NCR ADP-47 ESDI
DISK CONTROLLER
JULY 1987

To maintain the quality of our publications, we need your comments on the accuracy, clarity, organization, and value of this document.

Address correspondence to:

Publication Services
NCR Corporation
WHQ-4
Dayton, Ohio 45409
U.S.A.

PREFACE

This document is intended for use by system engineers, system integrators, and service technicians. It provides the information needed to install, configure, program, operate, and maintain the NCR ADP-47 Disk Controller.

REFERENCE DOCUMENTS

To obtain information about the Small Computer System Interface (SCSI) standard, contact the following organization.

American National Standard
Small Computer System Interface (SCSI)
ANSI X3.131-1986

ANSI
1430 Broadway
New York, New York 10018

Sales Dept. (212) 642-4900

It is the policy of NCR Corporation to improve products as new technology, components, software, and firmware become available. NCR Corporation, therefore, reserves the right to change specifications without prior notice.

All features, functions, and operations described herein may not be marketed by NCR in all parts of the world. In some instances, photographs are of equipment prototypes. Therefore, before using this document, consult your NCR representative or NCR office for information that is applicable and current.

REVISION RECORD		
Revision	**Date**	**Affected Pages/Remarks**
	July 87	First printing

CONTENTS

CHAPTER 1
GENERAL DESCRIPTION

INTRODUCTION 1-1
PURPOSE OF PRODUCT 1-1
FEATURE SUMMARY 1-2
BLOCK DIAGRAM 1-5

CHAPTER 2
INTERFACES

HARDWARE INTERFACE 2-1
HOST SYSTEM I/O 2-1
ESDI DISK DRIVE I/O 2-2
SOFTWARE INTERFACE 2-3

CHAPTER 3
SCSI-CCS COMMANDS

INTRODUCTION 3-1
TEST UNIT READY (00) 3-2
REZERO UNIT (01) 3-3
REQUEST SENSE (03) 3-4
FORMAT UNIT (04) 3-5
Format Options Valid (FOV) Bit 7 3-8
Disable Primary (DPRY) Bit 6 3-9
Disable Certification (DCRT) Bit 5 3-9
Stop Format (STPF) Bit 4 3-9
REASSIGN BLOCKS (07) 3-10
READ DATA (08) 3-11
WRITE DATA (0A) 3-12
SEEK (0B) 3-13
INQUIRY (12) 3-14
Inquiry Data Format 3-14
MODE SELECT (15) 3-18
Save Mode Parameters (SP) Bit 3-18
Mode Select Parameter List 3-19

RESERVE (16) 3-24
Extent Bit 3-24
RELEASE (17) 3-29
Extent Bit 3-29
Third-Party Release Option 3-30
Third-Party (3rdPTY) Bit 3-30
MODE SENSE (1A) 3-31
RECEIVE DIAGNOSTIC RESULTS (1C) 3-37
Receive Diagnostic File 3-38
SEND DIAGNOSTIC (1D) 3-39
Self Test Bit 3-40
READ CAPACITY (25) 3-41
Partial Medium Indicator (PMI) Bit 3-41
READ EXTENDED (28) 3-43
WRITE EXTENDED (2A) 3-44
SEEK EXTENDED (2B) 3-45
WRITE AND VERIFY (2E) 3-46
VERIFY (2F) 3-47
READ DEFECT DATA (37) 3-48
Defect List Format 3-48
WRITE BUFFER (3B) 3-50
READ BUFFER (3C) 3-51

NCR DIAGNOSTIC COMMANDS 3-53
DIAGNOSTIC INQUIRY (D0) 3-54
TEST BUFFER (D1) 3-55
UNIT TEST (D3) 3-55
WRITE DATA/MAINTENANCE (D5) 3-55
READ DATA/MAINTENANCE (D6) 3-56
WRITE WITH CHECK BYTES/MAINTENANCE (D7) . . . 3-56
READ WITH CHECK BYTES/MAINTENANCE (D8) . . . 3-57
ADDRESS CONVERT (D9) 3-57
SEEK TO PHYSICAL BLOCK ADDRESS (E4) 3-57
WRITE DATA (E5) 3-58
READ DATA (E6) 3-59
WRITE WITH CHECK BYTES (E7) 3-59
READ WITH CHECK BYTES (E8) 3-59
ADDRESS LOCATOR (E9) 3-60
WRITE FORMAT (EA) 3-60
READ FORMAT (EB) 3-61

SCSI MESSAGES 3-62
COMMAND COMPLETE (00) 3-62
SAVE DATA POINTER (02) 3-62
RESTORE POINTERS (03) 3-62

DISCONNECT (04) 3-63
INITIATOR-DETECTED ERROR (05) 3-63
ABORT (06) 3-63
MESSAGE REJECT (07) 3-63
NO OPERATION (08) 3-63
MESSAGE PARITY ERROR (09) 3-63
BUS DEVICE RESET (0C) 3-63
IDENTIFY (80-FF) 3-64

COMPLETION STATUS 3-65

SENSE INFORMATION 3-66
SENSE KEYS 3-67
INFORMATION BYTES 3-67
ADDITIONAL SENSE LENGTH 3-67
ADDITIONAL SENSE CODE 3-68
FIELD REPLACEABLE UNIT FAILED 3-69
FIELD POINTER VALID 3-69
FIELD POINTER 3-69
RECOVERY ACTION 3-70
RETRY COUNT 3-70
TRANSFER COUNT 3-70
NUMBER OF ALTERNATE SECTORS 3-70
NUMBER OF ALTERNATE TRACKS 3-70

ERROR RECOVERY 3-71

DISK DRIVE INTERFACE 3-71
COMMAND CABLE 3-71
DATA CABLES 3-71
TRACK FORMAT 3-71
Sector Format 3-72
Address Format 3-73
Alternate And Defective Sectors 3-73
Alternate And Defective Tracks 3-74
Error Detection And Correction Code Format 3-74

CHAPTER 4
USER INTERFACE

INSTALLATION 4-1
COMPONENT LOCATION 4-1
PHYSICAL SIZE 4-2
SCSI BUS TERMINATORS 4-2

TROUBLE-SHOOTING 4-3

PREPARING THE BOARD 4-3
EIGHT-POSITION SWITCH PACK 4-4

FOUR-POSITION SWITCH PACK 4-5

SINGLE-ENDED CONTROLLER BOARD 4-7

SINGLE-ENDED BOARD CONNECTORS 4-8
J1 - POWER CONNECTOR 4-8
J2 - SINGLE-ENDED SCSI BUS CONNECTOR 4-8
J3 - FIXED DISK COMMAND CABLE 4-9
J4, J5, J6, & J7 - UNIT 0, 1, 2, & 3 FIXED DISK DATA CABLE 4-9

DIFFERENTIAL CONTROLLER BOARD 4-10

DIFFERENTIAL BOARD CONNECTORS 4-11
J1 - POWER CONNECTOR 4-11
J2 - DIFFERENTIAL SCSI BUS CONNECTOR 4-11
J3 - FIXED DISK COMMAND CABLE 4-12
J4, J5, J6 & J7 - UNIT 0, 1, 2 & 3 FIXED DISK DATA CABLE 4-12

CHAPTER 1

GENERAL DESCRIPTION

INTRODUCTION

The NCR ADP-47 Disk Controller is a SCSI (Small Computer System Interface) device incorporating the NCR (SDC) SCSI Disk Controller and the NCR (DIF) Drive Interface VLSI chips. The controller provides a high level interface between the SCSI bus and ESDI (Enhanced Small Device Interface) disk drive(s). The controller provides electronic control of the SCSI bus, automatic bus protocol handling, and retry/ECC correction for fixed disk drives.

The NCR ADP-47 Disk Controller is a high performance, very-low-overhead disk drive controller. The disk controller works with high performance disk drives in single or multi-tasking user applications.

PURPOSE OF PRODUCT

The controller operates with either single-initiator or multiple-initiator systems. It provides the host with access to varied, multiple disk units. Listed below are the two different controller configurations.

- ADP-47-03 ESDI with single-ended SCSI.
- ADP-47-04 ESDI with differential SCSI.

FEATURE SUMMARY

Industry Standard SCSI Interface - ANSI X3.131-1986 (Single Ended or Differential)

Industry Standard ESDI Fixed Disk Drive Interface

SCSI Common Command Set (CCS)

I/O Performance Features

- Minimal controller overhead time
- Dual rotating sector buffers
- Programmable sector interleave, track skew-factor and cylinder skew-factor
- Automatic sector-level defect handling
- SCSI implementation includes arbitration, disconnection, re-selection, and parity
- 1.6 Mbyte nominal SCSI bus transfer rate
- Consecutive multi-sector transfer with one-to-one interleave over track boundaries (entire cylinder transfer without losing a revolution)
- Rotational Position Sensing (RPS) for just-in-time re-connection
- Programmable bus disconnect options
- Logical block addressing
- Implied seek
- Seek overlap capability

Data Integrity and Test Features

- 56-bit ECC corrects up to 11 bit burst errors
- Parity throughout controller to insure data integrity
- Self diagnostics
- Extensive list of diagnostic commands

Fixed Disk Drive Support

- Drive parameter selection and geometry parameters obtained from the drive
- Hard- and soft-sector support
- Alternate sector-per-track option
- Sector size - 256, 512 or 1024 bytes
- Number of drives - 4 maximum
- Number of heads - 16 maximum

ESDI Features

- The following general-configuration options are supported.
  - Formal speed-tolerance gap
  - Track-offset option
  - Data-strobe-offset option
  - Rotational-speed tolerance
  - Transfer rate >5 MHz
  - Spindle-motor-control option
  - Head-switch time
  - Hard sectors
  - Soft sectors
- The following specific configuration options are supported.
  - Number of fixed cylinders
  - Number of fixed heads (16 maximum)
  - Minimum unformatted bytes per track
  - Minimum unformatted bytes per sector (hard sector only)
  - Number of sectors per track (hard sectors only)
  - Minimum bytes in ISG field
  - Minimum bytes in PLO field
  - Number of bytes vendor unique status
  - Vendor identification

Single-ended Signal Transfer

The controller permits single-ended signal transfer over the SCSI bus.

Differential Signal Transfer

The controller permits differential signal transfer over the SCSI bus.

SCSI Arbitration

The controller can be used with hosts that use arbitration (multiple hosts).

Parity

The controller provides a hardware option to enable or disable SCSI data bus parity.

SCSI Messages

The controller sends and accepts those SCSI messages required for the SCSI features that are supported. It sends only the Command Complete message to a host that does not support other messages. Extended messages, which include Modify Data Pointer, Synchronous Data Transfer Request, and Extended Identify are not supported. The controller does not send the Linked Command Complete message because Linked Commands are not supported.

Asynchronous Data Transfer

The controller supports asynchronous data transfer.

Programmable Interleave

An interleave (lacing) factor up to the track capacity can be specified in the Format Unit command. An interleave factor of 1 is permitted, but a factor of 2 is required to access logically sequential blocks in a single revolution.

Implied Seek

A Seek command is implied in every data transfer command; heads are automatically positioned. In a multiple-block access that crosses track or cylinder boundaries, movement to the next track or cylinder is automatic.

Hard Reset Option

The controller uses the "hard" reset option in response to the Reset signal (RST). Reservations are terminated, and the Mode Select conditions are returned to the default values. System and application software have the responsibility for recovery from the Reset condition. This may include re-issuing Reserve and Mode Select commands, re-positioning the unit, and then re-issuing the last command or series of commands.

Error Handling

The controller automatically performs retries of a Read operation. A recoverable Read error on a fixed disk is automatically corrected by the ECC.

Device Independence

Logical Unit Numbers (LUNs) are independent of physical port numbers. All accesses specify LUNs.

Defect Handling

The controller automatically assigns and maintains alternate tracks for media defects.

Fault Detection

Extended fault detection is available from the interface as a status message.

Shielded or Non-shielded Connectors

The use of shielded or non-shielded connectors is dependent upon specific product requirements.

Performance Rates

The maximum rate of data transfer is 1.6 MB/s. The maximum throughput of the controller depends upon the interleave specified in formatting the disk unit. The controller is capable of transferring one track per revolution with an interleave of one.

BLOCK DIAGRAM

Figure 1-1 is a block diagram of the controller.

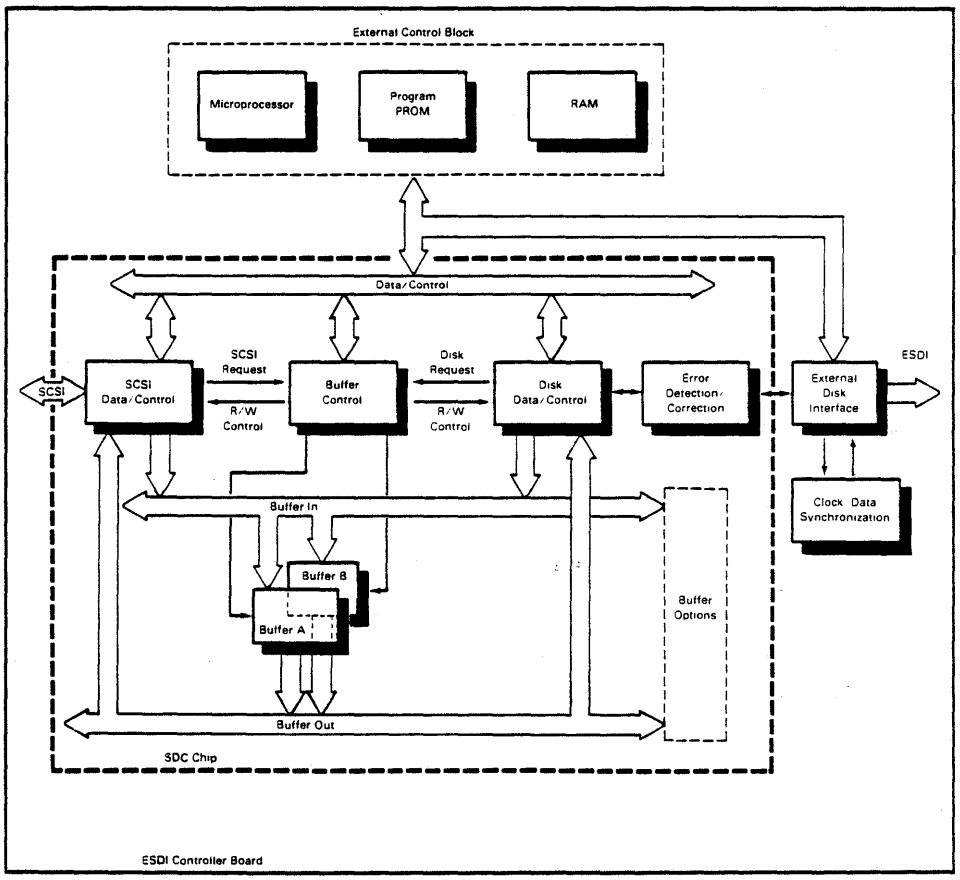


Figure 1-1 ADP-47 block diagram

CHAPTER 2

INTERFACES

HARDWARE INTERFACE

The disk controller complies with the electrical, logical, timing, and protocol requirements specified in the increased performance "SCSI Specification ANSI X3.131-1986" documentation. The controller has the following SCSI options:

- Single-ended or differential drivers and receivers
- Parity checking
- Arbitration
- Message capability
- Disconnect/reconnect capability

HOST SYSTEM I/O

The controller interfaces to the host system through the SCSI bus that operates at a nominal rate of 1.6 Mbytes per second.

The SCSI interface uses logical addressing for the data structures. Data is addressed as logical blocks up to the maximum number specified by the subsystem controller for each device.

The SCSI architecture handles connections for up to eight devices using a maximum cable length of 19.68 feet (6 meters) for Single-ended or 82.02 feet (25 meters) for Differential. The interface protocol includes provision for the connection for multiple Initiators (SCSI bus devices that initiate operations) and Targets (SCSI bus devices that respond to a request to perform an operation).

Arbitration is built into the SCSI architecture. The Arbitration Phase takes place when multiple contenders request access to a shared system device. Arbitration is the period of actual bus occupancy when the requesting access occurs. Before arbitrating for the bus, an Initiator ensures that the bus is available, or waits until the bus is released. The SCSI bus device that wins arbitration gains interface control through a logical priority system.

Actual data transfer over the SCSI bus is accomplished with a Request/Acknowledge handshake scheme.

ESDI DISK DRIVE I/O

The controller transfers control signals to the fixed disk drive(s), and receives status information from them over the daisy-chained, 34-pin command cable. Radial, 20-pin data cable provides the receive and transmit data capability to and from the fixed disk drive(s).

The four fixed drives supported by the controller are addressed as logical units 00, 01, 02, and 03.

SOFTWARE INTERFACE

The controller interfaces to the host system through the SCSI bus. The host Initiator originates the SCSI commands and selects a Target (controller) in the Selection Phase. The controller requests the additional transfer of command, data, status, or message information required to complete the originally-initiated command. Upon command completion, the controller sends a Command Complete message to the host.

SCSI protocol allows the controller to accept only one command at a time for each host/logical unit combination. However, the controller accepts up to eight different commands for different hosts/logical units. The command priority is as follows:

- Highest priority:
  - Inquiry command
- Next to highest priority, all commands except:
  - Inquiry command
  - Format Unit command
  - Send Diagnostic command
  - Receive Diagnostic command
- Next to lowest priority:
  - Format Unit command
- Lowest priority:
  - Send Diagnostic Result command
  - Receive Diagnostic Result command

CHAPTER 3

SCSI CCS COMMANDS

INTRODUCTION

The controller supports the following SCSI Common Command Set (CCS) commands. The number preceding the command is the hexadecimal operation code. The operation code is always byte 00 in the command descriptor for each CCS command.

- (00) Test Unit Ready
- (01) Rezero Unit
- (03) Request Sense
- (04) Format Unit
- (07) Reassign Blocks
- (08) Read Data
- (0A) Write Data
- (0B) Seek
- (12) Inquiry
- (15) Mode Select
- (16) Reserve
- (17) Release
- (1A) Mode Sense
- (1C) Receive Diagnostic Result
- (1D) Send Diagnostic
- (25) Read Capacity
- (28) Read Extended
- (2A) Write Extended
- (2B) Seek Extended
- (2E) Write and Verify
- (2F) Verify
- (37) Read Defect Data
- (3B) Write Buffer
- (3C) Read Buffer

TEST UNIT READY (00)

This command returns a Completion Status with no Check Condition if the selected logical unit is powered on and ready. (Refer to the "Completion Status" and the "SCSI Messages" sections.) This is not a request for unit self test. Figure 3-1 shows the command descriptor.

	BIT							
BYTE	7	6	5	4	3	2	1	0
00	0	0	0	0	0	0	0	0
01	Logical Unit Number (LUN)			Reserved				
02	Reserved							
03	Reserved							
04	Reserved							
05	Reserved							

Figure 3-1 Test Unit Ready command descriptor

The host expects a fast response for this command. This command does not use the Logical Block Address and Number of Blocks fields. Both fields are zero-filled.

REZERO UNIT (01)

This command causes the controller to move the heads of the specified unit to cylinder zero. The controller uses this command primarily to set the unit to a specific known state. Figure 3-2 shows the command descriptor.

	BIT							
BYTE	7	6	5	4	3	2	1	0
00	0	0	0	0	0	0	0	1
01	LUN			Reserved				
02	Reserved							
03	Reserved							
04	Reserved							
05	Reserved							

Figure 3-2 Rezero Unit command descriptor

REQUEST SENSE (03)

This command returns Sense information for the addressed logical unit (LUN). The Sense data, which is reserved for the host, is valid for the most recent Check Condition (Completion Status) presented to the host. (Refer to the "Completion Status" and "SCSI Messages" sections.) However, Sense data is cleared when the faulty unit receives a subsequent command from the host that received the Check Condition. Figure 3-3 shows the command descriptor.

	BIT							
BYTE	7	6	5	4	3	2	1	0
00	0	0	0	0	0	0	1	1
01	LUN			Reserved				
02	Reserved							
03	Reserved							
04	Allocation Length							
05	Reserved							

Figure 3-3 Request Sense command descriptor

Byte 04 (Allocation Length) of the Command descriptor specifies the number of bytes that the host allocates for returned Sense data. The controller may not return more bytes of Sense information than the number of bytes the host allocated. If descriptor byte 04 is less than four, the controller returns a default value of four bytes. (Refer to the "Sense Information" section.)

FORMAT UNIT (04)

This command causes the controller to format and certify the specified logical unit. The entire disk is formatted except for the controller cylinder. The controller cylinder is cylinder zero for all heads and it contains controller information like Mode Sense, Defect List, scratch area, and so on. The controller cylinder is only formatted under the following conditions: (A) when the first format is performed on an unformatted drive or (B) when the bytes per sector has changed through a drive-strap change in the hard-sector mode or a Mode Select command in the soft-sector mode followed by a Format command. Once the format is complete, the controller digitally certifies all tracks not in the defect list. The controller assigns alternate sectors or tracks to user and maintenance tracks which do not pass certification or are in the defect list. Figure 3-4 shows the command descriptor.

	BIT							
BYTE	7	6	5	4	3	2	1	0
00	0	0	0	0	0	1	0	0
01	LUN			Fmt Data	Compl List	List Format		
02	Reserved							
03	MSB Interleave							
04	LSB Interleave							
05	Reserved							

Figure 3-4 Format Fixed Unit command descriptor

All defective sectors and tracks found during certification are added to the Growth Defect List (G List). After successfully completing the Format Unit function, the controller writes and maintains the Defect List on the controller cylinder of the disk drive. After termination of the Format Unit command, the controller formulates and returns to the host a Completion Status byte followed by a Command Complete message.

The cylinders on the formatted drive are utilized in the following manner.

Physical Cylinder Number	Logical Cylinder Number	Utilization
0	-	Mode Select parameter save area, alternate track table
1	-	Maintenance Cylinder
2 — M	0 — N	User Space including alternate tracks

The user will always use the logical cylinder number (except for certain diagnostic commands) and will never be aware of the other two cylinders.

Bytes 03 and 04 of the Format command descriptor specify the lacing factor or interleave to be used when formatting. Interleaves are indicated as follows:

Interleave of zero
: An interleave of zero or greater than the number of sectors on a track indicates the controller uses the default interleave of one when formatting.

Interleave of one
: An interleave of one indicates that consecutive logical blocks are also consecutive physical blocks.

Interleave of two
: An interleave of two indicates that consecutive logical blocks are placed at every other consecutive physical block.

Interleave of three
: An interleave of three indicates that consecutive logical blocks are placed at every third consecutive physical block. This formatting pattern continues in numerical order.

Byte 01, bits 0, 1, 2, 3, and 4 of the Format Unit command descriptor provide the controller with the following Defect List information:

	LIST TYPE						LIST FORMAT
Bit:	4	3		2	1	0	
	0	X	No List	0	X	X	Block Format
	1	0	Partial List	1	0	0	Bytes From Index Format
	1	1	Complete List	1	0	1	Physical Sector Format

The controller handles the alternate-storage assignment for the defective areas. Since this is done independently of the host system, a Unit Defect Table and information specifying the alternate sectors and tracks assigned to the alternates are stored on a dedicated, non-user area of each disk drive. By using the dedicated disk space, a permanent record of the Unit Defect Table and the remaining alternate-storage space is maintained for controller use. The controller is directly responsible for the integrity and contents of dedicated disk areas.

No Defect List (No List)

If the controller receives a Format Unit command without a Defect List (No Format Data, or Length of Defect List = 00 and no Complete List bit) the controller receives defect information from the existing Unit Defect Table which is maintained on each unit by the controller. The controller formats and verifies as good, any blocks which are not specified in the Unit Defect Table.

Incomplete Defect List (Partial List)

If the controller receives a Format Unit command with a partial Defect List, the controller adds these values to those maintained in the existing Unit Defect Table. The controller uses this resultant Unit Defect Table to format the media. A partial list will contain logical blocks only.

Complete Defect List (Complete List)

If the controller receives a Format Unit command with a complete Defect List, the controller formats any block not specified in this complete Defect List as good and verifies the format.

The controller marks any sector which cannot be verified after formatting as defective and assigns an alternate-sector. If the controller assigns an alternate-track, the controller adds to the Unit Defect Table the logical cylinder, head, and sector-address of the defective sector.

In any of the three above cases - No Defect List, Incomplete Defect List, or Complete Defect List - the controller uses a resultant defect list to format the disk. All tracks containing more defective blocks, which are specified in this list, than alternate-sectors on the track is automatically formatted as defective, and the controller assigns an alternate-track.

The following table explains the bit settings of the format data the controller receives from the host.

	DEFECT LIST HEADER BIT							
BYTE	7	6	5	4	3	2	1	0
00	Reserved							
01	FOV	DPRY	DCRT	STPF	Reserved			VU
02	Defect List Length (MSB)							
03	Defect List Length (LSB)							

Byte 01, bits 4, 5, 6, and 7 of the Defect List Header provides optional format control. These bits define how the host optionally controls the Primary Defect List and the Target Certification flaw management schemes during the Format Unit command. The bits are defined as follows:

- Bit 0: Vendor-Unique (VU)
- Bit 1: Reserved
- Bit 2: Reserved
- Bit 3: Reserved
- Bit 4: Analyzed by the controller
- Bit 5: Analyzed by the controller
- Bit 6: Analyzed by the controller
- Bit 7: Analyzed by the controller

Format Options Valid (FOV) Bit 7

FOV bit 7 = 0

Indicates that the host requests implementation of the controller's format-default scheme for the functions defined by bits 4, 5, and 6. When bit 7 is set to zero, the host sets bits 4, 5, and 6 to zero; otherwise, the controller creates the Check Condition status with Illegal Request Sense key.

FOV bit 7 = 1

Authorizes setting bits 4, 5, and 6. If the controller does not support the functions defined by bits 4, 5, and 6 set to one, the controller then creates the Check Condition status with Illegal Request Sense key.

Disable Primary (DPRY) Bit 6

DPRY bit 6 = 0
FOV bit 7 = 1

Indicates that the controller manages the Primary (P) List of defects during formatting. When the controller fails to find the P List or does not know if it exists, the controller creates the Check Condition status.

DPRY bit 6 = 1
FOV bit 7 = 1

Indicates that the controller excludes the P List from the list of flaws to manage during formatting.

Disable Certification (DCRT) Bit 5

DCRT bit 5 = 0
FOV bit 7 = 1

Indicates that the controller enables the controller certification routine during formatting.

DCRT bit 5 = 1
FOV bit 7 = 1

Indicates that the controller disables the controller certification routine during formatting.

Stop Format (STPF) Bit 4

STPF bit 4 = 0
FOV bit 7 = 1

Indicates that the controller continues the format process when the P or Growth (G) Lists are not accessed successfully in whole or in part. The controller creates a Check Condition status when the format process with the Recovered Error Sense key is completed, if no errors occurred other than failure to successfully access the P or G Lists.

STPF bit 4 = 1
FOV bit 7 = 1

Indicates that the controller stops the format process upon failure to access successfully, in whole or in part, any of the P or G Lists. The controller creates the Check Condition status with Medium Error Sense key.

REASSIGN BLOCKS (07)

This command passes the Defect List of logical blocks to the controller. The controller assigns an alternate-storage space to logical blocks specified in the Defect List. Data on the blocks in the Defect List is destroyed. Data on blocks that are not in the Defect List is preserved. Figure 3-5 shows the Reassign Blocks command descriptor.

	BIT							
BYTE	7	6	5	4	3	2	1	0
00	0	0	0	0	0	1	1	1
01	LUN			Reserved				
02	Reserved							
03	Reserved							
04	Reserved							
05	Reserved							

Figure 3-5 Reassign Blocks command descriptor

Figure 3-6 shows the Defect List format.

DEFECT LIST FORMAT		
Byte Offset	**Length**	**Definition**
00	2	Reserved. Must be zero.
02	2	Length of Defect List in bytes. Must be less than 5632.
04	X	Defect list. A logical block address is four bytes long.

Figure 3-6 Defect List format

READ DATA (08)

This command transfers a specified number of blocks to the host, starting at the specified logical starting block address given in the command descriptor Logical Block Address field. To perform this command, the selected disk drive moves the heads to the track containing the block or sector addressed by the command descriptor. Figure 3-7 shows the command descriptor.

	BIT							
BYTE	7	6	5	4	3	2	1	0
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	Transfer Length							
05	Reserved							

Figure 3-7 Read Data command descriptor

The controller transfers two bytes of SLI (Sector Length Indicator which is prefixed to each block of data) and 256, 512 or 1024 bytes of data from the drive into the controller's sector buffer. Next, the controller removes the SLI bytes from the data block. Then the controller transfers the 256, 512 or 1024 bytes of data to the host. Logically consecutive sectors or blocks are read, and seeks are performed as necessary to transfer the number of blocks specified in the Number of Blocks field (transfer length) of the command descriptor. The controller automatically handles alternate tracks and sectors. In case of read errors, the controller automatically handles retries. The controller corrects correctable-bit-errors using Error Correction Code (ECC).

WRITE DATA (0A)

This command transfers to the controller the specified number of blocks starting at the specified logical-starting-block address given in the command descriptor Logical Block Address field. To perform this command, the selected disk drive moves the heads to the track containing the block or sector addressed by the command descriptor. Figure 3-8 shows the command descriptor.

	BIT							
BYTE	7	6	5	4	3	2	1	0
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	Transfer Length							
05	Reserved							

Figure 3-8 Write Data command descriptor

The controller transfers data from the host to the controller's sector data buffer. Next, the controller prefixes two bytes of SLI (Sector Length Indicator) onto the 256, 512 or 1024 byte data block. The two SLI bytes contain the length of the sector (256, 512 or 1024). The controller transfers 258, 514 or 1026 bytes (2 SLI bytes and 256, 512 or 1024 data bytes) to the drive to be written. (Sectors of 1024 bytes are only available on external buffer controllers.)

Logically consecutive sectors or blocks are written, and seeks are performed as necessary to transfer the number of blocks specified in the Number of Blocks field (transfer length) of the Command Descriptor. The controller handles alternate sectors and tracks automatically.

SEEK (0B)

This command causes the controller to move the heads of the selected drive to the cylinder indicated by the command descriptor Block Address. Figure 3-9 shows the command descriptor.

	BIT							
BYTE	7	6	5	4	3	2	1	0
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	Reserved							
05	Reserved							

Figure 3-9 Seek command descriptor

INQUIRY (12)

This command requests the controller to send to the host information regarding its parameters and the parameters of its associated peripheral devices. Figure 3-10 shows the command descriptor.

	BIT							
BYTE	7	6	5	4	3	2	1	0
00	0	0	0	1	0	0	1	0
01	LUN			Reserved				
02	Reserved			Desired Data Format				
03	Reserved							
04	Allocation Length							
05	Reserved							

Figure 3-10 Inquiry command descriptor

The Allocation Length specifies the number of bytes that the host allocates for returned Inquiry data. An Allocation Length of zero indicates that no Inquiry data transfers. This condition is not an error. Any other value indicates the maximum number of bytes to transfer. The controller terminates the Data-In phase when either the allocation length bytes have been transferred or when all available Inquiry data has been transferred to the host (whichever is less).

The Inquiry command returns a Check Condition status only when the controller cannot return the requested Inquiry data.

If the host sends an Inquiry command with a pending unit attention condition (before the controller reports the Check Condition status), the controller performs the Inquiry command without clearing the unit attention condition.

Inquiry Data Format

The Desired Data Format field specifies the desired format for the Inquiry data. This field is analogous to the Response Data Format field in the Inquiry data. The following entries are accepted:

- 0: Return data in the SCSI-1 Controller format (45 bytes of vendor-unique data)
- 1: Return data in the CCS format (55 bytes of vendor-unique data)

Figure 3-11 shows the Inquiry data format for command data.

COMMAND DATA FORMAT			
Offset Byte	**Offset Bit**	**Byte Length**	**Description**
00	All	01	DEVICE TYPE: 00 - Direct access magnetic disks 7F - Device not present
01	7	—	REMOVABLE MEDIUM: 0 - Medium fixed 1 - Medium removable
01	6-0	—	Device Type Qualifier (From Mode Select)
02	All	01	Version: 00
03	7-4	—	Reserved: 0
03	3-0	—	RESPONSE DATA FORMAT: As requested in Inquiry command 0 - SCSI-1 format 1 - CCS format
04	All	01	ADDITIONAL LENGTH: 2D (45 bytes) - SCSI-1 format 37 (55 bytes) - CCS format

Figure 3-11 Command data format

Figure 3-12 shows the Inquiry data format for SCSI-1 Controller additional data.

SCSI-1 CONTROLLER ADDITIONAL DATA FORMAT			
Offset Byte	**Offset Bit**	**Byte Length**	**Description**
05	All	01	FEATURES SUPPORTED: (1 = supported) (0 = reserved) Bit 7=1 — NCR commands w/SLI option Bit 6=1 — NCR commands w/ECC option Bits 5-1=0 — Reserved Bit 0=1 — SCSI extended commands
06	All	01	Controller firmware release level
07	All	01	Controller firmware release level
08	—	04	"NCR"
12	—	16	Controller identification in ASCII
28	—	16	Unit identification in ASCII (from Mode Select)
44	—	06	Controller firmware release level in ASCII

Figure 3-12 SCSI-1 Controller additional data format

Figure 3-13 shows the Inquiry data format for CCS additional data.

CCS ADDITIONAL DATA FORMAT			
Offset Byte	**Offset Bit**	**Byte Length**	**Description**
05	—	03	Reserved — 00
08	—	08	Vendor identification: "NCR"
16	—	16	Controller identification in ASCII
32	—	04	Hardware release level in ASCII
36	—	08	Firmware release level in ASCII
44	—	16	Unit identification in ASCII (from Mode Select)

Figure 3-13 CCS additional data format

The controller Identification field that is returned as part of the Inquiry data field (Byte offset 12 — SCSI-1 data format or Byte Offset 16 — CCS data format) will contain the following format for SDC controllers. All data is returned in ASCII.

SDC CONTROLLER IDENTIFICATION		
Byte Offset in field	**Byte Length**	**Description**
0	4	SDC
4	2	SDC chip used 01-SDC1
6	2	Hard disk interface 01 — ST-506 02 — ESDI
8	2	Buffer type 01 — Internal Rotating
10	2	Flex support 00 — None 01 — Single/Double density 02 — High density
12	4	To be determined

Figure 3-14 SDC Controller identification

MODE SELECT (15)

This command provides a means for the host to communicate with the controller to specify or change the medium, logical unit, or peripheral device parameters. Figure 3-15 shows the command descriptor.

	BIT							
BYTE	7	6	5	4	3	2	1	0
00	0	0	0	1	0	1	0	1
01	LUN			Reserved				SP
02	Reserved							
03	Reserved							
04	Parameter List Length							
05	Reserved							

Figure 3-15 Mode Select command descriptor

Save Mode Parameters (SP) Bit

The SP bit 0, byte 01 set to one indicates the following:

- The controller updates the current mode values with the values defined in the following Pages. (See NOTE.)
- The controller saves all Savable Pages, except those defined by Page Code 03 which is to be saved during the next successfully completed Format Unit command.
- After completing the above functions, the controller reports Command Complete with no Check Condition status.

NOTE: Pages are blocks of parameters. Savable Pages are Pages the preceding Mode Sense command returns with the PS bit (bit 7, byte 0) of the Page Header set to one.

The SP bit 0, byte 01 set to zero indicates the following:

- The controller updates current mode values with the values defined in the following Pages.
- The controller does not save the Savable Pages.
- The controller does not modify the saved parameters for Pages defined by Page Codes 03.
- After successfully completing the above functions, the controller reports Command Complete with no Check Condition status.

The Parameter List Length specifies the length (in bytes) of the Mode Select parameter list transferred during the Data-Out phase. A Parameter List Length of zero indicates no data transfers. This is not an error condition.

Mode Select Parameter List

The following Mode Select parameter list has a four-byte header followed by zero or more Pages. Figure 3-16 shows the Mode Select Parameter List.

	MODE SELECT HEADER BIT							
	7	6	5	4	3	2	1	0
BYTE								
00	Reserved							
01	Medium Type: 00 = Fixed disk							
02	Reserved							
03	Reserved							

	PAGE DESCRIPTOR(S)
BYTE	
00	Page Code
01	Page Length (in bytes)
02-n	Refer to Page

Figure 3-16 Mode Select parameter list

In the Data-Out phase of the Mode Select command the host sends additional blocks of parameters called "Pages" to the controller. This occurs after the host sends the Mode Select Header.

The Page Length indicates the number of bytes the controller supports for each Page. The Page Length value for each defined Page does not include the Page Length byte. The Page Length, set in the Mode Select

command pages, is the same value (zero value included) that the controller returns in the Mode Sense Page Length bytes. Otherwise, the controller creates a Check Condition status with the Illegal Request Sense key.

Before issuing a Mode Select command, the host may need to know which Page(s) the controller implemented and the length of each Page for a particular Logical Unit Number (LUN). The host obtains this data by issuing a Mode Sense command requesting the controller to return all Changeable values (refer to the PCF field configuration 01 in byte 02 of the Mode Sense command descriptor). The disk drive parameters are obtained from the ESDI drive interface.

Figure 3-17 provides the direct access device format parameters.

DIRECT ACCESS DEVICE FORMAT PARAMETERS PAGE CODE 03 (HEX)				
Bytes (DEC)	**Function**	**Change-able**	**Range (Hex)**	**Default (Hex)**
00	Page Code	No	03	Required (No default)
01	Page Length	No	16	Required (No default)
02-03	Tracks per Zone	No	0001	Required (No default)
04-05	Alternate Sectors per Zone	Yes	0000-Zero or 0001-One	0000-Zero
06-07	Alternate Tracks	No	0000	No support
08-09	Alternate Tracks per Volume, with 1664 tracks maximum.	Yes	Max/25% of total tracks. Min/No. of tracks on Cylinder 1 (Number rounded up to cyl. boundary)	82
10-11	Physical Sectors per Track	Yes/No	Variable (Note 2)	0022 (Note 2)
12-13	Data Bytes per Physical Sector	Yes/No	0100, 0200, 0400	0200
14-15	Interleave	No	XXXX	No support (Parameter passed in Format Unit command/value returned in Mode Sense command)

Figure 3-17 Direct access device format parameters (1 of 2)

DIRECT ACCESS DEVICE FORMAT PARAMETERS PAGE CODE 03 (HEX)				
Bytes (DEC)	**Function**	**Changeable**	**Range (Hex)**	**Default (Hex)**
16-17	Track Skew Factor	Yes	0 to PSPT-1 (Note 1)	0000
18-19	Cylinder Skew Factor	Yes	0 to PSPT-1 (Note 1)	0000
20	Drive Type Field	No	80-Soft(2) 40-Hard C0-Both	No default
21-23	Reserved	NO	000000	Required (No default)

(1) Physical Sectors Per Track = PSPT (Bytes 10-11)

(2) For hard sector drives, the physical sectors per track and data bytes per physical sector are determined by the drive and can be obtained by doing a Mode Sense command for soft sector drives. The number of physical sectors per track that can be used for a particular number of data bytes per physical sector is a function of the total unformatted bytes per track, various parameters and the motor speed tolerance of the individual drive. Typically, there will be 62 256-byte-sectors or 34 512-byte-sectors or 19 1024-byte-sectors available. This can vary.

Figure 3-17 Direct access device format parameters (2 of 2)

Figure 3-18 provides the vendor-unique fixed disk drive parameters.

VENDOR-UNIQUE FIXED DISK DRIVE PARAMETERS
PAGE CODE 20 (HEX)

Bytes (DEC)	Function	Change-able	Range (Hex)	Default (Hex)
00	Page Code	No	20	Required (No default)
01	Page Length	No	14	Required (No default)
02-17	Unit ID in ASCII (Returned by Inquiry)	Yes	—	(Blanks)
18	Device Type	No	—	00
19	Device Type Qualifier	Yes	—	07
20	Rotational Position Sensing (RPS) Offset	Yes	00-No RPS 01 to (LSPT-1) Offset requested	00
21	Disconnect Option Byte	Yes	Bit 0: Disconnect after receiving command. 0 = No 1 = Yes Bit 1: Disconnect during seek. 0 = No 1 = Yes Other bits ignored.	03

Figure 3-18 Vendor-unique fixed disk drive parameters

RESERVE (16)

This command reserves logical units, or extents within logical units, for the host. When using the Third-party Reservation option, the logical units or extents are reserved for another specified SCSI device. The Reserve and Release commands provide the basic mechanism for contention resolution in systems having multiple-hosts. Figure 3-19 shows the command descriptor.

	BIT							
BYTE	7	6	5	4	3	2	1	0
00	0	0	0	1	0	1	1	0
01	LUN			3rd PTY	3rd Party Device ID			Ex-tent
02	Reserved							
03	Reserved							
04	Reserved							
05	Reserved							

Figure 3-19 Reserve command descriptor

Extent Bit

Extent bit = 0

This command requests that the host receive exclusive use of the logical unit. This reservation is in effect until one of the following occurs:

- Another valid Reserve command from the host originating the reservation supersedes it.
- A Release command from the originating host releases it.
- Any host issuing a Bus Device Reset message.
- A hard Reset condition occurs.

The system permits a host system to reserve a logical unit that is currently reserved by that same host. If the extent bit is zero, the Reservation Identification and the Extent List Length are ignored.

If the logical unit, or any extent within the logical unit, is reserved for another host, the controller responds by returning a Reservation Conflict status.

If another host honors the reservation, but later attempts to send commands to the reserved logical unit, the system rejects all commands having a Reservation Conflict status, except the Release command, which is ignored.

The Reservation Identification permits a host to identify each Extent Reservation. The Reservation Identification also permits a host, in a multiple tasking environment, to have multiple reservations outstanding. In the Release command, the Reservation Identification specifies which reservation to release. If used in superseding Reserve commands, the Reservation Identification specifies which reservation to supersede.

The Extent Reservation and the Extent Release options permit multiple extents within the logical unit selected for reservation, each with a separate reservation type.

Extent bit = 1

The controller processes the reservation request as follows:

1. The controller checks for the number of extents in the reservation request. If the Extent List Length is zero, no reservations change. This condition is not an error. If the Extent List contains more extents than allowed on a logical unit, the command terminates with a Check Condition status and the sense key sets to Illegal Request. If the extent list contains more extents than are currently available on the logical unit, then the controller returns Reservation Conflict status.
2. The controller checks for valid extent logical block addresses. If any logical block address is invalid for this logical unit, the command terminates with a Check Condition status and the sense key sets to Illegal Request. The controller checks for invalid extent overlaps (defined by reservation type) with other extent descriptors in the Extent List. If invalid overlaps occur, the command terminates with a Check Condition status and the Sense key sets to Illegal Request.
3. If no conflict occurs between the requested reservation and any active (or previously requested reservation), the specified extents remain reserved until one of the following occurs:
   - Another valid Reserve command from the host originating the reservation supersedes it.
   - A Release command from the originating host releases it.
   - Any host issues a Bus Device Reset message.
   - A hard Reset condition occurs.

   When a Bus Device Reset or hard Reset occurs, the next command from each host system terminates with a Check Condition status and the sense key sets to Unit Attention.
4. If the reservation request conflicts with an active reservation, the controller returns a Reservation Conflict status.

Figure 3-20 provides the data format of extent descriptors.

BYTE	BIT 7	6	5	4	3	2	1	0
00	Reserved						Reservation Type	
01	Number of Blocks (MSB)							
02	Number of Blocks							
03	Number of Blocks (LSB)							
04	Logical Block Address (MSB)							
05	Logical Block Address							
06	Logical Block Address							
07	Logical Block Address (LSB)							

Figure 3-20 Data format of extent descriptors

The Extent List Length parameter defines the size of the Extent List. This list consists of zero or more descriptors. Each extent descriptor defines an extent beginning at the specified Logical Block Address for the specified number of blocks. If the number of blocks is zero, the extent begins at the specified Logical Block Address and continues through the last Logical Block Address of the logical unit.

The controller supports a maximum of eight extents, with a maximum of four extents per logical unit.

The reservation-type field determines the reservation for an extent. Figure 3-21 shows the four types of reservations.

DB (1)	DB (0)	Reservation Type
0	0	Read Shared (RS)
0	1	Write Exclusive (WX)
1	0	Read Exclusive (RX)
1	1	Exclusive Access (XA)

Figure 3-21 Extent reservation types

Figure 3-22 shows the validity of reservation request and commands for host B when host A reserved an extent.

HOST A TYPE OF EXTENT RESERVED	HOST B REQUEST: EXTENT RESERVATION				HOST B REQUEST: COMMAND TYPE	
	RS 00	WX 01	RX 10	XA 11	READ	WRITE
RS 00	X	RC	RC	RC	X	RC
WX 01	RC	RC	X	RC	X	RC
RX 10	RC	X	RC	RC	RC	X
AX 11	RC	RC	RC	RC	RC	RC

X = No Conflict
RC = Reservation Conflict

Figure 3-22 Reservation validity

If a host attempts a command to a reserved logical block, the reservation prohibits access. The command terminates with a Reservation Conflict status. If a reservation conflict precludes any part of the command, none of the command is performed.

The Third-party Reservation option for the Reserve command permits a host to reserve a logical unit or extents within a logical unit for another SCSI device.

If the 3rdPTY bit is zero, the Third-party Reservation option is not reserved.

If the 3rdPTY bit is one, the Reserve command reserves the specified logical unit or extents for the SCSI device specified in the third-party device ID field. The controller holds the reservation until one of the following occurs:

- Another valid Reserve command from the host originating the reservation supersedes it.
- A Release command from the originating host releases it.
- Any host issuing a Bus Device Reset message.
- A hard Reset condition occurs.

The controller ignores attempts to release a reservation made by any other host.

A host with a current reservation may modify that reservation with another Reserve command to the same logical unit. If the new reservation request is granted, the new Reserve command releases the existing reservation. When the new reservation request is not granted, the existing reservation is not modified. If conflicts prohibit granting the new reservation (other than the reservation being superseded), the controller returns a Reservation Conflict status.

RELEASE (17)

This command releases previously-reserved logical units, or previously reserved extents within logical units. A host attempt to release an inactive reservation is not an error. When this occurs, the controller returns a Good status without altering any other reservation. Figure 3-23 shows the command descriptor for this command.

	BIT							
BYTE	7	6	5	4	3	2	1	0
00	0	0	0	1	0	1	1	1
01	Logical Unit Number			3rd PTY	3rd Party Device ID			Ex-tent
02	Reservation Identification							
03	Reserved							
04	Reserved							
05	Reserved							

Figure 3-23 Release command descriptor

Extent Bit

If the extent bit is zero, the controller terminates all logical unit and extent reservations that are active from the host to the specified logical unit.

If the extent bit is one, a host request for a reservation with a matching reservation identification is terminated. Other reservations from the requesting host remain in effect.

Third-Party Release Option

The Third-party Release option allows a host to release a logical unit or extents within a logical unit that were previously reserved through the Third-party Reservation option.

Third-Party (3rdPTY) Bit

If the 3rdPTY bit is zero, the Third-party Release option is not requested.

If the 3rdPTY bit is one, the controller releases a specified logical unit or extents if the following are true:

- The host requesting the release used the Third-party Reservation option to make the reservation.
- The release is for the same SCSI device specified in the third-party device ID field.

MODE SENSE (1A)

This command provides a means for the controller to report its medium, logical unit, or peripheral device parameters to the host. This command is a complementary command to the Mode Select command. Figure 3-24 shows the command descriptor for this command.

	BIT							
BYTE	7	6	5	4	3	2	1	0
00	0	0	0	1	1	0	1	0
01	LUN							
02	PCF		Page Code					
03	Reserved							
04	Allocation Length							
05	Reserved							

Figure 3-24 Mode Sense command descriptor

The Page Control Field (PCF) bits 6 and 7 of byte 02 define the type of Page Parameter values to return.

- (00) Current
- (01) Changeable
- (10) Default
- (11) Save

The Page Code bits 5 through 0 of byte 2 indicates which Page(s) to return.

The Allocation Length specifies the number of bytes that the host allocated for returned Mode Sense data. An Allocation Length of zero indicates that no Mode Sense data transfers. This condition is not an error. Any other value indicates the maximum number of bytes to transfer.

The controller terminates the Data-In phase when the Allocation Length transfers, or when all available Mode Sense data transfers to the host, whichever is less.

The Mode Sense data contains a four-byte header, followed by zero or more eight-byte block descriptors, followed by zero or more Pages.

The command descriptor PCF bits 6 and 7 of byte 02 report current values, changeable values, default values, and saved values. The information that follows describes these bits.

COMMAND DESCRIPTOR BYTE 02		
Bit 7	**Bit 6**	**Description**
0	0	Report Current Values If the Page Code is 3F, all Pages that the controller implements are returned to the host with fields and bits set to Current values. If the Page Code is not 3F, the Page defined by the Page Code (if supported by the controller) is returned to the host with fields and bits set to Current values. Current values are either: * As set in the last successfully completed Mode Select command * Are identical to the Saved values if a Mode Select command was not issued since the most recent power on * Are identical to the Default values if no Saved values are available Fields and bits not supported by the controller are set to zero.

COMMAND DESCRIPTOR BYTE 02		
Bit 7	**Bit 6**	**Description**
0	1	Report Changeable Values If the Page Code is 3F, all Pages that the controller implements are returned to the host with fields and bits that the host is allowed to change, set to one. The host is not allowed to change fields and bits set to zero. If the Page Code is not 3F, the Page defined by the Page Code (if supported by the controller) is returned to the host with fields and bits that the host is allowed to change, set to one. The host is not allowed to change fields and bits set to zero.

COMMAND DESCRIPTOR BYTE 02		
Bit 7	**Bit 6**	**Description**
1	0	Report Default Values If the Page Code is 3F, all Pages that the controller implements are returned to the host with fields and bits set to the controller's or device's Default values. If the Page Code is not 3F, the Page defined by the Page Code (if supported by the controller) is returned to the host with fields and bits set to the controller's or device's Default values. Fields and bits not supported by the controller are set to zero

COMMAND DESCRIPTOR BYTE 02		
Bit 7	**Bit 6**	**Description**
1	1	Report Saved Values If the Page Code is 3F, all Pages that the controller implements are returned to the host with fields and bits set to Saved values. If the Page Code is not 3F, the Page defined by the Page Code (if supported by the controller) is returned to the host with fields and bits set to the Saved values. The Saved values are: * Values saved during the most recent successfully completed Format Unit or Mode Select commands. The mode of Saving is vendor-unique, and values may be recorded on disk. Fields and bits not supported by the controller are set to zero.

Current values may be modified by successfully completed Mode Select commands. Saved values are updated only by successfully completed Format Unit commands. A Format Unit command completing with no Check Condition status indicate that the saved values were successfully saved.

A host may request that the controller return a specific Page by selecting its code in byte 02 of the command descriptor.

When a host selects a particular Page code in byte 02 of the command descriptor, the controller returns that Page.

The command descriptor Page Codes for bits 0-5 of byte 02 are described as follows:

COMMAND DESCRIPTOR BYTE 02	
Page Code (Hex)	**Description**
03	Direct Access Device Format Parameters
20	Vendor-Unique
3F	Return all Pages to the host. (Refer to the PCF bit configuration.) Page Code is valid for Mode Sense commands only.

Figure 3-25 Mode Sense page code descriptors (Bits 0-5)

The controller returns the same Page Length value in each Page that it supports with the 3F Page Code, dependent on the value of each bit of the PCF field.

Figure 3-26 shows the Mode Sense Header.

	BIT							
BYTE	7	6	5	4	3	2	1	0
00	Sense Data Length							
01	Medium Type							
02	Reserved							
03	Reserved							

Figure 3-26 Mode Sense header

The Sense Data Length byte specifies the length in bytes of the following Mode Sense data available for transfer during the Data-In phase. The Sense Data Length byte does not include itself. If the command descriptor Allocation Length is not large enough to transfer all the Sense Data Length, the Sense Data Length does not adjust to reflect the truncation.

Figure 3-27 shows the Mode Sense Page Descriptor.

BYTE	BIT 7	6	5	4	3	2	1	0
00	PS	Page Code						
01	Page Length (in bytes)							
02-n	Refer to Page definition in Mode Select							

Figure 3-27 Mode Sense page descriptor

The Parameters Savable (PS) bit 7 of byte 00 of each Page Header set to one by the controller indicates that the controller saves the supported parameters.

The PS bit set to zero indicates that the controller does not save the supported parameters.

Bit 6 of byte 00 is reserved.

The Page Code identifies the meaning of the bytes in the Page. The Page Code is defined, reserved, or vendor-unique. The defined Page parameters are classified in priority to ease implementation by the controller.

The Page Length indicates the number of bytes the controller supports in each Page. The Page Length value for defined Pages does not include the Page Length bytes.

Before issuing any Mode Select commands, the host issues a Mode Sense command to find out which Pages the controller implemented and the length of the Pages for the specific LUN. The controller returns all Changeable values (PCF field configuration 01 and Page Code 3F in byte 02 of the Mode Sense command descriptor).

A Mode Sense command issued after a power on or reset results in one of the following conditions:

Mode Sense Request:	Controller Response:
Default values	Reports Default values
Saved values	Reports existing valid restore of parameters, or returns a Check Condition status. The Sense key sets to Illegal Request if the requested Pages are not saved.
Current values	Reports a valid set of saved parameters (if available) or the default parameters.

RECEIVE DIAGNOSTIC RESULTS (1C)

This command requests that analysis data be sent to the host following completion of a Send Diagnostic command. Figure 3-28 shows the command descriptor for this command.

	BIT							
BYTE	7	6	5	4	3	2	1	0
00	0	0	0	1	1	1	0	0
01	LUN			Reserved				
02	Reserved							
03	Allocation Length (MSB)							
04	Allocation Length (LSB)							
05	Reserved							

Figure 3-28 Receive Diagnostic Results command descriptor

The allocation length specifies the number of bytes that the host allocates for returned diagnostic data. An allocation length of zero indicates that no diagnostic data transfers. Any other value indicates the maximum number of bytes allowed to transfer. The controller terminates the Data-In phase when allocation length bytes transferred or when all available diagnostic data transferred to the host, whichever is less.

Receive Diagnostic File

Diagnostic Result File. Figure 3-29 shows this file.

Byte:		
	00	Flag *
	01	Reserved
	02	MSB DATA Length
	03	LSB DATA Length
		Data Field
	N	
	N+1	Sense Length
		Sense Field **
	M	

* Flag: 0 = Valid Data/1 = Invalid Data
(Test Buffer Command Only)

** Sense Field Format: Same as Extended Sense Format

Figure 3-29 Receive Diagnostic File Format

A Check Condition status is not returned when sense information is in the sense field.

SEND DIAGNOSTIC (1D)

This command requests that the controller perform diagnostic tests on itself, on the attached peripheral devices, or on both. A Receive Diagnostic Results command follows this command, except when the self test (SelfTest) bit is one. Figure 3-30 shows the command descriptor.

	BIT							
BYTE	7	6	5	4	3	2	1	0
00	0	0	0	1	1	1	0	1
01	LUN			Reserved		Self Test	Reserved	
02	Reservation Identification							
03	Diagnostic File Length (MSB)							
04	Diagnostic File Length (LSB)							
05	Reserved							

Figure 3-30 Send Diagnostic command descriptor

The Diagnostic File Length specifies in bytes the length of the diagnostic file transferred during the Data-Out phase. A Diagnostic File Length of zero indicates that no data transfers. This condition is not an error. The parameter list is vendor-unique.

Self Test Bit

A self test bit of one directs the controller to complete its default self test. If the self test is requested, the Parameter List Length is set to zero and no data transfers. When the self test passes successfully, the command terminates with a Good status. Otherwise, the command terminates with a Check Condition status and the Sense key sets to Hardware Error.

A self test bit of zero directs the controller to get the actual function performed from the Send Diagnostic File Format, byte 03. Figure 3-31 shows this file format.

Byte:		
	00	MSB File Length
	01	LSB File Length
	02	Reserved (Must be zero)
	03	Function Code
	04	MSB Physical Block Address *
	05	Physical Block Address
	06	Physical Block Address
	07	LSB Physical Block Address *
	08	MSB Number of Blocks **
	09	LSB Number of Blocks **
		Data Field
	N	

* Treated as Logical Block Address for Address Convert command.

** Number of bytes for test buffer diagnostic function.

Figure 3-31 Send Diagnostic File Format

READ CAPACITY (25)

This command provides a means for the host to request information regarding the logical unit capacity. Figure 3-32 shows the command descriptor.

	BIT							
BYTE	7	6	5	4	3	2	1	0
00	0	0	1	0	0	1	0	1
01	LUN			Reserved				
02	Logical Block Address (MSB)							
03	Logical Block Address							
04	Logical Block Address							
05	Logical Block Address (LSB)							
06	Reserved							
07	Reserved							
08	Reserved							PMI
09	Reserved							

Figure 3-32 Read Capacity command descriptor

Partial Medium Indicator (PMI) Bit

A PMI bit of zero indicates that the information returned in the Read Capacity data is the logical block address and block length (in bytes) of the last logical block of the logical unit. The logical block address in the command descriptor block is set to zero for this option.

A PMI bit of one indicates that the information returned is the logical block address and block length (in bytes) of the last logical block address encountered after a substantial delay in data transfer. This logical block address is greater than or equal to the logical block address specified in the command descriptor block.

Figure 3-33 shows the eight-bytes of Read Capacity data sent during the Data-In phase of the command.

BYTE	DESCRIPTION
00	Logical Block Address (MSB)
01	Logical Block Address
02	Logical Block Address
03	Logical Block Address (LSB)
04	Block Length (MSB)
05	Block Length
06	Block Length
07	Block Length (LSB)

Figure 3-33 Read Capacity data-bytes/data-in phase

READ EXTENDED (28)

This command transfers a specified number of blocks to the host system, starting at the specified logical-starting-block-address given in the command descriptor Logical Block Address field. To perform this command, the selected disk drive moves the heads to the track containing the block or sector addressed by the command descriptor. Figure 3-34 shows the command descriptor.

	BIT							
BYTE	7	6	5	4	3	2	1	0
00	0	0	1	0	1	0	0	0
01	LUN			Reserved				
02	Logical Block Address (MSB)							
03	Logical Block Address							
04	Logical Block Address							
05	Logical Block Address (LSB)							
06	Reserved							
07	Transfer Length (MSB)							
08	Transfer Length (LSB)							
07	Reserved							

Figure 3-34 Read Extended command descriptor

WRITE EXTENDED (2A)

This command transfers a specified number of blocks to the controller, starting at the specified logical starting block address given in the command descriptor Logical Block Address field. To perform this command, the selected disk drive moves the heads to the track containing the block or sector addressed by the command descriptor. Figure 3-35 shows the command descriptor.

	BIT							
BYTE	7	6	5	4	3	2	1	0
00	0	0	1	0	1	0	1	0
01	LUN			Reserved				
02	Logical Block Address (MSB)							
03	Logical Block Address							
04	Logical Block Address							
05	Logical Block Address (LSB)							
06	Reserved							
07	Transfer Length (MSB)							
08	Transfer Length (LSB)							
07	Reserved							

Figure 3-35 Write Extended command descriptor

SEEK EXTENDED (2B)

This command causes the controller to move the heads of the selected drive to the cylinder indicated by the command descriptor Block Address. Figure 3-36 shows the command descriptor.

	BIT							
BYTE	7	6	5	4	3	2	1	0
00	0	0	1	0	1	0	1	1
01	LUN			Reserved				
02	Logical Block Address (MSB)							
03	Logical Block Address							
04	Logical Block Address							
05	Logical Block Address (LSB)							
06	Reserved							
07	Reserved							
08	Reserved							
09	Reserved							

Figure 3-36 Seek Extended command descriptor

WRITE AND VERIFY (2E)

This command transfers a specified number of blocks to the controller, starting at the specified logical starting block address in the command descriptor Logical Block Address field. The command moves the heads of the selected disk drive to the track with the block or sector addressed by the command descriptor.

After completion of the Write Data operation, the system verifies that the written blocks are read without errors. If data errors occur, the command terminates with a Check Condition status. Figure 3-37 shows the command descriptor.

	BIT							
BYTE	7	6	5	4	3	2	1	0
00	0	0	1	0	1	1	1	0
01	LUN			Reserved				
02	Logical Block Address (MSB)							
03	Logical Block Address							
04	Logical Block Address							
05	Logical Block Address (LSB)							
06	Reserved							
07	Transfer Length (MSB)							
08	Transfer Length (LSB)							
09	Reserved							

Figure 3-37 Write and Verify command descriptor

VERIFY (2F)

This command requests the controller to verify the data written on the medium.

After completion of the Write Data operation, the system verifies that the written blocks are read without errors. If data errors occur, the command terminates with a Check Condition status. Figure 3-38 shows the command descriptor.

	BIT							
BYTE	7	6	5	4	3	2	1	0
00	0	0	1	0	1	1	1	1
01	LUN			Reserved				
02	Logical Block Address (MSB)							
03	Logical Block Address							
04	Logical Block Address							
05	Logical Block Address (LSB)							
06	Reserved							
07	Verification Length (MSB)							
08	Verification Length (LSB)							
09	Reserved							

Figure 3-38 Verify command descriptor

READ DEFECT DATA (37)

This command causes the controller to return the medium defect data to the host. Figure 3-39 shows the command descriptor.

	BIT							
BYTE	7	6	5	4	3	2	1	0
00	0	0	1	1	0	1	1	1
01	LUN			P	G	Defect List Format		
02	Reserved							
03	Reserved							
04	Reserved							
05	Reserved							
06	Reserved							
07	Allocation Length (MSB)							
08	Allocation Length (LSB)							
09	Control Byte							

Figure 3-39 Read Defect Data command descriptor

Defect List Format

Byte 01, bits 0, 1, and 2 of the Read Defect Data command descriptor provides the controller with Defect List format information. Figure 3-40 shows these formats.

BYTE 01				
Bits:	2	1	0	Format:
	0	X	X	Block
	1	0	0	Bytes From Index
	1	0	1	Physical Sector

Figure 3-40 Defect list formats

A Defect List format request to the controller (except a format of cylinder, head, and sector) causes the controller to return the Defect List in the cylinder, head, and sector format with a Check Condition status and a Sense key of Recovered Error.

When the P bit is set to one, the controller returns the primary defect list. When the G bit is set to one, the controller returns the growth defect list. The P and G bits can be set in any combination. When the bits are zero, the controller returns no list.

The host uses the Allocation Length to determine the maximum number of defects returned. The controller does not return defect data if the Allocation Length is zero.

The controller terminates the Data-In phase when the Allocation Length transfers, or when all available defect data transfers to the host, whichever is less.

Figure 3-41 provides the Defect List Header information .

BYTE	BIT 7	6	5	4	3	2	1	0
00	Reserved							
01	Reserved			P	G	Defect List Format		
02	Defect List Length (MSB)							
03	Defect List Length (LSB)							

Figure 3-41 Defect list header

Byte 01, bits 0, 1, and 2 are defined in Figure 3-40. The Defect List Format and bits P and G indicate the Defect List that the controller actually returns. The length of each defect descriptor is eight bytes in the following format:

- Cylinder = Three Bytes
- Head = One Byte
- Sector = Four Bytes

The Defect List Length specifies the total length in bytes of the defect descriptors that follow.

If the Allocation Length of the command descriptor is too short to transfer all of the defect descriptors, the Defect List Length is not adjusted to reflect the truncation. A Check Condition status is not created by the controller. The defect descriptors may, or may not, be sent in ascending order.

WRITE BUFFER (3B)

This command is used with the Read Buffer command as a diagnostic function to test the controller's data buffer memory and the SCSI bus integrity. While this command executes, there is no access to the medium. Figure 3-42 shows the command descriptor.

	BIT							
BYTE	7	6	5	4	3	2	1	0
00	0	0	1	1	1	0	1	1
01	LUN			Reserved				
02	Reserved							
03	Reserved							
04	Reserved							
05	Reserved							
06	Reserved							
07	Byte Transfer Length (MSB)							
08	Byte Transfer Length (LSB)							
09	Reserved							

Figure 3-42 Write Buffer command descriptor

The Byte Transfer Length specifies the maximum number of bytes transferred to, and retained in the controller's buffer. The Byte Transfer Length contains a four-byte header, followed by the Write Buffer data.

A Byte Transfer Length of zero indicates that the controller does not transfer the Write Buffer header and Write Buffer data. This condition does not create a Check Condition status. Controllers with only internal buffers can transfer a maximum of 1042-bytes of data (four-bytes of header and a maximum of 1038-bytes of Write Buffer data). Controllers with external buffers can transfer a maximum of 2066-bytes.

If the Byte Transfer Length is greater than the Available Length that the Read Buffer command reports, the controller creates the Check Condition status and a Sense key of Illegal Request. In this case, data is not transferred from the host. A request for a Byte Transfer Length that is less than the Available Length is not an error.

READ BUFFER (3C)

This command is used with the Write Buffer command as a diagnostic function to test the controller's data buffer memory and the SCSI bus integrity. While this command executes, there is no access to the medium. Figure 3-43 shows the command descriptor.

	BIT							
BYTE	7	6	5	4	3	2	1	0
00	0	0	1	1	1	1	0	0
01	LUN			Reserved				
02	Reserved							
03	Reserved							
04	Reserved							
05	Reserved							
06	Reserved							
07	Byte Transfer Length (MSB)							
08	Byte Transfer Length (LSB)							
09	Reserved							

Figure 3-43 Read Buffer command descriptor

The Allocation Length specifies the maximum number of bytes the host allocates for returned data. The Allocation Length contains a four-byte header, followed by the Read Buffer data.

An Allocation Length of zero indicates that the Read Buffer header and Read Buffer data are not transferred. This condition does not create a Check Condition status. The host uses the data for comparison with the data pattern sent during the Write Buffer command. Controllers with only internal buffers can transfer a maximum of 1042-bytes of data (four-bytes of header and a maximum of 1038-bytes of Write Buffer data). Controllers with external buffers can transfer a maximum of 2066-bytes.

If the Allocation Length is greater than the Available Length, the Available Length transfers to the host. A request for an Allocation Length that is less than the Available Length is not an error.

The controller terminates the Data-In phase when the Allocation Length transfers, or when the Available Length transfers to the host, whichever is less.

Figure 3-44 provides the Read Buffer Header information.

BYTE	BIT 7	6	5	4	3	2	1	0
00	Reserved							
01	Reserved							
02	Available Length (MSB)							
03	Available Length (LSB)							

Figure 3-44 Read Buffer header

The following steps are recommended to prevent corruption of the controller's Read Buffer by another host:

- The host issues the Reserve Unit command to all logical units of a controller before issuing the Write Buffer command.
- The host issues the Release Unit command after completing the Read Buffer command.

NCR DIAGNOSTIC COMMANDS

The controller issues the NCR diagnostic commands as a sub-function of the SCSI CCS Send Diagnostic (1D) command. The controller returns the NCR diagnostic command results with the SCSI CCS Receive Diagnostic Result (1C) command.

The following diagnostic functions do not access data areas on the disk drive. The functions execute with other host commands concurrently.

- (D0) Diagnostic Inquiry
- (D3) Unit Test
- (D5) Write Data
- (D6) Read Data
- (D7) Write with Check Bytes
- (D8) Read with Check Bytes
- (D9) Address Convert

The Write Data, Read Data, Write with Check Bytes, and Read with Check Bytes commands are for fixed disk drive maintenance use only.

DIAGNOSTIC INQUIRY (D0)

This command instructs the controller to assemble and return 64 bytes of information about the designated unit. The data returns in the Data field of the Receive Diagnostic Result file. Figure 3-45 defines the Diagnostic Inquiry field.

Field Offset	Byte Length	Identification
0	2	Data buffer size (521 bytes)
2	2	Ram buffer size
4	4	Last physical block address
8	4	Maintenance area (Fixed drive) Start of the physical block address
12	2	Maintenance area (Fixed drive) Length in blocks (Block size defined by controller Read Capacity commands.)
14	2	Check byte block size (Fixed drive) Checked Record bytes + Check byte = 521
16	20	Reserved. Always zero.
30	4	Alternate Track Area Start address (Fixed drive)
34	2	Alternate Track Area Length in blocks (Fixed drive)
36	2	Number of cylinders (physical)
38	2	Number of heads/cylinders
40	2	Number of logical blocks/tracks
42-63		Not defined. Always zero filled.

Figure 3-45 Diagnostic inquiry data field

TEST BUFFER (D1)

This command instructs the controller to transfer data from the host memory to its internal sector buffer. Upon completion of this data transfer, the controller sets an internal flag to identify the Test Buffer command and the host sending it.

If the controller writes to this buffer with any other data transfer command, the internal Test Buffer command flag resets. The controller samples this flag when executing the ensuing Receive Diagnostic Result command to verify that the original data buffer was overwritten. Byte 00 of the Receive Diagnostic Result sets to one if the original data is overwritten. The Test Buffer data is returned to the host for comparison.

The maximum length of data allowed to transfer is 1042 bytes for internal buffers and 2066 bytes for external buffers. Data lengths exceeding this maximum length cause an Illegal Request Sense key to return in the Sense field of the Receive Diagnostic Result file.

UNIT TEST (D3)

This command causes the controller to perform a series of diagnostic tests to verify the functional integrity of the controller and the addressed logical unit (the disk drive).

If a failure occurs during execution of any of these tests, an Error Sense key returns in the Receive Diagnostic Result file associated with the diagnostic function.

WRITE DATA/MAINTENANCE (D5)

This maintenance command for fixed disk drives instructs the controller to transfer data from the host memory to the controller-identified maintenance area cylinder of the addressed logical unit.

If errors occur during execution, the controller does not perform any error recovery procedures. The Returned status and Sense information identify the error type.

The physical block address is an offset in the maintenance area (the start of the maintenance area is zero). The maximum length of the data transferred is identified in the Diagnostic Inquiry Field. If the data length exceeds the maintenance area block length, an Illegal Request Sense key returns in the Sense field of the Receive Diagnostic Result file.

READ DATA/MAINTENANCE (D6)

This maintenance command for fixed disk drives instructs the controller to transfer data from the maintenance area of the addressed logical unit to the host memory.

If errors occur during execution, the controller does not perform any Read retries or alternate assignments. When a data error occurs, the controller performs the error correction procedure and transfers the data to the host. If the error correction is performed, the Sense field of the Receive Diagnostic Result file indicates whether a correctable or uncorrectable error occurred.

The physical block address is an offset in the maintenance area. The maximum length of the data transferred is identified in the Diagnostic Inquiry Field. If the data length exceeds the maintenance area block length, an Illegal Request Sense key returns in the Sense field of the Receive Diagnostic Result file.

WRITE WITH CHECK BYTES/MAINTENANCE (D7)

This maintenance command for fixed disk drives instructs the controller to transfer data from the host memory to one block of the maintenance area. This data includes all data bytes contained in the Checked Data field, as well as the Check bytes.

If errors occur during execution, the controller does not perform error recovery procedures. The returned Sense field of the Receive Diagnostic Result file identifies the error.

The physical block address is an offset into the maintenance area. The total length of data bytes transferred is identified in the Diagnostic Inquiry field.

READ WITH CHECK BYTES/MAINTENANCE (D8)

This maintenance command for fixed disk drives instructs the controller to transfer data from a block of the maintenance area to the host memory. This data includes all data bytes contained in the Checked Data field, as well as the Check bytes. This command returns SLI, data, and ECC bytes to the user.

If errors occur during execution, the controller does not perform error recovery procedures. The returned Sense field of the Receive Diagnostic Result file identifies the error.

The physical block address is an offset into the maintenance area. The total length of data bytes transferred is identified in the Diagnostic Inquiry field.

ADDRESS CONVERT (D9)

This command causes the controller to convert the user's logical block address to a physical block address of the device. The user's logical block address is given in the Send Diagnostic file, and the physical block address returns as data in the Receive Diagnostic Result file.

SEEK TO PHYSICAL BLOCK ADDRESS (E4)

This command instructs the controller to position the heads of a selected disk unit to the cylinder identified by the physical block address given in the Send Diagnostic file.

The controller reads an address field from the disk to verify the Seek function. This command causes Seeks to execute for the entire disk area rather than limiting them to the user's area (logical address).

WRITE DATA (E5)

This command instructs the controller to transfer data from the host memory to the physical block address specified in the Send Diagnostic file. A write to the controller cylinder is not allowed.

If errors occur, the controller does not perform error recovery procedures. The Sense field returned in the Receive Diagnostic Result file identifies the error type.

Some special conditions exist when addressing the disk with a physical addressing function. Included are the addressing of defective sectors or tracks and addressing alternate sectors or tracks. When these conditions are encountered, the controller completes the data transfer and returns a Recoverable Error Sense key in the Sense field of the Receive Diagnostic Result file.

Byte 12 of the Sense information is 00 (Hex) to indicate No Sense.

Byte 18 of the Sense information is one of the following codes:

SENSE INFORMATION		
Byte	**Code**	**Meaning**
18	01	Defector sector or track addressed
18	02	Alternate sector or track addressed

Figure 3-46 Sense information

Code 01

If a defective sector or track is addressed, the controller transfers data to the alternate sector or track, then returns the 01 code.

Code 02

If alternate track or sector is addressed, the controller transfers the data to the alternate sector or track, then returns the 02 code.

READ DATA (E6)

This command transfers data from any physical block address of the disk to the host memory.

The controller follows the same procedure indicated in the Write Data command when finding an alternate sector or track.

If errors occur, the controller does not perform any Read retries or alternate sector or track assignments.

If the error occurs on a fixed disk drive, the controller performs the error correction procedure and transfers the data to the host. After the error correction is performed, the Sense field of the Receive Diagnostic Result file indicates whether a correctable or uncorrectable error occurred.

WRITE WITH CHECK BYTES (E7)

This command for fixed disk drives transfers data from the host memory to any physical block address on the disk except the controller cylinder. The data includes all data bytes in the Checked Data field and the Check bytes.

The controller follows the same procedure indicated in the Write Data command when finding an alternate sector or track.

READ WITH CHECK BYTES (E8)

This command for fixed disk drives transfers data from any physical block address of the disk to the host memory. This data includes all data bytes in the Checked Data field and the Check bytes.

The controller follows the same procedure indicated in the Write Data command when finding an alternate sector or track.

ADDRESS LOCATOR (E9)

This command converts the physical block address value to physical cylinder, head, and sector. The physical block address (cylinder, head, and sector values) is returned in the data field of the following Receive Diagnostic Result command.

The field contains the following data bytes:

Bytes	Length	Identification (MSB,LSB)
0-1	2	Physical cylinder number
2-3	2	Physical head number
4-5	2	Physical sector number

Figure 3-47 Address locator information

WRITE FORMAT (EA)

This command for fixed disk drives causes the controller to write format data to a specific track on the disk. The controller starts at Sector 0 and writes the entire track format with each Write Format command. The Send Diagnostic file contains the physical block address and the format data for the entire track.

The format data must comply with the "Address format" section except that a 10th byte equal to zero is required. The controller verifies cylinder and head data before writing the format.

READ FORMAT (EB)

This command causes the controller to read and assemble format data from a specific track of the disk. This data transfers to the host memory and contains the format data, starting at Sector 0, for the entire track. The Block Address field of the Send Diagnostic file contains the physical block address of the designated track to read.

The first 5 bytes of format data returned must comply with the "Address Format" section. In addition to the address field; the Read Format function also returns the following 5 bytes.

BYTE	FLAG=80H/04H	FLAG=01H
06	00	Alternate cylinder MSB
07	00	Alternate cylinder LSB
08	00	Alternate head
09	00	Alternate sector
10		Address ECC error indication
	00	No address ECC error
	FF	Address ECC error

Figure 3-48 Read format information

SCSI MESSAGES

The controller supports the following SCSI messages:

SCSI MESSAGES	
Code	**Message**
00	Command Complete
02	Save Data Pointer
03	Restore Pointers
04	Disconnect
05	Initiator-detected Error
06	Abort
07	Message Reject
08	No Operation
09	Message Parity Error
0C	Bus Device Reset
80-FF	Identify

Figure 3-49 SCSI message codes

COMMAND COMPLETE (00)

The controller sends this message to the host to indicate that the command execution terminated and the Valid status was sent to the host.

SAVE DATA POINTER (02)

The controller sends this message to direct the host to save a copy of the data pointers that define the present state of the physical path for the currently attached logical unit.

RESTORE POINTERS (03)

The controller sends this message to direct the host to restore all pointers to the most recently saved state for the currently attached logical unit (LUN).

DISCONNECT (04)

The controller sends this message to inform the host that a break will occur in the present physical path (the controller releases the Busy (BSY) line, causing a Disconnect). Later a Reconnect is required to complete the current operation.

INITIATOR-DETECTED ERROR (05)

The host sends this message to inform the controller that the host detected the occurrence of a re-tryable error.

ABORT (06)

The host sends this message to direct the controller to abort the specified command.

MESSAGE REJECT (07)

The controller or the host sends this message to indicate that the last message received was either inappropriate or not implemented.

NO OPERATION (08)

The host sends this message in response to a controller request for a message when the host does not currently have any other valid message to send.

MESSAGE PARITY ERROR (09)

The host sends this message to indicate that the last message received had a parity error.

BUS DEVICE RESET (0C)

A host sends this message to direct a controller to clear all current commands on that SCSI device. This message forces the SCSI device to an initial state with no operations pending for any host.

IDENTIFY (80-FF)

The controller or host sends this message to establish the physical path connection between the controller and host for a particular logical unit (LUN). The message content is defined as follows:

BIT	DEFINITION
7	Always ON. Signifies "IDENTIFY" message.
6	Host sets this bit to indicate the disconnect/reconnect capability.
5-3	Reserved.
2-0	Specifies LUN address in the controller.

Figure 3-50 Identify message

COMPLETION STATUS

The host system must always receive the Completion status before the Command Complete message is sent. Abnormal conditions encountered during command execution initiate a command termination and a Completion status message to the host. The Completion status is reported as one byte with the following bit conditions:

- Bit 0: Reserved (Always zero)
- Bit 1: Check Condition. Sense information available.
- Bit 2: Reserved (Always zero)
- Bit 3: Busy
- Bit 4: Reservation Conflict when ON with Bit 3
- Bit 5: Reserved (Always zero)
- Bit 6: Reserved (Always zero)
- Bit 7: Reserved (Always zero)

SENSE INFORMATION

The Request Sense command returns Sense information to a host. The host initiates the Request Sense command after receiving a Check Condition in the Completion status.

The controller returns the Extended Sense format to the host in response to the execution of the Request Sense command. The Valid bit (bit 7 of byte 00) in the format indicates that the Information field (bytes 03-06) contains the block address associated with the Sense key in byte 02. If the Valid bit is not set, the Information field has no defined meaning. The table that follows provides Sense Format information.

	BIT							
	7	6	5	4	3	2	1	0
BYTE 00	Valid	1	1	1	0	0	0	0
01	Reserved = 00							
02	0	0	0	0	Sense key			
03-06	Information Bytes (MSB-LSB)							
07	Additional Sense Length							
08-11	Reserved = 00							
12	Additional Sense Code							
13	Reserved = 00							
14	FRU Failed							
15	Field Pointer Valid							
16-17	Field Pointer							
18	Recovery Action							
19	Retry Count							
20-23	Transfer Count (MSB-LSB)							
24	Number of Alternate Sectors (Fixed Format/Reassign Blocks)							
25	Number of Alternate Tracks (Fixed Format/Reassign Blocks)							

Figure 3-51 Sense format information

SENSE KEYS

The controller returns the Sense keys defined in the following table:

SENSE KEYS		
Key	**Definition**	**Additional Sense Length**
00	No Sense	00
01	Recoverable Error	16 (18 to Format Unit or Reassign Blocks)
02	Not Ready	00/16
03	Media Error	16
04	Hardware Error	14
05	Illegal Request	00/16
06	Unit Attention	00
07	Data Protect	00
0B	Aborted Command	16

Figure 3-52 Sense keys information

INFORMATION BYTES

Bytes 03-06 contain the block address associated with the Sense key when the Valid bit in byte 00 is set.

ADDITIONAL SENSE LENGTH

This byte indicates the number of Sense bytes that follow byte 07.

ADDITIONAL SENSE CODE

This byte contains codes to aid the host in determining the nature of an error. The Additional Sense codes are defined in the following table:

ADDITIONAL SENSE CODES		
Code	**Definition**	**Related Sense key**
00	No Secondary Error Code	Recovered error
03	Write Fault	Hardware error
06	No Track Zero found	Hardware error
08	Logical Unit Comm Failure	Medium error
10	ID CRC or ECC error	Hardware error or Medium error
11	Unrecovered Read error of data blocks	Medium error
12	No Address Mark found in ID field	Medium error
15	Seek Positioning error	Hardware error or Medium error
17	Recovered Read data with Target's Read retries (not with ECC)	Recovered error
18	Recovered Read data with Target's ECC correction (not with retries)	Recovered error
19	Defect List Error	Medium error
24	Illegal Field in command descriptor	Illegal request
26	Illegal Field in Parameter List	Illegal request
2A	Mode Select Parameters changed	Unit attention
32	No Defect Spare location available	Medium error

Figure 3-53 Additional sense code information (1 of 2)

ADDITIONAL SENSE CODES		
Code	**Definition**	**Related Sense key**
42	Power On diagnostic failure	Hardware error
43	Message Reject error	Hardware error or Aborted command
44	Internal controller error	Hardware error or Aborted command
45	Select/Reselect failed	Hardware error or Aborted command
47	SCSI I/F parity error	Hardware error or Aborted command
48	Initiator-detected error	Hardware error or Aborted command
49	Inappropriate or illegal Message	Hardware error or Aborted command
80	Data field not found	Medium error
81	Data buffer parity error	Hardware error
82	Buffer not available	Hardware error
83	Controller cylinder error	Medium error
84	Drive unformatted	Not ready
85	Divide error	Hardware error

Figure 3-53 Additional sense code information (2 of 2)

FIELD REPLACEABLE UNIT FAILED

If the FRU (controller) failed during power-up diagnostics, this field contains the error code.

FIELD POINTER VALID

This field contains a 80 (Hex) if the Field Pointer is valid; otherwise, the field is 00.

FIELD POINTER

If valid, this field contains the most significant byte address for the first field in error.

RECOVERY ACTION

This byte contains a code describing controller action taken to recover from the error. The following table defines the Recovery Action codes:

RECOVERY ACTION CODES	
Code	**Definition**
00	No action
01	Defective sector/track addressed
02	Alternate track addressed
03	Retries
04	ECC correction
05	Alternate sector/track assigned
06	Alternate assigned/one spare left
07	Alternate assigned/no spares left
08	Alternate needed/no spares left
09	None-recoverable error

Figure 3-54 Recovery action code information

RETRY COUNT

This byte indicates the number of retries the controller performed before terminating the command.

TRANSFER COUNT

These bytes contain the number of blocks transferred to/from the host.

NUMBER OF ALTERNATE SECTORS

This byte contains the number of alternate-sectors assigned.

NUMBER OF ALTERNATE TRACKS

This byte contains the number of alternate-tracks assigned.

ERROR RECOVERY

The controller automatically performs the following error recovery procedures for LUNs 00, 01, 02, and 03 without host intervention.

- During a Write or Read operation, if the controller fails to find a sector after 16 attempts, the controller terminates with a Check Condition status and a Media Error Sense key in the Sense data.
- Data error recovery for all commands except the Write and Verify and the NCR Write and Verify commands are restricted to multiple retries and ECC correction.

DISK DRIVE INTERFACE

The controller interfaces to the fixed disk drives through the daisy-chained command cable and radially-connected data cables.

COMMAND CABLE

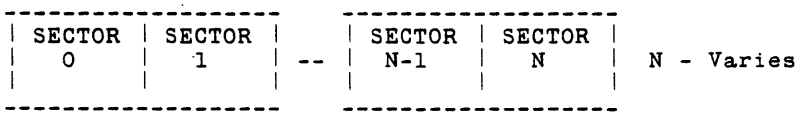
The 34-pin command cable supplies command information to the disk drives and receives drive status from the selected drive. The controller allows up to four daisy-chained disk drives to connect to the cable.

DATA CABLES

The controller allows a maximum of four 20-pin data cables, one for each disk drive. The cable maintains a high level of data integrity between the controller and the disk drive.

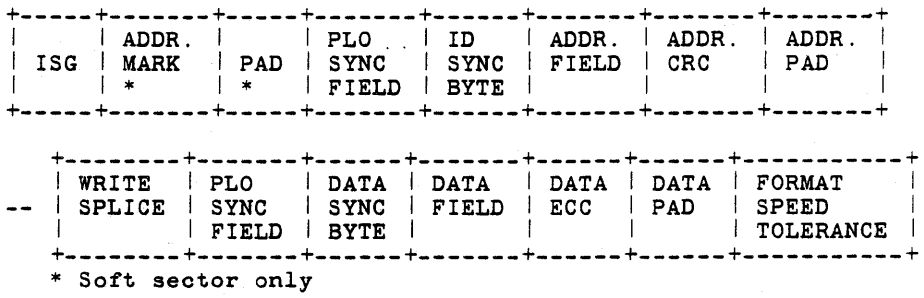
TRACK FORMAT

The tracks for both hard and soft sectors are formatted on the disk as follows:



The controller performs the Format Unit command independent of the host. The host system is not responsible for knowing the track format. This information is included only for use by the host diagnostic software.

Sector Format



SECTOR FORMAT DEFINITION	
FIELD	**VALUE**
ISG	12 bytes of zero - drive dependent
Address Mark	3 bytes - soft sectors only
PAD	1 byte - soft sectors only
PLO sync field	11 bytes - drive dependent
ID Sync Byte	1 byte - value of "FE"
Address Field	5 bytes - see Address Format section
Address CRC	2 bytes
Address Pad	2 bytes
Write Splice	1 byte
FLO Sync Field	11 bytes - drive dependent
Data Sync Byte(1)	1 byte - value of "FE"
Data Field	256, 512 or 1024 bytes
Data ECC	7 bytes of plynomial code - see Error Detection and Correction Code Format section
Data Pad	2 bytes
Format Speed Tolerance	15 bytes of zero - drive dependent

(1) Included in ECC calculations.

Figure 3-55 Sector format information

Address Format

The address field has the following 9 bytes of information:

FIXED DISK DRIVE ADDRESS FIELD FORMAT	
Byte	**Address**
01	Cylinder Address MSB
02	Cylinder Address LSB
03	Head Number
04	Logical Sector Number
05	Flag Bytes
	80 Good Primary or Alternate-Sector 01 User-declared Defective Tract 04 Alternate-Track

Figure 3-56 Address format information

Alternate And Defective Sectors

The alternate-sector mode is chosen through the Mode Select command. The alternate-sector mode reduces the number of user sectors per track by one.

If the user selects the Alternate Track Only option, no alternate-sectors are available. Defect Reassignment is through Alternate Track Assignment only.

If the user selects the Alternate Sector/Alternate Track option, one alternate-sector on all user tracks is reserved. Therefore, a maximum of one defective sector is permitted per track. If more than one sector is found to be defective, then the controller assigns an alternate-track.

An alternate-sector reassignment is permitted only during the Format Unit and Reassign Blocks commands. When a sector normally available to the user is defective, then determination is made as to whether the address field is still good. The address field is needed to format the bad sector as defective. If the address field is determined good, the sector is reformatted to a 77 (hex) sector number, indicating a defective sector.

Alternate And Defective Tracks

A defective track must contain at least one good sector. The controller flags defective tracks in the address field of every sector on the track by setting the flag byte in the address fields to indicate one of the defective track status codes. The address of the alternate-track is contained in the first four bytes of the data field on the defective track. The first three of those bytes must contain the cylinder number and head number of the alternate-track in hex; the alternate-sector number is not significant in this case and should contain zero. A defective track will not point to another defective track as its alternate-track.

Error Detection And Correction Code Format

The sector format includes seven Error Detection and Correction bytes that follow each Address field and Data field. The controller generates these ECC bytes for error detection and correction. The controller generates the ECC bytes that follow the Address field during Format functions and those following the Data field during the Write Data functions.

The following polynomial code generates the seven ECC bytes:

$$(X22+1)(X11+X7+X6+X+1)(X12+X11+...X2+X+1)(X11+X9+X7+X6+X5+X+1)$$

This 56-bit ECC code detects 22-bit error bursts, and corrects burst errors up to 11 bits long. The ECC bytes that follow the Address field are for error detection only, and those following the Data field are for error detection and correction when a Read error occurs.

CHAPTER 4

USER INTERFACE

INSTALLATION

COMPONENT LOCATION

The user interface consists of the following items:

- An eight-position switch pack used for SCSI device ID selection and controller options
- A four-position switch pack used for hardware options
- LEDs to display error codes. All LEDs are located near the outer edge of the printed circuit board to facilitate accessibility
- SCSI bus terminators

The user interface components listed above are at the following locations:

	8-Bit Switch	4-Bit Switch	LEDs
Single-ended board	U3	U16	CR2
Differential board	2I	11F	11I (CR3)

Figure 4-1 Component locations

PHYSICAL SIZE

The ESDI Disk Controller boards have the following nominal measurements:

- ADP-47-03 Single-ended SCSI (4.0 x 6.25 x .062 inches)
- ADP-47-04 Differential SCSI (5.75 x 7.8 x .062 inches)

SCSI BUS TERMINATORS

Each controller contains terminator resistors. If the controller is the last physical device on the daisy-chained SCSI bus, the terminator resistors must be in place. If the controller is not an end device, remove the terminator resistors. Removal of the terminators does not effect any other operation. Refer to Figures 4-6 and 4-11 for the location of the terminator resistors.

TROUBLE-SHOOTING

The controller board contains four status LEDs. These LEDs display power-up diagnostic results as error codes. Listed below are the error codes.

HEX CODE	DESCRIPTION
01	8088 Power-up error
02	ROM checksum error
03	RAM error
04	SDC interrupt error
05	SDC SCSI control error
06	SDC DMA control error
07	SDC data buffer error
08	SDC Control Store RAM error
09	SDC diagnostic control error
0A	SDC disk control error
0B	SDC ECC control error
0C	SDC CRC control error
0D	Differential chip error
0E	Passed power-up diagnostics

Figure 4-2 LED error codes

PREPARING THE BOARD

The controller board contains two switch packs, one four-position switch pack and one eight-position switch pack. These switches control the options of the controller and its SCSI identification.

EIGHT-POSITION SWITCH PACK

The controller uses the following switch positions on the eight-position switch pack to select diagnostic options and the SCSI ID.

SWITCH	1	2	3	4	5	6	7	8
Not used	OFF							
No flex support		OFF						
Single-ended SCSI			ON					
Differential SCSI			OFF					
Continue on error				OFF	OFF			
Loop on error				OFF	ON			
Halt on error				ON	OFF			
RAM read loop				ON	ON			
SCSI ID 0						OFF	OFF	OFF
SCSI ID 1						OFF	OFF	ON
SCSI ID 2						OFF	ON	OFF
SCSI ID 3						OFF	ON	ON
SCSI ID 4						ON	OFF	OFF
SCSI ID 5						ON	OFF	ON
SCSI ID 6						ON	ON	OFF
SCSI ID 7						ON	ON	ON

Figure 4-3 Eight-position switch pack

FOUR-POSITION SWITCH PACK

The controller uses the Power/Fail circuit to protect the disk media in the event a power failure occurs. After a power failure occurs, the Power/Fail circuit performs a board Reset. The Power/Fail switch on the four-position switch pack controls how the controller uses the Power/Fail circuit. If the power supply has a Power/Fail circuit, connect it to pin-2 of the power connector and position the Power/Fail switch accordingly. If the power supply does not have a Power/Fail circuit, use the Power/Fail circuit on the controller board by positioning the Power/Fail switch accordingly.

The following hardware options are selectable on the Single-ended controller board by the switches on the four-position switch pack.

SINGLE-ENDED				
Option Switch	**1**	**2**	**3**	**4**
Factory testing	ON	ON	ON	
ON connects external Power/Fail to pin-2 of J1				ON
OFF for Power/Fail from the controller				OFF

Figure 4-4 Four-position switch pack

The following hardware options are selectable on the Differential controller board by the switches on the four-position switch pack.

DIFFERENTIAL CONTROLLER				
OPTION SWITCH	**1**	**2**	**3**	**4**
Power/Failure form controller	ON	OFF		
Power/Failure at pin-2	OFF	ON		
Differential Sense enabled			ON	
Switch 4 is not used				OFF

ON, ON and OFF, OFF are illegal switch combinations for switches 1 and 2.

Figure 4-5 Differential controller, four-position switch pack

SINGLE-ENDED CONTROLLER BOARD

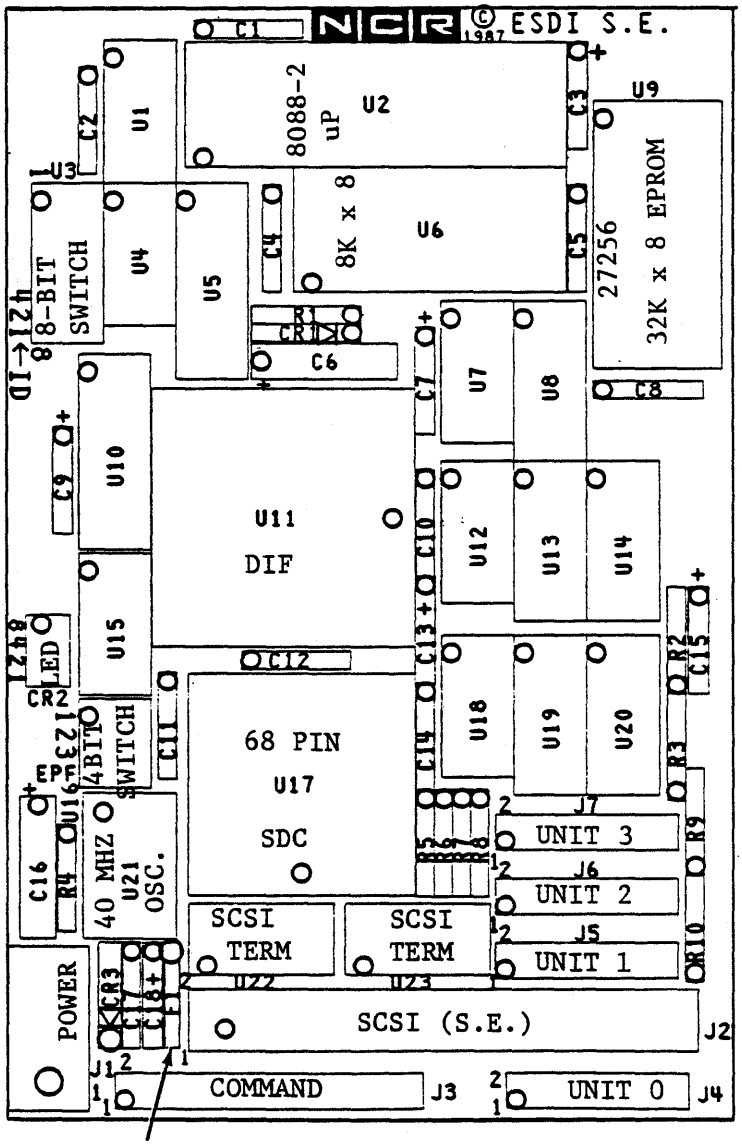


Figure 4-6 NCR ADP-47-03 ESDI Single-ended Controller board

SINGLE-ENDED BOARD CONNECTORS

J1 - POWER CONNECTOR

PIN	DESCRIPTION
1	Not connected
2	Power/Fail
3	Ground
4	+5 Volts dc

Figure 4-7 Power connector pin-out

J2 - SINGLE-ENDED SCSI BUS CONNECTOR

PIN	DESCRIPTION	PIN	DESCRIPTION
1	Ground	2	-DB0
3	Ground	4	-DB1
5	Ground	6	-DB2
7	Ground	8	-DB3
9	Ground	10	-DB4
11	Ground	12	-DB5
13	Ground	14	-DB6
15	Ground	16	-DB7
17	Ground	18	-DBP
19	Ground	20	Ground
21	Ground	22	Ground
23	Ground	24	Ground
25	Open	26	TRMPWR
27	Ground	28	Ground
29	Ground	30	Ground
31	Ground	32	-ATN
33	Ground	34	Ground
35	Ground	36	-BSY
37	Ground	38	-ACK
39	Ground	40	-RST
41	Ground	42	-MSG
43	Ground	44	-SEL
45	Ground	46	-C/D
47	Ground	48	-REQ
49	Ground	50	-I/O

Figure 4-8 Single-ended SCSI connector pin-out

J3 - FIXED DISK COMMAND CABLE

PIN	DESCRIPTION	PIN	DESCRIPTION
1	Ground	2	HDSEL3/
3	Ground	4	HDSEL2/
5	Ground	6	WRITEGATE/
7	Ground	8	CSTAT/
9	Ground	10	TACK/
11	Ground	12	ATTEN/
13	Ground	14	HDSEL0/
15	Ground	16	SECTOR/AMF/
17	Ground	18	HDSEL1/
19	Ground	20	INDEX/
21	Ground	22	READY/
23	Ground	24	TREQ/
25	Ground	26	DRVSEL0/
27	Ground	28	DRVSEL1/
29	Ground	30	DRVSEL2/
31	Ground	32	RDGATE/
33	Ground	34	CDATA/

Figure 4-9 Single-ended board command cable pin-out

J4, J5, J6, & J7 - UNIT 0, 1, 2, & 3 FIXED DISK DATA CABLE

PIN	DESCRIPTION	PIN	DESCRIPTION
1	DRVSELDX/	2	SECTOR/AMF/
3	CMD CMP/	4	AME/
5	Ground	6	Ground
7	WRCLK+	8	WRCLK-
9	Ground	10	REFCLK+
11	REFCLK-	12	Ground
13	WDATA+	14	WDATA-
15	Ground	16	Ground
17	RDATA+	18	RDATA-
19	Ground	20	INDEX/

Figure 4-10 Single-ended board data cable pin-out

DIFFERENTIAL CONTROLLER BOARD

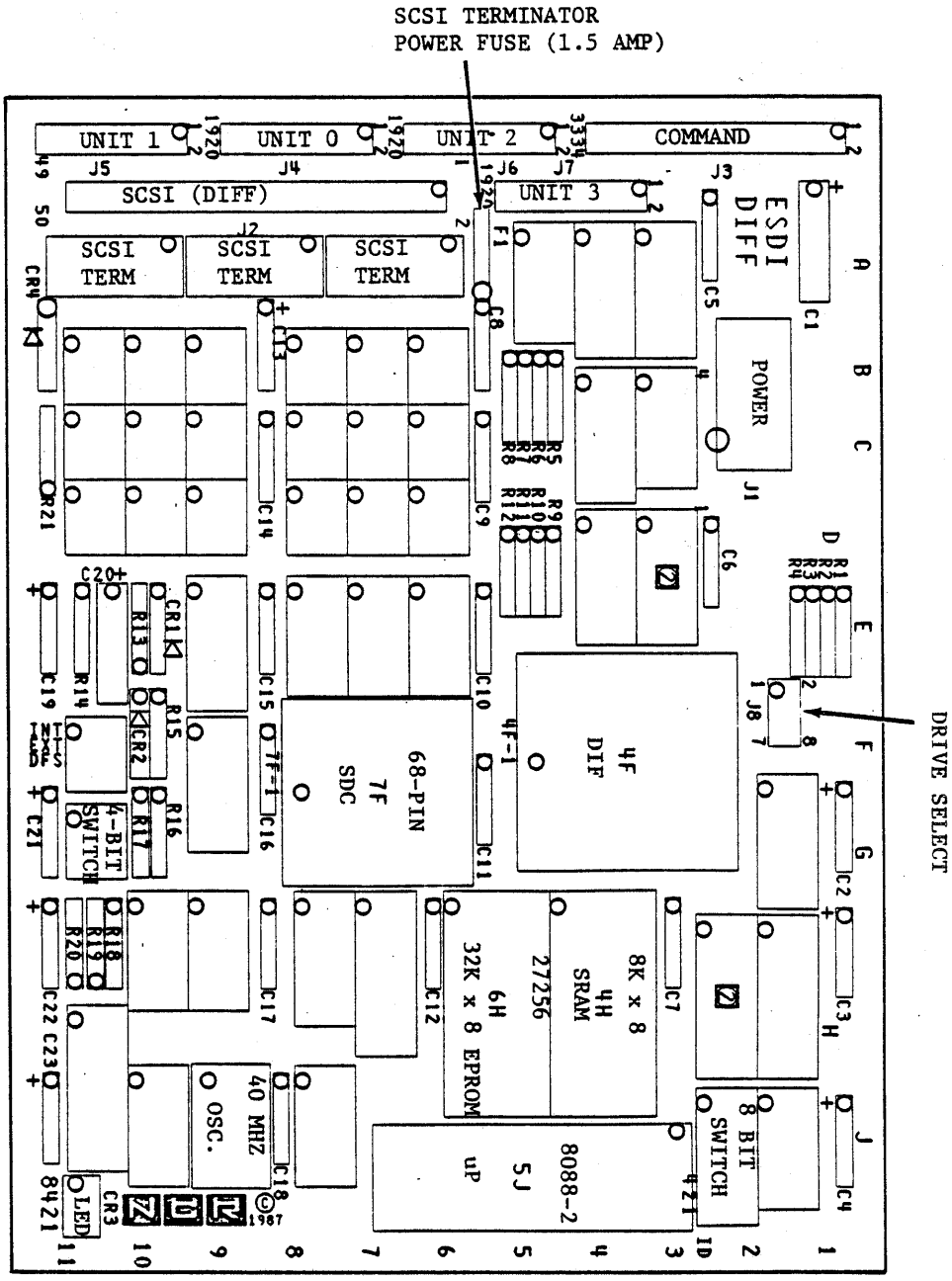


Figure 4-11 NCR ADP-47-04 ESDI Differential Controller board

DIFFERENTIAL BOARD CONNECTORS

J1 - POWER CONNECTOR

PIN	DESCRIPTION
1	Not connected
2	Power/Fail
3	Ground
4	+5 Volts dc

Figure 4-12 Power connector pin-out

J2 - DIFFERENTIAL SCSI BUS CONNECTOR

PIN	DESCRIPTION	PIN	DESCRIPTION
1	Not connected	2	Ground
3	+DB0	4	-DB0
5	+DB1	6	-DB1
7	+DB2	8	-DB2
9	+DB3	10	-DB3
11	+DB4	12	-DB4
13	+DB5	14	-DB5
15	+DB6	16	-DB6
17	+DB7	18	-DB7
19	+DBP	20	-DBP
21	DIFFSENS	22	Ground
23	Ground	24	Ground
25	TRMPWR	26	TRMPWR
27	Ground	28	Ground
29	+ATN	30	-ATN
31	Ground	32	Ground
35	+BSY	34	-BSY
37	+ACK	36	-ACK
39	+RST	38	-RST
41	+MSG	40	-MSG
43	+SEL	42	-SEL
45	+C/D	44	-C/D
47	+REQ	46	-REQ
49	+I/O	48	-I/O
49	Ground	50	Ground

Figure 4-13 Differential SCSI connector pin-out

J3 - FIXED DISK COMMAND CABLE

PIN	DESCRIPTION	PIN	DESCRIPTION
1	Ground	2	HDSEL3/
3	Ground	4	HDSEL2/
5	Ground	6	WRITEGATE/
7	Ground	8	CSTAT/
9	Ground	10	TACK/
11	Ground	12	ATTEN/
13	Ground	14	HDSEL0/
15	Ground	16	SECTOR/AMF/
17	Ground	18	HDSEL1/
19	Ground	20	INDEX/
21	Ground	22	READY/
23	Ground	24	TREQ/
25	Ground	26	DRVSEL0/
27	Ground	28	DRVSEL1/
29	Ground	30	DRVSEL2/
31	Ground	32	RDGATE/
33	Ground	34	CDATA/

Figure 4-14 Differential board command cable pin-out

J4, J5, J6 & J7 - UNIT 0, 1, 2 & 3 FIXED DISK DATA CABLE

PIN	DESCRIPTION	PIN	DESCRIPTION
1	DRVSELDX/	2	SECTOR/AMF/
3	CMD CMP/	4	AME/
5	Ground	6	Ground
7	WRCLK+	8	WRCLK-
9	Ground	10	REFCLK+
11	REFCLK-	12	Ground
13	WDATA+	14	WDATA-
15	Ground	16	Ground
17	RDATA+	18	RDATA-
19	Ground	20	INDEX/

Figure 4-15 Differential board data cable pin-out