Seagate

Elite Disc Drive

ST43401N/ND

ST43402ND

Reference Manual

Contents

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December 1994

Preface

This is a reference manual for users of Seagate® ST43401N/ND and ST43402ND Elite™ disc drives employing the SCSI interface. It supplements the information presented in the user's manual (publication 83327720). It is intended to aid engineers who design subsystems using the drive and customer engineers who install and check out the drive. This manual should be used in conjunction with the user's manual.

Electrostatic discharge protection

Caution. Removal of circuit boards by personnel not performing depot repair will damage components and may void the warranty.

All drive electronic assemblies are sensitive to static electricity due to the electrostatically sensitive devices used within the drive circuitry. Although some devices such as metal-oxide semiconductors are extremely sensitive, all semiconductors, as well as some resistors and capacitors, may be damaged or degraded by exposure to static electricity.

Electrostatic damage to electronic devices may be caused by the direct discharge of a charged conductor, or by exposure to the static fields surrounding charged objects. To avoid damaging drive electronic assemblies, service personnel must observe the following precautions when servicing the drive:

- Ground yourself to the drive whenever the drive electronics are or will be exposed. Connect yourself to ground with a wrist strap (Seagate part number 12263496). Connection may be made to any grounded metal assembly. As a general rule, remember that you and the drive electronics must all be grounded to avoid potentially damaging static discharges.
- Turn off power before removing or installing the DC power cable.
- Do not remove any circuit boards from the drive.
- Never use an ohmmeter on any circuit boards.

Important safety information and precautions

Caution. Use forced-air ventilation when bench-testing the drive to ensure proper cooling of drive components.

Use proper safety and repair techniques for safe, reliable operation of this unit. Service should be done only by qualified persons. We recommend the procedures in this manual as effective ways of servicing the unit. Some procedures require the use of special tools. For proper maintenance and safety, you must use these tools as recommended.

The procedures in this manual contain warnings and cautions that must be carefully read and followed to minimize or eliminate the risk of personal injury. The warnings point out conditions or practices that may endanger you or others. The cautions point out conditions or practices that may damage the unit, possibly making it unsafe for use.

You must also understand that these warnings and cautions are not exhaustive. We cannot possibly know, evaluate, and advise you of all the ways in which maintenance might be performed or the possible risk of each technique. Consequently, we have not completed any such broad evaluation. If you use a non-approved procedure or tool, first ensure that the method you choose will not risk either your safety or unit performance.

Always observe the following warnings and precautions:

- Perform all maintenance by following the procedures in this manual.
- Follow all cautions and warnings in the procedures.
- Use sound safety practices when operating or repairing the unit.
- Use caution when troubleshooting a unit that has voltages present. Remove power from the unit before servicing it.
- Wear safety shoes when removing or replacing heavy parts.
- Ensure that the internal temperature of the rack or cabinet will not exceed the limits defined for the drive when the drive is mounted in an equipment rack or cabinet. When units are stacked vertically, pay special attention to the top where temperatures are usually highest.
- Follow the precautions listed under “Electrostatic discharge protection” above.

- Do not remove any circuit boards from the drive chassis. Return the entire drive for depot repair if any circuit board is defective. Removal of circuit boards by personnel not performing depot repair will damage components and may void the warranty.
- Do not remove the head and disc assembly (HDA) from the drive chassis. Return the entire drive for depot repair if the HDA is defective.
- Do not attempt to disassemble the HDA. It is not field repairable. If the sealed HDA is opened by personnel not performing depot repair, this will damage components and void the warranty.
- As a component, this drive is designed to be installed and operated in accordance with UL1950, IEC950, EN60950, CSA C22.2 950, and VDE0805. Refer to Section 2 for information about installation.
- Ensure that the power supply meets the specifications in this manual and is designed to be used in accordance with UL1950, IEC950, EN60950, CSA C22.2 950, and VDE0805.

Seagate takes all reasonable steps to ensure that its products are certifiable to currently accepted standards. Typical applications of these disc drives include customer packaging and subsystem design. Safety agencies conditionally certify component assemblies, such as the Elite disc drive, based on their final acceptability in the end-use product. The subsystem designers are responsible for meeting these conditions of acceptability in obtaining safety/regulatory agency compliance in their end-use products and in certifying where required by law. A necessary part of meeting safety requirements is the provision for overcurrent protection on drive SELV supply voltages.

This unit is a component part and as such is not meant to comply with FCC or similar national requirements as a stand-alone unit. Engineering radiated and conducted emissions test results are available through the Seagate Safety Department to assist the subsystem designer.

Technical support services

Seagate Technology provides technical support literature and diagnostic utilities to authorized distributors. Please contact your dealer for technical support and installation troubleshooting. Product technical support is available for all Seagate products by calling the SeaFAX™, SeaFONE™, SeaTDD™, or SeaBOARD™ services. These are toll calls if you dial from outside of the number's local dialing area.

SeaFAX:
USA (408) 438-2620; England 44-62-847-7080
Use a touch-tone telephone to access Seagate's automated FAX system and select technical support information by return FAX. This service is available 24 hours a day, 7 days a week.

SeaFONE: (408) 438-8222
Technical support specialists are available from 8:00 A.M. to 5:00 P.M. PST, Monday through Friday. Recorded technical information for selected Seagate products is accessible 24 hours a day, 7 days a week.

SeaTDD: (408) 438-5382
TDD is a telecommunication device for the deaf where two people can communicate using a keyboard connected to the phone line. A TDD device is required to access this service, which is available from 8:00 A.M. to 5:00 P.M. PST, Monday through Friday.

SeaBOARD:
The Seagate Technical Support Bulletin Board System (BBS) is available 24 hours a day, 7 days a week. A modem is required to access this service. The communications software must be set for 8 data bits, no parity, and 1 stop bit (8N1). All BBS numbers operate at 9600 baud max. With this service you can access:

- Specifications and jumper configurations for Seagate products
- Reprints of Seagate documentation
- A directory of information and helpful utilities that you can download to your computer

Location	Telephone number
USA, Mexico, Latin America	(408) 438-8771
England	44-62-847-8011
Germany	49-89-140-9331
Singapore	65-292-6973
Australia	61-2-756-2359
Canada	(416) 856-5581
France	33-1-40-67-1034
Korea	82-2-556-7294

Section 1. General maintenance information

This section contains general information relating to maintenance of the drive. You should be familiar with the information in this section and with drive operation before attempting any maintenance procedures. Information is divided into the following areas:

- Maintenance tools and materials—lists the tools and materials required to perform maintenance on the drive
- Testing the drive—provides information concerning testing drive electronics, including a procedure for checking DC voltages supplied to the drive
- Identifying assemblies in the drive—identifies the various parts of the drive

Note. Refer to the user's manual (publication 83327720) for information about arranging for depot repair, removing and replacing a drive or power supply, and packing a drive for shipment.

Maintenance tools and materials

The procedures described in this section require the use of certain special tools, test equipment, and materials. These are listed below along with the Seagate part number. Note that the list includes only special tools. We assume that you have normal maintenance tools.

Description	Seagate part number
Static ground wrist strap 6 1/2 to 8 inch wrist	12263496
Volt/ohmmeter	Ballantine 345 or equivalent digital voltmeter

Testing the drive

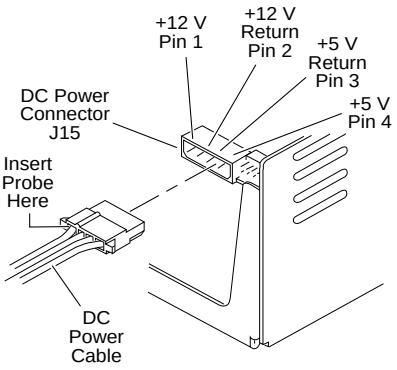
During testing and troubleshooting, the drive normally performs various operations such as reading and writing test data. System software can be used to control the drive during these operations. Refer to manuals or other documentation applicable to the specific system or subsystem for information concerning the system software routines.

The drive also has built-in diagnostic tests. These diagnostic tests may be performed through the interface as described in Section 3.

The following procedure provides an overall check of the DC voltages used by the drive. Before performing this procedure, you should be familiar with the other information in this section and the safety information in the preface.

The illustration to the right shows where the individual voltages appear on the drive's DC power connector (J15).

Insert your test probe into the contact openings on the back surface of the 4-pin DC cable connector.



1. Using system software, command continuous read/write operations with the drive on a single cylinder.
2. Connect the voltmeter ground lead to J15 - Pin 3 (+5 V Return [Ground]).
3. Measure at the appropriate connection point to check the following voltages:

Voltage	Connection	Specification
+5.0 volts	J15 - Pin 4	+4.75 to +5.25 volts
+12 volts	J15 - Pin 1	+11.4 to +12.6 volts

Identifying assemblies in the drive

The drive's major assemblies and components are shown in Figures 1 and 2. The components are supported by a chassis, and the head and disc assembly (HDA) is supported by shock mounts attached to the chassis. The control board is mounted above the HDA. The power board has a right-angle connection to one end of the control board. An optional bezel is available.

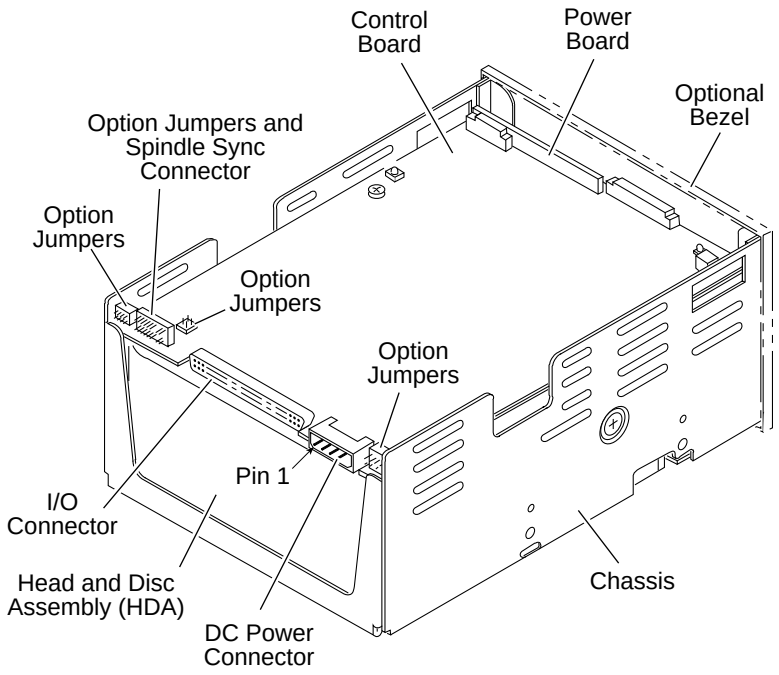


Figure 1. ST43401N/ND drive components

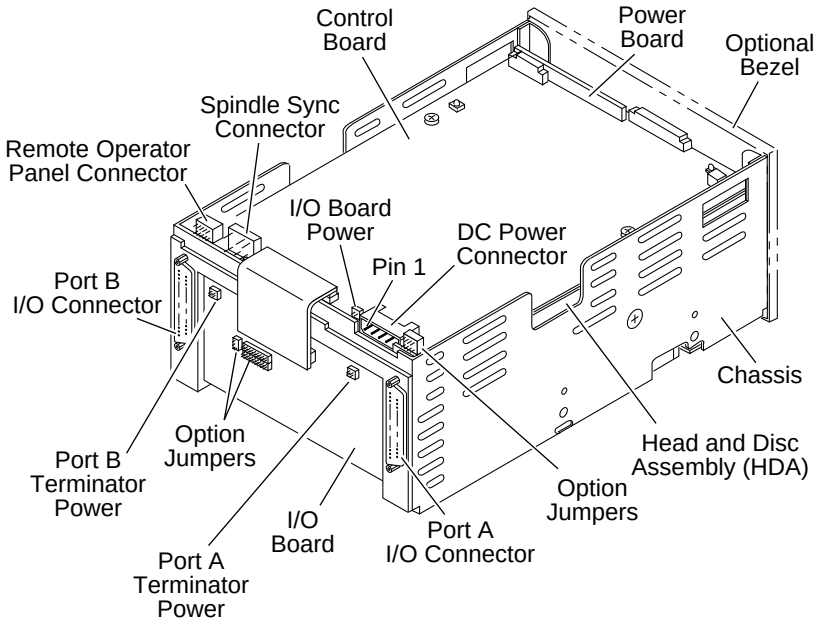


Figure 2. ST43402ND drive components

Section 2. Planning the system

This section supplements the installation instructions presented in the user's manual (publication 83327720). To aid in configuring the drive for specific system requirements, the following subjects are discussed:

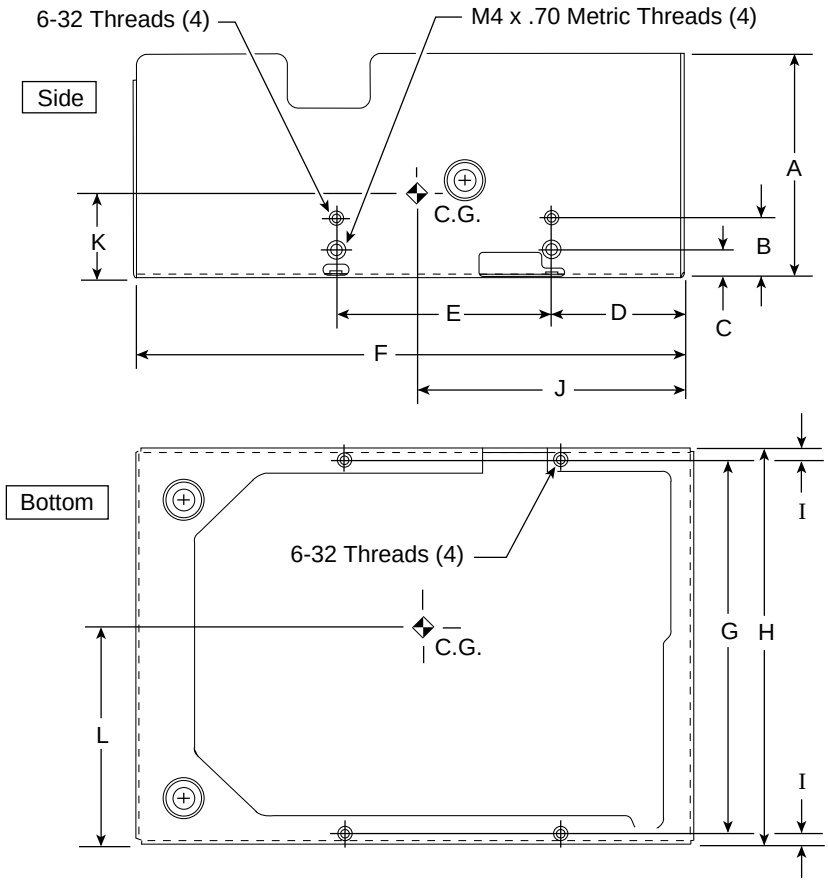
- Guidelines for enclosure design
- Guidelines for proper air flow
- Guidelines for I/O cabling
- Using the sweep cycle function

Guidelines for enclosure design

The drive is a component for installation in an enclosure that you have designed. The enclosure design must provide for mounting the drive and power supply, cable routing, and cooling. See the next topic for guidelines on providing proper cooling.

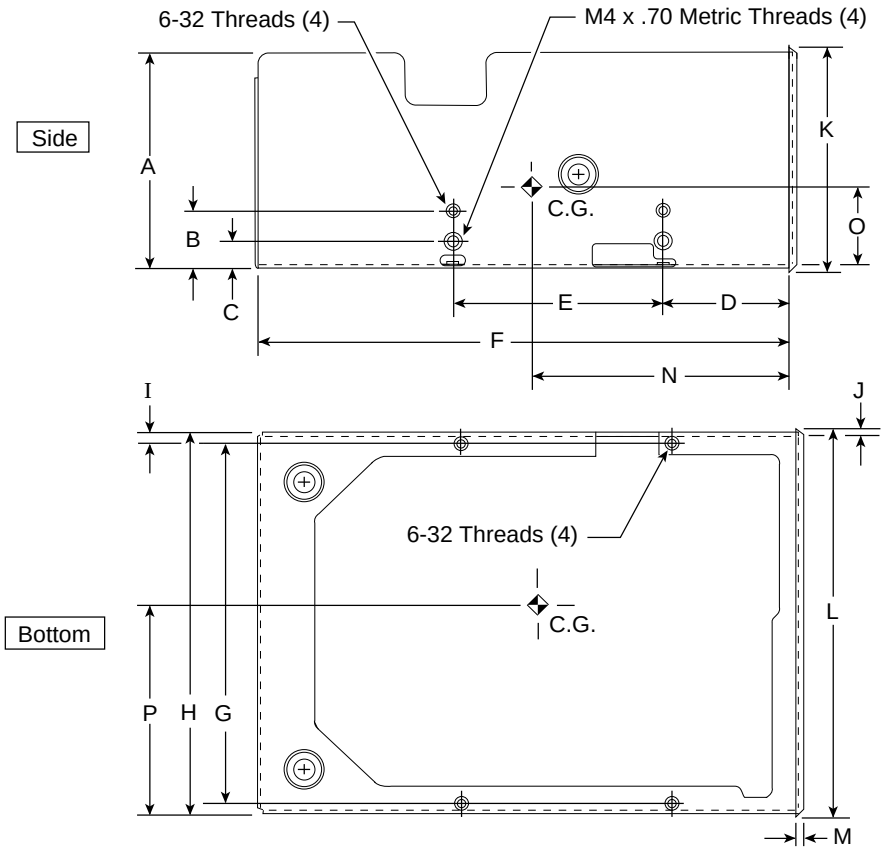
The system designer is responsible for obtaining any needed agency approvals such as UL, CSA, and VDE.

Figure 3 provides mounting dimensions for ST43401N/ND and ST43402ND drives without a bezel. Figure 4 provides the same information for ST43401N/ND drives with the optional bezel attached. As described in the user's manual, the drive can be mounted using either side-mounting screws or bottom-mounting screws.



	in			mm
A	3.25	±	0.01	82.55
B	0.86	±	0.01	21.84
C	0.39	±	0.01	9.91
D	1.93	±	0.01	49.02
E	3.120	±	0.005	79.25
F	8.60	±	0.03	218.44
G	5.50	±	0.01	139.70
H	5.75	±	0.01	146.05
I	0.12	±	0.01	3.05
J	3.96	±	0.05	100.58
K	1.58	±	0.05	40.13
L	3.13	±	0.05	79.50

Figure 3. Mounting dimensions for ST43401N/ND and ST43402ND drives without a bezel



	in	mm
A	3.25 ± 0.01	82.55
B	0.86 ± 0.01	21.84
C	0.39 ± 0.01	9.91
D	1.87 ± 0.02	47.50
E	3.120 ± 0.005	79.24
F	8.00 max	203.20
G	5.50 ± 0.01	139.70

	in	mm
H	5.75 ± 0.01	146.05
I	0.12 ± 0.01	3.05
J	0.06 ± 0.02	1.52
K	3.38 ± 0.02	85.85
L	5.88 ± 0.01	149.35
M	0.19 ± 0.01	4.83
N	3.90 ± 0.05	99.06
O	1.58 ± 0.05	40.13
P	3.13 ± 0.05	79.50

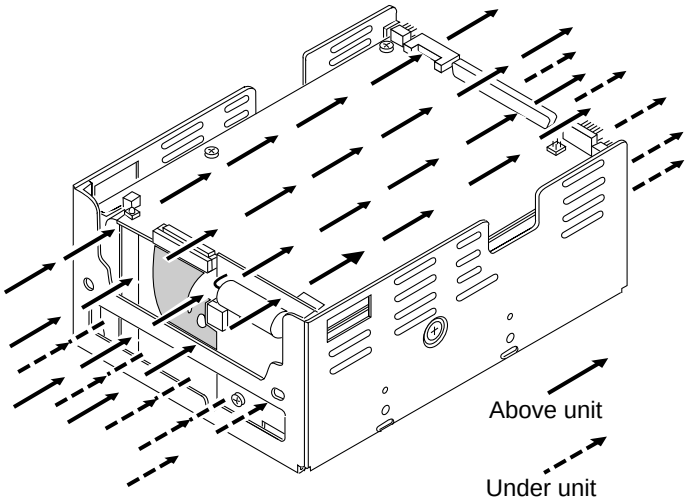
Figure 4. Mounting dimensions for ST43401N/ND with a bezel

Guidelines for proper air flow

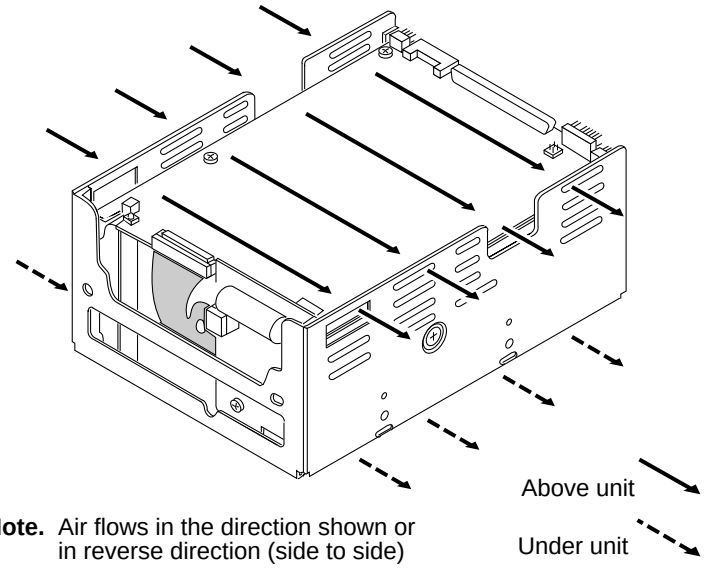
Your enclosure design must ensure adequate cooling for the drive.

We recommend orienting the drive or directing the air flow in a way that creates the least amount of air-flow resistance while providing air flow above the circuit boards and around the head and disc assembly (HDA). Also, choose the shortest possible path between the air inlet and exit. This minimizes the distance traveled by air that is heated by the drive and by other nearby heat sources.

Figure 5 shows the design approach with one or more fans installed. The air-flow patterns can be created by the fans either pushing or drawing air. The overall flow pattern can be directed from front to back, back to front, or side to side.



Note. Air flows in the direction shown (front to back) or in reverse direction (back to front)



Note. Air flows in the direction shown or in reverse direction (side to side)

Figure 5. Suggested air flow

To evaluate the air-flow design, place the drive in its final mechanical position and perform random read and write operations. After the temperatures stabilize, measure the surface (case) temperatures of the components listed in the appropriate table below. The mean time between failures (MTBF) values assume that the drive operates below the specified reliability guidelines.

Table 1. ST43401N/ND air-flow evaluation

Card	Component	Reference	Office environment MTBF 200k hours case temp*	Computer room MTBF 300k hours case temp*	Max allowable case temp*
S/RYFX	PERI-2	D540	45	35	60
S/RYFX	Video AMP	F826	55	45	70
S/RYFX	RDS	G115	55	45	70
S/RYFX	ECLTTL	D212	47	37	62
S/RYFX	SCRAM	C051	44	34	59
S/RYFX	DRAM	B405	42	32	57
FYEX	Motor control	U10(A211)	51	41	66
HDA housing		Figure 6			60

*Temperature in ^{o}C

Table 2. ST43402ND air-flow evaluation

Card	Component	Reference	Office environment MTBF 200k hours case temp*	Computer room MTBF 300k hours case temp*	Max allowable case temp*
AYGX	PERI-2	U40 (D540)	45	35	60
AYGX	Video AMP	U44 (F826)	52	42	67
AYGX	RDS	U56 (G115)	56	46	71
AYGX	ECLTTL	U33 (D709)	46	36	61
AYGX	SCRAM	U6 (B145)	45	35	60
AYGX	Driver	U26 (B107)	45	35	60
FYEX	Motor control	U10 (A211)	49	39	64
BYGX	ECLTTL	U7 (D417)	52	42	67
HDA housing		Figure 6			60

*Temperature in ^{o}C

Guidelines for I/O cabling

This topic provides recommendations for I/O cabling and lists the parts that can be used in various cables. There are three general cabling schemes, as illustrated in the following figures:

- Figure 7 describes how to design cables when the initiator and all the drives are located in one cabinet
- Figure 8 describes how to design cables when the initiator is located in one cabinet and all the drives are located in another cabinet
- Figure 9 describes how to design cables when the initiators and drives are distributed within three cabinets

Refer to the appropriate figure to determine the types of components required for your installation. All three figures show how drives inside a cabinet are connected by continuous unshielded I/O cables that have a connector for each drive. In some cases, these internal cables connect to a bulkhead that allows external shielded cables to be connected. Shielded cables must be used if the cables run between cabinets.

Cumulative cable length in a daisy-chain system cannot exceed 25.0m (82.0 ft) for drives using differential I/O. With single-ended I/O, cumulative cable length cannot exceed 3.05m (10.0 ft).

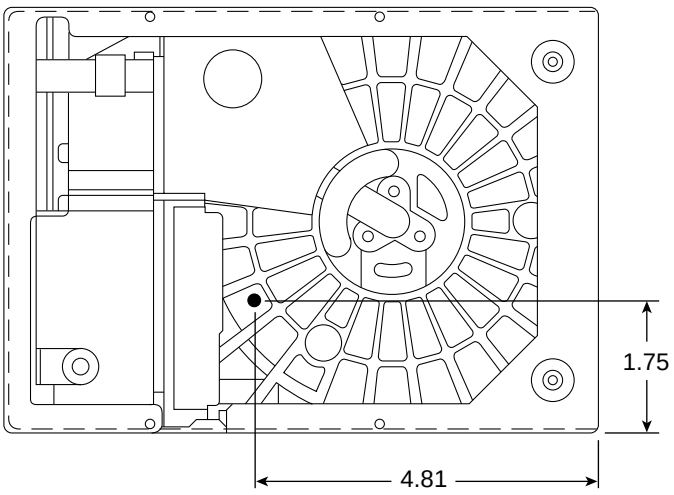
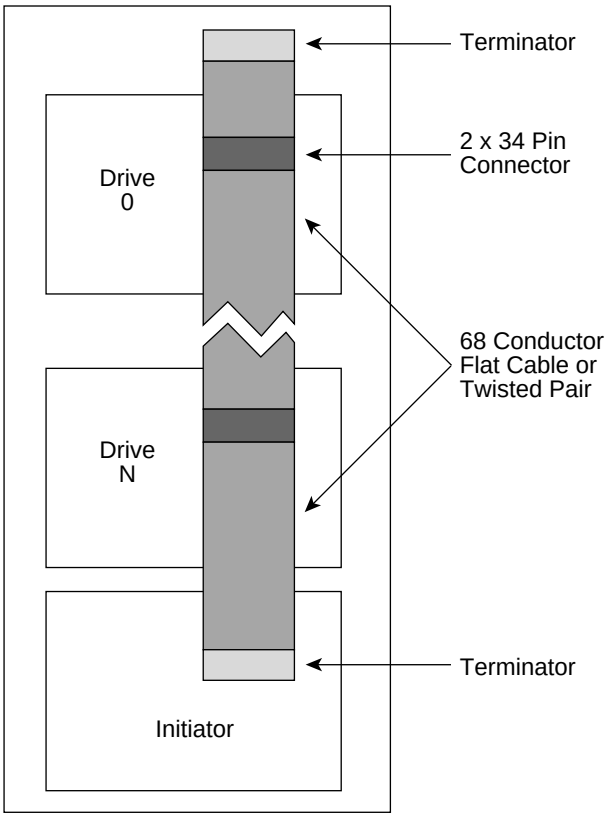


Figure 6. Temperature measurement location on the HDA (bottom)

Drives and initiator in one cabinet

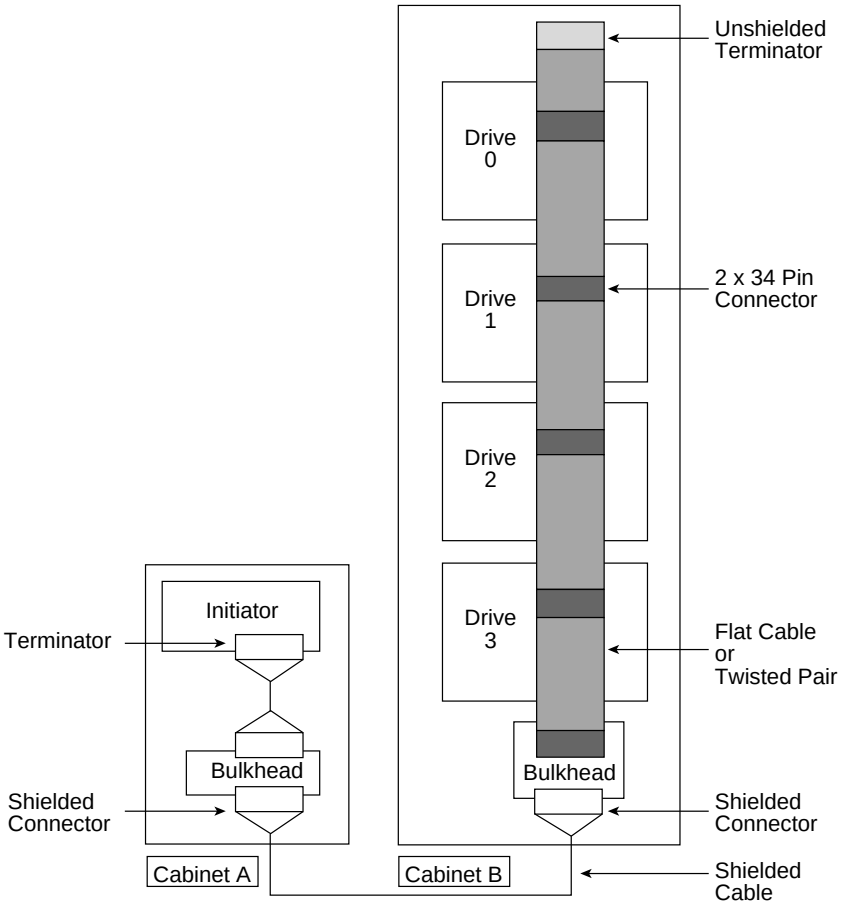


Notes:

1. Cables and terminators shown are unshielded.
2. Flat cable can be used with single-ended drivers. Twisted-pair flat cable must be used with differential drivers.
3. Total length of cables and stubs cannot exceed 25m (82.0 ft) with differential drivers or 3.05m (10.0 ft) with single-ended drivers.

Figure 7. Cabling with one cabinet

Drives and initiator in separate cabinets



Notes:

1. Initiator in one cabinet (A).
2. All drives in another cabinet (B).
3. Both bulkheads have shielded connectors.
4. Flat cable can be used with single-ended drivers. Twisted-pair flat cable must be used with differential drivers.
5. Total length of cables and stubs cannot exceed 25m (82.0 ft) with differential drivers or 3.05m (10.0 ft) with single-ended drivers.

Figure 8. Cabling with two cabinets

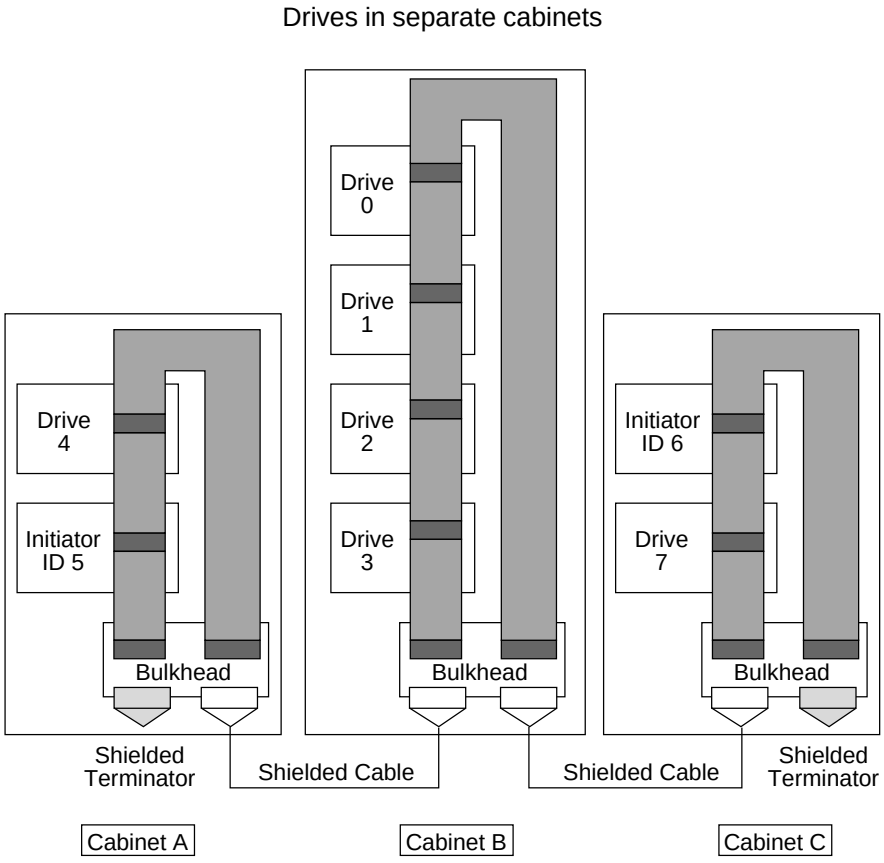


Figure 9. Cabling with three cabinets

Table 3 lists the parts needed to construct unshielded I/O cables. Table 4 lists part numbers and lengths of synchronized spindle cables. Table 5 provides part numbers of external terminators and resistor-pak terminators.

ST43402ND (dual port) drives have both I/O connectors (one for Port A and the other for Port B) located on the I/O board. You must use an adapter (part number 70935801) to terminate each I/O cable following the last drive in the daisy chain.

ST43401N/ND (single-ended) drives are shipped with resistor-pak terminators installed on the control board. Each end of the daisy-chain I/O cable must be terminated. If the resistor-pak terminators are in place on the drive, external terminators are not needed. Single-ended terminators and differential terminators have different part numbers and electrical characteristics (they cannot be interchanged).

Table 3. Unshielded I/O cabling components

Vendor part number	**Description**
Connectors for cable ends	
AMP-786090-7	Connector, unshielded male, straight
Connectors in daisy chain	
AMP-786096-7	Connector, shielded male, straight (two used per cable)
Cable	
Hitachi-A3007-51-68T	Flat cable, twisted-pair, 68-conductor, 30 AWG (for single-ended or differential I/O)

Table 4. Synchronized spindle cables

Length	Seagate part number
1.5 feet (0.46 meter)	70703929
3 feet (0.91 meter)	70703921
5 feet (1.52 meter)	70703922
7 feet (2.13 meter)	70703923
10 feet (3.05 meter)	70703924
20 feet (6.09 meter)	70703925
30 feet (9.14 meter)	70703926
40 feet (12.19 meter)	70703927
50 feet (15.24 meter)	70703928

Table 5. Terminators

Description	Seagate part number
Terminator resistor-pak, single-ended	96752447
Terminator resistor-pak, differential	70906701
Terminator, external shielded single-ended	89501152
Terminator, external shielded differential	89501030
Terminator, external unshielded single-ended	15387807
Terminator, external unshielded differential	15459255
Terminator, adapter for dual-port drives	70935801

Using the sweep cycle function

The sweep cycle is a feature that periodically moves the heads to different locations on the discs during intervals when the drive is idle. The following are highlights of the sweep cycle function:

- Using the sweep cycle enhances drive reliability. We encourage you either to enable the drive sweep cycle or to use a sweep cycle controlled by the host (initiator). Consult with an analyst in making this choice.
- The sweep routine consumes approximately 11 seconds of a 13-hour period. The drive is available to the system more than 99.98 percent of the time.
- You may disable the sweep cycle (described below) without affecting the specified mean time between failures (MTBF) or warranty agreements.

The drive is preset during manufacturing with the sweep cycle option selected. A jumper on the control board makes the selection, as shown in Figure 10. The other jumpers on the control board are discussed in the user's manual.

The jumper is identified as Sweep Cycle Option, which either enables or disables the sweep cycle function. The jumper can be positioned as follows:

- Jumper disconnected—disables the sweep cycle function
- Jumper connected—enables the sweep cycle function

Sweep movements, if enabled, can occur only in conjunction with seeks required by the controller or with any SCSI read or write operation having an implied seek. Each time the drive performs a sweep cycle, it starts a 12-minute timeout.When the timeout has elapsed, the drive performs another sweep cycle only when it receives the Seek command. When combining a sweep cycle with a seek, the drive performs the sweep cycle first and then executes the Seek command.

If a sweep segment was initiated by the Seek command, the drive performs the sweep function and then moves the heads to the cylinder requested by the controller. If about 15 minutes elapse with no disc access commands received from the SCSI bus, the SCSI I/O logic sends a one-track seek command to the drive logic. This command causes the drive to perform its sweep cycle.

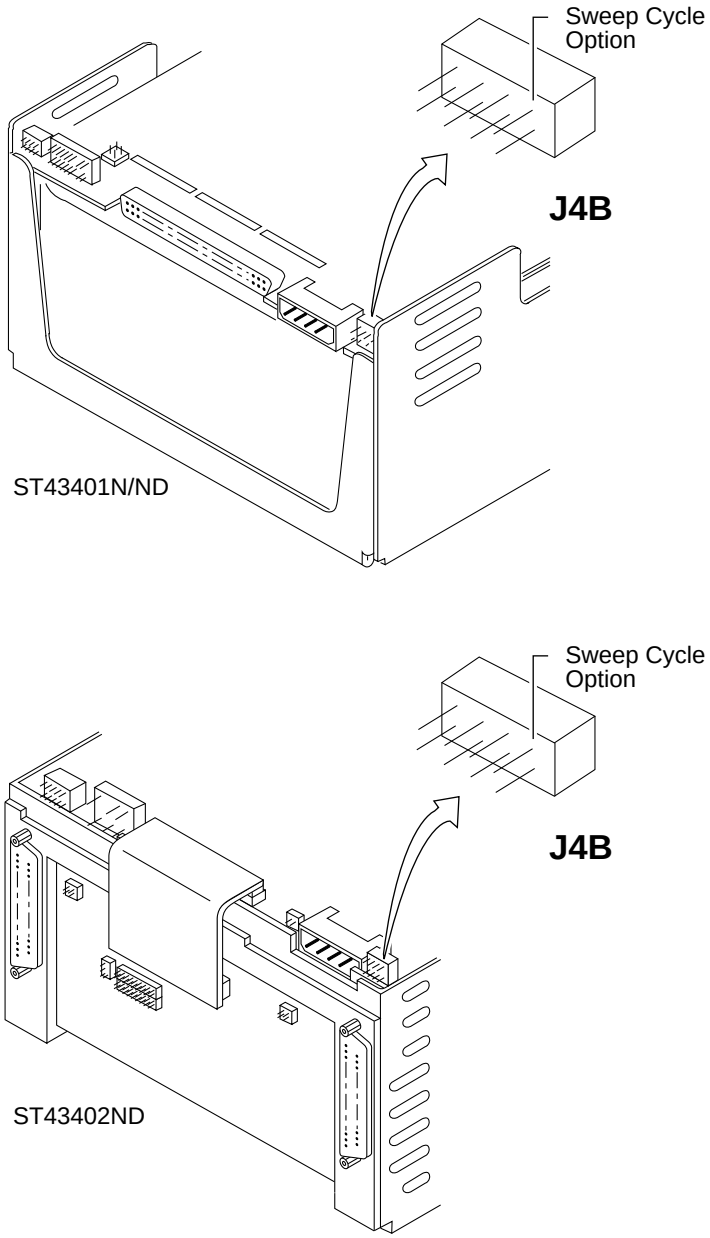


Figure 10. Control board jumpers

Section 3. Interface functions

This section provides an overview of the small computer system interface (SCSI) as it is used in the Elite drive. It is beyond the scope of this manual to provide a detailed description of all the features, capabilities, variations, and protocol of SCSI-2. This information is provided in the SCSI Interface Specification for the Elite Product Family (document 64721702).

All communications between drive and controller must pass through the interface. This communication includes all commands, status, control signals, and read/write data transfers. The interface consists of the I/O cables and the logic (on part of the control board) required to process the signals sent between the drive and controller.

Dual port drive (ST43402ND) considerations

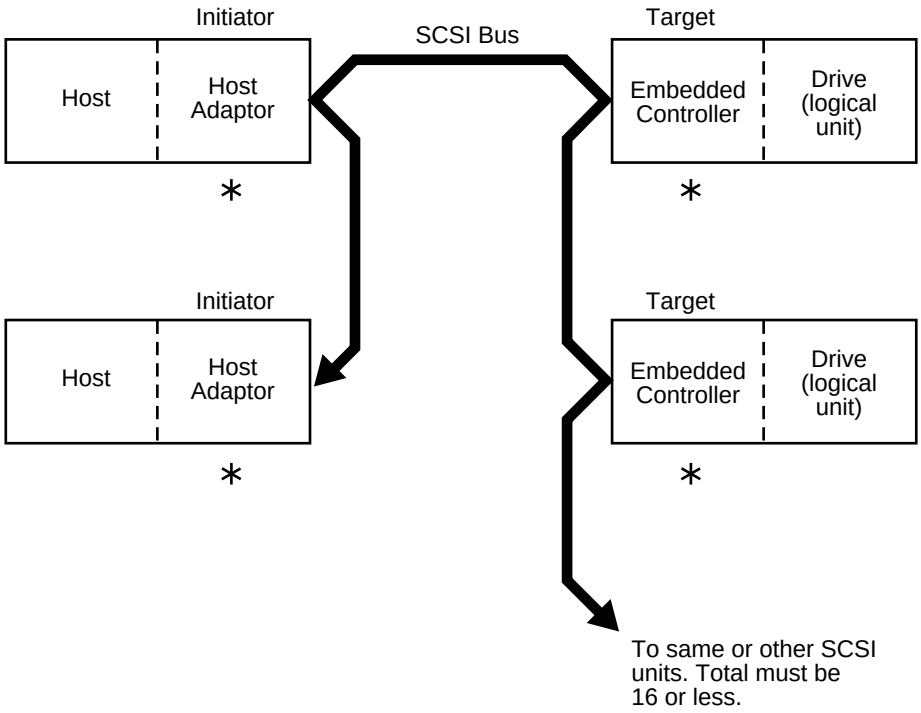
ST43402ND dual port drives have some different operating limits from the single port drives discussed in this manual. These differences are listed below.

- Dual port drives have separate sense buffers, synchronous transfer agreements, and unit attention conditions for each initiator on both ports.
- Any initiator may place commands in the queue on either port.
- Data placed in the cache by one port may be used to satisfy a read request from the other port. A write from one port may cause data cached by a read request from the other port to be purged from the cache.

SCSI bus configuration

Figure 11 illustrates the SCSI bus configuration. The SCSI bus can have a maximum of 16 devices connected to it, and communication can occur between any 2 devices at any given time. The device that originates an operation is referred to as the initiator and the device that performs the operation is the target.

The drive uses one unshielded I/O cable to attach it to the SCSI bus. You must supply all unshielded cables (see “Guidelines for I/O cabling” in Section 2). Shielded cables are typically used for connections between cabinets where electromagnetic compatibility (EMC) and electrostatic discharge (ESD) protection are required. The I/O cable carries commands, data, and status information across the SCSI bus. Figure 12 shows the lines (except those not used) in the I/O cable. The function of each of these lines is explained in Table 6.



Data Bus Bit	DB (7)	DB (6)	DB (5)	DB (4)	DB (3)	DB (2)	DB (1)	DB (0)
SCSI ID	7	6	5	4	3	2	1	0

Data Bus Bit	DB (15)	DB (14)	DB (13)	DB (12)	DB (11)	DB (10)	DB (9)	DB (8)
SCSI ID	15	14	13	12	11	10	9	8

Figure 11. SCSI bus configuration

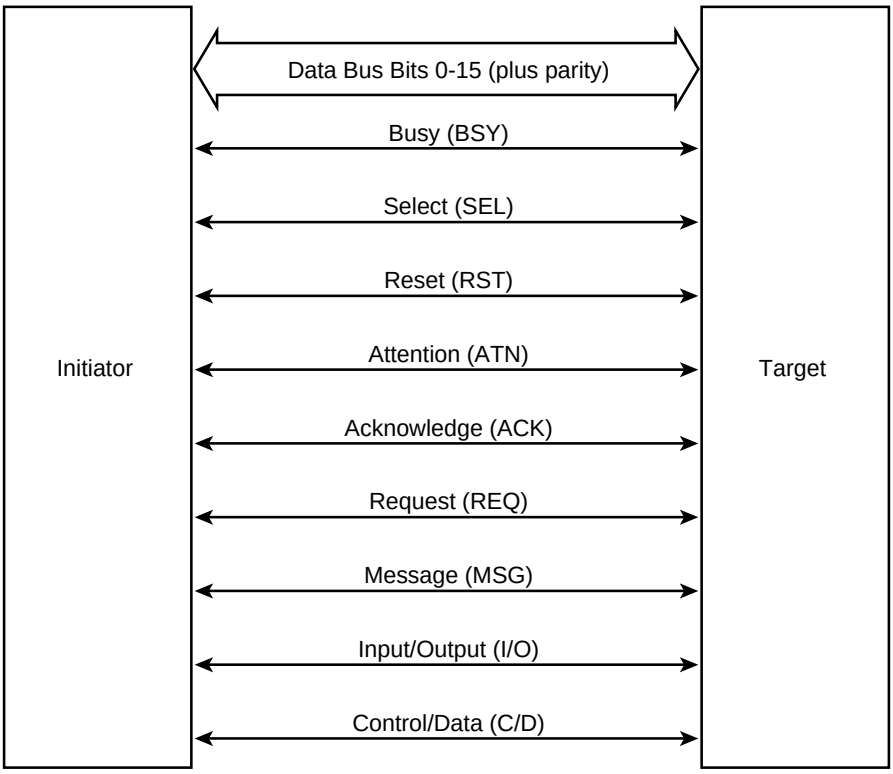


Figure 12. SCSI bus signal lines

Table 6. SCSI bus signal lines

Signal	Source	Function
Data Bus (DB 15–0+P)	I–T	Sixteen data-bit signals, plus a parity bit signal that form the Data Bus. DB(15) 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 1 when the signal is true and 0 when false. Data parity DB(P) is odd. The use of parity is a selectable option and is not valid during the Arbitration phase.
Busy (BSY)	I–T	An “or-tied” signal that indicates to the initiator or target that the bus is being used.
Select (SEL)	I–T	Used by an initiator to select a target, or by a target to reselect an initiator.
Reset (RST)	I–T	An “or-tied” signal that indicates the Reset condition exists.
Attention (ATN)	I	Driven by the initiator to indicate an Attention condition.
Acknowledge (ACK)	I	Driven by the initiator to acknowledge a REQ/ACK data transfer handshake.
Request (REQ)	T	Driven by the target to indicate a request for a REQ/ACK data transfer handshake.
Message (MSG)	T	Driven by target during the Message phase.
Input/Output (I/O)	T	Driven by the target to control the direction of data movement on the data bus with respect to the initiator. True indicates input to the initiator. Also used to distinguish between Selection and Reselection phases.
Control/Data (C/D)	T	Driven by the target to indicate whether control or data information is on the data bus. True indicates control.

T = target and I = initiator

I/O signal processing

The following paragraphs describe the basic SCSI bus communication process. They describe the bus phases, a typical command sequence, command set, and message codes. The Request Sense command and the Receive Diagnostic Results command provide information to the initiator about drive functions. The coding of this information is explained later in this section.

SCSI bus phases

Communication on the SCSI bus occurs in eight phases depending on the type of operation or information transfer being performed. The bus phases pertain to the condition or state of the lines at a given time. The SCSI bus can never be in more than one phase at any given time.

The information phases are defined by the MSG, C/D, and I/O signals as shown in Table 7. The SCSI bus phases are listed and described in Table 8.

Table 7. Information transfer phases

MSG	C/D	I/O	Phase Name	Direction of Transfer
0	0	0	Data Out	Initiator------> Target
0	0	1	Data In	Target-------> Initiator
0	1	0	Command	Initiator------> Target
0	1	1	Status	Target-------> Initiator
1	0	0	Reserved	
1	0	1	Reserved	
1	1	0	Message Out	Initiator------> Target
1	1	1	Message In	Target-------> Initiator

0 = false, 1 = true

Table 8. SCSI bus phase descriptions

Phase	Description
Bus Free	No SCSI device asserts Busy or Select for at least one bus settle delay.
Arbitration	Allows one SCSI device to gain access to the bus based on its priority ID bit.
Selection	Allows an initiator to select a target. The I/O line must not be asserted in this phase.
Reselection	Allows a target to reconnect to an initiator so it can continue an operation started by an initiator but suspended by the target before it was complete. The I/O line must be asserted during this phase.
Command	Allows the target to request command information from the initiator.
Data	The Data In phase allows the target to request that data be sent to the initiator from the target. The Data Out phase allows the target to request that data be sent from the initiator to the target.
Status	Allows the target to request that status information be sent from the target to the initiator.
Message	The Message In phase allows the target to request that messages be sent to the initiator from the target. The Message Out phase allows the target to request that messages be sent from the initiator to the target. The target can invoke this phase at its convenience in response to an Attention signal created by the initiator.

SCSI command execution

Figure 13 illustrates the basic flow of a command sequence. The sequence illustrated cannot and does not represent all variations. Refer to the SCSI Interface Specification for the Elite Product Family (document 64721702) for command descriptions, execution details, and timing constraints. The following information appears at the end of this topic:

- Table 9 describes the command set for the drive
- Table 10 lists the message codes and shows the direction of flow for each
- Table 11 describes the status codes

As shown in Figure 13, the communication sequence starts with the SCSI bus in the Bus Free phase. This phase indicates that no other SCSI devices are using the bus and it is free for use by other devices. Each device detects the Bus Free phase when the Select and Busy lines are both false.

The Bus Free phase is followed by an Arbitration phase where the initiator attempts to gain access to the bus. Access to the bus is based on the device priority ID bit. Arbitration occurs when the device asserts Busy and its ID on the data bus. This ID bit is a single bit on the data bus that corresponds to the unique SCSI address assigned to each device when it was installed. The other 15 bits are released by the SCSI device. The SCSI device examines the data bus. If a higher priority SCSI ID bit is true (data bus bit 15 is the highest) the SCSI device loses arbitration and the device releases its signals. If no higher priority bit is true, the device wins arbitration.

After winning the Arbitration, the initiator selects the target (Selection phase). The initiator places the SCSI ID of the target on the bus (asserts the data bus bit), as well as its own ID. After a delay, the initiator asserts the Select line. The target determines it is selected when its SCSI bus ID bit and the Select line are true, and the Busy and I/O lines are false. Selection with Attention informs the target that the initiator has a message ready.

Note. For dual port drives, a SCSI hard reset causes a unit attention condition for all initiators on the port receiving the reset. Commands, reservations, wide negotiations, and synchronous negotiation agreements associated with the alternate port are not affected.

The selected device responds to the initiator by entering the Message Out phase if the initiator has Attention asserted. In this phase, the target requests that the initiator send messages to it. The Message, Control/ Data, and Input/Output lines are used in combinations to indicate the various information transfer phases. The state of the three signal lines is controlled by the target, and the phase selected by the state of these three signal lines is shown earlier in Table 7**.**

In this example, the Identify message is the first message sent by the initiator after the Selection phase. This message identifies the physical path for the logical unit (only logical unit 0 is supported) specified by the initiator. The Identify message is also the first message sent by the target following the Reselection phase. The initiator can request a Message Out phase by asserting Attention.

Following the Message Out phase, the initiator responds to the Command phase and, in this example, issues a Read command to the drive. The Message In phase is entered (Disconnect message) followed by the Bus Free phase. The Arbitration phase is again entered, followed by the Reselection and the Message In (Identify message) phases. Reselection is a phase that allows the target to reconnect to the initiator so it can continue an operation that was started by an initiator but suspended by the target before it was complete. The requested read data is then transferred to the initiator.

Following the Data In phase, the target enters the Message In phase and, in this example, requests the initiator to Save Data Pointer. There are current (also called active) pointers that represent the state of the interface and point to the next command, data, or status byte to be transferred between the initiator's memory and the target. Current pointers are used with the target currently connected to the initiator.

Another set of pointers called saved pointers is provided for each active command, whether or not it is currently connected. The command pointer points to the start of the command descriptor block for that command. The saved data pointer points to the start of the data area at the beginning of each command and it remains at this value until the target sends the Save Data Pointer message to the initiator. In response to this message, the initiator stores the value of the current data pointer into the saved data pointer. Only the saved pointer values are retained when a device disconnects from the bus. The current pointer values are restored from the saved values at the next reconnection.

At this point, the Message In phase is entered with a Disconnect message code. Following the disconnect, the bus is in the Bus Free phase in preparation for the Arbitration and Reselection phases.

After Reselection, the process continues with the Message In and Data In phases previously described. The Status phase occurs at the end of the operation. It allows the target to send status information to the initiator. Status codes are contained in bits 5 to 1 of the status byte. The various codes are shown in Table 11. The process ends with the Message In phase and a Command Complete message followed by the Bus Free phase.

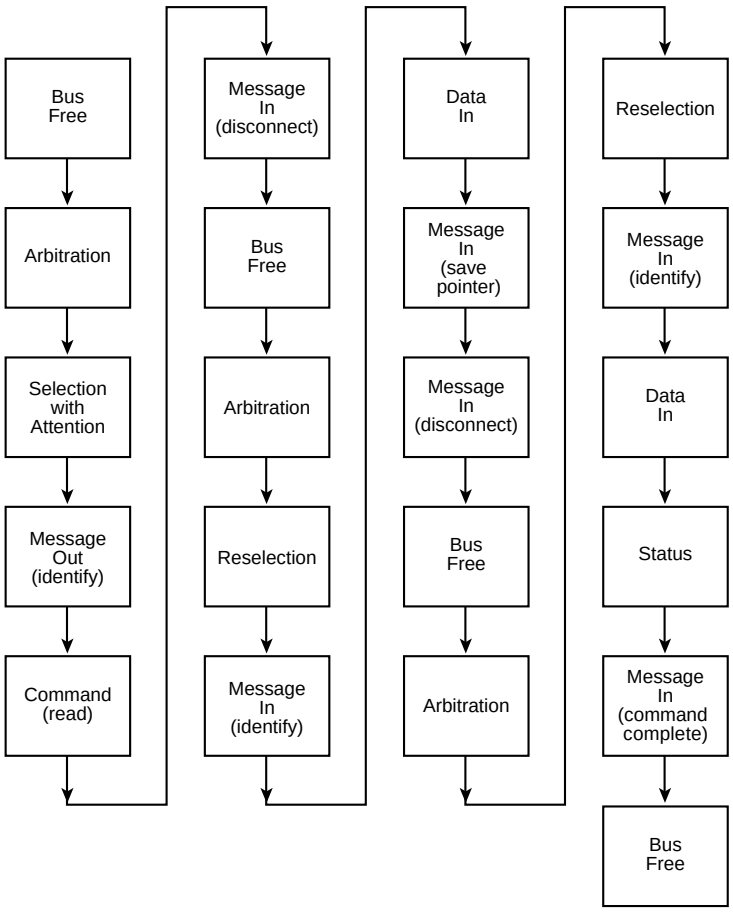


Figure 13. Sequence of a typical command

Table 9. Command set

Group 0 commands for direct access devices

Op code	Command name
00	Test Unit Ready
01	Rezero Unit
02	
03	Request Sense
04	Format Unit
05–06	
07	Reassign Blocks
08	Read
09	
0A	Write
0B	Seek
0C–10	
11	Port Status (0 dual port only)
12	Inquiry
13–14	
15	Mode Select
16	Reserve (see note 1)
17	Release
18–19	
1A	Mode Sense (see note 2)
1B	Start/Stop Unit
1C	Receive Diagnostic Results
1D	Send Diagnostic
1E–1F	

Note 1. For dual port drives, when a reservation is granted to an initiator on one port, all initiators on both ports receive reservation conflict status.

Note 2. Dual port drives do not support Mode Sense. Dual port drives support Expanded Mode Sense (page 08h), which includes all previous functions supported by Mode Sense (page 38h).

continued

continued from previous page

Group 1 and 2 Commands for Direct Access Devices

Op Code	Command Name
20–24	
25	Read Capacity
26–27	
28	Read Extended
29	
2A	Write Extended
2B	Seek Extended
2C–2D	
2E	Write and Verify
2F	Verify
30–36	
37	Read Defect Data
38–3A	
3B	Write Buffer
3C	Read Buffer
3D	
3E	Read Long
3F	Write Long
40	Change Definition

Table 10. Message code descriptions

Code (Hex)	Initiator	Target	Description	Direction of Transfer
00	M	M	Command complete	Target ------> Initiator
01//00	O	O	Modify data pointer	Target ------> Initiator
01//01	O	O	Sync data transfer request	Target <-----> Initiator
02	O	O	Save data pointer	Target ------> Initiator
03	O	O	Restore pointers	Target ------> Initiator
04	O	O	Disconnect	Target ------> Initiator
05	O	M	Initiator detected error	Initiator ------> Target
06	O	M	Abort	Initiator ------> Target
07	M	M	Message reject	Target <-----> Initiator
08	M	M	No operation	Initiator ------> Target
09	M	M	Message parity error	Initiator ------> Target
0A	O	O	Linked command complete	Target ------> Initiator
0B	O	O	Linked command complete with flag	Target ------> Initiator
0C	O	M	Bus device reset (see note 1)	Initiator ------> Target
0D	O	M	Abort tag	Initiator ------> Target
0E	O	O	Clear queue (see note 2)	Initiator ------> Target
0F-13			Reserved	— —
14	O	O	Reset other port message	Initiator ------> Target
15-1F			Reserved	— —
20	O	O	Simple queue tag (two bytes)	Target <-----> Initiator
21	O	O	Head of queue tag (two bytes)	Initiator ------> Target
22	O	O	Ordered queue tag (two bytes)	Initiator ------> Target
23-7F			Reserved	— —
80-FF	M	M	Identify (establishes the communication path between an initiator and target for a logical unit)	Target <-----> Initiator

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continued from previous page

Bit 7 = 1: Indicates an Identify message

Bit 6 = 1: Indicates the initiator allows disconnection and reselection

Bit 6 = 0: Indicates that disconnection is not allowed

Bit 5 = 0: Indicates the I/O is directed to or from a logical unit

Bit 5 = 1: Indicates the I/O is directed to or from a target routine

Bits 4 to 3: Reserved

Bits 2 to 0: Specify a logical unit number or target routine number, depending on bit 5

M = Mandatory for SCSI-2

O = Optional for SCSI-2

Note 1. For dual port drives, a bus device reset message from either port causes a unit attention condition for all initiators on both ports. Commands, reservations, wide negotiations, and synchronous negotiation agreements associated with the alternate port are not affected.

Note 2. For dual port drives, a clear queue message from either port causes all commands from that port to be cleared. A unit attention condition is set for all initiators on that port except the one that sent the Clear Queue message. Commands for the other port are not affected.

Table 11. Status codes

Status Byte:

Byte		Bit						
	7	6	5	4	3	2	1	0
	RESVD	RESVD	<<---------- Status Byte Code ---------->>					RESVD

Status Byte Codes:

Bits of the Status Byte*								Status Description
7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	Good
0	0	0	0	0	0	1	0	Check condition
0	0	0	0	0	1	0	0	Condition met
0	0	0	0	1	0	0	0	Busy
0	0	0	1	0	0	0	0	Intermediate
0	0	0	1	0	1	0	0	Intermediate-condition met
0	0	0	1	1	0	0	0	Reservation conflict
0	0	1	0	0	0	1	0	Command terminated
0	0	1	0	1	0	0	0	Queue full
*All other codes are reserved								

The Request Sense command

The Request Sense command (03H) requests that the target transfer sense data to the initiator. This data is returned in the extended sense format. Within this format are the following three levels of information:

- Sense key—defined in Table 12.
- Additional Sense Code—see byte 12 listing in Table 13.
- Additional Sense Code qualifiers—see byte 13 listing in Table 13. These qualifiers differentiate between related definitions all having the same Additional Sense Code.

All codes not shown in Table 13 are reserved.

Table 12. Sense key descriptions

Sense Key	Description
0_H	No sense
1_H	Recovered error
2_H	Not ready
3_H	Medium error
4_H	Hardware error
5_H	Illegal request
6_H	Unit attention
7_H	Data protect
8_H	Reserved
9_H	Reserved
A_H	Reserved
B_H	Aborted command
C_H	Reserved
D_H	Reserved
E_H	Miscompare
F_H	Reserved

Table 13. Additional sense codes and their qualifiers

Byte 12	Byte 13	Description
00	00	No additional sense information
01	00	No index/sector signal
02	00	No seek complete
03	00	Peripheral device write fault
04	00	Logical unit not ready—cause not reportable
04	01	Logical unit is in process of becoming ready
04	02	Logical unit not ready—initializing command required
04	03	Logical unit not ready—mutual intervention required
04	04	Logical unit not ready—format in progress
05	00	Logical unit does not respond to selection
06	00	No reference position found (track zero or equivalent)
08	00	Logical unit communication failure
08	01	Logical unit communication time-out
08	02	Logical unit communication parity error
09	00	Track-following error
0A	00	Error log overflow
0C	01	Write error recovered with auto reallocation
0C	02	Write error—auto reallocation failed
10	00	ID CRC or ECC error
11	00	Unrecovered read error
11	01	Read retries exhausted
11	02	Error too long to correct
11	03	Multiple read errors
11	04	Unrecovered read error—auto reallocate failed
11	0A	Miscorrected error
12	00	Address mark not found for ID field
13	00	Address mark not found for data field
14	00	Recorded entity not found
14	01	Record not found
15	00	Random positioning error
15	01	Mechanical positioning error
15	02	Positioning error detected by read of medium
16	00	Data synchronization mark error
17	00	Recovered data with no error correction applied
17	01	Recovered data with retries

continued

continued from previous page

Byte 12	Byte 13	Description
17	02	Recovered data with positive head offset
17	03	Recovered data with negative head offset
17	05	Recovered data with previous sector ID
17	06	Recovered data without ECC—data auto-reallocated
18	00	Recovered data with error correction applied
18	01	Recovered data with error correction and retries applied
18	02	Recovered data with ECC and/or retries—data auto-reallocated
19	00	Defect list error
19	01	Defect list not available
19	02	Defect list error in primary list
19	03	Defect list error in grown list
1A	00	Parameter list length error
1B	00	Synchronous data transfer error
1C	00	Defect list not found
1C	01	Primary defect list not found
1C	02	Grown defect list not found
1D	00	Miscompare during verify operation
1E	00	Recovered ID with ECC correction
20	00	Invalid command operation code
21	00	Logical block address out of range
24	00	Invalid field in CDB—check field pointer in sense data
25	00	Logical unit not supported
26	00	Invalid field in parameter list—check field pointer in sense data
26	01	Parameter not supported—check field pointer in sense data
26	02	Parameter value invalid—check field pointer in sense data
26	03	Threshold parameters not supported
27	00	Write protected
28	00	Not ready to ready transition—medium may have changed
29	00	Power on, reset, or bus device reset occurred
29	00	Device reset message, bus reset (dual port only)
29	01	Power on, reset (dual port only)
2A	00	Parameters changed
2A	01	Mode parameters changed
2A	02	Log parameters changed
2B	00	Copy cannot execute since host cannot disconnect
2C	00	Command sequence error

continued

continued from previous page

Byte 12	Byte 13	Description
2F	00	Commands cleared by another initiator
30	01	Cannot read medium—unknown format
30	02	Cannot read medium—incompatible format
31	00	Medium format corrupted
31	01	Format command failed
32	00	No defect spare location available
32	01	Defect list update failure
37	00	Rounded parameter
39	00	Saving parameters not supported
3A	00	Medium not present
3D	00	Invalid bits in identify message
3E	00	Logical unit has not self-configured yet
3F	00	Target operating conditions have changed
3F	01	Microcode has been changed
3F	02	Changed operating definition
3F	03	Inquiry data has changed
40	NN	Diagnostic failure—more description in ASCQ (Byte 13 codes 80H–FFH)
40	00	RAM failure (should use 40 NN)
41	00	Data path failure (should use 40 NN)
42	00	Power on or self-test failure (should use 40 NN)
43	00	Message error
44	00	Internal target failure
45	00	Select/reselect failure
46	00	Unsuccessful soft reset
47	00	SCSI parity error
48	00	Initiator detected error message received
49	00	Invalid message error
4A	00	Command phase error
4B	00	Data phase error
4C	00	Logical unit failed self-configuration
4E	00	Overlapped commands attempted
53	02	Medium removal prevented
5A	00	Operator request or state change input (unspecified)
5A	01	Operator medium removal request
5A	02	Operator selected write protect

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continued from previous page

Byte 12	Byte 13	Description
5A	03	Operator selected write permit
5B	00	Log exception
5B	01	Threshold condition met
5B	02	Log counter at maximum
5B	03	Log list codes exhausted
5C	00	RPL status change
5C	01	Spindles synchronized
5C	02	Spindles not synchronized
XX		Additional Sense Codes in the range of 80H–FFH are vendor unique
	XX	Additional Sense Code Qualifiers in the range of 80H–FFH are vendor unique

The Receive Diagnostic Results command

The Receive Diagnostic Results command (1CH) requests that analysis data be sent to the initiator after completion of a Send Diagnostic command. The results of power on initialization tests are available through the Request Sense command as well as this command. Diagnostic data return bytes are shown in Table 14.

Table 14. Diagnostic data return bytes

Byte	Description
0	Additional length (bit 7 = most significant bit)
1	Additional length (bit 0 = least significant bit)
2	FRU code (most probable)
3	FRU code
4	FRU code
5	FRU code (least probable)
6	Error code (bit 7 = most significant bit)
7	Error code (bit 0 = least significant bit)

Additional length field

This two-byte field indicates the number of additional bytes included in the diagnostic data list. This value will always be 0006H. This means there are six additional bytes (bytes 2–7).

Field replaceable unit (FRU) code

In the event of a failure, the FRU code byte identifies the assembly that may have failed. The codes are listed in probability order with the most probable assembly listed first and the least probable listed last. FRU codes are shown in Table 15.

Table 15. SCSI online FRU codes

Code	Description
00H	No information or unknown
01H	Replace entire drive
02H	Undefined
03H	Undefined

Error code

This two-byte value provides information about what part of the diagnostic operation has failed. The error codes are shown in Table 16.

Table 16. Error codes

Code	Description
0001H	Formatter diagnostic error
0002H	Microprocessor RAM diagnostic error
0004H	No drive ready
0008H	No sector or index detected
0009H	Fatal hardware error while doing drive diagnostics
000CH	No drive command complete
0010H	Unable to set drive sector size
0014H	Unable to clear drive attention
0018H	Unable to start spindle motor
0020H	Unable to recalibrate drive
0030H	Unable to send write current data to drive
0034H	Unable to issue drive seek command
0040H	Unable to read user table from drive
0041H	Ran out of sectors while doing drive diagnostics
0042H	Unable to read reallocation table
0043H	Unable to read ETF log
0044H	Unable to read firmware stored on disc
0045H	Firmware read from disc or sent by host has an invalid checksum
0060H	Thermal calibration failure
0070H	Microprocessor internal timer error
0080H	Buffer controller diagnostic error
0081H	Buffer RAM diagnostic error
00C1H	Data miscompare while doing drive diagnostics
00F0H	PROM checksum error
00F1H	CPU error
00F2H	SCSI protocol chip error
00F3H	ECC subsystem error

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