

# HP 88780 SCSI INTERFACE SPECIFICATION



HEWLETT  
PACKARD

HP Part No. 5959-3542  
Printed in USA January 1990

Edition 5  
E0190

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## Using This Document

The HP 88780 SCSI Interface Specification contains general information for the 88780 1/2-inch tape drive family of Hewlett-Packard products. Note that some enhancements to the original 88780A product are documented. Individual OEMs may find that their 88780 varies from the general product described in this manual, depending on their contract specifications with Hewlett-Packard.

This document is based on ANSI Standard X3.131-1986. It also includes changes described in the ANSI Working Draft Proposal X3T9.2/86-109, Revision 6.

This document is divided into four parts:

- **Part 1 - Introduction:** The Introduction provides general, high-level information about the HP88780 family of products.
- **Part 2 - Hardware Description:** The Hardware Implementation section parallels Section 4 of the ANSI SCSI X3.131-1986 document, and provides the requirements for the HP 88780.
- **Part 3 - Messages:** Section 5 of the ANSI standard is covered in the Messages section.
- **Part 4 - Commands:** The Commands section covers SCSI commands implemented by the HP 88780.

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## Introduction

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The Small Computer System Interface (SCSI) is an industry standard interface, approved by the American National Standards Institute (ANSI). Three available SCSI documents, listed below, along with the HP 88780 OEM Technical Reference Manual, offer the information required to integrate the HP 88780 with SCSI-compatible computer systems.

Small Computer System Interface (SCSI),  
ANSI X3.131-1986.

- The ANSI authorized standard for SCSI implementation.
- Available through ANSI.

Common Command Set of the Small Computer System Interface (SCSI),  
ANSI X3T9.2-85-82 (Rev 4B).

- Available through ANSI.

HP 88780 OEM Technical Reference Manual,

- Available from Hewlett-Packard, Greeley Storage Division.

The ANSI Standard documents define the interface in general while this document describes the specific HP 88780 implementation. It is recommended that the general and specific documents be used together for system integration.

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## Overview of the HP 88780 SCSI Interface

The HP 88780 SCSI implementation provides a unit with a standard set of features and functions. These include the following:

- Asynchronous communication mode.
- Differential or Single-Ended connectors.
- Full implementation of mandatory commands.
- Implementation of all non-mandatory commands EXCEPT Copy and Verify, Track Select, Read Reverse, Locate, Read Position, and Compare.
- Configurable parameters: Default Block Length, Bus Inactivity Limit, Disconnect Time Limit, Disconnect Data Length (SCSI-2 Compatible), Inquiry Field, Reset Method, Read EOM Reported.



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## Supported and Unsupported Commands

The following commands are supported by the HP 88780 tape drive. This list includes all mandatory commands, most optional commands, and two vendor-unique commands.

- Test Unit Ready.
- Rewind.
- Request Sense.
- Read Block Limits.
- Read.
- Write.
- Extended Diagnostics (vendor-unique).
- Write Filemarks.
- Space.
- Inquiry.
- Verify.
- Recover Buffered Data.
- Mode Select.
- Reserve Unit.
- Release Unit.
- Copy.
- Erase.
- Mode Sense.
- Load/Unload.
- Receive Diagnostic Results.
- Send Diagnostic.
- Prevent/Allow Media Removal.
- Read Log (vendor unique).
- Write Buffer.
- Read Buffer.

For implementation details on these commands, see Chapter 4.

The following commands are not supported by the HP 88780 tape drive.

- Read Reverse.
- Track Select.
- Locate.
- Read Position.
- Compare.
- Copy and Verify.

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## Status Messages

The following messages are supported by the HP 88780 tape drive:

- Command Complete.
- Extended Message - Synchronous Data Transfer Request.
- Save Data Pointer.
- Restore Pointers.
- Disconnect.
- Initiator Detected Error.
- Abort.
- Message Reject.
- No Operation.
- Message Parity Error.
- Linked Command Complete.
- Linked Command Complete (With Flag).
- Bus Device Reset.
- Identify.

For implementation details, see Chapter 3.

## Hardware

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This section describes the physical and electrical characteristics of the interface. Elements of this section come from Section 4, Physical Characteristics, of the ANSI X3.131-1986 Standard document.

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### Cable Description

Both Single-Ended and Differential SCSI connector configurations are supported with the following restrictions:

- The Differential SCSI Interface supports the shielded cable option only.
- Both shielded and flat-ribbon cable connectors are both available on the Single-Ended SCSI interface. External termination is required in any configuration.
- The Single-Ended Interface requires a shielded cable, terminated and grounded to the Shielded Cable connector, to ensure compliance to VDE 0877 level-B EMI requirements and to provide sufficient protection from electrostatic discharge. Possible cable and terminator sources are listed on the following page. It is not implied that these are the only sources for SCSI accessories.

### Cable and Terminator Sources

Interface	Manufacturer	Part Number
<b>SCSI DIFFERENTIAL:</b>		
<b>SHIELDED</b>		
Cable:	Quintec Interconnect Systems Amphenol	SCUSI-A-OXM 200 Series
Terminator:	AMP Amphenol	868875-2 2002S000-0X000
<b>SINGLE-ENDED:</b>		
<b>UNSHIELDED</b>		
The following unshielded ribbon cable and connector are suggested for use for evaluation/test systems only. Compliance with VDE 0877 level-B EMI standards is not assured unless a shielded cable, grounded to the connector, is used.		
Cable:	28AWG Ribbon, Spectra Strip	132-2899-887 style 2697
Connector:	AMP	1-746094-0
<b>SHIELDED</b>		
Cable:	Quintec Interconnect Systems Amphenol	SCUSI-A-0XM 200 Series
Terminator:	AMP Amphenol	868875-1 2001S000-0X000

## Message Specification

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This section includes all HP 88780 supported and unsupported SCSI Messages. Elements of this section come from Section 5, Logical Characteristics, of the ANSI Standard documents.

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### Messages

#### COMMAND COMPLETE (00H)

The target sends this message to an initiator to indicate that the execution of a command (or a series of linked commands) is complete and that valid status has been sent to the initiator. After successfully sending this message, the target goes to the BUS FREE phase by releasing BSY.

#### EXTENDED MESSAGE (01H)

Either the initiator or the target sends this message as the first byte of a multiple-byte message.

A value of one in the first byte of the message indicates the beginning of a multiple-byte extended message. The *minimum* number of bytes sent for an extended message is three. The extended message is received and rejected with a MESSAGE REJECT. The drive proceeds to the command state if the rejected message is a synchronous transfer negotiation.

#### SAVE DATA POINTER (02H)

This message, sent from a target to the initiator, saves a copy of the present active data pointer for the currently attached logical unit.

The HP 88780 accepts this message when in the initiator mode, and sends this message before a disconnect when in the target mode.

#### RESTORE POINTERS (03H)

The target sends this message to direct the initiator to restore the most recently saved pointers (for the currently attached logical unit) to the active state. Pointers to the command, data, and status locations for the logical unit are restored to the active pointers. Command and status pointers are restored to the beginning of the present command and status areas. The data pointer is restored to the value at the beginning of the data area, in the absence of a SAVE DATA POINTER message, or to the value at the point at which the last SAVE DATA POINTER message occurred for that logical unit.

The HP 88780 does not send a RESTORE POINTERS message. Instead, it relies on the implicit Restore Pointers inherent in a reselection. When acting as an initiator, the 88780

accepts a RESTORE POINTERS (or a reselection without a Restore Pointers) if a prior SAVE DATA POINTERS was received.

### **DISCONNECT (04H)**

The target sends this message to inform an initiator that the present physical path is going to be broken (the target plans to disconnect by releasing BSY). Later, reselection will be required in order to complete the current operation. The initiator detects a catastrophic error condition when the BUS FREE phase occurs (other than as the result of a RESET condition) without first receiving a DISCONNECT or COMMAND COMPLETE message. If the target intentionally creates this condition, the target clears the current command. This message does not cause the initiator to save the data pointer.

The HP 88780 will support this message as an initiator. It will send this message as a target depending on the front panel configurations. The HP 88780 may go to BUS FREE without a DISCONNECT message if an error condition is encountered. Error conditions that can cause this include a re-selection timeout, an initiator detected error message, and a parity error message.

### **INITIATOR DETECTED ERROR (05H)**

The initiator sends this message to inform a target that an error (e.g. parity error) has occurred that does not prevent the target from retrying the operation. At this point, present pointer integrity is not assured. A RESTORE POINTERS message, or a disconnect followed by a reselection, will cause the pointers to be restored to their defined prior state.

The drive will not send this message when the drive is acting as an initiator. When received as a target, it will cause the drive to release BSY and go to a BUS FREE state.

### **ABORT (06H)**

The initiator sends this message to the target to clear the present operation. All pending data and status from the affected logical unit is cleared, and the target goes to the BUS FREE phase. This message *can* be sent to a logical unit that is not currently performing an operation for the initiator.

A transaction which has not yet been acknowledged with a good Status byte will cause the transaction to be aborted. If a transaction has already been acknowledged, the abort will force a write of any pending data. The device will then proceed directly to BUS FREE state.

### **MESSAGE REJECT (07H)**

Either the initiator or the target sends this message to indicate that the last message it received was inappropriate or has not been implemented.

In order to indicate its intentions of sending this message, the initiator asserts the ATN signal prior to its release of ACK for the REQ/ACK handshake of the message that is to be rejected. When a target sends this message, it changes to MESSAGE IN phase and sends this message prior to requesting additional message bytes from the initiator. This provides an interlock so that the initiator can determine which message is rejected. MESSAGE REJECT is sent by the drive on any messages it considers illegal or that occur at an inappropriate time.

### **NO OPERATION (08H)**

The initiator sends this message in response to a target's request for a message, when the initiator does not currently have any other valid message to send. This message is accepted when the drive is acting as a target, and may be sent when it is an initiator. If a NO-OP is received during a selection, the drive proceeds to Command phase. If a NO-OP is received during reselection, the drive proceeds to message in-phase to send the IDENTIFY message. Receiving a NO-OP during any other phase results in an illegal message response.

### **MESSAGE PARITY ERROR (09H)**

The initiator sends this message to the target to indicate that one or more bytes in the last message it received had a parity error.

To indicate its intentions of sending this message, the initiator sends the ATN signal prior to its release of ACK for the REQ/ACK handshake of the message that has the parity error. This provides an interlock so that the target can determine which message has the parity error. A message parity error causes the drive to release BSY and go to BUS FREE state.

### **LINKED COMMAND COMPLETE (0AH)**

The target sends this message to an initiator to indicate that the execution of a linked command is complete, and status has been sent. The initiator sets the pointers to the initial state for the next linked command. The drive implements this message when linked commands are required, and the flag bit is not set. Otherwise, it implements the LINKED COMMAND COMPLETE (WITH FLAG) message.

### **LINKED COMMAND COMPLETE, with flag (0BH)**

The target sends this message to an initiator to indicate that the execution of a linked command (with the flag bit set to one) is complete, and status has been sent. The initiator sets the pointers to the initial state of the next linked command. Typically, this message would be used to cause an interrupt in the initiator between two linked commands.

The drive will implement this message when linked commands are required, and the flag bit is set. Otherwise, it implements the LINKED COMMAND COMPLETE message.

### **BUS DEVICE RESET (0CH)**

The initiator sends this message to direct a target to clear all current commands on the device. This message forces the SCSI device to an initial state with no operations pending for any initiator. Upon recognizing this message, the target goes to the BUS FREE phase.

A BUS DEVICE RESET message leaves the drive in a state similar to a power-up. Current commands are aborted. ALL WRITE DATA PENDING IN THE BUFFER MAY BE LOST. All data pending from another host may also be lost.

Due to the catastrophic nature of this command, it should be used cautiously in a multi-initiator system.

## IDENTIFY (80H-0FFH)

Either the initiator or the target sends this message to establish the physical connection path between an initiator and target for a particular logical unit.

- Bit 7: This bit is always set to one to distinguish these messages from other messages.
- Bit 6: This bit is only set to one by the initiator. When set to one, it indicates that the initiator has the ability to disconnect and reconnect. The target will never set this bit.
- Bit 5: Reserved
- Bit 4: Zero
- Bit 3: Reserved
- Bit 2-0: Indicate the Logical Unit Number

Only one logical unit number is to be identified for any one selection sequence. A second IDENTIFY message with a new logical unit number is not issued before the bus has been released (BUS FREE phase).

When sent from a target to an initiator during reconnection, an implied RESTORE POINTERS message will be performed by the initiator prior to completion of this message.

B7	B6	B5	B4	B3	B2	B1	B0
(1)	Initiator Disconnect Ability	Reserved	(0)	Reserved	Logical Unit Number (LUN)		



## Command Specification

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This section includes all supported and unsupported HP 88780 SCSI commands. Elements of this section come from Sections 7 and 9 of the ANSI X3T9.2/86/109 Standard draft revision document.

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### Commands

There are two groups of SCSI commands, each with a specific, required length (in bytes). The majority of the HP 88780 commands are 6-byte-long Group 0 commands. Group 1 commands are 10 bytes long. Note that the drive waits until the required bytes are transferred; the unit appears to “hang” if the required number of bytes are not sent.

## Group 0 Commands

Operation Code	Type	Command Name
00H	S	TEST UNIT READY
01H	S	REWIND
02H	U	
03H	S	REQUEST SENSE
04H	U	
05H	S	READ BLOCK LIMITS
06H	U	
07H	U	
08H	S	READ
09H	U	
0AH	S	WRITE
0BH	U	TRACK SELECT
0CH	U	
0DH	V	EXTENDED DIAGNOSTICS
0EH	U	
0FH	U	READ REVERSE
10H	S	WRITE FILEMARKS
11H	S	SPACE
12H	S	INQUIRY
13H	S	VERIFY
14H	S	RECOVER BUFFERED DATA
15H	S	MODE SELECT
16H	S	RESERVE UNIT
17H	S	RELEASE UNIT
18H	S	COPY
19H	S	ERASE
1AH	S	MODE SENSE
1BH	S	LOAD/UNLOAD
1CH	S	RECEIVE DIAGNOSTIC RESULTS
1DH	S	SEND DIAGNOSTIC
1EH	S	PREVENT/ALLOW MEDIUM REMOVAL
1FH	V	READ LOG

### Key:

- S = Command is supported. See the command description for details on this support.
- U = Command is not supported. This command will be rejected if requested.
- V = Supported vendor-unique command.

## Group 1 Commands

Operation Code	Type	Command Name
20H	U	
21H	U	
22H	U	
23H	U	
24H	U	
25H	U	
26H	U	
27H	U	
28H	U	
29H	U	
2AH	U	
2BH	U	LOCATE
2CH	U	
2DH	U	
2EH	U	
2FH	U	
30H	U	
31H	U	
32H	U	
33H	U	
34H	U	READ POSITION
35H	U	
36H	U	
37H	U	
38H	U	
39H	U	COMPARE
3AH	U	COPY AND VERIFY
3BH	S	WRITE BUFFER
3CH	S	READ BUFFER
3DH	U	
3EH	U	
3FH	U	

**Key:**

- S = Command is supported. See the command description for details on this support.
- U = Command is not supported. This command will be rejected if requested.

## **Command Descriptions**

Several commands have associated parameter lists in which two or more adjacent bytes are to be considered as one multi-byte word. These will be indicated by a range of numbers in the "Byte" column. The description will also identify Least Significant Byte (LSB). Within every byte in the Command Descriptions, Bit 7 is always the most significant bit, and Bit 0 is always the least significant.

Reserved bits must be zero. Non-zero Reserved bits sent to the tape drive will produce a CHECK CONDITION on the command.

VU means Vendor Unique. These bits, or bytes, are unique to HP.

Unused bits or bytes may also contain any values.

Fixed values for a particular field will appear in parentheses. The values are usually hexadecimal.

---

## TEST UNIT READY (00H)

Byte	7	6	5	4	3	2	1	0
0	Operation Code (00H)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Unused		Reserved				Flag	Link

The TEST UNIT READY command provides a means to determine if the logical unit is ready. This is not a request for a self-test. If the logical unit is online, this command will return a GOOD status. Otherwise, the sense key will be NOT READY. If the tape drive is in the process of loading a tape, a TEST UNIT READY will return a BUSY status.

## REWIND (01H)

### Rewind

Byte	7	6	5	4	3	2	1	0
0	Operation Code (01H)							
1	Logical Unit Number			Reserved				Immed
2	Reserved							
3	Reserved							
4	Reserved							
5	Unused		Reserved				Flag	Link

The REWIND command requests the target to position the logical unit at the beginning-of-tape sticker or load-point. Prior to the execution of the rewind operation, the target writes any buffered write data to the media.

An immediate (Immed) bit of one indicates that status will be returned as soon as the rewind operation has been initiated (prior to any buffered data being written to the tape). An Immed bit of zero indicates that status will be returned after the rewind operation has completed.

A REWIND command may return the following sense keys on a check condition:

**NOT READY:** Drive is not online.

**MEDIUM ERROR:** A previously acknowledged write-type of operation experienced an error probably related to the condition of the tape or the cleanliness of the head. This condition will also be marked by the Valid bit being set, indicating that the information bytes contain residue information, and the Error Code being a 71H indicating a deferred error (if this is supported).

**HARDWARE ERROR:** Either a previously acknowledged write-type of operation had a major non-tape related failure or the rewind itself experienced the failure. If a previously acknowledged write was the cause of the problem, the Valid bit will be set.

**ILLEGAL REQUEST:** If a reserved or unused bit is set, an ILLEGAL REQUEST will be returned.

**UNIT ATTENTION:** If a front panel reset, bus reset, or power failure occurred during the rewind, a UNIT ATTENTION will be present.

**ABORTED COMMAND:** If an invalid or inappropriate message was received during the operation, the operation will be terminated in an indeterminate state, and ABORTED COMMAND will be returned.

## REQUEST SENSE (03H)

Request Sense

Byte	7	6	5	4	3	2	1	0
0	Operation Code (03H)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Allocation Length							
5	Unused		Reserved				Flag	Link

The REQUEST SENSE command requests that the target transfer sense data to the initiator.

The sense data will be valid for a CHECK CONDITION or RESERVATION CONFLICT status returned on the prior command. It may or may not be valid for any other returned status. This sense data will be preserved by the target until retrieved by the REQUEST SENSE command or until the receipt of any other command from the same initiator. Sense data will be cleared upon receipt of any subsequent command to the logical unit.

The allocation length specifies the maximum number of sense bytes to be returned. An allocation length of zero indicates that zero bytes of sense data will be transferred when in SCSI-2 mode. When the drive is in SCSI-1 mode, 4 bytes of data will be transferred. Any other value indicates the maximum number of bytes that will be transferred. The target will terminate the DATA IN phase when allocation length bytes have been transferred or when all available sense data has been transferred to the initiator, whichever is less.

The REQUEST SENSE command will return the CHECK CONDITION status only to report fatal errors for the REQUEST SENSE command. Examples of fatal errors for this command include the following:

- The target receives a non-zero reserved bit in the command descriptor block.
- An unrecovered parity error occurs on the DATA BUS.
- A target malfunction prevents return of the sense data.

If any non-fatal error occurs during the execution of the REQUEST SENSE command, the target will return the sense data with GOOD status. Following a fatal error on a REQUEST SENSE command, sense data may be invalid.

A Valid bit of zero indicates that the information bytes are invalid.

The sense data value 70H indicates a current error, i.e., the report is associated with the most recently received command. Sense data value 71H indicates a deferred error or one that occurred on a previously acknowledged command.

The segment number will always be zero, unless the sense data is for a COPY Command (see COPY description).

The filemark bit indicates that the current command has read a filemark.

The end-of-tape (EOM) bit indicates that an end-of-tape condition (end-of-tape or beginning-of-tape) exists. The meaning of this bit is command dependent. For example, crossing the EOT sticker in the forward direction on a write sets the bit, while crossing on a read doesn't. If the command was in the reverse direction, the EOM bit will be set on encountering the BOT sticker.

The incorrect length indicator (ILI) bit indicates that the requested logical block length did not match the logical block length of the data on the tape.

The Sense Key, Additional Sense Code (ASC), and Additional Sense Code Qualifier (ASCQ) combinations are defined in Table 4-1.

The contents of the information bytes are command specific and are defined within the command of interest. Unless specified otherwise, these bytes contain the difference (residue) of the requested length minus the actual length in either bytes or blocks, as determined by the command. (Negative values are indicated by two's complement notation.)

The additional sense length specifies the number of additional sense bytes to follow. If the allocation length of the command descriptor block is too small to transfer all of the additional sense bytes, the additional sense length is not adjusted to reflect the truncation.

Non-zero values in the field replaceable unit field are used to define a device-specific mechanism or unit that has failed. A value of zero in this field will indicate that no specific mechanism or unit has been identified to have failed or that the data is not available. In general, the FRU number is identical to the last two digits of the PCA number. (See the 88780 Diagnostic ERS.)

The Sense-Key specific bytes are unused and will be zero.

A UNIT ATTENTION CONDITION is a state entered by the drive following any of several events. There is sense data associated with these events, although the sense key may not always be UNIT ATTENTION. The events are as follows:

- Selftest Hardware Failure.
- Reset (Bus Reset, BUS DEVICE RESET Msg Out, Power on Reset).
- Offline Tape Motion.
- Offline to Online with no tape motion.
- Reselect Timeout (250ms).

The list is in order of priority, with top priority first. If multiple events occur, only the highest priority ATTENTION CONDITION will be preserved. The ATTENTION CONDITION is preserved for each possible initiator (ID = 0-7) until that initiator clears the ATTENTION CONDITION with a REQUEST SENSE, or a second command is sent after the CHECK CONDITION Status was reported.



### Request Sense Data

Byte	7	6	5	4	3	2	1	0
0	Valid	Error Code (70H or 71H)						
1	0 (Segment Number)							
2	Filemark	EOM	ILI	Reserved	Sense Key			
3-6	Information Bytes (Byte 3 is the MSB, Byte 6 is the LSB)							
7	Additional Sense Length (14H)							
8-11	Command Specific Information Bytes (Byte 8 is the MSB, Byte 11 is the LSB)							
12	Additional Sense Code							
13	Additional Sense Code Qualifier							
14	Field Replaceable Unit Code							
15-17	Sense-Key-specific bytes (00)							
18	Report flags (Vendor Unique)							
19	Error code from data buffer (VU)							

**Request Sense Data (continued)**

Byte	7	6	5	4	3	2	1	0
20	Tape position flags (VU)							
21-23	Data record byte count (VU) (Byte 21 is the MSB, Byte 23 is the LSB)							
24	Retry count (VU)							
25-26	Back reference count (VU) (Byte 25 is the MSB, Byte 26 is the LSB)							
27	Last error causing retry (VU)							

Table 4-1, below, gives the meaning of various combinations of sense key, Additional Sense Code, and Additional Sense Code Qualifier. Appendix B contains a brief description of every valid combination, along with the error code from the data buffer (byte 19).

**Table 4-1. Sense Key Descriptions**

S Key	Byte 12	Byte 13	Description
0H	00	00	NO SENSE. Indicates that there is no specific sense key information to be reported for the designated logical unit. This would be the case, for example, for a successful command or a command that received a CHECK CONDITION status because any of the filemark, EOM, or ILI bits are set to one.
	00	01	FM Detected.
	00	02	EOM Detected.
	00	04	BOM Detected.
	00	05	EOD Detected.
	00	88	Buffer Empty (cannot retrieve record from buffer).
1H	00	00	RECOVERED ERROR. Indicates that the last command completed successfully with some recovery action performed by the target. Details are determinable by examining the additional sense bytes and the information bytes.
2H	00	00	NOT READY. Indicates that the logical unit is offline.
	04	00	Drive Not Ready.
	04	01	Drive Is Offline.
	04	02	No Tape Is Loaded.
	04	80	Drive Is Not Offline.
	04	81	Tape Is Loaded (preventing access to test).
	04	82	Front Door or Top Cover is Open.
	04	83	Controller Is In Diagnostics/Options Mode.
	04	84	Controller Is Not In Diagnostic Mode.
3H	00	00	MEDIUM ERROR. Indicates that the command terminated with a non-recovered error condition that was probably caused by a flaw in the tape or a dirty head. A hardware problem may cause this error but it is most likely to be tape related.
	11	00	Unrecovered Read.
	1F	00	Unrecovered Write.
	30	00	Cannot Read Tape (unknown format).

**Table 4-1. Sense Key Descriptions (continued)**

<b>S Key</b>	<b>Byte 12</b>	<b>Byte 13</b>	<b>Description</b>
4H	00	00	<b>HARDWARE ERROR.</b> Indicates that the target detected a non-recoverable hardware failure while performing the command or during a self test.
	08	00	<b>LUN Communication Failure.</b>
	40	00	<b>Diagnostic Fail.</b>
	42	00	<b>Power-on Fail.</b>
	44	00	<b>Internal Error On Controller.</b>
	44	97	<b>Byte Count Mismatch On Write.</b>
	55	00	<b>Drive-Reported Error.</b>
	89	00	<b>Tape Positioning or Servo Error.</b>
	8A	00	<b>Buffer Controller Error.</b>
	91	00	<b>Erroneous DPR Reset.</b>
	92	00	<b>Erroneous SPIFI Reset.</b>
5H	00	00	<b>ILLEGAL REQUEST.</b> Indicates that there was an illegal parameter in the command descriptor block or in the additional parameters supplied as data for some commands.
	20	00	<b>Invalid Command Op-Code During Copy.</b>
	20	01	<b>Illegal Function Request For Device Type During Copy.</b>
	20	02	<b>Unsupported Function Request During Copy.</b>
	20	03	<b>Non-Zero Reserved Field During Copy.</b>
	20	04	<b>Invalid Field In Parameter List During Copy.</b>
	25	00	<b>Invalid LUN.</b>

**Table 4-1. Sense Key Descriptions (continued)**

<b>S Key</b>	<b>Byte 12</b>	<b>Byte 13</b>	<b>Description</b>
	26	00	Invalid Field In Parameter List.
	26	06	Requested Density Not Available.
	26	85	Requested Test Is Not Remotely Accessible.
	26	86	Illegal Mode Select/Sense Length.
	26	87	Requested Write Length Exceeds Maximum.
	26	8B	Verify Immediate Is Not Supported.
	26	90	Bad Page Selected In Read Log.
	26	94	Unsupported Mode Sense/Select Page.
	34	00	Invalid CDB.
	34	01	Invalid Command Operation Code.
	34	04	Non-Zero Reserved Field.
	34	06	Illegal Mode Select Parameter.
	34	07	Fixed Bit and Fixed Mode Settings Mismatched.
	34	8E	Byte Compare Mode Not Supported.
	34	8F	SILI Bit Set While In Fixed Mode.
	34	93	Immediate Bit Set When Not In Buffered Mode.
	34	95	Invalid Length.
	34	96	Invalid Header.
6H	00	00	UNIT ATTENTION. Indicates that the removable tape may have been changed or the target has been reset or powered on.
	28	00	Tape Changed.
	28	80	Offline to Online With No Position Change.
	29	00	Power-on Reset, Bus Device Reset.
	29	86	Test Aborted By Reset.

**Table 4-1. Sense Key Descriptions (continued)**

S Key	Byte 12	Byte 13	Description
7H	00	00	DATA PROTECT. Indicates that a command that writes to the tape was attempted on a reel that is write protected.
	27	00	Write Protected.
8H	00	00	BLANK CHECK. Indicates that the device encountered blank tape on a read type of operation.
9H	00	00	Unused.
AH	00	00	COPY ABORTED. Indicates that a COPY command was aborted due to an error condition on the source or the destination device.
	45	00	Firmware Timeout Of Selection During Copy.
BH	00	00	ABORTED COMMAND. Indicates that the target aborted the command. The initiator may be able to recover by trying the command again.
	47	00	Parity Error.
	49	00	Message-Out Error.
	49	02	Illegal Message.
	4E	00	Bus Protocol or Reselect Error.
	FF	00	Target Went to Incorrect Phase or Sent Unexpected Status.
CH			EQUAL. Unused.
DH	00	00	VOLUME OVERFLOW. *
	3B	0B	Ten Feet Past EOT and Cannot Write.
EH			MISCOMPARE. Unused.
FH			Reserved.

\* Indicates that the target has reached physical EOT and data may remain in the buffer that was not written to tape. A RECOVER BUFFERED DATA command may be issued to read unwritten data from the buffer.

### Additional Sense Code Qualifier (ASCQ) Positional Information REV 6.57

Current 88780 documentation defines ASCQ for key of No Sense as 02 = EOM detected and 04 = BOM detected. The SCSI-2 specification defines 5 positional information ASCQ codes. None of these were ever implemented in the SCSI code. These are now implemented in Revision 6.57 SCSI firmware as follows.

**Table 4-2. HP Positional Information**

Commands	FM*	EOM*	Sense Key*	ASCQ
Read and Verify commands				
Runaway and NOT EOT	0	0	8	5
Runaway and EOT	0	1	8	5
Filemark	1	0	0	1
Configuration 87 ON and EOT **	0	1	0	0
Space command, Space code = 0-2 (Blocks,FM,Seq FM) Forward				
Runaway and NOT EOT	0	0	8	5
Runaway and EOT	0	1	8	5
Filemark	1	0	0	1
Configuration 87 ON and EOT **	0	1	0	0
Space command, Space code = 0-2 (Blocks,FM,Seq FM) Reverse				
Runaway and NOT BOT	0	0	8	0
BOT	0	1	0	4
Filemark	1	0	0	1
Write, Write Filemark and Erase commands				
EOT	0	1	0	2

\* Byte 2 of sense data

\*\* With Configuration 87 (Read EOM Reported) ON, Check Condition will always be sent after crossing EOT in the forward direction. All other cases still apply.

For further details regarding the Sense Keys, refer to Appendix B.

## VENDOR UNIQUE BYTES (see Appendix A)

### Byte 18: Report Flags:

- Bit 7 - Command Rejected.
- Bit 6 - Reset Acknowledged.
- Bit 5 - Transfer Abort Acknowledged.
- Bit 4 - Hard Error Encountered.
- Bit 3 - Unexpected EOF/BOT/Runaway.
- Bit 2 - Data Correction Occurred.
- Bit 1 - Immediate Report Message.
- Bit 0 - Transparent Status Message.

### Byte 19: Error Codes.

### Byte 20: Tape position flags:

- Bit 7 - Beginning of Tape (BOT).
- Bit 6 - End of File (EOF).
- Bit 5 - End of Tape (EOT).
- Bit 4 - Early EOT (pre-EOT).
- Bit 3 - 10 feet beyond EOT (EOT+10).
- Bit 2 - Tape Runaway.
- Bit 1 - Position Lost.
- Bit 0 - (reserved).

### Byte 21-23: Data Record Byte Count.

### Byte 24: Retry Count. Number of physical retries.

### Byte 25,26: Back Reference Count. Number of Immediate Responded commands Pending.

### Byte 27: Last error causing retry.



## READ BLOCK LIMITS (05H)

Read Block Limits

Byte	7	6	5	4	3	2	1	0
0	Operation Code (05H)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Unused		Reserved				Flag	Link

The READ BLOCK LIMITS command requests that the target's maximum block length be returned for the logical unit. The READ BLOCK LIMITS data shown below will be sent during the DATA IN phase of the command. The READ BLOCK LIMITS command does not reflect the currently selected block size, only the available limits. A MODE SENSE command will return the current block size.

READ BLOCK LIMITS Data

Byte	Description
0	Reserved
1-3	Maximum Block Length (Byte 1 is the MSB, Byte 3 is the LSB)
4	Minimum Block Length (00H) (MSB)
5	Minimum Block Length (01H) (LSB)

The maximum block length when the drive is in Phase Encoded (PE) format is 20000H. The maximum block length in GCR format is 40000H. The maximum block length in Non-Return-to-Zero (NRZI) format is 10000H.

A READ BLOCK LIMITS command may return the following sense keys on a check condition:

**MEDIUM ERROR:** A previously acknowledged write type of operation experienced an error probably related to the condition of the tape, or the cleanliness of the head. This condition is marked by setting the Valid bit, indicating that the information bytes contain residue information. A deferred error is indicated when the Error Code has a value of one (if this is supported).

**HARDWARE ERROR:** A previously acknowledged write type of operation had a major non-tape related failure. The Valid bit will be set.

**ILLEGAL REQUEST:** If a reserved or unused bit is set, an ILLEGAL REQUEST will be returned.

**UNIT ATTENTION:** If a front panel reset, bus reset, or power fail occurred during the command (however unlikely), a UNIT ATTENTION will be present.

**ABORTED COMMAND:** If an invalid or inappropriate message was received during the operation, the operation will be terminated and ABORTED COMMAND will be returned.

## READ (08H)

Read								
Byte	7	6	5	4	3	2	1	0
0	Operation Code (08H)							
1	Logical Unit Number			Reserved			SILI	Fixed
2-4	Transfer Length (Byte 2 is the MSB, Byte 4 is the LSB)							
5	Unused		Reserved			Flag	Link	

The READ command transfers one or more data block(s) to the initiator beginning with the next block on the logical unit. The fixed bit specifies both the meaning of the transfer length field and whether fixed-length or variable-length block(s) are to be transferred.

If the fixed bit is set to zero, a single block will be transferred with the transfer length specifying the maximum number of bytes the initiator has allocated for the returned data. This is the preferred mode of operation. A SILI bit of one indicates that the target will not return CHECK CONDITION status if the only error is that the transfer length is not equal to the actual block length recorded on the tape.

If the fixed bit is set to one, the transfer length specifies the number of blocks to be transferred to the initiator. This form of the READ command is valid only if the logical unit is currently operating in fixed block mode. The drive is in fixed block mode when the logical unit has been instructed to use fixed-length blocks with the MODE SELECT command. The current block length is the block length defined in the MODE SELECT command or by the front panel configuration. A mode select command supersedes a front panel configuration until the next power on or reset.

The 88780 can be defaulted to variable or fixed mode using Configuration 81.

When the transfer length is zero, no data will be transferred and the current position on the logical unit will not be changed.

A successful READ command with the fixed bit equal to one will transfer the current block length times the transfer length bytes of data to the initiator. Upon termination of the READ command, the tape will be logically positioned after the last block transferred (end-of-tape side).

**UNIT ATTENTION:** If a front panel reset, bus reset, or power fail occurred during the command, a UNIT ATTENTION will be present.

**BLANK CHECK:** If a blank area on the tape is encountered during a read, the sense key will be BLANK CHECK and the valid bit will be set with an appropriate residue.

**ABORTED COMMAND:** If an invalid or inappropriate Message was received during the operation, the operation will be terminated in an indeterminate state and ABORTED COMMAND will be returned.

## WRITE (0AH)

Write								
Byte	7	6	5	4	3	2	1	0
0	Operation Code (0AH)							
1	Logical Unit Number			Reserved				Fixed
2-4	Transfer Length (Byte 2 is the MSB, Byte 4 is the LSB)							
5	Unused		Reserved				Flag	Link

The WRITE command transfers one or more block(s) from the initiator to the current logical position. The fixed bit specifies both the meaning of the transfer length field and whether fixed-length or variable-length block(s) are to be transferred.

If the fixed bit is set to zero, a single block will be transferred from the initiator and will be written to the logical unit beginning at the current logical tape position. The Transfer Length field specifies the number of bytes in the block. Upon successful termination, the tape will be logically positioned after this block (end-of-tape side).

If the fixed bit is set to one, the transfer length field specifies the number of block(s) to be transferred to the logical unit beginning at the current tape position. This form of the WRITE command is valid only if the logical unit is currently operating in fixed block mode. Upon termination, the tape will be logically positioned after these block(s) (end-of-tape side).

The 88780 can be defaulted to variable or fixed mode using Configuration 81.

If the EOT sticker is encountered while writing, an attempt to finish writing any buffered data will be made. The command will terminate with CHECK CONDITION status and the EOM bit in extended sense will be set to one. Any further writes will result in a CHECK CONDITION status with EOM set.

If the transfer length is zero, no data will be transferred and the current position on the logical unit will not be changed.

A WRITE command may return the following sense keys on a check condition:

**NO SENSE:** The EOM bit will be set once the EOT sticker has been detected on a buffered write. All buffered data will be written to the tape, therefore the valid bit will be set but the information bytes will be zero.

**NOT READY:** Drive is not online.

**MEDIUM ERROR:** The current record being written or a previously acknowledged write type of operation experienced an error probably related to the condition of the tape, or the cleanliness of the head. If the tape error occurred on a previously acknowledged write, the Valid bit will be set indicating that the information bytes contain residue information, and the Error Code will be a one indicating a deferred error.

**HARDWARE ERROR:** Either a previously acknowledged write type of operation had a major non-tape related failure or the current write itself experienced the failure. The Valid bit will be set and the information field will contain the appropriate residue.

**ILLEGAL REQUEST:** If a reserved or unused bit is set, an **ILLEGAL REQUEST** will be returned. If the fixed bit does not match the current mode, the target will reject the command with an **ILLEGAL REQUEST**.

**UNIT ATTENTION:** If a front panel reset, bus reset, or power fail occurred during the command, a **UNIT ATTENTION** will be present.

**DATA PROTECT:** The write enable ring is not installed.

**ABORTED COMMAND:** If an invalid or inappropriate Message was received during the operation, the operation will be terminated in an indeterminate state and **ABORTED COMMAND** will be returned.

#### **BUFFERED MODE OPERATION**

Mode Select Buffered Mode parameter was used to enable or disable immediate response (Configuration 50) on writes. This forced a reposition on each write command to the buffer. In fixed mode where multiple records are written to tape with one Host command, the drive repositioned for every blocked record. This has been changed to define **UNBUFFERED FIXED MODE** as "Immediate response on" until the end of the Host data transfer. The SCSI interface will then send down a **REQUEST STATUS** that will flush the contents of the buffer to tape followed by the **STATUS** phase to the Host that will report any errors for the entire blocked data transfer to tape.

---

## TRACK SELECT (0BH)

Byte	7	6	5	4	3	2	1	0
0	Operation Code (0BH)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Track Value							
5	Unused		Reserved				Flag	Link

The TRACK SELECT command is not supported by the HP 88780 and will return a CHECK CONDITION with ILLEGAL REQUEST if requested.

## EXTENDED DIAGNOSTIC (vendor-unique) (0DH)

Table 4-3. Command Description

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (0DH)							
1	Logical Unit Number			Reserved		Target Controller Value		
2	Extended Diagnostic Function Code							
3-4	Byte count/Parameter (Byte 3 is the MSB, Byte 4 is the LSB)							
5	Unused		Reserved			Flag		Link

The **EXTENDED DIAGNOSTIC** command is a Hewlett-Packard 88780 specific command used to access diagnostic functions. The extended diagnostic functions available are as follows:

Table 4-4. Function Code Descriptor

Function code	Description
00H	Return Drive Status
01H	Host Set Configuration
02H	Identify Firmware Revisions
04H	Interface Memory Dump
40H	Return Drive Configuration *
80H	Read Loopback
81H	Write Loopback
All others Reserved	

\* Function code 40H (Return Drive Configuration) defines Bytes 3 - 4 of the Command Data Bytes as a parameter. All others use Bytes 3 - 4 as a byte count.



## Return Drive Status

Function code 00 (Return Drive Status) has been added to supported function codes. This will allow the Host to return the current state of the machine. If there are back referenced errors pending in the buffer, this command will be rejected (no data transferred) and a check condition status will be returned with the sense key set to the appropriate error. The information bytes will report records/bytes in the buffer (dependent on Fixed/Variable mode), and the vendor unique bytes of the sense data will contain status information relevant to drive status at the time of the error. If no errors are pending, then any data in the buffer not flushed to tape will be flushed by a REQUEST STATUS command that is sent down by the SCSI Interface. THIS COMMAND CAN DEGRADE PERFORMANCE IF USED DURING WRITE OPERATIONS TO TAPE. Bytes 1 through 10 (CCL1) and bytes 1 through 12 (CCL2) are discussed further in the Request Sense section of this chapter. A description of the bytes returned for this function code are defined in the Return Drive Status Data Format table.

**Table 4-5. Return Drive Status Data Format**

Byte	CCL1 Description	CCL2 Description
0	CCL ID = 1	CCL ID = 2
1	Report flags	Report flags
2	Error code	Error code
3	Tape position	Tape position
4	Byte count (msb)	Reserved
5	Byte count	Byte count (msb)
6	Byte count (lsb)	Byte count
7	Retry count	Byte count
8	Back reference (msb)	Byte count (lsb)
9	Back reference (lsb)	Back reference (msb)
10	Last error	Back reference (lsb)
11	Reserved	Retry count
12	Reserved	Last error
13-16	Reserved	

**Table 4-5. Return Drive Status Data Format (continued)**

Byte	CCL1 Description	CCL2 Description
17	Auxiliary status flags B7-B1 - (reserved) B0 - (Drive is online)	
18	Status area flags B7 - Tape is loaded B6 - Tape is write enabled B5 - Tape format is blocked B4 - Tape format data compressed B3 - Data compression enabled B2 - Media removal enabled B1 - Readheads enabled B0 - Immediate response enabled	
19	Status area - Current tape density 0 - Blank 1 - 800 NRZI 2 - 1600 PE 3 - (reserved) 4 - 6250 GCR 5+ - (reserved) 255 - Unknown	

## Host Set Configuration

Function code 01 (Host Set Configuration) has been added to supported function codes. This will allow the Host to set any drive configuration. Host configuration change procedure is simplified from front panel changes because no passwords are required for locked configurations. To save a configuration in non-volatile RAM requires that configuration 80 (Interface NV change) be set to On (One). The configuration number and the value will be received by the drive in the data out phase. Byte counts allowed are Zero (This is a NOP) and Two. Any other byte count will return Illegal Request. If the configuration number is not supported or the parameter is out of range, the command will be rejected with Illegal Request. A complete description of the supported configurations can be found in the HP 88780 OEM Technical Reference Manual. A description of the bytes sent by the Host for this function code are defined in the Host Set Configuration Data Format table.

**Table 4-6. Host Set Configuration Data Format**

Byte	Description
0	Configuration number 40-80 - Drive specific 81-96 - Interface specific 100-101 - Front panel passwords 120-123 - Data compression specific 140-196 - Configuration locks
1	Configuration parameter (As defined by OEM Technical Manual)

## Identify Firmware Revisions

Function code 02 (identify firmware revisions) would return 20 bytes as defined in the FRU table in the HP 88780 OEM Technical Reference Manual. Additional information will now be appended to this data. The complete description of the returned bytes are shown in the Identify Firmware Revisions Data Format table.

**Table 4-7. Identify Firmware Revisions Data Format**

Byte	Description
0	Identify byte count (1D)
1	Number of controllers
2	Controller One ID*
3	Firmware Version
4	Firmware Revision
5	FRU ID number
6	Controller Two ID*
7	Firmware Version
8	Firmware Revision
9	FRU ID number
10	Controller Three ID*
11	Firmware Version
12	Firmware Revision
13	FRU ID number
14	Controller Four ID*
15	Firmware Version
16	Firmware Revision
17	FRU ID number

**Table 4-7. Identify Firmware Revisions Data Format (continued)**

Byte	Description
18-24	SCSI Option ID (ascii)
25	CCL ID (CCL1=1 CCL2=2)
26	Option available flags B4+ - Reserved B3 - XC Data compression B2 - 6250 GCR B1 - 1600 PE B0 - 800 NRZI
27	Reserved
28	Reserved
29	Reserved

**\*Possible Controllers:**

- ID - Controller Specified
- 3—Drive Controller
- 4—Buffer Controller
- 8—Front Panel Controller
- 15 - Interface Controller (SCSI Single-Ended)
- 16 - Interface Controller (SCSI Differential)

**Interface Memory Dump**

Function code 04H (Memory Dump) has been redefined because of changes in the current version of the CCL1/CCL2 specification. Op code 0F8H (Return Memory) has been deleted. This function code will now only allow a Target Controller Field of 3 (SCSI Interface Controller).

**Return Drive Configuration**

Function code 40H (Return Drive Configuration) has been added to supported function codes. This will allow the Host to return the CURRENT value of any drive configuration. The default configurations (configurations saved in non-volatile RAM) can be returned to the Host with the READ LOG command using the vendor unique page code (00H/10H). A complete description of the data returned for the READ LOG command is documented in the 88780 diagnostic manual in the CONTROLLED AREA OF NON-VOLATILE RAM section of the data structures.

This function will use the Byte count/Parameter field of the command data bytes for the configuration number the Host wishes to return. If the configuration is not supported, the command will be rejected with Illegal Request. If there are back referenced errors pending in the buffer, this command will be rejected (no data transferred) and a check condition status will be returned with the sense key set to the appropriate error. If no errors are pending then any data in the buffer not written to tape will be flushed with a Request Status command that is sent down by the SCSI interface. THIS COMMAND CAN DEGRADE

**4-30 Command Specification**

PERFORMANCE IF USED DURING READ/WRITE OPERATIONS. If the configuration number is valid and no errors are pending, two bytes will be returned in the data phase. A description of the bytes returned to the Host for this function code are defined in the Return Drive Configuration Data Format table.

**Table 4-8. Return Drive Configuration Data Format**

Byte	Description
0	Configuration number 40-80 - Drive specific 81-96 - Interface specific 100-101 - Front panel passwords 140-196 - Configuration locks
1	Current configuration value

### Read Loopback

The Read Loopback will test the functionality of the SCSI bus and control circuitry on the SCSI Interface board. The loopback data always consists of the same data pattern which goes FFH, 00H, 01H, 02H ... FFH, 00H, etc. for the length specified in the byte count field of the CDB up to a maximum of 512 bytes. The loopback data will be sent from the target to the initiator with proper parity. The initiator should determine if the proper data pattern has been received. A byte count of zero will not be considered an error.

### Write Loopback

The Write Loopback will test the functionality of the SCSI bus and control circuitry on the SCSI Interface board. The loopback data consists of the same data pattern which goes FFH, 00H, 01H, 02H ... FFH, 00H, etc. for the length specified in the byte count field of the CDB up to a maximum of 512 bytes. The loopback data will be sent from the initiator to the target. The target will determine if the proper data pattern has been received. A byte count of zero will not be considered an error.

---

## READ REVERSE (0FH)

### Read Reverse

Byte	7	6	5	4	3	2	1	0
0	Operation Code (0FH)							
1	Logical Unit Number			Reserved			SILI	Fixed
2-4	Transfer Length (Byte 2 is the MSB, Byte 4 is the LSB)							
5	Unused		Reserved			Flag	Link	

The READ REVERSE command is not supported by the HP 88780 and will return a CHECK CONDITION with ILLEGAL REQUEST if requested.

## WRITE FILEMARKS (10H)

Write Filemarks

Byte	7	6	5	4	3	2	1	0
0	Operation Code (10H)							
1	Logical Unit Number			Reserved				Immed
2-4	Number of Filemarks (Byte 2 is the MSB, Byte 4 is the LSB)							
5	Unused		Reserved				Flag	Link

The WRITE FILEMARKS command causes the specified number of filemarks to be written beginning at the current logical media position on the tape drive. A zero value in the Number of Filemarks field indicates that no filemarks are to be written. This can be useful to force any buffered write data to be written to the tape.

An immediate bit (Immed) of one indicates that the target will return status as soon as the operation has been initiated. An immediate bit of zero indicates that status will not be returned until the operation has completed.

If the EOT sticker is encountered while writing filemarks, an attempt to finish writing any buffered write data or filemarks will be made.

A WRITE FILEMARKS command may return the following sense keys on a check condition:

**NO SENSE:** The EOM bit will be set once the EOT sticker has been detected on a buffered write. All buffered data will be written to the tape. The valid bit may be set with the information bytes set to a residue when in block mode.

**NOT READY:** Drive is not online.

**MEDIUM ERROR:** The current filemark being written or a previously acknowledged write type of operation experienced an error probably related to the condition of the tape, or the cleanliness of the head. If the tape error occurred on a previously acknowledged write, the Valid bit will be set indicating that the information bytes contain residue information, and the Error Code will be a one indicating a deferred error.

**HARDWARE ERROR:** Either a previously acknowledged write type of operation had a major non-tape related failure or the current write filemark itself experienced the failure. The Valid bit will be set, and the information field will contain the appropriate residue.



**ILLEGAL REQUEST:** If a reserved or unused bit is set, an **ILLEGAL REQUEST** will be returned. If the device is in un-buffered mode and the immediate bit is set to one, the target will return **ILLEGAL REQUEST**.

**UNIT ATTENTION:** If a front panel reset, bus reset, or power fail occurred during the command, a **UNIT ATTENTION** will be present.

**DATA PROTECT:** The write enable ring is not installed.

**ABORTED COMMAND:** If an invalid or inappropriate Message was received during the operation, the operation will be terminated in an indeterminate state and **ABORTED COMMAND** will be returned.

## SPACE (11H)

Space								
Byte	7	6	5	4	3	2	1	0
0	Operation (11H)							
1	Logical Unit Number			Reserved			Code	
2-4	Count (Byte 2 is the MSB; Byte 4 is the LSB)							
5	Unused		Reserved			Flag	Link	

The SPACE command provides a variety of positioning functions that are determined by the code and count. Both forward (toward end-of-tape) and reverse (toward beginning-of-tape) positioning are provided.

The code is defined as follows:

DB(1)	DB(0)	Description
0	0	Blocks
0	1	Filemarks
1	0	Sequential Filemarks
1	1	Logical End-of-Data

When spacing over blocks or filemarks, the count field specifies the number of blocks or filemarks to be spaced over. A positive value N in the count field will cause forward tape movement over N blocks or filemarks ending on the end-of-tape side of the last block or filemark. A zero value in the count field will cause no tape movement. A negative value -N (2's complement notation) in the count field will cause reverse tape movement over N blocks or filemarks ending on the logical beginning-of-tape side of the last block or filemark.

If a filemark is encountered while spacing over blocks, the command will be terminated. The logical position will be located on the end-of-tape side of the filemark if movement was in the forward direction and on the beginning-of-tape side of the filemark if movement was in the reverse direction.

When spacing over sequential filemarks, the count field is interpreted as follows:

- (1) A positive value N will cause forward movement to the first occurrence of N or more consecutive filemarks being logically positioned after the Nth filemark (on the EOT side).
- (2) A zero value will cause no change in the logical position.
- (3) A negative value -N (2's complement notation) will cause reverse movement to the first occurrence of N or more consecutive filemarks being logically positioned on the beginning-of-tape side of the Nth filemark.

When spacing to logical end-of-data, the count field is ignored. Forward movement will occur until the logical unit encounters logical end-of-data. The default end-of-data is defined as the last block or filemark before 25 feet of blank (erased) tape if the tape is positioned before the EOT sticker, and 6 feet if past the sticker. The logical position will be such that a subsequent WRITE command would append data after the logical end-of-data.

A SPACE command may return the following sense keys on a check condition:

**NO SENSE:** If a filemark occurs while spacing over blocks, the filemark and valid bits in extended sense will be set to one. The information bytes will be set to the difference (residue) in the requested count and the actual number of blocks spaced over (not including the filemark).

If beginning-of-tape or load-point is encountered while spacing over blocks or filemarks in the reverse direction, end-of-tape (EOM) bit will be set in extended sense. The valid bit will be set to one and the information bytes will be set to the difference (residue) between the requested count and the actual number of blocks or filemarks spaced over. This value will always be positive.

If the early-warning point (EOT) is encountered during a SPACE command and CONF87=ON, the device will report a CHECK CONDITION status with the EOM bit in the extended sense data set to one. If CONF87=OFF, the target will not report CHECK CONDITION status at the early-warning point. Normally, the target does not report the early-warning condition during a READ type command because data may be present after the early-warning point.

**NOT READY:** Drive is not online.

**MEDIUM ERROR:** A previously acknowledged write type of operation experienced an error probably related to the condition of the tape, or the cleanliness of the head. The Valid bit will be set indicating that the information bytes contain residue information, and the Error Code will be a one indicating a deferred error (if this is supported).

**HARDWARE ERROR:** Either a previously acknowledged write type of operation had a major non-tape related failure or the current space command itself experienced the failure. The Valid bit will be set, and the information field will contain the appropriate residue.

**ILLEGAL REQUEST:** If a reserved or unused bit is set, an ILLEGAL REQUEST will be returned.

**UNIT ATTENTION:** If a front panel reset, bus reset, or power fail occurred during the command, a UNIT ATTENTION will be present.

**BLANK CHECK:** If a blank area on the tape is encountered during a space block or filemark, the sense key will be BLANK CHECK and the valid bit will be set with an appropriate residue.

**ABORTED COMMAND:** If an invalid or inappropriate Message was received during the operation, the operation will be terminated in an indeterminate state and ABORTED COMMAND will be returned.

## INQUIRY (12H)

### Inquiry

Byte	7	6	5	4	3	2	1	0
0	Operation Code (12H)							
1	Logical Unit Number			Reserved				
2	Reserved				Desired Data Format (00)			
3	Reserved							
4	Allocation Length							
5	Unused		Reserved			Flag	Link	

The INQUIRY command requests that information regarding parameters of the target be sent to the initiator.

The desired data format field is unused and must be zero. The data will be returned as shown below in the Inquiry Data Table.

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

The INQUIRY command will return a CHECK CONDITION status only when there is an invalid bit in the CDB.

If an INQUIRY command is received from an initiator with a pending UNIT ATTENTION condition (before the target reports CHECK CONDITION status), the target will perform the INQUIRY command and will not clear the unit attention condition.

### Inquiry Data

Byte	7	6	5	4	3	2	1	0
0	Peripheral Device Type (01)							
1	RMB (1)	Device-Type Qualifier (00)						
2	ISO Version (0)		ECMA Version (0)			ANSI-Approved Version (1)		
3	Reserved				Response Data Format (1)			
4	Additional Length (1FH)							
5	Reserved							
6	Reserved							
7	Reserved							
8-15	Vendor Identification (Byte 8 is MSB, Byte 15 is LSB)							
16-31	Product Identification (Byte 16 is MSB, Byte 31 is LSB)							
32-35	Product Revision Level (Byte 32 is MSB, Byte 35 is LSB)							

The peripheral device type is 01H, a Sequential access device. If a non-zero LUN is sent, this field will be 7FH. The removable medium bit (RMB) will be one indicating that the medium is removable.

The device-type qualifier is a seven-bit user-specified code. This code is set through the front panel. The ISO version and ECMA version fields will be zero, indicating that the 88780 makes no statement about compliance with the ISO and ECMA version of SCSI. The version number is one, indicating the current standard (ANSI X3.131-1986). The additional length will specify the length in bytes of the parameters.

The vendor identification field contains eight bytes of ASCII data identifying the vendor of the product as "HP." The product identification field contains sixteen bytes of ASCII data, "88780" and the option identifiers (ex., H06, H01, etc.). The product revision level field contains four bytes of ASCII data: "A", followed by the SCSI code version and revision levels (ex., A387, A662, etc.).

## VERIFY (13H)

### Verify

Byte	7	6	5	4	3	2	1	0
0	Operation Code (13H)							
1	Logical Unit Number			Reserved		Immed (00)	BytCmp (00)	Fixed
2-4	Verification Length (Byte 2 is the MSB, Byte 4 is the LSB)							
5	Unused		Reserved			Flag	Link	

The VERIFY command verifies one or more block(s) beginning with the next block on the logical unit. The fixed bit specifies both the meaning of the verification length field and whether fixed-length or variable-length block(s) are to be verified. Neither the BytCmp function nor the Immed bit is supported by the 88780.

The verification will be simply a tape verification (CRC, ECC, etc). No data will be transferred between the initiator and target.

A fixed bit set to zero requests that the next block of the logical unit be verified (the verification length specifies the number of bytes that should be in the next block). A fixed bit set to one requests verification length blocks be verified beginning with the next logical block on the logical unit. This form of the VERIFY command is only valid if the logical unit is currently in fixed block mode as defined in the READ command.

The VERIFY command will terminate when the verification length has been satisfied, when a filemark or the physical end-of-tape is encountered, or when an incorrect length is detected. The status and sense data for each of these conditions are handled in the same manner as in the READ command. Upon completion of the VERIFY command, the logical position will be located after the last block from which data was verified or after the filemark, if encountered.

When the verification length is zero, no data will be verified and the current logical position on the logical unit will not be changed.

A VERIFY command may return the following sense keys on a check condition:

**NO SENSE:** If the actual block length is different from the specified transfer length, the incorrect length indicator (ILI) bit and valid bit will be set to one. The information bytes in extended sense will be set to the difference (residue) between the requested length and the actual block length. In blocked mode, the information bytes in the extended sense will be set to the difference (residue) between the requested number of blocks and the actual number of blocks verified.

If the unit reads a filemark during a VERIFY command, it will set the filemark bit. Upon termination, the tape will be logically positioned after the filemark (end-of-tape side). If the fixed bit is one, the valid bit will be one and the information bytes will be set to the difference (residue) between the requested transfer length and the actual number of blocks read (not including the filemark). If the fixed bit is zero, the information bytes will be set to the difference (residue) between the requested transfer length and the actual number of bytes read. Filemarks are considered to have a byte count of zero.

**RECOVERED ERROR:** The current record being verified experienced an error that was recovered using retries or other correction methods. The valid bit and information bytes will be set, and the transaction will halt on the recovered record.

**NOT READY:** Drive is not online.

**MEDIUM ERROR:** The current record being verified or a previously acknowledged write type of operation experienced an error probably related to the condition of the tape, or the cleanliness of the head. The Valid bit will be set indicating that the information bytes contain residue information, and the Error Code will be a one indicating a deferred error (if this is supported).

**HARDWARE ERROR:** Either a previously acknowledged write type of operation had a major non-tape related failure or the verify itself experienced the failure. The Valid bit will be set, and the information field will contain the appropriate residue.

**ILLEGAL REQUEST:** If a reserved or unused bit is set, an ILLEGAL REQUEST will be returned. If the fixed bit does not match the current mode, the target will reject the command with an ILLEGAL REQUEST.

If the BytCmp field is set to one or the Immed bit is set to one, an ILLEGAL REQUEST will be returned.

**UNIT ATTENTION:** If a front panel reset, bus reset, or power fail occurred during the command, a UNIT ATTENTION will be present.

**BLANK CHECK:** If a blank area on the tape is encountered during a verify, the sense key will be BLANK CHECK and the valid bit will be set with an appropriate residue.

**ABORTED COMMAND:** If an invalid or inappropriate Message was received during the operation, the operation will be terminated in an indeterminate state and ABORTED COMMAND will be returned.



## RECOVER BUFFERED DATA (14H)

Recover Buffered Data

Byte	7	6	5	4	3	2	1	0
0	Operation Code (14H)							
1	Logical Unit Number			Reserved				Fixed
2-4	Transfer Length (Byte 2 is the MSB, Byte 4 is the LSB)							
5	Unused		Reserved				Flag	Link

The RECOVER BUFFERED DATA command is used to read data that has been transferred to the data buffer but has not been written onto the tape. It is normally only used to recover from error or exception conditions that make it impossible to write the buffered data.

The order in which block(s) are transferred is the same as if they would have been transferred to the tape. One or more RECOVER BUFFERED DATA commands may be used to read the unwritten buffered data.

Refer to the READ command for a definition of the fixed bit and the transfer length field.

A RECOVER BUFFERED DATA command may return the following sense keys on a check condition:

**NO SENSE:** If the actual block length is different from the specified transfer length, the incorrect length indicator (ILI) bit and valid bit will be set to one. The information bytes in extended sense will be set to the difference (residue) between the requested length and the actual block length. In blocked mode, the information bytes in extended sense will be set to the difference (residue) between the requested number of blocks and the actual number of blocks verified.

If the unit reads a filemark during a RECOVER BUFFERED DATA command, it will set the filemark bit. Upon termination, the buffer will be logically positioned after the filemark (end-of-tape side). If the fixed bit is one, the valid bit will be one and the information bytes will be set to the difference (residue) between the requested transfer length and the actual number of blocks read (not including the filemark). If the fixed bit is zero, the information bytes will be set to the difference (residue) between the requested transfer length and the actual number of bytes read.

If an attempt is made to recover more logical blocks of data than are contained in the buffer, the EOM bit in extended sense will be set to one. If the fixed bit is set to one, the valid bit will be set to one and the information bytes will be set to the difference (residue) between the requested transfer length and the actual number of blocks transferred.

Data can not be recovered when the tape format is compressed (XC on). Because information required to uncompress data may already be written to tape, it is not possible at this time for this data to be returned to the Host.

**ILLEGAL REQUEST:** If a reserved or unused bit is set, an **ILLEGAL REQUEST** will be returned. If the fixed bit does not match the current mode, the target will reject the command with an **ILLEGAL REQUEST** .

**UNIT ATTENTION:** If a front panel reset, bus reset, or power fail occurred during the command, a **UNIT ATTENTION** will be present.

**ABORTED COMMAND:** If an invalid or inappropriate Message was received during the operation, the operation will be terminated in an indeterminate state and **ABORTED COMMAND** will be returned.

## MODE SELECT (15H)

Mode Select

Byte	7	6	5	4	3	2	1	0
0	Operation Code (15H)							
1	Logical Unit Number			PF	Reserved			SP
2	Reserved							
3	Reserved							
4	Parameter List Length							
5	Unused		Reserved			Flag	Link	

The MODE SELECT command provides a means by which the initiator can specify tape, logical unit, or peripheral device parameters to the tape drive.

The save parameters (SP) bit and the format bit (PF) are not supported.

The parameter list length specifies the length in bytes of the MODE SELECT parameter list that will be transferred during the DATA OUT phase. A zero parameter list length indicates that no data will be transferred. These values must fall on header or block descriptor boundaries. Valid values are 0H, 04, and 0CH.

The MODE SELECT parameter list shown below contains a four-byte header, followed by one eight-byte block descriptor.

### MODE SELECT Parameter List

Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	Reserved							
2	Reserved	Buffered Mode			Speed			
3	Block Descriptor Length (08H)							
BLOCK DESCRIPTOR								
0	Density Code							
1-3	Number of Blocks (00H) (Byte 1, bit 7 is the MSB; Byte 3, bit 0 is the LSB)							
4	Reserved							
5-7	Block Length (Byte 5, bit 7 is the MSB; Byte 7, bit 0 is the LSB)							

A buffered mode of zero indicates that the target will not report a GOOD status on WRITE commands until the data blocks are actually written on the tape. A buffered mode of one indicates that the target may report a GOOD status on WRITE commands as soon as the data block has been transferred to the buffer. One or more blocks may be buffered prior to writing the block(s) to the tape.

The speed field may be any value as there is only one available speed. The selected speed will also be returned on a mode sense.

The block descriptor length specifies the length in bytes of all the block descriptors. As there is only one block descriptor allowed, this value must be eight or zero. A block descriptor length of zero indicates that no block descriptors are included in the parameter list.

Each block descriptor specifies the tape characteristics for the tape drive. The block descriptor contains the density code, number of blocks and block length fields.

Supported values for the density code field are defined in the following table.

**Table 4-9. Density Codes Supported**

Code Value	Width	Density		ANSI Ref		
	mm (inch)	Tracks	bpmm	bpi	Code	Standard Note
00H	Default (6250 GCR for the 88780, 1600 PE for the 88779A)					
01H	12.7 (0.5)	9	31	(800)	NRZI	
02H	12.7 (0.5)	9	63	(1,600)	PE	X3.39-1986 1
03H	12.7 (0.5)	9	246	(6,250)	GCR	X3.54-1986 1
7FH	No change from previous density (NO-OP) •					
0C3H	Compressed 6250 (available only with XC option)					
083H	Uncompressed 6250 (available only with XC option)					

#### KEY FOR NOTE COLUMN

1 - Parallel Recorded.

If Block Length is zero, then the drive is in Variable Mode and the blocks written on tape will be the same size as the transferred records. If Block Length is non-zero, then the drive is in Fixed Mode and the transferred records must be exactly the length indicated by the Block Length.

#### VENDOR UNIQUE DENSITY

Rev 6.30+ code has the addition of two new modeselect densities (0C3H is Compressed 6250 and 083H Uncompressed is 6250) and the ability for these to be selected from the front panel (Configuration 47 values XC OFF, XC ON, IXC OFF, IXC OFF). Configuration 91 will define if these densities will be returned in the modesense density byte. If Configuration 91 has the value of On, Host selection of 003H, 083H or 0C3H combined with the front panel selection or the default value of Configuration 47 will determine if Bits 6-7 of the modesense density byte are set. This will allow the Host to determine what is actually being written to tape independent of the modeselect. (For example, the Host does a modeselect with density byte having the value of 03H. Configuration 47 is set to XC ON. A modesense will return a density byte of 0C3H meaning 6250 with data compression enabled). If Configuration 91 has the value of Off, Bits 6-7 of the modesense density byte will always be zero. It should be noted that any front panel density change done after the Host modeselect will override the modeselect and the values returned in the modesense.

## RESERVE UNIT AND RELEASE UNIT COMMANDS (16H and 17H)

Reserve Unit and Release Unit Commands

Byte	7	6	5	4	3	2	1	0
0	Operation Code (16H & 17H)							
1	Logical Unit Number			3rdPty	Third Party Device ID			Reserved
2	Reserved							
3	Reserved							
4	Reserved							
5	Unused		Reserved			Flag	Link	

### Reserve Unit

The RESERVE UNIT command (operation code 16H) will reserve the specified logical unit for the exclusive use by the requesting initiator or to another specified SCSI device.

The reservation will remain in effect until superseded by another RESERVE UNIT command from the initiator that made the reservation or until released by a RELEASE UNIT command from the same initiator, a BUS DEVICE RESET message from any initiator, or a "hard" RESET condition. The occurrence of the last two conditions is indicated by a sense key of UNIT ATTENTION on the next command following the condition. It is not an error to issue this command to a logical unit that is currently reserved to the requesting initiator.

If the logical unit is previously reserved by another initiator, then the target will return a RESERVATION CONFLICT status.

If, after honoring the reservation, any other initiator attempts to perform any command other than INQUIRY, REQUEST SENSE, or RELEASE UNIT, the command will be rejected with a RESERVATION CONFLICT status. A RELEASE UNIT command issued by another initiator will be ignored by that reserved logical unit.

The third-party reservation option for the RESERVE UNIT command allows an initiator to reserve a logical unit for another SCSI device. This option is intended for use in multiple-initiator systems that use the COPY command. The 88780 implements both the third-party reservation option and the third-party release option.

If the third-party (3rdPty) bit is zero, then the third-party reservation option is not requested. If the 3rdPty bit is one, the RESERVE UNIT command will reserve the specified logical unit for the SCSI device specified in the third-party device ID field. The target will preserve the reservation until superseded by another RESERVE UNIT command from the initiator that made the reservation or until released by the same initiator, by a BUS DEVICE RESET message from any initiator, or by a "hard" RESET condition. The target will ignore (i.e., return GOOD status) any attempt made by any other initiator to release the reservation.

An initiator that holds a current reservation may modify that reservation (e.g., switch third-parties) by issuing another RESERVE UNIT command to the same logical unit. The superseding RESERVE UNIT command will release the previous reservation state only when the new reservation is granted. A superseding reservation takes priority over any previously queued reservation request.

### **Release Unit**

The RELEASE UNIT command (operation code 17H) will release the logical unit if it is currently reserved by the requesting initiator.

It is not an error to attempt to release a logical unit that is not currently reserved to the requesting initiator, but it will not be released.

The third-party release option for the RELEASE UNIT command allows an initiator to release a logical unit that was previously reserved using the third-party reservation option.

If the third-party (3rdPty) bit is zero, then the third-party release option is not requested. If the 3rdPty bit is one, then the target will release the specified logical unit, but only if the reservation was made using the third-party reservation option by the initiator that is requesting the release. It must be for the same SCSI device as specified in the third-party device ID field.

## ERASE (19H)

Erase								
Byte	7	6	5	4	3	2	1	0
0	Operation Code (19H)							
1	Logical Unit Number			Reserved			Immed	Long
2	Reserved							
3	Reserved							
4	Reserved							
5	Unused		Reserved			Flag	Link	

The ERASE command causes part or all of the remaining tape to be erased beginning from the current logical position.

An immediate bit (Immed) set to zero indicates that the target will not return status until the selected operation has completed. An Immed bit set to one indicates that status will be returned as soon as the operation has been initiated.

The distance to be erased is controlled by the Long bit. A long bit of one indicates that all remaining tape on the logical unit will be erased. A long bit of zero specifies a short erase length. The erased gap will be 2 inches long. Normally, short erases are used to create an extended gap for software controlled error recovery or for support of "update in-place" functions.

An ERASE command may return the following sense keys on a check condition:

**NO SENSE:** The EOM bit will be set once the EOT sticker has been detected on a short erase. All buffered data gaps will be written to the tape, therefore the valid bit will be set but the information bytes will be zero.

**NOT READY:** Drive is not online.

**MEDIUM ERROR:** A previously acknowledged write type of operation experienced an error probably related to the condition of the tape, or the cleanliness of the head. The Valid bit will be set indicating that the information bytes contain residue information, and the Error Code will be a one indicating a deferred error.

**HARDWARE ERROR:** Either a previously acknowledged write type of operation had a major non-tape related failure or the current erase itself experienced the failure. The Valid bit will be set, and the information field will contain the appropriate residue.

**ILLEGAL REQUEST:** If a reserved or unused bit is set, an ILLEGAL REQUEST will be returned.



**UNIT ATTENTION:** If a front panel reset, bus reset, or power fail occurred during the command, a **UNIT ATTENTION** will be present.

**DATA PROTECT:** The write enable ring is not installed.

**ABORTED COMMAND:** If an invalid or inappropriate Message was received during the operation, the operation will be terminated in an indeterminate state and **ABORTED COMMAND** will be returned.

## MODE SENSE (1AH)

Mode Sense

Byte	7	6	5	4	3	2	1	0
0	Operation Code (1AH)							
1	Logical Unit Number			Reserved				
2	PC		Page Code (00H)					
3	Reserved							
4	Allocation Length							
5	Unused		Reserved				Flag	Link

The MODE SENSE command provides a means for a target to report its tape, logical unit, or peripheral device parameters to the initiator. It is a complementary command to the MODE SELECT command.

The Page Code field and Page Control field (PC) are not supported. If the page code is NOT zero, then CHECK CONDITION status will be returned with a sense key of ILLEGAL REQUEST.

The Allocation Length field specifies the number of bytes that the initiator has allocated for returned MODE SENSE data. An allocation length of zero indicates that no MODE SENSE data will be transferred. Any other value indicates the maximum number of bytes that will be transferred. The target will terminate the DATA IN phase when allocation length bytes have been transferred or when all available MODE SENSE data have been transferred to the initiator, whichever is less. The allocation length must fall on header or block descriptor boundaries or it will be considered an error. Valid values are 0H, 04H, and 0CH or larger.

The MODE SENSE data contains a four-byte header, followed by one eight-byte block descriptor.

**MODE SENSE Data**

Byte	7	6	5	4	3	2	1	0
0	Sense Data Length							
1	00 (Media Type)							
2	WP	Buffered Mode			Speed			
3	Block Descriptor Length							
<b>BLOCK DESCRIPTOR</b>								
0	Density Code							
1-3	Number of Blocks (00H) (Byte 1 is the MSB, Byte 3 is LSB)							
4	Reserved							
5-7	Block Length(MSB is Byte 5, LSB is Byte 7)							

The supported Density Codes are described in the Density Codes Supported Table in the Mode Select section of this chapter.

The Sense Data Length field specifies the length in bytes of the following mode sense data that is available to be transferred during the DATA IN phase. The sense data length does not include itself.

The media value will be zero; only one media is supported.

A write protected (WP) bit of zero indicates that the write ring is in place. A write protected bit of one indicates that the tape is write protected.

A buffered mode of zero indicates that the target does not report a GOOD status on WRITE commands until the data blocks are actually written on the tape. A buffered mode of one indicates that the target may report a GOOD status on WRITE commands as soon as the data block has been transferred to the target's buffer. One or more blocks may be buffered prior to writing the block(s) to the tape.

The Speed field will be zero, only one speed is supported, or the last value selected by a MODE SELECT command.

The block descriptor length specifies the length in bytes of the block descriptor (eight).

Values for the Density Code field are defined in the MODE SELECT description. The density code 7FH is reserved for MODE SELECT only.

The Number of Blocks field will be zero, indicating that an unspecified (or unknown) number of the remaining logical blocks of the logical unit may have the tape characteristics specified by the block descriptor.

The block length specifies the length in bytes of each logical block described by the block descriptor. A block length of zero indicates that the length is variable.

## LOAD/UNLOAD (1BH)

### Load/Unload

Byte	7	6	5	4	3	2	1	0
0	Operation Code (1BH)							
1	Logical Unit Number			Reserved				Immed
2	Reserved							
3	Reserved							
4	Reserved						RETen (0)	Load
5	Unused		Reserved				Flag	Link

The LOAD/UNLOAD command requests that the target enable or disable the logical unit for further operations.

A load bit of one indicates that the tape on the logical unit will be loaded and positioned to the beginning-of-tape or load-point as determined by the peripheral device. A load bit of zero indicates that the tape on the logical unit will be positioned for removal from the peripheral device. Prior to the device performing the unload operation, the target controller will force any buffered data to be written to the tape.

Status will be returned after the tape is positioned for a LOAD . For an UNLOAD , status will be returned after the tape is positioned unless the immediate (Immed) bit is one. If the Immed bit is one, status will be returned as soon as the operation has been initiated. An Immed bit of one has no effect on a LOAD.

The RETen bit should always be zero as re-tensioning is unnecessary and unsupported.

A LOAD/UNLOAD command may return the following sense keys on a check condition:

**NOT READY:** Drive is not online for an unload command

**MEDIUM ERROR:** A previously acknowledged write type of operation experienced an error probably related to the condition of the tape, or the cleanliness of the head. The Valid bit will be set, indicating that the information bytes contain residue information, and the Error Code will be a one indicating a deferred error (if this is supported).

**HARDWARE ERROR:** Either a previously acknowledged write type of operation had a major non-tape related failure or the current operation itself experienced the failure. The Valid bit will be set if it was a previously acknowledged write, and the information field will contain the appropriate residue.

**ILLEGAL REQUEST:** If a reserved or unused bit is set, an ILLEGAL REQUEST will be returned.

**UNIT ATTENTION:** If a front panel reset, bus reset, or power fail occurred during the operation, a **UNIT ATTENTION** will be present.

**ABORTED COMMAND:** If an invalid or inappropriate Message was received during the operation, the operation will be terminated in an indeterminate state and **ABORTED COMMAND** will be returned.

## RECEIVE DIAGNOSTIC RESULTS (1CH)

Receive Diagnostic Results

Byte	7	6	5	4	3	2	1	0
0	Operation Code (1CH)							
1	Logical Unit Number			Reserved				
2	Reserved							
3-4	Allocation Length (Byte 3 is the MSB, Byte 4 is the LSB)							
5	Unused		Reserved				Flag	Link

The RECEIVE DIAGNOSTIC RESULTS command requests analysis data be sent to the initiator after completion of a SEND DIAGNOSTIC command.

The Allocation Length field will specify the number of bytes that the initiator has allocated for returned diagnostic data. An allocation length of zero indicates that no diagnostic data will be transferred. Any other value indicates the maximum number of bytes that will be transferred. The target terminates the DATA IN phase when allocation length bytes have been transferred or when all available diagnostic data have been transferred to the initiator, whichever is less.

Format for Diagnostic Results

Byte	7	6	5	4	3	2	1	0
0	Power-on Error	Time Resync	Reserved		Error Set			
1	Error Code							
2	FRU 1							
3	FRU 2							
4	Test Number							

### Error Set Definitions:

- 0 - Runtime Error
- 3 - Drive Controller Diagnostic Error
- 4 - Buffer Controller Diagnostic Error
- 6 - Interface Controller Diagnostic Error
- C - Multiprocessor errors (Loopback and DPR)
- F - Operational Status (for internal use, not logged)

## SEND DIAGNOSTIC (1DH)

### Send Diagnostic

Byte	7	6	5	4	3	2	1	0
0	Operation Code (1DH)							
1	Logical Unit Number			Reserved		Selftest	DevOff	UnitOff
2	Reserved							
3-4	Parameter List Length (Byte 3 is the MSB, Byte 4 is the LSB)							
5	Unused		Reserved			Flag	Link	

The SEND DIAGNOSTIC command requests the target to perform diagnostic tests on itself, on the attached peripheral devices, or on both. The only mandatory implementation of this command is the self test (SelfTest) feature. This command is usually followed by a RECEIVE DIAGNOSTIC RESULTS command, except when the self-test bit is set to one.

### Diagnostic Parameter List

Byte	7	6	5	4	3	2	1	0
0	Test Number							
1	Loop Count Identifier							
2	Optional Test Specific Parameter A							
3	Optional Test Specific Parameter B							
4	Optional Test Specific Parameter C							

#### Loop Count Identifier:

- 1 - Run once
- 2 - Run ten times
- 3 - Run one hundred times
- 4 - Run one thousand times
- 0 - Infinite looping



## PREVENT/ALLOW MEDIA REMOVAL (1EH)

Prevent/Allow Media Removal

Byte	7	6	5	4	3	2	1	0
0	Operation Code (1EH)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							Prevent
5	Unused		Reserved			Flag	Link	

The PREVENT/ALLOW MEDIUM REMOVAL command requests that the target enable or disable the removal of the tape from the logical unit.

A prevent bit of one will prevent the door from opening on an unload from the initiator or on an UNLOAD key-press from the front panel. A prevent bit of zero will allow removal of the tape.

This prevention of tape removal condition will terminate upon receipt of a PREVENT/ALLOW MEDIUM REMOVAL command with the prevent bit set to zero, or by the receipt of a BUS DEVICE RESET message from any initiator or by a "hard" RESET condition. It may also be disabled by a front panel command.

A PREVENT/ALLOW MEDIUM REMOVAL command may return the following sense keys on a check condition:

**MEDIUM ERROR:** A previously acknowledged write type of operation experienced an error probably related to the condition of the tape, or the cleanliness of the head. The Valid bit will be set indicating that the information bytes contain residue information. The Error Code will be a one indicating a deferred error (if this is supported).

**HARDWARE ERROR:** A previously acknowledged write type of operation had a major non-tape related failure. The Valid bit will be set and the information field will contain the appropriate residue.

**ILLEGAL REQUEST:** If a reserved or unused bit is set, an ILLEGAL REQUEST will be returned.

**UNIT ATTENTION:** If a front panel reset, bus reset, or power fail occurred during the operation, a UNIT ATTENTION will be present.

**ABORTED COMMAND:** If an invalid or inappropriate Message was received during the operation, the operation will be terminated in an indeterminate state and ABORTED COMMAND will be returned.

## READ LOG (vendor unique) (4FH)

### Read Log (vendor unique)

Byte	7	6	5	4	3	2	1	0
0	Operation Code (1FH)							
1	Logical Unit Number			Reserved			NLR	
2	Page Code							
3-4	Allocation Length (Byte 3 is the MSB, Byte 4 is the LSB)							
5	Unused		Reserved			Flag		Link

The READ LOG command is used to obtain statistical information maintained by the device about the device or the installed tape.

The No Log Reset bit (NLR) set to one causes any log data to be transferred but not cleared. When this bit is set to zero, the log is reset after the data has been transferred. If the allocation length is zero and the NLR bit is zero, the log will reset with no data transferred.

The page code determines what type of statistical information is being requested. The page code definitions are as follows:

**Table 4-10. Page Code Parameter Description**

Page Code		Log Type	Total Length (in Bytes)	
CCL1	CCL2		CCL1	CCL2
00	10	Vendor Unique Log (Controlled Area of NVR)	277	307
01	11	Device Specific Log (Error Log)	537	386
02	12	Media Specific Log (Error Rate Log)	320	588
3F	1F	All Logs	1134	1281

Note that the data returned by the drive varies in length depending upon the page code value in the READ LOG command. The data returned includes a 3-byte header, preceding the log information. The returned data format is as follows:

Byte	7	6	5	4	3	2	1	0
0	Page Code							
1	(MSB) Additional Page Length							
2	Additional Page Length (LSB)							
3-n	Vendor-Unique Bytes							

The format of the logs are defined as follows:

**Table 4-11. Device Specific Log (Error Log)**

FRU = 4		FRU <> 4		Description
Byte #	LEN	Byte #	LEN	
0	1	0	1	Index of last entry made in log (0..29)
1	1	1	1	Number of entries in log (0..30)
2	1	2	1	Currently displayed log (0..29)
***	0	3	1	Entries log since poweron (if non zero)
3-273	270			30 error log entries*, 9 bytes each
		4-303	300	30 error log entries*, 10 bytes each
274	4	304	4	Current time stamp in 1/20 second increments (3.85 and later firmware only)

**Table 4-12. \* Error Log Entries**

FRU = 4		FRU <> 4		Description
Byte #	LEN	Byte #	LEN	
0-4	5	0-4	5	Diagnostic error message
***	0	5	1	(reserved)
5-8	4	6-9	4	Time stamp in 1/20 second increments

**Table 4-13. Media Specific Log (Error Rate Log)**

FRU = 4		FRU<>4		Description
Byte #	LEN	Byte #	LEN	
0	1	0	1	Index of last entry made in log (0..19)
1	1	1	1	Number of entries in log (0..20)
2	1	2	1	Currently displayed log (0..29)
3	1	3	1	Density of current tape
4-5	2	4-5	2	Current write hard errors
6-7	2	6-7	2	Current write soft errors
8-12	5			Currently write data (in 256 byte increments)
		8-13	6	Currently write data
13-14	2	14-15	2	Current read hard errors
15-16	2	16-17	2	Current read soft errors
17-21	5			Currently read data (in 256 byte increments)
		18-23	6	Currently read data
22-281	260			20 error rate log entries*1*, 13 bytes each
		24-343	300	20 error rate log entries*1*, 16 bytes each
282-299	18			GCR cumulative error rate log*2* (INFO 3)
		344-363	20	GCR cumulative error rate log*2* (INFO 3)
300-317	18			PE cumulative error rate log*2* (INFO 4)
		364-383	20	PE/NRZI cumulative error rate log (INFO 4)

**Table 4-14. \*1\* Error Rate Log Entry (INFO 1)**

FRU = 4		FRU<>4		Error Rate Log Entry
Byte #	LEN	Byte #	LEN	
0	1	0	1	Density ( 1=NRZI, 2=PE, 4=GCR )
1	1	1	1	Write hard errors
2-3	2	2-3	2	Write soft errors
4-6	3			Write data (in 256 byte increments)
		4-7	4	Write data
***		8	1	(reserved)
7	1	9	1	Read hard errors
8-9	2	10-11	2	Read soft errors
10-12	3			Read data (in 256 byte increments)
		12-15	4	Read data

**Table 4-15. \*2\* Cumulative Error Rate Log Entry**

FRU = 4		FRU<>4		Description
Byte #	LEN	Byte #	LEN	
0-1	2	0-1	2	Write hard errors
2-3	2	2-3	2	Write soft errors
4-8	5			Write data (in 256 byte increments)
		4-9	6	Write data
9-10	2	10-11	2	Read hard errors
11-12	2	12-13	2	Read soft errors
13-17	5			Read data (in 256 byte increments)
		14-19	6	Read data

**Table 4-16. Controlled Area of Non-Volatile RAM (Vendor Unique Log)**

FRU = 4		FRU<>4		Description
Byte #	LEN	Byte #	LEN	
0	1			(reserved)
1-6	6	0-5	6	Odometer in 0.1 foot increments (INFO 10)
7-8	2	6-7	2	Number of power cycles (INFO 13)
9	1	8	1	Current interface FRU number
		9	1	(reserved)
10-49	40	10-49	40	Info/config 0-39
50-106	57	50-106	57	Configurations 40-96
107-149	43	107-149	43	Special (internal) configurations 97-139
150-206	57			Configurations 140-196 (locks for 40-96)
		150-207	58	Configurations 140-197 (locks for 40-97)
207-208	2			used length of interface global area 0 and 1
		208	1	used length of interface global area 0
		209	1	(reserved)
209-248	40	210-249	40	interface global area 0
		250	1	used length of interface global area 1
		251	1	(reserved)
249-288	40	252-291	40	interface global area 1
289-294	6			used length of drive global areas 0 .. 5
295-534	240			drive global areas 0 .. 5 (40 bytes each)
		292-585	294	drive global areas 0 .. 6 (42 bytes each)
				with each area beginning with a length byte followed by a reserved byte.

## LOCATE (2BH)

### Locate

Byte	7	6	5	4	3	2	1	0
0	Operation Code (2BH)							
1	Logical Unit Number			Reserved		BT	CP	Immed
2	Reserved							
3-6	Logical Block Address (Byte 37 is the MSB, Byte 6 is the LSB)							
7	Reserved							
8	Partition							
9	Unused		Reserved			Flag	Link	

The LOCATE command is not supported by the 88780 and will return a CHECK CONDITION with ILLEGAL REQUEST if requested.

## READ POSITION (34H)

Read Position

Byte	7	6	5	4	3	2	1	0
0	Operation Code (34H)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
8	Reserved							
9	Unused		Reserved				Flag	Link

The READ POSITION command is not supported by the 88780 and will return a CHECK CONDITION with ILLEGAL REQUEST if requested.



## COMPARE (39H)

### Compare

Byte	7	6	5	4	3	2	1	0
0	Operation Code (39H)							
1	Logical Unit Number			Reserved				Pad
2	Reserved							
3-5	Parameter List Length (Byte 3 is the MSB, Byte 5 is the LSB)							
6	Reserved							
7	Reserved							
8	Reserved							
9	Unused		Reserved				Flag	Link

The COMPARE command is not supported by the 88780 and will return a CHECK CONDITION with ILLEGAL REQUEST if requested.

## COPY AND VERIFY (3AH)

### Copy and Verify

Byte	7	6	5	4	3	2	1	0
0	Operation Code (3AH)							
1	Logical Unit Number			Reserved			BytCHK	Pad
2	Reserved							
3-5	Parameter List Length (Byte 3 is the MSB, Byte 5 is the LSB)							
6	Reserved							
7	Reserved							
8	Reserved							
9	Unused		Reserved			Flag	Link	

The COPY AND VERIFY command is unsupported and will return a CHECK CONDITION with ILLEGAL REQUEST if requested.

## WRITE BUFFER (3BH)

Write Buffer

Byte	7	6	5	4	3	2	1	0
0	Operation Code (3BH)							
1	Logical Unit Number			Reserved			0 (Mode)	
2	Buffer ID (0)							
3-5	Buffer Offset (0) (Byte 3 is the MSB, Byte 5 is the LSB)							
6-8	Transfer Length (Byte 6 is the MSB, Byte 8 is the LSB)							
9	Unused		Reserved				Flag	Link

The WRITE BUFFER command is used in conjunction with the READ BUFFER command as a diagnostic function for testing target memory and the SCSI bus integrity. This command will not alter the tape.

The mode field must be zero, indicating a combined header and data format. In this mode, data to be transferred is preceded by a four-byte header. The four-byte header consists of all reserved bytes (all 00H). The buffer ID and the buffer offset are zero. The transfer length specifies the maximum number of bytes that will be transferred during the DATA OUT phase. This number includes four bytes of header, so the data length to be stored in the target's buffer is transfer length minus four. The initiator should attempt to ensure that the transfer length is not greater than four plus the available length that is returned in the header of the READ BUFFER command (0FFFFH).

A WRITE BUFFER command may return the following sense keys on a check condition:

**MEDIUM ERROR:** A previously acknowledged write type of operation experienced an error probably related to the condition of the tape, or the cleanliness of the head. The Valid bit will be set indicating that the information bytes contain residue information, and the Error Code will be a one indicating a deferred error (if this is supported).

**HARDWARE ERROR:** Either a previously acknowledged write type of operation had a major non-tape related failure or the current write buffer itself experienced the failure. The Valid bit will be set, and the information field will contain the appropriate residue.

**ILLEGAL REQUEST:** If a reserved or unused bit is set, an illegal request will be returned. If the transfer length exceeds the available length plus four, the target will return ILLEGAL REQUEST.

**UNIT ATTENTION:** If a front panel reset, bus reset, or power fail occurred during the command, a UNIT ATTENTION will be present.

**ABORTED COMMAND:** If an invalid or inappropriate Message was received during the operation, the operation will be terminated in an indeterminate state and ABORTED COMMAND will be returned.

## READ BUFFER (3CH)

Read Buffer

Byte	7	6	5	4	3	2	1	0
0	Operation Code (3CH)							
1	Logical Unit Number			Reserved			Mode (0)	
2	Buffer ID (0)							
3-5	Buffer Offset (0) (Byte 3 is the MSB, Byte 5 is the LSB)							
6-8	Allocation Length (Byte 6 is the MSB, Byte 8 is the LSB)							
9	Unused		Reserved				Flag	Link

The READ BUFFER command is used in conjunction with the WRITE BUFFER command as a diagnostic function for testing target memory and the SCSI bus integrity. This command will not alter the tape.

The mode field must be zero, indicating a combined header and data format. 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 are reserved. The allocation length specifies the maximum number of bytes that the initiator has allocated for returned header and data. An allocation length of zero indicates that no header or data will be transferred. Any other value indicates the maximum number of bytes that will be transferred. The target terminates the DATA IN phase when allocation length bytes of header plus data have been transferred or when all available header and data have been transferred to the initiator, whichever is less. The four-byte READ BUFFER header is followed by data bytes from the target's data buffer.

### READ BUFFER Header

Byte	7	6	5	4	3	2	1	0
0	Reserved							
1-3	Available Length (00FFFCH) (Byte 1 is the MSB, Byte 3 is the LSB)							

The available length specifies the total number of data bytes that are available in the target'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 target will transfer data from its data buffer. The number of data bytes transferred following the READ BUFFER header will be the lesser of allocation length minus four or available length.

A READ BUFFER command may return the following sense keys on a check condition:

**MEDIUM ERROR:** A previously acknowledged write type of operation experienced an error probably related to the condition of the tape, or the cleanliness of the head. The Valid bit will be set, indicating that the information bytes contain residue information, and the Error Code will be a one indicating a deferred error (if this is supported).

**HARDWARE ERROR:** Either a previously acknowledged write type of operation had a major non-tape related failure or the current write buffer itself experienced the failure. The Valid bit will be set, and the information field will contain the appropriate residue.

**ILLEGAL REQUEST:** If a reserved or unused bit is set, an illegal request will be returned.

**UNIT ATTENTION:** If a front panel reset, bus reset, or power fail occurred during the command, a UNIT ATTENTION will be present.

**ABORTED COMMAND:** If an invalid or inappropriate message was received during the operation, the operation will be terminated in an indeterminate state and ABORTED COMMAND will be returned.

## COPY (18H)

### Copy

Byte	7	6	5	4	3	2	1	0
0	Operation Code (18H)							
1	Logical Unit Number			Reserved				Pad
2-4	Parameter List Length (Byte 2 is the MSB, Byte 4 is the LSB)							
5	Vendor Unique		Reserved				Flag	Link

### Introduction

This section discusses the operation and features of the SCSI COPY command. SCSI commands are shown in **BOLD** text.

The purpose of this section is to provide the user integrating the COPY command on a host system with the 88780 as the Copy Manager with a working knowledge of the supported copy functions, as well as a reference of the 88780's error handling and error reporting. The ANSI document X3T9.2/86-109 is the design center for the 88780 implementation of the COPY command. This standard indicates the function to be performed by the command without specifying the implementation method. Quoting the Standard, "The COPY command ... provides a means to copy data from one logical unit to another or the same logical unit." The ANSI standard discusses five types of copy functions:

- Sequential Access Devices to Direct Access Devices
- Direct Access Devices to Sequential Access Devices
- Direct Access Devices to Direct Access Devices
- Sequential Access Devices to Sequential Access Devices
- Image Copy

Hereafter, the terms "disk" or "disk drive" will be understood to refer to a Direct Access Device, and the terms "tape" or "tape drive" will be understood to refer to a Sequential Access Device.

## Commands Used During Copy

The COPY command for the HP 88780 will be implemented for Direct Access devices supporting the document known as Common Command Set (CCS) Revision 4B. It will also be implemented for Sequential Access devices supporting the ANSI document X3.131-1986. The commands used by the Copy Manager are shown below, and the command block descriptions for each command are included at the end of this section.

TARGET	COMMAND
Copy Manager	COPY command (Opcode 18H) (as a target)
All Devices	INQUIRY command (Opcode 12H) - To verify device type of the target.  REQUEST SENSE command (Opcode 03H) - In order to pass target's sense bytes back to the Copy Host.
Direct Access	READ CAPACITY command (Opcode 25H) - To verify block size compatibility.  READ command (Opcode 28H) - To read a given number of blocks from a disk drive.  WRITE command (Opcode 2AH) - To write a given number of blocks on a disk drive.
Sequential Access	MODE SENSE command (Opcode 1AH) - To verify device's reported block size with size given in copy segment.  READ command (Opcode 08H) - To read a given number of blocks or data bytes from a tape drive. WRITE command (Opcode 0AH) - To write a given number of blocks or data bytes on a tape drive.

## Supported Fields in the Copy Command

### Copy Command Block

Within the command block itself, the HP 88780 supports all fields and bits with the exception of the PAD bit. It is the job of the Copy Host to configure the source and destination devices so that the padding function is not necessary. If the PAD bit is set, the Copy Operation is terminated with a Check Condition/Illegal Request status. For operation recommendations, refer to the block mode discussion in "Front Panel/Mode Select Configurations" later in this section.

### Parameter List

Within the parameter list, the Copy Manager supports copying from a disk to the 88780 and from the 88780 to a disk. The copy function codes for these capabilities are 0 and 1 respectively. As implied above, the 88780 will not support what is known as "Third Party" copies where neither logical unit is attached to the 88780. It also does not support tape to tape copies. This obviously precludes controlling Direct Access to Direct Access copies, which is copy function code 2. The Image Copy, copy function code 4, is also not supported due to its redundancy and ambiguous definition. The priority field may be set to any value, but will have no effect on the transaction. There are no vendor unique functions at this time, so the vendor unique field may be any value.

### Segment Descriptors

Within each segment descriptor, having the CAT bit set is not allowed (see handling of the PAD bit above). For accesses to an 88780, the LUN field must be set to zero. The block length will depend on the drives involved. However, the tape block lengths given in the segment descriptor must meet two criteria.

The block length specified within the segment descriptor must equal the block length returned by a MODE SENSE command to the 88780, which will be compared internally.

Given that criterion 1 has been met, the block lengths of the source and destination devices will be checked for compatibility. For a more detailed description of this, refer to "Operation" later in this section.

### Integration

It is the system integrator's responsibility to verify operation of the COPY command on their system and with the disk and tape drives they are using. Hewlett-Packard has verified correct operation of the 88780 tape drive with the following Hewlett-Packard equipment during the development cycle of the HP 88780 Copy Function:

7936/37S 8-inch SCSI Disk Drive

9753XS 5 1/4-inch SCSI Disk Drive

97504 3 1/2-inch SCSI Disk Drive and Controller



## Front Panel/Mode Select Configurations

The HP 88780 can be configured prior to a COPY command in any way that is allowable in a normal read/write operation. This includes reading or writing in both Variable and Fixed Block modes, as well as such front panel configurations as setting the Bus Inactivity Limit, the Gap Size, etc. Specific recommendations for settings are described below.

Front panel configurations 40 through 79 may be set as the Copy Host prefers, with the exception of configuration 50 (enable Immediate Response mode) which should be On for performance reasons. Immediate Response may also be enabled through byte 3, bit 4 of the Mode Select Command. Refer to the HP 88780 USER'S GUIDE for a full description of the configurations.

Configuration 81 allows the user to select a block length for the 88780 including variable mode and fixed block lengths of 8, 256, 512, 1K, 4K, 16K, 32K, 128K, and 256K bytes. The block length is also selectable using bytes 10 through 12 of the Mode Select Command (prior to the execution of the COPY command). It should be set as follows:

Source Device Type	Destination Device Type	HP 88780 mode
Disk	Tape	Variable
Tape	Disk	Variable

Refer to the Operation section for further details on block compatibility.

Configurations 82-Bus Inactivity Time, 83-Disconnect Time Limit, and 84-Disconnect Length relate to disconnection when the 88780 is the Target. As such, they affect the relationship between the Copy Host and the Copy Manager, but not the interactions between the Copy Manager and the Copy Target.

All other configurations are at the preference of the customer.

## Operation

### Host Recommendations And Requirements

The Copy Host must allow DISCONNECTS. If the Copy Manager is not allowed to disconnect a Check Condition/Illegal Request status will be sent.

The Copy Host should configure the source and destination devices (if necessary) before the Copy Operation is initiated.

The Copy Host should verify the operable state of the source and destination devices before initiating the COPY command.

The Copy Host should reserve any sequential access devices involved in the Copy transaction to prevent other initiators from attempting to alter tape position during the command.

The Copy Host should not mix READs and WRITEs to the same sequential access device during a single COPY command. Although this is not prohibited, it may result in strange tape drive operation.

## **Copy-Host Arbitration And Selection**

The Copy Host will arbitrate and select the Copy Manager. The host will issue the COPY command which will be validated by the Copy Manager. If valid, the Copy Manager will take in at most 86 segments of the command and disconnect from the bus. If more segments are available, the drive will re-select to a Data Out phase after processing the last of the previous set of segments.

## **Segment Validation**

Validation of a segment means the segment descriptor passes three criteria. The first is that none of the reserved or cat bits are set. Secondly, the source and destination ids and LUN's must match the device type as indicated in the copy function code in the parameter header. Thirdly, the block lengths between the two devices must be compatible. See description below for an explanation of block compatibility.

Each segment is parsed and analyzed prior to its immediate execution. An invalid segment is therefore not recognized until it is about to be performed. If the segment appears to be correct, the Copy Manager must determine if the correct type of device is resident at the indicated ID and LUN, and if the block sizes of the devices are compatible. If the ID and LUN have not changed since the previous segment, no action needs to be taken and the operation continues to the read or write. Otherwise, the following commands take place. Any byte or block length that does not validate will cause the Copy process to terminate with an Illegal Request sense.

The Copy Manager will arbitrate on the bus and select the device, indicated in the segment, which is not attached to the Copy Manager. This may be either the source or the destination device. Once selected, the Copy Manager will issue a TEST UNIT READY command and, if necessary, clear out the Unit Attention with a REQUEST SENSE. It will then return CHECK CONDITION status to the host with a sense key of COPY ABORTED. If the sense is not a Unit Attention, the Copy process terminates with COPY ABORTED and returns the target's sense. If there is no error, the Copy process continues with an INQUIRY command to verify that the peripheral device type matches the Copy segment.

If the selected target is the correct type, the Copy Manager will issue a READ CAPACITY command to compare the block sizes and determine if source/destination block sizes are compatible.

If the block lengths of the devices are not compatible, no padding or catenating of data will be attempted. Instead, the COPY command will halt and a CHECK CONDITION will be returned to the Copy Host. The possible conditions are shown below.

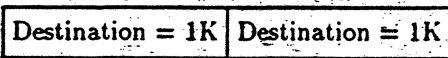
**Block Compatibility Interpretation.** Since the COPY command is vague in its definition of what the block length for the participating tape drive means in disk-tape transactions, the following definition is imposed. There are two variations of the copy process that the 88780 can perform with its copy target. The first is a disk to tape or tape to disk transfer with the tape drive in fixed-mode. The second variation includes disk to tape and tape to disk transfers with the tape drive in variable-mode. The fixed-mode transfers are defined in the table below. The next paragraph describes the operation of the 88780 when in variable-mode.

**Copy Transfers With Direct Access Devices In Variable-Mode.** The block length of the segment descriptor when the 88780 is in variable-mode is understood to be the "recommended" block length to be written to or read from tape. If the block length in the segment descriptor is zero, then the recommended block length becomes that of the participating disk drive as reported in the Read Capacity data. If the block length in the segment descriptor is non-zero, block length must pass a compatibility check. For blocks to be compatible, they must be integer multiples of each other. For example, if the disk block length is 512 bytes, acceptable block lengths for the 88780 in the segment descriptor would be 256 bytes, 512 bytes, 1024 bytes, and so on. Obviously, in the interest of backup performance, a larger block length for the 88780 in the segment would be preferred.

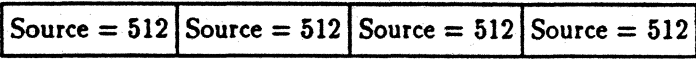
There exists the possibility that the number of disk blocks to be transferred is not enough to exactly fill the last tape block of the transfer. In this case, the last tape block length will be equal to the number of disk blocks remaining to be transferred multiplied by the disk block length. For example, for a segment descriptor specifying that 5 (512 byte) disk blocks are to be transferred with the tape block length set at 1024 bytes, the blocks written to or read from the 88780 will be one 1K block followed by one 512 byte block.

**Copy Transfers With Direct Access Devices In Fixed-Mode.** If the 88780 is in fixed-mode, the block length in the segment descriptor must equal the fixed-mode block length of the 88780. If they are not equal, the Copy process will fail with an Illegal Request. Once this requirement has been met, a compatibility check will be made that verifies that the block lengths for the 88780 and the participating disk drive are integer multiples.

Since the 88780 is in fixed-mode, it cannot read or write partial blocks on the tape, and therefore a further requirement is necessary if the source device's block length is less than the destination device's block length. For such cases, the number of disk blocks to be transferred must be an integer multiple of the number computed by dividing the larger block length by the smaller block length. For example, the following scenario would be valid:



Number of blocks = 4



In segment descriptors for Copy Command transfers among sequential access devices, the block length indicated in the descriptor must be zero if the device is in variable-mode or equal the device's fixed-mode block length. With the 88780 in fixed-mode, the block compatibility issue is as described above. Support the definition of variable-mode to variable-mode transfers among sequential access devices is still under review at Hewlwt-Packard.

Direct access devices supporting multiple block sizes within different volume ranges are not supported.

Once the segment has been verified, a READ or WRITE command is sent to the Copy Target. The 88780 is then set up to send/receive the data. The target may disconnect and re-select as needed or as configured by the Copy Host. If an unexpected block length is read off the tape, that block will not be transferred to the copy target, and the Copy process will terminate with a Copy Abort sense key. This process is repeated until an error is encountered or all of the segments are performed.

### **Copy Status**

A re-selection is then initiated by the Copy Manager and the STATUS and COMMAND COMPLETE are returned to the Copy Host. If no errors were detected a GOOD status is sent. For further discussion of STATUS and sense bytes, see "Error Conditions" later in this section.

### **Operating Abnormalities During COPY Operation**

#### **MESSAGES**

When selecting the Copy Target, the Copy Manager will send an Identify message that allows the Copy Target to disconnect. If the Copy Target does not sequence through the Identify message, the Copy Operation will terminate. Any time the Copy Target sequences to a MESSAGE OUT phase, the Copy Manager will respond with a No Operation message if the Identify message has already been sent. The Copy Manager will send a Message Reject in response to a Synchronous Data Transfer Request message if the Copy Target sequences through this phase. It is anticipated that this message will be encountered only when the Copy Manager selects the Copy Target for an INQUIRY command. If the Copy Target does not go through a COMMAND phase, this is considered to be an error. When the Copy Target has re-selection but does not give an Identify message, this will be considered an error. When disconnecting during a DATA phase, the Copy Target must send a Save Data Pointers message if the DATA phase is to be returned to upon re-selection. If the Save Data Pointers message is not sent and the Copy Target returns to a DATA phase, the data will be sourced or synched accordingly and an Abort message will be sent to the Copy Target. A Restore Data Pointers is understood upon re-selection, although it is not an error if an actual Restore Data Pointers message is sent.

**Unexpected Phases.** If the Copy Target sequences to an unexpected COMMAND phase or DATA phase, this will be considered to be an error and an Abort message will be sent. If the Copy Target sequences to a Command Complete without a prior STATUS phase, this will be considered to be an error. If the Copy Target sequences to the wrong DATA phase, the Copy Manager will source or sink data bytes as needed and send an Abort message. Any unexpected MESSAGE IN phase will be considered to be an error. This includes:

EXTENDED MESSAGE

MESSAGE REJECT

LINKED COMMAND COMPLETE

LINKED COMMAND COMPLETE (with Flag)

AUTOSENSE DATA FOLLOWS

RESERVED CODES

IDENTIFY

## Initiator Selections During Copy Operation

### Copy Host Selection

**Initiator Selections During Copy Operation.** While the 88780 is the Copy Manager but not on the SCSI bus, it can be selected by an initiator on the bus. If the Copy Host selects the 88780, the COPY command will terminate.

### Non-disconnecting Initiators

If the selecting initiator does not allow Disconnects (or does not send an IDENTIFY Message) the 88780 will send a BUSY status to that initiator.

### Disconnecting Initiators

If the selecting initiator allows Disconnects, the 88780 will disconnect from that initiator. After the COPY operation has been completed but before sending STATUS and COMMAND COMPLETE back to the Copy Host, the 88780 will reselect. The initiators will be reselected in the order of descending SCSI ID's.

If the initiator has sent a Message, the 88780 will reselect and send a MESSAGE REJECT. If the initiator has sent a command, the 88780 will check to see if it is an INQUIRY command or a REQUEST SENSE command and respond accordingly. If the command is not an INQUIRY or a REQUEST SENSE command, the 88780 will send a BUSY status.

### Error Conditions

Error conditions may be detected by the Copy Manager function, by the 88780 itself, or the Copy Target. Any Check Condition status from the Copy Target will cause termination of the COPY command. The Copy Manager will issue a REQUEST SENSE command to the Copy Target and add the returned sense bytes on to the end of the Copy Manager's sense bytes. The Copy Manager will send the Copy Host a Check Condition/Copy Abort status. If the 88780 detects an error when acting in the capacity as a source or destination device, the Copy Manager will send a Check Condition/Copy Abort status with the 88780's computed sense bytes added to the Copy Manager's sense bytes. If the 88780 detects an error when acting in the capacity of a Copy Manager, a Check Condition status will be sent, but not with a Copy Abort sense key. The Copy Manager will compute and send up to eighteen sense bytes according to the detected error.

The Request Sense data returned by the Copy Manager for a Check Condition/Copy Abort status will appear as follows:

The valid bit will be set to one. The Error Code will be 70H.

The segment number will indicate the number of the segment descriptor being processed when the error was being detected by the Copy Manager.

The sense key will be set to Copy Aborted. Filemark, EOM, and ILI will not be set.

The information bytes will contain the number of blocks that were not copied relative to the Number of Blocks field within the indicate segment descriptor.

The additional sense length will be thirty-five plus the length of any attached source or destination Request Sense data.

The first byte of the command specific information bytes will be either a zero or a 0BH, indicating respectively that there is no data present for the source device, or that the twelfth byte after the first byte contains the status byte from the source device. The following bytes will be its request sense information.

The second byte of the command specific information bytes will be either a zero or a 0BH, indicating respectively that there is no data present for the destination device or that the twelfth byte after the first byte contains the status byte from the destination device. The following bytes will be its request sense information.

The Additional sense code and the Additional sense code qualifier will give more details on the Copy failure.

The Sense key specific bytes will be zero.

If the sense keys are set to Copy Abort and the command specific bytes are set to zero, the Copy Target's sense bytes were not made available to the Copy Manager. This would probably indicate the Copy Target has been timed out during a REQUEST SENSE command.

If the Copy Manager detected the error, it will return up to fifty sense bytes set accordingly for the detected error. Note that Suppress Incorrect Length Indicator (SILI) is not available in a copy initiated READ from a Sequential Access Device. If a READ is attempted and the record length doesn't match exactly, a Check Condition/Copy Abort status will be generated.

#### **Glossary Of Terms for the COPY Command**

**Copy Host.** The device which originally initiates the COPY command.

**Copy Manager.** The device which is examining the COPY command and initiating the reads and writes to the appropriate devices (the 88780).

**Source device.** The device that provides the data through a read command.

**Destination device.** The device that writes the data to its tape.

**Selected target.** (Also the Copy Target.) The source or destination device that participates in the COPY command and is not attached to the Copy Manager.

**Segment.** Twelve bytes of data supplied by the Copy Host to indicate the Source, Destination, length and address for a piece of the COPY command. The Copy Host can send up to 256 segments for each COPY command performed.

**LUN ID.** Refers to the SCSI identifier (0 through 7) used during selection. LUN is the abbreviation for Logical Unit Number which indicates a specific unit within a device.

**Padding and Catenating.** Two methods of expanding data to match a required block length. Padding adds extra bytes. Catenating allows blocks to be joined together.

## Copy Command Block and Segments

### Note



In all of these data block descriptions, numbers in parentheses are the length of that field (in bits). When multiple fields exist for a one byte description, the top item on the list is the most significant, and the last item is the least significant.

### COMMAND BLOCK RECEIVED ON COPY COMMAND

BYTE	DESCRIPTION	VALUE	INVALID	ACTION
0	Opcode	18H		Previously checked
1	LUN (3)	0	1 ▶ 7	Previously checked
	Reserved (4)	0	1 ▶ FH	Previously checked
	Pad	0	1	
2-4	Param length	0 4, 16, 28, etc.	Any (number-4) not a multiple of 12	ILLEGAL REQUEST
5	Vendor Uniq(2)	0 ▶ 3		IGNORE
	Reserved (4)	0	1 ▶ FH	Previously checked
	Flag/Link (2)	0,1,3	2	Previously checked

### Note



The action "Previously checked" in the table above indicates that the command is screened before reaching the COPY state within the HP 88780.

### PARAMETER LIST HEADER

BYTE	DESCRIPTION	VALID	INVALID	ACTION
0	FCN Code (5)	0,1	2,3,4 ▶ 31	ILLEGAL REQUEST
	Priority (3)	0 ▶ 7		IGNORE
1	Vendor Unique	0 ▶ FFH		IGNORE
2	Reserved	0	1 ▶ FFH	ILLEGAL REQUEST
3	Reserved	0	1 ▶ FFH	ILLEGAL REQUEST

**SEGMENT DESCRIPTOR FOR FUNCTION CODE 00H  
(disk to tape)**

BYTE	DESCRIPTION	VALID	INVALID	ACTION
0	Source addr(3)	0 ▶ 7	<>disc,=host, nothing	ILLEGAL REQUEST
	Reserved	0	1	ILLEGAL REQUEST
	Cat	0	1	ILLEGAL REQUEST
	Source LUN(3)			Checked in INQUIRY
1	Dest addr (3)	88780A/B	Anything else	ILLEGAL REQUEST
	Reserved (2)	0	1 ▶ 7	ILLEGAL REQUEST
	Dest LUN (3)	0	1 ▶ 7	ILLEGAL REQUEST
2-3	Tape block length	0 ▶ FFFFH	Not compatible, size not configured for if fixed-mode	ILLEGAL REQUEST
4-7	Disk number of blocks	0 ▶ FFFF FFFFH		Not checked
8-11	Block Address	0 ▶ FFFF FFFFH		Not checked



**SEGMENT DESCRIPTOR FOR FUNCTION CODE 01H**  
(tape to disc)

BYTE	DESCRIPTION	VALID	INVALID	ACTION
0	Source addr(3)	88780A/B	Anything else	ILLEGAL REQUEST
	Reserved	0	1	ILLEGAL REQUEST
	Cat	0	1	ILLEGAL REQUEST
	Source LUN(3)	0	1 ▶ 7	ILLEGAL REQUEST
1	Dest addr(3)		88780A/B	ILLEGAL REQUEST
	Reserved (2)	0	1 ▶ 7	ILLEGAL REQUEST
	Dest LUN (3)			Checked in INQUIRY
2-3	Tape block length	0 ▶ FFFFH	Not compatible, size not configured for if fixed-mode	ILLEGAL REQUEST
4-7	Disk number of blocks	0 ▶ FFFF FFFFH		Not checked
8-11	Block Address	0 ▶ FFFF FFFFH		Not checked

## Commands Used and Fields Checked

### COMMAND BLOCK SENT ON INQUIRY COMMAND

BYTE	DESCRIPTION	VALUE
0	Opcode	12H
1	LUN (3) Reserved (5)	Target LUN 0
2	Reserved (4) Desired Data Format (4)	0 0H
3	Reserved	0
4	Allocation length	4
6	Vendor Unique (2) Reserved (4) Flag/Link (2)	0 0 0

### DATA RECEIVED FROM AN INQUIRY COMMAND

BYTE	DESCRIPTION	VALID	INVALID	ACTION
0	Peripheral type	0 (disc) 1 (tape) 7F (bad LUN)	2 ▶ 7EH, 80 ▶ FFH	ILLEGAL REQUEST  ILLEGAL REQUEST
1	RMB Dev type qual (7)			IGNORE
2	ISO vers (2) ECMA vers (3) ANSI vers (3)			IGNORE
3	Reserved (4) Response data Format (4)	0	1 ▶ F	ILLEGAL REQUEST IGNORE

**COMMAND BLOCK SENT ON READ CAPACITY COMMAND**

BYTE	DESCRIPTION	VALUE
0	Opcode	25H
	LUN (3)	Target LUN
1	Reserved (4)	0
	Rel Addr	0
2-5	Log block addr	0
6	Reserved	0
7	Reserved	0
	Vendor Uniq(2)	0
8	Reserved (5)	0
	PMI	0
	Vendor Uniq(2)	0
9	Reserved (4)	0
	Flag/Link (2)	0

**DATA RECEIVED FROM READ CAPACITY COMMAND**

BYTE	DESCRIPTION	VALID	INVALID	ACTION
0-3	Logical Block Address	0 ▶ FFFF FFFFH		IGNORE
4-7	Block length	0 ▶ 00FF FFFFH*1*	1000000H ▶ FFFF FFFFH	ILLEGAL REQUEST

\*1\*Value to be stored for later use in comparison.

**COMMAND BLOCK SENT ON MODE SENSE COMMAND (tape)**

BYTE	DESCRIPTION	VALUE
0	Opcode	1AH
1	LUN (3) Reserved (5)	Target LUN 0
2	PCF (2) Page Code (6)	0 0
3	Reserved	0
4	Allocation length	12
5	Vendor Uniq(2) Reserved (4) Flag/Link (2)	0 0 0

**DATA RECEIVED FROM MODE SENSE COMMAND**

BYTE	DESCRIPTION	VALID	INVALID	ACTION
0	Sense Data Length			IGNORE
1	Medium type			IGNORE
2	WP Buffered Mode (3) Speed (4)			IGNORE
3	Blk disk length	≥ 8	<8	ILLEGAL REQUEST
4	Density Code			IGNORE
5-7	# of blocks	0	1 ▶ FFFFFFFH	ILLEGAL REQUEST
8	Reserved	0	1 ▶ FFH	ILLEGAL REQUEST
9-11	Block length	0 ▶ FFFFFFFH		Stored for use in comparisons later

**COMMAND BLOCK SENT ON REQUEST SENSE COMMAND**

BYTE	DESCRIPTION	VALUE
0	Opcode	03H
1	LUN (3)	Target LUN
	Reserved (5)	0
2	Reserved 0	
3	Reserved 0	
4	Allocation length	28 (for 88780)
5	Vendor Uniq(2)	0
	Reserved (4)	0
	Flag/Link (2)	0

**DATA RECEIVED FROM REQUEST SENSE COMMAND**

Any data the Copy Manager receives from a request sense is not interpreted but merely concatenated onto the Copy Manager's sense data sent back to the host.

## Data Transfer Commands Sent to a Copy Target

### COMMAND BLOCK SENT ON READ COMMAND (tape)

BYTE	DESCRIPTION	VALUE
0	Opcode	08H
1	LUN (3) Reserved (3) SILI Fixed	0 0 0 0,1 depending on mode
2-4	Transfer length	Value (partial) taken from segment or may need to be computed depending on DC bit
5	Vendor Uniq(2) Reserved (4) Flag/Link (2)	0 0 0

### COMMAND BLOCK SENT ON WRITE COMMAND (tape)

BYTE	DESCRIPTION	VALUE
0	Opcode	0AH
1	LUN (3) Reserved (4) Fixed	Target LUN 0 0,1 depending on mode
2-4	Transfer length	Value (partial) taken from segment or may need to be computed depending on DC bit
5	Vendor Uniq (2) Reserved (4) Flag/Link (2)	0 0 0

**COMMAND BLOCK SENT ON READ COMMAND (disc)**

BYTE	DESCRIPTION	VALUE
0	Opcode	28H
1	LUN (3)	Target LUN
	DPO	0
	FUA	0
	Reserved (2)	0
	Rel Adr	0
2-5	Logical Block Address	Value taken from segment
6	Reserved	0
7-8	Transfer length	Value (partial) taken from segment
9	Vendor Uniq(2)	0
	Reserved (4)	0
	Flag/Link (2)	0

**COMMAND BLOCK SENT ON WRITE COMMAND (disc)**

BYTE	DESCRIPTION	VALUE
0	Opcode	2AH
1	LUN (3)	Target LUN
	DPO	0
	FUA	0
	WrtSme	0
	Reserved	0
	Rel Adr	0
2-5	Logical Block Address	Value taken from segment
6	Reserved	0
7-8	Transfer length	Value (partial) taken from segment
9	Vendor Uniq(2)	0
	Reserved (4)	0
	Flag/Link (2)	0

## Tables for Sense Data

### REQUEST SENSE DATA FOR MANAGER DETECTED ERROR

BYTE	7	6	5	4	3	2	1	0
0	Valid=1	Error class = 7H			Error code = 0H			
1	Segment Number							
2	FM=0	EOM=0	ILI=0	R=0	Sense Key			
3-6	Residue (Byte 3 is the MSB, Byte 6 is the LSB)							
7	Additional sense length (10 + 22 + 10); 10 is for rest of sense data. 22 is COPY command/header/segment; 10 is additional 88780 vendor unique data.							
8-11	Command Specific Information Bytes (00H)							
12	Additional Sense Code							
13	Additional Sense Code Qualifier							
14	Field Replaceable Unit Code							
15-17	Sense Key Specific Bytes (00H)							
18-23	COPY command descriptor block							
24-27	COPY parameter list header							
28-39	COPY segment descriptor that failed							
40-49	88780 Vendor Unique data							



**REQUEST SENSE DATA FOR COPY ABORT SENSE KEY**

BYTE	7	6	5	4	3	2	1	0
0	Valid=1	Error class = 7H			Error code = 0H			
1	Segment Number (0=first segment)							
2	FM=0	EOM=0	ILI=0	R=0	Sense Key = Copy Abort			
3-6	Residue (Byte 3 is the MSB, Byte 6 is the LSB)							
7	Additional sense length (2 + 1 + 8 + y + 22 + 10); 2 is for the rest of Manager's sense data; 1 is for the status byte from source or destination; 8 is number of base sense bytes sent by target; y is MIN (additional sense length of target, 20); 22 is COPY command/header/segment; 10 is additional 88780 Vendor Unique data							
8	Source Sense Data (0 or 0BH)							
9	Destination Sense Data (0 or 0BH)							
10	SCSI Status from source/destination							
11	Source/destination error code							
12	Source/destination segment number							

**REQUEST SENSE DATA FOR COPY ABORT SENSE KEY (continued)**

BYTE	7	6	5	4	3	2	1	0
13	FM	EOM	ILI	R	Sense Key			
14-17	Residue (Byte 14 is the MSB, Byte 17 is the LSB)							
18	Source/destination additional sense length (y)							
19 - 18+y	Additional sense from source or destination							
19+y - 24+y	COPY command descriptor block							
25+y - 28+y	COPY parameter list header							
29+Y - 40+y	COPY segment descriptor that failed							
41+y - 50+y	88780 Vendor Unique data							

**Note**



In bytes 8 and 9, the value 0BH will only be set for either the source or the destination, but not both. The other will be zero. It will be up to the host to know that the target sense data has been truncated if the target's additional sense length is more than 20.

## Vendor-Unique Bytes

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Appendix A contains expanded definitions of the Vendor-Unique bytes described in Chapter 4, Command Specification. Appendix A is divided into three sections; Report Flags, Error Codes and Position Flags.

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### Report Flags

- Bit 7 = Command Rejected
- Bit 6 = Reset Acknowledge
- Bit 5 = Transfer Abort Acknowledge
- Bit 4 = Hard Error Encountered
- Bit 3 = Unexpected EOF/BOT/Runaway
- Bit 2 = Data Correction Occurred
- Bit 1 = Immediate Response Message
- Bit 0 = Transparent Status Message

#### Bit 7 Command Rejected

This bit is set to indicate that the received command has been rejected by the Data Buffer Controller. The reason for the rejection will be contained in the error code.

#### Bit 6 Reset Acknowledge

This bit is set to indicate that the current command has been terminated due to a reset request.

#### Bit 5 Transfer Abort Acknowledge

This bit is set to indicate that the current command has been terminated due to a transfer abort request. This only applies to commands which send data across the data transfer bus.

#### Bit 4 Hard Error Encountered

This bit is set when a hard error is encountered during the execution of the received command. Detail of the actual error encountered will be contained in the error code.

#### Bit 3 Unexpected EOF/BOT/Runaway

This bit is set to indicate that an end of file (EOF), beginning of tape (BOT) or tape runaway was encountered on a read, forward space block, or backspace block operation (no data record was found).

#### Bit 2 Data correction required

This bit is set to indicate that data correction had to be performed on the requested operation to recover correct data.

### Bit 1 Immediate Response message

This bit is set to indicate that the report returned is an immediate response message. The completion of the command is pending. Immediate response mode must be enabled before immediate response reports can be returned on write operations.

### Bit 0 Transparent Status Message

This bit is set to indicate that this report is a Transparent Status message. It is returned to transfer information on recovered errors which occurred on an immediate response command. The back reference register indicates the number of commands pending at the time of the recovered error.

---

## Error Codes

Errors are divided into the following subranges:

RANGE	DEFINITION
0	No error
1-31 (01H-1FH)	Command Rejected errors
32-63 (20H-3FH)	Tape read errors
64-95 (40H-5FH)	Tape write error
96-127 (60H-7FH)	Tape position/servo errors
128-159 (80H-9FH)	Drive controller hardware/firmware errors
160-191 (A0H-BFH)	Buffer controller hardware/firmware errors
192-255 (C0H-FFH)	SCSI controller hardware/firmware errors

### Command Reject Error Codes (1..31)

- 1 (01H) = No tape is loaded.
- 2 (02H) = Drive is not online.
- 3 (03H) = Drive is not offline.
- 4 (04H) = Drive is write protected.
- 5 (05H) = Tape loaded prevents access to test.
- 6 (06H) = Front door or top cover is open.
- 7 (07H) = Controller is currently in diagnostic/options mode.
- 8 (08H) = Controller is not in diagnostic mode.
- 9 (09H) = Drive not streaming (when streaming command was received).
- 10 (0AH) = Cannot read tape with unidentified or unsupported format.
- 11 (0BH) = Cannot write tape with unidentified or unsupported format.
- 12 (0CH) = Tape not positioned at BOT for write density ID command.

### A-2 Vendor-Unique Bytes

- 13 (0DH) = Tape already at BOT when backspace command was issued.
- 14 (0EH) = Tape past EOT.
- 16 (10H) = Unknown or unsupported command received.
- 17 (11H) = Invalid parameter for requested command.
- 18 (12H) = Invalid test/info number.
- 19 (13H) = Test not remotely accessible.
- 20 (14H) = Test aborted by reset.
- 21 (15H) = User defined sequence is full, can't add test to sequence.
- 22 (16H) = Requested density is not available.
- 23 (17H) = Invalid target id for command.
- 24 (18H) = Requested write record length exceeded maximum supported.
- 25 (19H) = Write record request did not precede write record transfer.
- 26 (1AH) = Write record transfer did not follow write record request.
- 27 (1BH) = Command Rejected due to poweron selftest failure.
- 28 (1CH) = Buffer is empty, cannot retrieve record from buffer.
- 29 (1DH) = Buffer is full, cannot place record in buffer.
- 31 (1FH) = Invalid header on non-volatile memory read.

### **Tape Read Errors (32..63)**

- 32 (20H) = Buffer overrun.
- 33 (21H) = Gap detected before end of data on read.
- 34 (22H) = Two or more tracks in error on read.
- 35 (23H) = Two tracks in error on read.
- 36 (24H) = Single track in error on read (NRZI only).
- 37 (25H) = CRC error on read.
- 38 (26H) = ACRC error on read.
- 39 (27H) = Residual error on read.
- 40 (28H) = Syndrome detected single track in error on read.
- 41 (29H) = Formatter CRC error on read.
- 42 (2AH) = Unknown formatter error on read.
- 43 (2BH) = Data block timeout.
- 44 (2CH) = Block detect error.
- 45 (2DH) = End block detect error.
- 46 (2EH) = Bad gap after ID.
- 47 (2FH) = Gap check timeout.

- 48 (30H) = Short gap after block.
- 49 (31H) = Block overrun.
- 50 (32H) = False ID block detected.
- 51 (33H) = Bad tape mark read.
- 52 (34H) = Hitch into a block failed.
- 53 (35H) = Hitch into a gap failed.
- 58 (3AH) = Tracks with gain too low during autocal.
- 59 (3BH) = Tracks with gain too high during autocal.
- 60 (3CH) = Tracks with gain too low and too high during autocal.

### **Tape Write Errors (64..95)**

- 64 (40H) = Buffer underrun.
- 65 (41H) = Gap detected before end of data on write.
- 66 (42H) = Two or more tracks in error on write.
- 67 (43H) = Two tracks in error on write.
- 68 (44H) = One track in error on write.
- 69 (45H) = CRC error on write.
- 70 (46H) = ACRC error on write.
- 71 (47H) = Residual error on write.
- 72 (48H) = Syndrome detected single track in error on write.
- 73 (49H) = Formatter CRC error on write.
- 74 (4AH) = Unknown formatter error on write.
- 75 (4BH) = Data block timeout.
- 76 (4CH) = Data block detect error.
- 77 (4DH) = End data block detect error.
- 78 (4EH) = Bad gap after ID.
- 79 (4FH) = Gap check timeout.
- 80 (50H) = Erase verify error.
- 81 (51H) = PE density ID detect error.
- 82 (52H) = PE density ID verify error.
- 83 (53H) = GCR density ID detect error.
- 84 (54H) = GCR density ID verify error.
- 85 (55H) = GCR ARA burst detect error.
- 86 (56H) = GCR ARA burst verify error.
- 87 (57H) = GCR ARA ID detect error.

- 88 (58H) = GCR ARA ID verify error.
- 89 (59H) = Tape mark detect error.
- 90 (5AH) = Tape mark verify error.
- 91 (5BH) = Bad pregap on write.
- 92 (5CH) = Buffer data parity error during write record.
- 93 (5DH) = No block detected during write record verify.
- 94 (5EH) = No block detected during write tape mark verify.
- 95 (5FH) = No block detected during write ID verify.

### **Tape Positioning/Servo Errors (96..127)**

- 96 (60H) = Tension shutdown.
- 97 (61H) = Tape speed out of specifications.
- 98 (62H) = Tape ramping error.
- 110 (6EH) = No reel found.
- 111 (6FH) = Hub lock failure.
- 112 (70H) = Reel will not seat.
- 113 (71H) = Reel inverted.
- 114 (72H) = Tape stuck to reel.
- 115 (73H) = Tape stuck in path.
- 116 (74H) = Unable to establish tension.
- 117 (75H) = Tape eject timeout.
- 118 (76H) = Door open abort.
- 120 (78H) = No BOT marker detected.
- 121 (79H) = Operator reset abort.
- 122 (7AH) = Host reset abort.
- 125 (7DH) = Last block not found.
- 126 (7EH) = Gap recapture position error.
- 127 (7FH) = Block recapture position error.

### **Drive Controller Errors (128..159)**

- 128 (80H) = Reel size detector failure.
- 131 (83H) = Unable to thread tape into tape path.
- 132 (84H) = Open loop motor control error.
- 133 (85H) = Gap timer circuitry check failed.

### **Buffer Controller Errors (160..191)**

- 160 (A0H) = Interface data parity error.
- 161 (A1H) = Drive data parity error.
- 162 (A2H) = Byte count mismatch on read.
- 163 (A3H) = Prior error reject.
- 164 (A4H) = Write stopped at EOT.

### **SCSI Controller Errors (192..255)**

- C0 = Unsupported command.
- C1 = Drive not online.
- C2 = Illegal field In Command Data Block.
- C3 = Illegal mode select parameter.
- C4 = Illegal mode length.
- C5 = Fixed mode, but fixed bit not set in command byte.
- C6 = Microprocessor halted.
- C7 = Byte compare not supported.
- C8 = Front panel reset.
- C9 = Suppress Incorrect length indication ON and fixed bit set.
- CA = Rewind while offline.
- CB = Clear log occurred correctly (reported to host only).
- CC = Parity error.
- CD = Bad log page (error code for SCSI bus).
- CE = Power-on has occurred (reported to host only).
- CF = Tape Changed (reported to host only).
- D0 = Spurious reset.
- D1 = Spurious SCSI Interrupt.
- D2 = Write length too long.
- D3 = Verify Immediate not supported.
- D4 = Illegal message abort.
- D5 = Invalid logical unit number.
- D6 = Diagnostic failure (reported to host only).
- D7 = Immediate bit set without IR mode.
- D8 = Unsupported page in mode select.
- D9 = Invalid length.
- DA = Invalid header.



DB = Non zero reserved fields.  
DC = Write byte count mismatch.  
DD = Power-on selftest failure.  
DE = Bus protocol error.  
DF = Reselection error.  
E0 = Lost data reset.  
E1 = COPY aborted.  
E2 = COPY Illeg req.  
E3 = Invalid command op code.  
E4 = Illegal function for device type.  
E5 = Unsupported function.  
E6 = Non-zero field set.  
E7 = Reserved field use.  
E8 = Invalid field in param list.  
F0 = Copy aborted due to target.

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## Position Flags

Bit 7 - Beginning of Tape (BOT)  
Bit 6 - End of File (EOF)  
Bit 5 - End of Tape (EOT)  
Bit 4 - Early EOT (PRE-EOT)  
Bit 3 - 10 Feet Beyond EOT (EOT+10)  
Bit 2 - Tape Runaway  
Bit 1 - Position Lost  
Bit 0 - (Reserved)

### Bit 7 Beginning of Tape (BOT)

This bit is set to indicate that the logical tape position is at BOT (also referred to as load point). It is cleared when a command is processed which moves the tape away from BOT (such as a write, forward read, or forward space operation). Commands which cause the tape to return to BOT (such as a rewind operation) will set this bit. A backspace operation which encounters BOT will also set this bit. BOT status is required before a write density ID operation can be performed.

### Bit 6 End of File (EOF)

This bit is set to indicate that the logical tape position is at an end of file (EOF, also referred to as a tape mark). If the end of file was set from a write tape mark operation, or a forward read or forward space operation which encountered an EOF, then the logical tape position is AFTER the EOF marker. If the end of file was the result of a reverse read or reverse space operation which encountered an EOF, then logical tape position is BEFORE the EOF marker.

This bit is cleared by any operation where the tape is not positioned at an EOF (ie., at BOT or after a data record). This bit is also cleared when no tape is loaded.

**Bit 5 End of Tape (EOT)**

This bit is set to indicate that the logical tape position is past the end of tape (EOT) marker. It is set at the completion of any operation where the logical tape position is beyond the EOT marker. This bit is cleared at the completion of any operation where the logical tape position is prior to the EOT marker. When the EOT status is first encountered there is 10 feet of usable recording area left on the tape. This bit is cleared when no tape is loaded.

## HP 88780 SCSI Error Codes

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### SCSI Error Codes

This appendix contains a brief description of every valid combination of Sense Key, Additional Sense Code, and Additional Sense Code Qualifier, along with the error code from the data buffer (byte 19).

#### KEY

- SK = SCSI Sense Key
- AS = Additional Sense Code
- AQ = Additional Sense Code Qualifier
- EC = 88780 Error Codes from the buffer

**Table B-1. 88780 SCSI Error Codes**

SK	AS	AQ	EC	Description
00	00	00	00	No error.
00	00	00	CB	No error.
00	00	01	00	Tape at filemark.
00	00	02	0E	Tape past EOT.
00	00	04	0D	Backspace at BOT requested.
02	04	00	C1	The drive is not online.
02	04	00	CA	A rewind was requested while offline.
02	04	01	02	Drive is not online.
02	04	02	01	No tape is loaded.
02	04	80	03	Drive is not offline.
02	04	81	05	Tape loaded prevents access to test.
02	04	82	06	Front door or top cover is open.
02	04	83	07	Test is currently in diagnostic mode.
03	04	84	08	Drive is not in diagnostic mode.
03	11	00	20	Buffer overrun error.
03	11	00	21	Gap before EOD error.
03	11	00	22	2 or more Tracks in error.
03	11	00	23	2 Tracks in error.

#### **Bit 4 Early EOT (PRE-EOT)**

This bit is set to indicate that the logical tape position is beyond approximately 50 feet before the end of tape (EOT) marker. It is set at the completion of any operation where the logical tape position is past this threshold. This bit is cleared at the completion of any operation where the logical tape position is more than 50 feet before the EOT marker. This bit is cleared when no tape is loaded.

#### **Bit 3 10 Feet Beyond EOT (EOT+10)**

This bit is set to indicate that the logical tape position is approximately 10 feet or more beyond the end of tape (EOT) marker. It is set at the completion of any operation where the logical tape position is past this threshold. This bit is cleared at the completion of any operation where the logical tape position is less than 10 feet beyond the EOT marker. This bit is cleared when no tape is loaded. If this status is received on a write operation it should be interpreted as a warning that the data may not be recoverable when reading without unspooling the tape off of the supply reel.

#### **Bit 2 Tape Runaway**

This bit is set to indicate that the tape runaway limit was reached on a read or space operation. This limit is 25 feet in 800 NRZI and 1600 PE densities, and is 15 feet at 6250 GCR density. Beyond EOT the tape runaway limit is 6 feet in any density. The logical tape position is in the gap at the end of the runaway limit. This bit is cleared after the report containing this status is returned.

#### **Bit 1 Position Lost**

This bit is set to indicate that the logical tape position has been lost relative to the last known block position. It is set upon completion of read, write, or space command when the gap position after the last known block cannot be relocated, or when a servo error is encountered such that the tape cannot be ramped up to speed at the desired position. The reason for the position lost will be contained in the status flags and the error code. This bit is cleared after the report containing this status is returned.

**Table B-1. 88780 SCSI Error Codes (continued)**

<b>SK</b>	<b>AS</b>	<b>AQ</b>	<b>EC</b>	<b>Description</b>
03	11	00	24	1 Track in error.
03	11	00	25	CRC error.
03	11	00	26	ACRC error.
03	11	00	27	Residual error.
03	11	00	28	Syndrome detected 1 track in error.
03	11	00	29	Formatter CRC error.
03	11	00	2A	Unknown RF error.
03	11	00	2B	Block timeout error.
03	11	00	2C	Block detect error.
03	11	00	2D	End block error.
03	11	00	2E	Bad gap after ID error.
03	11	00	2F	Gap check error.
03	11	00	30	Short postgap error.
03	11	00	31	Block overrun error.
03	11	00	32	False ID block error.
03	11	00	33	Bad tape mark error.
03	11	00	34	Hitch into block error.

**Table B-1. 88780 SCSI Error Codes (continued)**

<b>SK</b>	<b>AS</b>	<b>AQ</b>	<b>EC</b>	<b>Description</b>
03	11	00	35	Hitch into gap error.
03	11	00	39	Bad NRZI tape mark read.
03	11	00	3A	Tracks with gain too low during read channel autocalibration.
03	11	00	3B	Tracks with gain too high during read channel autocalibration.
03	11	00	3C	Tracks with gain too low and high during read channel autocal.
03	11	00	3F	Tape runaway during diagnostic test.
03	1F	00	40	Buffer underrun error.
03	1F	00	41	Gap before EOD error.
03	1F	00	42	2 or more Tracks in error.
03	1F	00	43	2 Tracks in error.
03	1F	00	44	1 Track in error.
03	1F	00	45	CRC error.
03	1F	00	46	ACRC error.
03	1F	00	47	Residual error.
03	1F	00	48	Syndrome detected 1 track in error.
03	1F	00	49	Formatter CRC error.
03	1F	00	4A	Unknown RF error.

**Table B-1. 88780 SCSI Error Codes (continued)**

<b>SK</b>	<b>AS</b>	<b>AQ</b>	<b>EC</b>	<b>Description</b>
03	1F	00	4B	Block timeout error.
03	1F	00	4C	Block detect error.
03	1F	00	4D	End block error.
03	1F	00	4E	Bad gap after ID error.
03	1F	00	4F	Gap check error.
03	1F	00	50	Erase verify error.
03	1F	00	51	PE ID detect error.
03	1F	00	52	PE ID verify error.
03	1F	00	53	GCR ID detect error.
03	1F	00	54	GCR ID verify error.
03	1F	00	55	GCR burst detect error.
03	1F	00	56	GCR burst verify error.
03	1F	00	57	GCR ARA detect error.
03	1F	00	58	GCR ARA verify error.
03	1F	00	59	Bad TM detect error.
03	1F	00	5A	Bad TM verify error.
03	1F	00	5B	Bad pregap error.

**Table B-1. 88780 SCSI Error Codes (continued)**

<b>SK</b>	<b>AS</b>	<b>AQ</b>	<b>EC</b>	<b>Description</b>
03	1F	00	5C	Buffer parity error.
03	1F	00	5D	No data detect error.
03	1F	00	5E	No TM detect error.
03	1F	00	5F	No ID detect error.
03	30	00	0A	Invalid format on read.
04	08	00	09	Not streaming error.
04	08	00	0B	Invalid format on write.
04	08	00	0C	Not at BOT for a write ID.
04	08	00	15	Nested sequence error.
04	08	00	17	Invalid target id.
04	08	00	19	Write record request did not precede write record transfer.
04	08	00	1A	Write record transfer did not follow write record request.
04	08	00	1D	Buffer is full, cannot place a record in buffer.
04	08	00	1E	Block header invalid for a non-volatile memory load.
04	40	00	D6	A diagnostic failed.
04	42	00	1B	Command rejected due to poweron selftest failure.
04	42	00	DD	The poweron self test failed.



**Table B-1. 88780 SCSI Error Codes (continued)**

<b>SK</b>	<b>AS</b>	<b>AQ</b>	<b>EC</b>	<b>Description</b>
04	44	00	1C	Buffer is empty, cannot retrieve a record from buffer.
04	44	00	C6	The microprocessor is behaving incorrectly.
04	44	97	DC	The data written to the buffer didn't match the requested length.
04	55	00	80	Reel encoder failure.
04	55	00	83	Unable to thread tape.
04	55	00	84	Open loop motor error.
04	55	00	85	Gap timer circuitry check failed.
04	55	00	86	Invalid measurement error.
04	55	00	87	Read skew test not executed.
04	55	00	88	Skew measurement verify error.
04	55	00	89	Corrupt skew measurement data.
04	55	00	8A	Invalid measurement limit exceeded.
04	55	00	8B	Excessive write skew.
04	55	00	8C	Excessive write correction.
04	55	00	8D	Excessive dynamic skew.
04	89	00	60	Tension shutdown error.

**Table B-1. 88780 SCSI Error Codes (continued)**

<b>SK</b>	<b>AS</b>	<b>AQ</b>	<b>EC</b>	<b>Description</b>
04	89	00	61	Tape speed error.
04	89	00	62	Tape ramping error.
04	89	00	63	Servo unresponsive error.
04	89	00	6E	No reel found error.
04	89	00	6F	Hub lock error.
04	89	00	70	Reel not seated error.
04	89	00	71	Reel inverted error.
04	89	00	72	Tape stuck to reel error.
04	89	00	73	Tape stuck in path error.
04	89	00	74	Tape tensioning error.
04	89	00	75	Tape eject error.
04	89	00	76	Door open error.
04	89	00	78	No BOT detected.
04	89	00	79	Operator reset abort of tape operation.
04	89	00	7A	Host reset abort of tape operation.
04	89	00	7D	Block missing error.
04	89	00	7E	Gap recapture error.

**Table B-1. 88780 SCSI Error Codes (continued)**

<b>SK</b>	<b>AS</b>	<b>AQ</b>	<b>EC</b>	<b>Description</b>
04	89	00	7F	Block recapture error.
04	8A	00	A0	Pop parity error.
04	8A	00	A1	Push parity error.
04	8A	00	A2	Byte count mismatch.
04	8A	00	A3	Prior error reject.
04	8A	00	A4	Write stopped at EOT.
04	8A	00	A5	Zero byte record read or requested.
04	8A	00	A6	Final report not valid.
04	8A	00	A7	Tape runaway during manual commands.
04	8A	00	A8	Tape position synchronization mismatch.
04	8A	00	A9	Physical data record too small to deblock.
04	8A	00	AA	Invalid pointer found during deblocking of physical record.
04	8A	00	AB	Access table contents were invalid.
04	8A	00	AC	Access table contents were incomplete.
04	8A	00	AD	Improper byte count sum of access table entries.
04	8A	00	B0	Hardware error detected in data compression (XC) circuitry.
04	8A	00	B1	Bad parity detected from Data compression circuitry.

**Table B-1. 88780 SCSI Error Codes (continued)**

SK	AS	AQ	EC	Description
04	8A	00	B2	Data compression circuitry not properly flushed of data.
04	8A	00	B3	Bad parity detected from interface into data compression hardware.
04	8A	00	B4	Bad parity detected from buffer into data compression hardware.
04	8A	00	B5	Data compression-to-interface byte count mismatch.
04	8A	00	B6	Data compression-to-buffer byte count mismatch.
04	8A	00	BF	Fatal error encountered.
04	91	00	D0	A spurious reset occurred.
04	92	00	D1	A spurious SCSI chip interrupt occurred.
05	00	00	E2	There was an illegal request during copy.
05	20	00	E3	There was an invalid command op code during copy.
05	20	01	E4	There was an illegal function requested for the device type (copy).
05	20	02	E5	There was an unsupported function requested during copy.
05	20	03	E6	There was a reserved field used during copy.
05	20	04	E7	There was an invalid field in the parameter list during copy.
05	25	00	D5	An invalid LUN was detected.
05	26	00	11	Invalid param error.
05	26	00	12	Invalid test/info number.

**Table B-1. 88780 SCSI Error Codes (continued)**

<b>SK</b>	<b>AS</b>	<b>AQ</b>	<b>EC</b>	<b>Description</b>
05	26	06	16	Density NA error.
05	26	85	13	Test not remotely accessible.
05	26	86	C4	The mode length is not on a legal boundary.
05	26	87	18	Requested record length exceeded maximum supported.
05	26	87	D2	The requested write length was too great.
05	26	8B	D3	Verify immediate is not supported.
05	26	90	CD	An invalid log was requested.
05	26	94	D8	An unsupported mode page was requested.
05	34	00	10	Invalid cmd error.
05	34	00	C2	There is an illegal field in the CDB.
05	34	01	C0	This command is not supported.
05	34	04	DB	There were non-zero reserved fields.
05	34	06	C3	There is an illegal mode select parameter.
05	34	07	C5	There was a fixed bit set, but drive not in fixed mode.
05	34	8E	C7	The Byte compare bit is not supported.
05	34	8F	C9	The SILI bit is set in fixed mode.
05	34	93	D7	Immediate bit set when not in immediate response mode.

**Table B-1. 88780 SCSI Error Codes (continued)**

SK	AS	AQ	EC	Description
05	34	95	D9	An invalid mode length was requested.
05	34	96	DA	An invalid field in the mode was detected.
06	28	00	CF	The medium was changed.
06	28	80	F1	The drive transitioned to Online with no position change.
06	29	00	C8	A front panel reset occurred.
06	29	00	CE	A power on occurred.
06	29	00	E0	There was a reset during copy due to lost data.
06	29	86	14	Test aborted by reset.
07	27	00	04	Drive is write protected.
08	00	05	00	Blank tape.
0A	00	00	E1	There was an error detected from the target during copy.
0B	47	00	CC	A parity error was detected.
0B	49	02	D4	An illegal message caused an abort.
0B	4E	00	DE	There was a bus protocol error.
0B	4E	00	DF	There was a failure to reselect.
0B	FF	00	F0	The target went to an incorrect phase or sent an unexpected status.
0D	3B	0B	0E	Tape ten feet past EOT, cannot write to tape.