI device that is actively arbitrating; the other seven data bits must be released (that is, not driven) by this SCSI device. The parity bit, DB(P), may be undriven or driven to the true state, but must never be driven to the false state during this phase.
I&T	The signal must be driven by the initiator, target, or both, as specified in the Selection and Reselection phases.
Init	If driven, this signal must be driven only by the active initiator.
None	The signal must be released; that is, not be driven by any SCSI device. The bias circuitry of the bus terminators pulls the signal to the false state.
Win	The signal must be driven by the one SCSI device that wins arbitration.
Targ	If the signal is driven, it must be driven only by the active target.

1.7 SCSI Bus Timing

ANSI SCSI-2 specification, Section 4.7 through 4.7.16.

Unless otherwise indicated, you must calculate the delay-time measurement for each SCSI device from the signal conditions that exist at that SCSI device's SCSI bus connection. You can make these measurements (except Cable Skew delay) without considering delays in the cable. Table 1–5 describes the timing characteristics of each signal.

VMS

The device should not hold the bus ''busy'' in a single state before disconnecting for longer than the following periods of time:

- 500 µs is recommended for optimum system performance.
- 3 ms is required for performance reasons.

Table 1–5 SCSI Bus Timing Values

Signal Condition	Delay Time	Explanation
Arbitration delay	2.4 μs	The minimum time a SCSI device waits (from asserting BSY for arbitration to examining the data bus) to see if arbitration has been won. There is no maximum time.
Assertion period	90 ns	The minimum time that a target must assert REQ while using synchronous data transfers. Also, the minimum time that an initiator must assert ACK while using synchronous data transfers.
Bus Clear delay	800 ns	The maximum time for a SCSI device to stop driving all bus signals after: ■ The Bus Free phase is detected (the BSY and SEL signals are both false for a Bus Settle delay). ■ The SEL signal is received from another SCSI device during the Arbitration phase. ■ The transition of RST to true. The maximum time for a SCSI device to clear the bus is 1200 nanoseconds from the time BSY and SEL first both become false. If a SCSI device requires more than a Bus Settle delay to detect the Bus Free phase, it must clear the bus within a Bus Clear delay minus the excess time.
Bus Free delay	800 ns	The minimum time that a SCSI device must wait from its detection of the Bus Free phase (BSY and SEL both become false for a Bus Settle delay) until its assertion of BSY when going to the Arbitration phase.
Bus Set delay	1.8 μs	The maximum time for a SCSI device to assert BSY and its SCSI ID bit on the data bus after it detects the Bus Free phase (BSY and SEL both become false for a Bus Settle delay) for the purpose of entering the Arbitration phase.

(continued on next page)

Table 1–5 (Cont.) SCSI Bus Timing Values

Signal Condition	Delay Time	Explanation
Bus Settle delay	400 ns	The minimum time to wait for the bus to settle after changing certain control signals as called out in the protocol definitions.
Cable Skew delay	10 ns	The maximum difference in propagation time allowed between any two SCSI bus signals measured between any two SCSI devices.
Data Release delay	400 ns	The maximum time for an initiator to release the DATA BUS signals following the transition of the I/O signal from false to true.
Deskew delay	45 ns	The minimum time required for deskew of certain signals.
Disconnection delay	200 µs	The minimum time that a target must wait after releasing BSY before participating in an Arbitration phase when honoring a DISCONNECT message from the initiator.
Hold time	45 ns	The minimum time added between the assertion of REQ and the changing of the data lines to provide hold time in the initiator or target during synchronous data transfers.
Negation period	90 ns	The minimum time that a target must negate REQ during synchronous data transfers. Also, the minimum time that an initiator must negate ACK during synchronous data transfers.
Power-on to Selection time	15 sec recommended	The maximum time from power application until a SCSI target is able to respond with appropriate status and sense data to the TEST UNIT READY, INQUIRY, and REQUEST SENSE commands.
Reset to Selection time	250 ms recommended	The maximum time after a hard RESET condition until a SCSI target is able to respond with appropriate status and sense data to the TEST UNIT READY, INQUIRY, and REQUEST SENSE commands.
Reset Hold time	25 µs	The minimum time for which RST is asserted. There is no maximum time.

(continued on next page)

Table 1–5 (Cont.) SCSI Bus Timing Values

Signal Condition	Delay Time	Explanation
Selection Abort time	200 µs	The maximum time that a target (or initiator) may take from its most recent detection of being selected (or reselected), until asserting a BSY response. This time-out is required to ensure that a target (or initiator) does not assert BSY after a Selection (or Reselection) phase has been aborted. This is not the selection time-out period. See Section 2.1.3 and Section 2.1.4 for additional information.
Selection Time-out delay	250 ms minimum	The minimum time that an initiator (or target) must wait for a BSY response during the Selection (or Reselection) phase before starting the time-out procedure. Consult the peripheral device's specifications for actual timing requirements.
Transfer period	Set during an SDTR message	The minimum time allowed between the leading edges of successive REQ pulses and of successive ACK pulses during synchronous data transfers. (See Section 2.1.5 for additional information.)

2

Logical Characteristics

This chapter defines the logical characteristics of the SCSI bus in the following sections:

- SCSI bus phases, Section 2.1
- SCSI bus conditions, Section 2.2
- SCSI bus phase sequences, Section 2.3
- SCSI pointers, Section 2.4
- Message system, Section 2.5
- Messages, Section 2.6

2.1 SCSI Bus Phases

ANSI SCSI-2 specification, Section 5.1.

The SCSI architecture provides eight bus phases, as shown in Table 2–1:

Table 2–1 SCSI Bus Phases

Bus Phase	Description
	Bus control phases:
Bus Free	Indicates that no SCSI device is actively using the bus
Arbitration	Allows one SCSI device to gain control of the bus
Selection	Allows an initiator to select a target
Reselection	Allows the target to reconnect to an initiator
	Information transfer phases:
Command	Allows the target to request command information from the initiator
Data	Provides data transfer between the initiator and the target
Status	Provides status information from the target to the initiator
Message	Allows the transfer of messages between the initiator and the target

The SCSI bus is in only one phase at a time. Unless otherwise noted in the following sections, signals that are not mentioned are not asserted.

- Bus Free phase, Section 2.1.1
- Arbitration phase, Section 2.1.2
- Selection phase, Section 2.1.3
- Reselection phase, Section 2.1.4
- Information transfer phase, Section 2.1.5
- Command phase, Section 2.1.6
- Data phase, Section 2.1.7
- Status phase, Section 2.1.8
- Message phase, Section 2.1.9

The target must always wait for the initiator to act. The device should proceed quickly through all phases of a SCSI command, and should not hold the bus for long periods without **disconnecting**.

2.1.1 Bus Free Phase

ANSI SCSI-2 specification, Section 5.1.1.

The Bus Free phase indicates that a SCSI device is not actively using the SCSI bus and whether or not it is available for users. A target may revert to the Bus Free phase to indicate an error condition that it has no other way to handle. This is called an **unexpected disconnect**.

SCSI devices detect the Bus Free phase after the SEL and BSY signals are both false for at least a bus settle delay.

SCSI devices release all SCSI bus signals within a bus clear delay after BSY and SEL become continuously false for a bus settle delay. If a SCSI device requires more than a bus settle delay to detect the Bus Free phase, then it must release all SCSI bus signals within a bus clear delay minus the excess time to detect the Bus Free phase. The total time to clear the SCSI bus must not exceed a bus settle delay plus a bus clear delay.

The target must not drive any SCSI bus lines after the deassertion of BSY, except during selection or reselection, as outlined in the SCSI-2 specification.

2.1.2 Arbitration Phase

ANSI SCSI-2 specification, Section 5.1.2.

The Arbitration phase allows one SCSI device to gain control of the SCSI bus so that it can initiate or resume an **I/O process**. Implementation of the Arbitration phase is a requirement of the SCSI-2 specification.

2.1.3 Selection Phase

ANSI SCSI-2 specification, Section 5.1.3.

The Selection phase allows an initiator to select a target for the purpose of initiating some target function, for example, a READ or WRITE command.

Note *During the Selection phase the I/O signal is negated so that this phase can be distinguished from the Reselection phase.*

The SCSI device that won the arbitration has both BSY and SEL asserted and has delayed at least a bus clear delay plus a bus settle delay before ending the Arbitration phase. The SCSI device that won the arbitration becomes an initiator by not asserting the I/O signal.

2.1.4 Reselection Phase

ANSI SCSI-2 specification, Section 5.1.4 through 5.1.4.2.

Reselection is an optional phase that allows a target to **reconnect** to an initiator for the purpose of continuing some operation that was previously started by the initiator but was suspended by the target; that is, the target disconnected by allowing a Bus Free phase to occur before the operation was complete.

Upon completing the Arbitration phase, the winning SCSI device asserts both the BSY and SEL signals. The device delays at least a bus clear delay plus a bus settle delay before entering the Reselection phase. The winning SCSI device becomes a target by asserting the I/O signal.

When the host responds to a target reselection by asserting the BSY signal, the target deasserts the SEL signal within 500 microseconds of the BSY **signal assertion**. The target also asserts REQ for the first command or message byte within 500 microseconds of the BSY assertion.

When a device is disconnected from the bus, it must respond to a selection with ATN by entering the Message Out phase and accepting the message from the CPU. The device must be prepared to properly handle either the ABORT or the BUS DEVICE RESET message at this time.

If the initiator fails to respond to reselection, the device must time out the reselection attempt after 250 milliseconds as described in Section 5.1.4.2 of the SCSI-2 specification: Reselection Time-out Procedure. The device must employ the second option described in this section of the specification to release the bus; the device may not assert the RST signal.

After a Reselection time-out, the target should retry the host at least four times, but not more than ten times. If the device retries more than ten times, it can unnecessarily tie up the bus in an error condition. In order to prevent the retries from timing out other devices, the device should delay at least 20 microseconds between retry attempts.

2.1.5 Information Transfer Phases

ANSI SCSI-2 specification, Section 5.1.5.

The Command, Data, Status, and Message phases are grouped together as the Information Transfer phases because they are used to transfer data or control information on the data bus.

The C/D, I/O, and MSG signals are used to distinguish between the different Information Transfer phases (see Figure 2–1). The target drives these three signals and therefore controls all changes from one phase to another. The initiator requests a Message Out phase by asserting ATN; the target causes the Bus Free phase by releasing all SCSI signals.

Figure 2–1 Information Transfer Phases

Signal					
MSG	C/D	I/O	Phase Name	Direction of Transfer	Comment
0	0	0	Data Out	Initiator to Target	Data Phase
0	0	1	Data In	Initiator from Target	Data Phase
0	1	0	Command	Initiator to Target	
0	1	1	Status	Initiator from Target	
1	0	0	*		
1	0	1	*		
1	1	0	Message Out	Initiator to Target	Message Phase
1	1	1	Message In	Initiator from Target	Message Phase

Key:
0 = False
1 = True
* = Reserved for future standardization.

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Table 2–2 shows the modes of data transfer that are supported on Digital systems:

Table 2–2 Digital Systems and Associated Host Adapter

System	Host Adapter	Maximum Asynchronous Transfer Rate[1]	Maximum Synchronous Transfer Rate[1]
VAXstation 3100 and MicroVAX 3100	NCR 5380	1.5 MB/s	Not Implemented
DECstation 2100/3100	DEC SII	2 MB/s	4+ MB/s
VAXstation 3520/3540	DEC SII	2 MB/s	4+ MB/s

[1]Optimized rates are shown.

Note *Maximum asynchronous transfer rate is a function of cable length, number of devices, and device propagation delay. The fast synchronous transfer option is not supported on Digital systems.*

Asynchronous Information Transfer

ANSI SCSI-2 specification, Section 5.1.5.1.

The target controls the direction of information transfer by means of the I/O signal. When the I/O signal is true, information is transferred from the target to the initiator. When I/O is false, information is transferred from the initiator to the target.

Synchronous Data Transfer

ANSI SCSI-2 specification, Section 5.1.5.2.

Synchronous data transfer is optional. It is used only in Data phases. It must be used in a Data phase if a synchronous data transfer agreement has been established. The agreement specifies the REQ/ACK offset and the minimum transfer period.

2.1.6 Command Phase

ANSI SCSI-2 specification, Section 5.1.6.

The Command phase allows the target to request command information from the initiator.

The target asserts the C/D signal and negates the I/O and MSG signals during the REQ/ACK handshakes in this phase.

VMS

The device can enter the Command phase only once per command; for example, linked commands cannot be issued to the device.

2.1.7 Data Phase

ANSI SCSI-2 specification, Sections 5.1.7 through 5.1.7.2.

The Data phase is a term that encompasses both the Data In phase and the Data Out phase.

- Data In phase

  The Data In phase allows the target to request that data be sent to the initiator from the target.

  The target must assert the I/O signal and negate the C/D and MSG signals during the REQ/ACK handshakes of this phase.

- Data Out phase

  The Data Out phase allows the target to request that data be sent from the initiator to the target.

  The target must negate the C/D, I/O, and MSG signals during the REQ/ACK handshakes of this phase.

2.1.8 Status Phase

ANSI SCSI-2 specification, Section 5.1.8.

The Status phase allows the target to request that status information be sent from the target to the initiator.

The target must assert C/D and I/O and negate the MSG signal during the REQ/ACK handshake of this phase.

VMS

A device may enter the Status phase only once per command. The one exception is during an error condition when the device goes immediately to the Bus Free phase. Storage devices should not enter the Status phase following a WRITE command until the data is written to nonvolatile media, in order to avoid accidental loss of user data.

2.1.9 Message Phase

ANSI SCSI-2 specification, Section 5.1.9.

The Message phase is a term that references either a Message In or a Message Out phase. Multiple messages may be sent during either phase. The first byte transferred in either phase must be a single-byte message or the first byte of a multiple-byte message. Multiple-byte messages must be contained wholly within a single Message phase.

2.1.10 Signal Restrictions Between Phases

ANSI SCSI-2 specification, Section 5.1.10.

See the draft SCSI-2 specification for restrictions that apply to SCSI bus signals, when the SCSI bus is between two Information Transfer phases.

2.2 SCSI Bus Conditions

ANSI SCSI-2 specification, Section 5.2.

The SCSI bus has two asynchronous conditions:

- The Attention condition, Section 2.2.1
- The Reset condition, Section 2.2.2

These conditions cause the SCSI device to perform certain actions and alter the phase sequence.

Each SCSI device, as it is powered on, must perform appropriate internal reset operations and internal test operations. It is recommended that within 15 seconds of Power-on to Selection time, SCSI targets be able to respond with appropriate status and sense data to the TEST UNIT READY, INQUIRY, and REQUEST SENSE commands.

2.2.1 Attention Condition

ANSI SCSI-2 specification, Section 5.2.1.

The Attention (ATN) condition allows an initiator to inform a target that the initiator has a message ready. The target may get this message by performing a Message Out phase.

VMS

The device must respond to an ATN condition at every phase transition, as long as the VAX CPU running the VMS operating system sets the ATN signal before it asserts the ACK signal for the last byte of the previous phase. During the Data phase, the device should also respond to an ATN condition at least once per millisecond.

2.2.2 Reset Condition

ANSI SCSI-2 specification, Sections 5.2.2 and 5.2.2.1.

The Reset (RST) condition is used to immediately clear all SCSI devices from the bus. This condition takes precedence over all other phases and conditions. During the Reset condition, the state of all SCSI bus signals other than RST is not defined.

All SCSI devices must release all SCSI bus signals (except RST) within a bus clear delay of the transition of RST to true. The Bus Free phase always follows the Reset condition.

SCSI devices must implement a hard Reset as defined in the draft ANSI SCSI-2 specification. The device, upon detection of the Reset condition, performs the following:

- Clears all I/O processes including queued I/O processes.
- Releases all SCSI device reservations.
- Returns any SCSI device operating modes to their appropriate initial conditions, similar to those conditions that would be found after a normal Power-on Reset. Mode Select conditions must be restored to their last saved values if saved values have been established. Mode Select conditions for which no values have been saved must be returned to their default values.
- Sets the Unit Attention condition (see Section 3.8).

No peripheral device on the SCSI bus can assert Reset. Only the Digital host adapter can assert a Reset when appropriate.

If a data storage device receives a hard Reset condition, it must be able to complete writing the current block of data and not leave the medium in a corrupted state before responding to the hard Reset.

It is recommended that following a Reset to Selection Time after a hard Reset condition ends, SCSI targets be able to respond with appropriate status and sense data to the TEST UNIT READY, INQUIRY, and REQUEST SENSE commands.

2.3 SCSI Bus Phase Sequences

ANSI SCSI-2 specification, Section 5.3.

The order in which phases are used on the SCSI bus follows a prescribed sequence.

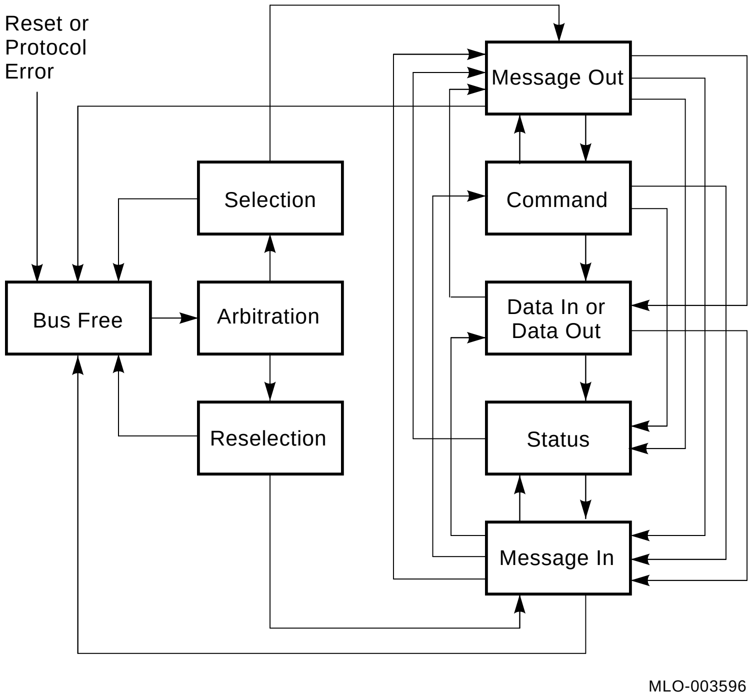
The Reset condition can abort any phase and is always followed by the Bus Free phase. Also, any other phase can be followed by the Bus Free phase, but many such instances indicate error conditions (see Section 2.1.1).

All devices must conform to the bus state transition sequences shown in Figure 2–2. The normal progression is as follows:

- From the Bus Free phase to Arbitration phase
- From Arbitration phase to Selection phase or Reselection phase
- From Selection phase or Reselection phase to one or more of the Information Transfer phases (Command, Data, Status, or Message)

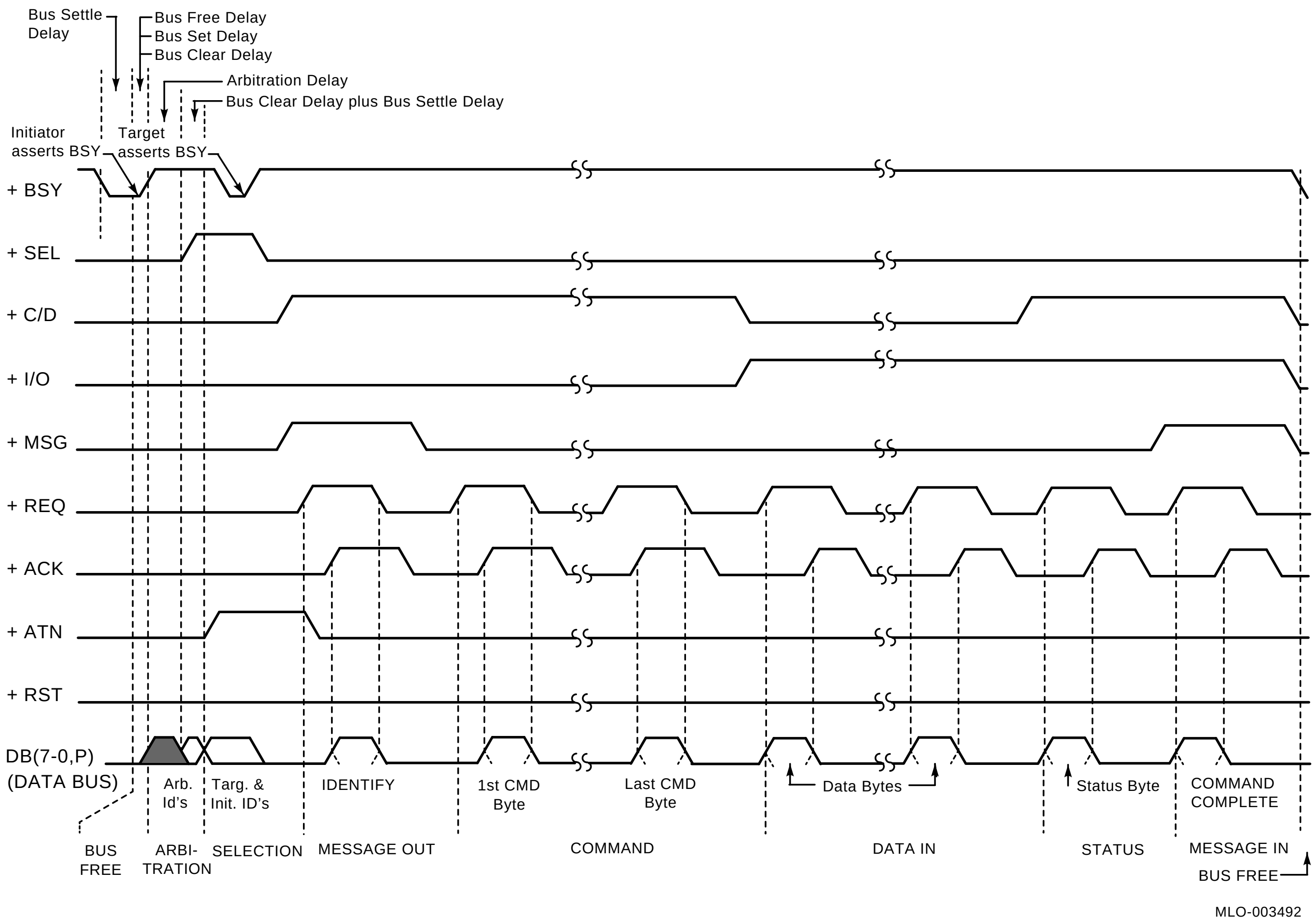
The final information transfer phase is normally the Message In phase in which a DISCONNECT and a COMMAND COMPLETE message is transferred, followed by the Bus Free phase.

Figure 2–2 SCSI Bus Phase Sequences



During the bus phases, devices must first contend for access to the bus. Then a physical path is established between the initiator and target. One way of viewing bus phase operation is by looking at a signal sequence diagram (Figure 2–3) for the INQUIRY command. Note that in this example the target does not disconnect from the SCSI bus before the **I/O process** has completed.

Figure 2–3 Sequence of Signals in an INQUIRY Command



Compare the bus phases for the INQUIRY command (Figure 2–3) with the following information:

- Bus Free Phase

  The **Bus Free** phase begins when the SEL and BSY signals are false for one Bus Settle delay.

- Arbitration Phase

  After the initiator sees that the bus is free, the BSY signal is **asserted**, the initiator arbitrates for the bus, and its assigned SCSI device ID is put on the data bus.

- Selection Phase

  During the Selection phase, the initiator asserts the ATN signal and tells the target that it wants to send a message.

- Message Out Phase

  The target enters the Message Out phase and the initiator sends a 1-**byte** message to enable reselection for the command. In Figure 2–3, the initiator sends an IDENTIFY message to the target.

- Command Phase

  The device enters the Command phase and the device controller sends the 6-byte command.

- Data In Phase

  During the Data In phase, the target requests a data transfer with the initiator. The device transfers the data. The device now determines what to do next.

- Status

  The device controller reads the (1-byte) Status code from the target device. The data transfer is from target to initiator.

- Message In Phase

  During the Message In phase, the target requests that the initiator take the 1-byte COMMAND COMPLETE message.

- Bus Free Phase

  The target device releases the BSY signal and returns to the Bus Free phase. The bus is now available.

2.4 SCSI Pointers

ANSI SCSI-2 specification, Section 5.4.

Consider the system shown in Figure 2–4 in which the initiator (the SCSI host adapter) and the target (the SCSI controller) communicate on the SCSI bus in order to execute an I/O process.

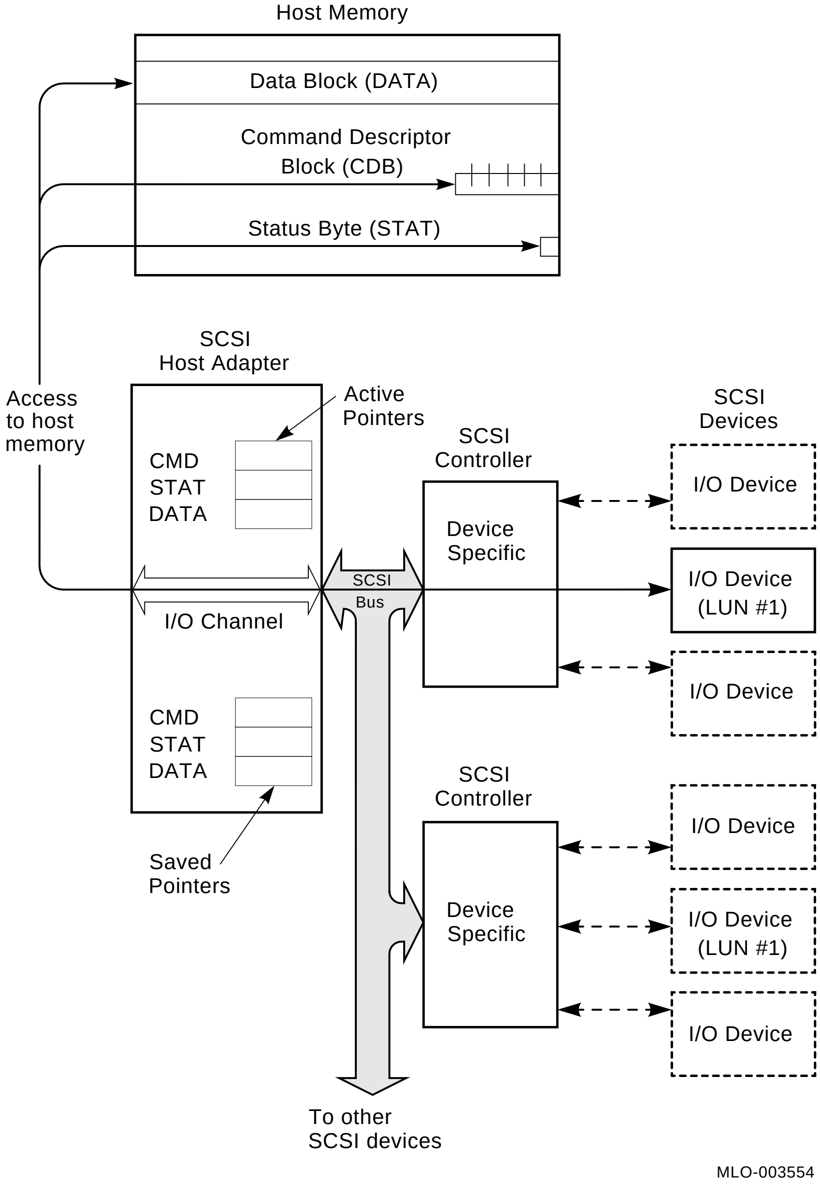
The SCSI architecture provides three pointers, called **saved pointers**, for each I/O process. One pointer is for the command (CMD), one is for the data (DATA), and one is for the status byte (STAT). When an I/O process becomes active, its three saved pointers are copied into the initiator's set of three active pointers. There is only one set of active pointers in each initiator. The active pointers point to the next command, data, or status byte to be transferred between the initiator's memory and the target. The saved and active pointers reside in the initiator.

- The Saved Command pointer always points to the start of the command descriptor block. (See Section 3.2 for a discussion of the I/O process.)
- The Saved Status pointer always points to the start of the status area for the I/O process.
- The Saved Data pointer points to the start of the data area until the target sends a SAVE DATA POINTER message for the I/O process.

In response to the SAVE DATA POINTER message, the initiator stores the value of the Active Data Pointer in the Saved Data Pointer for that I/O process. The target may restore the active pointers to the saved pointer values for the active I/O process by sending a RESTORE POINTERS message to the initiator (see Section 2.6.4). The initiator then copies the set of saved pointers into the set of active pointers. Whenever a target disconnects from the bus, only the set of saved pointers is retained. The set of active pointers is restored from the set of saved pointers upon reconnection of the I/O process.

Note *Since the data pointer value may be modified by the target before the I/O process ends, do not use it to test for actual transfer length.*

Figure 2–4 SCSI Pointers



VMS

The VMS operating system always performs an implicit RESTORE POINTERS message when the target reselects. The target should not use this message because it adds unnecessary overhead to the CPU at each I/O operation. Do not use the

RESTORE POINTERS message to restart the Command phase or Status phase.

2.5 SCSI Message System

ANSI SCSI-2 specification, Section 5.5.

The SCSI message system allows communication between an initiator and a target for the purpose of interface management. This section covers the following topics:

- Messages—Format and Codes, Section 2.5.1
- Messages—Implemented by the VMS Operating System, Section 2.5.2

A message may be one, two, or multiple bytes in length. One or more messages may be sent during a single Message phase, but a message may not be split over Message phases. The initiator is required to end the Message Out phase (by negating ATN) when it sends certain messages identified in Figure 2–5.

2.5.1 Messages—Format and Codes

One-byte, two-byte, and extended message formats are defined. The first byte of the message determines the format as follows:

Value	Message Format
00h	One-byte message (COMMAND COMPLETE)
01h	Extended messages
02h–1Fh	One-byte messages
20h–2Fh	Two-byte messages
30h–7Fh	Reserved for future standardization
80h–FFh	One-byte message (IDENTIFY)

One-byte messages consist of a single byte transferred during a Message phase. The value of the byte determines which message is to be defined. See Figure 2–5.

Note *Digital has designed its hardware and software so that it adheres to the SCSI-2 standard and yet provides as much flexibility as possible. To work with Digital's systems, third-party devices must implement all the mandatory features of the SCSI-2 interface. Third-party devices may implement optional features, as long as they are implemented according to the SCSI-2 specification. Devices may implement **vendor-specific** features as long as the features are implemented in areas clearly designated as such by the SCSI-2 specification.*

Figure 2–5 Message Codes

Code	VMS Implementation*	Support Init	Support Targ	Message Name	Message Direction	Negate ATN Before Last ACK
06h	A, C	O	M	ABORT	Out	Yes
0Dh	N	O	O	ABORT TAG	Out	Yes
0Ch	A	O	M	BUS DEVICE RESET	Out	Yes
0Eh	N	O	O	CLEAR QUEUE	Out	Yes
00h	A, C	M	M	COMMAND COMPLETE	In	–
04h	A	O	O	DISCONNECT	In	–
04h	N	O	O	DISCONNECT	Out	Yes
80h	A	M	O	IDENTIFY	In	–
80h	A	M	M	IDENTIFY	Out	No
24h	N	O	O	IGNORE WIDE RESIDUE (two bytes)	In	–
0Fh	N	O	O	INITIATE RECOVERY	In	–
0Fh	N	O	O	INITIATE RECOVERY (see note)	Out	Yes
05h	A	M	M	INITIATOR DETECTED ERROR	Out	Yes
0Ah	N	O	O	LINKED COMMAND COMPLETE	In	–
0Bh	N	O	O	LINKED COMMAND COMPLETE (with flag)	In	–
09h	A	M	M	MESSAGE PARITY ERROR	Out	Yes
07h	A	M	M	MESSAGE REJECT	In Out	Yes
***	N	O	O	MODIFY DATA POINTER	In	–
08h	A	M	M	NO OPERATION	Out	Yes
				Queue Tag Messages (two bytes)		
21h	N	O	O	HEAD OF QUEUE TAG	Out	No
22h	N	O	O	ORDERED QUEUE TAG	Out	No
20h	N	O	O	SIMPLE QUEUE TAG	In Out	No
10h	N	O	O	RELEASE RECOVERY	Out	Yes
03h	A, C	O	O	RESTORE POINTERS	In	–
02h	A, C	O	O	SAVE DATA POINTER	In	–
***	A**	O	O	SYNCHRONOUS DATA TRANSFER REQUEST	In Out	Yes
***	N	O	O	WIDE DATA TRANSFER REQUEST	In Out	Yes
11h	N	O	O	TERMINATE I/O PROCESS	Out	Yes
12h -1Fh				Reserved		
24h - 2Fh				Reserved for two-byte messages		
30h -7Fh				Reserved		

Note:
Outbound INITIATE RECOVERY messages are valid only during asynchronous event notification protocol.
The ABORT TAG and CLEAR QUEUE messages are required if tagged queuing is implemented.
* Use of messages other than those implemented by Digital may result in an error message.
** Implemented on the VAXstation 3520/3540.

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Table 2–3 describes the mnemonics used in Figure 2–5:

Table 2–3 Mnemonics Used in Figure 2–5

Mnemonic	Description[1]
A	Used by Digital as described in the draft ANSI SCSI-2 specification
C	Digital change to ANSI SCSI-2 specification
M	Mandatory support
N	Not implemented by Digital
O	Optional; implement according to the draft ANSI SCSI-2 specification
In	Target to initiator
Out	Initiator to target
Yes	Initiator must negate ATN before last acknowledgment (ACK) of message
No	Initiator may or may not negate ACK before last ACK of message (see Section 2.2.1)
–	Not applicable
***	Extended message (see Table 2–4 and Table 2–5)
80h+	Codes 80h through FFh are used for IDENTIFY messages

[1]Use of messages other than those implemented by Digital may result in an error message.

Two-byte messages consist of two consecutive bytes transferred during a Message phase. The value of the first byte determines which message is to be performed, as defined in Figure 2–5. The second byte is a **parameter** byte, which is used as defined in the message description (see Section 2.6).

A value of one in the first byte of a message indicates the beginning of a multiple-byte extended message. Extended messages send a minimum of three bytes. The extended message format and the extended message codes are shown in Table 2–4 and Table 2–5, respectively.

Table 2–4 Extended Message Format

Byte	Value	Description
0	01h	Extended message
1	n	Extended message length
2	y	Extended message code
3 to n+1	x	Extended message arguments

The extended message length specifies the length in bytes of the extended message code plus the extended message arguments to follow. Therefore, the total length of the message is equal to the extended message length plus two. A value of zero for the extended message length indicates that 128 bytes follow.

The extended message codes are listed in Table 2–5. The extended message arguments are specified within the extended message descriptions (see Section 2.6).

Table 2–5 Extended Message Codes

Code (y)	Description
02h	Reserved
00h	MODIFY DATA POINTER
01h	SYNCHRONOUS DATA TRANSFER REQUEST
03h	WIDE DATA TRANSFER REQUEST
04h–7Fh	Reserved
80h–FFh	Vendor unique

The first message sent by the initiator after the Selection phase must be the IDENTIFY, ABORT, or BUS DEVICE RESET message. If a target receives any other message, it must go to the Bus Free phase (see Section 2.1.1).

2.5.2 Messages—Implemented by the VMS Operating System

The VMS operating system accepts the following messages during the Message In phase. The target device must not generate any messages except the following:

- COMMAND COMPLETE
- DISCONNECT

- IDENTIFY
- RESTORE POINTERS
- MESSAGE REJECT
- SAVE DATA POINTER
- SYNCHRONOUS DATA TRANSFER REQUEST (implemented on the VAXstation 3520/3540 systems)

The VMS operating system generates the following messages, which the target must accept and process as described in the SCSI-2 standard.

- ABORT
- BUS DEVICE RESET
- IDENTIFY
- INITIATOR DETECTED ERROR
- MESSAGE PARITY ERROR
- MESSAGE REJECT
- NO OPERATION
- SYNCHRONOUS DATA TRANSFER REQUEST (VAXstation 3520/3540 systems only)

When a device selects the host for the purpose of performing an **asynchronous event notification** (AEN), the host accepts the following messages in addition to those stated above. When one of these messages is received, the VMS operating system notifies the third-party class driver of the received message.

- ABORT
- BUS DEVICE RESET
- INITIATOR DETECTED ERROR
- MESSAGE PARITY ERROR
- MESSAGE REJECT
- NO OPERATION

2.6 Messages

ANSI SCSI-2 specification, Section 5.6.

Table 2–6 lists the SCSI messages implemented by Digital. The following messages are described in this guide:

- ABORT, Section 2.6.1
- COMMAND COMPLETE, Section 2.6.2
- DISCONNECT, Section 2.6.3
- RESTORE POINTERS, Section 2.6.4
- SAVE DATA POINTER, Section 2.6.5

Table 2–6 SCSI Messages

Message[1]	Reference
ABORT	Section 2.6.1 of this guide
BUS DEVICE RESET	ANSI SCSI-2 spec, Section 5.6.3
COMMAND COMPLETE	Section 2.6.2 of this guide
DISCONNECT	ANSI SCSI-2 spec, Section 5.6.6
IDENTIFY	ANSI SCSI-2 spec, Section 5.6.7
INITIATOR DETECTED ERROR	ANSI SCSI-2 spec, Section 5.6.10
MESSAGE PARITY ERROR	ANSI SCSI-2 spec, Section 5.6.13
MESSAGE REJECT	ANSI SCSI-2 spec, Section 5.6.14
MODIFY DATA POINTER	ANSI SCSI-2 spec, Section 5.6.15
NO OPERATION	ANSI SCSI-2 spec, Section 5.6.16
RELEASE RECOVERY	ANSI SCSI-2 spec, Section 5.6.18
RESTORE POINTERS	Section 2.6.4 of this guide
SAVE DATA POINTER	Section 2.6.5 of this guide
SYNCHRONOUS DATA TRANSFER REQUEST	ANSI SCSI-2 spec, Section 5.6.21
TERMINATE I/O PROCESS	ANSI SCSI-2 spec, Section 5.6.22

[1]Use of messages other than those implemented by Digital may result in an error message.

2.6.1 ABORT

ANSI SCSI-2 specification, Section 5.6.1.

The ABORT message is sent from the initiator to the target to clear the present I/O process plus any queued I/O process for the **I_T_x nexus**. The target goes to the Bus Free phase following successful receipt of this message. Pending data, status, and queued I/O processes for any other I_T_x **nexus** are not cleared.

If only an **I_T nexus** is established, the target goes to the Bus Free phase. No status or message is sent for the I/O process and the I/O process queue is not affected.

No errors occur if the initiator issues this message to an I_T_x nexus that does not currently have an active or queued I/O process. Transmission of this message terminates any extended contingent allegiance condition that exists between the I_T_x nexus.

Note *The BUS DEVICE RESET and ABORT messages end one or more active I/O processes prior to normal termination. The BUS DEVICE RESET message ends all I/O processes for all initiators on all **logical units** of the target. The ABORT message clears all I/O processes for the selecting initiator on the specified logical unit or target routine of the target.*

VMS

On VMS systems, the ABORT message must be implemented as described in the SCSI-2 standard. When the target receives an ABORT, it must terminate the current operation. The device must stop in a manner that does not cause side effects. For example, no parity errors should be written to the media, and devices such as tape drives that store user data in nonvolatile memory must write the data back to nonvolatile media before honoring the ABORT. Following the ABORT, the device must use the recovery guidelines described in Chapter 5.

2.6.2 COMMAND COMPLETE

ANSI SCSI-2 specification, Section 5.6.5.

The COMMAND COMPLETE message is sent from a target to an initiator to indicate that the execution of a command of an I/O process has completed and that valid status has been sent to the initiator. After successfully sending this message, the target goes to the Bus Free phase by releasing a BSY signal. The target considers the message transmission to be successful when it detects the negation of ACK for the COMMAND COMPLETE message with the ATN signal false.

Note *The command executes successfully or unsuccessfully as indicated in the status.*

2.6.3 DISCONNECT

ANSI SCSI-2 specification, Section 5.6.6.

The DISCONNECT message is sent from the target to inform an initiator that the present connection is to be broken (the target plans to disconnect by releasing BSY) and that a later reconnect is required in order to complete the current I/O process.

This message must not cause the initiator to save the data pointer. After successfully sending this message, the target goes to the Bus Free phase by releasing the BSY signal after 10 microseconds. The target should consider the message transmission to be successful when it detects the negation of the ACK signal for the DISCONNECT message with the ATN signal false.

VMS

On VMS systems, the device may not hold the BSY signal for more than 10 microseconds after sending the COMMAND COMPLETE or DISCONNECT message.

2.6.4 RESTORE POINTERS

ANSI SCSI-2 specification, Section 5.6.19.

The RESTORE POINTERS message is sent from a target to direct the initiator to copy the most recently saved command, data, and status pointers for the I/O process to the corresponding active pointers. The command and status pointers are restored to the beginning of the present command and status areas. The data pointer is restored to the value at the beginning of the data area in the absence of a SAVE DATA POINTER message or to the value at the point at which the last SAVE DATA POINTER message occurred for that nexus.

VMS

The VMS operating system always performs an implicit RESTORE POINTERS when the target reselects. The target should not use this message because it adds unnecessary overhead to the CPU at each I/O operation. Note that the RESTORE POINTERS message cannot be used to retry the Command or Status phases. (See Section 2.4 for a definition of pointers.)

2.6.5 SAVE DATA POINTER

ANSI SCSI-2 specification, Section 5.6.20

The SAVE DATA POINTER message is sent from a target to direct the initiator to save a copy of the present active data pointer for the current nexus. (See Section 2.4 for a definition of pointers.)

VMS

The VMS operating system uses this message to save the context of an operation while a device is disconnected from the bus. However, the message is not necessary or useful when the target disconnects before data transfer begins. In this case, the target should not use the message because it adds unnecessary overhead to the CPU at each I/O operation. Once the device transfers data, it must issue the SAVE DATA POINTER message before disconnecting.

3

SCSI Commands and Status

This chapter defines and provides examples of the SCSI command and status structures in the following sections:

- Command implementation requirements, Section 3.1
- Command descriptor block, Section 3.2
- Status, Section 3.3
- Command processing exception conditions, Section 3.4
- Asynchronous event notification, Section 3.5
- Contingent allegiance condition, Section 3.6
- Extended contingent allegiance condition, Section 3.7
- Unit attention condition, Section 3.8

If you keep the functions essential to communicate by means of this protocol to a minimum, a wide range of peripheral devices can operate in the same environment. Because subsets of the full architecture may be implemented, optional functions are noted in the following sections.

3.1 Command Implementation Requirements

ANSI SCSI-2 specification, Section 6.1.

The first byte of all SCSI commands must contain an operation code as defined in this document. Three bits (bits 7–5 in the command descriptor block) of the second byte of each SCSI command specify the logical unit if it is not specified using the IDENTIFY message (see Section 2.5). The last byte of all SCSI commands must contain a control byte as defined in Section 3.2.7.

VMS

The VMS operating system allows commands up to 128 bytes in length. There are no restrictions on the size or type of commands that may be sent, as long as they conform to the SCSI-2 specification.

3.1.1 Reserved

ANSI SCSI-2 specification, Section 6.1.1.

Reserved bits, **fields**, bytes, and code values are set aside for future standardization. Their use and interpretation may be specified by future extensions to this specification. A reserved bit, field, or byte must be set to zero or in accordance with a future extension to this specification. See the ANSI SCSI-2 specification for additional information.

3.1.2 Operation Code Types

ANSI SCSI-2 specification, Section 6.1.2.

Table 3–1 describes the operation codes used in the first byte of a SCSI command.

Table 3–1 Operation Code Types

Opcode Type	Description
M (Mandatory)	These commands must be implemented in order to meet the minimum requirement of the SCSI-2 specification.
O (Optional)	Use optional commands in accordance with the SCSI-2 specification.
V (Vendor Specific)	Operation codes are unique to the vendor's product.
R (Reserved)	These operation codes must not be used. They are reserved for future extensions to the SCSI-2 specification.

3.2 Command Descriptor Block

ANSI SCSI-2 specification, Section 6.2

A command is communicated by sending a **command descriptor block (CDB)** to the target. For several commands, the request is accompanied by a list of parameters sent during the Data Out phase.

The CDB always has an operation code as the first byte of the command. This is followed by an optional logical unit number, command parameters (if any), and a control byte.

For all commands, if there is an invalid parameter in the CDB, then the target terminates the command without altering the medium. Figure 3–1 illustrates the command descriptor block for a 6-byte command.

Figure 3–1 CDB for Six-Byte Commands

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			(MSB)				
2	Logical Block Address (if required)							
3								(LSB)
4	Transfer Length (if required) Parameter List Length (if required) Allocation Length (if required)							
5	Control							

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Figure 3–2 illustrates the command descriptor block for a 10-byte command.

Figure 3–2 CDB for Ten-Byte Commands

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Reserved				
2	(MSB)							
3	Logical Block Address (if required)							
4								
5								(LSB)
6	Reserved							
7	(MSB) Transfer Length (if required)							
8	Parameter List Length (if required) Allocation Length (if required)							(LSB)
9	Control							

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The following sections explain the elements of the command descriptor block:

- Operation Code, Section 3.2.1
- Logical Unit Number, Section 3.2.2
- Logical Block Address, Section 3.2.3
- Transfer Length, Section 3.2.4
- Parameter List Length, Section 3.2.5
- Allocation Length, Section 3.2.6
- Control Byte, Section 3.2.7

3.2.1 Operation Code

ANSI SCSI-2 specification, Section 6.2.1.

The operation code of the command descriptor block has a group code field and a command code field (see Figure 3–3). The 3-bit group code field provides for eight groups of command codes. The 5-bit command code field provides for 32 command codes in each group. Thus, there are 256 possible operation codes. See the ANSI SCSI-2 specification for additional information.

The group code specifies one of the following groups:

- Group 0: Six-byte commands (see Figure 3–1)
- Group 1: Ten-byte commands (see Figure 3–2)
- Group 2: Not implemented
- Group 3: Reserved
- Group 4: Reserved
- Group 5: Not implemented
- Group 6: Vendor specific
- Group 7: Vendor specific

Figure 3–3 Operation Code

Bit	7	6	5	4	3	2	1	0
	Group Code			Command Code				

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3.2.2 Logical Unit Number

ANSI SCSI-2 specification, Section 6.2.2.

The device logical unit number (LUN) distinguishes between the multiple units attached to a single SCSI controller. Set the logical unit number to zero in the CDB.

Digital supports logical unit numbers in the range 0–7 and stores the logical unit number in the IDENTIFY message that is sent prior to every command. Digital does not support sub-LUNs. Sub-LUNs are a feature described in the SCSI-1 standard, but the SCSI-2 specification has eliminated them.

3.2.3 Logical Block Address

ANSI SCSI-2 specification, Section 6.2.3.

The logical block address on logical units or within a partition on device volumes must begin with block zero and must be contiguous up to the last logical block on that logical unit or within that partition.

A 6-byte command descriptor block contains a 21-bit logical block address. The 10-byte command descriptor block contains a 32-bit logical block address. Logical block addresses in additional parameter data have their length specified for each occurrence.

3.2.4 Transfer Length

ANSI SCSI-2 specification, Section 6.2.4.

The transfer length field specifies the amount of data to be transferred, usually the number of logical blocks. For several of the commands, the transfer length indicates the requested number of bytes to be sent as defined in the command description. For these commands, the transfer length field in the CDB may be identified by a different name.

Commands that use one byte for transfer length allow a maximum of 256 blocks of data to be transferred by one command. A transfer length value of 1 to 255 indicates the number of blocks that must be transferred. A value of zero indicates 256 blocks.

Commands that use multiple bytes for transfer length allow a maximum of 65,535 blocks of data to be transferred by one command. For these commands, a transfer length of zero indicates that no data transfer must take place. A value of one or greater indicates the number of blocks that must be transferred.

VMS

VAX based VMS systems use an intermediate buffer for all incoming and outgoing SCSI data. When the VMS operating system performs an I/O operation to a SCSI device, it allocates a portion of this buffer for the duration of the operation. Because VMS allows multiple concurrent I/O operations on the SCSI bus, it cannot allocate the full buffer to a single device. The following list shows the internal buffer size, the maximum data transfer size, and the recommended data transfer size on the supported VAX systems:

- The internal buffer size is 128 kilobytes on all supported systems.
- The maximum data transfer size is 64 kilobytes on all supported systems. If a device needs to transfer more than the maximum transfer size, it must be modified to allow the data to be returned across multiple SCSI commands. A single SCSI command cannot transfer more than the maximum size.

- For the best overall system throughput, the device should transfer only 16 kilobytes of data per SCSI command.

Note *The restrictions described above that apply to the transfer length field also apply to the parameter list length and allocation length fields.*

3.2.5 Parameter List Length

ANSI SCSI-2 specification, Section 6.2.5.

The parameter list length specifies the number of bytes sent during the Data Out phase. This field typically is used in command descriptor blocks for parameters that are sent to a target; for example, it is used with mode parameters, diagnostic parameters, and log parameters.

3.2.6 Allocation Length

ANSI SCSI-2 specification, Section 6.2.6.

The allocation length field specifies the maximum number of bytes that an initiator has allocated for returned data. An allocation length of zero indicates that no data must be transferred. This condition must not be considered an error. The target must terminate the Data In phase when allocation length bytes have been transferred or when all available data have been transferred to the initiator, whichever is less.

The allocation length is typically used to return sense data, for example, mode data, log data, and diagnostic data, to an initiator.

3.2.7 Control Byte

ANSI SCSI-2 specification, Section 6.2.7.

The control byte is the last byte of every command descriptor block. The control byte is illustrated in Figure 3–4.

Figure 3–4 Control Byte

Bit	7	6	5	4	3	2	1	0
	Vendor Specific		Reserved				Flag	Link

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Digital does not currently set the link, flag, and vendor-specific bits in the command descriptor block.

3.3 Status

ANSI SCSI-2 specification, Section 6.3.

A status byte must be sent from the target to the initiator during the Status phase at the completion of each command. Figure 3–5 illustrates the status byte.

Figure 3–5 Status Byte

Bit	7	6	5	4	3	2	1	0
	Reserved		Status Byte Code				Reserved	

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The contents of the SCSI status byte must conform to rules of the SCSI-2 specification. Otherwise, there are no restrictions on the use of this byte. Table 3–2 describes the status byte codes.

Table 3–2 Status Byte Codes

Status Code	Description
Good	The target has successfully completed the command.
Check Condition	Any error, exception, or abnormal condition that causes sense data to be set must cause a Check Condition status. The REQUEST SENSE command must be issued following a Check Condition status, to determine the nature of the condition.
Condition Met	The SEARCH DATA command returns this status whenever a search condition is satisfied. The logical block address of the logical block that satisfies the search may be determined with a REQUEST SENSE command. This status is also returned by the PRE-FETCH command when there is sufficient space in the cache memory for all of the addressed logical blocks.
Busy	The target is busy. This status is returned whenever a target is unable to process the command from an otherwise acceptable initiator (that is, there are no conflicting reservations). The recommended initiator recovery action is to issue the command again at a later time. The VMS operating system implements the status byte according to the SCSI-2 specification.
Intermediate	Linked commands are not implemented.
Reservation Conflict	This status is returned whenever a SCSI device attempts to access a logical unit or an extent within a logical unit that is reserved with a conflicting reservation type for another SCSI device. The recommended initiator recovery action is to issue the command again at a later time.
Queue Full	Tagged queuing is not implemented.

3.4 Command Processing Considerations and Exception Conditions

ANSI SCSI-2 specification, Section 6.5.

Sections 3.4.1 through 3.4.4 describe exception conditions and errors associated with command processing and the sequencing of commands.

3.4.1 Programmable Operating Definition

ANSI SCSI-2 specification, Section 6.5.1.

Special applications require that the operating definition of a logical unit be modified to meet the requirements of a particular initiator. Digital does not implement this feature. See the ANSI SCSI-2 specification for additional information.

3.4.2 Incorrect Initiator Connection

ANSI SCSI-2 specification, Section 6.5.2.

See the ANSI SCSI-2 specification for information.

3.4.3 Selection of an Invalid Logical Unit

ANSI SCSI-2 specification, Section 6.5.3.

The target's response to selection of an **invalid** logical unit is described in the following paragraphs:

The target does not support the logical unit (that is, some targets support the attachment of only one peripheral device).

- In response to an INQUIRY command the target must return the inquiry data with the peripheral qualifier set.
- In response to any other command except REQUEST SENSE the target must terminate the command with Check Condition status.
- In response to a REQUEST SENSE command the target must return sense data. The sense key must be set to Illegal Request and the additional sense code must be set to Invalid Logical Unit.

The target supports the logical unit, but the logical unit is not attached to the target.

- In response to an INQUIRY command the target must return the INQUIRY data with the peripheral qualifier set.

- In response to any other command except REQUEST SENSE the target must terminate the command with Check Condition status.
- In response to a REQUEST SENSE command the target must return sense data. The sense key must be set to Illegal Request and the additional sense code must be set to Invalid Logical Unit.

The target supports the logical unit and it is attached, but the peripheral device is not operational.

- In response to an INQUIRY command the target must return the INQUIRY data with the peripheral qualifier set. The target's response to any other command is defined in the device specification for that device.

The target supports the logical unit but is incapable of determining if the peripheral is attached or is not operational when it is not ready.

- In response to an INQUIRY command the target must return the INQUIRY data with the peripheral qualifier set.
- In response to a REQUEST SENSE command the target must return the request sense data with a sense key of No Sense unless a prior error condition exists. The target's response to any other command is defined in the device specification for that device.

3.4.4 Parameter Rounding

ANSI SCSI-2 specification, Section 6.5.4.

Certain parameters sent to a target with various commands contain a range of values. Targets may choose to implement only selected values from this range. When the target receives a value that it does not support, it either rejects the command (Check Condition status with Illegal Request Sense key) or it rounds the value received to a supported value. The target must reject unsupported values unless rounding is permitted in the description of the parameter. See the referenced ANSI SCSI-2 section for additional information.

3.5 Asynchronous Event Notification

ANSI SCSI-2 specification, Section 6.5.5.

Asynchronous event notification (AEN) is an optional protocol used to inform **processor** devices that an asynchronous event has occurred. The notification comes in the form of a SEND command directed to the processor device with a data block that includes device Request Sense information. Devices that respond to INQUIRY commands as a processor device type with asynchronous event notification capability may be notified of asynchronous events using this protocol. A SCSI device has to be capable of acting as an initiator in order to perform asynchronous event notification.

VMS

Normally, the VAX CPU running VMS is the only entity that may act as an initiator on the SCSI bus. However, the user's device is also permitted to act as an initiator, as long as it is for the purpose of selecting and sending a command to the VAX CPU. The device cannot select or issue a command to any other device on the bus.

The use of AEN is governed by the permissions fields in the Asynchronous Event Notification parameters MODE SELECT **page**.

AEN is used for four purposes in a SCSI system:

- To request that a device promptly inform a processor of an error condition encountered after command completion

  An example is a tape that implements write caching. Notification of an *unable to write condition* can be sent to the processor that initiated the write through the AEN protocol. An extended contingent allegiance condition may also establish the same I_T_L nexus used for the SEND command with an AEN bit of one.

- To permit a newly initialized device to inform all the processor devices on the bus of its availability

- To have a device inform processors of other unit attention conditions

  An example is a device that supports removable media. AEN may be used to report a *not ready to ready transition* (that is, the media changed) and also operator-initiated state changes such as write-protect switch and start/stop switch actuations.

- To have a device inform processors of other state changes that supply sense key 0h information

An example is a tape performing a REWIND command with the immediate bit set. Notification of *beginning of media reached* may be reported through the AEN protocol. In a similar manner, completion of a CDROM Audio Play operation started in the immediate mode may be reported through an AEN notification.

Although other uses of AEN are not prohibited, the AEN protocol is not intended to be used while an I_T_L nexus exists between the processor (initiator of the nexus) and the device.

Notification of an asynchronous event is performed using the SEND command with the AEN bit set to one. The information identifying the condition being reported must be returned during the Data In phase of the SEND command. The data sent beginning at byte 4 of the SEND command AEN data format must be the same as that which would have been returned to report the event in response to a REQUEST SENSE command.

An error or unit attention condition successfully reported using the AEN protocol must not also cause a Check Condition termination of a subsequent command. Similarly, if a Check Condition termination of a command from some processor is caused by an event, an AEN protocol notification must not be initiated to report the same event to that processor. An event may be reported with either the Check Condition/Request Sense protocol or with the AEN protocol, but must not be reported to the same processor with both.

AEN protocol notification of command related exception conditions must be sent only to the processor that initiated the operation.

Systems in which devices can become available independent of the rest of the system may use the AEN protocol to inform processors when they become ready. In this case the SEND command must transfer a Request Sense data block with the Unit Attention sense key. Successful delivery of a unit attention condition notification through the AEN protocol must clear the unit attention condition with respect to the receiving processor device.

A device that wishes to perform asynchronous event notification must conduct a survey to determine which devices respond to the processor/device type command set and have AEN capability. To conduct this survey, the device sends an INQUIRY command to logical unit zero (0) of each device that responds to selection. This survey must be conducted prior to the first AEN and must be repeated whenever the device becomes aware of a new device or the AEN capability state information may have become invalid.

After conducting the survey, the device verifies that each processor device with AEN capability is ready to receive asynchronous event notifications by issuing a TEST UNIT READY command. If a Check Condition status is returned, a REQUEST SENSE command is issued. This procedure clears any pending Unit Attention conditions. A processor device that reports AEN capability and responds to a TEST UNIT READY command with Good status must be ready to accept a SEND command with an AEN bit of one.

Note *A SCSI device that uses AEN at initialization time must provide a means to defeat these notifications. You can do this with a switch or jumper wire. Devices that implement saved parameters may alternatively save the AEN permissions either on an individual SCSI ID or systemwide option. In any case, a device must conduct a survey with INQUIRY commands to be sure that the devices on the SCSI bus are appropriate destinations for SEND commands with an AEN bit of one. (The devices on the bus or the SCSI ID assignments may have changed.)*

3.6 Contingent Allegiance Condition

ANSI SCSI-2 specification, Section 6.6.

The Contingent Allegiance condition exists following the return of a Check Condition or Command Terminated status and may optionally exist following an unexpected disconnect. The Contingent Allegiance condition is preserved for the I_T_x nexus until it is cleared. The Contingent Allegiance condition is cleared upon the generation of a hard Reset condition, by the receipt of an ABORT message, by a BUS DEVICE RESET message, or by any subsequent command for the I_T_x nexus, except a REQUEST SENSE command. The Contingent Allegiance condition is cleared following the return of the sense data for the I_T_x nexus. While the Contingent Allegiance condition exists, the target must preserve the sense data for the initiator.

3.7 Extended Contingent Allegiance Condition

VMS

The VMS operating system does not support the extended Contingent Allegiance condition. See the ANSI SCSI-2 specification, Section 6.7, for information.

3.8 Unit Attention Condition

ANSI SCSI-2 specification, Section 6.9

A Unit Attention condition begins for each initiator whenever the target is reset by a BUS DEVICE RESET message, a hard Reset condition, or by a power-on reset. See the ANSI SCSI-2 specification for information.

4

Characteristics of Most Device Types

This chapter describes the general characteristics expected of most SCSI devices. It provides the following information:

- A model for all device types, Section 4.1. See also the ANSI SCSI-2 specification, Section 7.1.
- Commands for all device types, Section 4.2. See also the ANSI SCSI-2 specification, Section 7.2.

For the parameters applicable for all device types, see the ANSI SCSI-2 specification, Section 7.3.

4.1 Model for Most Device Types

ANSI SCSI-2 specification, Section 7.1.

The model described in Section 4.1.1 and Section 4.1.2 provides information for most device types; it does not define any new requirements or alter any requirements defined in the ANSI SCSI-2 specification.

4.1.1 SCSI Addresses

ANSI SCSI-2 specification, Section 7.1.1.

There are two levels of addresses within the SCSI architecture: the SCSI device address and the logical unit number or target routine number.

SCSI Device Address

SCSI devices occupy (that is, respond to) one address on the SCSI bus. Generally the SCSI device provides switches or jumpers to select one of the eight available addresses (0–7). The address is used during bus arbitration and selection or reselection of SCSI devices. Each device on the SCSI bus is assigned a unique address.

Normally, the SCSI device address is set when the system is configured and it remains static thereafter. Some systems and devices provide vendor-specific means to alter this address.

Logical Units

Each target has one or more logical units, beginning with logical unit zero. Each target can have a maximum of eight logical units. These logical units are usually mapped directly to peripheral devices. The logical units may be a portion of a peripheral device or may comprise multiple peripheral devices.

An initiator can determine whether a target implements a logical unit by issuing an INQUIRY command and examining the returned peripheral qualifier and peripheral device type.

The concept of a logical unit is not defined for an initiator. (A SCSI device may implement both the initiator role and the target role. In such cases, logical units are defined only for the target role.)

Target Routines

An optional feature of the SCSI architecture permits each target to have one or more target routines, beginning with target routine zero. Implement this routine using the ANSI SCSI-2 specification.

There are a maximum of eight target routines. These target routines are processes that execute directly on the target; they are not associated with a particular logical unit or peripheral device. Target routines are addressed using the LUNTAR bit of the IDENTIFY message.

Target routines are principally intended to return information about the target. The only valid commands are INQUIRY and REQUEST SENSE.

4.1.2 Commands Implemented by SCSI Targets

ANSI SCSI-2 specification, Section 7.1.2.

This section describes five commands that SCSI targets implement: INQUIRY, RECEIVE DIAGNOSTIC RESULTS, REQUEST SENSE, SEND DIAGNOSTIC, and TEST UNIT READY. These commands are used to configure the system, to test targets, and to return important information concerning errors and exception conditions.

VMS

The VMS operating system allows commands of up to 128 bytes in length. There are no restrictions on the size or type of command that may be sent, as long as the commands conform to the SCSI-2 specification.

INQUIRY Command

ANSI SCSI-2 specification, section 7.2.5

A system may use the INQUIRY command to determine the configuration of the SCSI bus. Target devices respond with information that includes their type and standard level and may include the vendor's identification, model number, and other useful information. A SCSI device may take longer to get certain portions of this information, especially if it retrieves the information from the medium.

RECEIVE DIAGNOSTIC RESULTS Command

ANSI SCSI-2 specification, Section 7.2.13.

The RECEIVE DIAGNOSTIC RESULTS command requests that analytical data be sent to the initiator after completion of a SEND DIAGNOSTIC command. If the target supports the optional page format, the page code field in the SEND DIAGNOSTIC command specifies the format of the returned data.

- To ensure that the diagnostic command information is not destroyed by a command sent from another initiator, the SEND DIAGNOSTIC command must either be linked to the RECEIVE DIAGNOSTIC RESULTS command or the logical unit must be reserved.
- Although diagnostic software is generally device-specific, this command and the SEND DIAGNOSTIC command provide a means to isolate the operating system software from the device-specific diagnostic software. Hence the operating system can remain device-independent. These commands allow diagnostic software to be transferred more easily to other operating systems.

REQUEST SENSE Command

ANSI SCSI-2 specification, section 7.2.14

Whenever a Contingent Allegiance condition is established (see Section 3.6), the initiator that received the error must issue a REQUEST SENSE command to receive the sense data describing what caused the Contingent Allegiance condition. If the initiator issues some other command, the sense data is lost.

SEND DIAGNOSTIC Command

ANSI SCSI-2 specification, section 7.2.15

The SEND DIAGNOSTIC command provides a means to request the target to perform a self-test. While the test is target-specific, the means of requesting the test is standardized and the response is Good status if all is well or Check Condition status if the test fails.

The SEND DIAGNOSTIC command also provides other powerful features when used in conjunction with the RECEIVE DIAGNOSTIC RESULTS command, but this capability is optional.

All SCSI devices should implement the **Common Command Set** commands and messages as described in Chapter 2 and Chapter 3 of this guide.

All fields in the INQUIRY command packet must be properly filled.

Device-dependent diagnostics should be implemented as follows:

- Developers should implement two levels of the SCSI SEND DIAGNOSTIC commands.
  - Device SCSI controller test.

    The SlfTST bit should be set in the SEND DIAGNOSTIC command packet. The preferred execution time is less than 1 second.
  - Specific media access tests.

    The SlfTst and UnitOffline bits should be set in the SEND DIAGNOSTIC command packet. The preferred execution time is less than 60 seconds.
- Developers should implement the RECEIVE DIAGNOSTIC commands with information that permits field replaceable unit (FRU) isolation (95 percent fault detection, 90 percent isolation to FRU) within the device.

Note *Vendor-specific commands (that is, commands not found in Digital documentation or the ANSI SCSI-2 specification) cannot be tested.*

TEST UNIT READY Command

ANSI SCSI-2 specification, section 7.2.16

The TEST UNIT READY command allows an initiator to poll a logical unit until it is ready without the need to allocate space for returned data. It is especially useful for checking the cartridge status of logical units with removable media. Targets are expected to respond promptly to indicate the current status of the device (that is, a target must avoid lengthy disconnections in an attempt to respond with Good status).

4.2 Commands for Most Device Types

ANSI SCSI-2 specification, Section 7.2.

Table 4–1 lists the operation codes for commands that apply to most device types.

Table 4–1 Commands for Most Device Types

Command Name	Operation Code	Type	ANSI SCSI-2 Specification Section
CHANGE DEFINITION	40h	O	7.2.1
COMPARE	39h	O	7.2.2
COPY	18h	O	7.2.3
COPY AND VERIFY	3Ah	O	7.2.4
INQUIRY	12h	M	7.2.5
MODE SELECT(6)	15h	Z	7.2.8
MODE SENSE(6)	1Ah	Z	7.2.10
READ BUFFER	3Ch	O	7.2.12
READ CAPACITY	25h	M	8.2.7
RECEIVE DIAGNOSTIC RESULTS	1Ch	Z	7.2.13
REQUEST SENSE	03h	M	7.2.14
SEND DIAGNOSTIC	1Dh	M	7.2.15
START/STOP UNIT	18h	O	8.2.17
TEST UNIT READY	00h	M	7.2.16
WRITE BUFFER	3Bh	O	7.2.17

Key

M—Mandatory command implementation. All commands must be implemented according to the ANSI SCSI-2 specification.
O—Optional command implementation. All commands should be implemented according to the ANSI SCSI-2 specification.
Z—Device-type specific command implementation.

5

Power-On Protocols and Initialization Procedures

ANSI SCSI-2 specification, Appendix F.

This chapter describes Digital's requirements for system initialization of SCSI devices. These requirements must be implemented in addition to the requirements listed in the ANSI SCSI-2 specification.

The topics are organized as follows:

- Dynamic Reconfiguration of Devices, Section 5.1
- External Boxes, Section 5.2
- Device Behavior Following Power-On, Section 5.3
- Device Behavior Following Bus Reset, Section 5.4

5.1 Dynamic Reconfiguration of Devices

Devices on the SCSI bus may not be added to the bus, removed from the bus, or re-cabled while the operating system is running.

Caution *Failure to meet this requirement may cause loss of user data or system failure.*

5.2 External Boxes

Devices that reside outside the main system box should remain powered on at all times while the system is in operation.

- Some powered-off SCSI devices fail to present high impedance to the SCSI bus, leaving the bus useless.
- A powered-off device can reduce the terminator power on the bus to unacceptable levels, causing corruption of user data or system failure.
- The device can spike various SCSI bus signals during power-on or power-off, leading to corruption of user data or system failure.

Note *Many users disregard warnings and cycle the power on external boxes while the system is running, because it often seems to work. Digital recommends that devices be designed to minimize this possibility and that external devices remain powered on at all times during system operation. Powering off devices can lead to data loss and hardware failure.*

5.3 Device Behavior Following Power-On

The device must meet the following requirements after it is powered on.

- Within 5 seconds of power-on, the device must be able to respond to a SCSI bus selection so that the VMS operating system knows that there is an active device at this SCSI ID. However, the device is permitted to return any of the following errors until it is ready for normal operation:
  - Busy status.
  - Check Condition status, followed by Not Ready sense key in response to the next REQUEST SENSE command.
  - Check Condition status, followed by Unit Attention sense key in response to the next REQUEST SENSE command. (Note that Unit Attention may be returned only once per power-up/bus reset, as described in the SCSI-2 specification.)
- Within 15 seconds of power-on, the device must be able to successfully complete an INQUIRY command so that the device can be identified.
- The VMS operating system does not specify a timeout value by which devices must respond to normal commands following power-on, because this value is determined by the user-written **class driver.**

5.4 Device Behavior Following Bus Reset

A SCSI bus reset may cause some devices such as tape drives to lose user data. Therefore, only the CPU can set the SCSI RST signal, and then only as a last resort. The device is prohibited from setting the SCSI RST signal. The device must behave as follows after a SCSI bus reset, except when the reset occurs as the result of power-on.

- The device must be able to respond to a SCSI bus selection within 5 seconds of the bus reset. However, the device is permitted to return one of the following once it begins to accept bus selections:
  - Busy status.
  - Check Condition status followed by Not Ready sense key in response to the next REQUEST SENSE command.
  - CHECK CONDITION status, followed by Unit Attention sense key in response to the next REQUEST SENSE command. (Note that Unit Attention may be returned only once per power-up/bus reset, as described in the SCSI-2 specification.)

  The device may not return any other status values or sense keys unless it is ready for normal operation.
- The device must be able to respond to normal commands within 10 seconds of the bus reset.

The device must be able to handle multiple bus resets in succession, with no ill effects. The device must recover within the time limits specified above, following the last bus reset.

A

Associated Documents

The manuals associated with Digital's implementation of the Small Computer System Interface (SCSI) are listed below.

- *American National Standard for Information Systems— Small Computer System Interface-2 (SCSI-2)*, X3T9.2/89-042 specification

  The SCSI-2 specification (Revision 10b) is a draft of a proposed standard. Copies of the draft document may be purchased from Global Engineering Documents, 2805 McGaw, Irvine, CA 92714, (800) 854-7179 or (714) 261-1455. Refer to document X3.131-198X.

- *American National Standard for Information Systems—Small Computer System Interface (SCSI)*, X3.131-1986 specification

  The document can be ordered from the American National Standards Institute, Inc., 1430 Broadway, New York, NY, 10018. This document is known as the SCSI-1 standard.

- *Small Computer System Interface: An Overview*, Order No. EK–SCSIS–OV

  Provides an overview of Digital's implementation of the SCSI-2 requirements. (Available on compact disc.)

  This document can be ordered from Digital Equipment Corporation, P. O. Box CS2008, Nashua, NH 03061. For an internal order, write Publishing and Circulation Services (P&CS), NRO3-1/W3, Digital Equipment Corporation, Northboro, MA 01532.

- *VMS Version 5.3 Small Computer System Interface (SCSI) Device Support Manual*, Order No. AA–PAJ2A–TE

Describes the mechanisms the VMS operating system provides that allow a SCSI device that is not supplied by Digital to be attached to certain VAXstation and MicroVAX systems.

This document can be ordered from Digital Equipment Corporation, P. O. Box CS2008, Nashua, NH 03061. For an internal order, write the Software Supply Business (SSB), Digital Equipment Corporation, Westminster, MA 01473.

- *VMS Device Support Manual*

  Describes the components of a VMS device driver and the basic rules to which device drivers not supplied by Digital must adhere.

- *VMS I/O User's Reference Manual*

  Contains information necessary to issue I/O requests from an application program to I/O device drivers supplied as part of the VMS operating system.

- *VMS System Dump Analyzer Utility Manual*

  Provides assistance in investigating system failures.

- *VMS Delta/XDelta Utility Manual*

  Provides information on debugging VMS device driver code.

- *VAX MACRO and Instruction Set Reference Manual*

  Describes the VAX MACRO assembly language. VMS device drivers are written in VAX MACRO.

- *VMS System Services Reference Manual*

  Describes the high-level language interface to the I/O subsystem of the VMS operating system.

- *IEZ11 Software Installation Guide*,
  Order No. AA–PA9DA–TE

- *IEZ11 User's Guide*, Order No. AA–NU45A–TE

- *IEZ11 Hardware Installation Guide*,
  Order No. AA–PA9EA–TE

For additional information, refer to:

NCR Corporation. *SCSI: Understanding Small Computers*. Englewood Cliffs, N.J.: Prentice-Hall, 1990.

B

ANSI SCSI-2 Specification Cross-Reference

Table B–1 is a cross-reference to the draft ANSI SCSI-2 specification. Use the table to find the Digital information in this manual associated with a numbered SCSI-2 specification section.

Table B–1 Cross-Reference to ANSI SCSI-2 Specification

ANSI SCSI-2 Specification	Subject	Where to Look In This Guide
Section 4.1	Physical Description	Section 1.1
Secton 4.2	Cable Requirements	Section 1.2
Section 4.2.1	Single-Ended Cable	Section 1.2
Section 4.3	Connector Requirements	Section 1.3
Section 4.4	Electrical Description	Section 1.4
Section 4.4.1	Single-Ended Signals	Section 1.4.1
Section 4.4.3	Terminator Power	Section 1.4.2
Section 4.4.4	Reserved Lines	Section 1.4.4
Section 4.5	SCSI Bus	Section 1.5
Section 4.6	SCSI Bus Signals	Table 1–4
Section 4.6.1	Signal Values	Section 1.6.1
Section 4.6.1	Signal Sources	Section 1.6.2
Section 4.7	SCSI Bus Timing	Table 1–5
Section 5.1	SCSI Bus Phases	Section 2.1

(continued on next page)

Table B–1 (Cont.) Cross-Reference to ANSI SCSI-2 Specification

ANSI SCSI-2 Specification	Subject	Where to Look In This Guide
Section 5.1.1	Bus Free Phase	Section 2.1.1
Section 5.1.2	Arbitration Phase	Section 2.1.2
Section 5.1.3	Selection Phase	Section 2.1.3
Section 5.1.4	Reselection Phase	Section 2.1.4
Section 5.1.5	Information Transfer Phases	Section 2.1.5
Section 5.1.6	Command Phase	Section 2.1.6
Section 5.1.7	Data Phase	Section 2.1.7
Section 5.1.8	Status Phase	Section 2.1.8
Section 5.1.9	Message Phase	Section 2.1.9
Section 5.1.10	Signal Restrictions Between Phases	Section 2.1.10
Section 5.2	SCSI Bus Conditions	Section 2.2
Section 5.2.1	Attention Condition	Section 2.2.1
Section 5.2.2	Reset Condition	Section 2.2.2
Section 5.3	SCSI Bus Phase Sequences	Section 2.3
Section 5.4	SCSI Pointers	Section 2.4
Section 5.5	SCSI Message System	Section 2.5
Section 5.6	Messages	Section 2.6
Section 5.6.1	ABORT Message	Section 2.6.1
Section 5.6.5	COMMAND COMPLETE Message	Section 2.6.2
Section 5.6.6	DISCONNECT Message	Section 2.6.3
Section 5.6.19	RESTORE POINTERS Message	Section 2.6.4
Section 5.6.20	SAVE DATA POINTER Message	Section 2.6.5
Section 6.1	Command Implementation Requirements	Section 3.1
Section 6.1.1	Reserved	Section 3.1.1
Section 6.1.2	Operation Code Types	Section 3.1.2
Section 6.2	Command Descriptor Block	Section 3.2
Section 6.2.1	Operation Code	Section 3.2.1
Section 6.2.2	Logical Unit Number	Section 3.2.2
Section 6.2.3	Logical Block Address	Section 3.2.3

(continued on next page)

Table B–1 (Cont.) Cross-Reference to ANSI SCSI-2 Specification

ANSI SCSI-2 Specification	Subject	Where to Look In This Guide
Section 6.2.4	Transfer Length	Section 3.2.4
Section 6.2.5	Parameter List Length	Section 3.2.5
Section 6.2.6	Allocation Length	Section 3.2.6
Section 6.2.7	Control Byte	Section 3.2.7
Section 6.3	Status	Section 3.3
Secton 6.5	Command Processing Considerations and Exception Conditions	Section 3.4
Section 6.5.1	Programmable Operating Definition	Section 3.4.1
Section 6.5.2	Incorrect Initiator Connection	Section 3.4.2
Section 6.5.3	Selection of an Invalid Logical Unit	Section 3.4.3
Section 6.5.4	Parameter Rounding	Section 3.4.4
Section 6.5.5	Asynchronous Event Notification	Section 3.5
Section 6.6	Contingent Allegiance Condition	Section 3.6
Section 6.7	Extended Contingent Allegiance Condition	Section 3.7
Section 6.9	Unit Attention Condition	Section 3.8
Section 7.1	Model for All Device Types	Section 4.1
Section 7.1.1	SCSI Addresses	Section 4.1.1
Section 7.1.2	Commands Implemented by All SCSI Devices	Section 4.1.2
Section 7.2	Commands for All Device Types	Section 4.2
Appendix F	Power-On Protocols and Initialization Procedures	Chapter 5

Glossary

ANSI

American National Standards Institute.

arbitrate

To select one device from several devices that are seeking access to the SCSI bus concurrently.

assertion

The process of driving a signal low, to the true state (0 V–0.5 V).

asynchronous event notification (AEN)

A SCSI protocol that allows a SCSI device (usually a target) to inform the processor (usually the initiator) that an event has occurred asynchronously with respect to the processor's current stream of execution.

AWG

American Wire Gauge.

bus

A flat or twisted-pair cable composed of individual identical circuits. A computer's SCSI port and SCSI peripheral devices can be installed anywhere along the cable.

bus free

No SCSI device is actively using the bus; therefore, the bus is available for use.

byte

A binary character string made up of eight bits.

central processing unit (CPU)

The part of the computer system that controls the interpretation and execution of instructions.

CISC

Complex Instruction Set Computer.

class driver

A component of the SCSI class/port architecture that acts as an interface between the user and the SCSI port. In the VMS implementation, the SCSI class driver translates I/O functions as specified in a user's $QIO request to a SCSI command targeted to a device on the SCSI bus.

Common Command Set (CCS)

A subset of eighteen commands in the SCSI command set. CCS is a proposal before the ANSI X3T9.2 subcommittee.

command descriptor block (CDB)

The structure used to communicate requests from an initiator to a target.

connect

The function that occurs when an initiator selects a target to start an operation. A connection can only occur between an initiator and a target.

contact

The electrically conductive portion of a connector associated with a single conductor in a cable.

controller

A computer module that interprets signals between the host and a peripheral device.

CPU

See **central processing unit**.

device

The general name for any unit connected to the system that is capable of receiving, storing, or transmitting data. *See also* **controller**.

device driver

A set of routines and tables that the system uses to process an I/O request for a particular device type.

disconnect

The action that occurs when a SCSI device releases control of the SCSI bus, allowing it to go to the Bus Free phase.

DMA

Direct Memory Access.

field

A group of one or more contiguous bits. Fields containing only one bit are usually referred to as the xx bit instead of the xx field.

EMC

Electromagnetic compatibility.

ESD

Electrostatic discharge.

host adapter

A device that connects a host system to the SCSI bus. The device usually performs the lower layers of the SCSI protocol and normally operates as an initiator. This function may be integrated into the host system.

initial connection

A connection that exists from the assertion of the BSY signal in a Selection phase until the next Bus Free phase occurs.

initiator

A SCSI device (usually a host system) that requests an operation to be performed by another SCSI device (a target).

invalid

Illegal (reserved) or unsupported. Refers to an illegal or unsupported bit, field, or code value.

I/O process

A process consisting of one initial connection and zero or more reconnections, all pertaining to a single command. An active I/O process is presently in execution. The current I/O process is the one that is presently connected on the SCSI bus. I/O connections pertain to a nexus in which one or more command descriptor blocks are usually transferred. An I/O process begins with the establishment of a nexus, and normally ends with the Bus Free phase following the successful transfer of a COMMAND COMPLETE, a RELEASE RECOVERY, or an ABORT message. An I/O process also ends when a hard Reset condition occurs, an unexpected Bus Free phase occurs, or when the Bus Free phase occurs following a BUS DEVICE RESET message.

I_T nexus

A nexus that exists between an initiator and a target.

I_T_x nexus

A nexus that is either an I_T_L or I_T_R nexus.

interrupt priority level (IPL)

The level at which a software or hardware interrupt is generated on a VAX system. There are 32 interrupt priority levels: IPL 0 is the lowest, 31 is the highest. The levels arbitrate contention for processor service. For example, a device cannot interrupt a processor if the processor is currently executing at an IPL greater than the IPL of the device's interrupt request.

logical unit

A physical or virtual peripheral device that is addressable through a target.

logical unit number (LUN)

An encoded 3-bit identifier for the logical unit.

LSB

Least significant byte.

LUN

See **logical unit number**.

MSB

Most significant byte.

negation

The process of driving a signal high, to the false state (2.5 V–5.5 V). The cable terminators bias the signal by placing the driver in a high impedance condition.

nexus

The point at which an initial connection is established and that ends with the completion of the I/O process. A nexus may specify a single logical unit or target routine by the successful transfer of an IDENTIFY message.

OEM

Original Equipment Manufacturer.

one

A true signal value.

open system

A vendor-neutral computing environment that is compliant with international standards, permits system and network interoperability or software applications portability, including consistency of data and human access, and satisfies one or more of a business's functional requirements.

page

Parameter structures used by several commands. Pages are identified with a value known as a page code.

parameter

A structure that contains one or more fields.

peripheral device

A physical device that can be attached to a SCSI device, which in turn connects to the SCSI bus. It provides the CPU with additional memory storage or communications capability. Examples of peripheral devices are: magnetic disks, printers, optical disks, and magnetic tapes.

port

See **SCSI port**

port driver

A component of the VMS SCSI class/port architecture that transmits and receives SCSI commands and data. It knows the details of transmitting data from the local processor's SCSI port hardware across the SCSI bus.

priority

The ranking of devices on the bus during arbitration.

processor

A functional section of hardware in a computer that changes instructions into a form the computer understands, and executes these instructions.

reconnect

The act of reviving a nexus to continue an I/O process. A target reconnects to an initiator by using the Reselection and Message In phases after winning arbitration. An initiator reconnects to a target by using the Selection and Message Out phases after winning arbitration.

reserved

The term used for bits, fields, and code values that are set aside for future standardization.

RISC

Reduced Instruction Set Computer.

saved pointers

A tracking process in which one pointer is for the command, one pointer is for the data, and one pointer is for the status.

SCSI

An interface designed for connecting peripheral devices to computer systems. SCSI is defined by an American National Standards Institute (ANSI) standard; in this guide, SCSI refers to either SCSI-1 or SCSI-2.

SCSI-1

ANSI Small Computer System Interface (X3.131–1986).

SCSI-2

Proposed ANSI Small Computer System Interface-2 (X3.131–198x).

SCSI device

A host computer adapter, a peripheral controller, or intelligent peripheral that can be attached to the SCSI bus.

SCSI device address

The octal representation of the unique address (7–0) assigned to a SCSI device. This address is normally assigned and set in the SCSI device during system installation.

SCSI device ID

The bit-significant representation of the SCSI address referring to one of the signal lines DB(7–0).

VMS systems: Typically, both the MicroVAX 3100 and VAXstation 3100 systems are assigned device ID 6 and assert at DB(6); the VAXstation 3520/3540 CPU is assigned device ID 7 and asserts at DB(7).

ULTRIX systems: The VAXstation 3100, VAXstation 3520/3540, DECstation 2100 and 3100 systems, as well as the DECsystem 3100, are assigned device ID 6, and the ULTRIX kernel asserts at DB(7). ULTRIX customers can reconfigure the SCSI ID to their needs.

SCSI port

Software: the channel that controls communications to and from a specific SCSI bus in the system. Hardware: The name of the logical socket at the back of the system unit to which a SCSI device is connected.

signal release

The act of allowing the cable terminators to bias the signal to the false state by placing the driver in the high impedance condition.

SII

System Interface Interconnect, a SCSI controller chip.

status

One byte of information sent from a target to an initiator upon completion of each command.

System Interface Interconnect

A gate array developed by Digital that manages the SCSI bus and the following activities: SCSI bus selection, bus to memory transfers, and DISCONNECT and RECONNECT commands.

target

A SCSI device that performs an operation requested by an initiator.

unexpected disconnect

A disconnection that occurs as a result of a protocol error.

vendor-specific

A term that refers to bits, fields, or code values that are not defined in this guide, and that may be used in a different way in vendor implementations.

zero

A false signal value.

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