HP 97556/58/60
5.25-inch
SCSI Disk Drives

Product Description Manual

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Edition 2 (Draft) ..... September 1990

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Product Description

The HP 97556/58/60 SCSI single-ended and differential interface disk drives are reliable, low cost, high capacity, high performance, random access mass storage devices. Each product utilizes sputtered thin-film 5.25-inch disks as storage media. The total unformatted capacity of the disk drives is 796 megabytes for the 97556, 1268 megabytes for the 97558, and 1606 megabytes for the 97560. This equates to 677, 1079 and 1367 megabytes of formatted user capacity, respectively.

Low cost, high capacity, and reliability are achieved with an advanced hybrid servo design that provides the flexibility and performance of a dedicated servo system and the dynamic head alignment of an embedded servo system.

High performance (13.5 msec random average seeks) and low power consumption are achieved with a state-of-the-art HP-designed actuator. Close tolerance disk spacing allows up to 10 platters in the standard 5.25-inch form factor for maximum capacity and low cost/megabyte. An HP-designed spindle motor provides the required starting torque for the disk stack of up to 10 platters.

The disk drive electrical interface is compatible with the industry standard Small Computer System Interface (SCSI). The drive is identical to the 5.25-inch minifloppy in size and voltage requirements. Figure 1-1 shows the major components of the disk drive. Mounting instructions are in chapter 2.

Key features of the HP 97556/58/60 Disk Drives are:

- High reliability (150,000 hours MTBF).
- Synchronous burst data transfer rate of up to ten megabytes per second.
- Embedded controller incorporating SCSI-2 compatibility.
- Unformatted capacities of 796, 1268, and 1606 Megabytes.
- Formatted capacities of 677, 1279, and 1367 Megabytes.
- Extensive use of HP's state-of-the-art VLSI processes.
- High performance HP-designed actuator.
- Industry standard 5.25-inch form factor and voltage requirements.

Options

The following options are available:

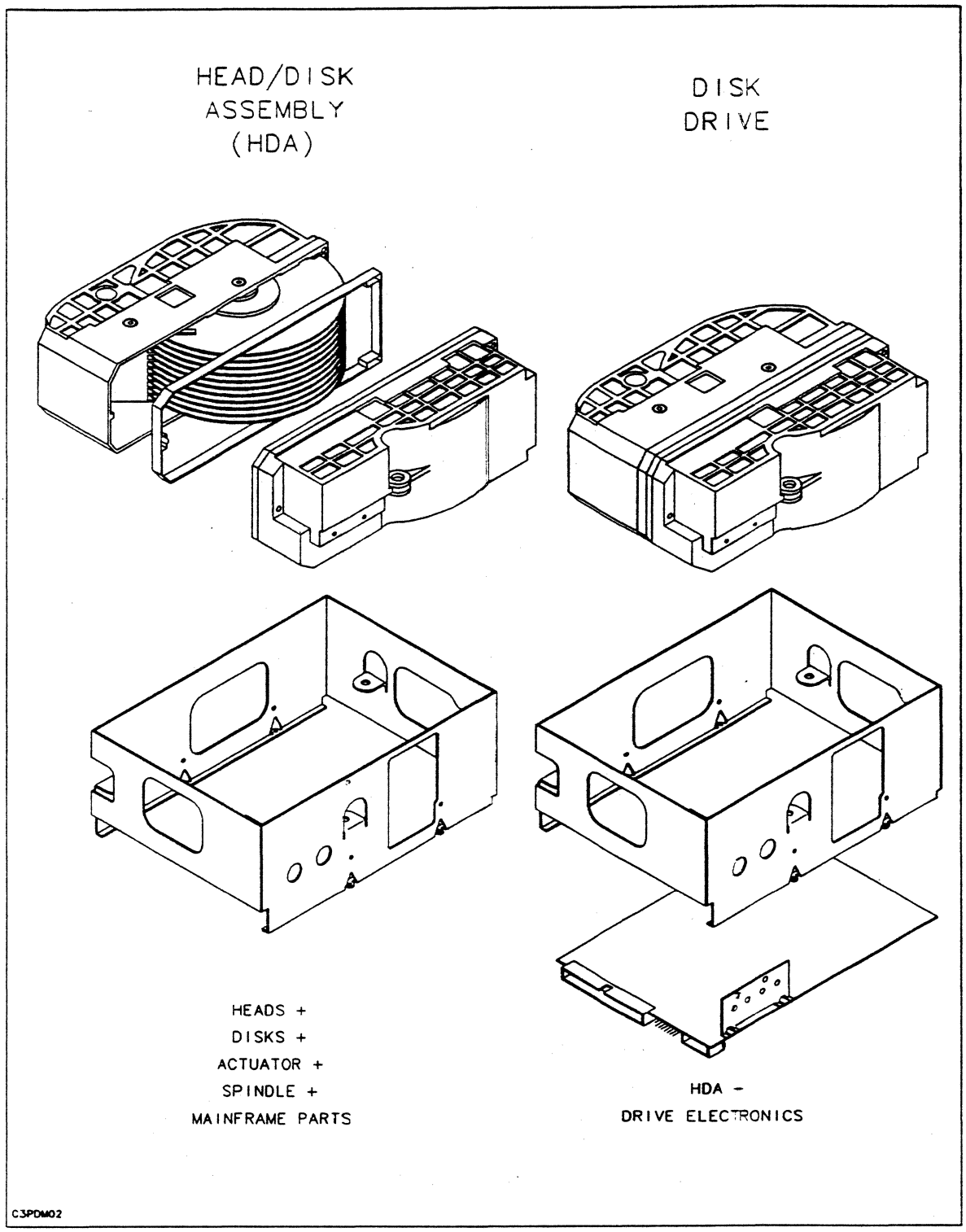
- Orderable with or without a front bezel.
- Orderable with or without a front panel LED indicator.
- Orderable with or without terminator resistor packs.
- Orderable with one of the following three terminator options:
  - The disk drive supplies +5 V to the on-board terminators only.
  - The disk drive supplies +5 V to the on-board terminators, and to pin 26 of the SCSI Connector.
  - The host or initiator supplies +5 V to pin 26 of the SCSI Connector for the on-board terminators.

Related Documentation

The following documentation provides information related to the operation of the HP 97556/58/60 T/P Disk Drives:

- *Small Computer Systems Interface: ANSI X3T9.2/86-109 (Rev 10C), X3T9/89-042*
- *Common Command Set (CCS) of the Small Computer System Interface (SCSI): ANSI X3T9.2/85-52 (Rev 4.B)*

Figure 1-1. Disk Drive major Components.



Specials

For customer needs that differ from the products described in this manual, Hewlett-Packard can provide specially modified products. These modifications are ordered, defined, engineered, and manufactured under "special" contract negotiations.

Disk Drive Specifications

The operating specifications for the HP 97556/58/60 disk drives are listed on the following pages.

Caution

The HP 97556/58/60 must be operated within the environmental limits specified in this chapter in order for it to function properly.

Interface

Interface type:	Industry Standard SCSI
Controller:	
Overhead time:	< 1 msec
Buffer size:	128 kbytes
Buffer type:	Dual-ported
Interleave:	1:1

Seek Time

Track to track seek:	3.0 msec
Random average seek:	13.5 msec
Maximum seek:	25.0 msec

Seek time is defined as the time from when the actuator begins to move until the head has settled over the target track. It does not include any controller overhead time. The values above are derived from a representative sample

of disk drives measured under normal temperature and voltage conditions.

Track to track seek time is the mean value of all seek times measured when performing all possible single track seeks.

Random average seek time is the time to do all possible random seeks divided by the number of random seeks possible.

Maximum seek time is the time it takes to seek 1962 cylinders.

Spin-up Time

From Power-on to Ready for Access:

Typical:	33 seconds
Maximum:	55 seconds

From Power-on to SCSI Bus Selection:

Typical:	3 seconds
Maximum:	5 seconds

Rotational Latency

Average time: 7.5 ms ±1%

Internal Data Transfer Rate (Controller/Disk)

Burst: 2.88 megabytes/s (23 megabits/second) for a single sector transfer.

Sustained: > 2.2 megabytes/second (17.6 megabits/second) for a continuous transfer.

External Data Transfer Rate (Host/Controller)

Asynchronous: 1.5 megabytes/second

Synchronous: up to 10 megabytes/second

Disk Drive Capacities

Formatted capacities are given in parentheses and are calculated using a 512-byte sector. When other sector sizes are used, formatted capacities will change.

	HP 97556	HP 97558	HP 97560
Disks per:	6	8	10
Data Surfaces:	11	15	19
Tracks per Surface: [1]	1680 (1670)	1962 (1952)	1962 (1952)
Sectors per:			
Track	72 (72)	72 (72)	72 (72)
Surface	120,960 (120,240)	141,264 (140,544)	141,264 (140,544)
Drive	1,330,560 (1,322,640)	2,118,960 (2,108,160)	2,684,016 (2,670,336)
Data Bytes Per:			
Sector	598 (512)	598 (512)	598 (512)
Track	43,100 (36,864)	43,100 (36,864)	43,100 (36,864)
Surface	72,408,800 (61,562,880)	84,562,200 (71,958,528)	84,562,200 (71,958,528)
Drive	796,488,000 (677,191,680)	1,268,433,000 (1,079,377,920)	1,606,681,800 (1,367,212,032)

Notes:

1. Eight physical tracks are reserved as spares, one is for defect list storage, and one is a maintenance track, leaving 1670 (97556) or 1952 (97558/60) user accessable tracks.

Recoverable Data Error Rate

Less than ten (10) errors in 10^{13} bits transferred when the disk drive is operated within the specified environmental limits.

Unrecoverable Data Error Rate

Less than ten (10) error in 10^{15} bits transferred when the disk drive is operated within the specified environmental limits.

Seek Error Rate

Less than ten (10) seek error in 10^{7} seeks when the drive is operated within the specified environmental limits.

Disk Speed

4002 rpm ±1%

Recording Density

1102 flux reversals/mm (28,000/in.) on innermost track.

Track Density

73 tracks/mm (1865 tracks/in.)

Coding System

2-7 Run Length Limited (RLL) Code:

Data Pattern	Transition Pattern
00	1000
01	0100
100	001000
101	100100
111	000100
1101	00100100
1100	00001000

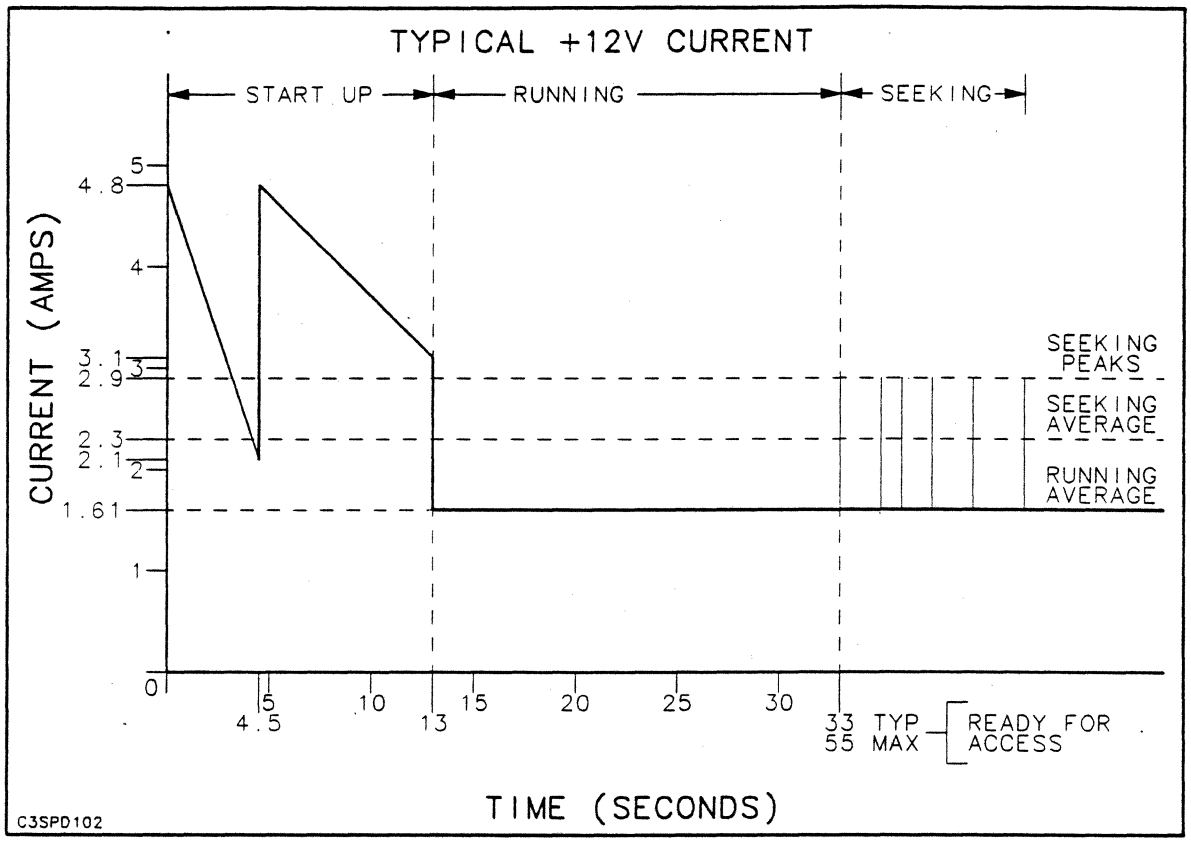
DC Power

Note: All values assume input voltages are within limits specified by the input power requiremts.

Operating Condition	+5 Vdc Current			+12 $Vdc_{(ave)}$ Current[1]	+12 $Vdc_{(peak)}$ Current[1,2]	Power	
	Single-Ended	Diff. (Idle)	Diff. (Rx/Tx)			Single-Ended	Diff.
Start-up							
- Typ.	1.7 A	2.3 A		4.8 A	5.1 A		
- Max.	1.9 A	2.6 A		5.1 A	5.1 A		
Running[3]							
- Typ.	1.7 A	2.3 A	3.3 A	1.60 A		28 W	31 W
- Max.	1.9 A	2.6 A	3.6 A	1.80 A		31 W	34 W
Seeking[4]							
- Typ.	1.7 A	2.3 A		2.3 A	2.9 A	35 W	38 W
- Max.	1.9 A	2.6 A		2.7 A	3.9 A	41 W	44 W

Notes:

1. Typical +12 Vdc currents are for sustained drive operation at 25°C ambient temperature. Maximum +12 Vdc currents are for initial drive turn on at 0°C ambient temperature.
2. Peak values shown are for occurrences greater than 5 msec duration.
3. Spindle up to speed and actuator is track following.
4. Assuming random seeks with a short (7.5 msec) latency between seeks.


TYPICAL +12V CURRENT
START UP
RUNNING
SEEKING
CURRENT (AMPS)
5
4.8
4
3.1
3
2.9
2.3
2.1
2
1.61
1
0
SEEKING PEAKS
SEEKING AVERAGE
RUNNING AVERAGE
5
4.5
10
13
15
20
25
30
33 TYP
55 MAX
READY FOR ACCESS
TIME (SECONDS)
C3SPD102

Electromagnetic Emissions

Radiated and conducted interference for the HP 975566/58/60T/P disk drives:

These products have been characterized from 10 kHz to 1 GHz as individual "components" (incomplete in nature). Data is available upon request.

End user system emissions are highly dependent upon the characteristics of the system in which the product is installed. A complete test and evaluation program should be performed on the end use application.

Acoustical Noise

Less than 50 dbA sound pressure level while performing random address seeks.

Safety

This product will be evaluated as a component (incomplete in nature) to:

- IEC: 950 (EN 60950)
- UL: 1950
- CSA: C22.2 No. 950-M89
- TUV: DIN IEC 950/VDE 0806/8.81

A complete test and evaluation program should be performed on the end use application.

Physical Characteristics

Unit Weight:	3.4 kg (7.5 lbs)
Shipping Weight:	
Single-Unit Package:	4.5 kg (10 lbs)
Four-Unit Package:	14.8 kg (33 lbs)
Dimensions[1]:	
Length:	203 mm (8.00 in.)
Width:	146 mm (5.75 in.)
Height:	83 mm (3.25 in.)

[1]Excluding front bezel.

Disk Drive Environmental Requirements

The environmental requirements for the proper operation of the HP 97556/58/60 disk drives are listed on the following pages.

Input Power Requirements

Voltages: +5 V, +12 V

Regulation:

+5 V:	±5%
+12 V:	±5%[1]

[1] ±10% tolerance allowed during start-up.

Ripple and Noise:

+5 V:	< 100 mV_{p-p}
+12 V:	< 150 mV_{p-p}

Ambient Air Temperature

Operating[2]: 0°C to 50°C (32°F to 122°F)

Nonoperating[2]: -40°C to 65°C (-40°F to 149°F)

[2] Maximum rate of change shall not exceed 20°C (36°F) per hour.

Relative Humidity

Operating[3]: 8% to 80% with wet bulb limit of 28°C

Nonoperating[3]: 5% to 80%

[3] Excludes all conditions which can cause condensation in or on the disk drive.

Altitude	**Operating:**	61 m (100 ft) below sea level to 3 046 m (10,000 ft) above sea level.
	Nonoperating:	305 m (1,000 ft) below sea level to 15 240 m (50,000 ft) above sea level.
Shock	**Operating:**	11 ms, half wave sine shock with a peak amplitude of 2.0 g's without change in performance. 11 ms, half wave sine shock with a peak amplitude of 6.0 g's without loss of data.
	Nonoperating:	11 ms, half sine shock with peak amplitude of 30 g. 26 ms, trapezoidal shock with peak amplitude of 25 g.
Swept Sine Vibration	**Operating:**	0.25 g (peak), 5 to 500 Hz with no loss in performance or data. 0.5 g (peak), 5 to 500 Hz with no loss of data.
	Nonoperating:	0.5 g (peak), 5 to 500 Hz.
Random Vibration	**Operating:**	Power spectral density of 0.0001 g^2/Hz from 5 to 350 Hz, decreasing by 6 dB/octave from 350 Hz to 500 Hz (approximately 0.21 g_{rms}) in any translational direction.

	Nonoperating:	Power spectral density of 0.015 g^2/Hz from 5 to 100 Hz, decreasing by 6 dB/octave from 100 to 137 Hz then constant from 137 Hz to 350 Hz, and decreasing by 6 dB/octave from 350 to 500 Hz (approximately 2.09 g_{rms}) in any translational direction.

Electromagnetic Radiation

Radiated:	< 3V/m from 14 kHz to 200 MHz
Conducted:	
+5 V:	< 200 mVp-p from 100 kHz to 250 MHz
+12 V:	< 400 mVp-p from 100 kHz to 250 MHz
Magnetic:	< 4 gauss 47.5 to 198 Hz

Electrostatic Discharge

Note: Current regulations do not specify or require Electrostatic Discharge (ESD) testing.

These products have been characterized as individual "components" (incomplete in nature) with a company-imposed set of operational and non-operational standardized tests. Data is available upon request.

ESD susceptibility is highly dependent upon the characteristics of the system in which the product is installed. A complete test and evaluation program should be performed on the end use application. Avoid ESD damage by using proper grounding procedures whenever the drive is handled.

Tilt

The disk drive will meet all performance specifications in any orientation. Refer to chapter two for mounting instructions.

2

Product Installation

Introduction

This chapter provides information for the mechanical and electrical installation of the disk drive. For your reference, the diagrams are included at the end of the chapter.

Note

The purpose of a correct installation is to provide an optimum environment for the disk drive. Continually subjecting the disk drive to the extremes of the environmental specifications results in stress on the product and can result in early failure or less reliable operation. All possible combinations of stresses have not been tested and the results of simultaneously applying worst case extremes of several environment parameters are unpredictable.

Unpacking/Repacking the Disk Drive

Note

The disk drive is shipped in a reusable shipping container. Retain the shipping container and all packing material for re-shipment.

Inspecting the Shipping Container

When your shipment arrives, ensure that it is complete as specified by the carrier's bill of lading. Inspect the shipping container immediately upon receipt for evidence of mishandling during transit. If the container is damaged or water stained, request that the carrier's agent be present when the container is unpacked.

Caution

Handle the disk drive with care. Until secured in an end user chassis, it is susceptible to excessive mechanical shock, vibration, and Electrostatic Discharge (ESD). Also, handle the printed circuit assembly (PCA) by the edges only. Follow approved grounding procedures. Improper handling may cause damage to the equipment which is not covered under your warranty.

Inspecting the Disk Drive

Refer to figure 2-1. Remove the disk drive from the shipping container and inspect it for any mechanical damage that may have occurred during shipment. If any damage is observed, immediately notify Hewlett-Packard and file a claim with any carrier involved.

Recording the Serial Number

Each drive carries an individual serial number. Keep a record of all serial numbers. If your drive is lost or stolen, the serial number is often necessary for tracing and recovery, as well as for any insurance claims.

Return Shipment Addresses

Vendor Purchases

Return the drive(s) to the vendor from which it was purchased. Refer to the original ordering information for the correct address for that vendor.

Hewlett-Packard Direct Purchases

If you purchased your drive(s) directly from Hewlett-Packard, return them to the following address:

Hewlett-Packard
Disk Mechanisms Division
11413 Chinden Blvd.
Boise, Idaho 83714

Re-Packing For Shipment

Use the original container and packaging material supplied with the drive for any shipments. If the original container is not available, you can order the following new packaging kits from Hewlett-Packard: HP 19518A for the single-unit kit, or HP 19519A for the four-unit kit. You can also order individual kit components (listed with their part numbers in figure 2-1). Consult your authorized distributor or Hewlett-Packard Sales Representative for ordering instructions. Hewlett-Packard recommends that all shipments be insured.

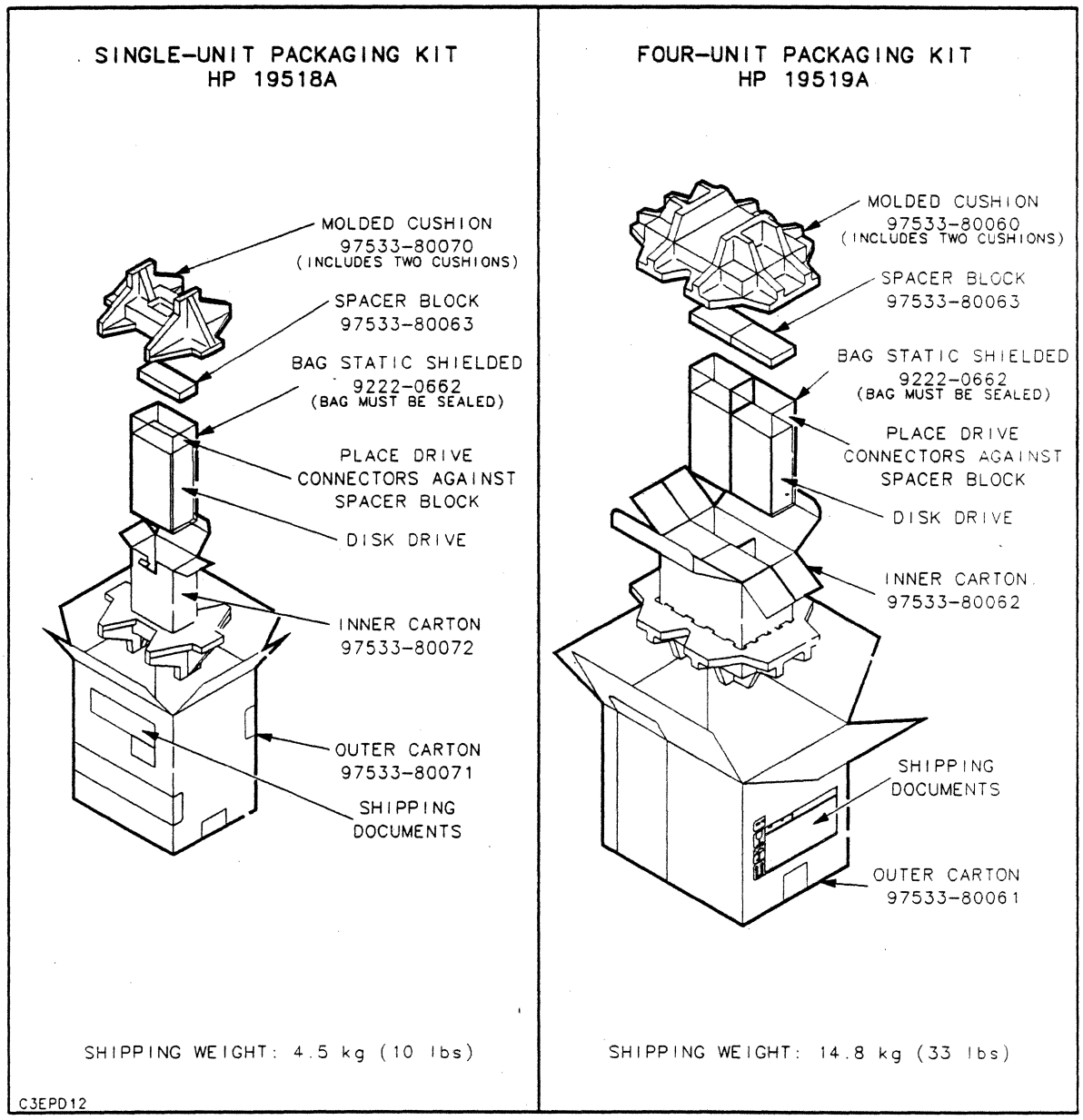
Caution

Never ship less than four drives in the four-unit package. The drives may be damaged in shipment if the four-unit package is not completely loaded. Use the single-unit package for shipments of less than four.

Packaging

Pack the drive or drives as shown in the figure 2-1. Seal each static shielded bag with adhesive tape. Seal both the inner and outer cartons securely with adhesive tape.

Figure 2-1. Single- and Four-Unit Packaging Kits.



Mounting Information

Since each installation of the product can be unique, the following information should be taken into consideration when mounting the product. The disk drive can be mounted in any axis.

Safety/Regulatory Considerations

- When installing an HP 97556/58/60 Disk Drive into an end use product, safety and regulatory conditions of acceptability should be considered.
- If the front bezel option has been installed, it should be evaluated in the intended end use application.

Chassis Dimensions and Mounting Screw Locations

The physical dimensions and mounting screw locations for the disk drive chassis are shown in figure 2-2. The length dimensions shown are for the chassis only and do not include clearances for power and interface connectors.

Connector Dimensions and Locations

The physical locations and dimensions of the Single Ended and Differential disk drive connectors are shown in figures 2-3 and 2-4 respectively.

Physical Mounting

There are eight (8) threaded mounting holes (for 6/32 threads) on the disk drive: two on each side, and four on the bottom. Typically, the disk drive is fastened directly to a chassis with 6/32 screws. Use the following guidelines to mount the disk drive:

- Use 6/32 screws and torque them to 10 inch-pounds.
- When mounted, the hardware must not protrude more than 1 mm (0.04 in.) beyond the inside of the disk drive frame.

Airflow Requirements

The disk drive must be installed such that the ambient air temperature surrounding the disk drive is maintained within the limits specified in chapter 1.

Airflow is required to maintain disk drive performance and reliability. The disk drive can be cooled by forced air or by natural cooling. Forced air may be necessary if the disk drive is located within a cabinet or other enclosure. If forced air cooling is not used, the disk drive must be located such that internal heat is conducted away from the drive and no outside heat sources raise the operating temperatures above the limits shown in chapter 1.

As a guideline, the estimated front to back airflow to prevent exceeding the maximum operating temperatures shown in figure 2-5 at 50°C ambient air temperature is seven cubic feet per minute. This is a function of the specific airflow pattern inside the cabinet where the disk drive is installed.

As an additional guideline, the airflow should be adjusted to prevent the temperature measuring points on the HDA casting and the printed circuit assembly from exceeding the limits shown in figure 2-5.

All temperature measurements should be made under normal operating conditions, i.e. the drive should be performing random seeks with a one/half latency between seeks. If the end use application requires consistent drive operation exceeding these conditions, the temperature measurements should be made under those conditions.

SCSI Address Selection

Refer to figure 2-6. The SCSI address for the drive is determined by the states (open or shorted) of three pin-sets located near the SCSI connector. The drive is shipped from the factory with shorting jumpers across all three pin-sets which sets up a SCSI Address of 7. Figure 2-6 shows the location of the pin-sets and the jumper setups for the SCSI addresses.

Note

Save any removed shorting jumpers for future use.

Synchronized Spindle

The Synchronized Spindle pins are located next to the Address selection pins. Refer to figure 2-6 for the location and identification of the Synchronized Spindle pins.

There are four synchronized spindle modes: Stand Alone, Slave, Master, and Master Control. The HP 97556/58/60 SCSI disk drives supports all four modes.

The power-on default for all drives is the Stand Alone Mode. Refer to figure 2-6 for the location and identification of the Synchronized Spindle pins, and the specifications for the Master Sync output and the Slave Sync input.

Stand Alone. When the drive is in the Stand Alone Mode:

- It does not transmit a Master Sync Signal.
- It does not accept externally sourced Slave sync inputs.

Slave. When the drive is set to the Slave configuration:

- It does not transmit a Master Sync signal.
- It receives input sync from pin 3.

Master. When the drive is set to the Master configuration:

- It transmits a Master Sync signal from pins 1 and 3.
- It syncs internally to the same signal.

Master Control. When the drive is set to the Master Control configuration:

- It transmits a Master Sync signal from pin 1.
- It receives input sync from pin 3.

Mode Select Command

Synchronized Spindle is controlled with the RPL bits in parameter page 04 (hex), byte 17 of the MODE SELECT command. In addition, byte 18 of the same page provides for positional offset from the input sync signal. Refer to the MODE SELECT, MODE SENSE section in the HP 97556/58/60 Technical Reference Manual for more details about implementing these functions.

MODE SELECT Synchronized Spindle Control

RPL Bits		
Bit 1	**Bit 0**	**Function**
0	0	Disables synchronization function (default).
0	1	Sets drive to SLAVE configuration.
1	0	Sets drive to MASTER configuration.
1	1	Sets drive to MASTER CONTROL configuration.

Options Connector

The Options connector located on the underside of the drive electronics/controller PCA consists of six pin-sets which control the operation of the options. See figure 2-7 for pin-set locations and option selections.

Note

Save any removed shorting jumpers for future use.

Termination Power Source Options

Refer to figure 2-7. The termination power source can be reconfigured with the appropriate shorting jumpers (0 = open, 1 = shorted) on pin-sets 1 and 2.

Terminator Resistor Packs

The drive is shipped with three (single-ended drives) or two (differential drives) terminator resistor packs installed. The resistor packs are located under the drive as shown in figures 2-3 and 2-4. When installing multiple drives on the SCSI channel, the packs must be removed from all but the last drive in the chain. The drives can be ordered from the factory with the packs removed. When re-installing the packs, ensure that they are properly keyed into their connectors (see figures 2-3 and 2-4).

Synchronous Data Transfer Request (SDTR)

Refer to figure 2-7. When pin-set 4 is shorted (1 position) the drive will initiate an SDTR message at power-on and RESET. When open (0 position) the drive will not initiate an SDTR message. The drive will respond to a host-initiated SDTR message whether this pin-set is open or shorted.

Parity Option Setting

Refer to figure 2-7. When pin-set 5 is shorted (1 position), the disk drive checks parity on commands and data. When open (0 position), the disk drive does not check for parity. Parity bits are generated whether this pin-set is open or shorted.

Auto Spin Up Option

Refer to figure 2-7. When pin-set 6 is shorted (1 position), the disk drive will automatically spin up at power on. If open (0 position), the drive will not spin up until the Initiator sends a Start Unit command. When not in the auto spin up mode the drive will return "Not Ready" to all commands except REQUEST SENSE, INQUIRY, RESERVE, RELEASE, and START UNIT until the drive is ready for access.

Drive Interface Connections

SCSI Connector

Refer to figure 2-6. The SCSI device connector is a nonshielded 50-pin connector consisting of two rows of 25 male pins with adjacent pins 2.54 mm (0.1 in.) apart. The physical construction and pin assignments for the connector conform to the SCSI specifications for single-ended and differential driver configurations. The connector pin assignments are listed in table 2-1 for the single-ended drive, and figure 2-2 for the differential drive.

The SCSI cable connector should be a nonshielded 50-pin keyed connector consisting of two rows of 25 female contacts with adjacent contacts 2.54 mm (0.1 in.) apart. A shroud and header body should be used.

DC Power Connector

Power requirements for the disk drive are listed in chapter 1. The power connector on the rear of drive electronics/controller PCA provides connection for dc power used by the drive. The pin assignments for the dc power connector are shown in figure 2-6.

Frame Ground Connector

The frame ground connector provides the ground contact to the HDA (see figures 2-3 and 2-4). This is a Faston®-type connector.

Mating Connector Requirements

The recommended mating connector manufacturer's part numbers are as follows:

Disk Drive Connector/Function	Recommended Mating Connector
SCSI Connector (single-ended and differential)	3M® 3425-6600
DC Power	AMP® 1-480424-0
Frame Ground	AMP® 62187-1
Options Connector (shorting jumper)	AMP® 531220-3 (9 supplied with the disk drive; manufacturer supplies rail of 10)
Synchronized Spindle Pins Connector	AMP® Housing 4-87456-9 Note: Also requires a contact set; refer to vendor documentation to select the proper contact set for the installed wire size. (For 20-24 gauge wire, use AMP® 1-87309-4.)

Cabling Requirements

The disk drive adheres to the cabling requirements and limitations set forth in the ANSI SCSI specifications. Figures 2-3 and 2-4 show the physical location and dimensions of the connectors for the Single-Ended and Differential disk drives (respectively).

Refer to the SCSI specifications for details.

- Cables with a characteristic impedance of 100 ohms ±10% are recommended for unshielded flat or twisted pair ribbon cable.
- Cables with a characteristic impedance of 90 ohms ±10% are preferred for shielded cables.
- To minimize discontinuities and signal reflections, do not use cables with different impedances on the same bus.

- A minimum cable size of 28 AWG should be used to minimize noise effects and ensure proper distribution of termination power.
- Cables must be properly terminated.

Single-ended Cable

For disk drives with single-end output, use the following cable information:

- A 50-conductor flat cable or 25-signal twisted-pair cable should be used. Cable length shall be equal to or less than 6.0 meters. This refers to internal and external cable length (except stubs).
- A stub length of no more than 0.1 meter is allowed off the main line interconnection within any connected device.

Differential Cable

For disk drives with differential output, use the following cable information:

- A 50-conductor flat cable or 25-signal twisted-pair cable should be used. Cable length shall be equal to or less than 25 meters. This refers to internal and external cable length (except stubs).
- A stub length of no more than 0.2 meter is allowed off the main line interconnection within any connected device.

Front Panel LED Indicator

The light emitting diode (LED) on the front of the disk drive is an activity light that indicates the operational status of the drive from power-on, through the self-test diagnostics, and into normal operation.

1. **On** — When the disk drive is switched on, the LED normally stays on during the power-on sequence. The LED stays on while the spindle motor is being started until it is up to speed. If the LED is does not go out, a catastrophic failure has occurred. The most probable cause is a failure of the drive electronics/controller PCA.
2. **Flashing** — A flashing LED (approximately 1 Hz) indicates that the controller has failed all or a portion of the internal diagnostic tests.
3. **Intermittent** — After the power-on diagnostics have completed, the LED functions as an activity light and will go on any time the disk drive is executing a command, reading, or writing. If the LED is off, the drive is idle.

Table 2-1. SCSI Connector Single-ended Pin Assignments

Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
2	-Data Bit 0	16	-Data Bit 7	28	Ground	40	-RST
4	-Data Bit 1	18	-Data Bit P	30	Ground	42	-MSG
6	-Data Bit 2	20	Ground	32	-ATN	44	-SEL
8	-Data Bit 3	22	Ground	34	Ground	46	-C/D
10	-Data Bit 4	24	Ground	36	-BSY	48	-REQ
12	-Data Bit 5	26	TERMPWR	38	-ACK	50	-I/O
14	-Data Bit 6						

Notes:

1. All odd numbered pins, except pin 25, must be connected to ground. Pin 25 should be left open.
2. Pin 26 is reserved for terminator resistor power source.

Table 2-2. SCSI Connector Differential Pin Assignments

Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
1	Shield GND	14	-DB(5)	27	Ground	39	+MSG
2	Ground	15	+DB(6)	28	Ground	40	-MSG
3	+DB(0)	16	-DB(6)	29	+ATN	41	+SEL
4	-DB(0)	17	+DB(7)	30	-ATN	42	-SEL
5	+DB(1)	18	-DB(7)	31	Ground	43	+C/D
6	-DB(1)	19	+DB(P)	32	Ground	44	-C/D
7	+DB(2)	20	-DB(P)	33	+BSY	45	+REQ
8	-DB(2)	21	DIFFSENS	34	-BSY	46	-REQ
9	+DB(3)	22	Ground	35	+ACK	47	+I/O
10	-DB(3)	23	Ground	36	-ACK	48	-I/O
11	+DB(4)	24	Ground	37	+RST	49	Ground
12	-DB(4)	25	TERMPWR	38	-RST	50	Ground
13	+DB(5)	26	TERMPWR				

Note: SHIELD GND is optional on some cables. (Implementors note: Some shielded flat ribbon cables use pin 1 as a connection to the shield.)

Figure 2-2. Disk Drive Dimensions.

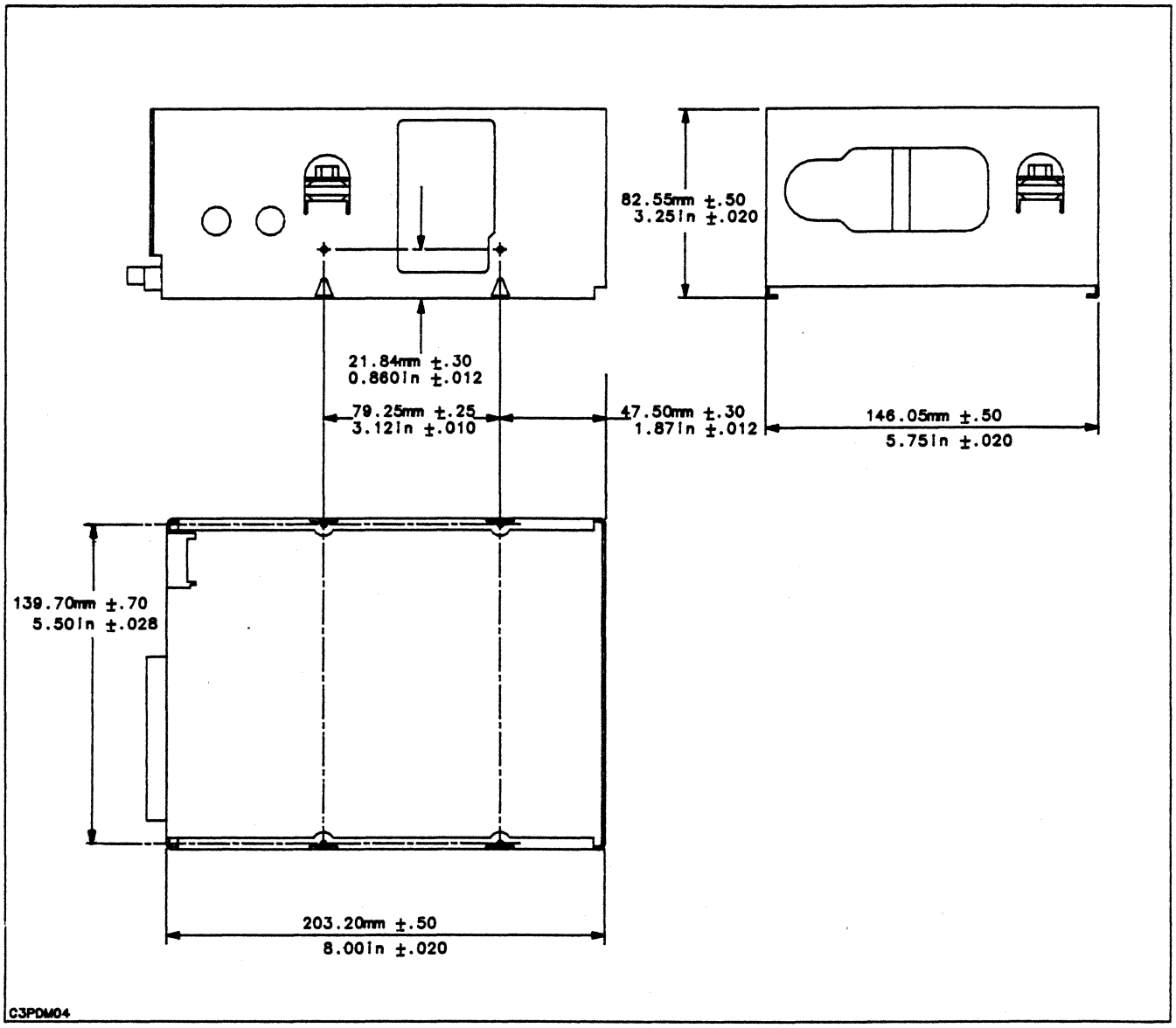


Figure 2-3. Connector Physical Dimensions, Single Ended Drives.

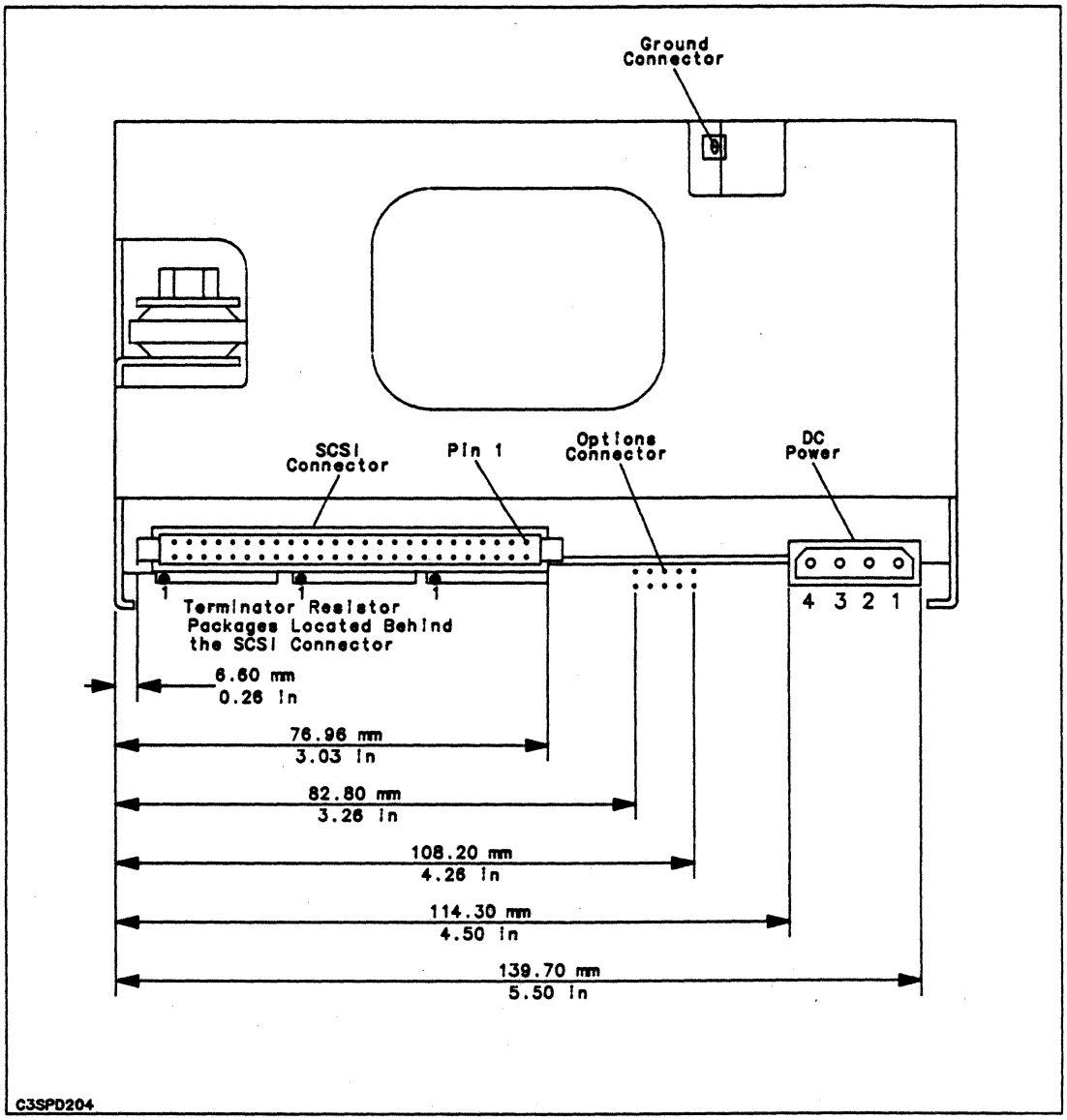


Figure 2-4. Connector Physical Dimensions, Differential Drives.

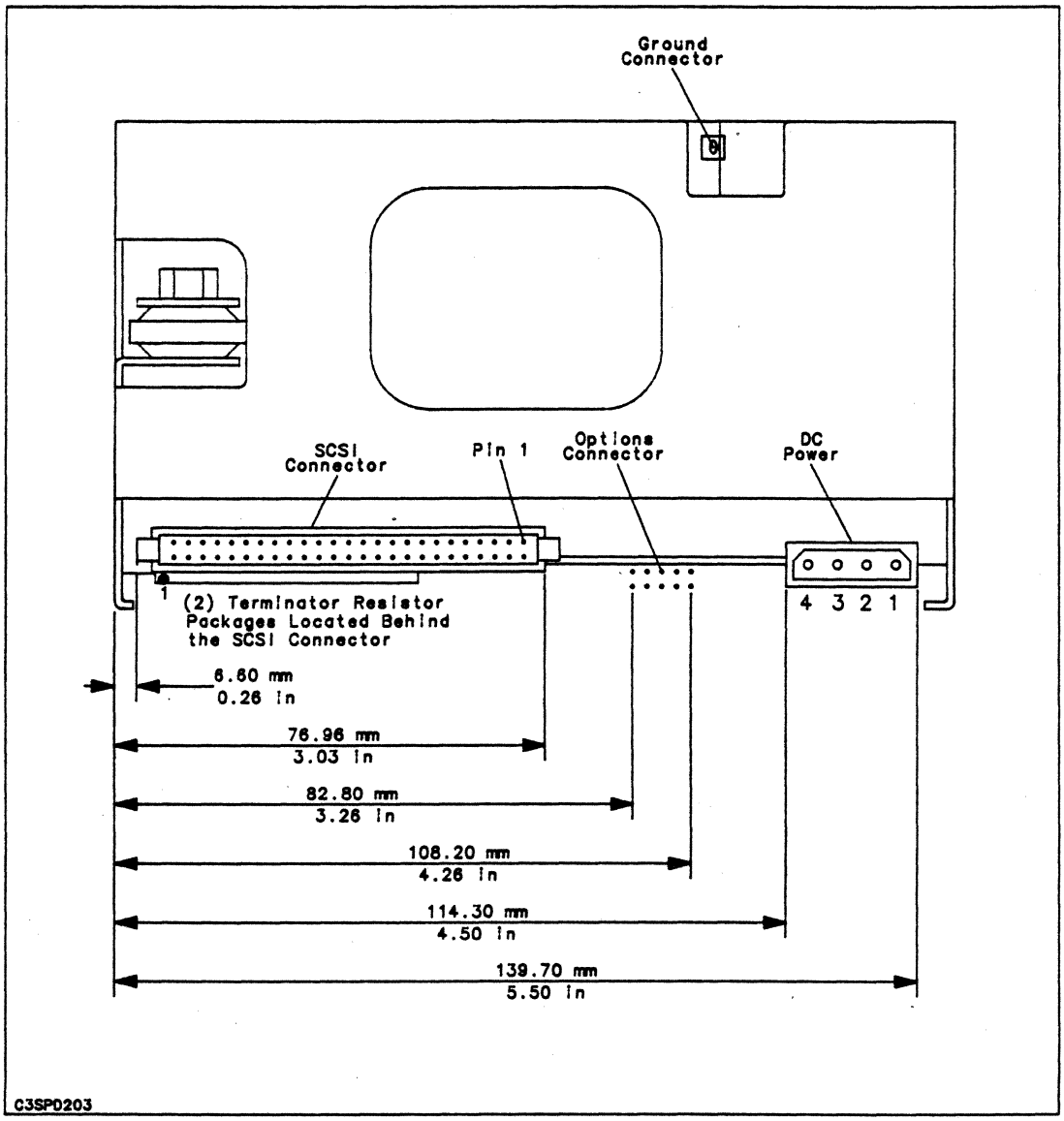


Figure 2-5. Temperature Measuring Points.

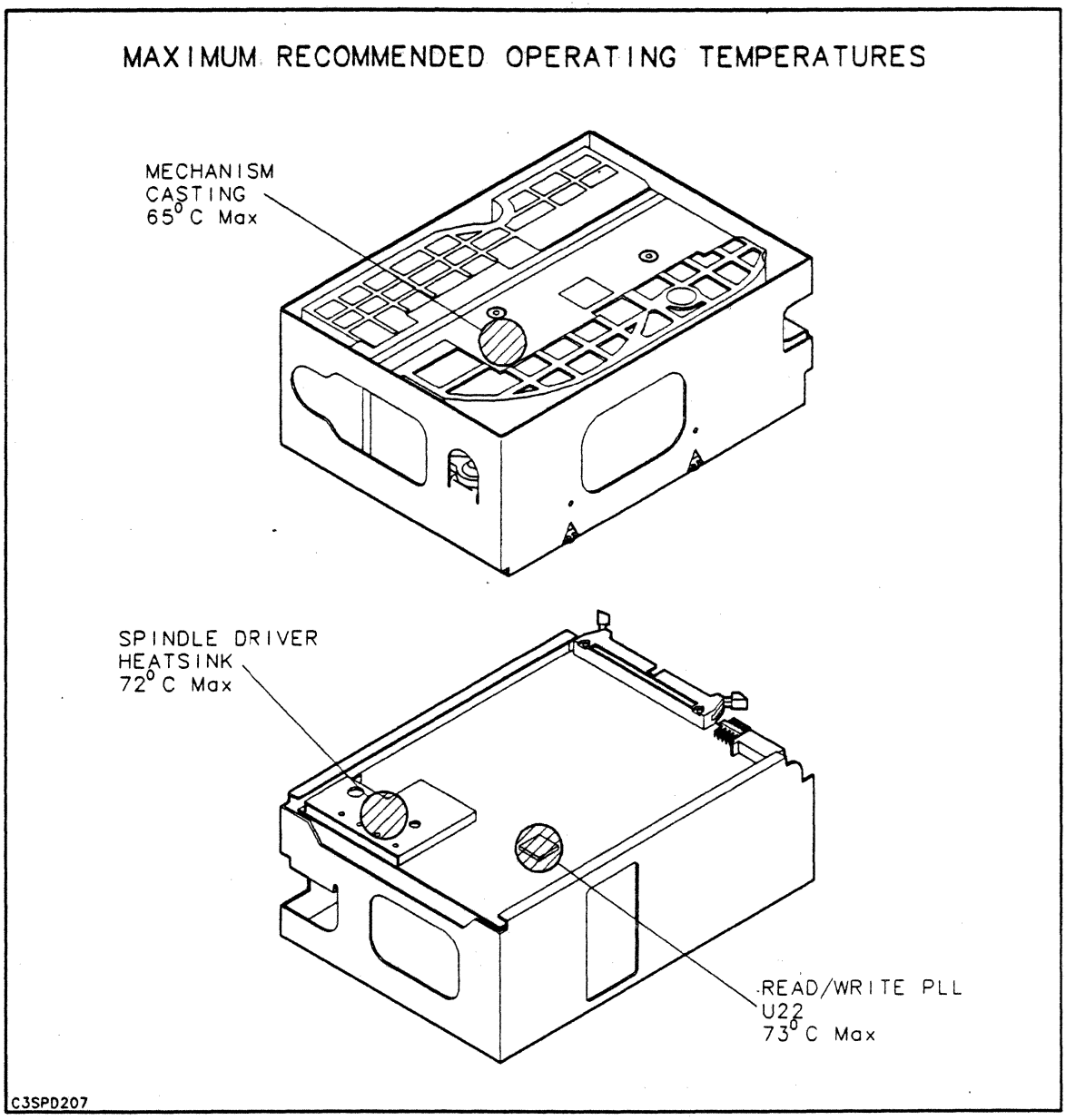


Figure 2-6. Interface Connectors.

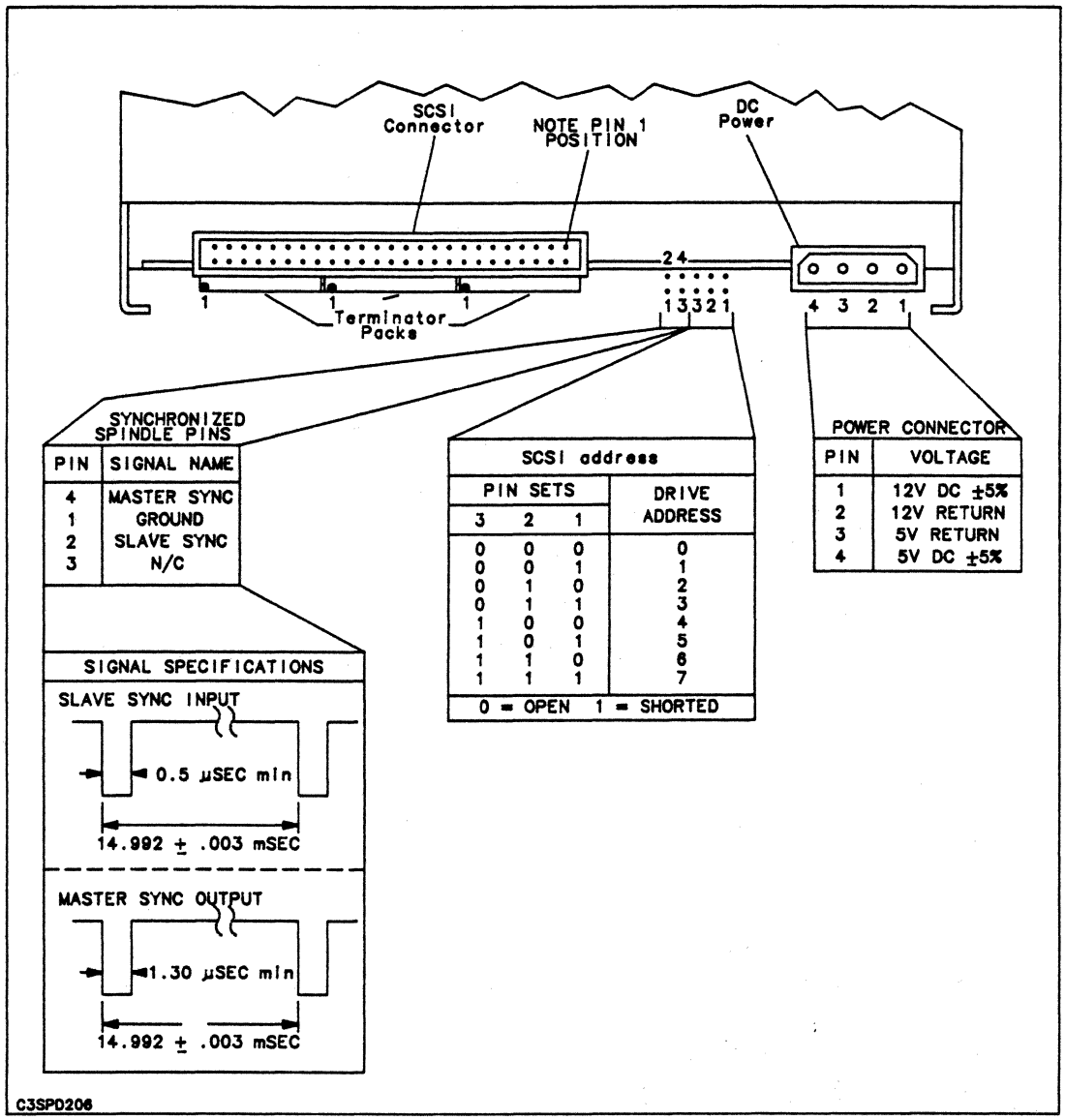
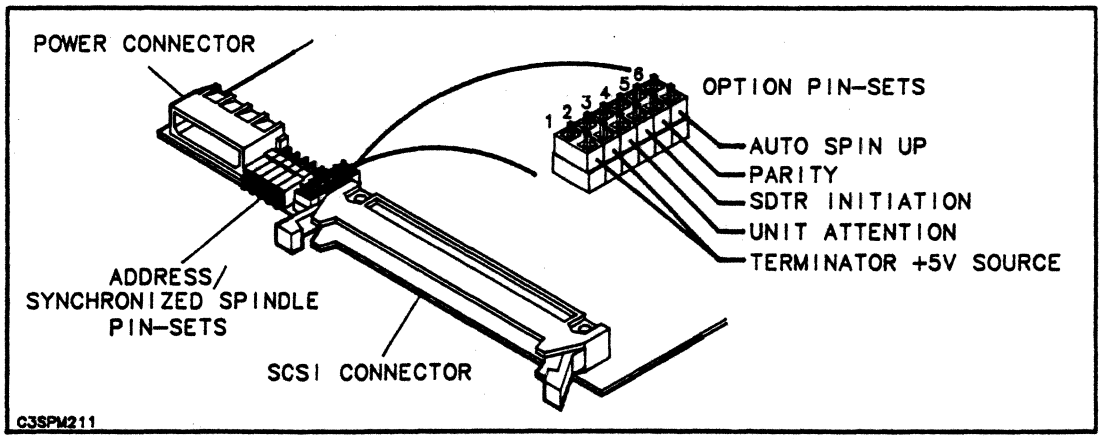


Figure 2-7. Option Pinsets.



Option Pin-Set Selections

Option Pin-Sets	
Pin-Sets 1 and 2	**On-Board Terminator +5V Source**
1 = open; 2 = open	**All Drives:** Drive +5V not connected to terminators; initiator supplied +5V not connected to terminators.
1 = shorted; 2 = open	**All Drives:** Drive +5V connected to on-board terminators but not to SCSI connector pins.
1 = open; 2 = shorted	**Single Ended Drives:** Initiator supplies +5V input to SCSI connector pin 26.
	Differential Drives: Initiator supplies +5V input to SCSI connector pins 25 and 26.
1 = shorted; 2 = shorted	**Single Ended Drives:** Drive +5V connected to on-board terminators and to SCSI connector pin 26.
	Differential Drives: Drive +5V supplied to on-board terminators and to SCSI connector pins 25 and 26
Pin-Set 3	**Unit Attention**
open	Enable Unit Attention
shorted	Inhibit Unit Attention
Pin-Set 4	**Drive Initiation of SDTR Message**
open	Inhibit drive Initiation of SDTR message
shorted	Enable drive Initiation of SDTR message at Power-On and Reset
Pin-Set 5	**Parity**
open	Inhibit parity checking
shorted	Enable parity checking
Pin-Set 6	**Auto Spin-Up**
open	Drive will not spin up until Initiator sends Start Unit command
shorted	Drive will spin up automatically at Power-On

3

Product Features

Introduction

This chapter provides information on supported features, supported commands, and a functional description of the HP 97556/58/60 disk drives.

Supported Features

The following features of the Small Computer Systems Interface (SCSI) are supported by the "Target". A "Target" is any HP 97556/58/60 disk drive. Device-specific information is also provided.

- **Single-ended or Differential Drivers.** The 97556/58/60 "T" products contain single-ended drivers, and the 97556/58/60 "P" products contain differential drivers.
- **Unshielded Connectors.** The Target is equipped with a 50-pin unshielded connector.
- **Arbitration.** Full arbitration is supported.
- **Disconnect.** If allowed, the Target may disconnect after a command is received, and for any significant delay occurring during a data transfer operation.

- **Power-on Self-test.** In response to a power-on condition, the Target performs the following self-test sequence:
  - Microprocessor Test
  - ROM Checksum
  - Microprocessor RAM Test
  - Partial Buffer RAM Test
  - SCSI Interface Test
  - Internal Data Path Test
  - Data Controller Test
  - Controller Initialization
  - Remaining Buffer RAM Test
  - ECC Verification Test
  - Initialize Spare Table
  - Initialize Log
  - Wait for Start Command (selectable with option switch)
  - Initialize Saved Pages Information
  - R/W Access Test (each head)
- **Bus Reset.** In response to a SCSI bus reset or Bus Device Reset message, the Target will perform the following reset sequence:
  - Finish any Logical Block Write in Progress
  - Abort Any Command in Progress
  - Controller Initialization
  - Initialize Spare Table
  - Initialize Log
  - Initialize Saved Pages Information

■ **SCSI Messages.** The following SCSI messages are supported:

Code (hex)	Length (bytes)	Message	Direction[1]
00	1	Command Complete	In
01	2[2]	Extended Message to Follow (SDTR only)	In/Out
		The following extended message is supported:	
01	3*	Request for SDTR * 3 = added length in bytes	In/Out
02	1	Save Data Pointers	In
04	1	Disconnect	In
05	1	Initiator Detected Error	Out
06	1	Abort	Out
07	1	Message Reject	In/Out
08	1	No Operation	Out
09	1	Message Parity Error	Out
0A	1	Link Command Complete	In
0B	1	Link Command Complete (with flag)	In
0C	1	Bus Device Reset	Out
80-FF	1	Identify	In/Out

Notes:

1. In=Target to Initiator; Out=Initiator to Target.
2. Second byte indicates length of extended message.

■ **Status Codes.** The following status codes are supported:

Code (hex)	Status
00	Good
02	Check Condition
08	Busy
10	Intermediate
18	Reservation Conflict

Supported SCSI Commands

This section describes the SCSI commands that are executed by the "Target". A Target is any HP 97556/58/60 disk drive. Table 3-1 lists SCSI commands that are executed by the Target. Product-specific information is also provided.

Table 3-1. Supported SCSI Commands

Command	Opcode (hex)	Description
Format Unit	04	Formats Target media into Initiator addressable logic blocks. Defect sources include P, D, and G lists (no C list). When formatting, it is recommended that the Initiator not include a D list (FMTDAT=0). However, if the Initiator does include a D list, it must be in the physical sector format or bytes from index format. The Target uses an interleave of 1 regardless of the value in the Interleave field.
Inquiry	12	Requests Target to send parameter information to the Initiator.
Mode Select (6-byte) (10-byte)	15 55	Enables Initiator to specify media, logical unit, or device parameters to the Target.
Mode Sense (6-byte) (10-byte)	1A 5A	Enables Target to report its media, logical unit, or device parameters to the Initiator.
Read (6-byte) (10-byte)	 08 28	Requests Target to transfer data to Initiator. Relative Addressing not supported (REL=0).
Read Buffer	3C	Used with WRITE BUFFER command to test Target's data buffer. Recommend executing RESERVE command to guarantee data integrity.
Read Capacity	25	Enables Initiator to request information regarding the capacity of a logical unit. Use of PMI bit supported. Relative Addressing not supported (REL=0).
Read Defect Data	37	Requests Target to transfer media defect data to Initiator. Target returns P, G, or P+G lists in physical sector or bytes from index format.
Read Long	3E	Requests Target to return the header, data field, and ECC bytes of one logical sector.
Reassign Blocks	07	Requests Target to reassign defective logical blocks to an area on a logical unit reserved for this purpose. It is recommended that the defect list contain only one defect location per command.

Table 3-1. Supported SCSI Commands (continued)

Command	Opcode (hex)	Description
Release	17	Releases previously reserved logical units. Third-Party Release supported. Extent Release not supported.
Request Sense	03	Requests Target to transfer sense data to the Initiator, including: Sense Key (0-6,B,E), Additional Sense Code, and Device Errors. The Bit Pointer and Field Pointer fields are not used. Only the Extended Sense Data format is supported.
Reserve	16	Reserves logical units for use by Initiator. Unit and Third-Party Reservations are supported. Extent Reservations are not supported.
Rezero Unit	01	Requests Target to perform a recalibrate and then to seek to logical address 0.
Seek (6-byte) (10-byte)	 0B 2B	Requests Target to seek to a specified address. Target returns GOOD status when seek is complete.
Send Diagnostic	1D	Requests Target to perform diagnostic self-test. If self-test fails, Check Condition status indicates that results are available via REQUEST SENSE command.
Start/Stop Unit	1B	Requests Target to enable or disable the logical unit for further operations. The immediate bit on START is supported.
Test Unit Ready	00	Checks Target spindle for proper speed. Target returns GOOD status if spindle is up to speed.
Verify	2F	Requests Target to verify the data written on the media by performing a selectable ECC check. Relative addressing not supported. (REL=0).
Write (6-byte) (10-byte)	 0A 2A	Requests Target to write the data transferred by the Intitiator to the media. Relative Addressing not supported (REL=0).
Write And Verify	2E	Requests Target to write the data transferred by the Initiator to the media, then do an ECC verify of the data that was written. Relative addressing not supported. (REL=0).
Write Buffer	3B	Used to test the Target's data buffer. To avoid possible data corruption, it is recommended that a RESERVE command be executed prior to the WRITE BUFFER command.
Write Long	3F	Requests Target to write one complete logical sector including header, data, and ECC fields.

Functional Description

This section provides a functional description of the HP 97556/58/60 disk drives.

Disk Format

The head/disk assembly (HDA) contains six (97556), eight (97558), or ten (97560) disks (see figure 3-1). The bottom disk surface on each drive is reserved for servo code. The remaining disks provide two data surfaces with a single read/write head accessing each surface.

Each data surface contains 1680 (97556) or 1962 (97558/60) physical tracks. Eight of these tracks are reserved for use as spares, one track is reserved for defect list storage, and one track is used for maintenance. This leaves a total of 1680 (97556) or 1952 (97558/60) tracks available for user data. Figure 3-2 displays the physical allocation of the tracks on the media.

Sector Format

The smallest directly addressable storage area on a data surface is a sector. Accessing a sector is accomplished when the controller specifies the address of the cylinder, head, and sector. The 97556/58/60 product support variable length sectors. Sector size is set with Parameter Page 03H of the Mode Select Command.

Addressing Structure

All addressing between the disk drive and the host is logical. The drive's embedded controller converts the logical block address into the appropriate physical address (i.e. cylinder, head, sector), allowing for any sparing operations that have been performed. To support multiple block sizes greater than 744 bytes, the drive automatically blocks and deblocks the physical sectors into the currently specified logical block size.

Error Correction Code

The HP 97556/58/60 Series of disk drives use a Reed-Solomon error correction code (ECC) for detection and correction of data errors. During a write operation, the ECC function generates 18 bytes of ECC information, and writes the information into the ECC field as the sector is written. During a read operation, the controller generates an 18-byte code from the data field being read, and compares it to the ECC field created during the write operation. If the 18-byte code differs from the ECC field, a data error is detected and the ECC field is used to correct the data.

The ECC function is enabled or disabled via the DCR (Disable Correction) bit in parameter page 01h of the MODE SELECT command. When enabled, the ECC algorithm divides a sector's data field into three interleaves, or rows, with a selectable correction factor of one, two, or three bytes per interleave. Mathematically, this converts to a maximum burst size of 72 bits per sector. However, the maximum number of bits that is guaranteed to fit into nine contiguous bytes is 65. Therefore, if an error burst longer than 65 bits falls exactly within the boundaries of nine contiguous bytes, it will be corrected. If it spreads across more than nine contiguous bytes, it will be flagged as unrecoverable.

The number of bytes that will be corrected in an interleave is selectable via the Correction Span field in parameter page 01h of the MODE SELECT command. The Correction Span field value is stated in bits-per-sector. The ECC algorithm converts this value to bytes-per-interleave by dividing it by 24 (8-bits per byte times three interleaves) and rounding it up to the nearest byte value.

The error correction capabilities of the ECC function are as follows:

- Unrecoverable Data Error Rate: less than 10 errors in 10^{15} bits transferred (using a correction span of 72 bits per sector).

- Recoverable Error Rate: less than 10 errors in 10^{13} bits transferred. (using a correction span of 24 bits per sector)

Cyclic Redundancy Check (CRC)

ECC is aided by a non-selectable 2-byte cyclic redundancy check (CRC) to decrease the probability of error miscorrection. With the correction span set to 72 bits, if a random error distribution is assumed, the calculated probabilities of error misdetection and miscorrection are as follows:

- Probability of misdetection (an error exists, but ECC does not recognize it) is less than 1×10^{-79}.
- Probability of miscorrection (an error is detected, but is improperly corrected) with CRC is less than 1×10^{-47}.

Sparing

Track sparing is implemented for tracks with one or more defective sectors. Cross-head track sparing is supported out of a single spare track pool. This allows for one or more surfaces to have a higher than normal number of spare operations without loss of drive operation. Spare track access is via a RAM lookup table with no seek to the defective track to provide for high performance and reliability.

Look Ahead Reads

The Look Ahead Read capability can improve the performance of a drive doing sequential READs by preloading the buffer with the data most likely to be requested with the next READ command. After a READ command is received by the controller, the drive seeks to the proper location and loads the requested data into the buffer. While that data is being transferred to the host, the Look Ahead Read function continues to read beyond track boundaries until the buffer is full. If, in following READ requests, the host asks for subsequent blocks, they will

already be in the buffer, and the data will be returned to the host without the delay of a media access.

If a new READ command requests data not contained in the buffer while the drive is performing a Look Ahead Read, the process is aborted, and the drive will immediately seek to the new location with minimal effect on access or transfer performance. Filling the buffer with unrequested data has a lower priority than delivering requested data.

Assembly Descriptions

The assemblies in the disk drive include the head/disk assembly (HDA) and the drive electronics/controller printed-circuit assembly (PCA). The sealed HDA contains the mechanical and electromechanical assemblies of the disk drive. The drive electronics/controller PCA provides the SCSI interface and all electronic control over the HDA. The following paragraphs describe the major functional components of each assembly (see figure 3-4).

Head/Disk Assembly

the head/disk assembly (HDA) contains disks, heads, an actuator assembly, head interface circuits, atmospheric controls, vibration isolators, and a spindle assembly. An aluminum casting provides the supporting structure for these parts. The entire assembly is sealed and is not field repairable.

Disks

The disks are 130 mm (5.1 inch) diameter aluminum substrate with a sputtered thin-film surface. The disks are mounted on the spindle assembly in stacks of six (HP 97556), eight (HP 97558), or ten (HP 97560 disks. Data is stored on both surfaces of all disks except for the bottom surface of the bottom disk which is reserved for servo information.

Heads

Eleven (HP 97556), 15 (HP 97558), or 19 (HP 97560) thin-film data heads in the HDA write and read user data. An additional head in each unit is used to recover the servo information from the bottom surface of the bottom disk.

Actuator Assembly

Mechanical positioning of the read/write heads is achieved using a Hewlett-Packard designed rotary actuator. Actuator current is supplied by the actuator driver, which amplifies position information from the servo circuits. A shipping latch captures the heads at the inside diameter of the disks (away from user data) whenever power is removed from the disk drive. This prevents the actuator from moving over data until power is applied to the disk drive. At power-on, the processor releases the latch, allowing normal movement of the heads.

Head Interface

The head interface circuits process the data signals transferred between the read/write heads and the drive electronics/controller PCA. These ICs include write drivers which provide the necessary current to the heads during write operations. Read preamplifiers amplify data read from the disk before transferring it to the read/write circuit on the drive electronics/controller PCA. Additional functions performed by the head interface include head selection and write control.

Atmospheric Controls

The atmospheric controls in the HDA consist of a breather system and a recirculating filter. The breather system equalizes air pressure within the HDA to ambient air pressure. A breather filter prevents contaminants from entering the HDA. The recirculating filter maintains a low particle count within the HDA.

Vibration Isolators

The HDA is mounted on vibration isolators to protect it from random external vibrations.

Spindle Assembly

The spindle assembly provides the mechanical mounting for the disks. The spindle rotates on a bearing system and is driven by an "in hub" brushless dc motor. The 3-phase drive current for the motor is supplied by the spindle driver circuit on the drive electronics/controller PCA. Three Hall-effect sensors, mounted on the spindle assembly, provide feedback signals to the spindle control electronics for coarse speed and phase switching control.

Block Diagram

Refer to figure 3-1. The drive/electronics PCA controls the operation of the drive, including head positioning, data transfer, spindle speed, and power distribution.

SCSI Interface

The SCSI Interface is the direct electrical interface between the SCSI channel and the drive electronics. It handles all SCSI timing and protocol, and transfer of commands, status and configuration information.

The SCSI interface handles SCSI protocol without intervention from the microprocessor, and is capable of automatically controlling the proper sequence of bus phases involved in each transaction. Full arbitration and disconnect/reselection are implemented by the SCSI interface.

RAM Buffer

The RAM Buffer contains 128-kilobytes of static RAM. All data transferred between the host and the disk must pass through the RAM buffer.It is protected by an additional 2 bits of parity for each 16-bit word transferred by the DMA.

Disk Controller

The disk controller coordinates the flow of data by interleaving RAM accesses between the SCSI interface and the disk controller. It contains a DMA section which controls the transfer of data between the SCSI interface, the buffer RAM and the disk controller. The DMA accesses the 128-kilobyte static RAM buffer to match the transfer speeds of the SCSI interface and the disk controller.

The disk controller also performs error checking on data being transferred from the disk to the RAM buffer and generates ECC on data transferred from the RAM buffer to the disk. The data controller also does header verification during read/write operations.

Data Encoder/Decoder

The primary function of the Data Encoder/Decoder is to convert between the NRZ (Non Return to Zero) data/clock present on the SCSI Channel and RLL (Run Length Limited, 2-7) data transferred to and from the disk surface. This includes sector length and content information provided by the host during format operations as well as data transfers during normal Read and Write operations.

Microcontroller

The microcontroller used on the drive/electronics PCA is an 80C196 single-chip device operating at 10 Mhz. The microcontroller is responsible for decoding incoming SCSI commands, controlling the servo processor and the read/write circuitry, and managing the head alignment function.

Servo Processor

The servo processor provides index and start-of-sector timing signals, and controls actuator movement, motor spin-up and speed control, and synchronized spindle operation. Actuator movement control consists of track-to-track seeks, track following, and correction for both DC and repeatable AC errors. Motor spin-up and speed control consists of regulated drive motor current modified by information derived from the dedicated servo surface. Synchronized spindle control is derived from an external sync input that is compared to position information from the disk surface.

Head Interface

The head interface processes the data signals transferred between the read/write heads and the data encoder/decoder. This includes head selection, providing analog write current to the heads, and amplification and conversion of impulses from the heads to RLL data.

Actuator Driver

The actuator driver provides the current necessary to operate the actuator assembly. The driver amplifies the control information provided by the servo processor, and outputs the resultant current to the actuator.

Servo Timing

The function of the servo timing circuit is to amplify and convert impulses from the servo head to position and rotation speed information for the servo processor.

Spindle Motor Driver

The spindle motor driver provides 3-phase current to start, drive, and control the speed of the in-hub spindle motor. Hall-effect sensors mounted on the spindle assembly provide feedback for phase switching control.

Power Distribution

The +5 and +12 voltages provided by an external dc power supply are distributed to the spindle motor driver, actuator driver, analog amplifiers, and digital circuitry. A reset output alerts the other circuits when power-on occurs and when power is lost. Each circuit responds in a predefined manner to the reset condition.

Figure 3-1. Drive Addressing Structure.

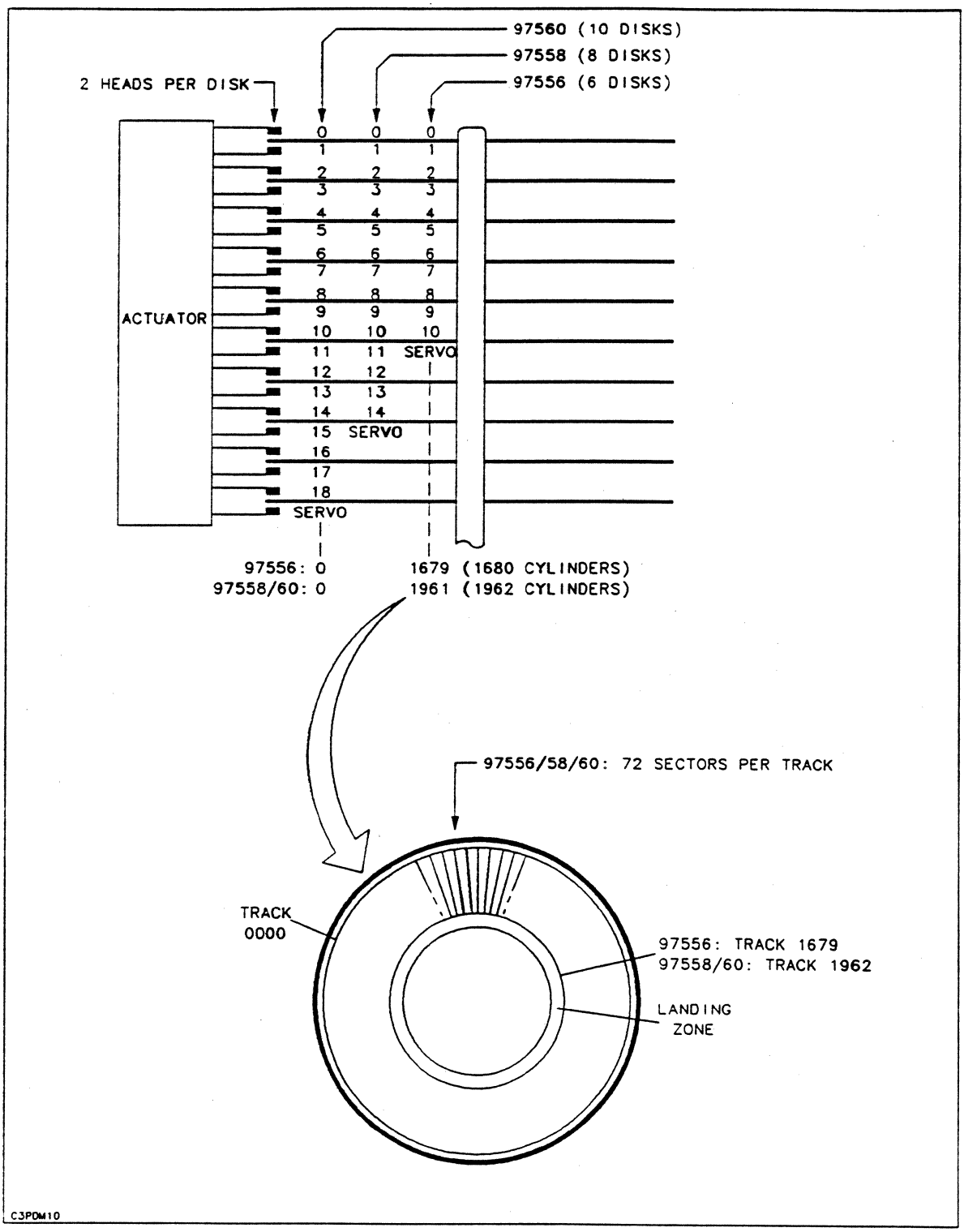


Figure 3-2. Track Allocation.

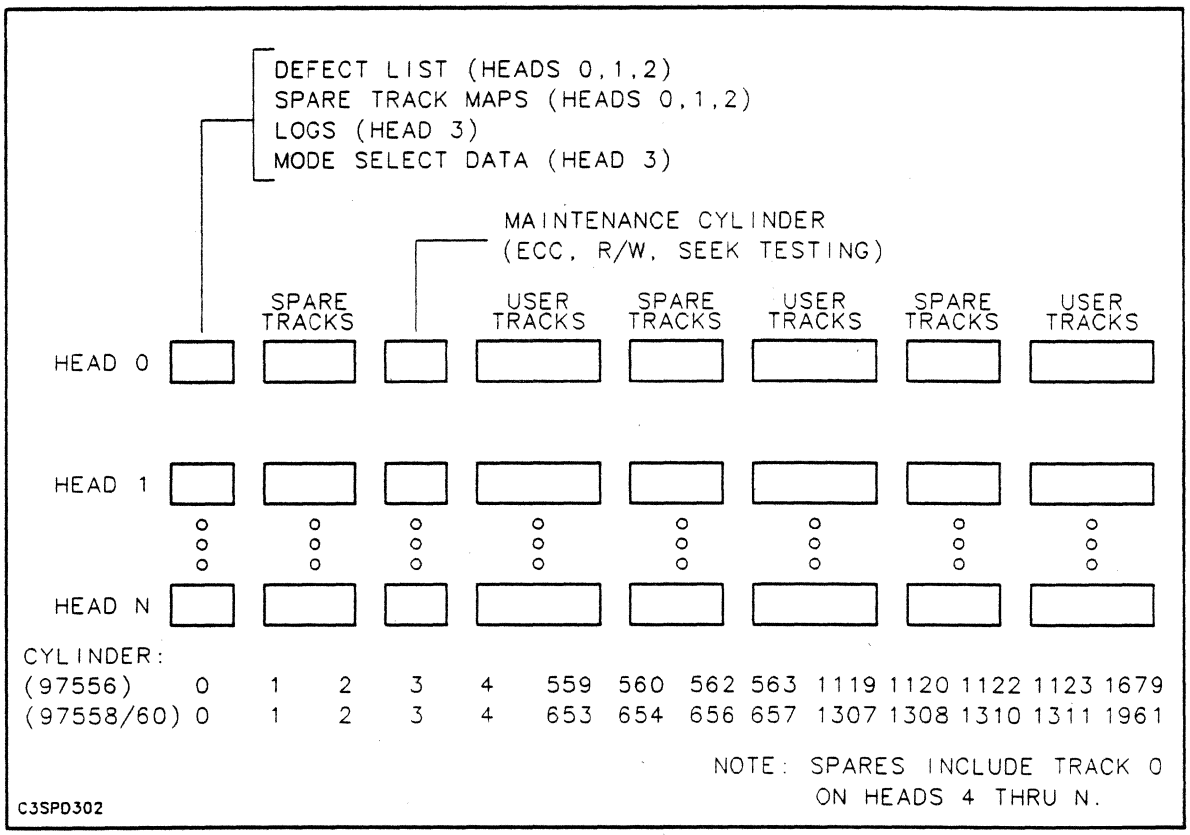


Figure 3-3. Formatted Physical Sector Allocation.

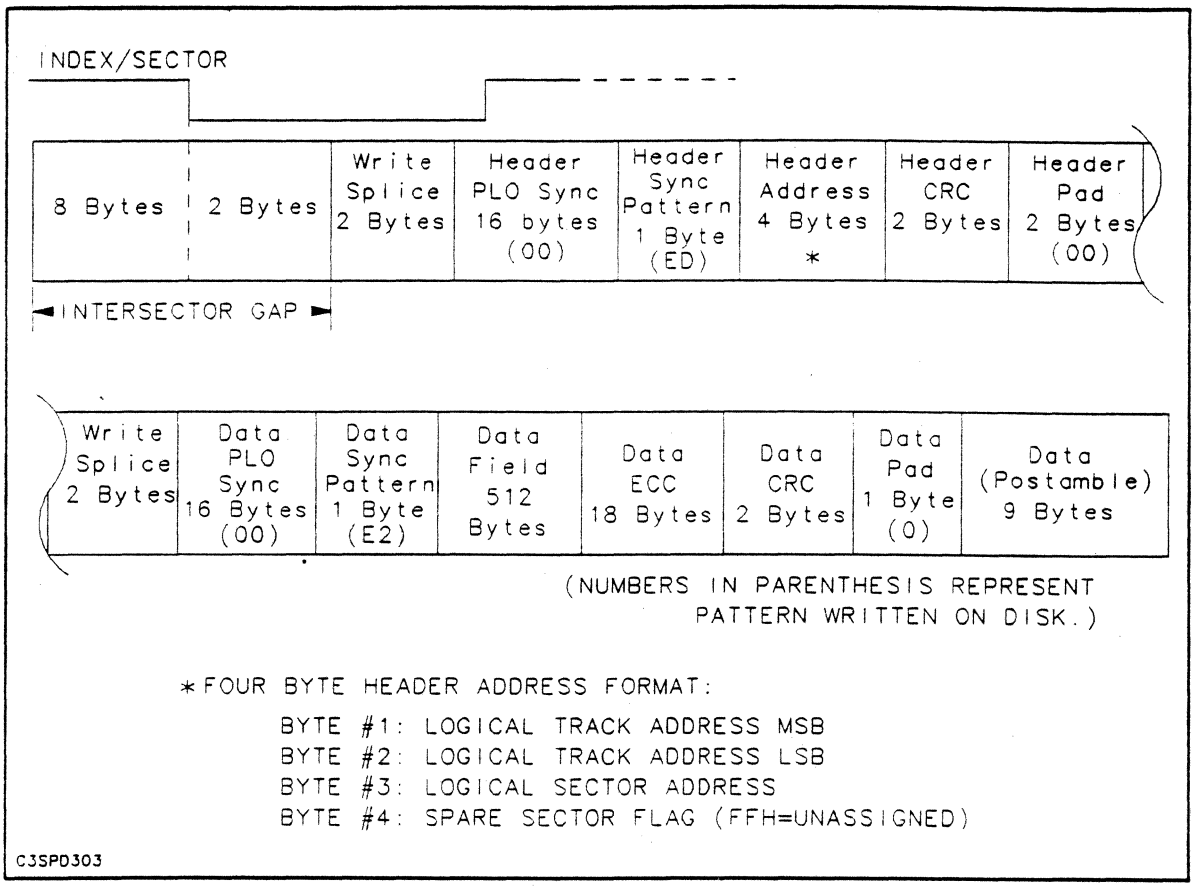


Figure 3-4. Disk Drive Block Diagram.