



OEM INTERFACE SPECIFICATIONS

for

IBM-H2xxx-Sx (172/258/344 MB)

2.5-Inch Hard Disk Drive with SCSI Interface

First Edition (December 1993)

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1.0 General

1.1 Introduction

This specification describes the host interface of IBM-H2344-S4, IBM-H2258-S3, and IBM-H2172-S2. The drives support both Synchronous SCSI and Asynchronous SCSI.

The interface conforms to the *draft proposed American National Standard for information systems - SMALL COMPUTER SYSTEM INTERFACE - 2 (SCSI-2) October 17, 1991*.

The vendor specific items and options supported by the drives are described in each section.

1.2 References

- *OEM FUNCTIONAL SPECIFICATIONS for IBM-H2xxxSx (172/258/344MB) 2.5-Inch Hard Disk Drive with SCSI Interface (SC18-2284)*
- *Draft proposed American National Standard for information systems - SMALL COMPUTER SYSTEM INTERFACE - 2 (SCSI-2) October 17, 1991*

2.0 SCSI Command Set

Summaries of the SCSI commands supported by the drive are listed below, where O=optional, M=mandatory, E=extended, R=reserved and V=vendor unique. The column "SCSI-1" refers to ANSI version 1 standard. The column "CCS" refers to the ANSI sub-committee Common Command Subset for DASD devices. The column "SCSI-2" refers to the current revision of the version 2 standard available at the time this document was created and is shown for information only for compliance with future ANSI standards.

SCSI-1	CCS	SCSI-2	CODE	Command
M	M	M	04h	Format Unit
E	M	M	12h	Inquiry
O	O	O	15h	Mode Select
O	O	O	1Ah	Mode Sense
M	M	M	08h	Read
E	M	M	25h	Read Capacity
O	O	O	37h	Read Defect Data
E	M	M	28h	Read Extended
R	O	O	3Ch	Read Buffer
R	R	O	3Eh	Read Long
O	O	O	07h	Reassign Block
O	M	M	17h	Release
M	M	M	03h	Request Sense
O	M	M	16h	Reserve
O	O	O	01h	Rezero Unit
O	O	O	0Bh	Seek
O	O	O	2Bh	Seek Extended
O	M	M	1Dh	Send Diagnostics
O	O	O	1Bh	Start/Stop Unit
O	M	M	00h	Test Unit Ready
O	O	O	2Fh	Verify
M	M	M	0Ah	Write
E	M	M	2Ah	Write Extended
O	O	O	2Eh	Write and Verify
R	O	O	3Bh	Write Buffer
R	R	O	3Fh	Write Long

Figure 1. Supported SCSI Commands. (In alphabetical order)

SCSI-1	CCS	SCSI-2	CODE	Command
O	M	M	00h	Test Unit Ready
O	O	O	01h	Rezero Unit
M	M	M	03h	Request Sense
M	M	M	04h	Format Unit
O	O	O	07h	Reassign Block
M	M	M	08h	Read
M	M	M	0Ah	Write
O	O	O	0Bh	Seek
E	M	M	12h	Inquiry
O	O	O	15h	Mode Select
O	M	M	16h	Reserve
O	M	M	17h	Release
O	O	O	1Ah	Mode Sense
O	O	O	1Bh	Start/Stop Unit
O	M	M	1Dh	Send Diagnostics
E	M	M	25h	Read Capacity
E	M	M	28h	Read Extended
E	M	M	2Ah	Write Extended
O	O	O	2Bh	Seek Extended
O	O	O	2Eh	Write and Verify
O	O	O	2Fh	Verify
O	O	O	37h	Read Defect Data
R	O	O	3Bh	Write Buffer
R	O	O	3Ch	Read Buffer
R	R	O	3Eh	Read Long
R	R	O	3Fh	Write Long

Figure 2. Supported SCSI Commands. (By command code)

2.1 Flag and Link Bits

Many of the structures in this section have field names, Flag and Link. The meanings of these fields are defined below.

Flag The flag bit specifies which message the target should return to the initiator if the link bit is one and the command completes without error. If link is zero, flag must also be zero. If link is one and the command terminates successfully, the drive will send either the Linked Command Complete message (flag=0) or the Linked Command Complete with flag message (flag=1). Typically this bit is used to cause an interrupt in the initiator between linked commands.

Link This bit is set to one to indicate that the initiator desires an automatic link to the next command upon successful completion of the current command. Upon successful completion of the command, the drive will return intermediate good status and then send one of the two messages defined under Flag above.

Upon unsuccessful completion of the command, the drive will return a check condition status or reservation conflict status and then send the command complete message. No further commands in the chain are executed.

2.2 Abbreviations

These abbreviations are used throughout the following sections:

CDB. Command Descriptor Block.

LBA. Logical Block Address.

LSB. Least Significant Bit.

LUN. Logical Unit Number. An encoded three-bit identifier for the logical unit.

MSB. Most Significant Bit.

RSVD. Reserved.

VU. Vendor Unique bits.

2.3 Format Unit (04)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Command code (04h)							
Byte 1	LUN			Format Level				
Byte 2	VU = 0							
Byte 3	(MSB)							
Byte 4	Interleave Factor (LSB)							
Byte 5	VU = 0	RSVD = 0			Flag	Link		

Figure 3. Format Unit (04)

The Format command performs a physical formatting of the drive media. This includes a rewrite of all the sector IDs, relocation of defective sectors, and the overwriting of all data areas with a constant data pattern. The Format command may be used to effectively erase the entire data area of the media. Reserved areas of the media are not affected by the Format command.

Only a null defect list will be accepted from the initiator. The drive manages two internal defect lists. The first is the time of manufacture, or “P” list. The second (“G” list) is a “grown defect list” consisting of entries corresponding to an initiator's use of the Reassign Block command. The “P” list must never be altered. Contents of the “G” list can be erased at format time.

Interleave Factor can be set to any value from 0 to 0FFFFh, but all of them are regarded as 1:1.

Format Level specifies whether the grown defect list should be erased or retained and used during the format operation.

Format Level	Description
--------------	-------------

00000	The grown defect list is retained and all data is erased without updating IDs. No data out phase is executed.
--------------	--

10000	The grown defect list is retained and all data is erased without updating IDs. A data out phase is executed but the defect list length must be 0 or the command will end with a check condition status with sense key of illegal request and additional sense code of invalid field in CDB.
--------------	--

11000	The grown defect list is erased and the drive is formatted with the manufacturing defect list only. A data out phase is executed but the defect list length must be 0 or the command ends with a check condition status with sense key of illegal request and additional sense code of invalid field in CDB.
--------------	---

The drive performs the verify operation automatically as follows:

1. Read back IDs. If failed, the drive aborts the Format command with a check condition status, sense key set to not ready, and additional sense code set to medium format corrupted.

Note: The Format command must be completed before the data area is usable. If the Format Unit command is interrupted by such as, a power outage, reset or abort, the drive returns a check condition status for all subsequent **data area access** commands except another Format Unit command. A sense key of not ready and an additional sense code of medium format corrupted will be returned by the Request Sense command. To clear this error condition, a Format Unit command must be reissued and must be completed successfully.

2.3.1 Defect List

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Reserved = 0							
Byte 1	0	0	0	0	0	0	Immd	0
Byte 2	Defect list length MSB = 0							
Byte 3	Defect list length LSB = 0							

Figure 4. Format of Defect List Header. Format of the defect list header sent during the data out phase for the B'10000' and B'11000' modes.

The immediate bit (bit 1 of byte 1) of the Format Unit Defect List Header specifies the following:

- When set to 1:
 - The drive immediately returns a status before starting the actual formatting process.
 - The Request Sense command is used to determine the progress of the Format Unit command.

A sense key of not ready is returned with an additional sense code of logical unit not ready, format in progress.

Bytes 16 and 17 of the additional sense data contains a value which indicates the current percentage to complete the Format Unit command process. The actual percentage can be calculated by dividing this value by X'10000'.

- When set to zero:
 - Status is returned when the Format Unit command operation is completed.

2.4 Inquiry (12)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Command Code = 12h							
Byte 1	LUN			RSVD = 0			EVPD	
Byte 2	Page Code							
Byte 3	RSVD = 0							
Byte 4	Allocation Length							
Byte 5	VU = 0		RSVD = 0			Flag	Link	

Figure 5. Inquiry (12)

The Inquiry command requests the parameters of the target to be sent to the initiator.

An EVPD bit of one specifies that the drive returns the optional vital product data specified by the page code field. The drive does not support this option.

EVPD	Page Code	Description
0	0	The drive returns the standard Inquiry data.
0	Non Zero	The drive returns a check condition status with the sense key of illegal request and the additional sense code of invalid field in CDB.

Allocation Length specifies the number of bytes that the initiator has allocated for inquiry data to be returned. An allocation length of zero implies that no data is to be returned. The drive terminates the data in phase when all available inquiry data has been transferred or when allocation length bytes have been transferred, whichever occurs first.

If an Inquiry command is received from an initiator with a pending unit attention condition (before the target reports check condition status), the drive processes the Inquiry command. The unit attention condition is not cleared by this action.

Two different formats for the Inquiry data are defined.

- The first format is returned when an invalid LUN is specified by the initiator.
- The second format is returned when a valid LUN is specified by the initiator.

Each of these formats is described in the following sections.

Note: Fields with a value shown inside quotes (for example, Value = 'xyz') are character fields. A value not in quotes is a numeric value. Character fields are alpha-numeric and represented in ASCII, not EBCDIC.

2.4.1 Inquiry Data Format (When Invalid LUN is Specified)

Byte	BIT							
	7	6	5	4	3	2	1	0
0	Qualifier			Peripheral Dev. Type				
1	RMB=0	Device-type Modifier						
2	ISO=0		ECMA=0			ANSI=2		
3	RSVD = 0			RDF=2				
4	Additional Length = 0							

Figure 6. Inquiry Data – Invalid LUN Specified

- **Qualifier** is set to 011b. This indicates that the LUN specified in the command block is not present.¹
- **Peripheral Dev. Type** is set to 1Fh.
- **Removal Media Bit (RMB)** is always set to zero to indicate that no removal media exists.
- **Device-Type Modifier** is set to zero.
- **ISO** is set to zero to indicate that this product does not claim compliance to the International Organization for Standardization (ISO) version of SCSI (ISO DP 9316).
- **ECMA** is set to zero to indicate that this product does not claim compliance to the European Computer Manufacturers Association (ECMA) version of SCSI (ECMA-111).
- **ANSI** indicates the level of the ANSI standard that is supported by the product. The drive supports ANSI SCSI version 2.
- **RDF** is set to two to indicate that the Inquiry Data Format as specified in ANSI SCSI version 2 is supported by the drive.

¹ In general, the drive will respond with a check condition status to all commands with an invalid LUN. The Inquiry command is the only exception.

2.4.2 Inquiry Data Format (When Valid LUN is Specified)

Byte	BIT							
	7	6	5	4	3	2	1	0
0	Qualifier = 0				Peripheral Device Type = 0			
1	RMB=0	Reserved = 0						
2	ISO = 0		ECMA = 0			ANSI = 2		
3	Rsvd = 0				RDF = 2			
4	Additional Length = 103							
5-6	Reserved = 0							
7	REL_A = 0	Wb_32 = 0	Wb_16 = 0	Sync = 1	Link = 1	Resrv = 0	CmdQu = 0	SftRe = 0
8-15	Vendor ID = 'IBM'							
16-31	Product ID = 'H2xxx-Sx'							
32-35	Product Revision Level (ASCII)							
36-43	Unit Serial Number (ASCII)							
44-55	RAM u Code P/N (ASCII)							
56-95	Reserved = 0							
96-97	Reserved = ' '							
98-101	Plant of Manufacture = ' '							
102-105	Date of Manufacture = MMY (ASCII)							
106-107	Reserved = ' '							

Figure 7. Inquiry Data – Valid LUN Specified

- **Qualifier** is set to zero to indicate that the LUN specified in the command block is currently supported.
- **Peripheral Device Type** is set to zero to indicate that the device is a direct-access drive.
- Field bytes 1– 3 are defined in 2.4.1, “Inquiry Data Format (When Invalid LUN is Specified)” on page 9.
- **Additional Length** indicates that 103 bytes of inquiry information follows.
- **REL_A** is set to zero to indicate that the drive does not support “Relative Address Mode”.
- **Wb_32** is set to zero to indicate that the drive does not support 32-bit wide data transfers.
- **Wb_16** is set to zero to indicate that the drive does not support 16-bit wide data transfers.
- **Sync** is set to one to indicate that the drive supports synchronous data transfer.
- **Link** is set to one to indicate that the drive supports linked commands.
- **CmdQu** is set to zero to indicate that the drive does not support command queuing.
- **SftRe** is set to zero to indicate that the target supports hard reset only.

- **Vendor ID** is 'IBM' padded with ASCII blanks.
- **Product ID** is specified in ASCII characters.
- **Product Revision Level** indicates the level of microcode. It indicates ROM microcode level until the power on reset completes and RAM microcode after the POR.
- **Unit Serial Number** contains the drive serial number. If before the POR completes, this field contains ASCII spaces (20h).
- **RAM Microcode P/N** is specified in ASCII characters.
- **Plant of Manufacture** is the plant code of manufacture. If before the POR completes, this field contains ASCII spaces (20h).
- **Date of Manufacture** contains the month in two digits followed by the year in two digits. If before the POR completes, this field contains ASCII spaces (20h).

2.5 Mode Sense (1A)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Command code = 1Ah							
Byte 1	LUN			RSVD = 0				
Byte 2	PCF		Page Code					
Byte 3	RSVD = 0							
Byte 4	Allocation Length							
Byte 5	VU = 0		RSVD = 0				Flag	Link

Figure 8. Mode Sense (1A)

The Mode Sense command provides a means for the drive to report various device parameters to the initiator. It is the complement to the Mode Select command.

Allocation Length indicates the maximum number of bytes that the initiator has set aside for the data in phase. A value of zero is not considered an error. If the allocation length is less than the amount available, then that portion of the data up to the allocation length is sent. It is noted that this may result in only a portion of a multi-byte field being sent.

2.5.1.1.1 Page Control Field: PCF (Page Control Field) defines the type of Page Parameter values to be returned.

PCF Meaning

0 0 Report current values. The drive returns the current values under which the logical unit is presently configured for the page code specified. The current values returned are:

1. The parameters set in the last successful Mode Select command.
2. The saved values if a Mode Select command has not been executed since the last power-on, hard reset condition, or bus device reset message .

Note: The drive will not process the Mode Select command until the completion of spin-up. Therefore, the initiator cannot modify the current values prior to the saved values being read in.

3. The default values if saved values are not available or not supported.

0 1 Report changeable value. The drive returns the changeable values for the page code specified. The page requested is returned containing information that indicate which fields are changeable. All bits of parameters that are changeable are set to one. Parameters that are *defined by the drive* are set to zero. If any part of a field is changeable, all bits in that field are set to one.

Note: For a value field such as the buffer ratios of Page 2, the bit field does not indicate the range of supported values but rather that the field is supported.

1 0 Report default value. The drive returns the default values for the page code specified. The parameters not supported by the drive are set to zero.

1 1 Report saved value. The drive returns the saved value for the page code specified.

Saved values are one of following:

- The values saved as a result of Mode Select command

- Identical to the default values
- Zero when the parameters are not supported

The page length byte value of each page returned by the drive indicates up to which fields are supported on that page.

2.5.1.1.2 Page Code: This field specifies which page or pages to return. Page code usage is defined in Figure 9.

Page Code	Description
01h – 1Fh	Return specific page.
3Fh	Return all available pages.

Figure 9. Page Code Usage

2.5.2 Mode Parameter List

The mode parameter list contain a header, followed by zero or more block descriptors, followed by zero or more variable-length pages.

2.5.2.1 Header

	7	6	5	4	3	2	1	0
Byte 0	Mode Data Length							
Byte 1	Medium Type = 0							
Byte 2	WP	RSVD = 0						
Byte 3	Block Descriptor Length (= 0 or 8)							

Figure 10. Mode Parameter List (Header)

- **Mode Data Length.** When using the Mode Sense command, the mode data length field specifies the length in bytes of the following data that is available to be transferred. The mode data length does not include the length byte itself. When using the Mode Select command, this field is reserved.
- **Medium Type** field is always set to zero in the drive. (Default medium type)
- **WP.** When used with the Mode Select command, the write protect (WP) bit is reserved.
When used with the Mode Sense command, a write protect (WP) bit of zero indicates that the medium is write enabled.
- **Block Descriptor Length.** This field specifies the length in bytes of the block descriptors.
When used with the Mode Select command, zero or eight are supported by the drive.
When used with the Mode Sense command, the drive returns eight to indicate that only a single block descriptor is available.

2.5.2.2 Block Descriptor

Byte 0	Density code = 0
Byte 1 Byte 2 Byte 3	Number of Blocks (MSB) (LSB)
Byte 4	RSVD = 0
Byte 5 Byte 6 Byte 7	Block Length = 200h

Figure 11. Mode Parameter Block Descriptor

The block descriptor provides formatting information about the number of blocks (user addressable) to format at the specified block length.

- **Number of Blocks**

H2172-S2	52184h
H2258-S3	7B24Ch
H2344-S4	A430Dh

When used with the Mode Select command, the **Number of Blocks** field must be:

- Zero to indicate all available blocks
- The exact number of blocks in the data area of the drive, which can be obtained with the Mode Sense command.

Any other value is invalid, and causes the command to fail with a check condition status.

When used with the Mode Sense command, the field contains the exact number of blocks.

- **Block Length**

When used with the Mode Select command, the **Block Length** field must contain 200h, or the drive terminates the command with a check condition status.

When used with the Mode Sense command, the returned field always contains 200h.

2.5.2.3 Page Descriptor

Byte 0	PS	RSVD=0	Page Code
Byte 1	Page Length		
Byte 2-n	Mode Parameters		

Figure 12. Mode Parameter Page Format

Each mode page contains a page code, a page length, and a set of mode parameters.

When using the Mode Sense command, a parameter savable (PS) bit of one indicates that the mode page can be saved by the drive in the reserved area of the file.

A PS bit of zero indicates that the supported parameters cannot be saved. When using the Mode Select command, the PS bit is reserved (zero).

The drive supports the following mode page code:

Page	Description	PS
01	Read-Write Error Recovery Parameters	1
02	Disconnect/Reconnect Control Parameters	1
03	Format Parameters	0
04	Geometry Parameters	0
08	Caching Parameters	1

Figure 13. Page Code Usage

The page length field specifies the length in bytes of the mode parameters that follow. If the initiator does not set this value to the value that is returned for the page by the Mode Sense command, the drive terminates the command with a check condition status.

2.5.3 Page 1 (Read/Write Error Recovery Parameters)

	BIT								
	7	6	5	4	3	2	1	0	
Byte 0	PS	RSVD=0	Page Code = 01h						
Byte 1	Page Length = 0Ah								
Byte 2	AWRE = 0	ARRE = 0	TB	RC = 0	EER = 0	PER	DTE	DCR	
Byte 3	Read Retry Count								
Byte 4	Correction Span = 28h								
Byte 5	Head Offset Count (Not used) = 00h								
Byte 6	Data Strobe Offset Count (Not used) = 00h								
Byte 7	Reserved = 00h								
Byte 8	Write Retry Count								
Byte 9	Reserved = 00h								
Byte 10	(MSB)	Recovery Time Limit (Not Used)						= 0000h	
Byte 11								(LSB)	

Figure 14. Page 1

The Read-Write recovery parameters are used during any command that performs a read or write operation to the medium.

- **AWRE**, an automatic write reallocation enabled bit. **Must be set to zero**, indicating that the drive will not perform automatic reallocation of defective data blocks during write operations.
- **ARRE**, an automatic read reallocation enabled bit. **Must be set to zero**, indicating that the drive will not perform automatic reallocation of defective data blocks during read operations.
- **TB**, transfer block bit, is set to one to indicate that a data block that is not recovered within the recovery limits specified will be transferred to the initiator before check condition status is returned. A TB bit of zero indicates that such a data block will not be transferred to the initiator. Data blocks that can be recovered within the recovery limits are always transferred, regardless of the value of the bit.
- **RC**, a read continuous bit. **Must be set to zero**, indicating that the error recovery operations that cause delays are acceptable during the data transfer. Data will not be fabricated.
- **EER**, an enable early recovery bit. **Must be set to zero**, indicating that the drive will use an error recovery procedure that minimizes the risk of mis-detection or miscorrection during the data transfer. Data will not be fabricated.
- **PER**, post error bit, is set to one to indicate that the drive reports recovered errors.
- **DTE**, disable transfer on error bit, is set to one to indicate that the drive terminates the data phase upon detection of a recovered error .
- **DCR**, disable correction bit, is set to one to indicate that error correction code is not used for data error recovery.
A DCR bit of zero indicates that ECC is applied to recover the data. (See 6.9, “Error Recovery Procedures” on page 83 for details.)

- **Read Retry Count** is set to one to indicate that the drive attempts its full recovery algorithm during read operations. A value of zero disables all error recovery procedures.
- **Correction Span** field specifies the size, in bits, of the largest data error burst for which data error correction may be attempted. A correction span of zero specifies that the drive will use its default value. The file only accepts value of zero, or the default value.
- **Head Offset Count** is not supported by the drive.

Note: Head offset is implemented in the read error recovery routine. The user cannot modify the offset value.

- **Write Retry Count** is set to one to indicate that the drive attempts its full recovery algorithm during write operations. A value of zero disables all error recovery procedures.

Changeable Parameter	Default Value
TB	0
PER	0
DTE	0
DCR	0
Read Retry Count	01
Write Retry Count	01

Note: The drive supports only 0 and 1 as read/write retry count. If the initiator sets a value larger than 1 by Mode Select command, the drive returns good status but changes the value to 1, and returns 1 as the read/write retry count for the Mode Sense command.

The following summarizes valid modes of operation.

PER	DTE	DCR	TB	Description
0	0	0	0	Retries and error correction are attempted. Recovered and/or corrected data (if any) is transferred with no check condition status at the end of the transfer. no err The transfer length is exhausted. soft err The transfer length is exhausted. Transferred data includes blocks containing recovered errors. hard err Data transfer stops when an irrecoverable error is encountered. The irrecoverable block is not transferred to the initiator. The drive then creates the check condition status with the appropriate sense key.
0	0	0	1	Retries and error correction are attempted. Recovered and/or corrected data (if any) is transferred with no check condition status at the end of the transfer. no err The transfer length is exhausted. soft err The transfer length is exhausted. Transferred data includes blocks containing recovered errors. hard err Data transfer stops when an irrecoverable error is encountered. The irrecoverable block is transferred to the initiator. The drive then creates the check condition status with the appropriate sense key.
0	0	1	0	Retries are attempted but no error correction (ECC) is applied. Recovered data (if any) is transferred with no check condition status at the end of the transfer. no err The transfer length is exhausted. soft err The transfer length is exhausted. Transferred data includes blocks containing recovered errors. hard err Data transfer stops when an irrecoverable error is encountered. The irrecoverable block is not transferred to the initiator. The drive then creates the check condition status with the appropriate sense key.
0	0	1	1	Retries are attempted but no error correction (ECC) is applied. Recovered data (if any) is transferred with no check condition status at the end of the transfer. no err The transfer length is exhausted. soft err The transfer length is exhausted. Transferred data includes blocks containing recovered errors. hard err Data transfer stops when an irrecoverable error is encountered. The irrecoverable block is transferred to the initiator. The drive then creates the check condition status with the appropriate sense key.
0	1	0	0	Illegal request-DTE must be zero when PER is zero.
0	1	0	1	Illegal request-DTE must be zero when PER is zero.
0	1	1	0	Illegal request-DTE must be zero when PER is zero.
0	1	1	1	Illegal request-DTE must be zero when PER is zero.
1	0	0	0	The highest level error, (See 4.2, "Priority of Error Reporting" on page 69) is reported at the end of transfer. Retries and error correction are attempted. Recovered and/or corrected data (if any) is transferred with check condition status and recovered error sense key set at the end of the transfer.

				<p>no err The transfer length is exhausted.</p> <p>soft err The transfer length is exhausted. Transferred data includes blocks containing recovered errors. The information byte in the sense data will contain the logical block address of the last recovered error.</p> <p>hard err Data transfer stops when an irrecoverable error is encountered. The irrecoverable block is not transferred to the initiator. The drive then creates the check condition status with the appropriate sense key.</p>
1	0	0	1	<p>The highest level error, (See 4.2, “Priority of Error Reporting” on page 69) is reported at the end of transfer. Retries and error correction are attempted. Recovered and/or corrected data (if any) is transferred with check condition status and recovered error sense key set at the end of the transfer.</p> <p>no err The transfer length is exhausted.</p> <p>soft err The transfer length is exhausted. Transferred data includes blocks containing recovered errors. The information byte in the sense data will contain the logical block address of the last recovered error.</p> <p>hard err Data transfer stops when an irrecoverable error is encountered. The irrecoverable block is transferred to the initiator. The drive then creates the check condition status with the appropriate sense key.</p>
1	0	1	0	<p>The highest level error, (See 4.2, “Priority of Error Reporting” on page 69) is reported at the end of transfer. Retries are attempted but ECC is not applied. Recovered and/or corrected data (if any) is transferred with check condition status and recovered error sense key set at the end of the transfer.</p> <p>no err The transfer length is exhausted.</p> <p>soft err The transfer length is exhausted. Transferred data includes blocks containing recovered errors. The information byte in the sense data will contain the LBA of the last recovered error.</p> <p>hard err Data transfer stops when an irrecoverable error is encountered. The irrecoverable block is not transferred to the initiator. The drive then creates the check condition status with the appropriate sense key.</p>
1	0	1	1	<p>The highest level error, (See 4.2, “Priority of Error Reporting” on page 69) is reported at the end of transfer. Retries are attempted but ECC is not applied. Recovered and/or corrected data (if any) is transferred with check condition status and recovered error sense key set at the end of the transfer.</p> <p>no err The transfer length is exhausted.</p> <p>soft err The transfer length is exhausted. Transferred data includes blocks containing recovered errors. The information byte in the sense data will contain the LBA of the last recovered error.</p> <p>hard err Data transfer stops when an irrecoverable error is encountered. The irrecoverable block is transferred to the initiator. The drive then creates the check condition status with the appropriate sense key.</p>
1	1	0	0	<p>The highest level error, (See 4.2, “Priority of Error Reporting” on page 69) is reported at the end of transfer. Retries and error correction are attempted. Recovered and/or corrected data (if any) is transferred with check condition status and recovered error sense key set at the end of the transfer.</p> <p>no err The transfer length is exhausted.</p>

				<p>soft err The transfer stops on the first soft error detected. The information in the sense data contains the LBA of the block in error.</p> <p>hard err Data transfer stops on the irrecoverable error. The drive then creates the check condition status with the appropriate sense key.</p>
1	1	0	1	<p>The highest level error, (See 4.2, “Priority of Error Reporting” on page 69) is reported at the end of transfer. Retries and error correction are attempted. Recovered and/or corrected data (if any) is transferred with check condition status and recovered error sense key set at the end of the transfer.</p> <p>no err The transfer length is exhausted.</p> <p>soft err The transfer stops on the first soft error detected. The information in the sense data will contain the LBA of the block in error.</p> <p>hard err Data transfer stops on the irrecoverable error. The irrecoverable error block is returned to the initiator. The drive then creates the check condition status with the appropriate sense key.</p>
1	1	1	0	<p>The highest level error, (See 4.2, “Priority of Error Reporting” on page 69) is reported at the end of transfer. Retries are attempted but ECC is not applied. Recovered data is transferred with a check condition status and recovered error sense key set at the end of the transfer.</p> <p>no err The transfer length is exhausted.</p> <p>soft err The transfer stops on the first soft error detected. The recovered error block is returned to the initiator. The information in the sense data will contain the logical block address of the block in error.</p> <p>hard err Data transfer stops on the irrecoverable error. The drive then creates the check condition status with the appropriate sense key.</p>
1	1	1	1	<p>The highest level error, (See 4.2, “Priority of Error Reporting” on page 69) is reported at the end of transfer. Retries are attempted but ECC in not applied. Recovered and/or corrected data (if any) is transferred with a check condition status and recovered error sense key set at the end of the transfer.</p> <p>no err The transfer length is exhausted.</p> <p>soft err The transfer stops on the first soft error detected. The information in the sense data will contain the logical block address of the block in error.</p> <p>hard err Data transfer stops on the irrecoverable error. The irrecoverable error block is returned to the initiator. The drive then creates the check condition status with the appropriate sense key.</p>

2.5.4 Page 2 (Disconnect/Reconnect Parameters)

		BIT							
		7	6	5	4	3	2	1	0
Byte	0	PS	RSVD=0	Page Code = 02h					
Byte	1	Page Length = 2							
Byte	2	Read Buffer Full Ratio							
Byte	3	Write Buffer Empty Ratio							

Figure 15. Page 2

The disconnect / reconnect page provides the initiator the means to tune the performance of the SCSI bus.

An initiator may use the identify message to grant the drive the general privilege of disconnecting. (Disconnect requests may still be selectively rejected by the initiator by issuing a message reject).

The drive uses the disconnect/reconnect parameters to control reconnection during Read (operation code 08h and 28h) and Write (0Ah , 2Ah and 2Eh) commands.

- **Read Buffer Full Ratio** is the numerator of a fraction whose denominator is 256. The fraction indicates how full the drive data buffer should be before attempting to reconnect to the SCSI bus.
- **Write Buffer Empty Ratio** is the numerator of a fraction whose denominator is 256. The fraction indicates how empty the drive data buffer should be before attempting to reconnect to the SCSI bus.

Changeable Parameter	Default Value
Read Buffer Full Ratio	30h
Write Buffer Empty Ratio	30h

2.5.4.1 Reconnection to a Disconnected Read Command

For a Read command, the reconnect is delayed relative to the availability of the first block in the drive data buffer by the fraction of the file data buffer size. If the remaining data transfer length is less than the fraction of the drive data buffer size, the file control program calculates the optimal reconnection point to complete the data transfer as early as possible while minimizing the time connected to the SCSI bus.

2.5.4.2 Reconnection to a Disconnected Write Command

For a Write command, the write buffer ratio is significant only if the total data transfer length is greater than the size of the drive data buffer. The fraction determines how empty the drive data buffer should be before reconnecting to begin filling the buffer again.

2.5.4.3 Single Block Buffers Calculation

The single block buffers value is calculated using the following equation:

$$\text{Single Block Buffers} = \frac{N * \text{Ratio Number}}{256} \quad (+ 1 \text{ only if result is zero})$$

Where: $N = \text{Buffer Size}/512$

Note: A ratio value of 0 is supported on the drive and will result in 100% of the buffer being filled/emptied.

2.5.5 Page 3 (Format Device Parameters)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	RSVD = 0		Page Code = 03h					
Byte 1	Page Length = 16h							
Byte 2 (MSB)	Track per Zone						= 0001h	
Byte 3	(LSB)							
Byte 4 (MSB)	Alternate Sectors per Zone						= 0001h	
Byte 5	(LSB)							
Byte 6 (MSB)	Alternate Tracks per Zone						= 0000h	
Byte 7	(LSB)							
Byte 8 (MSB)	Alternate Tracks per Logical Unit = 0008h							
Byte 9	(LSB)							
Byte 10 (MSB)	Sectors per Track						= 003Ch	
Byte 11	(LSB)							
Byte 12 (MSB)	Data Bytes per Physical Sector						= 0200h	
Byte 13	(LSB)							
Byte 14 (MSB)	Interleave						= 0000h	
Byte 15	(LSB)							
Byte 16 (MSB)	Track Skew Factor						= 000Fh	
Byte 17	(LSB)							
Byte 18 (MSB)	Cylinder Skew Factor						= 0016h	
Byte 19	(LSB)							
Byte 20	SSEC = 0	HSEC = 1	RMB = 0	SURF = 0	Reserved = 0000b			
Byte 21-23	Reserved						= 000000h	

Figure 16. Page 3

The format device page contains parameters which specify the medium format.

SSEC Zero. Indicates that the drive does not support soft sector formatting.

HSEC One. Indicates that the drive supports hard sector formatting.

RMB Zero. Indicates that the media is not removable. Fixed Disk.

SURF Zero. Indicates that progressive addresses are assigned to all logical blocks a cylinder prior to allocating an address within the next cylinder.

2.5.6 Page 4 (Rigid Disk Drive Geometry Parameters)

	BIT								
	7	6	5	4	3	2	1	0	
Byte 0	RSVD = 0		Page Code = 04h						
Byte 1	Page Length = 16h								
Byte 2 (MSB)	Number of Cylinders						= 0008D6h		
Byte 4	(LSB)								
Byte 5	Number of Heads								
Byte 6 (MSB)	Starting Cylinder-Write Precompensation = 000000h								
Byte 8	(Not used) (LSB)								
Byte 9 (MSB)	Starting Cylinder-Reduced Write Current = 000000h								
Byte 11	(Not used) (LSB)								
Byte 12 (MSB)	Drive Step Rate (Not used)						= 0000h		
Byte 13	(LSB)								
Byte 14 (MSB)	Landing Zone Cylinder (Not used) = 000000h								
Byte 16	(LSB)								
Byte 17	Reserved = 00						RPL = 0		
Byte 18	Rotational Offset (Not used)						= 00h		
Byte 19	Reserved						= 00h		
Byte 20 (MSB)	Medium Rotation Rate						= 0ED8h		
Byte 21	(LSB)								
Byte 22	Reserve						= 0000h		
Byte 23									

Figure 17. Page 4

The rigid disk drive geometric page specifies various parameters for the drive.

Product ID	Number of Heads
-------------------	------------------------

H2172-S2	2
-----------------	---

H2258-S3	3
-----------------	---

H2344-S4	4
-----------------	---

RPL	Zero. Indicates that the drive does not support spindle synchronization.
------------	--

2.5.7 Page 8 (Caching Parameters)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	PS	RSVD=0	Page Code = 08h					
Byte 1	Page Length = 2							
Byte 2	Reserved							RCD
Byte 3	Reserved							

Figure 18. Page 8

The caching parameters page defines parameters that affect the use of the cache.

- A read cache disable (RCD) bit of zero indicates that the drive may return data requested by a Read command by accessing either the cache or the read ahead buffer, or the media. A RCD bit of one indicates that the drive transfers all data requested by a Read command by accessing the media (that is, data cannot be transferred from the cache or read ahead buffer).

Changeable Parameter	Default Value
RCD (Read Cache Disable)	0

2.6 Mode Select (15)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Command Code = 15h							
Byte 1	LUN		PF=1	RSVD = 0			SP	
Byte 2	RSVD = 0							
Byte 3	RSVD = 0							
Byte 4	Parameter List Length							
Byte 5	VU = 0	RSVD = 0				Flag	Link	

Figure 19. Mode Select (15)

The Mode Select command provides a means for the initiator to alter LUN or device parameters. These include:

- Error Recovery Option
- Formatting Option

There is only one set of mode select parameters shared by all initiators.

PF Page Format.

- 0 The mode select parameters that follow the header and block descriptors are structured as page of related parameters and are as specified in standard ANSI SCSI-2.
- 1 The mode select parameters are as specified in SCSI-1 (that is, all parameters after block descriptors are vendor-specific).

SP Save Pages. This indicates:

- 0 The drive will not save the saveable pages² which are sent during the data out phase.
- 1 The drive will save the saveable pages in the reserved area on the disk.

Parameter List Length

This specifies the number of bytes to be sent from the initiator. A parameter list length of zero suppresses data transfer and is not considered as an error.

The mode select parameter list contains a four-byte header, followed by zeros or one block descriptor followed by zeros or more pages as shown in the subsequent sections.

2.6.1.1 Application Note

The initiator should issue a Mode Sense command requesting all changeable values (see PCF field in byte two of the CDB in 2.5, “Mode Sense (1A)” on page 12) prior to issuing a Mode Select command. This is necessary to find out which pages are implemented by the drive and the length of those pages. The drive will return, in the pages of the Mode Sense command, the number of bytes supported for each page. The page length set by the initiator in the Mode Select command must be the exact value as that returned by the

² Saveable Page is defined in 2.5, “Mode Sense (1A)” on page 12.

drive in mode sense page length. If this is not true, the drive will return a check condition status with a sense key of illegal request. See 2.5, “Mode Sense (1A)” on page 12.

Note: If an initiator sends a Mode Select command that changes any parameters that apply to other initiators, the drive will generate an unit attention condition for all initiators except the one that issued the Mode Select command. The drive will set the additional sense code to parameters changed (2Ah).

2.7 Read (08)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Command Code = 08h							
Byte 1	LUN			(MSB)	LBA			
Byte 2	Logical Block Address							
Byte 3	Logical Block Address (LSB)							
Byte 4	Transfer Length							
Byte 5	VU = 0	RSVD = 0			Flag	Link		

Figure 20. Read (08)

The Read command requests the drive to transfer the specified number of blocks of data to the initiator starting at the specified logical block address.

- **Logical block address** specifies the logical unit at which the read operation begins.
- **Transfer length** specifies the number of blocks to be transferred. A value of zero implies 256 blocks are to be transferred.³

Note: Error recovery is performed as specified by the Mode Select command.

³ Block is 512 bytes in length.

2.8 Read Capacity (25)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Command Code = 25h							
Byte 1	LUN			RSVD = 0				RelAdr
Byte 2 (MSB)	Logical Block Address							
Byte 3								
Byte 4								
Byte 5								(LSB)
Byte 6	RSVD = 0							
Byte 7	RSVD = 0							
Byte 8	RSVD = 0							PMI
Byte 9	VU = 0	RSVD = 0				Flag	Link	

Figure 21. Read Capacity (25)

The Read Capacity command returns information regarding the capacity of the drive.

- **RelAdr.** A relative address is not supported. It must be set to zero.
- **Logical Block Address** is used in conjunction with the PMI bit.
- **PMI**, Partial medium indicator indicates:

PMI	Description
-----	-------------

0	The drive returns the last logical block address of the drive.
---	--

1	The drive returns the last logical block address on the same track where the LBA in the command is located.
---	---

This option provides the information the initiator needs to determine the amount of space available on the same track that is accessible without head switching or seeking.

Note: The drive does not support PMI=1. The file will return the last logical block address of the drive even if PMI is set to one.

2.8.1.1 Returned Data Format

The data returned to the initiator in response to the Read Capacity command is described. The data is returned in the data in phase.

	7	6	5	4	3	2	1	0	
Byte 0	(MSB) Logical Block Address (LSB)								
Byte 1									
Byte 2									
Byte 3									
Byte 4	(MSB) Block Length (LSB)								
Byte 5									
Byte 6									= 512
Byte 7									

Figure 22. Format of Read Capacity Command Reply

- **Block Length** specifies the length in bytes of the block. It is set to 512.

2.9 Read Defect Data (37)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Command CODE = 37h							
Byte 1	LUN			Rsvd = 0				0
Byte 2	Rsvd = 0		Plist	Glist	Defect List Format			
Byte 3	Rsvd = 0							
Byte 4								
Byte 5								
Byte 6								
Byte 7	Allocation length (MSB)							
Byte 8								
Byte 9	VU = 0	RSVD = 0				Flag	Link	

Figure 23. Read Defect Data (37)

The Read Defect Data command requests that the target transfers the medium defect data to the initiator. If the target is unable to access any medium defect data it will return a check condition status with the appropriate sense key. The sense key will be set to either medium error (03h) if a medium error occurred or no sense (00h) if the list does not exist. The additional sense code of defect list error (19h) will be set.

The primary defect list (Plist) bit set to one indicates that the target returns the primary list of defects. A Plist bit of zero indicates that the target will not return the primary defect list of defects.

The grown defect list (Glist) bit set to one indicates that the target returns the grown defect list. A Glist bit of zero indicates that the target will not return the grown defect list of defects.

With both Plist and Glist bits set to one, the target will return both the primary and grown defect lists.

With both Plist and Glist bits set to zero the target will return defect list header only.

The defect list format field is used by the initiator to indicate the preferred format for the defect list. A defect list format of “000” (block format), “100” (bytes from index format), and “101” (physical sector format) are supported by the drive. If the requested format is not supported by the drive, it will return the defect list in its default format “101”.

The drive sends defect list (defect descriptors) in a eight byte descriptor format which follows the four byte defect list header.

The target will transfer all of the read defect data up to the number of bytes allocated by the initiator.

Note: The drive will terminate the data in phase when the allocation length has been transferred or when all available defect data has been transferred to the initiator, whichever occurs first.

The read defect data contains a four byte header, followed by zeros or more defect descriptors.

2.9.1 Defect List Header

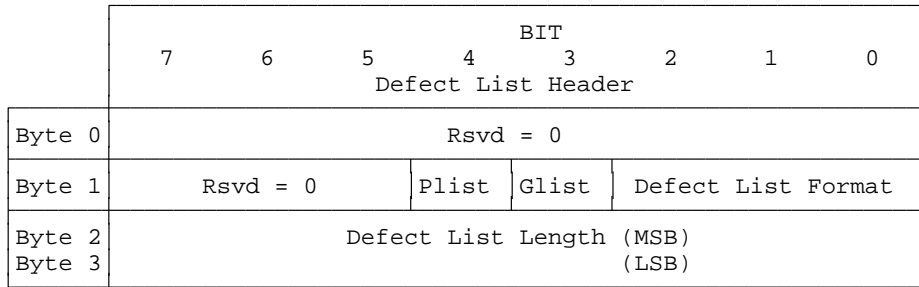


Figure 24. Defect List Header

2.9.2 Block Format (000b)

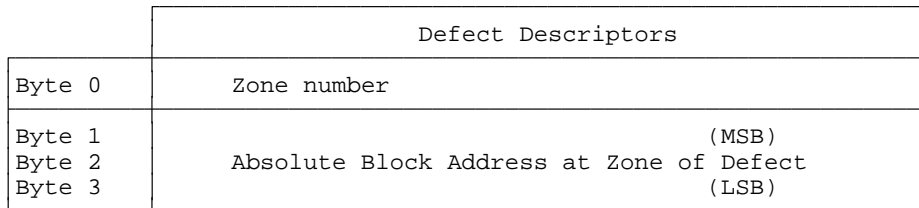


Figure 25. Defect Descriptors of Block Format

2.9.3 Bytes from Index Format (100b)

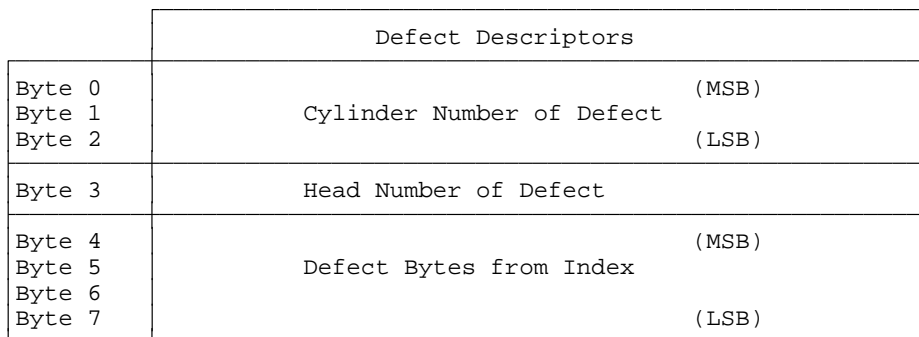


Figure 26. Defect Descriptors of Bytes from Index Format

The defect bytes from index is obtained with the following equation:

$$\text{Bytes from Index} = (\text{Physical Sector Number}) * N$$

Where: N = Bytes per physical sector (581 Bytes)

2.9.4 Physical Sector Format (101b)

Defect Descriptors	
Byte 0	Cylinder Number of Defect (MSB)
Byte 1	
Byte 2	
Byte 3	Head Number of Defect
Byte 4	Defective Sector Number (MSB)
Byte 5	
Byte 6	
Byte 7	
	(LSB)

Figure 27. Defect Descriptors of Physical Sector Format

The defect list format field specifies the format of the defect list data returned by the target. If the requested defect list format and the returned defect list format are not the same, the target will transfer the defect data and then terminate the command with check condition status. The sense key will be set to recovered error (01h) and the additional sense code will be set to defect list error (19h).

The defect list length field specifies the length in bytes of the defect descriptors that follow.

If the allocation length is insufficient to transfer all of the defect descriptors, the defect list length will not be adjusted to reflect the truncation. The target will not create a check condition status.

2.10 Read Extended (28)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Command Code = 28h							
Byte 1	LUN		DPO	FUA	Reserved		RelAdr	
Byte 2	(MSB) Logical Block Address							
Byte 3								
Byte 4								
Byte 5	(LSB)							
Byte 6	RSVD = 0							
Byte 7	(MSB) Transfer Length							
Byte 8	(LSB)							
Byte 9	VU = 0		RSVD = 0			Flag	Link	

Figure 28. Read Extended (28)

The Read Extended command requests the drive to transfer data to the initiator. The transfer length field permits specifying a larger number than that of the Read command.

DPO Disable page out. **Must be set to zero**, indicating that the data accessed by this command may be cached.

FUA Force unit access. **Must be set to zero**, indicating that the data accessed by this command may be transferred from the cache or read from the media.

RelAdr Relative block address. **Must be set to zero**, indicating that the logical block address field specifies the first logical block of the range of logical blocks to be operated on by this command. Relative address is not supported.

Transfer length The number of contiguous blocks to be transferred. If zero is specified, no data is transferred. This is not considered as an error.

2.11 Read Buffer (3C)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Command Code = 3Ch							
Byte 1	LUN			RSVD = 0		Mode		
Byte 2	Buffer ID							
Byte 3	(MSB) Buffer Offset							
Byte 4								
Byte 5	(LSB)							
Byte 6	(MSB) Allocation length							
Byte 7								
Byte 8	(LSB)							
Byte 9	VU = 0		RSVD = 0			Flag		Link

Figure 29. Read Buffer (3C)

The Read Buffer command is used in conjunction with the Write Buffer command as a diagnostic function for testing the drive's memory and the SCSI bus integrity. This command does not alter the medium.

The function of this command and the meaning of fields within the command descriptor block depend on the contents of the mode field.

Mode	Description
000	Read combined header and data
010	Data
011	Descriptor
All others	Not supported.

2.11.1 Combined Header and Data (Mode 000)

In this mode, a four-byte header followed by data bytes are returned to the initiator during the data in phase. The buffer ID and the buffer offset field are reserved.

The drive terminates the data in phase when allocation length bytes of the header, plus, the data, have been transferred or when the header and all available data have been transferred to the initiator, whichever occurs first.

The four-byte read buffer header (See Figure 30 on page 37) is followed by data bytes from the drive's data buffer.

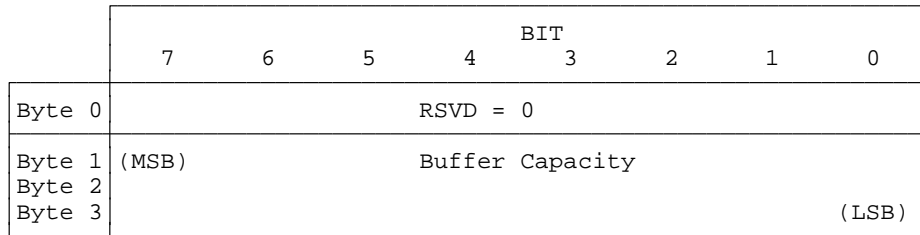


Figure 30. Read Buffer Header

The buffer capacity specifies the total number of data bytes that are available in the drive's data buffer. This number is not reduced to reflect the allocation length nor is it reduced to reflect the actual number of bytes written using the Write Buffer command.

Following the read buffer header, the drive will transfer data from its data buffer.

2.11.2 Read Data (Mode 010b)

In this mode, the data in phase contains buffer data.

- Buffer ID** This field must be set to zero, indicating the data transfer buffer. If other values are specified, the command is terminated with a check condition status. The drive sets the sense key to illegal request and additional sense code to illegal field in CDB.
- Buffer Offset** This specifies the offset of the memory space specified by the buffer ID. The initiator should conform to the offset boundary requirements returned in the read buffer descriptor. If the value exceeds the buffer specified, the command is terminated with a check condition status. The drive sets the sense key to illegal request and additional sense code to illegal field in CDB.
- Allocation Length** The drive terminates the data in phase when allocation length bytes of data have been transferred or when the header and all available data have been transferred to the initiator, whichever occurs first.

2.11.3 Descriptor (Mode 011b)

In this mode, a maximum of four bytes of read buffer descriptor information are returned. The drive returns the descriptor information for the buffer specified by the buffer ID. (See “Read Data” mode for the buffer ID.)

- Buffer ID** If there is no buffer associated with the specified buffer ID, the drive returns all zeros in the read buffer descriptor.
- Buffer Offset** This field is reserved.
- Allocation Length** This must be set to four or greater. The drive transfers the lesser of the allocation length or four bytes of read buffer descriptor. The read buffer descriptor is defined in Figure 31 on page 38.

	7	6	5	4	3	2	1	0
	BIT							
Byte 0	Offset Boundary							
Byte 1 (MSB)	Buffer Capacity							
Byte 2								
Byte 3	(LSB)							

Figure 31. Read Buffer Descriptor

The value contained in the buffer offset field of subsequent Write Buffer and Read Buffer commands should be a multiple of two to the power of the offset boundary. The offset boundary is always set to nine, which indicates sector (512 bytes) boundaries.

2.12 Read Long (3E)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Command Code = 3Eh							
Byte 1	LUN		Reserved			CORT	RelAdr	
Byte 2	(MSB) Logical Block Address (LSB)							
Byte 3								
Byte 4								
Byte 5								
Byte 6	Reserved							
Byte 7	(MSB) Byte Transfer Length (LSB)							
Byte 8								
Byte 9	VU = 0	RSVD = 0			Flag	Link		

Figure 32. Read Long (3E)

The Read Long command requests the drive to transfer **one block** of data to the initiator. The transfer data includes:

- 512 bytes of data
- ECC field data
- **CORT**
 - 0 A corrected bit of zero causes the logical block to be read without any correction made by the drive.
 - 1 Not supported by the drive. (A corrected bit of one causes the data to be corrected by ECC before transferring the data to the initiator.)
- **RelAdr.** Relative block address is not supported by the drive.
- **Logical Block Address** field specifies the logical block at which the read operation will occur.
- **Byte Transfer Length.** This field must exactly specify the number of bytes of data that are available for transfer. If a non-zero byte transfer length does not match the available data length, the target terminates the command with a check condition status, the sense key is set to illegal request and an additional sense code set to invalid field in CDB. The valid and ILI bits are set to one and the information field is set to the difference of the requested length minus the actual length in bytes. Negative values are indicated by two's complement.

2.13 Reassign Blocks (07)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Command Code = 07h							
Byte 1	LUN			RSVD = 0				
Byte 2	RSVD = 0							
Byte 3	RSVD = 0							
Byte 4	RSVD = 0							
Byte 5	VU = 0		RSVD = 0			Flag	Link	

Figure 33. Reassign Blocks (07)

The Reassign Blocks command requests the drive to reassign a logical block to an available spare. The logical block address is transferred to the drive during the data out phase. Only one block may be specified for relocation per each Reassign Blocks command.

Execution of this command does **not** cause movement of data being reassigned.

Reassignment is complete upon the completion of the Reassign Blocks command. At this time, the defective logical block address has been added to the grown (“G” list) defect list.

This command copies the current grown defect list to the drive's reserved area before the list is updated. If the command is interrupted (such as by a power outage) during the update of the grown defect list, the command will automatically put back the current list from the reserved area at the next power on or reset.

Data contained at the logical block address being reassigned is not preserved by the drive.

The Reassign Blocks command attempts to allocate spare blocks on the reserved track for this command.

Following is the format of the data sent by the initiator during the data out phase:

	7	6	5	BIT		2	1	0
Byte 0	RSVD = 0							
Byte 1	RSVD = 0							
Byte 2	(MSB) Defect list length = 4							
Byte 3	(LSB)							
Byte 4	(MSB) Defective							
Byte 5	Logical							
Byte 6	Block							
Byte 7	Address (LSB)							

Figure 34. Format of Reassign Blocks Data

2.14 Release (17)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Command Code = 17h							
Byte 1	LUN		3dPty	3d Party ID			Ext=0	
Byte 2	Reservation Identification = 0							
Byte 3	RSVD = 0							
Byte 4	RSVD = 0							
Byte 5	VU = 0		RSVD = 0			Flag	Link	

Figure 35. Release (17)

The Release command is used to release a LUN previously reserved.

Note: It is not an error for an initiator to release a LUN that is not currently reserved.

- **3dPty** bit indicates that:
 - 1 This release process is for a third party which is specified by 3d Party ID.
 - 0 This release process is for the initiator itself.
- **3d Party ID** specifies the ID of the third party for which the LUN is reserved.⁴
- **Extents** must be 0. Extension is not supported by the drive.
- **Reservation Identification** must be 0. Extension is not supported.
- **Extent List** length must be zero. Extension is not supported.

⁴ See 2.16, “Reserve (16)” on page 44.

2.15 Request Sense (03)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Command Code = 03h							
Byte 1	LUN			RSVD = 0				
Byte 2	RSVD = 0							
Byte 3	RSVD = 0							
Byte 4	Allocation Length							
Byte 5	VU = 0	RSVD = 0			Flag	Link		

Figure 36. Request Sense (03)

The Request Sense command requests the drive to transfer sense data.

The sense data is available for the following conditions:

- The previous command to the specified I_T_L nexus terminated with a check condition status.⁵
- Other information (for example, medium position) is available in any fields.
- The previous command to the specified I_T_L nexus ended with a bus free error.

If a Request Sense command with an invalid LUN is received, the drive returns good status and reports a sense key of illegal request and an additional sense code of logical unit not supported.

If the drive has no sense data available to return, it returns a sense key of no sense and an additional sense code of no additional sense information.

The sense data is preserved by the drive for the initiator until retrieved by the Request Sense command or until any other command for the same I_T_L nexus. Sense data is cleared upon receipt of a subsequent command including Request Sense to the same I_T_L nexus.

Separate sense data is maintained by the device for each initiator. Therefore, there is no requirement for an initiator to expeditiously clear a check condition as this will not affect other initiators in a multi-initiator system.

The drive will return the number of bytes in the allocation length or 32 bytes, whichever is less.

⁵ **I_T_L nexus.** A nexus which exists between an initiator, a target and a logical unit.

2.16 Reserve (16)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Command Code = 16h							
Byte 1	LUN		3rdPty	3rd Party ID			Ext=0	
Byte 2	Reservation Identification = 0							
Byte 3	Extent List = 0							
Byte 4	(LSB)							
Byte 5	VU = 0		RSVD = 0			Flag	Link	

Figure 37. Reserve (16)

The Reserve command is used to reserve a LUN for an initiator. This reservation can be either for:

- The initiator which sends this command.
- The third party which is specified in this command.

This command results in reserving the entire LUN for the initiator until one of the following occurs:

- The reservation is superseded by another valid Reserve command from the initiator that made the reservation.
- The LUN is released by a Release command from the same initiator.
- A hard reset condition occurs. (A SCSI bus reset assertion)
- A bus device reset message is received from any initiator.
- Power off/on occurs.
- The **3rdPty** bit indicates that:
 - 1 This reservation is for a third party which is specified by 3rd Party ID.
 - 0 This reservation is for the initiator itself.
- The **3rd Party ID** specifies the ID of the third party for which the LUN is reserved.

Note: The LUN may be released only by the initiator who sent the Reserve command.
- **Extents** must be 0. Extension is not supported by the drive.
- **Reservation Identification** must be 0. Extension is not supported.
- **Extent List** length must be zero. Extension is not supported.

2.16.1 Command Processing While Reserved

When a reservation for a LUN is made by an initiator for the same or a different initiator (third party option), the following rules apply.

- If the issuing initiator is the one that made the reservation and also the one to receive the reservation then:
 - All commands are permitted.
- If the issuing initiator is neither the one that made the reservation nor the one that receive the reservation then:

- A Request Sense or Inquiry command is permitted.
- A Release command is permitted but is ignored.
- All other commands result in a reservation conflict status.
- If the issuing initiator is the one that made the reservation, but is not the one to receive the reservation then:
 - A Request Sense, Inquiry, Release or Reserve command is permitted.
 - All other commands result in a reservation conflict status.
- If the issuing initiator is not the one that made the reservation, but is the one to receive the reservation then:
 - A Reserve command results in a reservation conflict status.
 - A Release command is permitted but is ignored.
 - All other commands are permitted.

Note: A third party reservation (3rdPty bit equal a one) with the third party ID set to equal the SCSI ID of the initiator that issued the Reserve command is not distinguishable from a Reserve command with the third party bit equal to zero.

2.17 Rezero Unit (01)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Command Code = 01h							
Byte 1	LUN			RSVD = 0				
Byte 2	RSVD = 0							
Byte 3	RSVD = 0							
Byte 4	RSVD = 0							
Byte 5	VU = 0		RSVD = 0			Flag	Link	

Figure 38. Rezero Unit (01)

The Rezero Unit command requests that the target seeks to logical block address 0.

2.18 Seek (0B)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Command Code = 0Bh							
Byte 1	LUN			(MSB) LBA				
Byte 2	Logical Block Address							
Byte 3	Logical Block Address (LSB)							
Byte 4	Reserved							
Byte 5	VU = 0		RSVD = 0			Flag	Link	

Figure 39. Seek (0B)

The Seek command requests the drive to seek to the specified logical block address.

2.19 Seek Extended (2B)

	BIT															
	7	6	5	4	3	2	1	0								
Byte 0	Command Code = 2Bh															
Byte 1	LUN			RSVD = 0				0								
Byte 2	(MSB) Logical Block Address															
Byte 3																
Byte 4																
Byte 5									(LSB)							
Byte 6									RSVD = 0							
Byte 7	RSVD = 0															
Byte 8	RSVD = 0															
Byte 9	VU = 0		RSVD = 0				Flag	Link								

Figure 40. Seek Extended (2B)

The Seek Extended command requests the drive to seek to the specified logical block address.

2.20 Send Diagnostic (1D)

	7	6	5	4	3	2	1	0
Byte 0	Command Code = 1Dh							
Byte 1	LUN			RSVD = 0		SlfTst	DevOf1	UntOf1
Byte 2	RSVD = 0							
Byte 3	Parameter List Length							
Byte 4	(MSB)							(LSB)
Byte 5	VU = 0	RSVD = 0				Flag	Link	

Figure 41. Send Diagnostic (1D)

The Send Diagnostic command requests the drive to perform its self-diagnostic test.

- **SlfTst** must be 1, indicating default self-tests.
- **DevOf1** must be 0, indicating that the diagnostic operations do not affect subsequent commands.
- **UntOf1** must be 0, indicating that the diagnostic operations do not affect subsequent commands.
- **Parameter List Length** must be set to zero.

Upon command completion, the following status is returned:

- Good status for successful test completion.
- Check condition status for unsuccessful test completion.

2.21 Start/Stop Unit (1B)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Command Code = 1Bh							
Byte 1	LUN			RSVD = 0				Immed
Byte 2	RSVD = 0							
Byte 3	RSVD = 0							
Byte 4	RSVD = 0							Start
Byte 5	VU = 0	RSVD = 0				Flag	Link	

Figure 42. Start/Stop Unit (1B)

The Start/Stop Unit command is used to spin up or stop the spindle motor.

- **Immed** bit specifies:

- 0** Status is returned at the end of the operation.
- 1** Good status will always be returned immediately after the command has been received. The Test Unit Ready command can be used to determine when the drive becomes ready after a spin-up.

- **Start** bit specifies:

- 0** Stop the spindle.
- 1** Start the spindle.

Note: Once the drive has become ready (after a power on) the Start/Stop Unit command can be used without any errors, regardless of the state of the motor, stopped or spinning.

2.22 Test Unit Ready (00)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Command Code = 00h							
Byte 1	LUN			RSVD = 0				
Byte 2	RSVD = 0							
Byte 3	RSVD = 0							
Byte 4	RSVD = 0							
Byte 5	VU = 0	RSVD = 0				Flag	Link	

Figure 43. Test Unit Ready (00)

The Test Unit Ready command allows the initiator to check if the drive is ready. The SCSI specification defines ready as the condition where the device will accept a media-access command without returning a check condition status.

The drive will first verify that the motor is spinning at the correct speed:

- If the spindle motor is not spinning at the correct speed, a check condition status is returned with a sense key of not ready.
- If the motor is spinning at the correct speed, the drive accepts normal media access commands.

The Test Unit Ready command is not intended as a diagnostic. No self diagnostic is performed by the device as a result of this command.

The Test Unit Ready command has special significance for power sequencing using the Start Unit command with an immediate bit of 1. In this mode, the Start Unit command returns a command complete status before the completion of motor spin-up and expects the initiator to issue Test Unit Ready commands to determine when the motor has reached the proper speed.

Note: The spindle automatically starts in automatic spin-up mode.⁶ The drive does not execute any commands other than Test Unit Ready, Inquiry, or Request Sense command until the the power on sequence is complete. The drive will return a check condition status with not ready sense key and in process of becoming ready sense code for all other commands during the power on period.

⁶ See 6.5, “Spindle Mode at Powering On” on page 82.

2.23 Verify (2F)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Command Code = 2Fh							
Byte 1	LUN			RSVD = 0			BytChk	0
Byte 2	(MSB) Logical Block Address (LSB)							
Byte 3								
Byte 4								
Byte 5								
Byte 6								
Byte 7	(MSB) Transfer Length (LSB)							
Byte 8								
Byte 9	VU = 0	RSVD = 0				Flag	Link	

Figure 44. Verify (2F)

The Verify command requests that the drive verify the data written on the media. A verification length of zero indicates that no data will be transferred. This condition is not considered an error.

- **BytChk** indicates:

- 0 The verification is performed by ECC check. No data transfer from the initiator is performed. If an ECC error is detected, a check condition status is returned with sense key set to medium error.
- 1 Byte-by-byte comparison is not supported.

2.24 Write (0A)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Command Code = 0Ah							
Byte 1	LUN			(MSB) LBA				
Byte 2	Logical Block Address							
Byte 3	Logical Block Address (LSB)							
Byte 4	Transfer Length							
Byte 5	VU = 0		RSVD = 0			Flag	Link	

Figure 45. Write (0A)

The Write command requests the drive to write the specified number of blocks of data from the initiator to the medium starting at the specified logical block address.

See 2.7, “Read (08)” on page 29 for the parameters.

2.25 Write Extended (2A)

	7	6	5	4	3	2	1	0
Byte 0	Command Code = 2Ah							
Byte 1	LUN		DPO	FUA	RSVD	0		
Byte 2	(MSB) Logical Block Address							
Byte 3								
Byte 4								
Byte 5	(LSB)							
Byte 6	RSVD = 0							
Byte 7	(MSB) Transfer Length							
Byte 8	(LSB)							
Byte 9	VU = 0	RSVD = 0			Flag	Link		

Figure 46. Write Extended (2A)

The Write Extended command requests that the drive writes the data transferred from the initiator. This command is processed like the standard Write command except that the transfer length is longer.

A transfer length of zero indicates that no data will be transferred. This condition is not considered an error.

DPO Disable page out. **Must be set to zero**, indicating that the data accessed by this command may be cached.

FUA Force unit access. **Must be set to zero**, indicating that the data accessed by this command may be transferred from the cache or read from the media.

2.26 Write and Verify (2E)

	7	6	5	4	3	2	1	0
Byte 0	Command Code = 2Eh							
Byte 1	LUN			RSVD = 0			BytChk	0
Byte 2	(MSB) Logical Block Address							
Byte 3								
Byte 4								
Byte 5	(LSB)							
Byte 6	RSVD = 0							
Byte 7	(MSB) Transfer Length							
Byte 8	(LSB)							
Byte 9	VU = 0		RSVD = 0				Flag	Link

Figure 47. Write and Verify (2E)

Write and Verify command requests that the drive writes the data transferred from the initiator to the medium and verifies that the data is correctly written.

- **ByteChk** the options:

ByteChk	Description
----------------	--------------------

- | | |
|----------|--|
| 0 | The data is read back from the disk and verified using ECC after the successful write operation. If an ECC error is detected in the verify process, a check condition status is returned with sense key set to medium error. |
| 1 | Not supported by the drive. |

2.27 Write Buffer (3B)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Command Code = 3Bh							
Byte 1	LUN			RSVD = 0		Mode		
Byte 2	Buffer ID							
Byte 3	(MSB) Buffer Offset							
Byte 4								
Byte 5	(LSB)							
Byte 6	(MSB) Parameter list length							
Byte 7								
Byte 8	(LSB)							
Byte 9	VU = 0		RSVD = 0			Flag		Link

Figure 48. Write Buffer (3B)

The Write Buffer command is used in conjunction with the Read Buffer command as a diagnostic function for testing the drive's memory and the integrity of the SCSI bus. This command does not alter the medium of the drive. Additional modes are provided for downloading microcode and for downloading and saving microcode.

The function of this command and the meaning of fields within the command descriptor block depend on the contents of the mode field.

Mode Description

000 Write combined header and data

010 Data

100 Download Microcode

101 Download Microcode and Save

--- All other modes are not supported by the drive.

2.27.1 Combined Header and Data (Mode 000b)

In this mode, the data to be transferred is preceded by a four-byte header.

Buffer ID

This field must be zero. If another values are specified, download functions are not performed and the command is terminated with a check condition status. The file sets the sense key to illegal request and additional sense code to illegal field in CDB.

Buffer Offset

This field must be zero. If another value is specified, download functions are not performed and the command is terminated with a check condition status. The file sets the sense key to illegal request and additional sense code to illegal field in CDB.

Parameter List Length This field specifies the number of bytes that are transferred during the data out phase. This number **includes** four bytes of that header; the data length stored in the drive's buffer is the transfer length minus four. If the length exceeds the buffer size, the command is terminated with a check condition status. The file sets the sense key to illegal request and additional sense code to illegal field in CDB.

The four-byte header consists of all reserved bytes.

	7	6	5	4	3	2	1	0
Byte 0	RSVD = 0							
Byte 1	RSVD = 0							
Byte 2	RSVD = 0							
Byte 3	RSVD = 0							

Figure 49. Write Buffer Header

2.27.2 Write Data (Mode 010b)

In this mode, the data out phase contains buffer data.

Buffer ID This field must be set to zero, indicating the data transfer buffer. If other values are specified, the command is terminated with a check condition status. The file sets the sense key to illegal request and additional sense code to illegal field in CDB.

Buffer Offset This specifies the offset of the memory space specified by the buffer ID. The initiator should conform to the offset boundary requirements returned in the read buffer descriptor. If the value exceeds the buffer specified, the command is terminated with a check condition status. The file sets the sense key to illegal request and additional sense code to illegal field in CDB.

Parameter List Length This field specifies the parameter list length. It must be:

- Less than the capacity of the buffer size.
- On a sector boundary. That is a multiple of 512.

If an invalid value is specified, the command is terminated with a check condition status. The file sets the sense key to illegal request and additional sense code to illegal field in CDB.

2.27.3 Download Microcode (Mode 100b)

In this mode, vendor-unique microcode is transferred to the control memory space of the drive. After a power on reset, the drive operates with the newly downloaded condition.

Buffer ID This field must be X'01'. If other value are specified, no download function is performed and the command is terminated with a check condition status. The file sets the sense key to illegal request and additional sense code to illegal field in CDB.

Buffer Offset	This specifies the starting address of the downloaded microcode. It must be less than the code area in size, and be on a sector boundary (multiple of 512 byte). If an invalid value is specified, the command is terminated with a check condition status. The file sets the sense key to illegal request and additional sense code to illegal field in CDB.
Transfer Length	The total microcode length must be specified. It must be less than the code area in size, and be on a sector boundary (multiple of 512 byte). If an invalid value is specified, the command is terminated with a check condition status. File shall set sense key to illegal request and additional sense code to illegal field in CDB.

Note: This process generates a unit attention condition for “Microcode Has Been Changed”.

2.27.4 Download Microcode and Save (Mode 101b)

In this mode, vendor-unique microcode is transferred to the drive and saved in the system reserved area on the disk. The downloaded code becomes effective after a power on reset, until it is supplanted in another download microcode and save option.

See 2.27.3, “Download Microcode (Mode 100b)” on page 57 for the parameters.

Note: This process generates a unit attention condition for “Microcode Has Been Changed”.

2.28 Write Long (3F)

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Command Code = 3Fh							
Byte 1	LUN			Reserved			RelAd	
Byte 2	(MSB) Logical Block Address (LSB)							
Byte 3								
Byte 4								
Byte 5								
Byte 6	Reserved							
Byte 7	(MSB) Byte Transfer Length (LSB)							
Byte 8								
Byte 9	VU = 0	RSVD = 0			Flag	Link		

Figure 50. Write Long (3F)

The Write Long command requests the drive to write **one block** of data that is transferred from the initiator. The transfer data must include:

- 512 bytes of data
- 18 bytes of ECC data

Parameters are:

- **RelAd** (Relative Block Address). This is not supported by the drive.
- **Logical Block Address** field specifies the logical block at which the read operation occurs.
- **Byte Transfer Length**. This field must exactly specify the number of bytes of data that are available for transfer. If a non-zero byte transfer length does not match the available data length, the target terminates the command with a check condition status, the sense key is set to illegal request and an additional sense code set to invalid field in CDB. The valid and ILI bits are set to one and the information field is set to the difference of the requested length minus the actual length in bytes. Negative values are indicated by two's complement.

3.0 SCSI Status Byte

Upon the completion of a command, a status byte is sent to the initiator. Additional sense information may also be available depending on the contents of the status byte. The following section describes the possible values for the status byte and sense data.

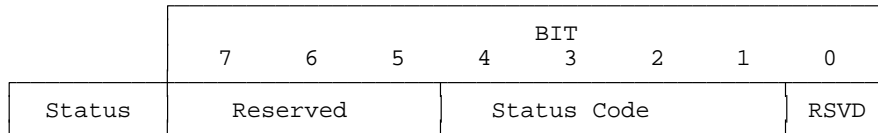


Figure 51. SCSI Status Byte. Format of the SCSI Status byte. The reserved (R) and vendor unique (VU) fields is set to zero.

Status Byte	Description
00h	Good The command has been successfully completed.
02h	Check Condition An error, exception, or abnormal condition has been detected. The sense data is set by the drive. The Request Sense command should be issued to determine the nature of the condition.
08h	Busy This condition is returned when disconnect privilege is not granted while the drive is busy processing another command for the other initiator. The normal initiator recovery action is to issue the command at a later time, or reissue the command and grant the disconnect privilege.
10h	Intermediate This status is returned for every command in a series of linked commands (except the last command), unless an error, exception, or abnormal condition causes a check condition status or a reservation conflict status to be set. If this status is not returned, the chain of linked commands is broken, and no further commands in the series are executed.
18h	Reservation Conflict This status is returned whenever an SCSI device attempts to access the drive, but it has been reserved by another initiator. (See 2.16, "Reserve (16)" on page 44.)

4.0 SCSI Sense Data

4.1 SCSI Sense Data Format

Format of the sense data returned by the drive in response to the Request Sense command.

	BIT							
	7	6	5	4	3	2	1	0
Byte 0	Valid	Error Code (70h or 71h)						
Byte 1	RSVD = 0							
Byte 2	0	ILI	0	Sense Key				
Byte 3	(MSB) Information Bytes							
Byte 4								
Byte 5								
Byte 6								
Byte 7	Additional Sense Length							
Byte 8	(MSB) Command Specific Information							
Byte 9								
Byte 10								
Byte 11								
Byte 12	Additional Sense Code							
Byte 13	Additional Sense Code Qualifier							
Byte 14	FRU = 0							
Byte 15	SKSV	Sense-Key Specific Bits						
Byte 16	Sense-Key Specific Bytes							
Byte 17								
Byte 18 -31	Vender Unique							

Figure 52. Format of Sense Data. Format of the Sense Data returned by the drive in response to the Request Sense command

4.1.1 Sense Data Description

4.1.1.1 Valid Bit

Bit 7 of byte 0.

- 0** The information bytes are not defined.
- 1** The information bytes contain a valid logical block address.

4.1.1.2 Error Code

Bit 6– 0 of byte 0.

- 70h** Current error. This indicates an error occurred for the current command.
- 71h** Deferred error. This indicates that the error is for a previous command that already returned a good status. Such commands are associated with the immediate bit, or command buffering. Format Unit command is an example of a command that may return a deferred error.

4.1.1.3 Sense Key

Bit 3– 0 of byte 2.

The sense key provides generic categories in which error and exception conditions can be reported. Initiators would typically use sense keys for high level error recovery procedures.

- 0** No Sense
There is no sense key information to be reported for the logical unit.
- 1** Recovered Error
The last command completed successfully with some recovery action performed by the drive. More detailed information is available in the additional sense code.
- 2** Not Ready
The logical unit addressed cannot be addressed. More detailed information is available in the additional sense code.
- 3** Medium Error
The command terminated with an irrecoverable error condition caused by a flaw in the media or an error in the recorded data. More detailed information is contained in the additional sense code.
- 4** Hardware Error
The drive detected an irrecoverable hardware error while performing a command or during a diagnostic test. More detailed information is contained in the additional sense code.
- 5** Illegal Request
There was an illegal parameter in the command descriptor block or additional parameter supplied as data. If an invalid parameter is found in the CDB, the command is terminated without altering the medium. If an invalid parameter is found in parameters supplied as data, the drive might have altered the medium.
- 6** Unit Attention
Indicates that the drive entered in the unit attention condition. (See 6.3, “Unit Attention Condition” on page 81.)
- 7-A** Not used.
- B** Aborted Command
The drive aborted the command.
- C-D** Not Implemented
- E** Miscompare
Not used.
- F** Reserved.

4.1.1.4 Information Bytes

Byte 3– 6

This field is only valid when the Valid bit is a one, and contains the unsigned LBA associated with the sense key.

4.1.1.5 additional Sense Length

Byte 7.

Indicates the remaining number of bytes in the sense data. (It is set to 18h in the drive.)

4.1.1.6 Command Specific Information

Byte 8– 11.

Not Used.

4.1.1.7 Additional Sense Code/Qualifier

Byte 12 and 13.

12	13	Description
00	00	No additional sense information
01	00	No index or sector
02	00	No seek complete
03	00	Write fault
04	00	Drive not ready. Cause not reportable.
04	01	Drive not ready. In process of becoming ready.
04	02	Drive not ready. Initializing command required. (Start Motor)
04	04	Format in progress
08	00	Communication failure
08	01	Communication time out
08	02	Communication parity error
09	00	Track following error
10	00	ID CRC error
11	00	Unrecovered read error
14	01	Record not found
15	00	Seek positioning error
15	02	Data synchronization mark error
17	00	Recovered read data without ECC applied
18	00	Recovered read data with ECC applied
19	00	Defect list error A defect list error occurs when a data error is detected while reading the manufacturing defect list or while reading or writing the grown defect list.
19	01	Defect list not available

- 1A 00** Parameter list length error
The number of parameters supplied is not equal to the value the command allows.
- 1B 00** Synchronous data transfer error
- 1C 00** Defect list not found
- 1D 00** Miscompare during verify operation
- 20 00** Invalid command operation code
This code is also returned when an unsupported command code is received.
- 21 00** Logical block address out of range
- 24 00** Invalid field in CDB
- 25 00** Unsupported LUN
The drive supports LUN 0 only.
- 26 00** Invalid field in the parameter list
- 26 01** Parameter not supported
- 26 02** Parameter value invalid
- 29 00** Power on reset or bus device reset occurred
- 2A 00** Mode select parameters changed
- 31 00** Medium format corrupted
A format operation was interrupted (power down, reset) prior to completion of a Format Unit command. The Format Unit command should be re-issued and must complete successfully for this error condition to be removed.
- 31 01** Format command failed
- 32 00** No defect spare location available
A no defect spare location available sense code indicates that the Reassign Block command can not proceed the process because all available spare sectors have been used, or it will exceed implementation limitation of defect handling of the drive.⁷
- 3D 00** Invalid bits in identify message
- 3F 01** Microcode has been changed
- 40 80** Diagnostic failure on RAM
- 42 00** Power on or diagnostics error
- 43 00** Message reject error
A message reject error occurs when an inappropriate or unexpected message reject is received from the initiator or the initiator rejects a message twice.
- 44 00** Internal controller error
An internal controller error occurs when the control microprocessor detects incorrect status or receives an illegal request from the device electronics.
- 45 00** Select/re-select failed
A select/re-select error occurs when the initiator fails to respond to a re-selection within 250 milliseconds after the drive gains bus arbitration. The re-selection is attempted a second time before setting select/re-select failed status.

⁷ Refer to 6.10, “Media Defect Strategy” on page 84.

- 47 00** SCSI parity error
- 48 00** Initiator detected error message received
An initiator detected error occurs when the initiator detects an error, sends a message to retry, detects the error again, and sends the retry message a second time. The drive then sets check condition status with Initiator Detected Status.
- 49 00** Inappropriate/illegal message
An inappropriate or illegal message occurs when the initiator sent a message that either is not supported or is not in a logical sequence.
- 4A 00** Command phase error
- 4B 00** Data phase error
- 4C 00** LUN failed self-configuration
- 4E 00** Overlapped commands attempted
- 80 01** Time out hang during read/write
- 80 0F** Bank RAM code error
- 81 00** Overlay read fail
- 81 01** Invalid overlay version
- 81 02** Improper overlay sector
- 81 0F** Invalid overlay requested

4.1.1.8 FRU (Field Replaceable Unit)

Byte 14.

The FRU (Field Replaceable Unit) field value will always be zero.

4.1.1.9 Sense Key Specific

Byte 15– 17

The definition of this field is determined by the value of the sense key field.

4.1.1.9.1 Illegal Request Case: Error driven pointer is returned.

	BIT							
	7	6	5	4	3	2	1	0
Byte 15	SKSV	C/D	Reserved	BPV	Bit Pointer			
Byte 16 Byte 17	(MSB)		Field Pointer				(LSB)	

Figure 53. Field Pointer Bytes

- SKSV** Sense-key specific valid
- C/D** Command/Data
 - 0 Indicates that an illegal parameter is in the data parameters sent by the initiator during data out phase.
 - 1 Indicates that an illegal parameter in the command descriptor block.

4.2 Priority of Error Reporting

Multiple errors can occur during the execution of a command. Since only one error is reported in the sense data, a priority scheme for determining which error to report is used. Following are the rules for reporting sense data:

4.2.1 Hard Errors

- An unrecovered (hard) error will always be reported in place of any soft error that may have occurred during the same operation.
- If multiple hard error conditions exist, the first hard error detected will be reported.

4.2.2 Soft Errors

- When PER=0, recovered data and non-data errors are not reported.
- When PER=1, the last recovered data or non-data error is reported, unless an unrecovered error occurs. In this case, the unrecovered error will be reported.

5.0 SCSI Message Set

5.1 Supported Messages

The messages supported by the drive are shown in Figure 56.

Message	CODE (hex)	Direction	Negate ATN Before last ACK
Command Complete	00	In	—
Synchronous Data Transfer Request	010301	In Out	Yes
Save Data Pointer	02	In	—
Restore Pointers	03	In	—
Disconnect	04	In	—
Disconnect	04	Out	Yes
Initiator Detected Error	05	Out	Yes
Abort	06	Out	Yes
Message Reject	07	In Out	Yes
No Operation	08	Out	Yes
Message Parity Error	09	Out	Yes
Linked Command Complete	0A	In	—
Linked Command Complete (w/Flag)	0B	In	—
Bus Device Reset	0C	Out	Yes
Identify	80–FF	In	—
Identify	80–FF	Out	No

Key: In = Target to initiator, Out = Initiator to target.
 Yes = Initiator negates ATN before last ACK of message.
 No = Initiator may or may not negate ACK before last ACK of message.
 — = Not applicable

Figure 56. Supported Messages

If an unsupported message is received, the drive will send the *Message Reject* message to the initiator.

5.1.1 Command Complete (00)

The drive sends this message to the initiator to indicate that the execution of a command has terminated and that valid status has been sent to the initiator. After successfully sending this message, the drive releases all bus signals and goes to bus free phase.

5.1.1.1 Synchronous Data Transfer Request (01,03,01H)

Byte	Value	Description
0	01H	Extended message
1	03H	Extended message length
2	01H	Synchronous Data Transfer Request code
3	TP	Transfer period (TP times 4 nanoseconds)
4	xH	REQ/ACK offset

Figure 57. Synchronous Data Transfer Request

A pair of Synchronous Data Transfer Request (SDTR) messages, as shown in Figure 57, are exchanged between an initiator and a target to establish the synchronous data transfer mode between the two devices. The message exchange establishes the permissible transfer period and REQ/ACK offset for a synchronous data transfer between the two devices. The initiator may initiate a synchronous data transfer negotiation at any time after the LUN has been identified. The drive initiates a synchronous transfer negotiation. A Synchronous Data Transfer Request message exchange is initiated by a SCSI device whenever a previously arranged data transfer agreement has become invalid. *The agreement becomes invalid after any condition which may leave the data transfer agreement in an indeterminate state such as:*

- After a hard reset condition.
- After a Bus Device Reset message.
- After a power on cycle.

TP The transfer period is the minimum time allowed between leading edges of successive REQ pulses and of successive ACK pulses to meet the device requirements for successful reception of data. The drive supports 55 or higher, which implies a minimum transfer period of 220 nsec. The data transfer rate at this rate is 4.5 MB/sec.

REQ/ACK Offset

The ACK/REQ offset is the maximum number of REQ pulses allowed to be outstanding before the leading edge of its corresponding ACK pulses is received at the drive. A REQ/ACK offset value of zero indicate asynchronous data transfer mode. The drive supports up to seven offsets.

If ATN is negated before all bytes of a multiple-byte extended message are received, the drive goes to **Bus Free** to signal an irrecoverable error.

5.1.2 Save Data Pointer (02)

This message is sent from the drive to direct the initiator to copy the active data pointer to the saved data pointer. The Save Data Pointer message is only sent if the initiator has previously indicated the ability to accommodate disconnection and reconnection via the Identify message.

The drive sends the Save Data Pointer message to the initiator prior to sending a Disconnect message to the initiator if a data phase has occurred and another data phase is required to successfully complete the command.

5.1.3 Restore Pointers (03)

This message is sent from the drive to direct an initiator to copy the most recently saved pointers to the corresponding command, data, and status pointers. Command and status pointers should be restored to the beginning of the present command and status areas. The data pointer should be restored to the value at the beginning of the data area in the absence of a Save Data Pointer message or to the value at the point at which the last Save Data Pointer message occurred. See 6.2, “SCSI Bus Related Error Handling Protocol” on page 78.

5.1.4 Disconnect (04)

This message is sent from the drive to inform an initiator that the present connection is going to be broken. A later reconnect will be required in order to complete the current command. The disconnection is to free the SCSI bus while the drive performs a relatively long operation that does not require the bus. These messages are only sent if the initiator previously indicated (via the Identify message) the ability to accommodate disconnection and reconnection.

The Disconnect message may also be sent from the initiator to the drive to disconnect from the SCSI bus. If the file supports disconnecting at the time the Disconnect message is received from the initiator, the drive

switches to the message in phase, send a Disconnect message to the initiator (possibly preceded by a Save Data Pointer message), and then goes to the bus free phase. The drive will not participate in another arbitration phase for at least a disconnection delay. If the drive does not support disconnecting at the time the Disconnect message is received from the initiator, the drive responds by sending a Message Reject message to the initiator.

5.1.5 Initiator Detected Error (05)

This message is sent from an initiator to inform the drive that an error has been detected that does not preclude the drive from retrying the previous command, data and status phase. The source of the error may be either related to previous activities on the SCSI bus or may be internal to the initiator and unrelated to any previous SCSI bus activity.

If the initiator intends to send this message, the initiator must assert the ATN signal prior to its release of ACK for the last byte transferred in the information phase that is to be retried. This provides an interlock so the drive can determine which information phase to retry.

After receiving this message, the drive may retry the previous phase by sending a Restore Pointers message to the initiator and then repeating the previous command, data, or status phase.

5.1.6 Abort (06)

This message is sent from the initiator to direct the drive to clear the present operation for this initiator and logical unit, including queued commands. If a logical unit has been identified, all pending data and status for the issuing initiator and this logical unit is cleared and the drive goes to the bus free phase. Pending data and status for other logical unit and initiators are not cleared. If a logical unit has not been identified, the drive goes to the bus free phase without affecting an operation on any logical unit for this initiator or any other initiator. In either case, no status or ending message will be sent to the initiator for this operation. It is not an error to send the Abort message to a logical unit that is not currently performing an operation for the initiator.

Note: It is permissible for an initiator to select the drive/LUN after the drive has disconnected from the initiator, for the purpose of sending an Identify message followed by an Abort message. This will abort the command on the specified logical unit.

5.1.7 Message Reject (07)

This message is sent from either the initiator or the drive to indicate that the last message received was inappropriate or has not been implemented.

If the initiator intends to send this message, the initiator must assert the ATN signal prior to its release of ACK for the REQ/ACK handshake of the message byte that is to be rejected. This provides an interlock so the drive can determine which message was rejected.

If the drive intends to send this message, the file changes to the message in phase and sends the Message Reject message to the initiator prior to transferring any additional message bytes (or any other information phase bytes) from the initiator regardless of ATN signal. This provides an interlock so the initiator can determine which message was rejected. After the drive sends a Message Reject message and if ATN signal is still asserted, it returns to the message out phase. The subsequent message out phase begins with first byte of a message.

5.1.8 No Operation (08)

This message is sent from the initiator to the drive when the initiator does not currently have any other valid message to send. This message is ignored by the drive and does not affect any operation.

5.1.9 Message Parity Error (09)

This message is sent from the initiator to inform the drive that the last message byte received had a parity error.

If the initiator intends to send this message, the initiator must assert the ATN signal prior to its release of ACK for the REQ/ACK handshake of the message byte that has the parity error. This provides an interlock so the drive can determine which message byte has the parity error.

If the drive receives this message under any other circumstance, the drive changes to bus free to signal an irrecoverable error. After receiving this message, the drive retries sending of the previous message to the initiator.

5.1.10 Linked Command Complete (0A)

The drive sends this message to the initiator to indicate that execution of a linked command (with flag bit equal to zero) has completed and that valid status has been sent to the initiator. After successfully sending this message, the drive goes to command phase to receive the next command.

5.1.11 Linked Command Complete with Flag (0B)

The drive sends this message to the initiator to indicate that the execution of a linked command with flag bit set to one has completed and that valid status has been sent to the initiator. After successfully sending this message, the drive goes to command phase to receive the next command.

5.1.12 Bus Device Reset (0C)

This message is sent from an initiator to direct the drive to clear all current commands. This message forces a hard reset condition which resets the drive to an initial state with no operations pending for any initiator. After receiving this message, the drive goes to the bus free phase.

5.1.13 Identify (80 - FF)

This message is set by either the initiator or the drive to establish a logical path connection between the two devices.

The Identify message is defined as follows:

- Bit 7** This bit is always set to one to distinguish the Identify message from other messages.
- Bit 6** This bit is only set to one by the initiator to grant the drive the privilege of disconnecting. If this bit is zero, the drive will not disconnect, unless the initiator instructs the drive to disconnect by sending a Disconnect message to the drive. This bit is set to zero when the drive sends an Identify message to the initiator.

Bits 5-3 These bits are reserved and must be zero for an Identify message.

Note: If an invalid Identify message is received with these bits not equal to zero, the drive sends a Message Reject message to the initiator and goes to the bus free phase with sense key set to illegal request and additional sense code set to invalid bits in identify message.

Bits 2-0 These bits specify the logical unit number (LUN).

Only one LUN can be identified for any one selection sequence. If the drive receives an Identify message with a new LUN after the LUN had previously been identified, the drive goes to the bus free phase to signal an irrecoverable error. The initiator may send more than one Identify message during a selection sequence in order to toggle disconnect/reconnect permission if the specified LUN remains the same.

When the Identify message is sent from the drive to the initiator during reconnection, an implied Restore Pointers message must be performed by the initiator.

6.0 SCSI System Implementation Information

The protocol in the drive is fully compliant with the ANSI SCSI architecture. Special note is made for the specific SCSI items that are not implemented by this SCSI drive.

The implementation of the supported messages will also include the following functions.

- Retry SCSI command, data in, data out, or status phase
The retry is caused by the following error condition.
 - The drive receives Initiator Detected Error message during or at the conclusion of an information transfer phase (command, data in, data out, or status phase)
Note: The initiator may send the Initiator Detected Error message as a result of an initiator detected SCSI Bus parity error or an internal error.
- Retry message in phase
 - The retry is caused by the receipt of a Message Parity Error message immediately following a message in phase.
Note: The initiator may send the Message Parity Error message as a result of an initiator detected SCSI bus parity error during the message in phase.
- Receipt of multiple Identify message
 - The initiator is allowed to send a multiple Identify message out in order to toggle the disconnect/reconnect permission bit. This may be used to selectively enable or disable disconnect/reconnect permission during portion of a command. Note that this function does not affect the operation of the Forced Disconnect function.
- Message reject during target disconnection
 - If the initiator rejects the Save Data Pointer message, the drive disables disconnect/reconnect permission. This is equivalent to receiving an Identify message with bit 6 equal to zero. This causes the drive to inhibit the pending disconnection.
 - If the initiator rejects the Disconnect message, the drive will not disconnect but may attempt to disconnect at a later time. This function may be used to selectively disable disconnection during portions of a command.

6.1 Attention Condition

The attention condition allows an initiator to inform the drive that a message out phase is desired. The initiator may create the attention condition by asserting the ATN signal at any time except during the arbitration or bus free phases.

The initiator must create the attention condition by asserting the ATN signal least two deskew delays before releasing ACK for the last byte transferred in a bus phase to guarantee that the attention condition will be honored before transition to a new bus phase. This will guarantee a predictable drive response to message received during the message out phase for this attention condition. If the ATN signal is asserted later, it might be honored in the current bus phase or the next bus phase and may not result in the expected action.

After the initiator asserts the ATN signal, the drive responds with the message out phase as follows:

Current Phase	Response
Command	Message out phase occurs after part or all of the command descriptor block has been transferred to the drive. The initiator must continue REQ/ACK handshakes during the command phase until the drive enters the message out phase.
Data	The message out phase occurs after part or all of the data bytes have been transferred and not necessarily on a logical block boundary. The initiator must continue REQ/ACK handshakes (asynchronous transfer) until it detects the phase change. Note: In synchronous transfer, the initiator must continue sending ACK pulses to reach an offset of zero.
Status	The message out phase occurs after the REQ/ACK handshake of the status byte has been completed.
Message In	The message out phase occurs before the drive sends another message.
Selection	If ATN occurs during a selection phase and before the initiator releases the BSY signal, the message out phase occurs immediately after that selection phase.
Re-selection	The message out phase occurs after the drive has sent its Identify message for that re-selection phase. (First, the drive tries to complete the re-selection.)

The initiator must keep the ATN signal asserted if more than one message byte is to be transferred during the message out phase. The drive processes each message byte (multiple-bytes for an extended message) prior to receiving the next message from the initiator. The drive continues to handshake and process bytes in the message out phase until ATN goes false unless one of the following condition occurs:

1. The drive receives an illegal or inappropriate message and goes to the message in phase to send a Message Reject message.
2. The drive detects an irrecoverable error condition and goes to the bus free phase.

6.2 SCSI Bus Related Error Handling Protocol

6.2.1 Unexpected Bus Free Phase Error Condition

There are several error conditions that will cause the drive to immediately change to the bus free phase, regardless of the state of the ATN signal. The drive will not attempt to reconnect to the initiator to complete the operation that was in progress when the error condition was detected. The initiator should interpret this as an irrecoverable error condition.

If the LUN was identified by the drive prior to the error condition, the drive aborts the active command for this initiator/LUN and generates sense data for this initiator/LUN to describe the cause of the irrecoverable error. The initiator may retrieve this sense data by issuing a Request Sense command to this LUN. Note however, that the Request Sense command may fail if the irrecoverable error condition persists.

If the LUN was not identified by the drive prior to the error condition, the drive does not affect the sense data or the operation of any currently executing command for this initiator or any other initiator.

6.2.2 Message Out Phase Parity Error

If the drive detects a parity error during the message out phase, the drive retries the message out phase one time as follows:

1. Continue the REQ/ACK handshakes until the initiator drops ATN. The drive ignores all the remaining message out phase bytes received after the parity error.
2. Assert the REQ signal prior to changing to any other phase. After detecting this condition, the initiator must resend all of the previous message bytes sent during this message out phase.
3. Repeat the transfer of the message out phase bytes. If the drive receives all of the message bytes successfully, the drive changes to:
 - Any other information transfer phase and transfer at least one byte.
 - Bus free phase if the message received was Abort or Bus Device Reset.

If a second parity error is detected, the target aborts the current command with a check condition status and sense data of aborted command / SCSI parity error.

6.2.3 Message In Phase Parity Error (Message Parity Error)

If the drive receives a Message Parity Error message, it is considered a retrievable error. The drive will do the following one time if there was no previous retrievable error and if a message in phase has just occurred:

1. Change phase to message in.
2. Send the last message again.

If this is the second retrievable error, the drive terminates the current command as follows:

1. Change to the bus free phase, regardless of the state of the ATN signal.
2. Abort the active command for this initiator/LUN and set the sense data to aborted command / SCSI parity error.

6.2.4 Command Phase Parity Error

1. Change phase to message in and send a Restore Pointers message.
2. If the Restore Pointers message is accepted, the phase is changed to command out and the command is received again.

If a second parity error is detected, the target aborts the current command with a check condition status and sense data of aborted command / SCSI parity error .

6.2.5 Data Out Phase Parity Error

If the drive detects a parity error during the data out phase, it will do the following one time:

1. Change the phase to message in and send a Restore Pointers message.
2. If Restore Pointers message is accepted, the phase is changed to data out and the data is received again.

6.2.6 Initiator Detected Error Message

An Initiator Detected Error message is valid after a command, data in/out or status phase has occurred. If the other phase has occurred, the message is rejected.

The recovery consists of:

1. Change phase to message in and send a Restore Pointers message.

2. Repeat previous information phase.

If a second Initiator Detected Error message is received in the same selection, the target will abort the current command with check condition status and a sense key of aborted command with additional sense code of initiator detected error.

6.2.7 Message Reject Message

The drive takes the following actions after receiving the Message Reject message in response to the messages listed below.

Disconnect	The drive will not disconnect but remains connected.
Command Complete	No error, continue to bus free.
Identify	Command aborted - bus freed - sense data set to message reject error.
Linked CMD CMPLT	Command aborted - link broken - bus freed - sense data set to message reject error.
Message Reject	Command aborted - status phase executed with a check condition - sense data set to message reject error.
Restore Pointers	Command aborted - status set to check condition - sense will be set with the error that caused the Restore Pointers message to be issued. (Assuming that error recovery is in progress).
Save Data Pointer	The drive will not disconnect from the SCSI bus. It will not be considered an error.
No previous Msg	The command is aborted, the bus freed, and sense data is set to message reject error. This occurs when the drive has not sent a message, but gets a message reject from the initiator.

6.2.8 Invalid LUN in Identify Message

There are three different circumstances defined within the SCSI protocol when the response to an invalid LUN will occur. Each of these result in a different response.

6.2.8.1 Case 1 - Selection message sequence with Inquiry command

The Inquiry command is a special case in SCSI. It is used to configure the bus when drive IDs and LUNs are not known. The proper response is to return the inquiry data with a peripheral drive type of 1Fh which indicates that the specified LUN is not supported.

6.2.8.2 Case 2 - Selection message sequence with any other command

Any other command, except Request Sense, returns a check condition status when an invalid LUN is specified in the message sequence following selection. In response to a Request Sense command the target returns sense data. The sense key is set to illegal request and the additional sense code is set to logical unit not supported.

6.2.8.3 Case 3 - After selection message sequence

It is permissible for the initiator to issue multiple Identify messages during a single command sequence provided the LUN remains the same. If the LUN is altered, the drive goes to the bus free phase.

6.2.9 Re-selection Timeout

When the drive attempts to re-select the initiator and the initiator does not respond within a selection timeout delay, the drive continues asserting the SEL and I/O signals and releases all data bus signals. If the drive has not detected the BSY signal to be true after at least a selection abort time plus two deskew delays, the drive releases SEL and I/O signals allowing the SCSI bus go to the bus free phase. The initiator that respond to the re-selection phase ensures that re-selection is still valid within a selection abort time of assertion of the BSY signal. The drive retries this process after 250 ms from the drive goes to bus free phase.

6.3 Unit Attention Condition

The drive generates a unit attention condition for each initiator whenever:

- The drive has been reset. This includes power on reset, SCSI bus reset, and SCSI bus device reset message.
- The mode parameters in effect for this initiator has been changed by another initiator.
- The microcode has been changed.

The Write Buffer command has been executed to download microcode.

In this case, a unit attention condition is generated for all initiators except the one that issued the command.

The unit attention condition persists for each initiator until that initiator clears the condition as described in the following paragraphs.

If the drive receives a command from each initiator before reporting a check condition status for a pending unit attention condition for that initiator, the drive's response varies with the command as follows.

Inquiry	The drive executes the command with good status and preserves the unit attention condition.
Request Sense	If the drive has an available pending sense data for the initiator, the drive sends the pending sense data and preserves the unit attention condition for the initiator. If the drive does not have an available pending sense data for the initiator, the drive sends sense data for the unit attention condition and clear the unit attention condition for the initiator.
All Other	The drive terminates the command with a check condition status and preserve the unit attention condition.

If the drive receives a command from each initiator after reporting a check condition status for a pending unit attention condition for that initiator, the drive's response varies with the command as follows.

Request Sense	The drive sends the sense data for a pending unit attention condition and returns good status. The drive clears the unit attention condition for the initiator.
All Other	The drive execute the command with good status and clears the unit attention condition unless another unit attention condition exists. The sense data for the unit attention condition is lost.

6.4 Degraded Mode

There are certain errors or conditions which may impair the drive's ability to function normally. Rather than have a hard failure, the drive is designed to be as responsive as possible. In most cases, some action on the part of the initiator may be used to restore normal operation. This mode of limited operation is called degraded mode. The following list shows the various operation modes.

Operation Mode	Reason entering Mode	Function Supported	Action to be taken.
Non Functional	Fatal error is detected during POR.	File is not operational. No response from the drive can not be expected.	
ROM	Waiting for initializing mode. Failed to load microcode.	Request Sense Inquiry Write Buffer Start/Stop Unit Test Unit Ready Read Buffer	Send Start Unit Down-load microcode
Error	Format aborted	Format Unit Non data area access commands	Reissue Format
	Reassign Block Aborted	Reassign starts automatically.	Wait for completion

Figure 58. Degraded Operation Modes

6.5 Spindle Mode at Powering On

The spindle motor spins up automatically at power on.

When the drive receives a command in this mode before the drive becomes ready, the drive's response varies with the command as follows:

- Request Sense** The drive sends sense data and returns appropriate status.
- Inquiry** The drive sends inquiry data and returns appropriate status.
- All Other** The drive terminates the command with a check condition status, sense key of not ready, and additional sense code of powering on.

6.6 Overlapped Commands to an Active LUN

The drive does not support the receiving of a second command from the same initiator for the same LUN before the current command in progress has terminated. If this protocol is violated, the drive will respond as follows:

The execution of both commands is stopped internally and the second command is terminated with a check condition status. The sense key generated will be aborted command and the additional sense code will specify overlapped command attempted.

Note: Only one status is returned for both commands.

6.7 Read Ahead

The read ahead function consists of reading data that the initiator has not requested to the drive to read. This function is intended to improve performance for an initiator that frequently accesses sequential data with successive SCSI read commands. The read ahead function works when the read cache disable bit of read cache page is set to 0.

The drive continues to read subsequent logical blocks into its buffer until:

- The buffer becomes full.

The read ahead operations continue across all physical boundaries (such as tracks and cylinders). The target will overwrite the data in the data buffer which has already been sent to the initiator and any data remaining from a previous read ahead operation.

- The target receives another command except:

- Inquiry
- Request Sense
- Test Unit Ready

- An error is encountered.

The error will not be reported to the initiator. None of the data including good data stored will be used.

If the next command is a Read command which accesses some of the blocks contained in the buffer, the drive supplies the requested data from the buffer.

6.8 Multiple Initiator Environment

6.8.1 Sense Data

Separate sense data is reserved for each initiator. Each initiator's sense data is maintained independent of commands from other initiators.

6.8.2 Initiator Mode Select/Mode Sense Parameters

A single shared copy of the mode select/mode sense parameters is maintained by the drive. This includes both the current and saved parameters.

6.8.3 Initiator Data Transfer Mode Parameter

A separate data transfer mode parameter area is reserved and maintained for each initiator.

6.9 Error Recovery Procedures

6.9.1 Data Error Recovery

6.9.1.1 Read Operations

If an ID or data field ECC check when reading data, or other related errors occur such as ID address mark not found or data address mark not found (for example, byte sync detection errors), the controller performs the following error recovery:

- Retries by reading the same track (on track)
- Retries by reading the same track with track-offset
- ECC correction

The track offsets may be restored to zero at the conclusion of the error recovery process.

If all the retries are exhausted, and the error persists, the sector in error is a candidate for inclusion in the defect map. (Defects are added to the defect map under host initiative only, using the Reassign Blocks command; the controller does not add the defect to the map on its own).

When retries are disabled (via the Mode Select command), the above listed recovery steps are not taken. For ID errors, disabling the retry means that only one revolution of the disk is allowed to locate the target ID.

6.9.1.2 Write Operations

If an ID ECC check, or other related errors occur such as ID address mark not found (for example, byte sync detection error), when writing data, the controller performs the following error recovery:

- Retries by writing on the same track

If all the retries are exhausted, and the error persists, the sector in error is a candidate for inclusion in the defect map. (Defects are added to the defect map under host initiative only, using the Reassign Blocks command; the controller does not add the defect to the map on its own).

When retries are disabled (via the Mode Select command), the above listed recovery steps are not taken. For ID errors, disabling the retry means that only one revolution of the disk is allowed to locate the target ID.

6.9.1.3 Positioning Error Recovery

The drive only attempts positioning retries (Recalibrates and Seeks) if the drive positively determines that it is on the wrong track by comparing the target LBA to the LBA values from the sector ID.

In the event that those sector IDs cannot be read, the data error recovery procedures are invoked until the target ID is found, and it is determined that the target sector is not on the cylinder, or retries are exhausted.

6.10 Media Defect Strategy

Media defects are skipped by a single block basis utilizing both a “bad block bit” mechanism in the ID field and a “push-down” formatting technique.

6.11 File Format

The drives format is subdivided into the following areas:

- User Data Area
- CE Cylinder
- System work area
- Primary Defect Map

The defect map is a list of defective sectors or blocks, as identified by the drive manufacturer. This map is used during format operations but it is never altered.

- Secondary Defect Map

The reserved area for a grown defect map. This map is empty at time of manufacture. Defect locations defined by the initiator with the Reassign Blocks command are maintained in this map.

- SCSI Parameters List

Configuration, products data, mode sense and controller data are saved in this area.

- Microcode

The drive microcode is contained in the reserved area.

7.0 SCSI Physical Interface

7.1 SCSI Interface Connector Pin Assignments

Signal Name	Pin Number		Signal Name
+5	1	2	+5
RET	3	4	RET
GND	5	6	-DB(0)
GND	7	8	-DB(1)
GND	9	10	-DB(2)
GND	11	12	-DB(3)
GND	13	14	-DB(4)
GND	15	16	-DB(5)
KEY	17	18	-DB(6)
GND	19	20	-DB(7)
GND	21	22	-DB(P)
GND	23	24	TERMPWR
-ATTN	25	26	-BSY
GND	27	28	-ACK
-RST	29	30	-MSG
GND	31	32	-SEL
-I/O	33	34	-C/D
GND	35	36	-REQ
RET	37	38	RET
+5	39	40	+5

Figure 59. SCSI Drive Cable Signal Lines

Note: The minus sign next to a signal indicates it is active low.

7.1.1 Signal Line Descriptions

The SCSI bus consists of nine control and nine data lines. Each line is described below.

Name	Description
BSY	Busy indicates that the bus is in use.
SEL	Select is used by an initiator to select a target or by a target to re-select an initiator.
C/D	Control/data indicates whether control (1) or data (0) information is on the bus.
I/O	Input/output indicates whether the data on the bus is an input (1) to the initiator or an output (0) to the target. This line is also used to differentiate between selection phase (0) and re-selection phase (1).
MSG	Message is driven by target and indicates a message phase.
REQ	Request is driven by target and indicates a request for a REQ/ACK data transfer handshake.
ACK	Acknowledge is driven by the initiator and indicates an acknowledgement of a REQ/ACK data transfer handshake.
ATN	Attention is driven by an initiator to inform a target that the initiator has a message ready.
RST	Reset clears all SCSI devices from the bus and resets them.

Note: The target will not drive this line.

DB(n) Eight data bits are used to transfer data over the bus. DB (7) is the most significant.

DB(P) Parity bit associated with DB (7-0). Data parity is odd.

7.1.2 Driver/Receiver Specification

The drive supports single ended drivers and receivers.

7.1.2.1 Output Characteristics.

Each signal driven by the drive has the following output characteristics when measured at the drive connector:

Signal assertion 0.0 volt DC to 0.5 volt DC

Minimum driver output capability 48 milliamperes (sinking) at 0.5 volt DC

Signal negation 2.5 volt DC to 5.25 volt DC at 250 micro ampere (open collector)

7.1.2.2 Input Characteristics.

Each signal received by the drive has the following input characteristics when measured at the drive's connector:

Signal true 0.0 volt DC to 0.8 volt DC

Maximum total input load –0.4 milliamperes at 0.5 volt DC

Signal false 2.0 volt DC to 5.25 volt DC

Minimum input hysteresis 0.2 volt DC

7.1.3 SCSI Bus Cable

The maximum cable length from the host system to the drive is limited to 15.2 centimeters (6 inches) with external 1 K-ohm pull-up resistors.

If the appropriate termination resistors are externally connected to the interface lines, the cable length can be extended.

The stub length is less than 10 centimeters (3.9 inches).

7.1.4 Signal Termination

The drive does not have termination nor pull-up resistors for the SCSI interface.

7.1.5 Device Address Selection

To set the SCSI device address for drives 0 through 7, the host system must have a way to control the ID signal. This address setting is read during processing:

- Power up.
- RST on SCSI bus (reset).

This value is used by the drive firmware as the device ID to:

- Respond to selection.
- Place the device ID on the bus during reconnection.

Note: Changing the ID setting after power on is ignored until RST or another power on. The default ID of the shipped drive is 0.

7.1.6 Parity Implementation

The drive supports odd parity. Parity checking may not be turned off. When a parity error is detected, the drive notifies the initiator to retry the last operation once. If the error persists, the drive goes into bus free phase. (See 6.2, “SCSI Bus Related Error Handling Protocol” on page 78 for more detail.)

7.1.7 SCSI Bus Timings

The drive conforms to the timings as specified in the ANSI SCSI-2 October 17, 1991.

7.1.8 Reset Implementation

The drive implements the hard reset option as defined in the SCSI-2 standard.

The drive responds to RST by:

1. Clearing all commands for all initiators, including commands in the queue.
2. Releasing all SCSI device reservations.
3. Generating a unit attention condition.
4. Restoring mode parameters to their last saved values.
5. Going into bus free phase.

Note: If a reset occurs during a write operation, the drive completes the write operation for the current sector. This is to protect the sector from being partially updated, which will later cause an ECC error.

The RST line should be held active for at least 25 usec to reset the drive. The drive, however, may respond to a reset which is active for less than 25 usec.

Action	Type	Self-Test	Clear Command	Clear Queue	Unit ATTN
RST	Hardware	no	yes	yes	yes
Power On	Hardware	yes	yes	yes	yes
Bus Device Reset	Message	no	yes	yes	yes
Abort	Message	no	yes	no	no
Send Diagnostics	Command	yes	no	no	no

Figure 60. Matrix of Resets/Abort and Self Test Actions

7.1.9 Multi-Initiator Support

The drive implements “Untagged Queuing” as specified in SCSI-2 to support the multiple initiator environment.

The actual implementation is described as following:

- Only one command for each initiator may be accepted at a time. If the second command is received, the drive responds with a check condition status and sense data of overlapped commands attempted. Both commands are aborted.
- If the disconnect privilege is not granted for a command, other than those listed next, from an initiator while one or more commands are in progress from different initiators, the drive responds with busy status.

- Test Unit Ready
 - Inquiry
 - Request Sense
- The priority of execution is:
 1. Test Unit Ready, Inquiry or Request Sense command is executed immediately without disconnect.
 2. All other commands are queued in the drive internal stack, and are executed in FIFO fashion.
 3. When a linked command has been executed, the drive waits for the command from the linked initiator instead of processing a command from other initiators stacked in the drive command queue.
 4. Separate request sense data is provided for each initiator.
 5. Separate synchronous data period and offset are supported for each initiator by means of the Synchronous Data Transfer Request message.

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