MD01

(MEDALIST)

DISK CONTROLLER

TECHNICAL MANUAL

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WARNING

This equipment generates, uses and can radiate radio frequency energy, and if not installed and used in accordance with the technical manual, may cause interference to radio communications. It has been tested and found to comply with the limits for a Class B computing device pursuant to Subpart J of Part 15 of the Federal Communications Commission (FCC) Rules, which are designed to provide reasonable protection against such interference when operating in a residential installation. However, there is no guarantee that interference will not occur in a particular installation.

The information in this manual is for information purposes and is subject to change without notice.

Emulex Corporation assumes no responsibility for any errors which may appear in the manual.

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EMULEX PRODUCT WARRANTY

CONTROLLER WARRANTY: Emulex warrants for a period of twelve (12) months from the date of shipment that each Emulex Controller Product supplied shall be free from defects in material and workmanship.

During this period, if the customer experiences difficulties with an Emulex controller and is unable to resolve the problem via the phone with Emulex Technical Support, a Return Authorization will be issued. Following receipt of a Return Authorization, the customer is responsible for returning the product to Emulex, freight prepaid. Emulex, upon verification of warranty will, at its option, repair or replace the controller in question, and return to the customer freight prepaid.

CABLE WARRANTY: All Emulex provided cables, not included as part of a subsystem, are warranted for ninety (90) days from the time of shipment. Questionable cables should be returned to Emulex, freight prepaid, where they will be repaired or replaced by Emulex at its option and returned to the customer freight prepaid.

The above warranties shall not apply to expendable components such as fuses, bulbs, and the like, nor to connectors and other items not a part of the basic product. Emulex shall have no obligation to make repairs or to cause replacement required through normal wear and tear or necessitated in whole or in part by catastrophe, fault or negligence of the user, improper or unauthorized use of the Product, or use of the Product in such a manner for which it was not designed, or by causes external to the Product, such as but not limited to, power failure or air conditioning. Emulex's sole obligation hereunder shall be to repair or replace items covered in the above warranties. Purchaser shall provide for removal of the defective Product, shipping charges for return to Emulex and installation of its replacement.

RETURNED MATERIAL: Warranty claims must be received by Emulex within the applicable warranty period. A replaced product, or part thereof, shall become the property of Emulex and shall be returned to Emulex at Purchaser's expense. All returned material must be accompanied by a RETURN AUTHORIZATION number assigned by Emulex.

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Section 1
GENERAL DESCRIPTION

1.1 INTRODUCTION

The MD01 SCSI Disk Controller, called the Medalist, was designed by Emulex Corporation to interface Small Computer System Interface (SCSI) hosts and controllers to one or two ST506 5 1/4-inch Winchester disk drives. (The SCSI bus can interface with up to eight host adapters and/or related microcontroller devices.) This manual is designed to help you install the MD01 Controller and to provide information about buffering, signal translation capabilities, and applications. The contents of the eight sections are described briefly below.

Section 1 General Description: This section contains an overview of the MD01 Controller.

Section 2 MD01 Controller Specifications: This section contains specifications for the major components of the MD01 Controller.

Section 3 Installation: This section contains the information necessary to install the MD01 Controller in your system.

Section 4 Troubleshooting: This section describes diagnostic procedures that can be used to pinpoint problem areas on the MD01 Controller.

Section 5 Functional Description: This section describes the architecture and disk operations of the MD01 Controller.

Section 6 Interfaces: This section describes the SCSI bus and ST506 disk drive interfaces.

Section 7 SCSI Bus Protocol: This section describes the SCSI bus protocol, including signals, phases, and timing.

Section 8 MD01 SCSI Command Set: This section describes SCSI commands and their corresponding Command Descriptor Blocks which are supported by the MD01 Controller.

For reference convenience, Section 1 is divided into four subsections, as listed in the following table:

Subsection	Title
1.1	Introduction
1.2	Physical Description
1.3	Functional Overview
1.4	Compatibility

1.1.1 RELATED DOCUMENTS

This manual is designed to be used by system programmers who are writing operating system drivers and support utilities. Familiarity with the SCSI standard and the ST506 disk drive interface specification are assumed.

The SCSI command set for the MD01 Controller is based on the ANSI X3T9.2/82-2 Rev. 14 (24 April 84) SCSI Specification. As the SCSI standard is currently changing, this ANSI specification is subject to change without notice. It is the intent of Emulex to maintain SCSI compatibility as the standard evolves.

The ST506 interface standard for 5 1/4-inch Winchester disk drives is described in standard #XXXXXXXXXX.

1.1.2 TECHNICAL MANUAL CONVENTIONS

To avoid possible confusion with other uses of the same words, throughout this manual we use the following conventions:

- All SCSI commands (such as **READ, MODE SELECT,** and **INQUIRY)** and diagnostic subcommands (such as **READ BAD SECTOR FILE** and **WRITE LONG**) are printed in uppercase boldface.
- All SCSI status and error messages (such as CHECK CONDITION and DRIVE NOT READY) are printed in uppercase.
- All SCSI bus phases and conditions (such as Arbitration Phase) and SCSI Command Descriptor Block names (such as Extended Sense Byte) are printed in initial caps.
- All SCSI command and message codes are given in their hexadecimal values.

1.2 PHYSICAL DESCRIPTION

The MD01 Controller, shown in Figure 1-1, is assembled on a single board (approximately 5 3/4-inches by 8-inches) and is installed directly on a mounting bracket located in the subsystem that contains an ST506 5 1/4-inch Winchester disk drive. The MD01 Controller contains two Emulex custom Very Large Scale Integration (VLSI) chips; one is a Buffer Controller and one is a Disk Formatter. It also contains an 8031 microprocessor chip, a 16-kilobyte Electrically Programmable Read Only Memory (EPROM), and a 16-kilobyte Random Access Memory (RAM) which provides 10 kilobytes of data buffering.

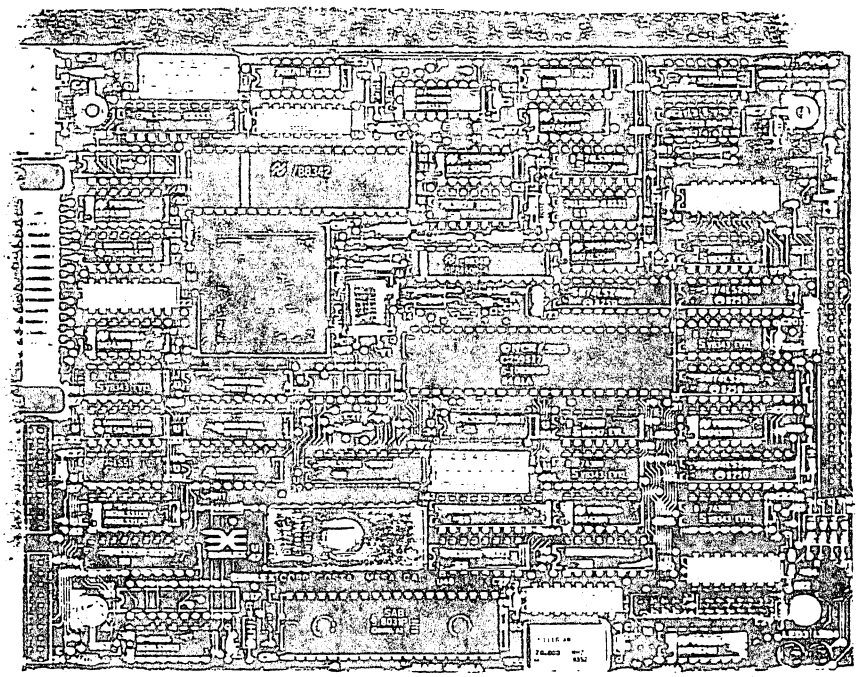

Figure 1-1. The MD01 (Medalist) Disk Controller

1.3 FUNCTIONAL OVERVIEW

In combination with an independent host adapter, the SCSI bus allows a wide variety of computers to interface with the MD01 Controller. Compatible computers include DEC systems that use the Q-bus and Unibus, IBM Personal Computer systems like the IBM PC/XT, and Intel Multibus-based computers. Up to eight bus devices, in any combination of host systems and intelligent controllers, can be supported by the SCSI bus. The MD01 Controller, in combination with one or two ST506 5 1/4-inch Winchester disk drives, provides a low-cost, compact, storage subsystem in a microcomputer environment.

The MD01 Controller's architecture and supported SCSI features make it an ideal building block for use by O.E.M.s and system integrators. The MD01 Controller supports a powerful set of SCSI commands. By using those commands, an efficient Multi-Initiator configuration can be constructed with the support of the Disconnect function. (The Disconnect function allows the MD01 Controller, when it is performing a time-consuming task, to release the SCSI bus temporarily and reconnect at a later time when the task is complete.) The MD01 Controller may be considered a SCSI extended-bus device because all standard and extended SCSI commands are used.

Emulex currently offers two additional SCSI bus microcontrollers that can be used with SCSI bus subsystems: the Titleist and the Champion. The Titleist Tape Controller interfaces the SCSI bus to Cipher 540 Cartridge Tape Drives. The Champion Disk Controller interfaces Enhanced Small Disk Interface (ESDI) 5 1/4-inch disk drives to the SCSI bus.

In addition to basic stand-alone controller products, Emulex also offers complete SCSI bus disk and tape packaged subsystems for microcomputer applications.

A sample configuration of a SCSI system is shown in Figure 1-2.

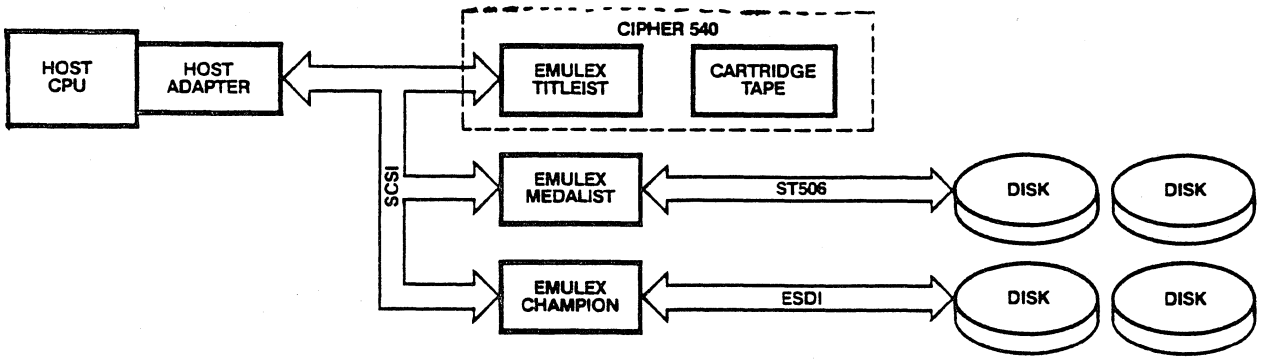

Figure 1-2. Sample SCSI Bus System Configuration

1.3.1 FEATURES

The MD01 Controller features are summarized below. More details on these features are given in subsequent sections.

- SCSI Implementation based on ANSI X3T9.2/ 82-2 Rev 14 (24 April 84) Specification
- Support of standard 5 1/4-inch Winchester Disk Drives with ST506 interfaces
- Powerful SCSI command set including:

  -Common Commands
  -Random Access Device Commands
  -**COPY** Command
  -Linked Command Support

- Support of Disconnect/Reconnect Function
- Command Queuing from multiple Initiators
- Hard Reset
- Buffered operation to optimize performances
- Extensive self-test and diagnostic facilities
- Compatible with Emulex's ESDI disk controller and Cipher 540 tape controller

There are two Dual In-Line Package (DIP) switch packs on the MD01 Controller. Both switch SW1 and switch SW2 are eight-pole general control switches used for configuring various disk parameters. For configuration details, see Section 3 (Installation).

1.4 COMPATIBILITY

Compatibility of the MD01 Controller with ST506 disk drives and SCSI host adapter systems and related microcontrollers is described in the following subsections.

1.4.1 SCSI BUS HARDWARE COMPATIBILITY

A disk drive or tape drive that is connected to the SCSI bus and that follows the protocol outlined in the ANSI X3T9.2 SCSI Specification is compatible with the MD01 Controller/ST506 disk drive unit. A 50-pin male IDC connector, reference designated J2, on the MD01 Controller plugs directly into the SCSI bus cable.

The MD01 Controller supports the SCSI single-ended bus option. The overall length of the cable that connects the SCSI host adapters and controllers in a daisy-chained manner can extend to 6 meters. All SCSI signals in the cable are terminated at each end by terminating resistors of 220 Ohms to +5 Vdc, and 330 Ohms to ground. Terminators are optionally installed, and depend on the physical profile of the SCSI bus (e.g., they would be installed if the MD01 Controller is used in an environment that includes an Emulex subsystem as the last device attached to the SCSI bus cable). The MD01 Controller complies with the FCC limits for a Class B computing device (see subsection 3.5).

1.4.2 SCSI BUS PROTOCOL AND COMMAND COMPATIBILITY

The MD01 Controller contains an on-board SCSI protocol controller that controls SCSI protocol and the SCSI bus. The MD01 Controller supports the SCSI arbitration and reselection capabilities, and data bus parity. The MD01 Controller supports all standard SCSI commands described in the ANSI X3T9.2 SCSI specification. For more information on commands supported by the MD01 Controller, see Section 8.

1.4.3 SCSI COMMAND SET

The hexadecimal codes for the SCSI commands supported by the MD01 Controller are shown in Table 1-1. Detailed command descriptions are given in Section 8.

Table 1-1. MT01 SCSI Command Set

Group 0 Command	Hex Code	Group 0 Command	Hex Code
TEST DRIVE READY	(00)	**REZERO UNIT**	(01)
REQUEST SENSE	(03)	**FORMAT UNIT**	(04)
REASSIGN BLOCK	(07)	**READ**	(08)
WRITE	(0A)	**SEEK**	(0B)
INQUIRY	(12)	**MODE SELECT**	(15)
RESERVE UNIT	(16)	**RELEASE UNIT**	(17)
COPY	(18)	**MODE SENSE**	(1A)
RECEIVE DIAGNOSTIC	(1C)	**SEND DIAGNOSTIC**	(1D)
Group 1 Command	Hex Code	Group 1 Command	Hex Code
READ CAPACITY	25	**SEEK (EXTENDED)**	0B
READ (EXTENDED)	28	**VERIFY**	2F
SEARCH DATA EQUAL	31	**WRITE (EXTENDED)**	0A
SEARCH DATA HIGH	30	**WRITE AND VERIFY**	2E
SEARCH DATA LOW	32		

1.4.4 DEVIATIONS FROM SCSI STANDARD

When the MD01 Controller performs the **COPY** command, it does not support Copy operations where both the source and destination Logical Units (LUNs) are on different controllers; however, it does support the third-party reservation needed for the Copy operation. Since the Copy operation may only be used between LUNs with compatible block sizes, the MD01 Controller supports block sizes of 256 or 512 byte blocks for external devices.

Commands from several Initiators are queued within the MD01 Controller. These commands may include the **RESERVE UNIT** command (see Table 1-1). If a second command is received from the same Initiator, and is directed towards the same LUN, the MD01 Controller returns a BUSY completion status.

1.4.5 ST506 DISK DRIVE INTERFACE COMPATIBILITY

The MD01 Controller can be connected to any ST506 5 1/4-inch Winchester disk drive via a 34-pin IDC connector reference designated P1 on the MD01 Controller, and one or two 20-pin IDC male connector reference designators J3 and J4 on the MD01 Controller. The MD01 Controller was designed specifically for use with ST506 disk drives.

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2.1 OVERVIEW

This section contains the general, electrical, and physical specifications for the components on the MD01 Controller. A general description of each component is included under **FUNCTIONAL** in the General and Electrical Specifications table. For a detailed description of the MD01 Controller's function as a whole, see Section 5, Functional Description. The general, electrical, and physical specifications for the MD01 Controller are described in separate subsections as listed in the following table.

Subsection	Title
2.1	Overview
2.2	General and Electrical Specifications
2.3	Physical Specifications

2.2 GENERAL AND ELECTRICAL SPECIFICATIONS

Table 2-1 lists and describes the general and electrical specifications for the MD01 Controller.

Table 2-1. General and Electrical Specifications

Parameter	Description
FUNCTIONAL	
Design	High-speed microprocessor-based disk controller for integration of one or two ST506 5 1/4-inch Winchester disk drives to SCSI bus
SCSI Bus/Controller Interface	Standard SCSI bus interface (ANSI X3T9.2/82-2 specification), via a 50-pin male IDC connector
Disk Drive Interface	ST506 interface for Winchester 5 1/4-inch disk drives, via a 34-pin IDC connector and a 20-pin IDC connector

continued on next page

Table 2-1. General and Electrical Specifications (continued)

Parameter	Description
FUNCTIONAL	
Subsystem Configuration	One or two non-intelligent 5 1/4-inch disk drives and controller per subsystem
Number of Heads	Up to 16 read/write heads
Soft Sectoring	256 byte sectors or 512 byte sectors supported
Data Buffering	Full track data buffer (16 kilobytes [kbytes]; approximately 6 kbytes for operating system and program, 10 kbytes for data buffering)
Self-Test	Controller automatically executes power-up self-diagnostics
Error Detection/ Correction	48-bit ECC corrects 11-bit error bursts. Bad sectors automatically remapped to spare sectors; bad tracks automatically remapped to spare tracks.
INDICATORS	
Fault/Activity Display	Light emitting diodes (LEDs) indicate detected MD01 Controller fault and read/write activity; MD01 Controller provides signals that can be used to control off-board LEDs
Option/Configuration Switches	On-board switch module for burn-in self-test and MD01 Controller configuration
INTERFACES	
Bus Interface	Standard SCSI single-ended option uses approved receivers and drivers
5 1/4-inch Winchester Disk Drive Interface	Standard ST506 disk drive interface

continued on next page

Table 2-1. General and Electrical Specifications (continued)

Parameter	Description
ELECTRICAL	
Power	+5 Volts direct current (Vdc), ± 5%, 1.5 Amperes (A) nominal

2.3 PHYSICAL SPECIFICATIONS

Table 2-2 lists and describes the physical specifications for the MD01 Controller.

Table 2-2. Physical Specifications

Parameter	Description
Packaging	Single board, 5 1/4-inch footprint, 5 3/4-inch by 8-inch
Cabling	Single 20-conductor, radial data cable and daisy chained 34-conductor control cable
Mounting	Mounts on a mounting bracket contained in the ST506 5 1/4-inch Winchester disk drive subsystem

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3.1 OVERVIEW

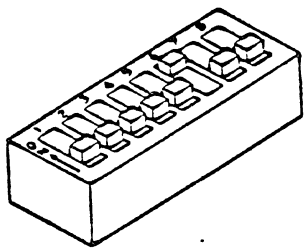
This section describes the step-by-step procedure for installing the MD01 Controller, including switch setting data and physical installation instructions. This installation procedure is divided into five subsections, as listed in the following table:

Subsection	Title
3.1	Overview
3.2	Inspection
3.3	MD01 Controller Setup
3.4	MD01 Controller Installation
3.5	FCC Compliance

If you are unfamiliar with the MD01 Controller installation procedure, we recommend reading this Installation Section before beginning.

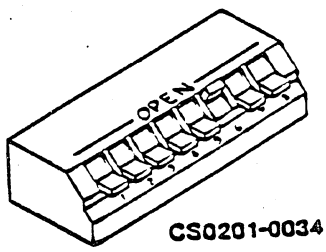
3.1.1 DIP SWITCH TYPES

DIP switches used in this product may be either of two types:



Slide Switch:

To place a slide switch in the ON position, slide the switch in the direction marked ON or CLOSED. To place a slide switch in the OFF position, slide the switch in the direction marked OFF or OPEN.



Piano Switch:

To place a piano switch in the ON position, move the switch toward the ON or CLOSED position. To place a piano switch in the OFF position, move the switch toward the OFF or OPEN position.

Switch-setting tables in this manual use numeral one (1) to indicate the ON (closed) position and numeral zero (0) to indicate the OFF (open) position, except where noted.

3.2 INSPECTION

Emulex products are shipped in special containers designed to provide full protection under normal transit conditions. Immediately upon receipt, the shipping container should be inspected for evidence of possible damage incurred in transit. Any obvious damage to the container, or indications of actual or probable equipment damage, should be reported to the carrier company in accordance with instructions on the form included in the container.

Unpack the MD01 Controller and verify that all components listed on the shipping invoice are present. Verify that the model or part number (P/N) designation, revision level, and serial numbers agree with those on the shipping invoice. These verifications are important to confirm warranty. If evidence of physical damage or identity mismatch is found, notify an Emulex representative immediately.

A visual inspection of the MD01 Controller is recommended after unpacking. Specific checks should be made for such items as bent or broken connector pins, damaged components or any other visual evidence of physical damage. Carefully examine all socketed components to ensure they are firmly and completely seated.

3.3 MD01 SCSI CONTROLLER SETUP

The switches in DIP switch packs SW1 and SW2 on the MD01 Controller allow configuration of various options available with the MD01 Controller. All switches on the MD01 Controller are set to a standard configuration before the MD01 Controller is shipped from the factory. DIP switch functions are listed and described in applicable tables in this section. Table 3-1 lists the function and factory configuration of all switches on the MD01 Controller. This subsection provides an overview of the switch settings, as well as a description of the function of each switch.

Table 3-1. DIP Switch Settings, MD01 SCSI Controller

Switch	Factory Setting	Function	Section
SW1-1	OFF (0)	Encoded Drive Type (LSB)	3.3.1
SW1-2	OFF (0)	Encoded Drive Type	3.3.1
SW1-3	OFF (0)	Encoded Drive Type	3.3.1
SW1-4	OFF (0)	Encoded Drive Type	3.3.1
SW1-5	OFF (0)	Encoded Drive Type	3.3.1
SW1-6	OFF (0)	Encoded Drive Type (MSB)	3.3.1
SW1-7	OFF (0)	Sector Size	3.3.2
SW1-8	OFF (0)	CPU Speed	3.3.3
SW2-1	OFF (0)	SCSI Bus Address (LSB)	3.3.4
SW2-2	OFF (0)	SCSI Bus Address	3.3.4
SW2-3	OFF (0)	SCSI Bus Address (MSB)	3.3.4
SW2-4	ON (1)	EPROM Selection	3.3.5
SW2-5	OFF (0)	Number of Spare Sectors/Track	3.3.6
SW2-6	OFF (0)	Number of Spare Sectors/Track	3.3.6
SW2-7	OFF (0)	Buffered Step Option	3.3.7
SW2-8	OFF (0)	Drive Configuration Source	3.3.8

ON (1) = Closed
OFF (0) = Open

Figure 3-1 shows the locations of the configuration switches, connectors, and jumpers referenced in the subsections below. The configuration switches should be set before the MD01 Controller and the disk drive are installed in a subsystem because the switches may not be accessible after the MD01 Controller/disk drive unit is installed.

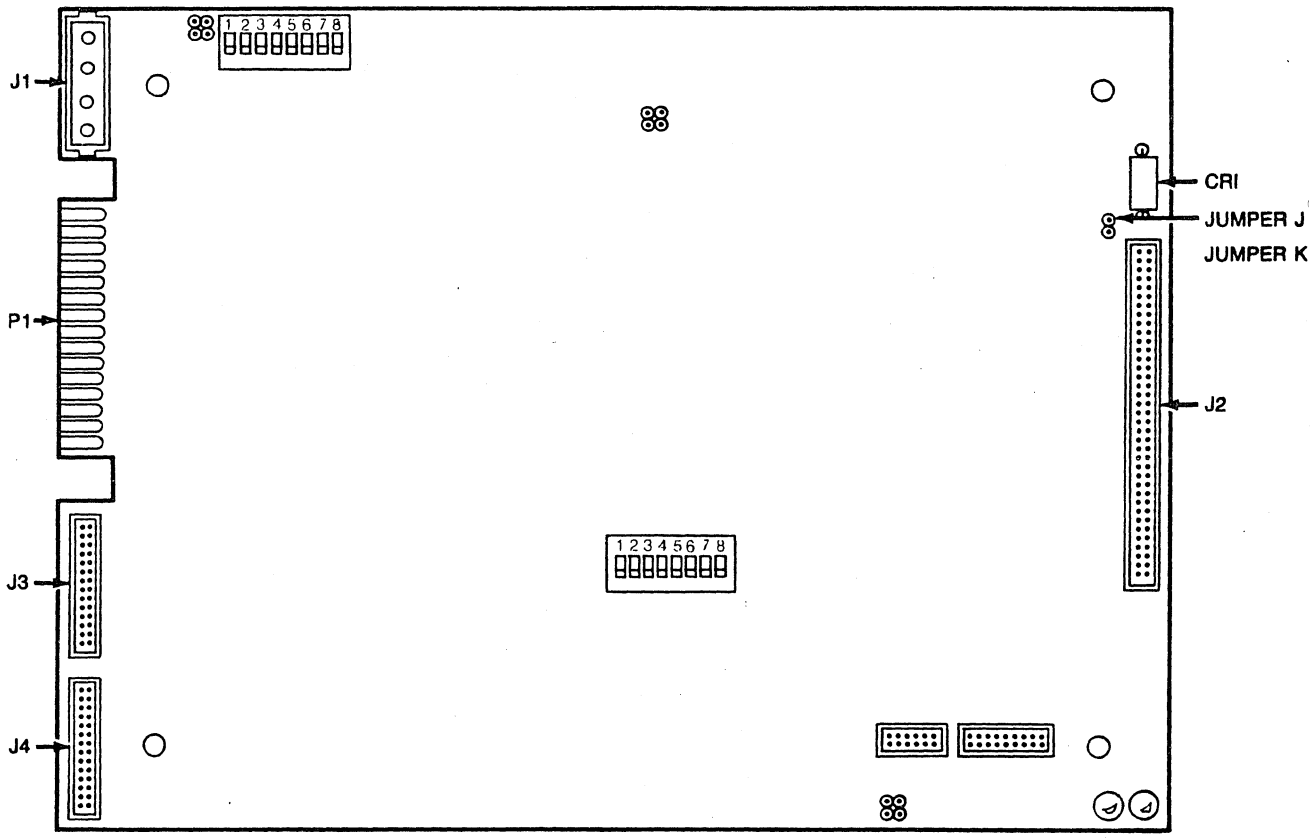


Figure 3-1. MD01 Switch and Jumper Locations

3.3.1 ENCODED DRIVE TYPE (SW1-1:SW1-6)

If switch SW2-8 is ON (closed), switches SW1-1 through SW1-6 are used to specify disk drive parameters. The switch settings specify a location in a table located in the firmware on the MD01 Controller. This table, called the Disk Drive Configuration Table, contains a list of all the disk drives currently supported by the MD01 Controller. Each disk drive entry in the table is associated with definitions of five parameters for that disk drive. The five parameters (and their corresponding mnemonic representation) are listed below.

- Last Sector Number/Track (LSN) - This parameter specifies the last sector number on the track. Since the sectors are numbered starting at zero, the last sector number/track parameter is equal to the total number of sectors/track less one.

- Last Track Address (LTA) - This parameter specifies the last track address on the disk drive. Since the heads on the disk drive are numbered starting at zero, the last track address parameter is equal to the total number of heads on the disk drive less one.

- Last Cylinder Address (LCA) - This parameter specifies the last cylinder address on the disk drive. Since the cylinders on the disk drive are numbered starting at zero, the last cylinder address parameter is equal to the total number of cylinders on the disk drive less one.

- Write Precompensation Cylinder Number (WPC) - This parameter specifies the number of the cylinder at which the disk drive will write data to disk using a time-precompensated form. The time-precompensated form is necessary for Write operations to inner cylinders (cylinders located near the center of the disk) where data is stored at a higher density than the density at outer cylinders. At inner cylinders, a magnetic effect (called peak shifting) occurs which is caused by the tendency of closely spaced flux reversal domains to migrate physically away from each other into areas of lower density. In the time-precompensated form, flux reversals that would tend to be shifted late due to magnetic interference are written early, and those that would tend to be shifted early are written late.

- Reduced Write Current Cylinder Number (RWC) - This parameter specifies the number of the cylinder at which the disk drive will supply a different amount of current to the head during a Write operation. The write current supplied to a selected head is not the same for all cylinder locations. More current is supplied for a Write operation on an outer cylinder than is supplied for an Write operation on an inner cylinder. If the write current is not reduced when writing on inner cylinders, flux saturation occurs. This action reduces frequency response and increases data interference (called crosstalk).

The disk drive entries (that specify those disk drive types supported by the MD01 Controller) contained in the Disk Drive Configuration Table are listed in Table 3-2.

Table 3-2. Disk Drive Configuration Table Entries

Switch SW1-6 MSB	SW1-5	SW1-4	SW1-3	SW1-2	SW1-1 LSB	Disk Drive Type	Config. Entry #
0	0	0	0	0	0	Maxtor xt-1000 (256 byte sectors)	1
0	0	0	0	0	1	Maxtor xt-1000 (512 byte sectors)	2
Config. Entry # = Disk Drive Configuration Table Entry Number							
0 = OFF (OPEN) 1 = ON (CLOSED)							

The parameters associated with each entry in the Disk Drive Configuration Table are listed in Table 3-3.

Table 3-3. Parameters for Entries in Disk Drive Configuration Table

Configuration Table Entry Number	LSN	LTA	LCA	WPC	RWC
1	31	6	284H	140H	140H
2	15	6	284H	140H	140H

LSN = Last Sector Number/Track
LTA = Last Track Address
WPC = Write Precompensation Cylinder Number
RWC = Reduced Write Current Cylinder Number
H = hexadecimal value

3.3.2 SECTOR SIZE (SW1-7)

The setting on switch SW1-7 indicates the size of the sector on the disk drive. Setting this switch to ON (closed) indicates the sector size on the disk drive is 256 bytes. Setting this switch to OFF (open) indicates the sector size is 512 bytes.

The sector size is selected by switch SW1-7. Normally, switch SW1-7 is set to OFF, as shown in the following table:

Switch	OFF	ON	Factory
SW1-7	512 bytes	256 bytes	OFF

3.3.3 CPU SPEED (SW1-8)

The setting on switch SW1-8 indicates the CPU speed of the on-board 8031 Microprocessor. Setting this switch to ON (closed) indicates the CPU speed is 12 Megahertz. Setting this switch to OFF (open) indicates the CPU speed is 10 Megahertz.

The CPU speed is selected by switch SW1-8. Normally, switch SW1-8 is set to OFF, as shown in the following table:

Switch	OFF	ON	Factory
SW1-8	10 Megahertz	12 Megahertz	OFF

3.3.4 SCSI DEVICE ADDRESS SELECTION (SW2-1:SW2-3)

Switches SW2-1, SW2-2, and SW2-3 are used to select any one of eight possible SCSI bus addresses. This address establishes the SCSI bus identity of the MD01 Controller in the system. An Initiator must specify this address to select the MD01 Controller as a Target device. Switch settings for the eight possible MD01 Controller Device Address identities are listed in Table 3-4. Make sure you do not assign the same SCSI Device Address to two separate host adapters or controllers.

Table 3-4. SCSI Device Address Selection Switches

Switch			SCSI Device Address
SW2-3 (MSB)	SW2-2	SW2-1 (LSB)	
0	0	0	00
0	0	1	01
0	1	0	02
0	1	1	03
1	0	0	04
1	0	1	05
1	1	0	06
1	1	1	07
0 = OFF (OPEN) 1 = ON (CLOSED)			

3.3.5 EPROM SELECTION (SW2-4)

The setting on switch SW2-4 specifies the memory size of the EPROM installed on the MD01 Controller. Setting this switch to ON (closed) indicates the MD01 Controller EPROM has a memory size of 256 kilobytes. Setting this switch to OFF (open) indicates the MD01 Controller EPROM has a memory size of 128 kilobytes.

The memory size of the on-board EPROM is indicated by switch SW2-4. Normally, SW2-4 is set to ON, as shown in the following table:

Switch	OFF	ON	Factory
SW2-4	128-kilobyte	256-kilobyte	ON

3.3.6 NUMBER OF SPARE SECTORS PER TRACK (SW2-5:SW2-6)

The setting on switches SW2-5 and SW2-6 specify the number of spare sectors per track available on the disk drive. Switch settings for the number of spare sectors per track are listed in Table 3-5.

Table 3-5. Number of Spare Sectors/Track Selection Switches

Switch SW2-5	Switch SW2-6	Number of Spare Sectors/Track
0	0	0 spares
0	1	1 spares
1	0	2 spares
1	1	3 spares

3.3.7 BUFFERED STEP OPTION (SW2-7)

The setting on switch SW2-7 indicates if the disk drive Step operation (involving the time intervals in which Step signal pulses occur) is or is not to be buffered. Setting this switch to ON (closed) indicates the Step operation is to be buffered. Setting this switch to OFF (open) indicates the Step operation is is not to be buffered.

The Buffered Step option is selected by switch SW2-7. Normally, switch SW2-7 is set to OFF, as shown in the following table:

Switch	OFF	ON	Factory
SW2-7	Nonbuffered	Buffered	OFF

3.3.8 DRIVE CONFIGURATION SOURCE (SW2-8)

Switch SW2-8 specifies if switches SW1-1 through SW1-7 and SW2-5 through SW2-8 are valid and are to be used to specify disk drive parameters. When this switch is ON (closed), the switches are valid. When this switch is OFF (open), the switches are not valid and disk drive parameters must be determined from the results of a **MODE SELECT** command (see subsection 8.3.4).

The Drive Configuration Source is determined by switch SW2-8. Normally, switch SW2-8 is set to OFF, as shown in the following table:

Switch	OFF	ON	Factory
SW2-8	**MODE SELECT** command	Switches SW1-1 through SW1-7, switches SW2-5 through SW2-8	OFF

NOTE

If two different types of disk drives (i.e., they do not have the same parameters such as sector size, brand-type, number of sectors/track, etc.) are connected to the **same** MD01 Controller, the disk drive parameters specified by switches SW1-1 through SW1-7 and SW2-5 through SW2-8 are not valid.

3.3.9 SCSI TERMINATION OPTION

The SCSI Termination option allows the MD01 Controller to supply +5 Vdc power to the terminators. If the SCSI Termination option is required, install a #IN5820 diode at reference designator CR1 on the MD01 Controller printed circuit board (PCBA). Also connect a wire-wrap jumper between jumper posts J and K on the MD01 Controller (see Figure 3-1) to supply +5 Vdc for the SCSI bus termination.

- - - - - - - - -
C A U T I O N
- - - - - - - - -

If diode leads are reversed so that anode of the diode is in wrong hole, system does not function properly.

If diode CR1 is to be installed, insert diode leads in holes provided at upper right corner of PCBA (see Figure 3-1). The anode of the diode must be inserted in hole next to reference designator CR1. After proper insertion of diode, secure it in place by soldering its leads on reverse (circuit) side of PCBA.

3.4 MD01 SCSI CONTROLLER INSTALLATION

To install the MD01 Controller in the disk drive chassis, see Figures 3-2 through 3-4 and use the following procedure:

1. Configure MD01 Controller. This action involves setting the switches on switch packs SW1 and SW2 before installing the MD01 Controller on the mounting bracket in the subsystem that contains the disk drive(s). All switches have been set at factory; however, you may need to reset certain switches to satisfy your specific needs.

2. Place disk drive subsystem on flat surface.

3. Place MD01 Controller (component side up) on top of mounting bracket. Align four screw holes on MD01 Controller with four screw holes on mounting bracket (see Figure 3-2). Secure MD01 Controller in place with four 4-40 x 1/4-inch screws.

4. Connect control cable from disk drive to 34-pin IDC connector P1 on MD01 Controller (see Figure 3-3).

5. Connect data cable from disk drive to 20-pin IDC connector J3 and/or J4 on MD01 Controller (see Figure 3-3).

6. Connect cable from power supply to power connector J1 on MD01 Controller (see Figure 3-3).

7. Connect SCSI bus cable to SCSI bus connector J2 on MD01 Controller (see Figure 3-4).

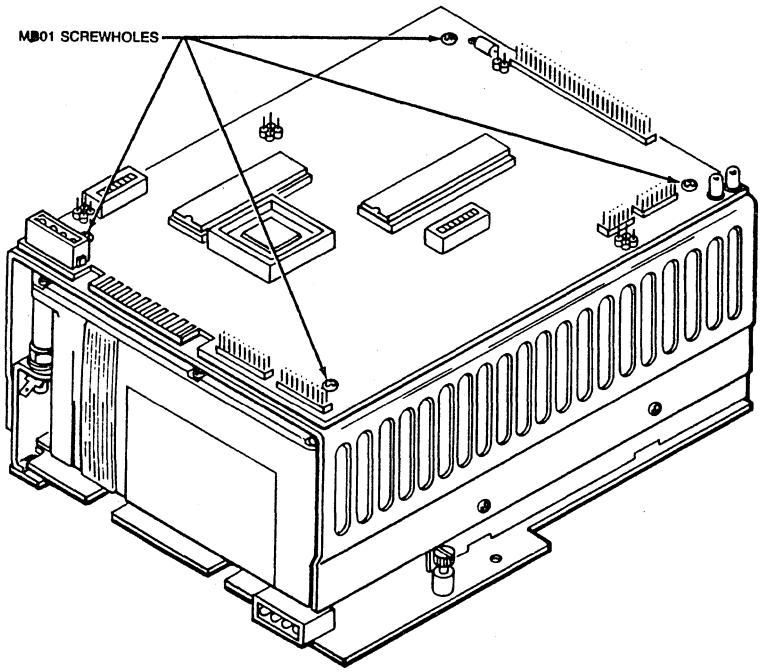


Figure 3-2. Installing MD01 Controller on Mounting Bracket

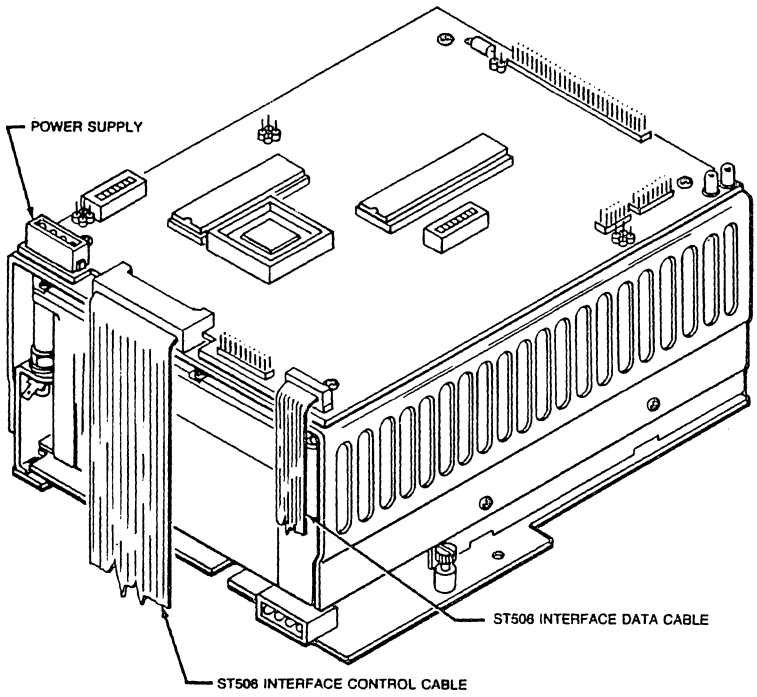


Figure 3-3. Connecting Disk Drive Data and Control Cables to MD01 Controller

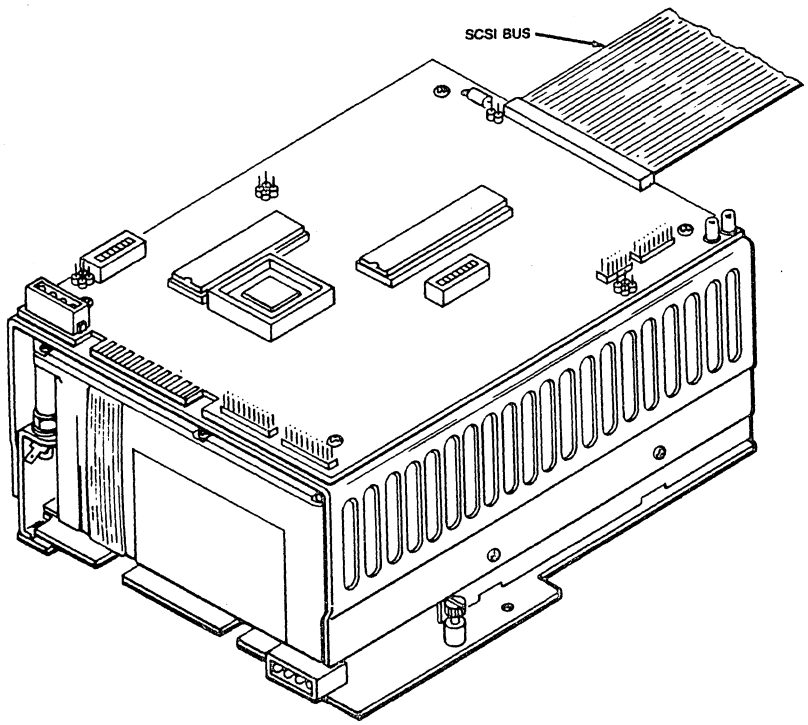


Figure 3-4. Connecting SCSI bus to MD01 Controller

3.5 FCC COMPLIANCE

The Federal Communications Commission (FCC) has established technical standards regarding radiation of electromagnetic interference (EMI) emitted by computing devices. The MD01 Controller has been type tested and found to comply with the EMI emission limits for a Class B computing device in accordance with the specifications in Subpart J of Part 15 of FCC Rules. However, there is no guarantee that interference will not occur in a particular installation.

The MD01 Controller was tested for FCC compliance in a compliant subsystem that was properly shielded (enclosed so that no electromagnetic radiation escapes). The subsystem was connected to other SCSI port devices via a shielded SCSI cable. Emulex offers shielded cables, compatible with the MD01 Controller, that are available in various lengths. For information on SCSI bus cable and connector requirements, see subsection 6.2.1.

Since the MD01 Controller equipment generates and uses radio frequency energy, if it is not installed and used in strict accordance with Emulex's instructions, it may cause EMI with radio and television reception. It is the responsibility of the user to properly install the MD01 Controller and ST506 disk drive in a subsystem. MD01 Controller installation instructions are described in subsection 3.4. Emulex is not responsible for any radio or TV interference caused by unauthorized modifications to the MD01 Controller.

4.1 OVERVIEW

This section describes the several diagnostic features with which the MD01 Controller is equipped. The MD01 Controller diagnostic procedures include power-up (and reset) self-test, and on-line host-initiated diagnostic routines. The principal purpose for these tests is to determine MD01 Controller functional integrity and to distinguish between MD01 Controller failures and disk drive failures. This section is divided into three subsections, as listed in the following table:

Subsection	Title
4.1	Overview
4.2	Power-Up Self-Test
4.3	On-Line Diagnostic Commands

4.1.1 SERVICE

The components of your Emulex MD01 Controller have been designed to give years of trouble-free service, and they were thoroughly tested before leaving the factory.

If one of the diagnostic procedures described in this section indicates a component is not working properly, the MD01 Controller must be returned to the factory, or to an Emulex authorized repair center, for service. Emulex products are not designed to be repaired in the field.

Before returning the component to Emulex, whether the product is or is not under warranty, contact Emulex Customer Support, or your nearest Emulex representative, for instructions and a Return Materials Authorization (RMA) number.

DO NOT RETURN AN MD01 CONTROLLER TO EMULEX WITHOUT AUTHORIZATION. An MD01 Controller returned for service without an authorization will be returned to the owner at the owner's expense.

In the continental United States, Alaska, and Hawaii contact:

Emulex Customer Support
3545 Harbor Boulevard
Costa Mesa, CA 92626
(714) 662-5600 TWX 910-595-2521

Outside the United States, contact the distributor from whom the MD01 Controller was initially purchased.

After you have received an RMA number, package the MD01 Controller (preferably by using the original packing material) and send the MD01 Controller **POSTAGE PAID** to the address provided by Emulex or your Emulex representative. The sender should also insure the package.

4.2 POWER-UP SELF-TEST

When power-up or reset conditions occur, the MD01 Controller performs a self-test to determine if its interface circuits, memory, and on-board microprocessor are operative. The self-test consists of several individual tests that exercise separate components of the MD01 Controller. These tests are performed sequentially; successful completion of one test enables the next test to be executed. If any individual test fails, the MD01 Controller self-test stops all self-test activities on the MD01 Controller.

Before the Self-Test procedure begins, a Power-up Reset Clear code is output to the two on-board LEDs to indicate the MD01 Controller is ready to perform a self-test. If the MD01 Controller Self-Test procedure succeeds, a Self-Test Pass code is output to the on-board LEDs. The LED locations on the MD01 Controller are shown in Figure 4-1, and LED Test Code descriptions are listed in Table 4-1.

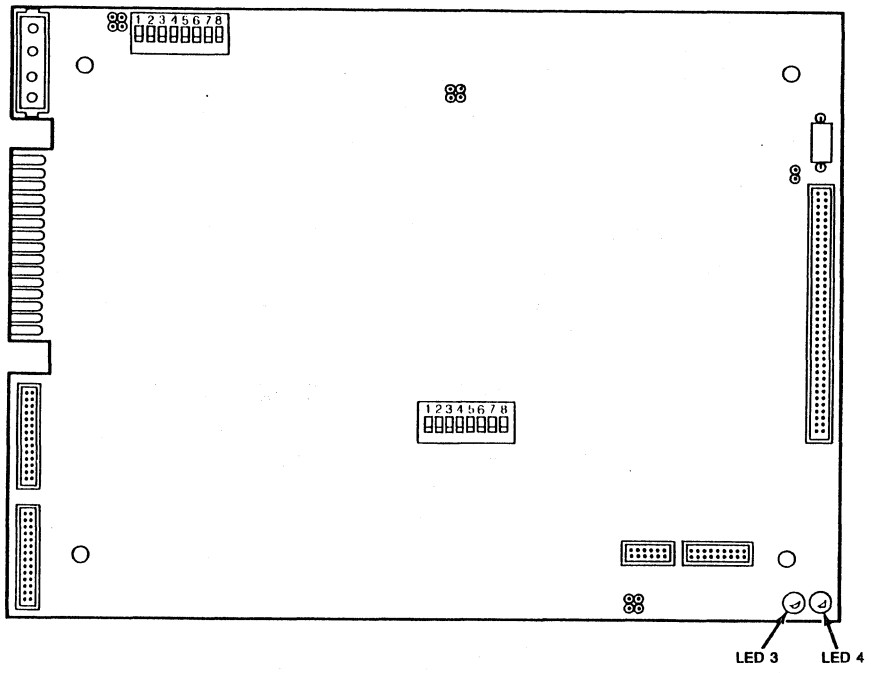


Figure 4-1. Location of LEDs on MD01 Controller

Table 4-1. LED Test Code Descriptions

LED4	LED3	Test Description
0	0	Power-up Reset Clear
1	1	Power-Up Self-Test Pass Code
0 = OFF (not lit)		1 = ON (lit)

After the Self-Test procedure is successfully completed, the MD01 Controller continues with the Initialization routine. If the SCSI interface circuits and the 8031 Microprocessor are functioning, the MD01 Controller enters the On-Line mode and is available to the Initiator. At this time, the Power-Up Self-Test Pass Code (see Table 4-1) is displayed by the on-board LEDs. Failures in the Disk Formatter and/or disk drive result in a CHECK CONDITION status code on the **TEST UNIT READY** command (see subsection 8.3.15) or on Data Transfer commands (such as **READ, WRITE,** etc.). Further analysis of these failures can be made by using the **SEND DIAGNOSTIC** command (see subsection 8.3.14).

NOTE

If the MD01 Controller self-test is invoked on-line, the host-supplied context is lost. MD01 Controller context must be re-submitted to the MD01 Controller by using the **MODE SELECT** command (see subsection 8.3.4).

4.3 ON-LINE DIAGNOSTIC SUBCOMMANDS

The MD01 Controller supports a set of on-line diagnostic subcommands, which are used to further delineate peripheral or MD01 Controller failures. These diagnostic subcommands are specified by the **RECEIVE DIAGNOSTIC** command and executed by the **SEND DIAGNOSTIC** command. The diagnostic subcommands are listed in Table 4-2 and described in subsection 8.3.14. The host may detect the diagnostic subcommand execution has been completed if the MD01 Controller responds to other commands after it has been Reset. If a failure occurs, the MD01 Controller halts. The host can issue a SCSI bus Reset instruction to cause a retry of the diagnostic procedures.

NOTE

Execution of the Self-Test diagnostic routine automatically Resets the MD01 Controller.

Table 4-2. MD01 Controller Diagnostic Subcommands

Diagnostic Subcommand	Description
PERFORM DRIVE DIAGNOSTICS	Causes MD01 Controller to perform Write and Verify operations on each surface of the diagnostic cylinder of the specified disk drive cylinder.
READ BAD SECTOR FILE	Causes MD01 Controller to transfer the contents of the Bad Sector File to the Initiator.
READ DISK PARTITIONS	Causes MD01 Controller to transfer the physical addresses related to the logical partitions on the specified disk drive to the Initiator.
READ LONG	Causes MD01 Controller to perform a Read operation of one data block, starting at the specified block address.
WRITE LONG	Causes MD01 Controller to perform a Write operation of one data block, starting at the specified block address.

5.1 OVERVIEW

This section describes MD01 Controller architecture and disk operation. For reference convenience, this section is divided into three subsections, as listed in the following table:

Subsection	Title
5.1	Overview
5.2	MD01 Controller Architecture
5.3	Disk Operations

5.2 MD01 CONTROLLER ARCHITECTURE

Figure 5-1 is a block diagram that shows the major functional elements of the MD01 Controller. The MD01 Controller is organized around the 8031 Microprocessor and the Disk Formatter and Buffer Controller custom VLSI chips designed by Emulex.

Two buses are used in the MD01 Controller: the Data Bus and the Microprocessor Bus.

The Data Bus is connected directly to the Disk Formatter, Buffer Memory, and Buffer Controller. The Buffer Controller is connected directly to the Buffer Memory and the Microprocessor Bus. Therefore, the Data Bus and Buffer Controller provide a data path between the registers in the Disk Formatter, the Buffer Memory, and the 8031 Microprocessor.

The Microprocessor Bus provides a path for transmission of control and status information. This information may be passed between the 8031 Microprocessor, the EPROM, the Buffer Controller, and the Disk Interface.

5.2.1 8031 MICROPROCESSOR

The 8031 Microprocessor (with the Disk Formatter) controls all disk drive operations. These operations include drive control, head positioning, and reading drive status. The Disk Formatter controls formatting of the data that is written to, and read from, the disk drive. The 8031 Microprocessor generates Read and Write commands that are executed by the Disk Formatter. All Read and Write commands involve operations only on a single data block (256 or 512 bytes).

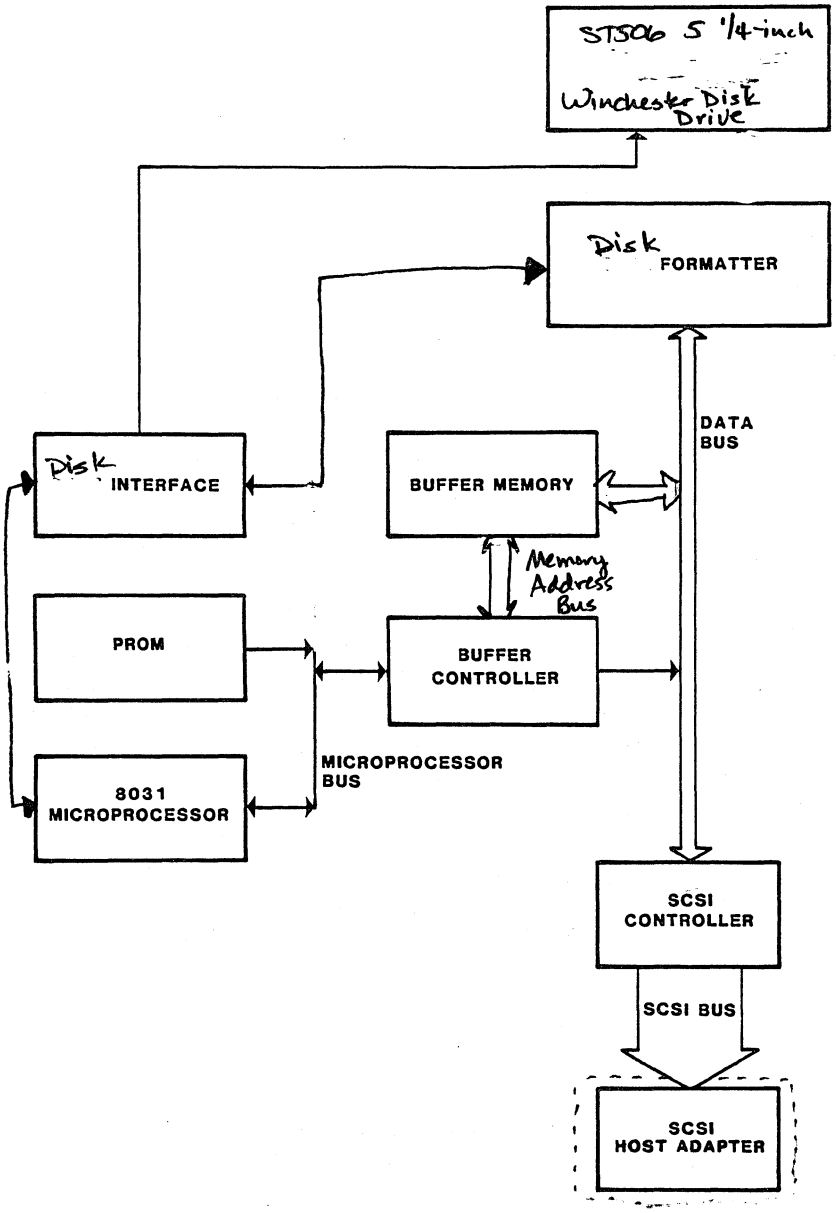


Figure 5-1. MD01 SCSI Controller Block Diagram

5.2.2 DISK FORMATTER

The Disk Formatter is a 40-pin VLSI integrated circuit fabricated with CMOS gate array technology. This circuit, in conjunction with the 8031 Microprocessor, handles the Read and Write operations of the disk drives.

5.2.3 BUFFER CONTROLLER

The Buffer Controller is a 68-pin VLSI integrated circuit fabricated with CMOS gate array technology. The circuit is basically a three-channel DMA controller. The Buffer Controller controls data movement into or out of a dynamic buffer memory and provides the connection between the Microprocessor bus and the Data bus.

The Buffer Controller circuit provides the address and control for multiple MD01 Controller activities accessing a dynamic buffer memory. The Buffer Controller does the following:

- handles addressing and control operations for the Disk Formatter.
- handles dynamic memory timing and refresh.
- performs parity checking and generation for the Buffer Memory.
- connects the Microprocessor bus to the Data bus.
- decodes the microprocessor address for the buffer memory and the internal MD01 Controller I/O space.
- determines priority of buffer memory access.

5.3 DISK OPERATIONS

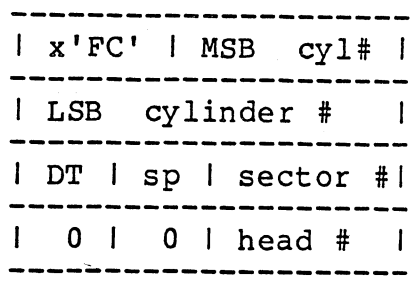
The following subsections describe MD01 Controller functions during disk operations.

5.3.1 TRACK FORMAT OPERATIONS

Data tracks are formatted with track addresses and appropriate sector addresses in each header. The MD01 Controller supports a 4-byte header; it is shown in Figure 5-2. The track address is defined as the cylinder and head address of the specified track. Spare sectors are allocated on each track. The spare sectors are used as a data storage sector if another sector on the same track becomes defective. The interleave factor is considered when the MD01 Controller formats a data track.

When a data track develops multiple error conditions which cannot be resolved by the use of spare sectors, the MD01 Controller reformats that data track as a flawed track. A defective data track is reformatted with the track address of the allocated alternate track in the header of each sector. Each header has the Defective Track bit set. The MD01 Controller does not consider the interleave factor when it formats a defective track.

An alternate track is a track in the reserved controller storage area on the disk drive. An alternate track remains unformatted until allocated as a data storage track. When an alternate track is allocated, it is formatted with the sector address of the defective track. The MD01 Controller considers the interleave factor when it formats an alternate track.



where:

DT - indicates defective track (will be set in each header of the track)

sp - indicates spare sector on the track

Figure 5-2. MD01 Controller Disk Header Format

5.3.2 BAD SECTOR FORMAT OPERATIONS

The MD01 Controller maintains the Bad Sector File (BSF) on one cylinder in an area that is not accessible to the host. The BSF is duplicated on each head of the BSF cylinder and may not be larger than a track. The BSF format is shown below.

Byte	Function
00	Length of Bad Sector File (Number of blocks)
01	Number of Remaining Alternate Tracks (MSB)
02	Number of Remaining Alternate Tracks (LSB)
03	Next Alternate Track Logical Block Address (MSB)
04	Next Alternate Track Logical Block Address
05	Next Alternate Track Logical Block Address
06	Next Alternate Track Logical Block Address (LSB)
07	Number of Bad Sector File Entries (MSB)
08	Number of Bad Sector File Entries (LSB)
09-15	Spare

Length of Bad Sector File - Byte 00

This byte specifies the length, in number of blocks, of the BSF.

Number of Remaining Alternate Tracks - Bytes 01 through 02

These bytes specify the number of remaining Alternate Tracks on the disk drive.

Next Alternate Track Logical Block Address - Bytes 03 through 06

These bytes specify the Logical Block Address of the next logical Alternate Track.

Number of Bad Sector File Entries - Bytes 07 through 08

These bytes specify the number of BSF entries.

The MD01 Controller formats data for each BSF entry in the following format:

Byte	Function
16 + 8(n-1)	Original Logical Block Address (MSB)
	Original Logical Block Address
	Original Logical Block Address
	Original Logical Block Address (LSB)
20+ 8(n-1)	Alternate Logical Block Address (MSB)
	Alternate Logical Block Address
	Alternate Logical Block Address
	Alternate Logical Block Address
	Alternate Logical Block Address

6.1 OVERVIEW

This section describes the interfaces used by the MD01 Controller. It includes information about how the MD01 Controller implements the SCSI bus interface electrical and mechanical requirements. This section is divided into four subsections, as listed in the following table:

Subsection	Title
6.1	Overview
6.2	SCSI Bus Interface
6.3	User's Panel Connection
6.4	Disk Drive Interface

6.2 SCSI BUS INTERFACE

Information about MD01 Controller implementation of SCSI bus electrical and mechanical requirements is provided in this subsection.

6.2.1 SCSI BUS INTERFACE PHYSICAL DESCRIPTION

SCSI bus devices are daisy-chained with a common cable, both ends of the cable are terminated. All signals are common between all SCSI bus devices. The MD01 Controller supports the SCSI specification single-ended option for drivers and receivers. The maximum cable length allowed is six meters (primarily for interconnection outside of the subsystem cabinet in which the MD01 Controller is installed).

6.2.1.1 Cable Requirements

A 50-conductor flat cable or a 25-twisted-pair flat cable must be used to connect SCSI bus host adapters and controllers. The maximum cable length is six meters. Each SCSI bus connection must have a 0.1-meter maximum stub length. SCSI bus termination can be internal to the SCSI devices located at the ends of the SCSI bus cable (such as the subsystem that contains the MD01 Controller and the ST506 disk drive or drives).

6.2.1.2 Shielded Cable Requirements

The connector for the SCSI bus shielded cable is a 50-pin connector that contains two rows of 25 female contacts on 100 mil centers. The system shielding via the connector ground pin must provide a dc resistance of less than 10 milliohms from the termination point of the connector ground pin to the SCSI device enclosure.

6.2.2 SCSI INTERFACE ELECTRICAL DESCRIPTION

The MD01 Controller interfaces to SCSI host adapters and other controllers via the SCSI bus (see Figure 1-2). A 50-pin male IDC connector reference designated J2 on the MD01 Controller plugs directly into the SCSI bus. Component locations for the MD01 Controller are shown in Figure 6-1. All signals use open collector drivers.

When measured at the SCSI device's connection, each signal driven by a SCSI device has the following output characteristics:

- Signal assertion = 0.0 Vdc to 0.4 Vdc
- Minimum driver output capability = 48 milliamperes (mA) (sinking) at 0.5 Vdc
- Signal negation = 2.5 Vdc to 5.25 Vdc.

All assigned signals are terminated with 220 Ohms to +5 Volts (nominal) and 330 Ohms to ground at each end of the SCSI cable as shown in Figure 6-2.

When measured at the SCSI device's connection, each signal received by a SCSI device has the following input characteristics:

- Signal true = 0.0 Vdc to 0.8 Vdc
- Maximum total input load = -0.4 mA at 0.4 Vdc
- Signal false = 2.0 Vdc to 5.25 Vdc
- Minimum input hysteresis = 0.2 Vdc.

6.2.2.1 Terminator Power (Optional)

The MD01 Controller supports the single-ended SCSI option; that is, it provides pin 26 with termination power that has the following characteristics:

V_{TERM} = 4.0 Vdc to 5.25 Vdc (through diode)
800 mA maximum source drive capability

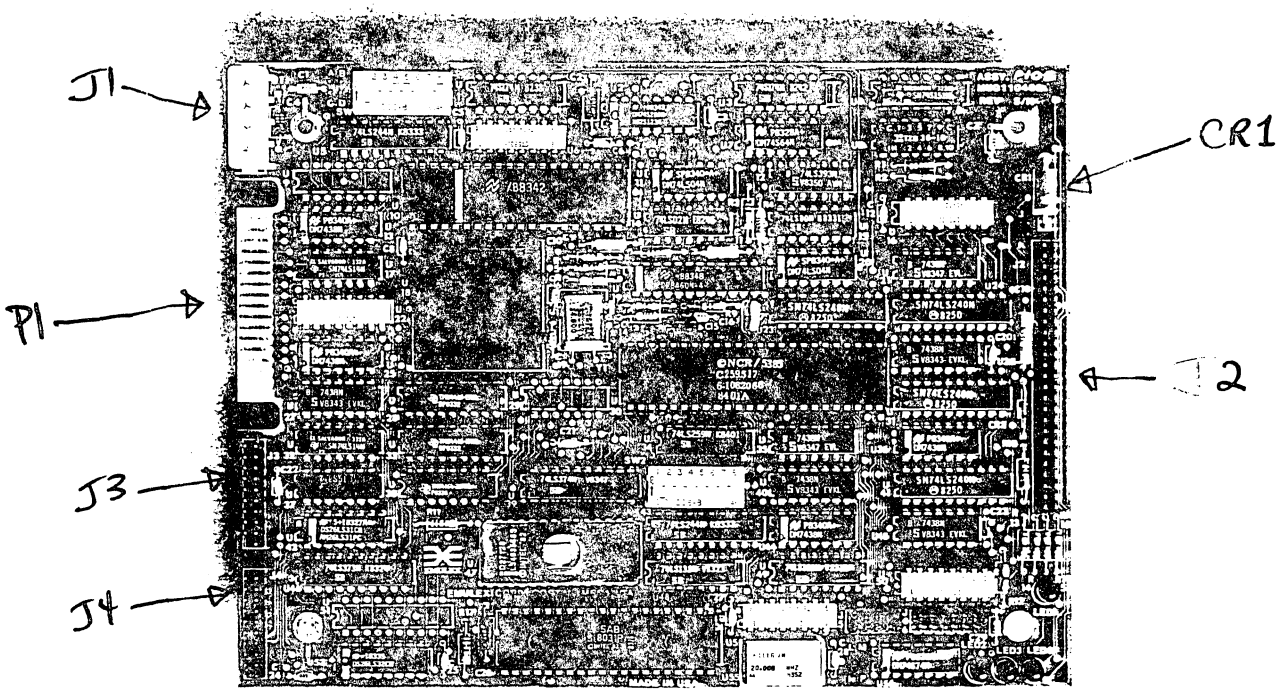


Figure 6-1. MD01 SCSI Disk Controller

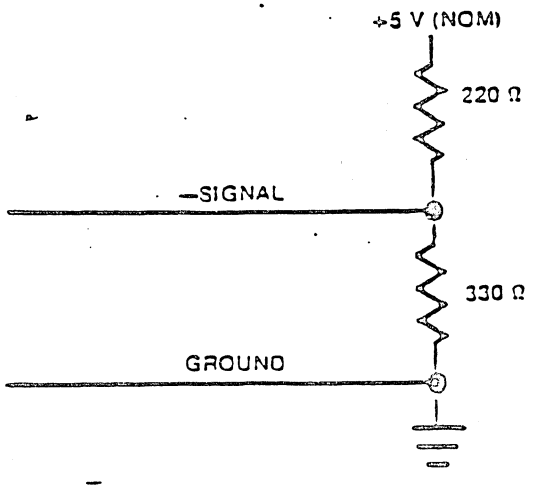


Figure 6-2. SCSI Bus Signals Termination

6.2.3 SCSI BUS SIGNALS AND TIMING

SCSI bus activities involve one or more of the following SCSI phases of operation:

- Arbitration Phase
- Selection Phase
- Reselection Phase
- Command Phase
- Data Phase
- Status Phase
- Message Phase.

These phases are described in Subsection 7.3. When the SCSI bus is not involved in one of the above phases, it is in the Bus Free Phase. SCSI phase sequencing is accomplished by asserting or de-asserting the SCSI signals; the signals are described in Subsection 6.2.3.1.

6.2.3.1 SCSI Bus Signals

There are 18 signals on the SCSI bus. Nine signals are control signals that coordinate transfer of data between SCSI host adapters/controllers; nine signals are for an eight-bit data bus with parity. The signals are listed and described in Table 6-1.

In Table 6-1, the eight data bit signals are represented by DB0 through DB7; DB7 is the most significant bit and has the highest priority during the Arbitration Phase. Bit number, significance, and priority decrease downward to DB0. The parity, represented by the DBP signal, is always odd. All host adapters/controllers on the SCSI bus generate parity and have parity detection enabled. During the Arbitration Phase, parity is not guaranteed to be valid.

Pin/signal assignments for the SCSI bus interface are listed in Table 6-2; they support only the SCSI single-ended option.

Table 6-1. SCSI Bus Signals

Mnemonic Name	Signal	Description
DB0	Data Bus	Data Bus Bit 0
DB1	Data Bus	Data Bus Bit 1
DB2	Data Bus	Data Bus Bit 2
DB3	Data Bus	Data Bus Bit 3
DB4	Data Bus	Data Bus Bit 4
DB5	Data Bus	Data Bus Bit 5
DB6	Data Bus	Data Bus Bit 6
DB7	Data Bus	Data Bus Bit 7
DBP	Data Bus	Data Bus Parity
ACK	Acknowledge	Indicates acknowledgement for a REQ/ACK data transfer handshake operation
REQ	Request	Indicates a request for a REQ/ACK data transfer handshake operation
ATN	Attention	Indicates ATTENTION condition (i.e., the Initiator has a message to send to the Target). The ATTENTION condition is described in Subsection 7.7.2.
RST	Reset	Indicates RESET condition (i.e., clears the SCSI bus of all activity). The RESET condition is described in subsection 7.7.1.
SEL	Select	Used to select/reselect a SCSI bus device
BSY	Busy	Indicates the SCSI bus is being used
C/D	Control/Data	Indicates command/status information transfer or data in/data out transfer
I/O	Input/Output	Indicates direction of data movement on the data bus with respect to an Initiator
MSG	Message	Indicates the SCSI bus is in the Message Phase

Table 6-2. Pin/Signal Assignments at SCSI Bus Interface

Pin	Signal Name	Input/Output
1	GND	--
2	-D0	Input/Output
3	GND	--
4	-D1	Input/Output
5	GND	--
6	-D2	Input/Output
7	GND	--
8	-D3	Input/Output
9	GND	--
10	-D4	Input/Output
11	GND	--
12	-D5	Input/Output
13	GND	--
14	-D6	Input/Output
15	GND	--
16	-D7	Input/Output
17	GND	--
18	-DP (Data parity)	Input/Output
19	GND	--
20	N/C	--
21	GND	--
22	N/C	--
23	GND	--
24	N/C	--
25	Optional GND	--
26	Optional Vcc	--
27	GND	--
28	N/C	--
29	GND	--
30	N/C	--
31	GND	--
32	-ATN	Input/Output
33	GND	--
34	N/C	--
35	GND	--
36	-BSY	Input/Output
37	GND	--
38	-ACK	Input/Output
39	GND	--
40	-RST	Input/Output
41	GND	--
42	-MSG	Input/Output
43	GND	--
44	-SEL	Input/Output
45	GND	--
46	-C/D	Input/Output
47	GND	--
48	-REQ	Input/Output
49	GND	--
50	-Input/Output	Input/Output

6.2.3.2 SCSI Bus Timings

Except where noted, the delay time measurements for each SCSI device (host adapter or controller) is calculated from signal conditions existing at the SCSI bus connection for that device. Normally these measurements do not consider delays in the SCSI cable. The SCSI timings are listed and described in Table 6-3.

The timing diagram shown in Figure 6-3, shows the typical relationship between SCSI bus signals and SCSI phase sequencing.

Table 6-3. SCSI Bus Timings

Timing	Duration	Description
Arbitration Delay	2.2 μ s	The minimum time a SCSI host adapter or controller needs from the time the -BSY signal is asserted for arbitration until the MD01 Controller can examine the Data Bus to determine if arbitration has been won. There is no maximum time.
Bus Clear Delay*	800 ns	The maximum time a SCSI host adapter or controller requires to stop driving all SCSI bus signals after: 1) a Bus Free Phase is detected 2) the -SEL signal is received from another SCSI host adapter or controller during the Arbitration Phase.
Bus Free Delay	800 ns	The minimum time a SCSI host adapter or controller waits after it has detected the Bus Free Phase until it asserts the BSY signal when going to the Arbitration Phase.

* In the Bus Clear Delay, for condition 1) the maximum time allowed for a SCSI device to clear the SCSI bus is 1200 ns from the time the -BSY and -SEL signals both first become false. If a SCSI device requires more than a Bus Settle Delay to detect the Bus Free Phase, it clears the SCSI bus within the time duration of a Bus Clear Delay minus the excess time.

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Table 6-3. SCSI Bus Timings (continued)

Timing	Duration	Description
Bus Set Delay	1.8 μs	The maximum time a SCSI host adapter or controller is allowed after it detects a Bus Free Phase to assert the -BSY signal and the SCSI ID bit on the Data Bus as a requirement for entering the Arbitration Phase.
Bus Settle Delay	400 ns	The time for the SCSI bus needs to settle after changing certain control signals.
Cable Skew Delay	10 ns	The maximum difference allowed in propagation time between any two SCSI bus signals when measured between any two SCSI bus devices.
Deskew Delay	45 ns	This time is used to calculate the minimum time required for deskew of certain signals.
Reset Hold Time	25 μs	The minimum time for which the RST signal is to be asserted. There is no maximum time.
Selection Abort Time	200 μs	The maximum timeout duration a Target (or Initiator) must take from its most recent detection of being selected (or reselected) until it asserts the BSY signal. This timeout is required to ensure a Target (or Initiator) does not assert the BSY signal after a Selection (or Reselection) Phase has been aborted. This timeout is not the same thing as the Selection Timeout Delay.
Selection Timeout Delay	250 ms	The minimum recommended time an Initiator (or Target) should wait for a -BSY response, during the Selection or Reselection Phase, before starting the timeout procedure.

ms = milliseconds
s = microseconds
ns = nanoseconds

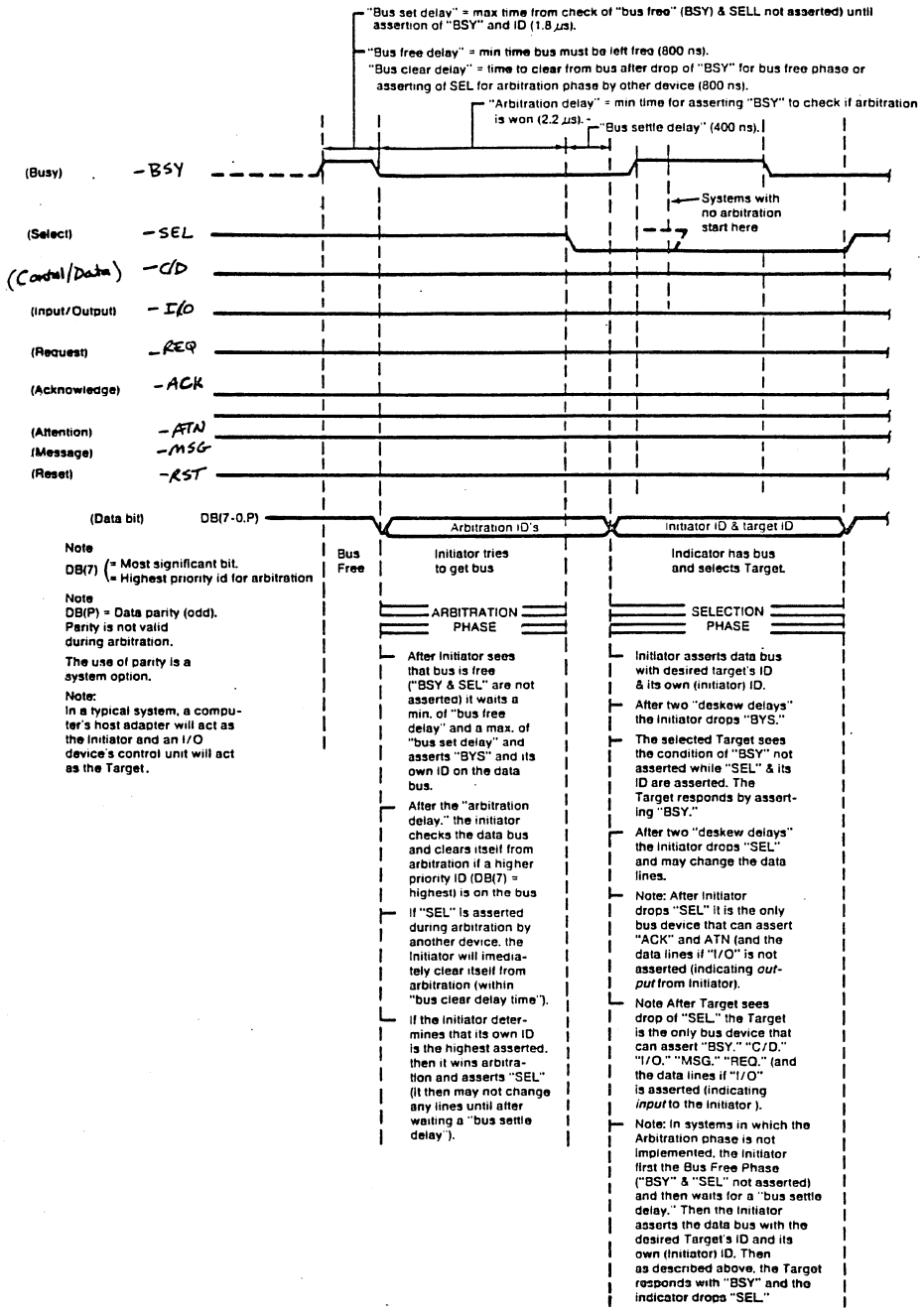

Figure 6-3. SCSI Bus Timing Diagram (Sheet 1 of 3)

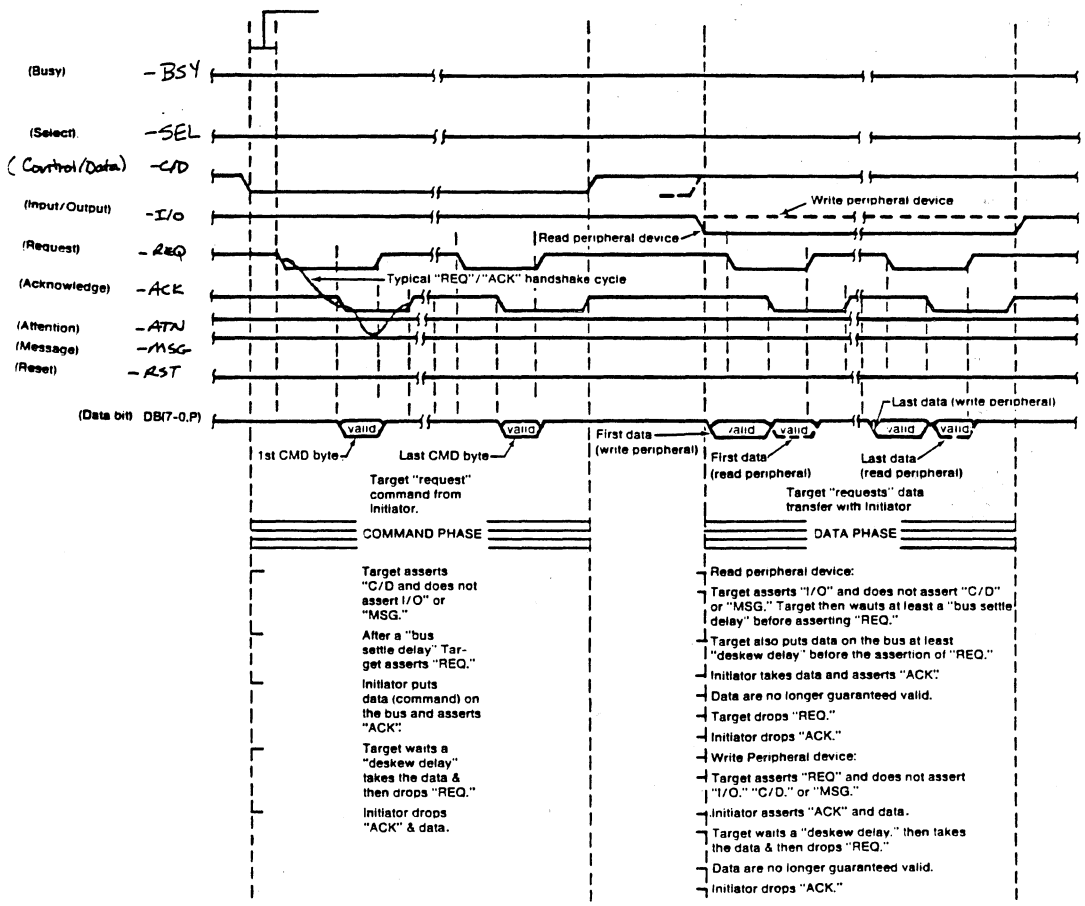

Figure 6-3. SCSI Bus Timing Diagram (Sheet 2 of 3)

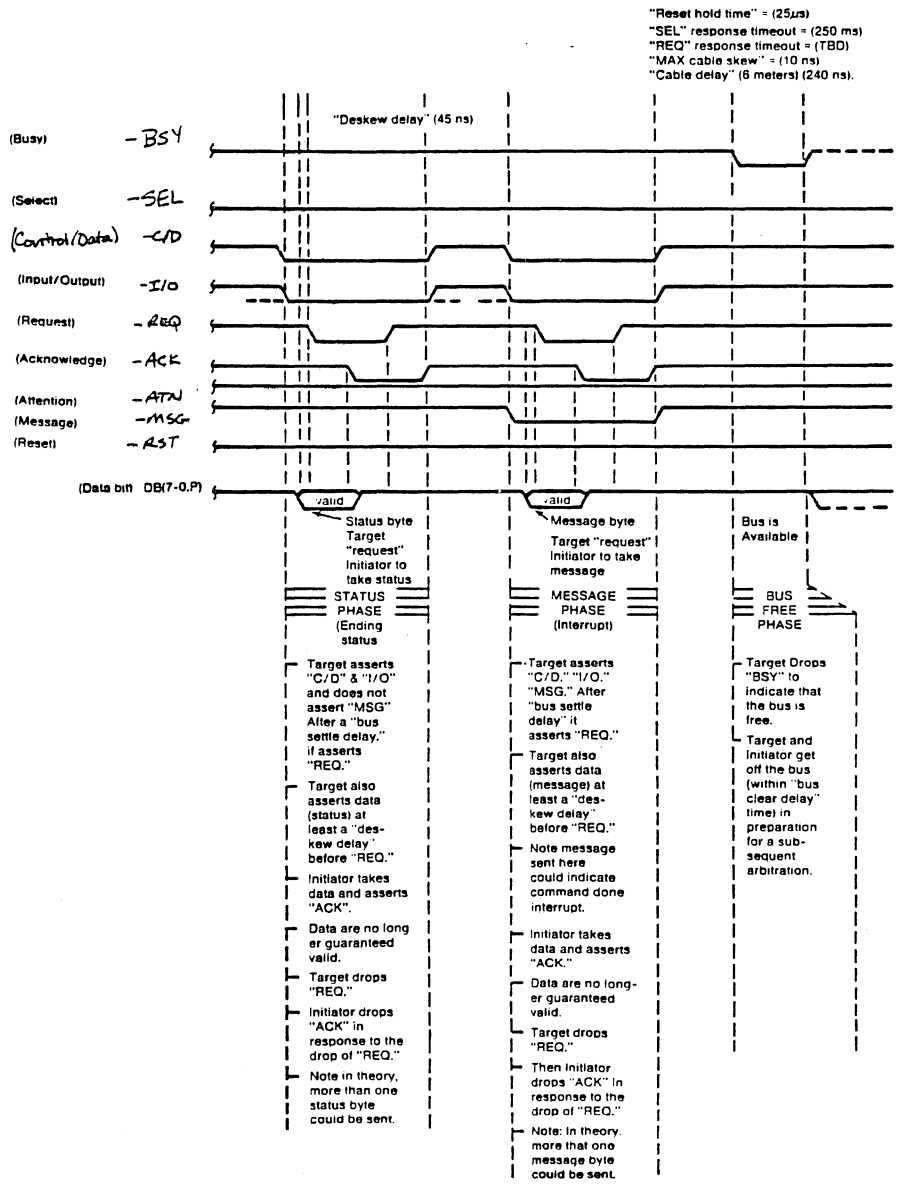

Figure 6-3. SCSI Bus Timing Diagram (Sheet 3 of 3)

6.3 MD01 CONTROLLER USER'S PANEL CONNECTION

Connector J5 (see Figure 6-1) on the MD01 Controller is used to connect the MD01 Controller to external LEDs. On Emulex subsystems, these external LEDs are on the user's panel located on the subsystem bezel. The connector pin descriptions are listed in Table 6-4 and described in this subsection.

Table 6-4. External LEDs Connector Pin Description

Pin-out	Connection	True	Function
J5-1	Ground	--	--
J5-2	--	--	--
J5-3	SW3	High	Not Used
J5-4	LED 3	Low	Drive 1 Write Protect On
J5-5	SW2	High	Drive 1 Write Protect
J5-6	LED 2	Low	Drive 1 Ready
J5-7	LED 1	Low	Drive 0 Write Protect On
J5-8	SW1	High	Drive 0 Write Protect
J5-9	LED 0	Low	Drive 0 Ready
J5-10	+5 volts	--	

LED 0 Ready - When the low level is applied to this signal line, LED 0 is lit to indicate Disk Drive 0 is in the On-Line mode and not busy.

LED 1 Write Protect On - When the low level is applied to this signal line, LED 1 is lit to indicate Disk Drive 0 is write protected.

LED 2 Ready - When the low level is applied to this signal line, LED 2 is lit to indicate Disk Drive 1 is in the On-Line mode and not busy.

LED 3 Write Protect On - When the low level is applied to this signal line, LED 3 is lit to indicate Disk Drive 1 is write protected.

6.4 ST506 DISK DRIVE INTERFACE

The MD01 Controller interfaces with an ST506 disk drives via a 34-pin control cable and an 20-pin data cables. A 34-pin male IDC connector at reference designator P1 on the MD01 Controller plugs directly into the ST506 disk drive control cable. The MD01 Controller contains two 20-pin male IDC connectors, one at reference designator J3 and one at reference designator J4. The MD01 Controller can integrate up to a maximum of two disk drives. Either 20-pin connector (reference designator J3 or J4) can plug directly into the data cable for the first disk drive. If a second disk drive is configured, the unused 20-pin connector is plugged into the data cable for that disk drive.

The pin/signal assignments for control signal interface between the MD01 Controller and an ST506 disk drive are shown in Figure 6-4. The pin/signal assignments for data signal interface between the MD01 Controller and an ST506 disk drive are shown in Figure 6-5.

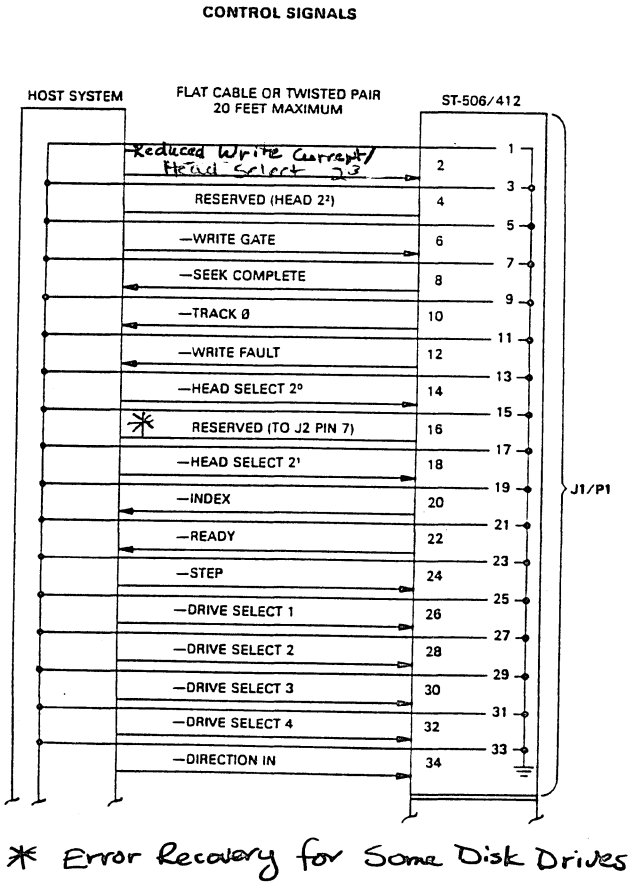

Figure 6-4. Control Pin/Signal Assignments at ST506 Disk Drive Interface

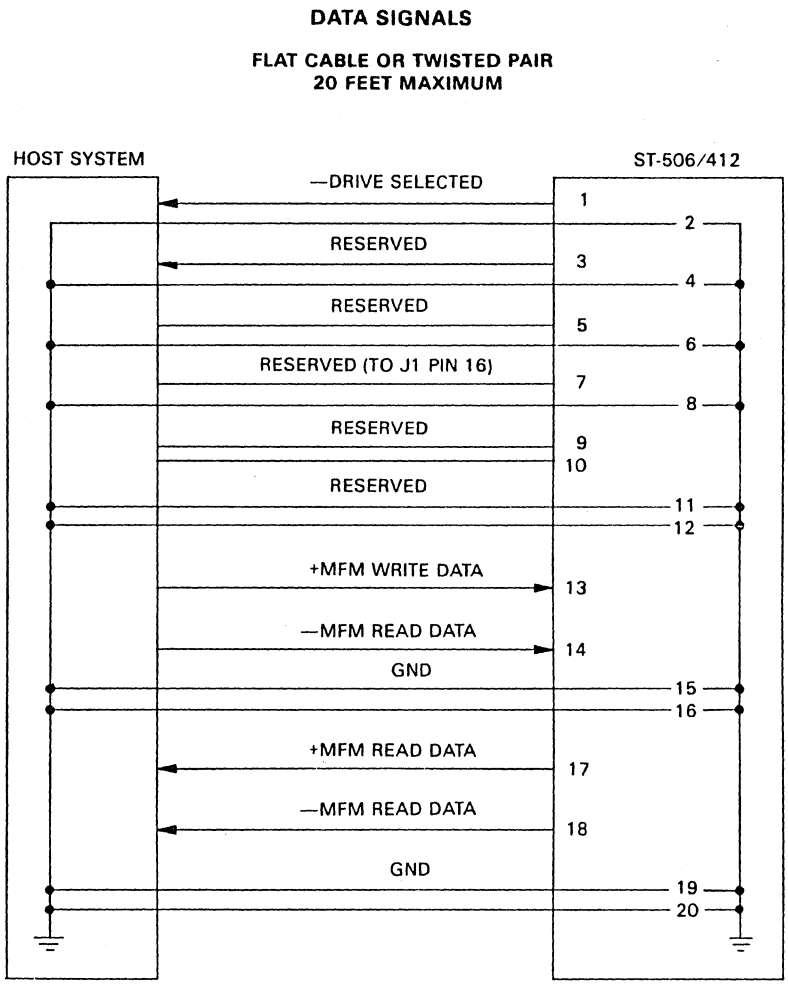

Figure 6-5. Data Pin/Signal Assignments at Disk Drive Interface

7.1 OVERVIEW

This section describes the SCSI bus protocol; it includes information on SCSI bus phases and phase sequencing, procedures for queuing SCSI bus commands, and procedures for passing control and status information between SCSI bus host adapters and controllers by using SCSI memory address pointers. This section is divided into seven subsections, as listed in the following table:

Subsection	Title
7.1	Overview
7.2	SCSI Bus Overview
7.3	SCSI Bus Phases
7.4	SCSI Bus Phase Sequencing
7.5	SCSI Memory Address Pointers
7.6	SCSI Command Queuing
7.7	SCSI Bus Conditions

7.2 SCSI BUS DESCRIPTION

The Small Computer System Interface (SCSI) is a standard interface established to support mass storage, printer output, and network communication for microcomputers and minicomputers. The interface is an eight-port, daisy-chained bus. The SCSI command standard for the MD01 Controller is based on the ANSI X3T.2/82-2 Revision 14 (24 April 84) SCSI Interface Specification.

Up to eight SCSI host adapters and/or controllers can be supported by the SCSI bus. Each controller can be connected to a maximum of eight devices (called Logical Unit Numbers, or LUNs). The MD01 Controller hardware supports any combination of host adapters, intelligent controllers or intelligent peripherals connected to the SCSI bus. The MD01 Controller supports up to two LUNs (ST506 disk drives). Three basic SCSI configurations are supported with the MD01 Controller and SCSI bus:

- single initiator, single target
- single initiator, multi target
- multi initiator, multi target.

Communication on the SCSI bus occurs between a host adapter and a controller. (The MD01 Controller also supports communication between two controllers, as in a Copy operation.) When a host adapter and a controller communicate, one acts as the Initiator and one acts as the Target. The Initiator (usually the host adapter) originates an operation and the Target (usually a peripheral controller such as the MD01 Controller) performs the operation. Sample system configurations supported by MD01 Controller hardware are shown in Figure 7-1.

Some SCSI bus functions are assigned to the Initiator and some functions are assigned to the Target. The Initiator can arbitrate for control of the SCSI bus and select a specific Target. The Target can request the transfer of command, data, status, or other information via the SCSI bus. In some circumstances, the Target can arbitrate for control of the SCSI bus to reselect an Initiator and continue an operation. Sometimes, the Target becomes an Initiator and arbitrates for control of the SCSI bus; e.g., when it performs a Copy operation.

SCSI bus Data Transfer Operations are asynchronous and follow a defined request/acknowledge (REQ/ACK) handshake protocol. (This protocol is defined in the ANSI SCSI specification.) One eight-bit byte of information can be transferred with each handshake.

The SCSI bus consists of 18 signal lines. Nine signal lines are for an eight-bit data bus with parity; the other nine signal lines are for control and status signals that coordinate Data Transfer operations between the host adapter and SCSI controllers. SCSI bus signals are described in detail in Section 6.2.3.1.

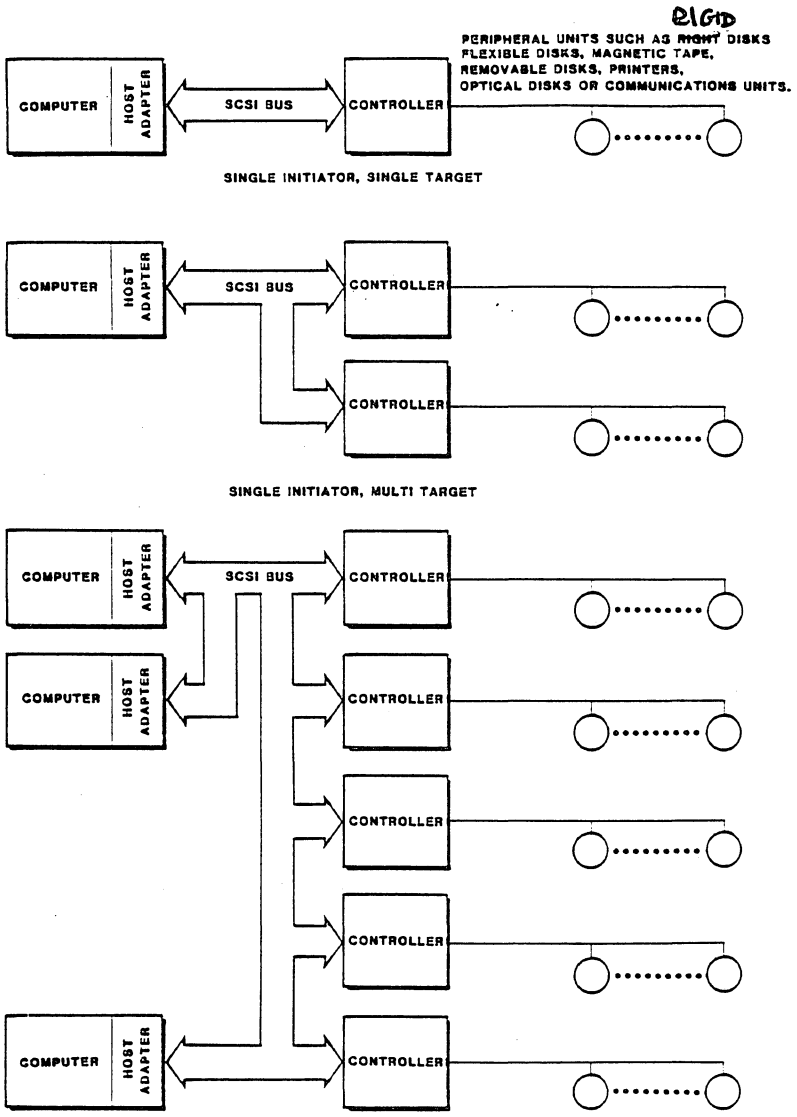

Figure 7-1. Sample SCSI Bus Configurations

7.3 SCSI BUS PHASES

The activities on the SCSI bus can be divided into seven phases of operation:

- Arbitration
- Selection
- Reselection
- Command
- Data
- Status
- Message.

These phases are supported as specified by the ANSI SCSI specification (listed in subsection 1.1.1). The phases are individually discussed in subsequent subsections. The last four phases (Command, Data, Status, and Message) are grouped together as Information Transfer Phases.

When the SCSI bus is not involved in one of the SCSI bus phases, it is in a Bus Free Phase. The Bus Free Phase indicates no host adapter or controller is actively using the SCSI bus and the SCSI bus is available for subsequent users.

The SCSI bus activities, implemented by the MD01 Controller, include the disconnect and reselection capabilities. Overlapped operations on multiple controllers and multiple logical units are supported.

In the following subsections, no attempt is made to detail the SCSI bus signal sequences; the signals are listed in subsection 6.2.3.1. If detailed signal sequence information is required, refer to the ANSI SCSI standard listed in subsection 1.1.1.

7.3.1 ARBITRATION PHASE

The Arbitration Phase is an optional implementation on the SCSI bus. This phase is used when multiple controllers/processors vie for SCSI bus ownership. Since multiple hosts adapters and/or controllers may desire control of the SCSI bus concurrently, arbitration for the SCSI bus is a requirement for the MD01 Controller.

7.3.2 SELECTION AND RESELECTION PHASES

The SCSI Selection and Reselection Phases provide methods for establishing a link between the Initiator and a desired Target.

Usually the MD01 Controller is selected by an Initiator to perform some function (e.g., Read or Write data). The controller then has the option of disconnecting from the SCSI bus. When the MD01 Controller needs to re-establish the link to its original Initiator, it reselects that Initiator.

For the Copy function, however, the MD01 Controller can behave as an Initiator and select another controller as a Target source or destination for the Copy operation. While in the Initiator mode, the MD01 Controller always issues an IDENTIFY message (see subsection 7.3.3.4) after selecting a Target.

The SCSI Selection and Reselection Phases can be terminated for any one of three conditions:

1. The preceding Selection or Reselection Phase is successfully completed by using the Selection/Reselection handshake protocol.

2. A Selection/Reselection timeout occurs. The timeout results if any Target or Initiator does not respond to the Selection/Reselection Phase within a timeout period of two seconds.

3. A Reset (-RST) signal occurs on the SCSI bus. When this signal is asserted, all SCSI bus sequences are immediately terminated and the SCSI bus signals are released by all Initiators and Targets.

The Initiator can use the Attention (-ATN) signal to notify the MD01 Controller that a message from the Initiator is ready. To guarantee the Target recognizes the Attention condition before the Command Phase is entered, the -ATN signal level must be true before the Selection or Reselection Phase is completed.

If an IDENTIFY message is used during the Selection Phase sequence, the specified Logical Unit Number (LUN) has precedence over the LUN field in the Command Descriptor Block (CDB). (CDB's are described in detail in Section 8.) The IDENTIFY message also informs the Target if the Initiator supports the Disconnect function (see Subsection 7.6, SCSI Command Queuing).

NOTE

If the Initiator selects a non-existent LUN, a vendor unique status of non-existent device (NED bit) and a CHECK CONDITION error status message is returned in the Status Byte (see Subsection 7.3.3.3.1). Selected LUNs that have not been initialized by the MD01 Controller report a BUSY status; e.g., at startup, or not connected to the controller.

7.3.3 INFORMATION TRANSFER PHASES

The Command, Data, Status, and Message Phases are grouped together as Information Transfer Phases because they are all used to transfer data or control information via the SCSI data bus. The Information Transfer Phases are described in the following subsections.

7.3.3.1 Command Phase

The Command Phase allows the Target to request command information from the Initiator. An Initiator issues SCSI commands to a Target by transferring a command packet, called a Command Descriptor Block (CDB). The length of the SCSI command and the meaning of the information in the command packet depends on which command is being transferred. (See Section 8 for definitions of SCSI commands and all SCSI CDBs supported by the MD01 Controller.)

The last byte of every command packet is a control byte and can be differentiated into the following bit groups:

- The low order two bits control the ability of linking commands in a sequence and notifying the host adapter when a particular command (CDB) step is completed. These two bits are designated Flag and Link in the descriptions of MD01 command packets in Section 8.

- The remaining bits in the control byte are reserved bits, and are always zero.

The remainder of the bytes of the command packet are primarily command-dependent.

The Command Phase is interrupted only for the following exception conditions:

- Reset Condition - This condition can occur when the SCSI Reset (RST) signal is asserted or a power fail/power-off condition in the Target occurs. In this case, the Command Phase and the connection established during the Select/Reselect Phase is terminated by the Target with the release of the BSY signal.

- Parity Error Condition - The Target detects a parity error on the SCSI bus during the Command Transfer operation. At this time, the MD01 Controller issues a RESTORE POINTERS message (see subsection 7.3.3.4) and tries once again to retrieve the command. If it cannot, the BSY signal is released and the connection is terminated.

7.3.3.2 Data Phase

The Data Phase of a connection controls the transfer of data between the Initiator and Target devices. The Data Phase includes both the Data In and the Data Out Phases. The Data In Phase allows the Target to request sending of data to the Initiator from the Target. The Data Out Phase allows the Target to request sending of data from the Initiator to the Target. The direction of the Data Transfer operation depends on the command being processed. Some commands may have no data to be transferred and therefore have a null Data Phase. Only the Asynchronous Data Transfer mode is supported by the MD01 Controller.

The Data Phase is interrupted only for the following exception conditions:

- Reset Condition - This condition can occur when the SCSI Reset (-RST) signal is asserted or when a power fail/power-off condition in the Target occurs. In this condition, the Data Phase and the connection established during the Select/Reselect Phase is terminated by the Target with the release of the -BSY signal.

- Data In Parity Error Condition - The Target detects a parity error on the SCSI bus during the Data Transfer operation from the Initiator to the Target. While in the Data Phase, the MD01 Controller periodically issues SAVE DATA POINTER messages to the Initiator. If the Target detects a parity error, a RESTORE DATA POINTER message is sent to the Initiator to attempt error recovery. For a discussion of the SCSI Memory Address Pointers, see subsection 7.5.

- Data Out Parity Error Condition - The Initiator detects a parity error on the SCSI bus during the Data Transfer operation from the Target to the Initiator. The Initiator can then assert the -ATN signal along with the Acknowledge (-ACK) signal. The Target detects this condition and enters the Message mode to receive a message. The Initiator sends an Initiator-detected error message in response. The Target immediately terminates the command with a CHECK CONDITION status message indicated in the status byte. An optional response to an Initiator-detected Data Phase parity error is to flag the Data Transfer operation as an error and re-issue the command when the current command has terminated.

7.3.3.3 Status Phase

The Status Phase is used by the Target to send completion information to the Initiator. The status is sent in a single byte, the format of which is defined in subsection 7.3.3.3.1.

The Target can initiate the Status Phase when any one of the following conditions occur:

- Busy Status - The Selection Phase is completed and the Target is in a BUSY state and unable to process any commands for an extended period of time. The Target can initiate the Status Phase immediately after this condition occurs. The status byte transferred has the BUSY status code set.

- Reservation Conflict Status - The Command or Reselection Phase is completed and the specified LUN is reserved for another Initiator. The status byte transferred has the RESERVATION CONFLICT status code set.

- Terminated Status - At the termination of a command. The status byte transferred has the GOOD STATUS code set to indicate the success of the command.

NOTE

In multi-Initiator environments, the Initiator delays a minimum of 200 microseconds before attempting another selection of a Target if a BUSY status for that Target is received.

7.3.3.3.1 Status Byte Format. The format of the status byte used by the Target to send completion information to the Initiator is defined below.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	Status Code				NED

Status Command Code - Bits <04:01>

These bits are used to specify the status command. Table 7-1 lists and describes the status codes.

Non-Existent Device (NED) - Bit 00

When the NED bit is set to one, the Initiator selected a LUN which is not configured in the system.

Table 7-1. Status Codes

Bits 04	03	02	01	Status	Description
X	0	0	0	GOOD STATUS	The MD01 Controller successfully completed the command.
0	0	0	1	CHECK CONDITION	An error, exception, or abnormal condition occurred.
X	0	1	0	CONDITION MET	A search condition is satisfied.
0	1	0	0	BUSY	The MD01 Controller is busy.
1	0	X	0	INTERMEDIATE STATUS	Sent for every command in a series of linked commands (see subsection 7.3.3.1) unless a CHECK CONDITION or RESERVATION CONFLICT status is detected.
1	1	0	0	RESERVATION CONFLICT	Sent to an Initiator that attempts to access a LUN connected to the MD01 Controller when another Initiator has reserved the LUN.
1 = Set				0 = Cleared	X = Don't Care

7.3.3.4 Message Phase

The Message Phase is used to transfer information about exception conditions between the Initiator and the Target. The Message Phase includes both the Message In and the Message Out Phases. The Message In Phase allows a Target to request that messages be sent to the Initiator from the Target. The Message Out Phase allows a Target to request that messages be sent from the Initiator to the Target. Messages from the MD01 Controller are a single byte in length; they (and their corresponding hexadecimal codes) are listed and described in Table 7-2.

Table 7-2. MT01 SCSI Messages

Code	Message	Description
00	COMMAND COMPLETE	Issued by the Target just before releasing the -BSY signal at the end of a command execution. This message is generally sent immediately after a Status Phase.
02	SAVE DATA POINTER	Issued by the Target to direct the Initiator to save a copy of the present active data pointer. This message is issued periodically during multiple block transfers.
03	RESTORE POINTERS	Issued by the Target to direct the Initiator to restore the most recently saved command, data, and status pointers in the corresponding current pointers. Command and status pointers are restored to the beginning of the current command in the absence of a SAVE DATA POINTER message, the data pointer is restored to the value it had at the beginning of the command or at the point where the last SAVE DATA POINTER message occurred. Pointers are described in subsection 7.6.
04	DISCONNECT	Issued by the Target just before releasing the -BSY signal to indicate to the Initiator that the present physical connection is temporarily broken with this message. The current data, command, and status pointers are not saved.
05	INITIATOR DETECTED ERROR	Issued by an Initiator to inform the Target that an error has occurred during a Read operation. At this time, the MD01 Controller retries the operation.
06	ABORT	Issued by the Initiator to the Target to clear the specified LUN and cause the SCSI bus to go to the Bus Free Phase.

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Table 7-2. MT01 SCSI Messages (continued)

Code	Message	Description
07	MESSAGE REJECT	Issued by the Initiator or Target in response to a received message that was undefined.
08	NO OPERATION	A null message issued by the Initiator if the Target requests a message from the Initiator but the Initiator has no message to convey.
09	MESSAGE PARITY ERROR	Issued by the Initiator to inform the MD01 Controller that a parity error has occurred on a Message Receive operation from the Target to the Initiator.
0A	LINKED COMMAND COMPLETE	Issued by the Target to the Initiator to indicate the completion of a linked command (see subsection 7.3.3.1).
0B	LINKED COMMAND COMPLETE WITH FLAG	Issued by the Target to the Initiator to indicate the completion of a linked command that had the Flag bit set.
0C	BUS DEVICE RESET	Issued by the Initiator to the Target to reset all current I/O on the SCSI bus MD01 Controller. This message generates a hard Reset Condition (see subsection 7.7.1).
80-FF	IDENTIFY *	Issued by the Target or Initiator to establish a connection to a particular LUN. The following bits have particular meaning: Bit 07 - Always set to one. Bit 06 - Set if the Initiator can support Disconnect and Reconnect sequences. Bits <02:00> - Specify (hexadecimal) LUN address in a Target.

* If the Disconnect function is supported, this message is issued to the MD01 Controller at the beginning of every command sequence.

7.4 SCSI BUS PHASE SEQUENCING

The status of the SCSI bus is a function of the control signals. (The control signals are described in subsection 6.2.3.) These signals place the SCSI bus in one of four phases: Arbitration, Selection/Reselection, Information Transfer, or Bus Free (see subsection 7.3). The order in which SCSI bus phases are used follows the prescribed sequence shown in Figure 7-2.

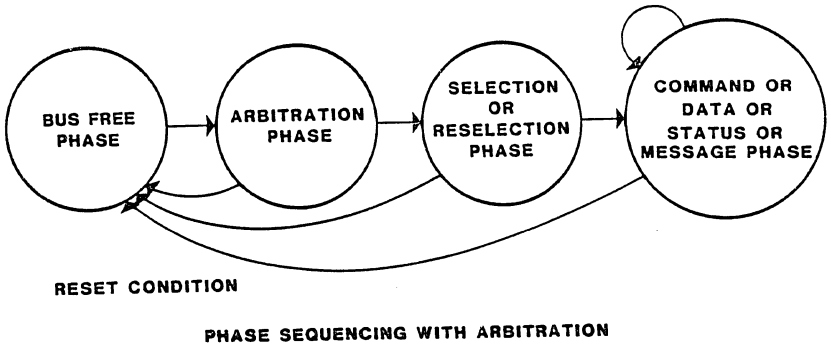
All SCSI command sequences start with the Bus Free Phase. The normal progression is from the Bus Free Phase to the Arbitration Phase. During arbitration, host adapters/controllers contest for control of the SCSI bus; priority is given to the contestant that has the highest SCSI bus address.

Once a host adapter or controller has control (i.e., is the bus master) of the SCSI bus, the SCSI bus enters the Selection/Reselection Phase. This phase allows the bus master to select a specific device for communication. An Initiator can select a Target to initiate an operation, or a Target can reselect an Initiator to continue an operation.

After a physical path between an Initiator and a Target is established, the SCSI bus enters one of the Information Transfer Phases. These phases include six types of information exchange:

- Data Out Phase
- Data In Phase
- Command Phase
- Status Phase
- Message In Phase
- Message Out Phase.

These types of SCSI bus information exchange are described in more detail in subsection 7.3.



PHASE SEQUENCING WITH ARBITRATION

Figure 7-2. SCSI Bus Phase Sequences

7.5 SCSI MEMORY ADDRESS POINTERS

To provide an efficient means of error retry and recovery during large data exchanges via the SCSI bus, the SCSI architecture uses current pointers and saved memory address pointers. There are three "conceptual" memory address pointers, located in host adapter memory, that point to the next byte of command, data, or status information to be accessed. The pointers are used to represent the state of the interface. After the pointers are initially loaded by the Initiator, their movement is under control of the Target. When the Target transfers a byte of information to or from one of the three pointers, the position of that pointer is incremented.

The SCSI command set is independent of the type of host adapters and peripheral device controllers (tape drives or disk drives) attached to the SCSI bus. The SCSI command set masks the internal structure of the device (cylinders, tracks, sectors, data blocks, etc.) from the SCSI bus. The SCSI command set supported by the MD01 Controller is defined in Section 8. The host memory contains three I/O blocks: command, data, and status. During SCSI bus I/O operations, the MD01 Controller initially reads a command block located in host memory to determine the I/O task to be performed. The MD01 Controller then reads from, or writes to, a host memory data block as an I/O task proceeds. At the end of an I/O operation, the MD01 Controller writes to a status block (in host memory).

There are two sets of three pointers within the host adapter. The first set, the Current Pointer Values, addresses the next command, status, or data byte to be transferred to the MD01 Controller. The second set, the Saved Pointer Values, always addresses the start of the command and status block, but increments for the data block.

During a Data Transfer operation, the MD01 Controller periodically enters the Message Phase and issues a SAVE DATA POINTER message to the Initiator. If an error occurs, the Target can attempt a recovery procedure. When the error is detected, the MD01 Controller goes into the Message Phase and issues a RESTORE DATA POINTER message. The Initiator then backs up its command, data, and status pointers to the last saved state. The MD01 Controller attempts a recovery (i.e., performs a retry) by transferring the data from the last saved state.

The frequency of SAVE DATA POINTER messages depends upon the block size of the addressed device and the dynamically assigned internal buffers used by the MD01 Controller. A SAVE DATA POINTER operation usually occurs every 10 blocks. The MD01 Controller also issues a SAVE DATA POINTER message any time it disconnects from the SCSI bus.

7.6 SCSI COMMAND QUEUING

The Command Queuing feature improves SCSI bus bandwidth by allowing the MD01 Controller to queue commands from multiple Initiators rather than requiring those Initiators to continually re-issue the commands. If an Initiator indicates it supports the Disconnect function in the IDENTIFY message sent to the MD01 Controller, the MD01 Controller may queue the command if the LUN is busy. The MD01 Controller saves the Initiator bus device ID and disconnects from the SCSI bus. After the MD01 Controller has completed execution of the current command, it can reselect the Initiator waiting at the top of its queue, if it is not reserved by a different Initiator.

The MD01 Controller issues a BUSY message instead of queuing the command if either of two conditions prevail:

- The Initiator does not support the Disconnect function and the addressed LUN is busy
- The addressed LUN is not busy but the MD01 Controller is busy because some other LUN is active (busy).

This method of avoiding command queuing avoids deadlocks if the non-disconnecting Initiator requires internal controller resources which are not available when the SCSI bus is in use (connected).

If the same Initiator sends a second command to the same LUN, the MD01 Controller ignores the second command and continues to execute the original command. The MD01 Controller sends a BUSY status message to the Initiator in response to the second command.

8.1 OVERVIEW

This section describes the SCSI commands supported by the MD01 Controller and it is divided into four subsections, as listed in the following table:

Subsection	Title
8.1	Overview
8.2	SCSI Command Descriptor Block Structure
8.3	SCSI Group Code 0 Command Descriptions
8.4	SCSI Group Code 1 Command Descriptions

8.2 SCSI COMMAND DESCRIPTOR BLOCK STRUCTURE

An Initiator issues SCSI commands to a Target device by transferring a command packet, called a Command Descriptor Block (CDB). The command contained in the CDB determines the length of the CDB. The first byte of a CDB contains the command. This byte is called the Operation Code; it has two components: the Group Code and the Command Code.

Only Group Code 0 and Group Code 1 commands are acceptable to the MD01 Controller. Group Code 0 CDBs contain six bytes, (see subsection 8.3). Group Code 1 CDBs contain ten bytes; they are described in subsection 8.4. The Command Code defines the type of SCSI command. SCSI command types are defined as specific CDB bit patterns in the ANSI SCSI specification; CDBs supported by the MD01 Controller follow the guidelines listed in the ANSI SCSI specification.

NOTE

CDB fields defined as equal to zero must be zero or the command packet is rejected by the MD01 Controller.

The structure of each SCSI Group Code 0 command packet, that can be accepted by the MD01 Controller, is shown in the individual command packet descriptions in subsection 8.3. The structure of each SCSI Group Code 1 command packet, acceptable to the MD01 Controller, is shown in the individual command packet descriptions in subsection 8.4.

8.3 SCSI GROUP CODE 0 COMMAND DESCRIPTIONS

SCSI Group Code 0 command names and operation codes supported by the MD01 Controller are listed by subsection number in the following table:

Subsection	MD01 SCSI Command	Code
8.3.1	**COPY**	18
8.3.2	**FORMAT UNIT**	04
8.3.3	**INQUIRY**	12
8.3.4	**MODE SELECT**	15
8.3.5	**MODE SENSE**	1A
8.3.6	**READ**	08
8.3.7	**RE-ASSIGN BLOCK**	07
8.3.8	**RECEIVE DIAGNOSTIC**	1C
8.3.9	**RELEASE UNIT**	17
8.3.10	**REQUEST SENSE**	03
8.3.11	**RESERVE UNIT**	16
8.3.12	**REZERO UNIT**	01
8.3.13	**SEEK**	0B
8.3.14	**SEND DIAGNOSTIC**	1D
8.3.15	**TEST UNIT READY**	00
8.3.16	**WRITE**	0A

This subsection provides detailed descriptions of the commands, including CDB formats, hexadecimal operation code, byte and bit functions, and any necessary event-sequence descriptions (i.e., effects produced by the commands). Each SCSI command is described in a separate subsection.

A sample Group 0 CDB is shown in Figure 8-1. The first byte of a command (Byte 00) contains two fields: the Group Code in the high-order three bits (bits <07:05>), and the Command Code in the low-order five bits (bits <04:00>). The Group Code determines the length of the command packet in the CDB, and together the Group and Operation Codes determine the operation to be performed.

Bits <07:05> of byte 01 in the CDB contain the LUN of the device being addressed. The MD01 Controller, acting as a SCSI Target, supports up to two LUNs (ST506 disk drives). Therefore, the value for the LUN field in byte 01 in the CDB is usually 000 or 001. The LUN must be specified for all commands. If a LUN value issued by the Initiator in an IDENTIFY message differs from the value specified in the CDB, that value supersedes the value specified in the CDB. The definition of the low-order bits in byte 01 is based on the current command.

The last byte (byte 05) in every CDB is a Control Byte which is differentiated into two groups:

- The low-order two bits control the ability of linking commands in a sequence and of notifying the host adapter that a particular command (CDB) step has been completed. These two bits are designated Flag and Link in the descriptions of command packets presented in this subsection for the MD01 Controller.
- The rest of the bits in the control byte are reserved bits and are always zero.

The remainder of the bytes in the CDB are primarily command-dependent.

NOTE

If a byte in a CDB can be any bit pattern, it is specified as **Not Used** in the paragraphs describing that CDB. If a byte in a CDB must be all zeros, it is specified as **Reserved** in the paragraphs describing that CDB.

Byte	Bit 07	06	05	04	03	02	01	00
00	Group Code			Command Code				
01	LUN			Command-Dependent Parameters				
02	Command-Dependent Parameters							
03	Command-Dependent Parameters							
04	Command-Dependent Parameters							
05	0	0	0	0	0	0	Flag	Link

Figure 8-1. Sample Group 0 Command Descriptor Block

8.3.1 COPY 18

The **COPY** CDB, shown below, causes an Initiator to move data from one device to another. The off-line Data Transfer operation is performed without Initiator resources.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	1	0	0	0
01	LUN			0	0	0	0	0
02	Length of Parameter List (n) (MSB)							
03	Length of Parameter List (n)							
04	Length of Parameter List (n) (LSB)							
05	0	0	0	0	0	0	Flag	Link

An external device controller may be specified as either the source device or destination device, but at least one device must be internal to the MD01 Controller. If an external device is specified as a source or destination and the host adapter does not support the Disconnect function, the **COPY** command terminates with an error because the MD01 Controller must disconnect from the host adapter before it can select the external device.

The Initiator is responsible for properly positioning any sequential devices before beginning the **COPY** command. Any necessary error-recovery procedures for any external device are also the responsibility of the Initiator.

The MD01 Controller may disconnect from the Initiator on the SCSI bus during execution of this command without an error message being generated.

Logical Unit Number (LUN) - Byte 01, Bits <07:05>

These bits specify the LUN of the device that is to receive the copied data.

Length of Parameter List - Bytes 02 through 04

The **COPY** command Parameter List specifies the length in bytes of the parameters that are sent during the data Out Phase of the **COPY** command. The Parameter List is sent to the MD01 Controller as data with Bytes 02 through 04 of the CDB specifying the length of the Parameter List (designated as n in the CDB above). A zero value in the length indicates no copy of any data, but this condition is not treated as an error.

The **COPY** command Parameter List begins with a four-byte header which contains the Copy Function Code. After the header, one or more segment descriptors are provided. The format, length, and number of segment descriptors is determined by the Copy Function Code (see Table 8-1). Up to 256 segment descriptors are permitted. The segment descriptors are identified by ascending numbers, beginning with zero.

Subsequent segments may change the source or destination LUN and device ID, if one of them matches the LUN specified in the CDB, or if one of them is specified by the IDENTIFY message.

The MD01 Controller supports sequential-to-random access, random-to-random access, and sequential-to-sequential access Copy operations (see subsections 8.3.1.1 through 8.3.1.3).

Flag - Byte 05, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 in Byte 05) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 05, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command from the Initiator. Status is returned for each command executed.

8.3.1.1 Random-to-Sequential Access and Sequential-to-Random Access Copy Operations

The **COPY** command data block for random-to-sequential access and sequential-to-random access Copy operations is shown and described below.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	CFC		0	0	0
01	0	0	0	0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0

Copy Function Code (CFC) - Byte 00, Bits <04:03>

These bits indicate the type of Copy operation. Table 8-1 lists and describes the possible Copy Function Codes.

Table 8-1. **COPY** Command Function Codes

Bits 04	03	Description
0	0	Random-to-Sequential Access
0	1	Sequential-to-Random Access
1	0	Random-to-Random Access
1	1	Sequential-to-Sequential Access

The segment descriptor, shown below, may be repeated (n-4)/12 times within the Parameter List Length specified in Bytes 02 through 04 of the **COPY** CDB (where n is the Parameter List Length).

Byte	Bit 07	06	05	04	03	02	01	00
00	SCID			0	0	SLUN		
01	DCID			0	0	DLUN		
02	Sequential Device Block Size in Bytes (MSB)							
03	Sequential Device Block Size in Bytes (LSB)							
04	Number of Blocks (Random Device) (MSB)							
05	Number of Blocks							
06	Number of Blocks							
07	Number of Blocks (LSB)							
08	Logical Block Address (Random Device) (MSB)							
09	Logical Block Address							
10	Logical Block Address							
11	Logical Block Address (LSB)							

Source Controller ID (SCID) - Byte 00, Bits <07:05>

These bits specify the SCSI bus address of the controller for the source device.

Source Logical Unit Number (SLUN) - Byte 00, Bits <02:00>

These bits specify the LUN of the source device.

Destination Controller ID (DCID) - Byte 01, Bits <07:05>

These bits specify the SCSI bus address of the controller for the destination device.

Destination LUN (DLUN) - Byte 01, Bits <02:00>

These bits specify the LUN of the destination device.

Sequential Device Block Size - Bytes 02 and 03

These bytes specify the block size to be used on the sequential-to-random access LUN during the Copy operation. If this block size cannot be supported, the MD01 Controller sends a CHECK CONDITION status message to the Initiator and sets the Sense Key in the Extended Sense Byte to the ILLEGAL REQUEST code. During a Read or Write operation to the sequential access device, if the MD01 Controller determines the block size is invalid, it terminates the Copy operation and sends a CHECK CONDITION status message to the Initiator and sets the Sense Key in the Extended Sense Byte to the COPY ABORTED code.

Number of Blocks (Random Device) - Bytes 04 through 07

These bytes specify the number of sequential-to-random access device blocks are to be transferred in the current segment. A zero value indicates that no blocks are to be transferred in this segment.

Logical Block Address (Random Device) - Bytes 08 through 11

These bytes specify the starting logical block address on the sequential-to-random access LUN for this segment.

8.3.1.2 Random-to-Random Access Copy Operations

The **COPY** command data block for random-to-random access Copy operations is shown and described below.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	0	0	0	0
01	0	0	0	0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0

The segment descriptor, shown below, may be repeated (n-4)/12 times within the Parameter List Length specified in Bytes 02 through 04 of the **COPY** CDB (where n is the Parameter List Length).

Byte	Bit 07	06	05	04	03	02	01	00
00	SCID			0	0	SLUN		
01	DCID			0	0	DLUN		
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	Source Number of Blocks (MSB)							
05	Source Number of Blocks							
06	Source Number of Blocks							
07	Source Number of Blocks (LSB)							
08	Source Logical Block Address (MSB)							
09	Source Logical Block Address							
10	Source Logical Block Address							
11	Source Logical Block Address (LSB)							
12	Destination Logical Block Address (MSB)							
13	Destination Logical Block Address							
14	Destination Logical Block Address							
15	Destination Logical Block Address (LSB)							

Source Controller ID (SCID) - Byte 00, Bits <07:05>

These bits specify the SCSI bus address of the controller for the source device.

Source Logical Unit Number (SLUN) - Byte 00, Bits <02:00>

These bits specify the LUN of the source device.

Destination Controller ID (DCID) - Byte 01, Bits <07:05>

These bits specify the SCSI bus address of the controller for the destination device.

Destination LUN (DLUN) - Byte 01, Bits <02:00>

These bits specify the LUN of the destination device.

Source Number of Blocks - Bytes 04 through 07

These bytes specify the number of random-to-random access device blocks to be transferred in the current segment of the Copy operation. A zero value indicates that no blocks are to be transferred in this segment.

Source Logical Block Address - Bytes 08 through 11

These bytes specify the starting Logical Block Address on the source device random-to-random access LUN for this segment of the Copy operation.

Destination Logical Block Address - Bytes 12 through 15

These bytes specify the starting Logical Block Address on the destination device random-to-random access LUN for this segment of the Copy operation.

8.3.1.3 Sequential-to-Sequential Access Copy Operations

The **COPY** command data block for sequential-to-sequential access Copy operations is shown and described below.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	1	0	0	0
01	0	0	0	0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0

The segment descriptor, shown below, may be repeated (n-4)/12 times within the Parameter List Length specified in Bytes 02 through 04 of the **COPY** CDB (where n is the Parameter List Length).

Byte	Bit 07	06	05	04	03	02	01	00
00	SCID			0	0	SLUN		
01	DCID			0	0	DLUN		
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	Source Block Length (MSB)							
05	Source Block Length (LSB)							
06	Destination Block Length (MSB)							
07	Destination Block Length (LSB)							
08	Source Number of Blocks (MSB)							
09	Source Number of Blocks							
10	Source Number of Blocks							
11	Source Number of Blocks (LSB)							

Source Controller ID (SCID) - Byte 00, Bits <07:05>

These bits specify the SCSI bus address of the controller for the source device.

Source Logical Unit Number (SLUN) - Byte 00, Bits <02:00>

These bits specify the LUN of the source device.

Destination Controller ID (DCID) - Byte 01, Bits <07:05>

These bits specify the SCSI bus address of the controller for the destination device.

Destination LUN (DLUN) - Byte 01, Bits <02:00>

These bits specify the LUN of the destination device.

Source Block Length - Bytes 04 and 05

These bytes specify the block size (i.e., number of blocks) to be used on the source device for this segment of the Copy operation. A zero value indicates no bytes are to be transferred in this segment. If these bytes are not zero, the Source Block Length field value matches the actual block length of the LUN. If the SCSI device that is managing the Copy operation detects Block Length mismatches, it terminates the command, sends a CHECK CONDITION status message to the Initiator, and sets the Sense Key in the Extended Sense Byte to ILLEGAL REQUEST. If the SCSI device that is managing the Copy operation detects the mismatches during the Read operation, it terminates the command, sends a CHECK CONDITION status message to the Initiator, and sets the Sense Key in the Extended Sense Byte to COPY ABORTED.

Destination Block Length - Bytes 06 and 07

These bytes specify the block size (i.e., number of bytes) to be used on the destination device for this segment of the Copy operation. A zero value indicates no bytes are to be transferred in this segment.

Source Number of Blocks - Bytes 08 through 11

These bytes specify the number of blocks to be transferred from the source device during this segment. A zero value indicates no blocks are to be transferred.

8.3.1.4 Error and Other Conditions During a Copy Operation

The following paragraphs describe unusual conditions that can occur during a Copy operation and the ways the MD01 Controller responds to such conditions.

8.3.1.4.1 End-of-Media Condition. If the End-of-Media condition is detected during execution of a **COPY** command while writing to a sequential access device, the MD01 Controller performs the following operations:

1) Terminates with CHECK CONDITION status message.

2) Sets the Valid Address (VADD) and End-of-Media (EOM) bits in appropriate Extended Sense Bytes to one. (These bits are described in the MT01 [Titleist] Tape Controller Technical Manual, P/N MT0151001.)

3) Sets Extended Sense Byte 01 to the current Segment Descriptor number. The Segment Descriptors are identified by ascending numbers beginning with zero.

4) Sets the Sense Information Bytes of the Extended Sense Bytes 03 through 06 to the difference (residue) between the value in the Number of Blocks field for the current segment and the actual number of blocks written on the destination device medium.

8.3.1.4.2 File Mark Condition. If a File Mark is encountered during a **COPY** command while reading from a sequential access device, the MD01 Controller performs the following operations:

1) Terminates with CHECK CONDITION status message.

2) Sets the VADD and File Mark (FM) bits in appropriate Extended Sense Bytes to one. (The FM bit is described in the MT01 [Titleist] Technical Manual.)

3) Sets Extended Sense Byte 01 to the current Segment Descriptor number. The Segment Descriptors are identified by ascending numbers beginning with zero.

4) Sets the Sense Information Bytes of the Extended Sense Bytes 03 through 06 to the difference (residue) between the value in the Number of Blocks field for the current segment and the value in the actual number of blocks written on the destination device media.

8.3.1.4.3 Incomplete Condition. If the MD01 Controller cannot complete the **COPY** command because of an error condition on the source and/or destination device, after it recovers the Sense data associated with the detected error, it performs the following operations:

1) Terminates with CHECK CONDITION status message.

2) Sets the VADD bit 07 in Extended Sense Byte 00 to one.

3) Sets the Segment Number in Extended Sense Byte 01 to the current Segment Descriptor number. The Segment Descriptors are identified by ascending numbers beginning with zero.

4) Sets the Sense Information Bytes of the Extended Sense Bytes 03 through 06 to the difference (residue) between the value in the Number of Blocks field for the current segment and the actual number of blocks written on the destination device medium.

5) Sets the code in the Sense Key field in Extended Sense Byte 02 to the code for COPY ABORTED.

6) Sets the First Additional Sense Length Byte (Byte 08) to the byte number (relative to Byte 00) of the beginning of the source device's status and sense data. A zero value in the byte indicates no status and sense data are being returned from the source device. Subsequent bytes contain the Sense data (unchanged) recovered from the source device.

7) Sets the Second Additional Sense Length Byte (Byte 09) to the byte number (relative to Byte 00) of the beginning of the destination device's status and sense data. A zero value in the this byte indicates no status and sense data are being returned from the destination device. Subsequent bytes contain Sense data (unchanged) recovered from the destination device.

8) If Byte 08 (First Additional Sense Length Byte) is not zero, returns the source device's sense data (if the status is CHECK CONDITION) in the Additional Sense Length Bytes beginning at the byte number defined in Byte 08.

9) If Byte 09 (Second Additional Sense Length Byte) is not zero, returns the destination device's sense data (if the status is CHECK CONDITION) in the Additional Sense Length Bytes beginning at the byte number defined in Byte 09.

8.3.2 FORMAT UNIT 04

The **FORMAT UNIT** CDB, shown below, is used to write header and data blocks on the entire disk. All appropriate headers and data sectors are verified and spare sectors/alternate tracks are appropriately re-assigned so that all logical data blocks can be accessed. Defective sector and track files are maintained on the disk by the MD01 Controller on a cylinder which is inaccessible to the Initiator. During the formatting process, sectors with errors and tracks that have more sectors with errors than available spares are re-assigned to spare sectors and alternate tracks, respectively. The Initiator may specify logical blocks to be added to the BSF.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	0	1	0	0
01	LUN			FMD	CPL	Defect List Format		
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	Interleave Code (LSB)							
05	0	0	0	0	0	0	Flag	Link

The command in this CDB may disconnect from the Initiator.

Logical Unit Number (LUN) - Byte 01, Bits <07:05>

These bits specify the LUN of the addressed device for this command.

Format Data (FMD) - Byte 01, Bit 04

When the FMD bit status is set to one, **FORMAT UNIT** data is supplied during the Data Out Phase of the command. The Defect List, included with this data, specifies the defects to be entered into the Defect Map. The Defect List is formatted in the block format (see subsection 8.3.2.1). When the FMD bit status is reset to zero, the Data Out Phase of the command does not occur and no defect data is supplied by the Initiator.

Complete List (CPL) - Byte 01, Bit 03

When the CPL bit status is set to one, data supplied in the Defect List is the complete list of known defects. Any previous Defect Map or defect data is erased. The Target may add to this Defect List as it formats the medium. The CPL bit is set to purge any previously specified Defect List and to build a new Defect List.

When the CPL bit status is reset to zero, data supplied in the Defect List is to be added to the existing Defect List by using the current format. The Defect List refers to the current block capacity (not to the new block capacity, if that block capacity is different), and it also refers to current Logical Block Addresses (not physical block addresses). The Target may add to this list as it formats the medium.

Defect List Format - Byte 01, Bits <02:00>

These bits specify additional information related to the format of the Defect List. Together with the FMD and CPL bits, these bits specify the mode of the MD01 Controller during a Format operation. The Format modes are listed in Table 8-2.

Interleave Code - Bytes 03 through 04

The code in the Interleave field requests that the logical blocks be related in a specific fashion to the physical blocks to make matching easier and faster. The most significant byte of the Interleave field (Byte 03) must be zero. An Interleave value of zero (hexadecimal) requests that the Target use its default Interleave (1:1 sequential). An Interleave value of one or greater (hexadecimal) requests that consecutive logical blocks be placed in consecutive physical order: 1:n (where n is between 1 and 255, inclusive, and may not be larger than the number of sectors per track minus one).

Table 8-2. MD01 Controller Format Modes

Bits 04	03	02	01	00	Mode
0	0	0	0	0	**Reformat Mode.** The MD01 Controller performs a complete format of the specified disk by using the existing bad sector file (BSF). If additional defects are found, they are added to the BSF.
0	1	0	0	0	**Format Mode.** The MD01 Controller performs a complete format of the specified disk while building a new BSF. This mode may be used during the Format operation on an uninitialized disk drive.
1	0	0	0	0	**Reformat with Update.** The MD01 Controller accepts a Defect List from the Initiator which is to be added to the BSF. The MD01 Controller performs a complete format of the specified disk by using the existing BSF and the Defect List supplied by the Initiator. The BSF is updated to reflect the updates in the Defect List. If additional defects are found, they are added to the BSF.
1	1	0	0	0	**Format Mode with Update.** The MD01 Controller accepts a Defect List from the Initiator which is to be used as the contents of the initial BSF. Any existing BSF is lost. If additional defects are found, they are added to the BSF. This mode may be used to format an uninitialized disk drive by using a zero-length Defect List.

8.3.2.1 Format Unit Data Format

During the Data Out Phase of the **FORMAT UNIT** command, data is sent in the following format:

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	0	0	0	0
01	0	0	0	0	0	0	0	0
02	Length of Defect List (n) (MSB)							
03	Length of Defect List (n) (LSB)						0	0

The defect descriptors, shown below, are repeated n/4 times within the Defect List Length specified (Bytes 02 through 03) in the **FORMAT UNIT** header (n is the Length of the Defect List defined in the **FORMAT UNIT** header).

Byte	Bit 07	06	05	04	03	02	01	00
00	Defect List Block Address (MSB)							
01	Defect List Block Address							
02	Defect List Block Address							
03	Defect List Block Address (LSB)							

Defect List Block Address - Bytes 00 through 04

These bytes specify the address of the block that contains the defect.

The Defect List Block Addresses are converted to the appropriate track and block addresses by the MD01 Controller and are specified in ascending order. Block addresses that specify previously detected or specified addresses are ignored and do not produce duplicate entries in the BSF.

8.3.3 INQUIRY 12

The INQUIRY CDB, shown below, causes a request to be made for the transfer of data from the Target to the Initiator. The data to be transferred describes unique parameters that are pertinent to the MD01 Controller. The number of bytes transferred depends on the number of bytes requested by the contents of Byte 04. The data transferred includes information about the parameters of the addressed LUN.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	0	0	1	0
01	LUN			0	0	0	0	0
02	0	0	0	0	0	0	0	1
03	0	0	0	0	0	0	0	0
04	0	0	0	0	0	0	0	0
05	0	0	0	0	0	0	Flag	Link

Logical Unit Number (LUN) - Byte 01, Bits <07:05>

These bits specify the LUN of the addressed device for this command.

Version of SCSI Standard - Byte 02

This byte indicates the version of the ANSI SCSI specification that specifies the protocol used in the Data Transfer operation. Currently only a value of one is acceptable.

Flag - Byte 05, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 in Byte 05) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 05, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command from the Initiator. Status is returned for each command executed.

8.3.3.1 Inquiry Data Format

During the Data In Phase of the **INQUIRY** command, data is transferred in the following format:

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	0	0	0	0
01	RMD	Device Type Qualifier						
02	X	X	X	X	X	X	REVL	
03	0	0	0	0	0	0	0	0
04	Number of Heads				SSZ		SST	BFS
05	Logical Number of Cylinders (MSB)							
06	Logical Number of Cylinders (LSB)							
07	Write Precomp Cylinder Number (MSB)							
08	Write Precomp Cylinder Number (LSB)							
09	Reduced Write Count Cylinder Number (MSB)							
0A	Reduced Write Count Cylinder Number (LSB)							
X = Don't Care								

Byte 00, Bit 00

Byte 00 indicates the Device Type code. Bit 00 is set to zero to indicate a random-access device is being used with the MD01 Controller.

Removable Media (RMD) - Byte 01, Bit 07

When the RMD bit is set to one, the medium is removable (i.e., tape cartridge). When the RMD bit is zero, the medium is not removable.

Device Type Qualifier - Byte 01, Bits <06:01>

These bits form a seven-bit user-specified code that can be set by switches or by **some other means** within the MD01 Controller. Self-configuring software can use these codes to determine the type of device at each SCSI bus address. This determination is valuable for devices that support multiple types of removable media.

Not Used - Byte 02, Bits <07:06>

These bits are not used and can be either one or zero.

Revision Level (REVL) - Byte 02, Bits <01:00>

The REVL bits <01:00> of Byte 02 indicate the revision level of the firmware in the MD01 Controller. If they are set to 00, it is an unspecified revision level; if they are set to 01, it is a first release of the firmware.

Number of Alternate Cylinders - Byte 03

This byte specifies the number of alternate cylinders to be accessed. Bad tracks are mapped on the alternate cylinders.

Number of Heads - Byte 04, Bits <07:04>

These bits indicate the number of heads on the disk drive.

Sector Size (SSZ) - Byte 04, Bit 03

This bit indicates the sector size. If the SSZ bit is set to one, the sector size is 512 bytes. If the SSZ bit is zero, the sector size is 256 bytes.

Spare Sectors/Track (SST) - Byte 04, Bits <02:01>

These bits indicate the number of spare sectors/track. The bit patterns are listed and described in Table 8-3.

Table 8-3. Spare Sectors/Track Bits

Bits 01 02	Number of Spare Sectors/Track
0 0	0
0 1	1
1 0	2
1 1	3

Buffered Step (BFS) - Byte 04, Bit 00

This bit indicates if the disk drive Step operation (involving the time interval in which the Step signal pulses occur) is or is not buffered. If the BFS bit is set to one, the Step operation is non-buffered. If the BFS bit is zero, the Step operation is buffered. This bit applies only to ST506 disk drives.

Logical Number of Cylinders - Bytes 05 through 06

These bytes specify the logical number of cylinders in the user's address space. Note that two of the cylinders cannot be accessed by the user because one cylinder is dedicated to the bad sector file and the other is dedicated to diagnostics.

Logical Number of Sectors/Track - Byte 0E

This byte specifies the logical number of sectors (the user can access) per track.

Logical Number of Cylinders - Bytes 0F through 10

These bytes specify the logical number of cylinders in the user's address space. Note that two of the cylinders cannot be accessed by the user because one cylinder is dedicated to the bad sector file and the other is dedicated to diagnostics.

Write Precomp Cylinder Number - Bytes 11 through 12

These bytes specify the write precomp cylinder number and are applicable only to ST506 disk drives.

Reduced Write Count Cylinder Number - Bytes 13 through 14

These bytes specify the reduced write count cylinder number and are applicable only to ST506 disk drives.

8.3.4 MODE SELECT 15

The **MODE SELECT** CDB, shown below, enables an Initiator to specify device parameters to the MD01 Controller.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	0	1	0	1
01	LUN			0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	Parameter List Length							
05	0	0	0	0	0	0	Flag	Link

Logical Unit Number (LUN) - Byte 01, Bits <07:05>

These bits specify the LUN of the addressed device for this command.

Parameter List Length - Byte 04

This byte specifies the length in bytes of the Parameter List sent during the Data Out Phase of this command. Valid **hexadecimal** values for bits in the Parameter List Length field are 13 (for Enhanced Small Disk Interface, ESDI) and 21 (for ST506 disk interface).

Flag - Byte 05, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 in Byte 05) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 05, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command from the Initiator. Status is returned for each command executed.

8.3.4.1 Mode Select Parameter List for ESDI Disk Drives

The Mode Select Parameter List, shown below, is sent during the Data Phase of the **MODE SELECT** command to specify parameters for an ESDI disk device.

Byte	Bit 07	06	05	04	03	02	01	00
00	Data Length							
01	VU	0	0	0	0	0	SCT	1
02	WRP	0	0	0	0	0	0	0
03	Block Descriptor Length							
04	0	0	0	0	0	0	0	0
05	Number Of Blocks (MSB)							
06	Number of Blocks							
07	Number of Blocks (LSB)							
08	0	0	0	0	0	0	0	0
09	Block Length (MSB)							
0A	Block Length							
0B	Block Length (LSB)							
0C	Number of Alternate Cylinders							
0D	Number of Heads				SSZ		SST	
0E	Logical Number of Sectors/Track							
0F	Number of Cylinders (MSB)							
10	Number of Cylinders (LSB)							
11	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0

Data Length - Byte 00

This byte specifies the length of the Parameter List is 21 (hexadecimal) bytes, starting at Byte 00.

Vendor Unique (VU) - Byte 01, Bit 07

This bit is set to one to specify that Byte 01 is an Emulex definition of that SCSI byte (Media Type).

Sector Type (SCT) - Byte 01, Bit 01

This bit state indicates the sector type. If the SCT bit is set to one, the LUN supports soft sectoring. If the SCT bit is reset to zero, the LUN supports hard sectoring.

Write Protect (WRP) - Byte 02, Bit 07

This bit specifies whether the disk drive is or is not write protected. When the WRP bit is set to one, the disk drive is write protected. When the WRP bit is reset to zero, the disk drive is not write protected.

Block Descriptor Length - Byte 03

This byte specifies the length of the Block Descriptor is 21 hexadecimal bytes, starting at Byte 04.

Density Code - Byte 04

This byte defines the density of the medium on the addressed LUN. The Density Code has a value of zero to indicate the LUN is a hard disk drive.

Number of Blocks - Bytes 05 through 07

This field specifies the number of logical blocks of the medium that fulfill the requirements of the Density Code and Block Length in the Block Descriptor (Bytes 04 through 10). If the Number of Blocks equals zero, all the remaining logical blocks of the LUN fulfill the requirements.

Block Length - Bytes 09 through 0B

The Block Length field specifies the length in bytes of the logical block.

Number of Alternate Cylinders - Byte 0C

This byte specifies the number of alternate cylinders to be accessed.

Number of Heads - Byte 0D, Bits <07:04>

These bits specify the number of heads on the disk drive.

Sector Size (SSZ) - Byte 0D, Bit 03

This bit indicates the sector size (i.e., capacity). If the SSZ bit is set to one, the sector size is 512 bytes. If the SSZ bit is reset to zero, the sector size is 256 bytes.

Spare Sectors/Track (SST) - Byte 0D, Bits <02:01>

These bits indicate the number of spare sectors/track. The bit patterns are listed and described in Table 8-3.

Logical Number of Sectors/Track - Byte 0E

This byte specifies the logical number of sectors per track which can be accessed by the user.

8.3.4.2 Mode Select Parameter List for ST506 Disk Drives

The Mode Select Parameter List, shown below, is sent during the Data Phase of the **MODE SELECT** command to specify parameters for an ST506 disk device.

Byte	Bit 07	06	05	04	03	02	01	00
00	Data Length							
01	VU	0	0	0	0	0	SCT	1
02	WRP	0	0	0	0	0	0	0
03	0	0	1	0	0	0	0	1
04	0	0	0	0	0	0	0	0
05	Number Of Blocks (MSB)							
06	Number of Blocks							
07	Number of Blocks (LSB)							
08	0	0	0	0	0	0	0	0
09	Block Length (MSB)							
0A	Block Length							
0B	Block Length (LSB)							
0C	Number of Alternate Cylinders							
0D	Number of Heads				SSZ		SST	BFS
0E	Logical Number of Sectors/Track							
0F	Logical Number of Cylinders (MSB)							
10	Logical Number of Cylinders (LSB)							
11	Write Precompensation Cylinder Number (MSB)							
12	Write Precompensation Cylinder Number (LSB)							
13	Reduced Write Count Cylinder Number (MSB)							
14	Reduced Write Count Cylinder Number (LSB)							

Data Length - Byte 00

This byte specifies the length of the Parameter List is 21 (hexadecimal) bytes, starting at Byte 00.

Vendor Unique (VU) - Byte 01, Bit 07

This bit is set to one to specify that Byte 01 is an Emulex definition of that SCSI byte (Media Type).

Sector Type - Byte 01, Bit 01

This bit indicates the sector type. If the SCT bit is set to one, the LUN supports soft sectors. If the SCT bit is reset to zero, the LUN supports hard sectors.

Write Protect (WRP) - Byte 02, Bit 07

This bit specifies whether the disk drive is or is not write protected. When the WRP bit is set to one, the disk drive is write protected. When the WRP bit is reset to zero, the disk drive is not write protected.

Block Descriptor Length - Byte 03

The byte specifies the length of the Block Descriptor is 21 (hexadecimal) bytes, starting at Byte 00.

Density Code - Byte 04

This byte defines the density of the medium on the addressed LUN. The Density Code has a value of zero to indicate the LUN is a hard disk drive.

Number of Blocks - Bytes 05 through 07

This field specifies the number of logical blocks of the medium that fulfill the requirements of the Density Code and Block Length in the Block Descriptor (Bytes 04 through 0B). If the Number of Blocks equals zero, all the remaining logical blocks of the LUN fulfill the requirements.

Block Length - Bytes 09 through 0B

This field specifies the length of the logical block in bytes.

Number of Alternate Cylinders - Byte 0C

This byte specifies the number of alternate cylinders to be accessed. Bad tracks are mapped on the alternate cylinders.

Number of Heads - Byte 0D, Bits <07:04>

These bits specify the number of heads on the disk drive.

Sector Size (SSZ) - Byte 0D, Bit 03

This bit indicates the sector size (i.e., capacity). If the SSZ bit is set to one, the sector size is 512 bytes. If the SSZ bit is reset to zero, the sector size is 256 bytes.

Spare Sectors/Track (SST) - Byte 0D, Bits <02:01>

These bits indicate the number of spare sectors/track. The bit patterns are listed and described in Table 8-3.

Buffered Step (BFS) - Byte 0D, Bit 00

This bit indicates if the disk drive Step operation (involving the time intervals in which the Step signal pulses occur) is or is not to be buffered. If the BFS bit is set to one, the Step operation is non-buffered. If the BFS bit is reset to zero, the Step operation is buffered. This bit applies only to ST506 disk drives.

Logical Number of Sectors/Track - Byte 0E

This byte specifies the logical number of sectors per track which can be accessed by the user.

Logical Number of Cylinders - Bytes 0F through 10

These bytes specify the logical number of cylinders in the user's address space. Two of the cylinders cannot be accessed by the user because one cylinder is dedicated to the BSF and the other is dedicated to diagnostic data.

Write Precompensation Cylinder Number - Bytes 11 through 12

These bytes specify the number of the cylinder at which the disk drive will write data to inner cylinders on the disk using a time-precompensated form. For more information on the Write Precompensation Number, see subsection 3.3.5. These bytes are applicable only to ST506 disk drives.

Reduced Write Count Cylinder Number - Bytes 13 through 14

These bytes specify the number of the cylinder at which the disk drive will supply a different amount of current to the head during a Write operation. For more information on the Reduced Write Current Cylinder Number, see subsection 3.3.5. These bytes are applicable only to ST506 disk drives.

8.3.5 MODE SENSE 1A

The **MODE SENSE** CDB, shown below, causes an Initiator to determine the parameters of the MD01 Controller. **MODE SENSE** is a complementary command, related to the **MODE SELECT** command, (see subsection 8.3.4), and is used for support of media that may contain different densities.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	1	0	1	0
01	LUN			0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	Allocation Length							
05	0	0	0	0	0	0	Flag	Link

During execution of this command, the MD01 Controller does not disconnect unless disconnection is enabled by two conditions:

- The LUN is busy with another Initiator
- The Disconnect function is supported.

Logical Unit Number (LUN) - Byte 01, Bits <07:05>

These bits specify the LUN of the addressed device for this command.

Reserved - Bytes 02 through 03

These bytes are reserved and must be zero.

Allocation Length - Byte 04

The Allocation Length specifies the number of bytes the Initiator has allocated for returned **MODE SENSE** data. If the MD01 Controller receives a zero value in Byte 04, it does not transfer any data and does not treat this condition as an error. A non-zero Allocation Length value indicates that number of bytes or fewer are to be transferred. The Target terminates the Data In Phase when the Allocation Length bytes have been transferred or when all available **MODE SENSE** data has been transferred to the Initiator.

Flag - Byte 05, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 in Byte 05) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 05, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command from the Initiator. Status is returned for each command executed.

8.3.5.1 Mode Sense Data Format

The Mode Select Parameter List, shown below, is sent during the Data In Phase of the **MODE SENSE** command to specify host-defined parameters for the disk drive.

Byte	Bit 07	06	05	04	03	02	01	00
00	Data Length							
01	VU	0	0	0	0	0	SCT	1
02	WRP	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	1
04	0	0	0	0	0	0	0	0

Data Length - Byte 00

This byte specifies the length of the Parameter List is one (hexadecimal) byte.

Vendor Unique (VU) - Byte 01, Bit 07

This bit is set to one to specify that Byte 01 is an Emulex definition of that SCSI byte (Media Type).

Sector Type (SCT) - Byte 01, Bit 01

This bit indicates the sector type. If the SCT bit is set to one, the LUN supports soft sectoring. If the SCT bit is reset to zero, the LUN supports hard sectoring.

Write Protect (WRP) - Byte 02, Bit 07

This bit specifies whether the disk drive is or is not write protected. When the WRP bit is set to one, the disk drive is write protected. When the WRP bit is reset to zero, the disk drive is not write protected.

Block Descriptor Length - Byte 03

This byte specifies the length of the Block Descriptor is one hexadecimal byte.

Density Code - Byte 04

This byte defines the density of the medium on the addressed LUN. The Density Code has a value of zero to indicate the LUN is a hard disk drive.

8.3.5.2 Mode Sense Data Format for ESDI Disk Drives

The Mode Select Parameter List, shown below, is sent during the Data Phase of the **MODE SENSE** command to specify parameters for an ESDI disk device.

Byte	Bit 07	06	05	04	03	02	01	00
00	Data Length							
01	VU	0	0	0	0	0	SCT	1
02	WRP	0	0	0	0	0	0	0
03	0	0	0	1	0	0	1	1
04	0	0	0	0	0	0	0	0
05	Number 0f Blocks (MSB)							
06	Number of Blocks							
07	Number of Blocks (LSB)							
08	0	0	0	0	0	0	0	0
09	Block Length (MSB)							
0A	Block Length							
0B	Block Length (LSB)							
0C	Number of Alternate Cylinders							
0D	Number of Heads				SSZ		SST	
0E	Logical Number of Sectors/Track							
0F	Logical Number of Cylinders (MSB)							
10	Logical Number of Cylinders (LSB)							
11	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0

Data Length - Byte 00

This byte specifies the length of the Parameter List is 21 (hexadecimal) bytes, starting at Byte 00.

Vendor Unique (VU) - Byte 01, Bit 07

This bit is set to one to specify that Byte 01 is an Emulex definition of that SCSI byte (Media Type).

Sector Type (SCT) - Byte 01, Bit 01

This bit indicates the sector type. If the SCT bit is set to one, the LUN supports soft sectoring. If the SCT bit is reset to zero, the LUN supports hard sectoring.

Write Protect (WRP) - Byte 02, Bit 07

This bit specifies whether the disk drive is or is not write protected. This bit specifies whether the disk drive is or is not write protected. When the WRP bit is set to one, the disk drive is write protected. When the WRP bit is reset to zero, the disk drive is not write protected.

Block Descriptor Length - Byte 03

This byte specifies the length of the Block Descriptor is 21 (hexadecimal) bytes, starting at Byte 04.

Density Code - Byte 04

This byte defines the density of the medium on the addressed LUN. The Density Code has a value of zero to indicate the LUN is a hard disk drive.

Number of Blocks - Bytes 05 through 07

This field specifies the number of logical blocks of the medium that fulfill the requirements of the Density Code and Block Length in the Block Descriptor (Bytes 04 through 10). If the Number of Blocks equals zero, all the remaining logical blocks of the LUN fulfill the requirements.

Reserved - Byte 08

This byte is reserved and must be zero.

Block Length - Bytes 09 through 0B

These bytes specify the length of the logical block in bytes.

Number of Alternate Cylinders - Byte 0C

This byte specifies the number of alternate cylinders to be accessed. Bad tracks are mapped on the alternate cylinders.

Number of Heads - Byte 0D, Bits <07:04>

These bits specify the number of heads on the disk drive.

Sector Size (SSZ) - Byte 0D, Bit 03

This bit indicates the sector size (i.e., capacity). If the SSZ bit is set to one, the sector size is 512 bytes. If the SSZ bit is reset to zero, the sector size is 256 bytes.

Spare Sectors/Track (SST) - Byte 0D, Bits <02:01>

These bits indicate the number of spare sectors/track. The bit patterns are listed and described in Table 8-3.

Logical Number of Sectors/Track - Byte 0E

This byte specifies the logical number of sectors per track which can be accessed by the user.

Logical Number of Cylinders - Bytes 0F through 10

These bytes specify the logical number of cylinders in the user's address space. Two of the cylinders cannot be accessed by the user because one cylinder is dedicated to the BSF and the other is dedicated to diagnostic data.

Reserved - Bytes 11 through 14

These bytes are reserved and must be zero.

8.3.5.3 Mode Sense Data Format for ST506 Disk Drives

The Mode Sense Parameter List, shown below, is sent during the Data Phase of the **MODE SENSE** command to specify parameters for an ST506 disk device.

Byte	Bit 07	06	05	04	03	02	01	00
00	Data Length							
01	VU	0	0	0	0	0	SCT	1
02	WRP	0	0	0	0	0	0	0
03	0	0	1	0	0	0	0	1
04	0	0	0	0	0	0	0	0
05	Number of Blocks (MSB)							
06	Number of Blocks							
07	Number of Blocks (LSB)							
08	0	0	0	0	0	0	0	0
09	Block Length (MSB)							
0A	Block Length							
0B	Block Length (LSB)							
0C	Number of Alternate Cylinders							
0D	Number of Heads				SSZ		SST	BFS
0E	Logical Number of Sectors/Track							
0F	Logical Number of Cylinders (MSB)							
10	Logical Number of Cylinders (LSB)							
11	Write Precompensation Cylinder Number (MSB)							
12	Write Precompensation Cylinder Number (LSB)							
13	Reduced Write Current Cylinder Number (MSB)							
14	Reduced Write Current Cylinder Number (LSB)							

Data Length - Byte 00

This byte specifies the length of the Parameter List is 21 (hexadecimal) bytes, starting at Byte 00.

Vendor Unique (VU) - Byte 01, Bit 07

This bit is set to one to specify that Byte 01 is an Emulex definition of that SCSI byte (Media Type).

Sector Type - Byte 01, Bit 01

This bit indicates the sector type. If the SCT bit is set to one, the LUN supports soft sectoring. If the SCT bit is reset to zero, the LUN supports hard sectoring.

Write Protect (WRP) - Byte 02, Bit 07

This bit specifies whether the disk drive is or is not write protected. When the WRP bit is set to one, the disk drive is write protected. When the WRP bit is reset to zero, the disk drive is not write protected.

Block Descriptor Length - Byte 03

This byte specifies the length of the Block Descriptor is 21 hexadecimal bytes, starting at Byte 04.

Density Code - Byte 04

This byte defines the density of the medium on the addressed LUN. The Density Code has a value of zero to indicate the LUN is a hard disk drive.

Number of Blocks - Bytes 05 through 07

This field specifies the number of logical blocks of the medium that fulfill the requirements of the Density Code and Block Length in the Block Descriptor (Bytes 04 through 0B). If the Number of Blocks equals zero, all the remaining logical blocks of the LUN fulfill the requirements.

Block Length - Bytes 09 through 0B

These bytes specify the length of the logical block in bytes.

Number of Alternate Cylinders - Byte 0C

This byte specifies the number of alternate cylinders to be accessed. Bad tracks are mapped on the alternate cylinders.

Number of Heads - Byte 0D, Bits <07:04>

These bits specify the number of heads on the disk drive.

Sector Size (SSZ) - Byte 0D, Bit 03

This bit indicates the sector size (i.e., capacity). If the SSZ bit is set to one, the sector size is 512 bytes. If the SSZ bit is reset to zero, the sector size is 256 bytes.

Spare Sectors/Track (SST) - Byte 0D, Bits <02:01>

These bits indicate the number of spare sectors/track. The bit patterns are listed and described in Table 8-3.

Buffered Step (BFS) - Byte 0D, Bit 00

This bit indicates if the step is or is not buffered. If the BFS bit is set to one, the step is non-buffered. If the BFS bit is reset to zero, the step is buffered. This bit applies only to ST506 disk drives.

Logical Number of Sectors/Track - Byte 0E

This byte specifies the logical number of sectors per track which can be accessed by the user.

Logical Number of Cylinders - Bytes 0F through 10

These bytes specify the logical number of cylinders in the user's address space. Two of the cylinders cannot be accessed by the user because one cylinder is dedicated to the BSF and the other is dedicated to diagnostic data.

Write Precompensation Cylinder Number - Bytes 11 through 12

These bytes specify the number of the cylinder at which the disk drive will write data to inner cylinders on the disk using a time-precompensated form. For more information on the Write Precompensation Number, see subsection 3.3.5. These bytes are applicable only to ST506 disk drives.

Reduced Write Count Cylinder Number - Bytes 13 through 14

These bytes specify the number of the cylinder at which the disk drive will supply a different amount of current to the head during a Write operation. For more information on the Reduced Write Current Cylinder Number, see subsection 3.3.5. These bytes are applicable only to ST506 disk drives.

8.3.6 READ 08

The **READ** CDB, shown below, causes the transfer of data from the Target device to the Initiator. The amount of transferred data is a multiple of the block length (i.e., 512 data bytes/ block). The **READ** command specifies the starting block number and the number of data blocks to be read. The **READ** command terminates when the number of data blocks to be read is transferred.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	1	0	0	0
01	LUN			Logical Block Address (MSB)				
02	Logical Block Address							
03	Logical Block Address (LSB)							
04	Number of Blocks to Transfer (LSB)							
05	ERTY	ECC	0	0	0	0	Flag	Link

If the Disconnect function is enabled, the MD01 Controller can disconnect from the Initiator while executing this command.

If any reservation access conflict exists (see subsection 8.3.11, **RESERVE UNIT** command), the MD01 Controller terminates the **READ** command with a RESERVATION CONFLICT status code; no data is read.

Table 8-7 lists several error conditions, and their corresponding Sense Keys, that can occur during a Read operation. If any of the conditions occur, the MD01 Controller terminates the **READ** command, sends a CHECK CONDITION status code to the Initiator, and sets the Sense Key that corresponds to the error condition in the Extended Sense Byte.

Table 8-4. **READ** Command Error Conditions

Sense Key	Condition
ILLEGAL REQUEST *	An invalid Logical Block Address was issued
UNIT ATTENTION	A Target Reset condition or medium change occurred since the last command was sent from this Initiator
MEDIUM ERROR	An unrecoverable Read error occurred
RECOVERED ERROR	A recoverable Read error occurred
ABORTED COMMAND	An overrun error occurred, or some other error which might be resolved by repeating the command occurred

* For this Sense Key, the Information Byte is set to the Logical Block Address of the first invalid Logical Block Address. The Logical Block Address is invalid if any part of the extent is invalid.

Logical Unit Number (LUN) - Byte 01, Bits <07:05>

These bits specify the LUN of the addressed device for this command.

Logical Block Address - Bytes 01 through 03

These bytes specify the logical block address where the Read operation is to begin.

Number of Blocks to Transfer - Byte 04

This byte specifies the number of contiguous logical blocks of data to be transferred. When the Number of Blocks to Transfer is zero, 256 logical blocks of data are transferred. Any other value between 1 and 256, inclusive, indicates that number of logical blocks are to be transferred.

Error Retry (ERTY) - Byte 05, Bit 07

Are we still using this bit ??????

Error Correction Code (ECC) - Byte 05, Bit 06

Are we still using this bit ??????

Flag - Byte 05, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 in Byte 05) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 05, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command from the Initiator. Status is returned for each command executed.

8.3.7 RE-ASSIGN BLOCK 07

The **RE-ASSIGN BLOCK** CDB, shown below, sends Defect List data to the Target during the Data Phase of the command. The defect data is a list of logical block addresses which are to be re-assigned.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	0	1	1	1
01	LUN			0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	0	0	0	0	0	0	0	0
05	0	0	0	0	0	0	Flag	Link

During the Re-assign operation, if all available spares on the track become allocated, the entire track is marked as defective and an alternate track is used. Unspecified data blocks on the track are also moved to the alternate track. The alternate track is fully verified before the original track is marked as defective. If an unspecified data block cannot be read and moved successfully, the **RE-ASSIGN BLOCK** terminates with an error message that indicates which logical block number of the block is in error. The Initiator may then issue another **RE-ASSIGN BLOCK** command with the logical block number added appropriately to the Defect List data. Using this algorithm, all data blocks on the defective track are eventually moved and noted as (also) defective. If the **RE-ASSIGN BLOCK** command is completed successfully, no blocks are altered by the command, except those blocks indicated in the Defect List.

If the MD01 Controller is unable to update the defective sector file on the specified disk drive, an error occurs.

During execution of this command, the MD01 Controller does not disconnect from the SCSI bus unless disconnection is enabled by two conditions:

- The LUN is busy with another Initiator
- The Disconnect function is supported.

Logical Unit Number (LUN) - Byte 01, Bits <07:05>

These bits specify the LUN of the addressed device for this command.

Reserved - Bytes 02 through 04

These bytes are reserved and must be zero.

Flag - Byte 05, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 in Byte 05) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 05, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command from the Initiator. Status is returned for each command executed.

8.3.7.1 Re-assign Block Data Format

During the Data In Phase of the **RE-ASSIGN BLOCK** command, data is sent in the following format:

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	0	0	0	0
01	0	0	0	0	0	0	0	0
02	Length of Defect List (n) (MSB)							
03	Length of Defect List (n) (LSB)							

The defect descriptors, shown below, are repeated n/4 times within the length specified (Bytes 02 through 03) in the **RE-ASSIGN BLOCK** CDB (n is the Length of the Defect List defined in the Re-assign Block Data Format).

Byte	Bit 07	06	05	04	03	02	01	00
00	Defect List Block Address (MSB)							
01	Defect List Block Address							
02	Defect List Block Address							
03	Defect List Block Address (LSB)							

The Defect List Block Address bytes are converted to the appropriate track and block addresses by the MD01 Controller and are specified in ascending order. Block addresses that specify previously detected or specified addresses are ignored and do not produce duplicate entries in the BSF.

If the LUN has insufficient capacity to re-assign all the defective logical blocks, the MD01 command terminates the **RE-ASSIGN BLOCK** command with a CHECK CONDITION status code and sets the Sense Key in the Extended Sense Byte to MEDIUM ERROR. The Logical Block Address of the last logical block re-assigned is returned in the Information Bytes of the sense data.

Defect List Block Address - Bytes 00 through 03

These bytes specify the address of the block that contains the defect.

8.3.8 RECEIVE DIAGNOSTIC 1C

The **RECEIVE DIAGNOSTIC** command allows the MD01 Controller to start diagnostic subcommands sent by the **SEND DIAGNOSTIC** command (see subsection 8.3.15). The **RECEIVE DIAGNOSTIC** command is only executed by the MD01 Controller if a **SEND DIAGNOSTIC** command previously was issued by the same Initiator that issued the **RECEIVE DIAGNOSTIC** command. If no **SEND DIAGNOSTIC** command has been received, the MD01 Controller rejects the **RECEIVE DIAGNOSTIC** command with a CHECK CONDITION status code and sets the ILLEGAL REQUEST Sense Key in the Extended Sense Byte (see subsection 8.3.10.2).

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	1	1	1	0
01	LUN			0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	Allocation Length							
04	Allocation Length							
05	0	0	0	0	0	0	Flag	Link

NOTE

Executing the self-test of the MD01 Controller automatically resets the MD01 Controller. Any context specified by the host adapter must be re-submitted to the MD01 Controller.

Logical Unit Number (LUN) - Byte 01, Bits <07:05>

These bits specify the LUN of the addressed device to be loaded or unloaded.

Reserved - Bytes 02

This byte is reserved and must be zero.

Allocation Length - Bytes 03 through 04

These bytes specify the number of bytes the Initiator has allocated for returned diagnostic data. If the Allocation Length has a value of zero, no diagnostic data is returned. If the Allocation Length has any other value, that number of bytes or fewer are transferred. The Target terminates the Data In Phase when all Allocation Length bytes have been transferred, or when all available diagnostic data has been transferred to the Initiator.

NOTE

Although diagnostic software is generally device-specific, the **RECEIVE DIAGNOSTIC** and **SEND DIAGNOSTIC** commands enable the system to isolate host operating system software from device-specific diagnostic software. This isolation allows the host operating system to remain device independent.

Flag - Byte 05, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 of Byte 05) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 05, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command for the Initiator. Status is returned for each command executed.

8.3.9 RELEASE UNIT 17

The **RELEASE UNIT** CDB, shown below, causes the LUN (connected to the MD01 Controller and previously reserved by the **RESERVE UNIT** command) to be released if the requesting Initiator was the last to reserve that LUN. Once the **RELEASE UNIT** command is issued, other Initiators can access the LUN.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	0	1	1	1
01	0	0	0	THPR	Third Party ID			0
02	Reservation Identification							
03	0	0	0	0	0	0	0	0
04	0	0	0	0	0	0	0	0
05	0	0	0	0	0	0	Flag	Link

An attempt to release to the requesting Initiator any LUN which is not currently reserved and which does not have a queued reservation pending, does not result in an error condition.

During the execution of this command, the MD01 Controller does not disconnect unless disconnection is enabled by two conditions:

- The LUN is busy with another Initiator
- The Disconnect function is supported.

Third Party Reservation Release Option (THPR) - Byte 01, Bit 04

This bit is set to one to release a reservation if that reservation was made by:

- the same Initiator for the SCSI bus device as specified in the Third Party ID field of this CDB (see next paragraph)
- using the optional THP bit in the **RESERVE UNIT** command (see subsection 8.3.11)

Third Party ID - Byte 01, Bits <03:01>

These bits specify the SCSI bus device code (ID) that identifies the LUN reserved by the Initiator, if the THPR bit (Byte 01, Bit 04) is set.

Reservation Identification - Byte 02

This byte allows an Initiator, that has more than one reserved LUN awaiting release, to specify a code that identifies which reserved LUN is to be released by this CDB.

Reserved - Bytes 03 through 04

These bytes are reserved and must be zero.

Flag - Byte 05, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 in Byte 05) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 05, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command from the Initiator. Status is returned for each command executed.

8.3.10 REQUEST SENSE 03

The **REQUEST SENSE** CDB, shown below, is used to obtain more detailed information, called sense information, after execution of a command has been completed successfully. Typically, a **REQUEST SENSE** command is issued after a previous command has been completed and a CHECK CONDITION status code has occurred. A **REQUEST SENSE** command may be issued at any time by a diagnostic routine, device driver routine, or program, regardless of whether an error has or has not occurred; because significant sense information is cleared only upon receipt of an I/O-type or access-type command.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	0	0	1	1
01	LUN			0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	Number of Requested Sense Bytes							
05	0	0	0	0	0	0	Flag	Link

During the execution of this command, the MD01 Controller does not disconnect unless disconnection is enabled by two conditions:

- The LUN is busy with another Initiator
- The Disconnect function is supported.

Logical Unit Number (LUN) - Byte 01, Bits <07:05>

These bits specify the LUN of the addressed device for this command.

Reserved - Bytes 02 through 03

These bytes are reserved and must be zero.

Number of Requested Sense Bytes - Byte 04

This byte contains the number of bytes of data the Initiator has allocated for the sense information. The count supplied determines the format of the returned sense data. The sense data can be returned in one of two supported Sense Byte Formats:

- Standard (non-extended)
- Extended.

These formats are described in subsections 8.3.10.1 and 8.3.10.2.

A requested sense byte count of four or fewer bytes results in a transfer of four bytes in the Standard Sense Byte format.

A requested sense byte count of more than four bytes results in a data transfer of up to the requested number of sense bytes (but never more than the maximum number of sense bytes defined) in the Extended Sense Byte format.

Flag - Byte 05, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 in Byte 05) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 05, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command from the Initiator. Status is returned for each command executed.

8.3.10.1 Standard Sense Byte Format

The Standard Sense Byte format, shown below, is used when the requested number of bytes (Byte 04 of the **REQUEST SENSE** CDB) is less than or equal to four bytes.

Byte	Bit 07	06	05	04	03	02	01	00
00	VADD	ERCL			ERCD			
01	0	0	0	Logical Block Address (MSB)				
02	Logical Block Address							
03	Logical Block Address (LSB)							

Valid Address (VADD) - Byte 00, Bit 07

Setting this bit indicates the Logical Block Address field (Bytes 01 through 03) contains valid information related to the error code.

Error Class (ERCL) - Byte 00, Bits <06:04>

These bits indicate the source of the error that occurred. Error Class codes are listed in Table 8-5. Error Classes 0 through 3 (hexadecimal) are valid for Standard Sense information.

Table 8-5. Standard Sense Error Classes

Bits 06 05 04	Error Class
0 0 0	DISK DRIVE ERRORS
0 0 1	TARGET ERRORS
0 1 0	SYSTEM-RELATED ERRORS
0 1 1	VENDOR UNIQUE ERROR CONDITIONS

Error Code (ERCD) - Byte 00, Bits <03:00>

These bits indicate the type of error that occurred. The hexadecimal Sense Error codes used in the Standard (nonextended) Sense Bytes for disk drive, Target, system-related, and vendor-unique errors are listed and described in Table 8-6.

Logical Block Address - Bytes 01 through 03

These bytes specify the Logical Block Address associated with the Sense Key.

Table 8-6. Standard Sense Byte Error Codes

DISK DRIVE ERRORS		
Code	Error	Description
00	NO SENSE	The MD01 Controller detected no error during execution of the previous command.
01	NO INDEX SIGNAL	????
02	NO SEEK COMPLETE	????
03	WRITE FAULT	?????
04	DRIVE NOT READY	The disk drive is not ready.
05	DRIVE NOT SELECTED	?????
06	NO TRACK ZERO	????
07	MULTIPLE DRIVES SELECTED	?????
09	MEDIA NOT LOADED	A **LOAD/UNLOAD** command has been issued but the media cartridge is not installed in the disk drive, as indicated by a disk drive status signal.
0A	INSUFFICIENT CAPACITY	The media does not have enough space to allow additional data from the Initiator to be accepted.
0B	DRIVE TIMEOUT	A timeout occurred during an operation being performed by the disk drive.

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Table 8-6. Standard Sense Error Codes (continued)

TARGET ERRORS		
Code	Error	Description
10	I.D. READ ERROR	??????
11	UNCORRECTABLE DATA ERROR	A block could not be written after 16 retry attempts.
12	I.D. ADDRESS MARK NOT FOUND	?????
13	DATA ADDRESS MARK NOT FOUND	??????
14	BLOCK NOT FOUND	The block sequence is improper, or a block is missing.
15	SEEK ERROR	??????
16	DMA TIMEOUT ERROR	System activity reached a point where DMA service for the MD01 Controller exceeded allowable time limits and was suspended, requiring one or more retry attempts.
17	WRITE PROTECTED	The disk is write protected. The outstanding **WRITE** command has been aborted.

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Table 8-6. Standard Sense Error Codes (continued)

TARGET ERRORS (continued)		
Code	Error	Description
18	CORRECTABLE DATA CHECK	To be read correctly, a block had to be read two or more times.
1A	INTERLEAVE ERROR	????
1C	COMMAND LATE ERROR	?????
1D	DATA LATE ERROR	?????
1E	WRITE CHECK ERROR	?????
1F	ECC SOFT ERROR	?????
SYSTEM-RELATED ERRORS		
Code	Error	Description
20	INVALID COMMAND	The issued command cannot be executed, or is not applicable.
21	ILLEGAL BLOCK ADDRESS	?????

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Table 8-6. Standard Sense Error Codes (continued)

SYSTEM-RELATED ERRORS		
Code	Error	Description
30	UNIT ATTENTION	The removable media may have been changed, or the addressed LUN has been reset (by the BUS DEVICE RESET message), after the last command was issued to the addressed LUN. This error is reported the first time any command is issued after the condition is detected; then the requested command is not performed. This condition is cleared when the next I/O command is issued by the same host adapter. UNIT ATTENTION is reported to all SCSI devices that subsequently issue a command to the LUN.
31	COMMAND TIMEOUT	Command execution was not completed by the MD01 Controller before a predetermined, command-specified time limit had expired.

8.3.10.2 Extended Sense Byte Format

The Extended Sense Byte format, shown below, is used when the requested number of bytes (Byte 04 of the **REQUEST SENSE** CDB) is greater than four bytes.

Byte	Bit 07	06	05	04	03	02	01	00
00	VADD	1	1	1	Vendor Unique Code			
01	Segment Number							
02	X	X	ILI	0	Sense Key			
03	Logical Block Address (MSB)							
04	Logical Block Address							
05	Logical Block Address							
06	Logical Block Address (LSB)							
07	Additional Sense Length							
08-NN	Additional Sense Length Bytes							
X = Don't Care								

Valid Address (VADD) - Byte 00, Bit 07

Setting this bit indicates the Logical Block Address (Bytes 03 through 06) contains valid information related to the error code.

Vendor-Unique Code - Byte 00, Bits <03:00>

These bits specify the type of Extended Sense Byte format to be used. Only hexadecimal values of 0 and F are valid. A value of zero specifies the Extended Sense Data format; a value of F specifies the Vendor Unique Extended Sense format (see subsection 8.3.10.3).

Segment Number - Byte 01

This byte contains the current segment number if the Extended Sense information is in response to a **COPY** command. Up to 256 segments are supported.

Not Used - Byte 02, Bits <07:06>

These bits are not used and can be either one or zero.

Incorrect Length Indicator (ILI) - Byte 02, Bit 05

Setting this bit indicates the requested block size did not match the block size of the data on the disk.

Sense Key - Byte 02, Bits <03:00>

These bits provide the Sense Key Error Codes for any errors detected during the operation. The errors are listed and defined in Table 8-7.

Logical Block Address - Bytes 03 through 06

These bytes specify the Logical Block Address where the error, specified by the Sense Key Error Code, occurred.

Additional Sense Length - Byte 07

This byte specifies the number of Additional Sense Bytes (represented as NN in the Extended Sense Byte format) that are to follow. If the Allocation Length of the CDB is too small to transfer all of the Additional Sense Length bytes, the Additional Sense Length is not adjusted to reflect the truncation. The Additional Sense Bytes contain command-specific data that further defines the nature of the CHECK CONDITION status. These bytes are used with:

- the COPY ABORTED status code
- the Sense Key 10 (hexadecimal)
- the Vendor Unique sense keys.

Table 8-7. Sense Key Error Codes

Bits 03	02	01	00	Error	Description
0	0	0	0	NO SENSE	There is no sense key information to be reported for the designated LUN. This code occurs for a successfully completed command.
0	0	0	1	RECOVERED ERROR	The last command was completed successfully, but with some recovery action performed by the Target.
0	0	1	0	NOT READY	The addressed LUN cannot be accessed. Operator intervention may be required.
0	0	1	1	MEDIUM ERROR	The command terminated with a nonrecoverable-error condition which was probably caused by a flaw in the media or by an error in the recorded data.
0	1	0	0	HARDWARE ERROR	A nonrecoverable hardware error (i.e., controller failure, device failure, parity error, etc.) was detected while the Target was performing the command or while the Target was performing a Self-Test operation.
0	1	0	1	ILLEGAL REQUEST	There was an illegal parameter in the command or in the additional required parameters supplied as data for some related commands.

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Table 8-7. Sense Key Error Codes (continued)

Bits 03 02 01 00	Error	Description
0 1 1 0	UNIT ATTENTION	The removable media may have been changed, or the LUN has been reset (by the BUS DEVICE RESET message), after the last command was issued to the addressed LUN. This error is reported the first time any command is issued after the condition is detected; then the requested command is not performed. This condition is cleared when the next I/O command is issued by the same host adapter. UNIT ATTENTION is reported to all SCSI devices that subsequently issue a command to the LUN.
0 1 1 1	WRITE PROTECT	A command that reads writes to the disk was attempted on a block that is protected from this operation. The Write operation was not performed.
1 0 0 0	RESERVED	
1 0 0 1	VENDOR UNIQUE	**A Vendor-Unique error condition occurred. The corresponding nonextended error class and code are specified in Byte 08 of the Vendor-Unique Extended Sense Byte (see subsection 8.3.10.3).**
1 0 1 0	**COPY ABORTED**	**A COPY command was aborted because an error condition was detected on the source or destination device.**

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Table 8-7. Sense Key Error Codes (continued)

Bits 03	02	01	00	Error	Description
1	0	1	1	ABORTED COMMAND	The Target aborted the command. The Initiator may recover by trying to execute the command again.
1	1	0	0	EQUAL	A **SEARCH DATA** command satisfied an equal comparison.
1	1	0	1	VOLUME OVERFLOW	A buffered device has reached the end-of-medium and data, which has not been written to disk, remains in the buffer. A **RECOVER BUFFERED DATA** command can be issued to read the unwritten data from the buffer.
1	1	1	0	RESERVED	
1	1	1	1	RESERVED	

8.3.10.3 Vendor-Unique Extended Sense Byte Format

The Vendor-Unique Extended Sense Byte format, shown below, is used for those nonextended error classes and codes that do not have a corresponding Sense Key.

Byte	Bit 07	06	05	04	03	02	01	00
00	VADD	1	1	1	1	1	1	1
01	Segment Number							
02	X	X	ILI	0	Sense Key			
03	Logical Block Address (MSB)							
04	Logical Block Address							
05	Logical Block Address							
06	Logical Block Address (LSB)							
07	0	0	0	0	0	0	0	1
08	ERCL				ERCD			
X = Don't Care								

Valid Address (VADD) - Byte 00, Bit 07

Setting this bit indicates the Logical Block Address field (Bytes 03 through 06) contains information related to the error code.

Segment Number - Byte 01

This byte contains the current segment number if the Extended Sense Information Byte pertains to a **COPY** command. Up to 256 segments are supported.

Incorrect Length Indicator (ILI) - Byte 02, Bit 05

Setting this bit indicates the requested block size did not match the block size of the data on the disk.

Not Used - Byte 02, Bits <07:06>

These bits are not used and can be either one or zero.

Sense Key - Byte 02, Bits <03:00>

These bits provide the Sense Key Error Codes for any errors detected during the operation (see Table 8-7).

Logical Block Address - Bytes 03 through 06

These bytes specify the Logical Block Address where the error, specified by the Sense Key Error Code, occurred.

Additional Sense Length - Byte 07

This byte specifies there is one Additional Sense Byte (Byte 08). The Additional Sense Byte contains command-specific data that further defines the nature of the CHECK CONDITION status. This byte is used with:

- the COPY ABORTED status code
- the Sense Key 10 (hexadecimal)
- the Vendor-Unique sense keys.

Error Class (ERCL) - Byte 08, Bits <07:04>

These bits indicate the source of the error that occurred (see Table 8-5). Error Classes 0 through 3 (hexadecimal) are valid for the Vendor-Unique Extended Sense Information.

Error Code (ERCD) - Byte 08, Bits <03:00>

These bits indicate the type of error that occurred. The hexadecimal sense error codes used in the Vendor-Unique Extended Sense Byte for the disk drive, Target, system-related, and vendor unique errors are listed and described in Table 8-6.

8.3.11 RESERVE UNIT 16

The **RESERVE UNIT** CDB, shown below, causes the LUN to be reserved for exclusive use by the Initiator until that Initiator sends an appropriate **RELEASE UNIT** command (see subsection 8.3.9). If the Extent Reservation option is used, the **RESERVE UNIT** command also causes extents within a specified LUN to be reserved for exclusive use by the Initiator.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	0	1	1	0
01	LUN			THP	Third Party ID			0
02	Reservation Identification							
03	0	0	0	0	0	0	0	0
04	0	0	0	0	0	0	0	0
05	0	0	0	0	0	0	Flag	Link

If no extent is reserved in the LUN by another Initiator when the current Initiator issues this CDB, this **RESERVE UNIT** command causes the LUN to be reserved for exclusive use by the current Initiator until the reservation is released by any of the following methods:

- a **RELEASE UNIT** command is issued by the same (current) Initiator
- a BUS DEVICE RESET status code is issued by any Initiator
- a Hard Reset Condition occurs.

An Initiator can reserve a LUN that is already reserved by that Initiator; but when it does, the Reservation Identification (Byte 02) in this CDB is ignored by the MD01 Controller.

If the LUN is previously reserved, the Target performs one of two operations, as applicable:

- Sends a RESERVATION CONFLICT status code
- Queues the reservation request and then disconnects until all previously queued reservations have been released. When the LUN is available, the Target reconnects to perform the task for which the reservation has been released.

If any other Initiator subsequently attempts to perform any operation on the reserved LUN, that command is rejected with a RESERVATION CONFLICT status code.

Third Party Reservation Option (THP) - Byte 01, Bit 04

This bit allows an Initiator to reserve a LUN for another device on the SCSI bus. If the THP bit is set, an Initiator is allowed to reserve the specified LUN for the SCSI bus device specified in the Third Party ID field (Byte 01, Bits <03:00>). This option is intended for use in multiple-host adapter systems in which the **COPY** command is used. The LUN retains the reservation until it is released by the same Initiator that reserved it. Any attempt by another Initiator to obtain the LUN is ignored. The MD01 Controller does not disconnect from the SCSI bus during execution of this command. Any Target that uses the THP option must also use the Third Party Reservation Release (THPR) option (see subsection 8.3.9).

Third Party ID - Byte 01, Bits <03:01>

These bits specify the SCSI bus device code (ID) that identifies the LUN reserved by the Initiator. The ID is valid only when the THP bit (Byte 01, Bit 04) is set.

Reservation Identification - Byte 02

This byte allows an Initiator that has more than one reserved LUN awaiting release, to specify a code that identifies which reserved LUN is to be released by this CDB.

Reserved - Bytes 03 through 04

These bytes are reserved and must be zero.

Flag - Byte 05, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 in Byte 05) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 05, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command from the Initiator. Status is returned for each command executed.

8.3.12 REZERO UNIT 01

The **REZERO UNIT** CDB, shown below, causes the selected disk drive to perform a recalibration of the head mechanism to physical cylinder 0.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	0	0	0	1
01	LUN			0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	0	0	0	0	0	0	0	0
05	DER	0	0	0	0	0	Flag	Link

The MD01 Controller can disconnect during the execution of this command.

Logical Unit Number (LUN) - Byte 01, Bits <07:05>

These bits specify the LUN of the addressed device for this command.

Reserved - Byte 04

This byte is reserved and must be zero.

Disable Error Retry (DER) - Byte 05, Bit 07

are we still using this bit ?????

Flag - Byte 05, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 in Byte 05) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 05, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command from the Initiator. Status is returned for each command executed.

8.3.13 SEEK 0B

The SEEK CDB, shown below, causes the selected disk drive to begin a Seek operation to the specified logical block location. If the logical block number specifies a block on a defective track, the Seek operation to the alternate track is not performed until the MD01 Controller receives and processes an I/O command.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	1	0	1	1
01	LUN			Logical Block Address (MSB)				
02	Logical Block Address							
03	Logical Block Address (LSB)							
04	0	0	0	0	0	0	0	0
05	ERTY	0	0	0	0	0	Flag	Link

Logical Unit Number (LUN) - Byte 01, Bits <07:05>

These bits specify the LUN of the addressed device for this command.

Logical Block Address - Bytes 01 through 03

These bytes specify the logical block where the Seek operation is to begin.

Reserved - Byte 04

This byte is reserved and must be zero.

Error Retry (ERTY) - Byte 05, Bit 07

Are we still using this bit???

Flag - Byte 05, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 in Byte 05) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 05, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command from the Initiator. Status is returned for each command executed.

8.3.14 SEND DIAGNOSTIC 1D

The **SEND DIAGNOSTIC** CDB, shown below, causes a diagnostic subcommand to be sent to the Target. The subcommand is specified in the Parameter List of the CDB. The subcommands currently supported by the MD01 Controller are listed in the subsections that follow the explanation of the **SEND DIAGNOSTIC** CDB.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	1	1	0	1
01	LUN			0	0	ST	0	0
02	0	0	0	0	0	0	0	0
03	Parameter List Length (MSB)							
04	Parameter List Length (LSB)							
05	0	0	0	0	0	0	Flag	Link

Logical Unit Number (LUN) - Byte 01, Bits <07:05>

These bits specify the LUN of the addressed device for this command.

Self-Test - Byte 01, Bit 02

Setting this bit indicates the Target is directed to complete its default Self-Test.

Reserved - Byte 02

This byte is reserved and must be zero.

Parameter List Length - Bytes 03 through 04

These bytes specify the length (in bytes) of the Parameter List transferred during the Data Out Phase of the **SEND DIAGNOSTIC** command. The Parameter List contains a diagnostic subcommand and any additional information required.

If the subcommand in the Parameter List indicates a Data Transfer operation from the Initiator to the MD01 Controller is required, the operation occurs during the Data Phase of the **SEND DIAGNOSTIC** command.
If the subcommand in the Parameter List indicates a Data Transfer operation from the Target to the Initiator is required, that Data Transfer operation is executed by the MD01 Controller after a **RECEIVE DIAGNOSTIC** command is issued by the Initiator.

The subcommand specified in the Parameter List is executed only if the MD01 Controller has received the **RECEIVE DIAGNOSTIC** command (after the Initiator has sent a **SEND DIAGNOSTIC** command), and only if the Initiator did not issue any other intervening command.

Flag - Byte 05, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 in Byte 05) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 05, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command from the Initiator. Status is returned for each command executed.

8.3.14.1 PERFORM DRIVE DIAGNOSTICS 02

The **PERFORM DRIVE DIAGNOSTICS** diagnostic subcommand, shown below, causes the MD01 Controller to perform Write and Verify operations on each surface of the diagnostic cylinder of the specified disk drive. If any sectors on this cylinder cannot be written or verified by using two different bit patterns, the MD01 Controller terminates the command with a CHECK CONDITION status code. The MD01 Controller then sets the Sense Key in the Extended Sense Byte to MEDIA ERROR and sets the Valid Address bit in the Extended Sense Byte to one. The Sense Information bytes contain the number of bad sectors found on this cylinder.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	0	0	1	0
01	0	0	0	0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	0	0	0	0	0	0	0	0
05	0	0	0	0	0	0	0	0

Subcommand Code - Byte 00

This byte is set to 02 (hexadecimal) to specify the **PERFORM DRIVE DIAGNOSTICS** diagnostic subcommand.

Reserved - Bytes 01 through 05

These bytes are reserved and must be zero.

8.3.14.2 READ BAD SECTOR FILE 05

The **READ BAD SECTOR FILE** diagnostic subcommand, shown below, causes the MD01 Controller to transfer the contents of the BSF to the Initiator. During the Transfer operation, the BSF header is the first information transferred followed by up to the maximum number of entries requested by the Initiator. If less than the requested number of entries exist, after all existing entries have been transferred, an error occurs. In this situation, the MD01 Controller sets the Sense Key in the Extended Sense Byte to ILLEGAL REQUEST and sets the Additional Sense Bytes to the Residue Entry Count.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	0	1	0	1
01	0	0	0	0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	Requested Entry Count (M) (MSB)							
05	Requested Entry Count (M) (LSB)							

The MD01 Controller begins to execute the subcommand and transfer data when it has received the appropriate **RECEIVE DIAGNOSTIC** command from the Initiator. For information about the data and header format, see subsection 5.3.1.

Subcommand Code - Byte 00

This byte is set to 05 (hexadecimal) to specify the **READ BAD SECTOR FILE** diagnostic subcommand.

Reserved - Bytes 01 through 03

These bytes are reserved and must be zero.

Requested Entry Count - Bytes 04 through 05

These bytes specify the number of entries in the BSF requested by the Initiator.

8.3.14.3 READ DISK PARTITIONS 06

The **READ DISK PARTITIONS** diagnostic subcommand, shown below, causes the MD01 Controller to read the physical addresses related to the logical partitions on the specified disk drive and to transfer those addresses to the Initiator.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	0	1	1	0
01	0	0	0	0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	0	0	0	0	0	0	0	0
05	0	0	0	0	0	0	0	0

The MD01 Controller begins to execute the subcommand and transfer data when it has received the appropriate **RECEIVE DIAGNOSTIC** command from the Initiator. For information about the data format, see subsection 8.3.14.3.1.

Subcommand Code - Byte 00

This byte is set to hexadecimal 06 to specify the **READ DISK PARTITIONS** diagnostic subcommand.

Reserved - Bytes 01 through 05

These bytes are reserved and must be zero.

8.3.14.3.1 READ DISK PARTITIONS Data Format. Data for the **READ DISK PARTITIONS** diagnostic subcommand is transferred in the following format:

Byte	Bit 07	06	05	04	03	02	01	00
(Start of Bad Sector File)								
00	Logical Block Address (MSB)							
01	Logical Block Address							
02	Logical Block Address							
03	Logical Block Address (LSB)							
(Start of Alternate Track Storage)								
04	Logical Block Address (MSB)							
05	Logical Block Address							
06	Logical Block Address							
07	Logical Block Address (LSB)							
(Start of Diagnostic Cylinder)								
08	Logical Block Address (MSB)							
09	Logical Block Address							
0A	Logical Block Address							
0B	Logical Block Address (LSB)							
(Start of Manufacturer's Bad Sector File, Optional)								
0C	Logical Block Address (MSB)							
0D	Logical Block Address							
0E	Logical Block Address							
0F	Logical Block Address (LSB)							

Bad Sector File Logical Block Address - Bytes 00 through 03

These bytes specify the starting logical block address of the BSF.

Alternate Track Storage Logical Block Address - Bytes 04 through 07

These bytes specify the starting logical block address of the Alternate Track Storage.

Diagnostic Cylinder Logical Block Address - Bytes 08 through 0B

These bytes specify the starting logical block address of the Diagnostic Cylinder.

Manufacturer's Bad Sector File Logical Block Address - Bytes 0C through 0F

These bytes specify the starting logical block address of the Manufacturer's BSF.

8.3.14.4 READ LONG 1A

The **READ LONG** diagnostic subcommand, shown below, causes the MD01 Controller to perform a Read operation of one data block, beginning at the specified block address. The data and the six Error Correction Code (ECC) bytes of the specified block are transferred to the Initiator.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	1	0	1	0
01	Logical Block Address (MSB)							
02	Logical Block Address							
03	Logical Block Address							
04	Logical Block Address (LSB)							
05	0	0	0	0	0	0	0	0

The MD01 Controller begins to execute and transfer data when it has received the appropriate **RECEIVE DIAGNOSTIC** command from the Initiator.

Subcommand Code - Byte 00

This byte is set to hexadecimal 1A to specify the **READ LONG** diagnostic subcommand.

Logical Block Address - Bytes 01 through 04

These bytes specify the logical block address where the Read Long Diagnostic operation is to begin.

Reserved - Byte 05

This byte is reserved and must be zero.

8.3.14.5 WRITE LONG 1B

The **WRITE LONG** diagnostic subcommand, shown below, causes the MD01 Controller to perform a Write operation of one data block, starting at the specified logical block address. The data and the six ECC bytes of the specified logical block are written for each logical block specified in the logical block address.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	1	1	0	1	1
01	Logical Block Address (MSB)							
02	Logical Block Address							
03	Logical Block Address							
04	Logical Block Address (LSB)							
05	0	0	0	0	0	0	0	0

Subcommand Code - Byte 00

This byte is set to hexadecimal 1B to specify the **WRITE LONG** diagnostic subcommand.

Logical Block Address - Bytes 01 through 04

These bytes specify the logical block address where the Write Long Diagnostic operation is to begin.

Reserved - Byte 05

This byte is reserved and must be zero.

8.3.15 TEST UNIT READY 00

The **TEST UNIT READY** CDB, shown below, causes a test to be performed to ensure the disk drive is powered-on and ready. This condition is indicated by a GOOD status code being returned in response to this command. The MD01 Controller can also return a CHECK CONDITION or BUSY status code in response to this command. If the disk drive is not ready, a **REQUEST SENSE** command can be issued to obtain detailed information about the reason the disk drive is not ready (unavailable).

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	0	0	0	0
01	LUN			0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	0	0	0	0	0	0	0	0
05	0	0	0	0	0	0	Flag	Link

During execution of this command, the MD01 Controller does not disconnect unless the disconnection is enabled by two conditions:

- The LUN is busy with another Initiator
- The Disconnect function is supported.

Logical Unit Number (LUN) - Byte 01, Bits <07:05>

These bits specify the LUN of the addressed device for this command.

Reserved - Bytes 02 through 04

These bytes are reserved and must be zero.

Flag - Byte 05, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 in Byte 05) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 05, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command from the Initiator. Status is returned for each command executed.

8.3.16 WRITE 0A

The **WRITE** CDB, shown below, causes data to be transferred from the Initiator to the Target device. The amount of data written is a multiple of the block length. The **WRITE** command specifies the starting logical block number and the number of blocks to be written.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	1	0	1	0
01	LUN			Logical Block Address (MSB)				
02	Logical Block Address							
03	Logical Block Address (LSB)							
04	Number of Blocks in Transfer							
05	ERTY	0	0	0	0	0	Flag	Link

If the Disconnect function is enabled, the MD01 Controller may disconnect from the Initiator while executing this command.

Logical Unit Number (LUN) - Byte 01, Bits <07:05>

These bits specify the LUN of the addressed device for this command.

Logical Block Address - Bytes 01 through 03

These bytes specify the logical block where the Write operation is to begin.

Number of Blocks to Transfer - Byte 04

This byte specifies the number of contiguous logical blocks of data to be transferred. When this byte contains all zeros, 256 logical blocks of data are transferred. Any other Number of Blocks to Transfer value indicates that number of blocks are to be transferred.

Flag - Byte 05, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 in Byte 05) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 05, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command from the Initiator. Status is returned for each command executed.

8.4 SCSI GROUP CODE 1 COMMAND DESCRIPTIONS

SCSI Group Code 1 command names and operation codes supported by the MD01 Controller are listed by subsection number in the following table:

Subsection	MD01 SCSI Command	Code
8.4.1	**READ CAPACITY**	25
8.4.2	**READ (EXTENDED)**	28
8.4.3	**SEARCH DATA EQUAL**	31
8.4.4	**SEARCH DATA HIGH**	30
8.4.5	**SEARCH DATA LOW**	32
8.4.6	**SEEK (EXTENDED)**	2B
8.4.7	**VERIFY**	2F
8.4.8	**WRITE (EXTENDED)**	2A
8.4.9	**WRITE AND VERIFY**	2E

This subsection provides detailed descriptions of the commands, including CDB formats, hexadecimal operation code, byte and bit functions, and any necessary event-sequence descriptions (i.e., effects produced by the commands). Each MD01 Controller SCSI command is described in a separate subsection.

A sample Group 1 CDB is shown in Figure 8-2. The first byte of a command (Byte 00) contains two fields: the Group Code in the high-order three bits (bits <07:05>), and the Command Code in the low-order five bits (bits <04:00>). The Group Code determines the length of the command packet in the CDB, and together the Group and Command Codes determine the operation to be performed.

Bits <07:05> of byte 01 in the CDB contain the LUN of the device being addressed. The MD01 Controller, acting as a SCSI Target, supports up to two LUNs (ST506 disk drives). Therefore, the value for the LUN field in byte 01 in the CDB is either 000 or 001. The LUN must be specified for all commands. If a LUN value, issued by the Initiator in an IDENTIFY message, differs from the value specified in the CDB, that value supersedes the value specified in the CDB. The definition of the low-order bits in byte 01 is based on the current command.

The last byte (byte 09) in every CDB is a Control Byte which is differentiated into two groups:

- The low-order two bits control the ability of linking commands in a sequence and of notifying the host adapter that a particular command (CDB) step has been completed. These two bits are designated Flag and Link in the descriptions of command packets presented in this subsection for the MD01 Controller.
- The remaining bits in the Control Byte are reserved bits and are always zero.

The remaining of the bytes in the CDB contain Command-Dependent Parameters.

NOTE

If a byte in a CDB can be any bit pattern, it is specified as **Not Used** in the paragraphs describing that CDB. If a byte in a CDB must be all zeros, it is specified as **Reserved** in the paragraphs describing that CDB.

Byte	Bit 07	06	05	04	03	02	01	00
00	Group Code			Command Code				
01	LUN			Command-Dependent Parameters				
02	Command-Dependent Parameters							
03	Command-Dependent Parameters							
04	Command-Dependent Parameters							
05	Command-Dependent Parameters							
06	Command-Dependent Parameters							
07	Command-Dependent Parameters							
08	Command-Dependent Parameters							
09	0	0	0	0	0	0	Flag	Link

Figure 8-2. Sample Command Descriptor Block

8.4.1 READ CAPACITY 25

The **READ CAPACITY** CDB, shown below, is used to determine the maximum logical block number on the specified LUN which can be read from or written to by the Initiator, and to determine the size of a logical block.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	1	0	0	1	0	1
01	LUN			0	0	0	0	0
02	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0
04	0	0	0	0	0	0	0	0
05	0	0	0	0	0	0	0	0
06	0	0	0	0	0	0	0	0
07	0	0	0	0	0	0	0	0
08	0	0	0	0	0	0	0	0
09	0	0	0	0	0	0	Flag	Link

Logical Unit Number (LUN) - Byte 01, Bits <07:05>

These bits specify the LUN of the addressed device for this command.

Reserved - Bytes 02 through 04

These bytes are reserved and must be zero.

Flag - Byte 09, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 in Byte 05) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 09, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command from the Initiator. Status is returned for each command executed.

8.4.1.1 Read Capacity Data Format

During the Data In Phase of the **READ CAPACITY** command, data is sent in the following format:

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	0	0	0	0	0	0
01	Last Block Address (MSB)							
02	Last Block Address							
03	Last Block Address (LSB)							
04	0	0	0	0	0	0	0	0
05	0	0	0	0	0	0	0	0
06	0	0	0	0	0	0	Block Size	
07	Block Size (in Bytes) (LSB)							

Last Block Address - Bytes 00 through 03

These bytes specify the logical block address where the Read Capacity operation is to begin.

Block Size (in Bytes) - Bytes 04 through 07

These bytes specify (in bytes) the number of bytes in the logical block. The MSB of the Block Size is Byte 04; however, the Block Size is limited to 256 or 512 bytes only.

8.4.2 READ (EXTENDED) 28

The **READ (EXTENDED)** CDB, shown below, performs the same function as the Group 0 **READ** command, it causes the transfer of data from the Target device to the Initiator. The amount of transferred data is a multiple of the block length (i.e., 512 data bytes/block). The **READ (EXTENDED)** command specifies the starting block number and the number of data blocks to be read. The **READ (EXTENDED)** command terminates when the number of data blocks to be read has been transferred.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	1	0	1	0	0	0
01	LUN			0	0	0	0	RELA
02	Logical Block Address (MSB)							
03	Logical Block Address							
04	Logical Block Address							
05	Logical Block Address (LSB)							
06	0	0	0	0	0	0	0	0
07	0	0	0	0	0	0	0	NBL
08	Number of Blocks (LSB)							
09	ERTY	ECC	0	0	0	0	Flag	Link

If the Disconnect function is enabled, the MD01 Controller can disconnect from the Initiator while executing this command.

If any reservation access conflict exists (see subsection 8.3.11, **RESERVE UNIT** command), the MD01 Controller terminates the **READ (EXTENDED)** command with a RESERVATION CONFLICT status code; no data is read.

Table 8-7 lists several error conditions, and their corresponding Sense Keys, that can occur during a Read operation. If any of the conditions occur, the MD01 Controller terminates the **READ (EXTENDED)** command, sends a CHECK CONDITION status code to the Initiator, and sets the Sense Key that defines the error condition in the Extended Sense Byte.

Logical Unit Number (LUN) - Byte 01, Bits <07:05>

These bits specify the LUN of the addressed device for this command.

Relative Address (RELA) - Byte 01, Bit 00

Setting this bit to one causes the Logical Block Address to be treated as a two's complement displacement. This displacement is added to the Logical Block Address last accessed on the LUN to form the Logical Block Address for this command. This feature is only available when the Linking Commands function is performed. The feature requires a previous command in the linked group to have accessed a Logical Block on the LUN; if it has not, the MD01 Controller terminates the **READ (EXTENDED)** command, sends a CHECK CONDITION status code, and sets the Sense Key in the Extended Sense Byte to the ILLEGAL REQUEST code.

Logical Block Address - Bytes 02 through 05

These bytes specify the logical block address where the Extended Read operation is to begin.

Reserved - Byte 06

This byte is reserved and must be zero.

Number of Blocks - Bytes 07 through 08

This byte specifies the number of contiguous logical blocks of data to be transferred. When this byte contains all zeros, no logical blocks of data are transferred. Any other value between 1 and 256, inclusive, indicates that number of logical blocks are to be transferred.

Error Retry (ERTY) - Byte 09, Bit 07

Are we still using this bit ??????

Error Correction Code (ECC) - Byte 09, Bit 06

Are we still using this bit ??????

Flag - Byte 09, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 in Byte 05) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 09, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command from the Initiator. Status is returned for each command executed.

8.4.3 SEARCH DATA EQUAL 31

The **SEARCH DATA EQUAL** CDB, shown below, is used to search one or more blocks for equality to a data pattern. The **SEARCH DATA EQUAL** command contains the concept of records within a data block to allow multiple records within a block to be searched. The **SEARCH DATA EQUAL** command is satisfied by comparing the disk data being examined with the Search Argument and finding equality.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	1	1	0	0	0	1
01	LUN			INV	Rcd Format		SPF	RELA
02	0	0	0	0	0	0	0	0
03	Logical Block Address							
04	Logical Block Address							
05	Logical Block Address (LSB)							
06	0	0	0	0	0	0	0	0
07	0	0	0	0	0	0	0	0
08	Number of Blocks (LSB)							
09	ERTY	0	0	0	0	0	Flag	Link

If the Disconnect function is enabled, the MD01 Controller can disconnect from the Initiator while executing this command.

If a command is linked to a **SEARCH DATA EQUAL** command, and the Search operation is successful, then the next command is fetched and executed. In this situation, if the RELA bit (Byte 01, bit 01) is set to one, then in the next command, the address portion of the command is used as a displacement from the block address at which the search was satisfied. If a linked search is not satisfied, the link is broken and an ending type of status code is sent.

If a **SEARCH DATA EQUAL** command is not linked to another command when the **SEARCH DATA EQUAL** command is satisfied, the MD01 Controller terminates the command with a CONDITION MET status code. A **REQUEST SENSE** command then can be issued to determine the block address and record offset of the matching record.

If a **REQUEST SENSE** command is issued after a **SEARCH DATA EQUAL** command completed successfully, the MD01 Controller performs the following event sequence:

1. Sets the Sense Key in the Extended Sense Byte to the EQUAL code if the Search operation was satisfied by an exact match (step 2 is then ignored).

2. Sets the Sense Key in the Extended Sense Byte to the NO SENSE code if the Search operation was not satisfied by an exact match.

3. Sets the Valid Address (VADD) bit in the Extended Sense Byte to one.

4. Reports the address of the block that contains the first matching record in the Information Bytes in the Extended Sense Byte.

5. Reports the record offset of the matching record in the first four bytes of Additional Sense Bytes in the Extended Sense Byte.

If a **REQUEST SENSE** command is issued after a **SEARCH DATA EQUAL** command was not completed successfully, the MD01 Controller performs additional steps in the event sequence:

6. Sets the Sense Key in the Extended Sense Byte to NO SENSE, if no errors occurred.

7. Sets the VADD bit in the Extended Sense Byte to zero.

Logical Unit Number (LUN) - Byte 01, Bits <07:05>

These bits specify the LUN of the addressed device for this command.

Invert Flag (INVF) - Byte 01, Bit 04

Setting this bit to one indicates no blocks were found that matched the specified data pattern.

Record Format (Recd Format) - Byte 01, Bits <03:02>

The Record Format field specifies whether Fixed Length or Variable Length Records are to be searched. If this field has a value of zero, Fixed Length records are to be searched; if this field has a non-zero value, Variable Length records are to be searched. The size of each Variable Length record is specified by a Variable Length Indicator (VLI) field at the beginning of each record. Values of one, two, or three in the Record Format field specify a one-, two-, or four-byte VLI field, respectively. The value contained in the VLI field is the record size in bytes (including the VLI).

Spanned Flag (SPF) - Byte 01, Bit 01

Setting this bit to one causes records to span block boundaries. A record may start in one block and end in the next, or a subsequent block. When the SPF bit is reset to zero, each record must be contained entirely within a single block. Any space at the end of the record that is smaller than the record size is ignored.

Relative Address (RELA) - Byte 01, Bit 00

Setting this bit to one causes the Logical Block Address to be treated as a two's complement displacement. This displacement is added to the Logical Block Address last accessed on the LUN to form the Logical Block Address for this command. This feature is only available when the Linking command function is performed. The feature requires that a previous command in the linked group has accessed a Logical Block on the LUN; if it has not, the MD01 Controller terminates the **SEARCH DATA EQUAL** command, sends a CHECK CONDITION status code, and sets the Sense Key in the Extended Sense Byte to the ILLEGAL REQUEST code.

Logical Block Address - Bytes 02 through 05

These bytes specify the logical block address where the Search operation is to begin. Byte 02 is the MSB of the Logical Block Address; it must be zero.

Reserved - Byte 06

This byte is reserved and must be zero.

Number of Blocks - Bytes 07 through 08

These bytes specify the number of contiguous logical blocks of data to be transferred. When the Number of Blocks to Transfer is zero, no logical blocks of data are transferred. Any other value between 1 and 256, inclusive, indicates that number of logical blocks are to be transferred.

Error Retry (ERTY) - Byte 09, Bit 07

?????

Flag - Byte 09, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 in Byte 09) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 09, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command from the Initiator. Status is returned for each command executed.

8.4.3.1 Search Data Commands Parameter List

During the Data In Phase of the Search commands (**SEARCH DATA EQUAL, SEARCH DATA HIGH,** and **SEARCH DATA LOW**), the Search Data Parameter List is sent in the following format:

Byte	Bit 07	06	05	04	03	02	01	00
00	Record Size (MSB)							
01	Record Size							
02	Record Size							
03	Record Size (LSB)							
04	First Record Offset (MSB)							
05	First Record Offset							
06	First Record Offset							
07	First Record Offset (LSB)							
08	Number of Records (MSB)							
09	Number of Records							
0A	Number of Records							
0B	Number of Records (LSB)							
0C	Search Argument Length (n) (MSB)							
0D	Search Argument Length (n) (LSB)							

Record Size - Bytes 00 through 03

The Record Size field specifies the record size in bytes for Fixed Size Records, or the maximum record size for Variable Length Records.

First Record Offset - Bytes 04 through 07

The First Record Offset field specifies the byte offset of the first record to search in the first block. Subsequent blocks are searched beginning with Byte 00. This action permits one or more records to be skipped initially.

Number of Records - Bytes 08 through 0B

The Number of Records field specifies the maximum number of records to be searched during the Search operation. A Search operation terminates when the Number of Records or the Number of Blocks (from the CDB) have been exhausted.

Search Argument Length - Bytes 0C through 0D

The Search Argument Length field specifies the length (in bytes) of the Search Argument. The Search Argument specifies one or more fields to compare within each record. For the search to be satisfied, all fields must match the search condition within a single record. The fields specified within the Search Argument must not overlap and must be in ascending order.

The variable length Search Argument, shown below, may be repeated n times (where n is the Search Argument Length specified in Bytes 0C through 0D in the Search Data Parameter List).

Byte	Bit 07	06	05	04	03	02	01	00
00	Displacement (MSB)							
01	Displacement							
02	Displacement							
03	Displacement (LSB)							
04	Pattern Size Field (M)							
05	Pattern Size Field (M)							
06-M+5	Pattern							

Displacement Field - Bytes 00 through 03

The Displacement Field specifies the byte displacement of the field to be compared with the relative start point of the record.

Pattern Size Field - Bytes 04 through 05

The Pattern Size field specifies the size of the Pattern field to be compared in bytes (specified as M in the Search Argument).

Pattern - Bytes 06 through M + 5

The Pattern is a variable-sized field that contains the data pattern to be compared with the current field.

8.4.4 SEARCH DATA HIGH 30

The **SEARCH DATA HIGH** CDB, shown below, is used to search one or more blocks for comparison with a data pattern. The **SEARCH DATA HIGH** command contains the concept of records within a data block to allow multiple records within a block to be searched. The **SEARCH DATA HIGH** command is satisfied when a comparison of the disk data is found to be greater than or equal to the Search Argument.

Data is sent during the Data In Phase of the **SEARCH DATA HIGH** command in the format of the Search Data Parameter List (see subsection 8.4.3.1.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	1	1	0	0	0	0
01	LUN			INV	Rcd Format		SPF	RELA
02	Logical Block Address (MSB)							
03	Logical Block Address							
04	Logical Block Address							
05	Logical Block Address (LSB)							
06	0	0	0	0	0	0	0	0
07	Number of Blocks (MSB)							
08	Number of Blocks (LSB)							
09	ERTY	0	0	0	0	0	Flag	Link

If the Disconnect function is enabled, the MD01 Controller can disconnect from the Initiator while executing this command.

If a command is linked to a **SEARCH DATA HIGH** command, and the Search operation is successful, then the next command is fetched and executed. In this situation, if the RELA bit (Byte 01, Bit 01) is set to one; and in the next command, the address portion of the command is used as a displacement from the block address at which the search was satisfied. If a linked search is not satisfied, the link is broken and an ending type of status code is sent.

If a **SEARCH DATA HIGH** command is not linked to another command when the **SEARCH DATA HIGH** command is satisfied, the MD01 Controller terminates the command with a CONDITION MET status code. A **REQUEST SENSE** command can then be issued to determine the block address and record offset of the matching record.

If a **REQUEST SENSE** command is issued after a **SEARCH DATA HIGH** command is completed successfully, the MD01 Controller performs the following event sequence:

1. Sets the Sense Key in the Extended Sense Byte to the EQUAL code if the Search operation was satisfied by an exact match (step 2 is then ignored).

2. Sets the Sense Key in the Extended Sense Byte to the NO SENSE code if the Search operation was not satisfied by an exact match.

3. Sets the Valid Address (VADD) bit in the Extended Sense Byte to one.

4. Reports the address of the block that contains the first matching record in the Information Bytes in the Extended Sense Byte.

5. Reports the record offset of the matching record in the first four bytes of Additional Sense Bytes in the Extended Sense Byte.

If a **REQUEST SENSE** command is issued after a **SEARCH DATA HIGH** command was not completed successfully, the MD01 Controller performs additional steps in the event sequence:

6. Sets the Sense Key in the Extended Sense Byte to NO SENSE, if no errors occurred.

7. Sets the VADD bit in the Extended Sense Byte to zero.

Logical Unit Number (LUN) - Byte 01, Bits <07:05>

These bits specify the LUN of the addressed device for this command.

Invert Flag (INVF) - Byte 01, Bit 04

Setting this bit to one indicates no blocks were found that were less than or equal to the specified data pattern.

Record Format (Recd Format) - Byte 01, Bits <03:02>

The Record Format field specifies whether Fixed Length or Variable Length Records are to be searched. If this field has a value of zero, Fixed Length records are to be searched; if this field has a non-zero value, Variable Length records are to be searched. The size of each Variable Length record is specified by a Variable Length Indicator (VLI) field at the beginning of each record. Values of one, two, or three in the Record Format field specify a one-, two-, or four-byte VLI field, respectively. The value contained in the VLI field is the record size in bytes (including the VLI).

Spanned Flag (SPF) - Byte 01, Bit 01

Setting this bit to one causes records to span block boundaries. A record may start in one block and end in the next, or a subsequent block. When the SPF bit is reset to zero, each record must be contained entirely within a single block. The MD01 Controller ignores any space at the end of the record that is smaller than the record size.

Relative Address (RELA) - Byte 01, Bit 00

Setting this bit to one causes the Logical Block Address to be treated as a two's complement displacement. This displacement is added to the Logical Block Address last accessed on the LUN to form the Logical Block Address for this command. This feature is only available when the Linking command function is performed. The feature requires that a previous command in the linked group has accessed a Logical Block on the LUN; if it has not, the MD01 Controller terminates the **SEARCH DATA HIGH** command, sends a CHECK CONDITION status code, and sets the Sense Key in the Extended Sense Byte to the ILLEGAL REQUEST code.

Logical Block Address - Bytes 02 through 05

These bytes specify the logical block address where the Search operation is to begin.

Reserved - Byte 06

This byte is reserved and must be zero.

Number of Blocks - Bytes 07 through 08

This byte specifies the number of contiguous logical blocks of data to be transferred. When the Number of Blocks to Transfer is zero, no logical blocks of data are transferred. Any other value between 1 and 256, inclusive, indicates that number of logical blocks are to be transferred.

Error Retry (ERTY) - Byte 09, Bit 07

?????

Flag - Byte 09, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 in Byte 09) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 09, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command from the Initiator. Status is returned for each command executed.

8.4.5 SEARCH DATA LOW 32

The **SEARCH DATA LOW** CDB, shown below, is used to search one or more blocks for comparison with a data pattern. The **SEARCH DATA LOW** command contains the concept of records within a data block to allow multiple records within a block to be searched. The **SEARCH DATA LOW** command is satisfied when a comparison of the disk data is found to be lesser than or equal to the Search Argument.

Data is sent during the Data In Phase of the **SEARCH DATA LOW** command in the format of the Search Data Parameter List (see subsection 8.4.3.1.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	1	1	0	0	1	0
01	LUN			INV	Rcd Format		SPF	RELA
02	0	0	0	0	0	0	0	0
03	Logical Block Address							
04	Logical Block Address							
05	Logical Block Address (LSB)							
06	0	0	0	0	0	0	0	0
07	0	0	0	0	0	0	0	0
08	Number of Blocks (LSB)							
09	ERTY	0	0	0	0	0	Flag	Link

If the Disconnect function is enabled, the MD01 Controller can disconnect from the Initiator while executing this command.

If a command is linked to a **SEARCH DATA LOW** command, and the Search operation is successful, then the next command is fetched and executed. In this situation, if the RELA bit (Byte 01, Bit 01) is set to one; and in the next command, the address portion of the command is used as a displacement from the block address at which the search was satisfied. If a linked search is not satisfied, the link is broken and an ending type of status code is sent.

If a **SEARCH DATA LOW** command is not linked to another command when the **SEARCH DATA LOW** command is satisfied, the MD01 Controller terminates the command with a CONDITION MET status code. A **REQUEST SENSE** command can then be issued to determine the block address and record offset of the matching record.

If a **REQUEST SENSE** command is issued after a **SEARCH DATA LOW** command successfully completes, the MD01 Controller performs the following event sequences:

1. Sets the Sense Key in the Extended Sense Byte to the EQUAL code if the Search operation was satisfied by an exact match (step 2 is then ignored).

2. Sets the Sense Key in the Extended Sense Byte to the NO SENSE code if the Search operation was not satisfied by an exact match.

3. Sets the Valid Address (VADD) bit in the Extended Sense Byte to one.

4. Reports the address of the block that contains the first matching record in the Information Bytes in the Extended Sense Byte.

5. Reports the record offset of the matching record in the first four bytes of Additional Sense Bytes in the Extended Sense Byte.

If a **REQUEST SENSE** command is issued after a **SEARCH DATA LOW** command was not completed successfully, the MD01 Controller performs additional steps in the event sequences:

6. Sets the Sense Key in the Extended Sense Byte to NO SENSE, if no errors occurred.

7. Sets the VADD bit in the Extended Sense Byte to zero.

Logical Unit Number (LUN) - Byte 01, Bits <07:05>

These bits specify the LUN of the addressed device for this command.

Invert Flag (INVF) - Byte 01, Bit 04

Setting this bit to one indicates no blocks were found that were greater than or equal to the specified data pattern.

Record Format (Recd Format) - Byte 01, Bits <03:02>

The Record Format field specifies whether Fixed Length or Variable Length Records are to be searched. If this field has a value of zero, Fixed Length records are to be searched; if this field has a non-zero value, Variable Length records are to be searched. The size of each Variable Length record is specified by a Variable Length Indicator (VLI) field at the beginning of each record. Values of one, two, or three in the Record Format field specify a one-, two-, or four-byte VLI field, respectively. The value contained in the VLI field is the record size in bytes (including the VLI).

Spanned Flag (SPF) - Byte 01, Bit 01

Setting this bit to one causes records to span block boundaries. A record may start in one block and end in the next, or a subsequent block. When the SPF bit is reset to zero, each record must be contained entirely within a single block. The MD01 Controller ignores any space at the end of the record that is smaller than the record size.

Relative Address (RELA) - Byte 01, Bit 00

Setting this bit to one causes the Logical Block Address to be treated as a two's complement displacement. This displacement is added to the Logical Block Address last accessed on the LUN to form the Logical Block Address for this command. This feature is only available when the Linking command function is performed. The feature requires that a previous command in the linked group has accessed a Logical Block on the LUN; if it has not, the MD01 Controller terminates the **SEARCH DATA LOW** command, sends a CHECK CONDITION status code, and sets the Sense Key in the Extended Sense Byte to the ILLEGAL REQUEST code.

Logical Block Address - Bytes 02 through 05

These bytes specify the logical block address where the Search operation is to begin.

Number of Blocks - Bytes 07 through 08

This byte specifies the number of contiguous logical blocks of data to be transferred. When the Number of Blocks to Transfer is zero, no logical blocks of data are transferred. Any other value between 1 and 256, inclusive, indicates that number of logical blocks are to be transferred.

Error Retry (ERTY) - Byte 09, Bit 07

?????

Flag - Byte 09, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 in Byte 09) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 09, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command from the Initiator. Status is returned for each command executed.

8.4.6 SEEK (EXTENDED) 2B

The **SEEK (EXTENDED)** CDB, shown below, causes the selected disk drive to begin a Seek operation to the specified logical block location. If the logical block number specifies a block on a defective track, the Seek operation to the alternate track is not performed until the MD01 Controller receives and processes an I/O command.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	1	0	1	0	1	1
01	LUN			0	0	0	0	0
02	Logical Block Address (MSB)							
03	Logical Block Address							
04	Logical Block Address							
05	Logical Block Address (LSB)							
06	0	0	0	0	0	0	0	0
07	0	0	0	0	0	0	0	0
08	0	0	0	0	0	0	0	0
09	ERTY	0	0	0	0	0	Flag	Link

If the Disconnect function is enabled, the MD01 Controller can disconnect from the Initiator while executing this command.

Logical Unit Number (LUN) - Byte 01, Bits <07:05>

These bits specify the LUN of the addressed device for this command.

Logical Block Address - Bytes 02 through 05

These bytes specify the logical block where the Extended Seek operation is to begin.

Reserved - Bytes 06 through 08

These bytes are reserved and must be zero.

Error Retry (ERTY) - Byte 09, Bit 07

?????

Flag - Byte 09, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 in Byte 09) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 09, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command from the Initiator. Status is returned for each command executed.

8.4.7 VERIFY 2F

The VERIFY CDB, shown below, causes the specified number of blocks to be verified.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	1	0	1	1	1	1
01	LUN			0	0	0	BYTC	RELA
02	Logical Block Address (MSB)							
03	Logical Block Address							
04	Logical Block Address							
05	Logical Block Address (LSB)							
06	0	0	0	0	0	0	0	0
07	Number of Blocks (MSB)							
08	Number of Blocks (LSB)							
09	ERTY	ECC	0	0	0	0	Flag	Link

If the Disconnect function is enabled, the MD01 Controller can disconnect from the Initiator while executing this command.

Logical Unit Number (LUN) - Byte 01, Bits <07:05>

These bits specify the LUN of the addressed device for this command.

Byte Check (BYTC) - Byte 01, Bit 01

Setting this bit to one causes the specified logical blocks to be read and compared with the data in the data buffer. Data is transferred from the Initiator just as in a Write operation. If the BYTC bit is reset to zero, the data is just read and and the ECC is checked for correctness; no Data Transfer operation occurs between the Initiator and the Target.

Relative Address (RELA) - Byte 01, Bit 00

Setting this bit to one causes the Logical Block Address to be treated as a two's complement displacement. This displacement is added to the Logical Block Address last accessed on the LUN to form the Logical Block Address for this command. This feature is only available when the Linking command function is performed. The feature requires that a previous command in the linked group has accessed a Logical Block on the LUN; if it has not, the MD01 Controller terminates the **VERIFY** command, sends a CHECK CONDITION status code, and sets the Sense Key in the Extended Sense Byte to the ILLEGAL REQUEST code.

Logical Block Address - Bytes 02 through 05

These bytes specify the logical block where the Verify operation is to begin.

Reserved - Byte 06

This byte is reserved and must be zero.

Number of Blocks - Bytes 07 through 08

This byte specifies the number of contiguous logical blocks of data to be transferred. When the Number of Blocks to Transfer is zero, no logical blocks of data are transferred. Any other value between 1 and 256, inclusive, indicates that number of logical blocks are to be transferred.

Error Retry (ERTY) - Byte 09, Bit 07

???

Error Correction (ECC) - Byte 09, Bit 06

????

Flag - Byte 09, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 in Byte 09) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 09, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command from the Initiator. Status is returned for each command executed.

8.4.8 WRITE (EXTENDED) 2A

The **WRITE (EXTENDED)** CDB, shown below, performs the same function as the Group 0 **WRITE** command, it causes data to be transferred from the Initiator to the Target device. The amount of data written is a multiple of the block length. The **WRITE (EXTENDED)** command specifies the starting logical block number and the number of blocks to be written.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	1	0	1	0	1	0
01	LUN			0	0	0	0	RELA
02	Logical Block Address (MSB)							
03	Logical Block Address							
04	Logical Block Address							
05	Logical Block Address (LSB)							
06	0	0	0	0	0	0	0	0
07	Number of Blocks (MSB)							
08	Number of Blocks (MSB)							
09	ERTY	ECC	0	0	0	0	Flag	Link

If the Disconnect function is enabled, the MD01 Controller may disconnect from the Initiator while executing this command.

Logical Unit Number (LUN) - Byte 01, Bits <07:05>

These bits specify the LUN of the addressed device for this command.

Logical Block Address - Bytes 02 through 05

These bytes specify the logical block where the Extended Write operation is to begin.

Number of Blocks - Bytes 07 through 08

This byte specifies the number of contiguous logical blocks of data to be transferred. When the Number of Blocks to Transfer is zero, no logical blocks of data are transferred. Any other value between 1 and 256, inclusive, indicates that number of logical blocks are to be transferred.

Error Correction (ECC) - Byte 09, Bit 06

????

Error Retry (ERTY) - Byte 09, Bit 07

??????

Flag - Byte 09, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 in Byte 09) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 09, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command from the Initiator. Status is returned for each command executed.

8.4.9 WRITE AND VERIFY 2E

The **WRITE AND VERIFY** CDB, shown below, causes data for the specified number of blocks to be written and then verified.

Byte	Bit 07	06	05	04	03	02	01	00
00	0	0	1	0	1	1	1	0
01	LUN			0	0	0	BYTC	RELA
02	Logical Block Address (MSB)							
03	Logical Block Address							
04	Logical Block Address							
05	Logical Block Address (LSB)							
06	0	0	0	0	0	0	0	0
07	Number of Blocks (MSB)							
08	Number of Blocks (LSB)							
09	ERTY	0	0	0	0	0	Flag	Link

If the Disconnect function is enabled, the MD01 Controller may disconnect from the Initiator while executing this command.

Logical Unit Number (LUN) - Byte 01, Bits <07:05>

These bits specify the LUN of the addressed device for this command.

Byte Check (BYTC) - Byte 01, Bit 01

Setting this bit to one causes the specified logical blocks to be read and compared with the data in the data buffer. Data is transferred from the Initiator just as in a Write operation. If the BYTC bit is zero, the data is just read and and the ECC is checked for correctness; no Data Transfer operation occurs between the Initiator and the Target.

Relative Address (RELA) - Byte 01, Bit 00

Setting this bit to one causes the Logical Block Address is treated as a two's complement displacement. This displacement is added to the Logical Block Address last accessed on the LUN to form the Logical Block Address for this command. This feature is only available when the Linking command function is performed. The feature requires that a previous command in the linked group has accessed a Logical Block on the LUN; if it has not, the MD01 Controller terminates the **WRITE AND VERIFY** command, sends a CHECK CONDITION status code, and sets the Sense Key in the Extended Sense Byte to the ILLEGAL REQUEST code.

Logical Block Address - Bytes 02 through 05

These bytes specify the logical block where the Write and Verify operation is to begin.

Number of Blocks - Bytes 07 through 08

This byte specifies the number of contiguous logical blocks of data to be transferred. When the Number of Blocks to Transfer is zero, no logical blocks of data are transferred. Any other value between 1 and 256, inclusive, indicates that number of logical blocks are to be transferred.

Error Correction (ECC) - Byte 09, Bit 06

????

Error Retry (ERTY) - Byte 09, Bit 07

??????

Flag - Byte 09, Bit 01

The Flag bit is meaningful only when the Link bit (bit 00 in Byte 09) is set. Therefore, if both the Flag and Link bits are set, an interrupt is requested for this command in a group of linked commands.

Link - Byte 09, Bit 00

The use of the Link bit is optional. If the Link bit is set, an automatic link is made to the next command at the successful completion of the current command from the Initiator. Status is returned for each command executed.