# HP C2233/C2234/C2235
# 3.5-inch
# SCSI Disk Drives

## Product Description Manual


**HP Part No. xxxx-xxxx**
**Printed in U.S.A. October 1990**

**Edition 1, Rev 10/24/90 (Preliminary)**
**Manual Order Number: HP xxxxx**
**DRAFT 10/24/90 13:31**

## Printing History

This edition of the manual is a preliminary draft. This manual will be revised without notice in order to reflect the latest version of the product it describes.

New editions are complete revisions of the manual. The dates on the title page change only when a new edition or a new update is published.

Many product updates do not require manual changes and, conversely, manual corrections may be done without accompanying product changes.

Edition 1, Rev 10/24/90 (Draft) ..... October 1990

# Contents

# Figures



# Tables

# 1

# Product Specifications

## Product Description

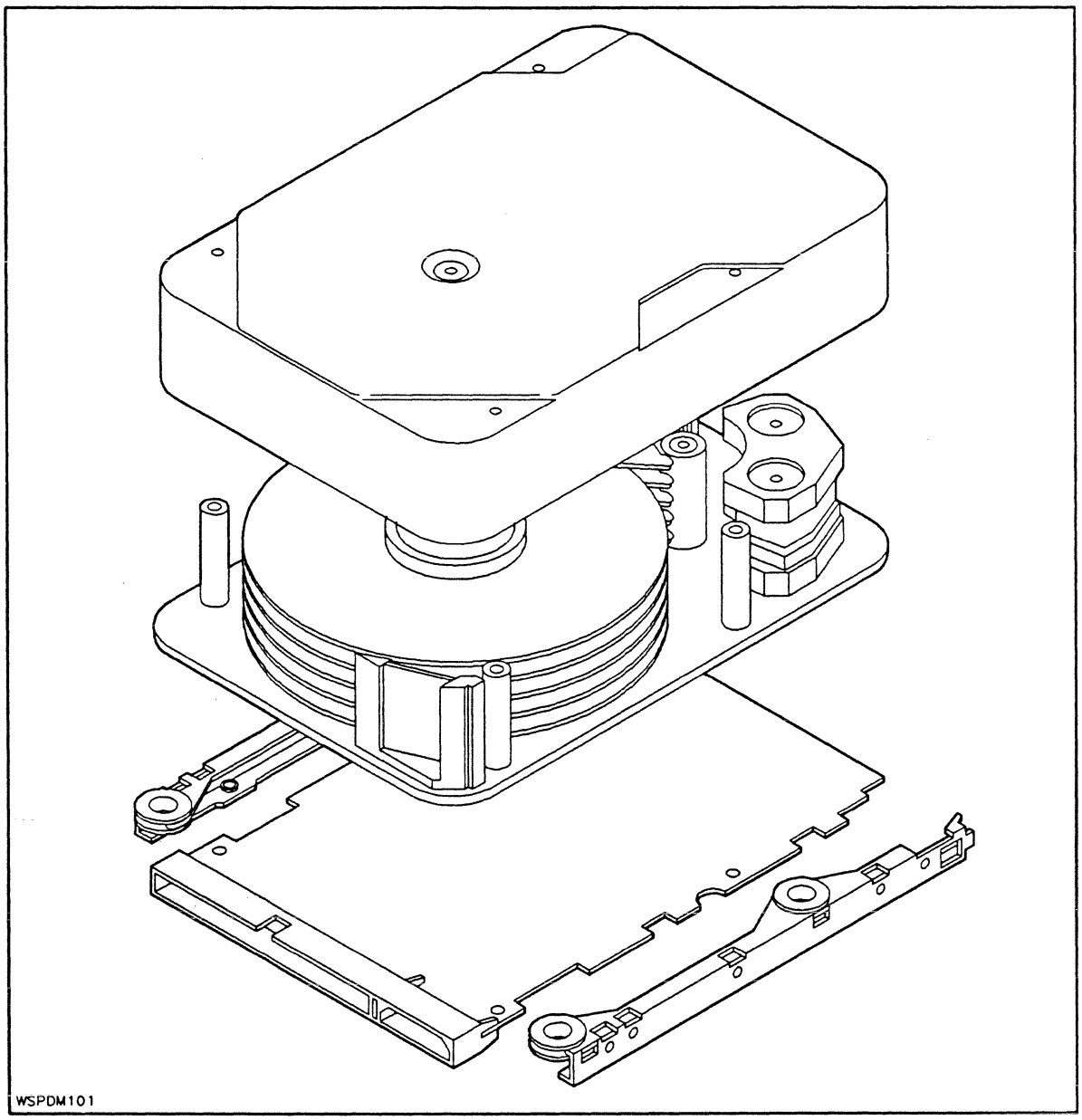
The HP C2233/34/35 single-ended SCSI interface disk drives are reliable, low cost, high capacity, high performance, random access mass storage devices. Each product utilizes sputtered thin-film 3.5-inch (95 mm) disks as storage media. Each disk has 1511 data tracks per data surface. The total formatted capacities of the disk drives are 234 magabytes for the 3-disk C2233, 328 megabytes for the 4-disk C2234, and 422 megabytes for the 5-disk C2235.

Low cost and high reliability are achieved with an advanced Digital Signal Processor (DSP) 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 capacity and improved average transfer rate is achieved by utilizing Multiple Zone Recording.

High performance (13 msec random average seeks) and low power consumption are achieved with a state-of-the-art HP-designed balanced rotary actuator.

The disk drive electrical interface is compatible with the new industry standard Small Computer System Interface (SCSI). Figure 1-1 shows the major components of the disk drive. Mounting instructions are provided in chapter 2.

Figure 1-1. Disk Drive Major Components



Key features of the HP C2233/34/35 disk drives are:

- High reliability (150,000 hours MTBF).
- Embedded controller incorporating SCSI-2 compatibility.
- Unformatted capacities of 275, 385, and 495 Megabytes.
- Formatted capacities of 234, 328, and 422 Megabytes.
- Extensive use of HP's state-of-the-art VLSI processes.
- Digital Signal Processor (DSP) hybrid servo sytem.
- High performance HP-designed balanced rotary actuator.
- Industry standard 3.5-inch form factor and voltage requirements.
- Synchronous data transfer rate of up to 5.0 megabytes per second.
- Powerful, HP designed Reed-Solomon ECC

## 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.

## Related Documentation

The following documentation provides information related to the operation of the HP C2233/34/35 disk drives:

- *Small Computer Systems Interface: ANSI XT39.2/86-109 (Rev 10C), XT39/89-042*
- *Common Command Set (CCS) of the Small Computer System Interface (SCSI): ANSI XT39.2/85-52 (Rev 4B)*

## 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 C2233/34/35 disk drives are listed on the following pages.

### Caution

The HP C2233/34/35 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 ms |
| Buffer size: | 64 kbytes |
| Buffer type: | Dual-ported |
| Sector size: | 180 - 992 Data Field Bytes |
| **Interleave:** | 1:1 |

### Seek Time

| | |
|---|---|
| **Track to Track Seek:** | 3 ms |
| **Average Random Seek:** | 13 ms |
| **Maximum Seek:** | 25 ms |

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 or

any initiator overhead time. The values above are derived from a representative sample of disk drives.

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

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

Maximum seek time is the time it takes to seek 1511 cylinders.

### Head Switch Time

1 millisecond

### Spin-up Time

**From Power-on to Ready for Access:**

| | |
|---|---|
| **Typical:** | 10 seconds |
| **Maximum:** | 13 seconds |

### Rotational Latency

| | |
|---|---|
| **Average time:** | 8.33 ms ±0.5% |

### Internal Data Transfer Rate (Controller/Disk)

| | |
|---|---|
| **Burst:** | Inside Zone: 1.73 megabytes/s (13.85 megabits/s)<br>Middle Zone: 2.16 megabytes/s (17.25 megabits/s)<br>Outside Zone: 2.58 megabytes/s (20.65 megabits/s) |
| **Sustained:** (Excludes Controller Overhead) | Inside Zone: 10.92 megabits/s<br>Middle Zone: 13.65 megabits/s<br>Outside Zone: 16.44 megabits/s |

### External Data Transfer Rate (Host/Controller)

| | |
|---|---|
| **Asynchronous:** | 1.5 megabytes/s |
| **Synchronous:** | 5.0 megabytes/s |

## 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 (refer to note 1).

| | HP C2233 | HP C2234 | HP C2235 |
|---|---|---|---|
| Data Surfaces: | 5 | 7 | 9 |
| Tracks per Surface:[2] | | | |
| ■ Inside Zone | 512 (509) | 512 (509) | 512 (509) |
| ■ Middle Zone | 414 (411) | 414 (411) | 414 (411) |
| ■ Outer Zone | 594 (591) | 594 (591) | 594 (591) |
| Sectors per track: | | | |
| ■ Inside Zone | 49 (48) | 49 (48) | 49 (48) |
| ■ Middle Zone | 61 (60) | 61 (60) | 61 (60) |
| ■ Outer Zone | 73 (72) | 73 (72) | 73 (72) |
| Data Bytes Per Sector (bytes): | 588 (512) | 588 (512) | 588 (512) |
| Data Bytes Per Track (bytes): | | | |
| ■ Inside Zone | 28,812 (24,576) | 28,812 (24,576) | 28,812 (24,576) |
| ■ Middle Zone | 35,868 (30,720) | 35,868 (30,720) | 35,868 (30,720) |
| ■ Outer Zone | 42,924 (36,864) | 42,924 (36,864) | 42,924 (36,864) |
| Data Bytes Per Surface (bytes): | 55,097,952 (46,921,728) | 55,097,952 (46,921,728) | 55,097,952 (46,921,728) |
| Data Bytes Per Drive (bytes): | 275,489,760 (234,608,640) | 385,685,664 (328,452,096) | 495,881,568 (422,295,552) |

Notes:

1. Unformatted capacities include one maintenance track each in the inside and outside zones, nine spare tracks (three per zone) and spare sectors (one per track). In addition, 76 bytes are reserved in each sector for other drive functions.
2. There are 1536 total cylinders per drive, allocated as follows: A. Data Cylinders - 1511; B. Alignment Cylinders - 14; C. Spare Cylinders - 9; D. Maintenance Cylinders - 2 (one each in the ID and OD zones).

| | |
|---|---|
| **Recoverable Data Error Rate** | Less than ten (10) errors in $10^{11}$ bits transferred when the disk drive is operated within the specified environmental limits. |
| **Unrecovereable Data Error Rate** | Less than ten (10) errors in $10^{13}$ bits transferred when the disk drive is operated within the specified environmental limits. |
| **Corrected Data Error Rate With Retries** | Less than ten (10) errors in $10^{14}$ bits transferred when the disk drive is operated within the specified environmental limits. |
| **Seek Error Rate** | Less than ten (10) seek errors in $10^{7}$ seeks when the drive is operated within the specified environmental limits. |
| **Disk Speed** | 3600 rpm $\pm$0.5% |
| **Recording Density (Flux Changes per Inch)** | Inner Zone: 27.42 KFCI<br>Middle Zone: 26.06 KFCI<br>Outer Zone: 26.19 KFCI |
| **Track Density** | 1850 Tracks/In. |
| **Coding System** | 2-7 Run Length Limited (RLL) Code. |

## DC Power

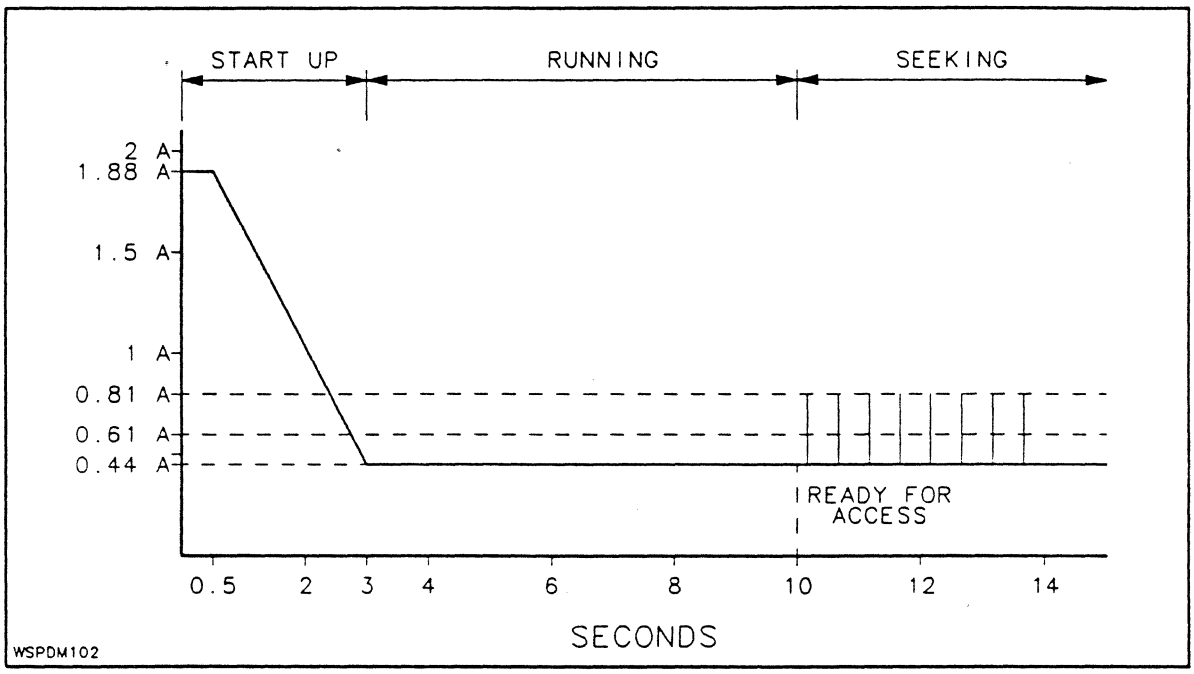
Note: All values are for single ended units and assume input voltages are within limits specified by the input power requirements.

| Operating Condition | +5 Vdc Current | +12 Vdc Current[1] | Power |
|---|---|---|---|
| **Start-up** | | | |
| **- Typical** | 0.85 A | 1.88 A | 26.8 W |
| **- Maximum** | 0.94 A | 2.0 A | 28.7 W |
| **Idling[2]** | | | |
| **- Typical** | 0.85 A | 0.44 A | 9.53 W |
| **- Maximum** | 0.94 A | 0.53 A | 11.06 W |
| **Seeking[3]** | | | |
| **- Typical** | 0.85 A | 0.61 A | 11.57 W |
| **- Maximum** | 0.94 A | 0.81 A | 14.42 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 and voltage at maximum specified limit.
2. Spindle up to speed and actuator is track following.
3. Assuming random seeks with an average latency between seeks.

Typical +12V Current



## Electromagnetic Emissions

Radiated and conducted interference for the HP C2233/34/35 disk drives:

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

(Note: FTZ and FCC regulations do not require "components" to meet emission specifications as free standing devices.)

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 27 db(A) sound presssure, idling, and less than 37 db(A) sound pressure, seeking.(measured per ISO 7779, Acoustics.) Sound is not impulsive.

## Safety

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

- IEC: 950, Edition 1
- UL: 1950, Edition 1
- CSA: C22.2 No. 950-M89
- EN: 60950, 1988
- TUV: EN 60950, 1988; DIN VDE 0805/05.90

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

## Physical Characteristics

| | |
|---|---|
| **Unit Weight:** | 1.1 kg (2.4 lbs) |
| **Shipping Weight:** | |
| Single-Unit Package: | **TBD** kg (**TBD** lbs) |
| Ten-Unit Package: | **TBD** kg (**TBD** lbs) |
| **Dimensions[1]:** | |
| Length: | 146.1 mm (5.75 in.) |
| Width: | 101.6 mm (4.00 in.) |
| Height: | 41.3 mm (1.63 in.) |

[1]Excluding front bezel.

## Disk Drive Environmental Requirements

The environmental requirements for the proper operation of the HP C2233/34/35 disk drives are listed on the following pages.

### Input Power Requirements

**Voltages:** +5 V, +12 V

**Regulation:**

| | |
|---|---|
| +5 V: | ±5% |
| +12 V: | ±10% |

**Ripple and Noise:**

| | |
|---|---|
| +5 V: | < 100 $mV_{p-p}$ |
| +12 V: | < 200 $mV_{p-p}$ |

### Ambient Air Temperature

**Operating[1]:** 5°C to 50°C (41°F to 122°F)

**Nonoperating[1]:** -40°C to 65°C (-40°F to 149°F)

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

### Relative Humidity

**Operating[2]:** 8% to 80% with wet bulb limit of 28°C

**Nonoperating[2]:** 5% to 90%

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

### Altitude

**Operating:** 305 m (1,000 ft) below sea level to 3,048 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 sine shock with a peak amplitude of 3.0 g's without change in performance.<br><br>11 ms, half sine shock with a peak amplitude of 10 g's without loss of data. |
| | **Nonoperating:** | 11 ms, half sine shock with peak amplitude of 50 g. |
| **Sinusoidal Vibration** | **Operating:** | 0.25 g (peak), 5 to 500 Hz with no loss in performance or data.<br><br>0.5 g (peak), 5 to 500 Hz with no loss of data. |
| | **Nonoperating:** | 2.0 g (peak), 5 to 500 Hz. |
| **Electromagnetic Susceptibility (Maximum values)** | **Radiated:** | < 10V/m from 14 kHz to 1 GHz |
| | **Conducted:**<br>+5 V: | < 200 mVp-p from 100 kHz to 250 MHz |
| | +12 V: | < 400 mVp-p from 100 kHz to 250 MHz |
| | **Magnetic:** | < 5 gauss 47.5 to 198 Hz |
| **Electrostatic Discharge** | Note: Current regulations do not specify or require Electrostatic Discharge (ESD) testing.<br><br>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 on any of the major mounting axes. 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. Information about handling and storage of the drive is also provided. For your reference, the diagrams are included at the end of the chapter.

## Handling and Storage

### Handling Cautions

- Handle the disk drive with care. Until secured in a protective chassis, it is susceptible to excessive mechanical shock, vibration, and Electrostatic Discharge (ESD).
- Follow approved grounding procedures.
- Improper handling may cause damage to the equipment which is not covered under your warranty.

### Storage Cautions

- Store the disk drive inside the anti-static bag shipped with each drive.
- Do not stack the drives unless they are secured inside their original shipping containers.

## Unpacking and Re-packing 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.

### Inspecting the Disk Drive

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.

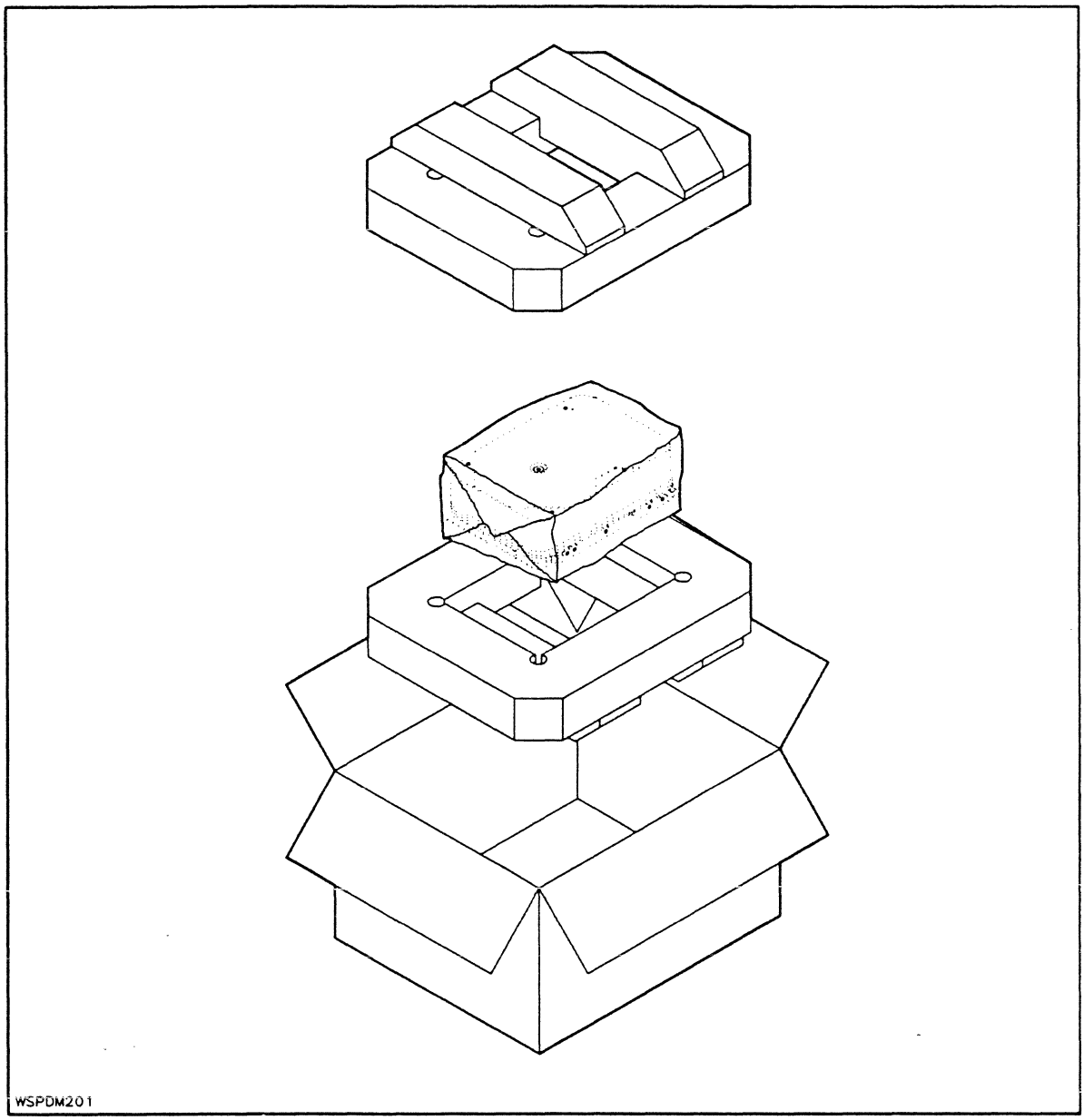
### Hewlett-Packard Direct Purchases

If you purchased your drive(s) directly from Hewlett-Packard, contact your Hewlett-Packard sales representative for instructions.

## Re-Packing For Shipment

Use the original container and packaging material supplied with the drive for any shipments.

Figure 2-1. C2233/34/35 Packaging Kit.



## Mounting Information

Since each design 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 of the major mounting axes. Refer to Figure 2-2.

### Safety/Regulatory Considerations

- When installing an HP C2233/34/35 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 are shown in figure 2-2. The length dimensions shown do not include clearances for power and interface connectors.

### Connector Dimensions and Locations

The physical locations and dimensions of the disk drive connectors are shown in figure 2-3.

### Physical Mounting

Typically, the disk drive is fastened directly to a chassis with four no. 6-32 screws. There are twelve (12) threaded mounting holes (for no. 6-32 screws) on the disk drive: four on each side, and four on the bottom (see figure 2-2). Use the following guidelines to mount the disk drive:

- Use 6-32 screws and torque them to 20 inch-pounds.
- When mounted, the hardware should not protrude more than 3 mm (0.12 in.) beyond the inside of the disk drive frame.

### Airflow Requirements

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

Airflow is required to assure disk drive reliability. Better reliability will be achieved with lower operating temperatures. The disk drive can be cooled by either forced air or 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 adequately removed from the drive and no outside heat sources raise the operating temperature above that specified in chapter 1.

As a guideline, the estimated front to back airflow to prevent exceeding the maximum operating temperature at a 50°C ambient temperature is 5 CFM. This is a function of the specific airflow pattern inside the cabinet where the disk drive is installed. This airflow estimate is to serve as a guideline.

As an additional guideline, the airflow should be adjusted to prevent the temperature measuring points on the HDA case from exceeding the limits shown in figure 2-4.

## Option/Address Selection

The drive options, SCSI address, and on-board terminator +5V source are selected by shorting jumpers across several pin-sets located on the drive electronics/controller PCA. Figure 2-5 and tables 2-1 and 2-2 show the location and jumper setups for the supported options.

**Note**

If you remove any of the shorting jumpers, save them for future use.

### Unit Attention

When pin-set 1 is open, the Unit Attention function is enabled. When shorted, it is disabled.

### Synchronous Data Transfer Request (SDTR)

When pin-set 2 is shorted the drive will initiate an SDTR message at power on and RESET. When open, 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

When pin-set 3 is shorted, the disk drive checks parity on commands and data. When open, the disk drive does not check for parity. Parity bits are generated whether this pin-set is open or shorted.

### Auto Spin Up Option

When pin-set 4 is shorted, the disk drive will automatically spin up at power on. If open, the drive will not spin up until the Intiator 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.

### Synchronized Spindle

There are three configurations of the synchronized spindle function: Slave, Master, and Master Control. The HP C2233/34/35 disk drives support the Slave and Master configurations, but not the Master Control configuration. The power-on default for all drives disables Synchronized Spindles. The Synchronized Spindle function is not saved during power cycles or drive resets and must be re-configured with the MODE SENSE command after these events. Refer to figure 2-5 and table 2-1 for the location and identification of the Synchronized Spindle pins and the signal specifications.

**Slave.** When the drive is set to the Slave configuration (by the MODE SENSE command):

- It receives input sync at the upper pin of pin-set 5 (or pin 29 of SCSI connector, refer to table 2-1)) to synchronize its Index Pulse.
- Drive Index synchronization is within ± 150 μSec.

**Master.** When the drive is set to the Master configuration by the MODE SENSE command):

- It generates a Master Sync Pulse and supplies it to the upper pin of pin-set 5 (or pin 29 of SCSI connector, refer to table 2-1)).
- It syncs internally to the same signal.

### 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 C2233/34/35 Technical Reference Manual* for more details about implementing these functions.

| 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 | Not supported. |

## Address Setting

Pin-sets 7, 8, and 9 select the disk drive SCSI address. The selection patterns are listed in table 2-1.

## Termination Power Source Options

### Terminator Resistor Packs

The single ended drive drive is shipped with 3 terminator resistor packs installed. The resistor packs are located under the drive as shown in figure 2.5. 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 figure 2-5).

### Changing Terminator Power Source

Refer to figure 2-5 and table 2-2. The power source for the terminator resistors can be reconfigured with the appropriate shorting jumpers (0 = open, 1 = shorted).

## Disk Drive Interface Connections

### SCSI Connector

An unshielded 50-pin SCSI connector is located on the rear of drive electronics/controller PCA (see figures 2-3 and 2-5). The physical construction and pin assignments for this connector conform to the SCSI specification for single-ended drives. The connector pin assignments are listed in table 2-1.

## 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 2-5.

## Mating Connector Requirements

The nonshielded SCSI cable connector should be a 50-conductor connector consisting of two rows of 25 female contacts with adjacent contacts 2.54 mm (0.1 in.) apart. Keyed connectors should be used. The nonshielded SCSI connector pin assignments are as shown in table 2-3.

The recommended mating connector manufacturer's part numbers are listed in table 2-4.

## Cabling Requirements

The disk drive adheres to the cabling requirements and limitations set forth in the ANSI SCSI specifications. Figure 2-3 shows the physical location and dimensions of the connectors.

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 must 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.

## Front Panel LED Indicator

The light emitting diode (LED) indicator 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 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.

Figure 2-2. Disk Drive Dimensions and Mounting Hole Locations.

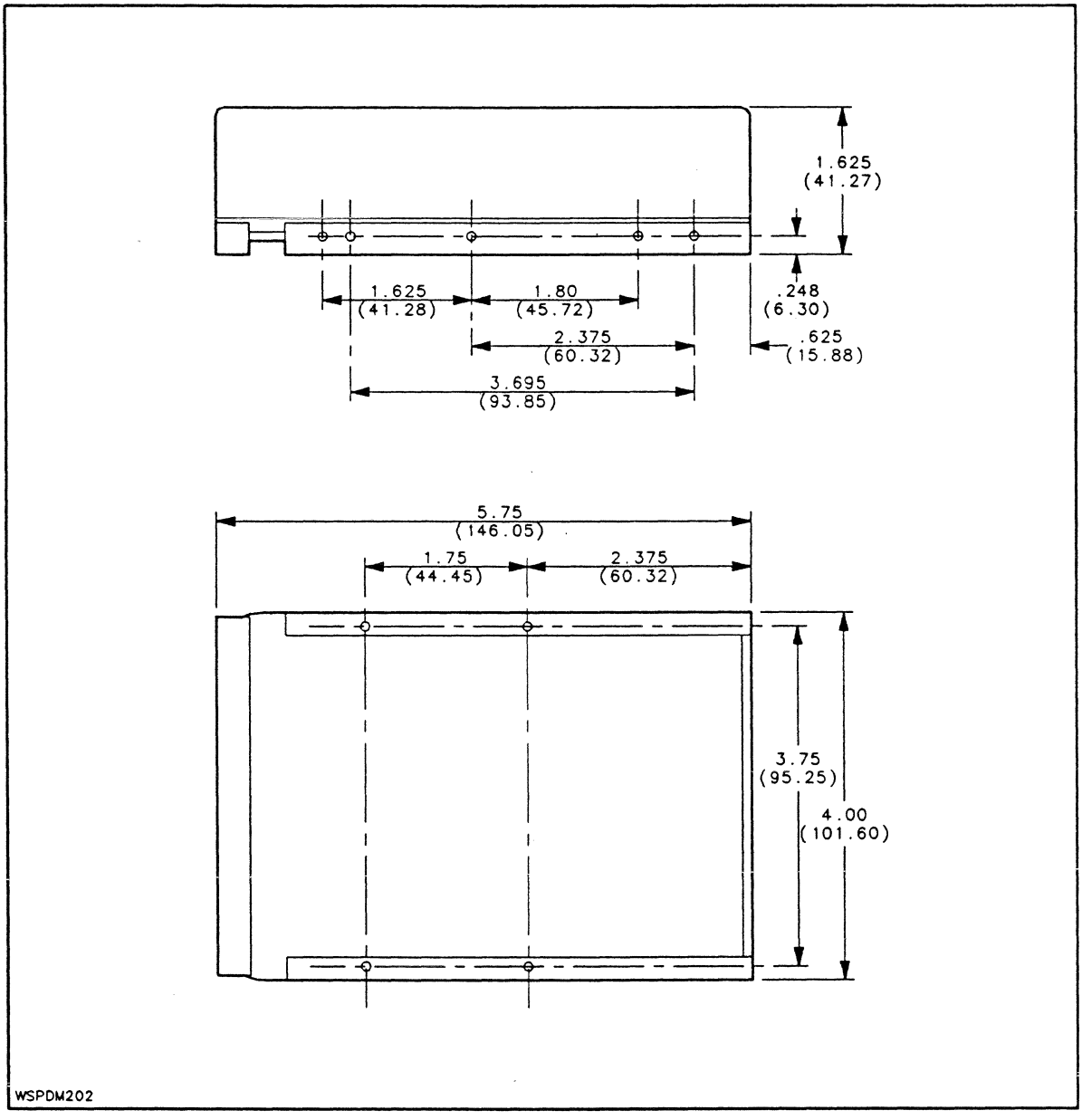


Figure 2-3. Connector Dimensions, Single-ended Unit.

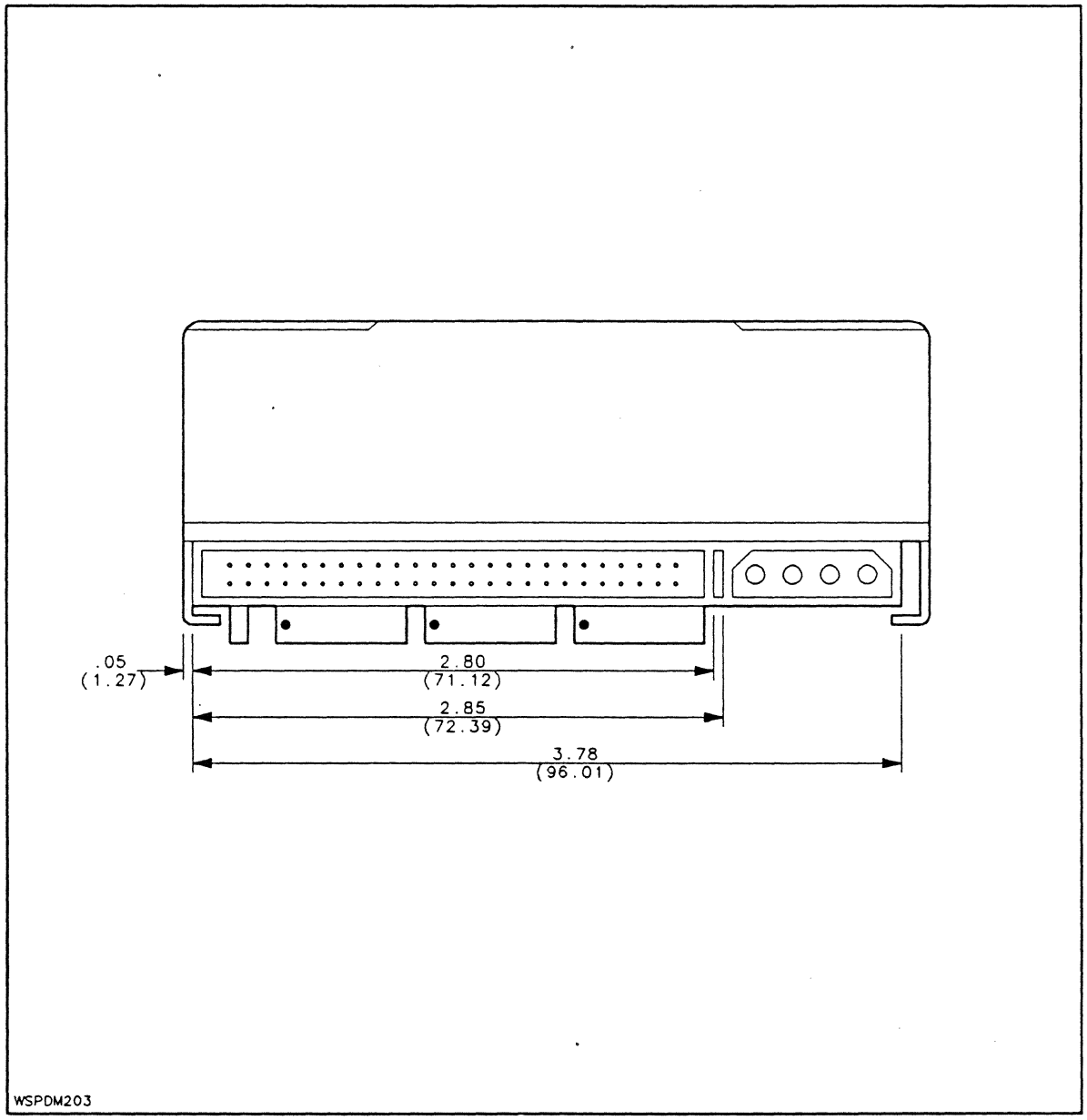


Figure 2-4. HDA Temperature Measuring Points.

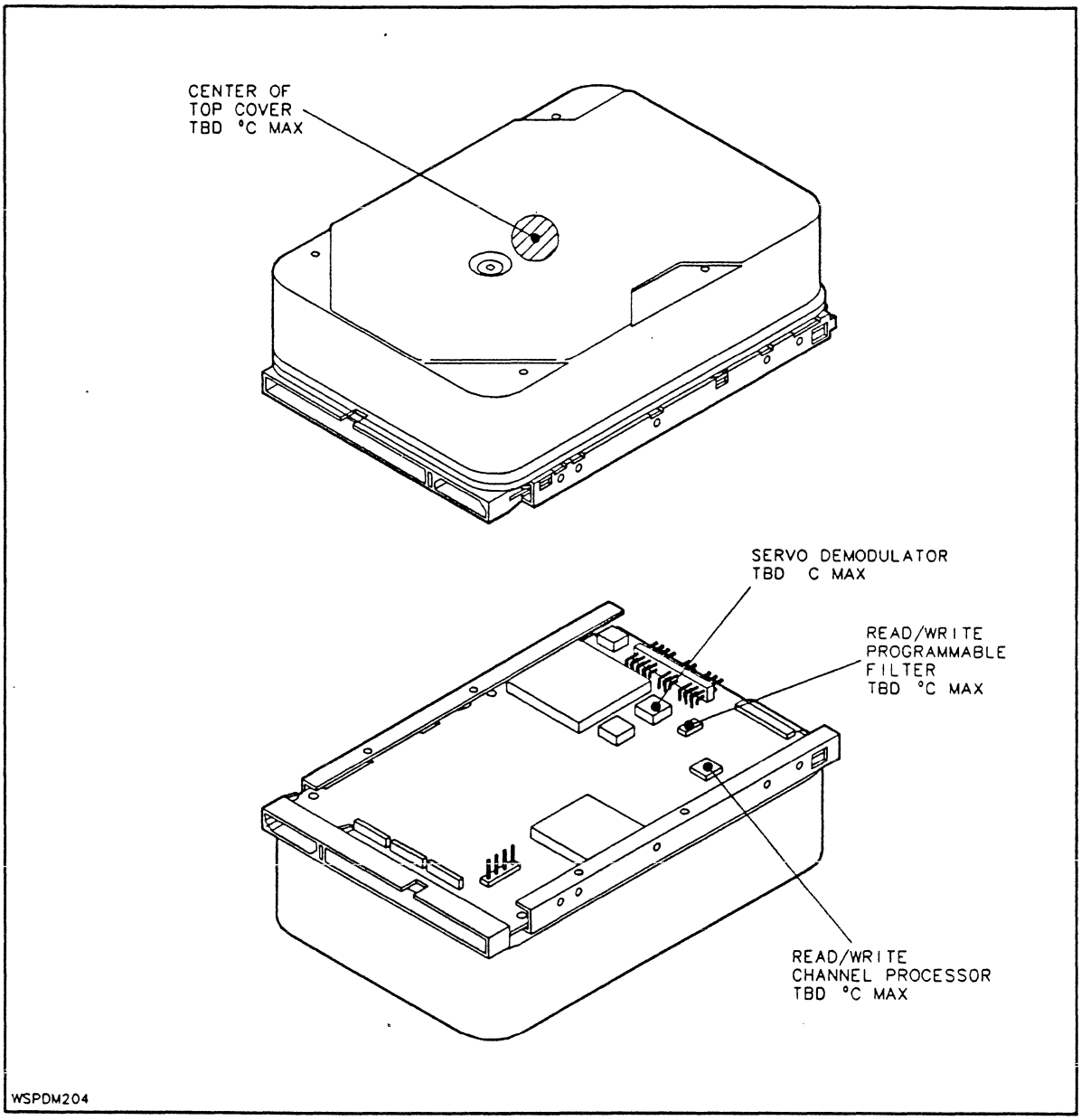
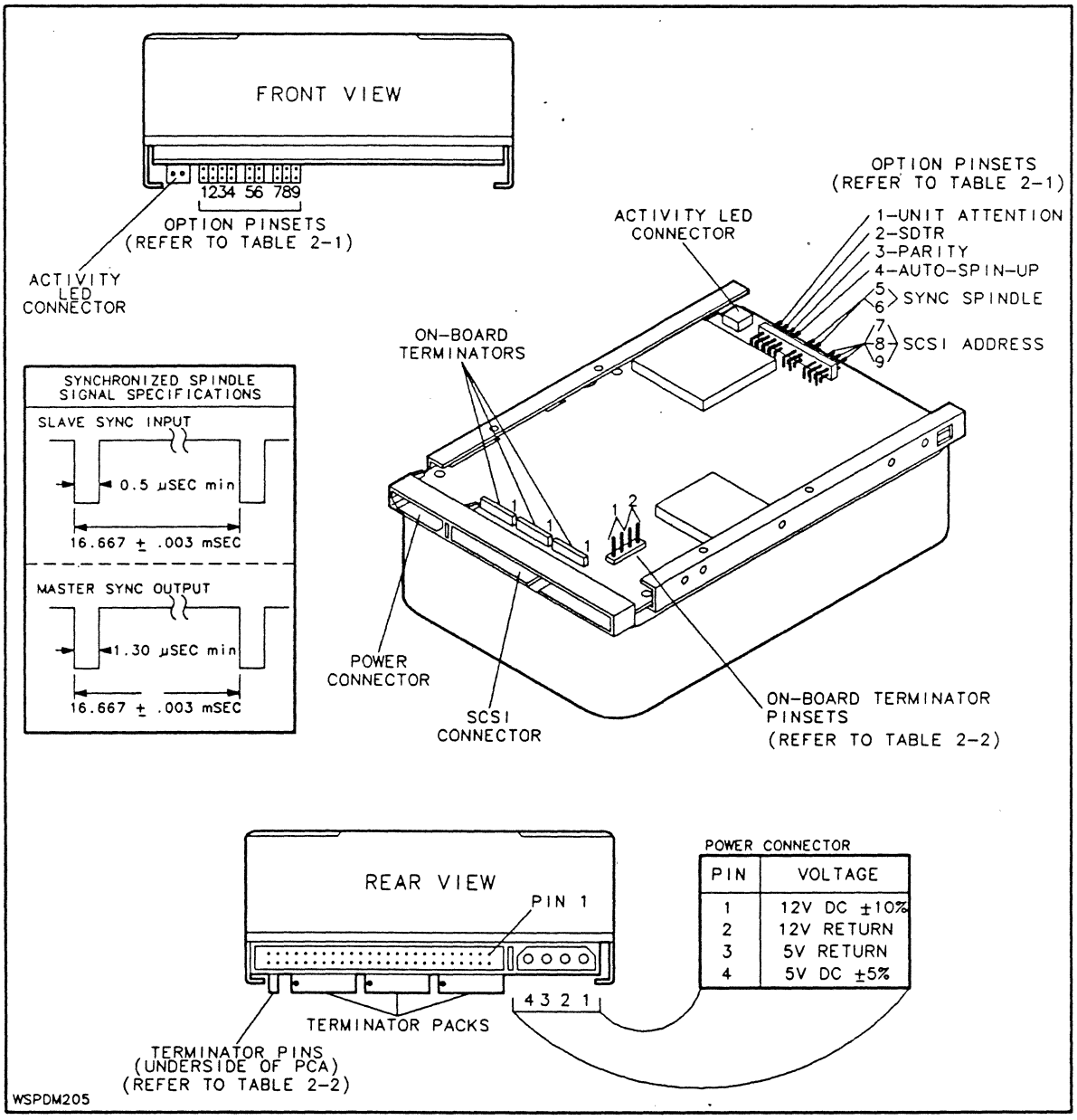


Figure 2-5. Interface Connectors and Settings.



## Table 2-1. Option Pin-Set Selections

| | | |
|---|---|---|
| **Pinset 1: Unit Attention** | | |
| open | | Unit Attention Enabled |
| shorted | | Unit Attention Disabled |
| **Pin-Set 2: 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 3: Parity** | | |
| open | | Inhibit parity checking |
| shorted | | Enable parity checking |
| **Pin-Set 4: Auto Spin-Up** | | |
| open | | Drive will not spin up until Initiator sends Start Unit command |
| shorted | | Drive will spin up automatically at Power-On |
| **Pinsets 5 and 6: Synchronized Spindle Pins** | | |
| 5 = shorted; 6 = open | | Pin-set 6, upper pin, is sync output in Master Mode, or sync input in Slave Mode. Lower pin is connected to ground. **NOTE:** when pinset 6 is open, pinset 5 *must* be shorted in order to connect pin 29 of the SCSI connector to ground. |
| 5 = open; 6 = shorted | | Connects sync signal line to pin 29 of SCSI connector. Pin 29 then becomes sync output in Master Mode, or sync input in Slave Mode. **NOTE:** when pinset 6 is shorted, pinset 5 *must* be open. |
| **Pinsets 7, 8, and 9: SCSI Address Selection** (0 = open; 1 = shorted) | | |
| **7** | **8** | **9** | **SCSI Bus Address** |
| 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 2 |
| 0 | 1 | 1 | 3 |
| 1 | 0 | 0 | 4 |
| 1 | 0 | 1 | 5 |
| 1 | 1 | 0 | 6 |
| 1 | 1 | 1 | 7 |

## Table 2-2. On-Board Terminator +5V Sources

| Pinset 1 = back 2 pins; Pinset 2 = front 2 pins | |
|---|---|
| 1 = open; 2 = open | Drive +5V not connected to on-board terminators or to SCSI connector pin 26. Initiator supplied +5V not connected to on-board terminators. |
| 1 = shorted; 2 = open | Drive +5V connected to on-board terminators but not to SCSI connector pin 26. |
| 1 = open; 2 = shorted | Initiator supplies +5V input to SCSI connector pin 26 for on-board terminators. |
| 1 = shorted; 2 = shorted | Drive +5V connected to on-board terminators and to SCSI connector pin 26. |

## Table 2-3. 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 2-4. Recommended Mating Connectors**

| Connector/Function | Recommended Mating Connector |
|---|---|
| SCSI Connector (single-ended) | **TBD** |
| DC Power | **TBD** |
| Options Connector (shorting jumper) | **TBD** |
| Synchronized Spindle Pins Connector | **TBD** |
| LED Connector | **TBD** |

# 3

# Product Features

## Introduction

This chapter provides information on supported features, supported commands, and a functional description of the HP C2233/34/35 disk drives.

## Supported Features

The following features of the Small Computer Systems Interface (SCSI) are supported by the "Target". A "Target" is any HP C2233/34/35 disk drive. Device-specific information is also provided.

- **Single-ended.**
- **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 jumper)
  - 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 | In/Out |
| | | The following extended message is supported: | |
| 01 | 3* | Request for SDTR<br>* 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 | Linked Command Complete | In |
| 0B | 1 | Linked Command Complete With Flag | In |
| 0C | 1 | Bus Device Reset | Out |
| 80-FF | 1 | Identify | In |

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 Good |
| 18 | Reservation Conflict |

## Supported Commands

This section describes SCSI commands that are executed by the "Target". A Target is any HP C2233/34/35 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 | 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)<br>Mode Select (10-byte) | 15<br>55 | Enables Initiator to specify media, logical unit, or device parameters to the Target. |
| Mode Sense (6-byte)<br>Mode Sense (10-byte) | 1A<br>5A | Enables Target to report its media, logical unit, or device parameters to the Initiator. |
| Read (6-byte)<br>Read (10-byte) | 08<br>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 | 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 (DERRORS). 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)<br>Seek (10-byte) | 0B<br>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. Using the immediate bit on START is not 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)<br>Write (10-byte) | 0A<br>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 C2233/34/35 disk drives.

### Disk Format

The head/disk assembly (HDA) contains three, four, or five disks (see figure 3-1). The bottom surface of the bottom disk is reserved for servo code. The remaining surfaces are available for user data.

Each data surface contains 1522 data tracks. Nine tracks are reserved for use as spares and two tracks are used for maintenance. This leaves a total of 1511 tracks available for user data. Figure 3-2 displays the physical allocation of the tracks on the media. The tracks are divided into 48, 60, and 72 user sectors in the inner, middle, and outer zones, respectively. In addition, there is one spare sector on each track. Each physical sector can store 512 bytes of user data in the standard format. The user can choose to format the drives using other sector sizes (from 180-992 bytes).

### 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 formatted sector bytes are allocated as shown in figure 3-3.

### 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 512-byte block sizes, the drive automatically blocks and deblocks the physical sectors into the currently specified logical block size.

## Error Correction Code

The HP C2233/34/35 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.

### Cyclic Redundancy Check (CRC)

ECC is aided by a 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 $1 \times 10^{-79}$.
- Probability of miscorrection (an error is detected, but is improperly corrected) with CRC is less than $1 \times 10^{-47}$.

## Track and Sector Sparing

The HP C2233/34/35 Series disk drives support sector sparing and track sparing.

Sector sparing is accomplished by "slip formatting" the track in question. There is one "extra" physical sector available at the end of each track. If a sector goes bad, the recoverable data from that sector, and the data from the following sectors is relocated "downtrack" by one physical sector. The bad sector is no longer used, and the logical addresses of the following sectors are re-sequenced to match the original logical addresses.

Track sparing is implemented for tracks with more than one defective sector, or when logical block length is not equal to the physical sector length. 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.

There are nine tracks reserved as spares on each disk surface, and one sector reserved as a spare in each data track. Defective tracks that require sparing may all reside on one surface, at the beginning, middle, or end of a cylinder, or at random locations. Defects causing a sector to be spared may exist in the header, the data field, or any other area within the physical sector.

The allocation of spared tracks and sectors is contained in a "spares allocation" RAM lookup table included in the microprocessor firmware. The spares allocation table contains locations for a total combination of 2044 track

and sector spares. The number of sector sparing locations available for each drive is 2044 minus the number of total spare track locations available for that drive. The following table lists the track and sector spare combinations.

| Drive | Data Surfaces | Spare Tracks Per Surface | Spare Tracks Per Drive | Spare Sectors Per Drive |
|---|---|---|---|---|
| C2233 | 5 | 9 | 45 | 1999 |
| C2234 | 7 | 9 | 63 | 1981 |
| C2235 | 9 | 9 | 81 | 1963 |

### Operating Notes

- A NO SPARES AVAILABLE error may occur for the following reasons:
  1. The user tried to allocate more track spares than are available on the mechanism.
  2. The user tried to allocate more than 2044 sector and track spares on the entire mechanism.
  3. The drive has attempted to auto-spare defect locations at an extremely high rate (indicative of a failing mechanism) when auto-sparing has been enabled.
- It is possible to have a sector spare on a spared track (a defective sector exists on a track to be spared). In this case, two tables entries are used: one for the track spare and one for the sector spare on the track.
- In order to optimize sparing speed and conserve spares allocation table space, the drive's internal defect list processing routines will pack the list whenever possible. For example, if three defects are detected in three separate sectors in a single track, the defect list processing routines in the drive will recognize the need to assign a spare track. As a result, the three sector spare

entries will be removed from the spares allocation table and replaced by a single track spare entry.

## Buffer Management

This product incorporates a 64-Kilobyte buffer to provide performance enhancements. Upon receiving a READ command, the controller will load the requested data plus the balance of the track into the first half of the buffer. If the next READ command asks for data not already resident in the buffer, the new data and the balance of the track is loaded into the second half of the buffer. The balance of both tracks tracks (up to 64-Kilobytes) are now loaded into the buffer. The data from either of these tracks can be read independently by future READ commands without accessing the media.

If a later READ command requests data not in either half of the buffer, the new data is accessed from the media and loaded into the half of the buffer that was not accessed last. The track that was accessed last is saved in the buffer. In this manner, the two tracks most recently accessed are retained in the buffer for higher performance READ operations. The controller manages the buffer contents with a Look Ahead Read function. The amount of data loaded into the buffer is determined by the Look Ahead Read function.

### Look Ahead Reads

The Look Ahead Read capability can improve the performance of a drive doing sequential READs by preloading the track 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 track 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 the remainder of the current track into the buffer. If in subsequent READ requests, the host asks for the following blocks on the same track, they will already be in the buffer, and the data

will be returned to the host without the delay of a media access. However, the controller is optimized to return any requested data to the host as fast as possible.

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 track with no effect on access or transfer performance. Filling the track buffer with unrequested data has a lower priority than delivering requested data. Other conditions that may affect completing a full-track READ before receiving the next READ command are: sector spares on the track being read, head position relative to the requested data, transfer size, and the host transfer rate.

## 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.

### 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. A stainless steel baseplate and cover provide the supporting structure for these parts. The entire assembly is sealed and is not field repairable.

#### Disks

The disks are 3.5-inch (95 mm) diameter aluminum substrates with sputtered thin-film surfaces. The disks are mounted on the spindle assembly in stacks of three

(HP C2233), four (HP C2234), or five (HP C2235) 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

Five (HP C2233), seven (HP C2234), or nine (HP C2235) MIG (Metal-In-Gap) data heads in the HDA write and read user data. An additional thin film head in each unit is used to recover the servo information from the bottom surface of the bottom disk.

### Actuator Assembly

A rotary actuator positions the read/write heads. A shipping latch captures the actuator arm at the inside diameter of the disks (away from user data) whenever power is removed from the disk drive. This prevents the heads from moving over data until power is applied and the disks are spinning, causing the heads to fly at a safe distance above the disk surfaces. During the power-up sequence, the processor releases the latch, allowing normal movement of the heads.

### Head Interface Electronics

The head interface circuits (located inside the HDA), process the data signals transferred between the read/write heads and the drive electronics/controller PCA. These circuits include write drivers which provide the necessary current to the heads during write operations, and read preamplifiers that 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 filter and a recirculating filter. The breather filter equalizes air pressure within the HDA to ambient air pressure and prevents contaminants from entering the HDA. The recirculating filter maintains the internal cleanliness of the HDA.

#### Vibration Isolators

The HDA is mounted on vibration isolators to protect it from high frequency 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 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 speed and phase switching control.

## Block Diagram

Refer to figure 3-4. 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 64-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 64-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 10.3 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. Disk Drive Addressing Structure.

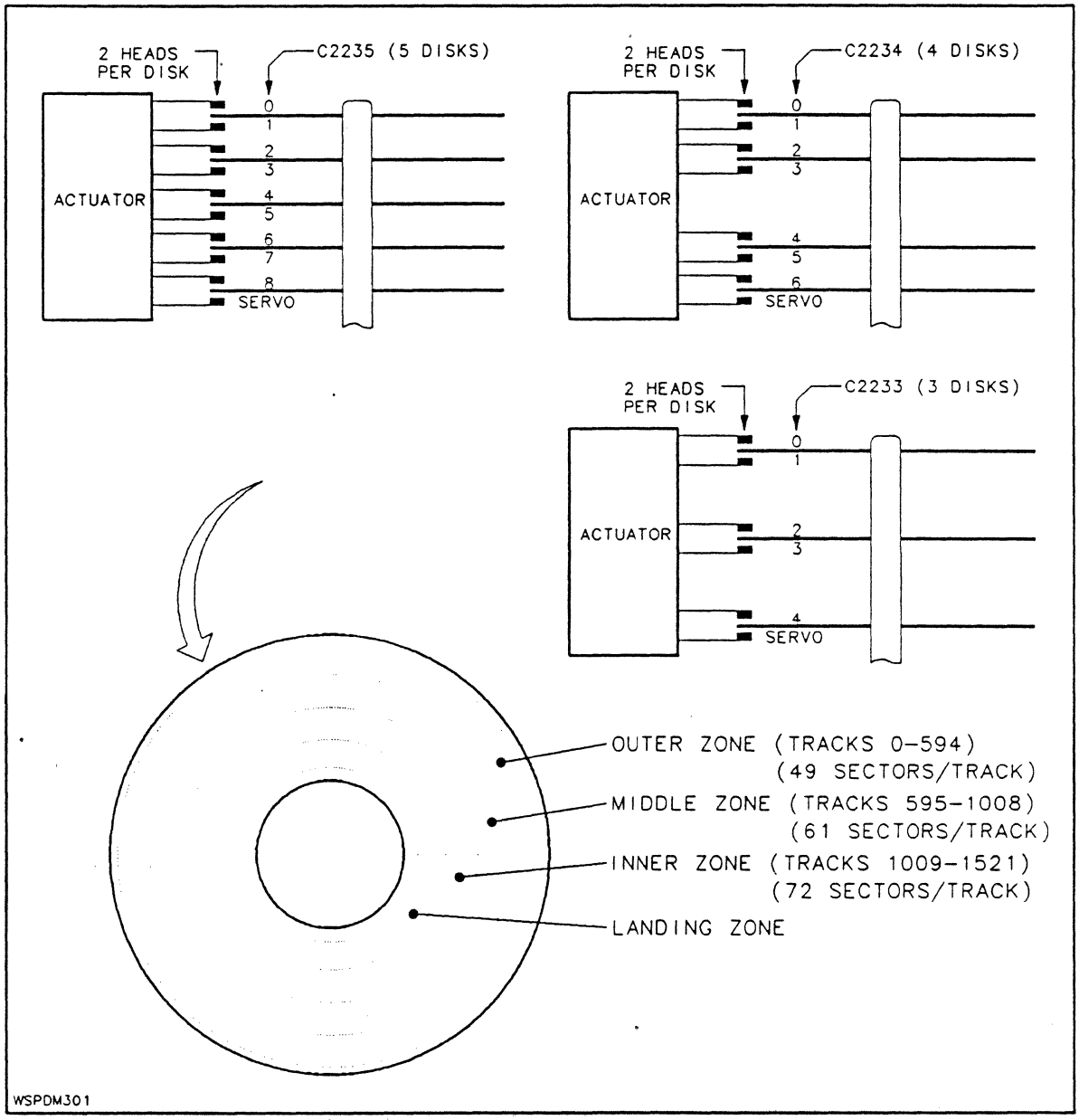


Figure 3-2. Track Allocation.

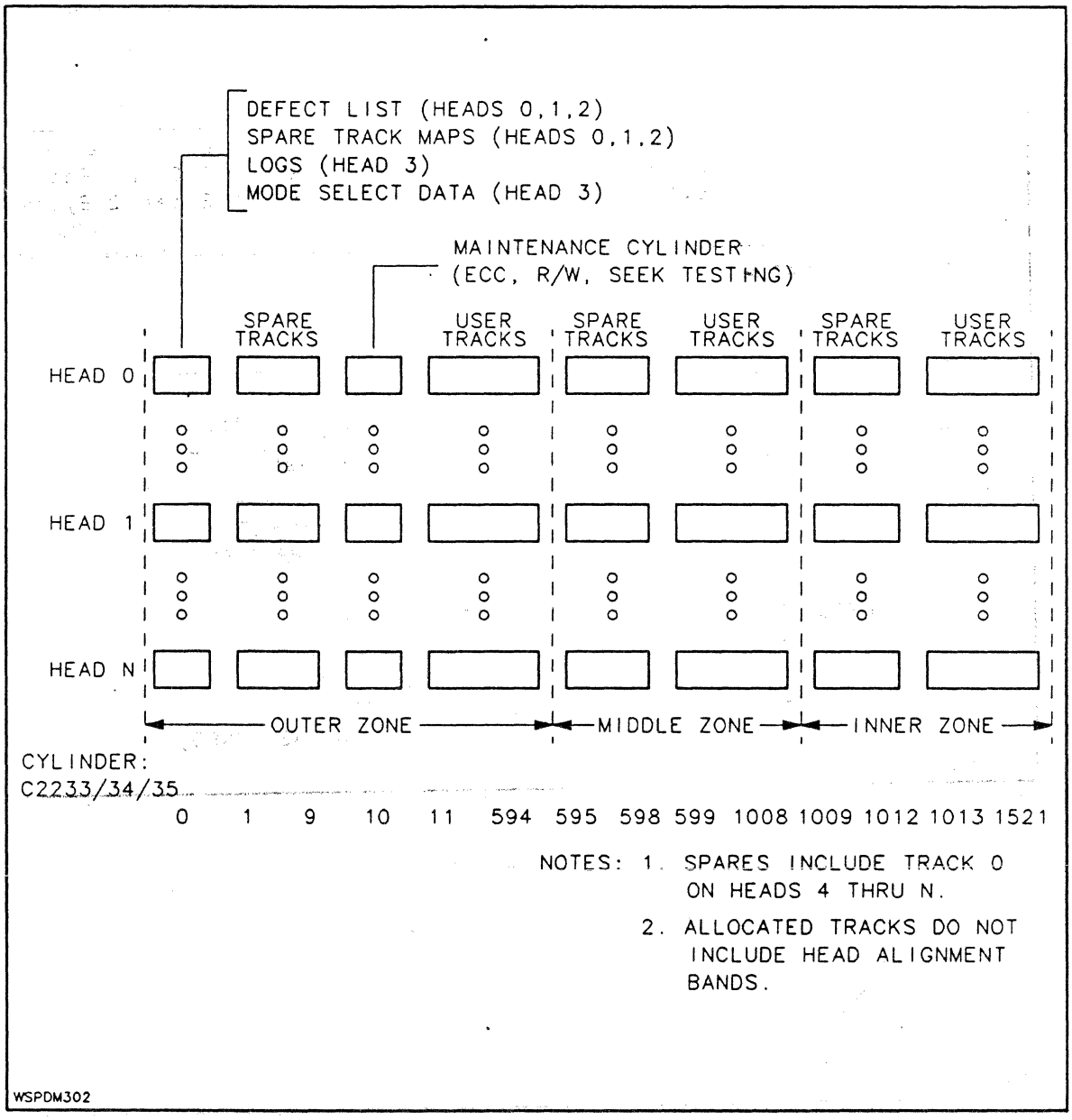


Figure 3-3. Formatted Physical Sector Allocation.

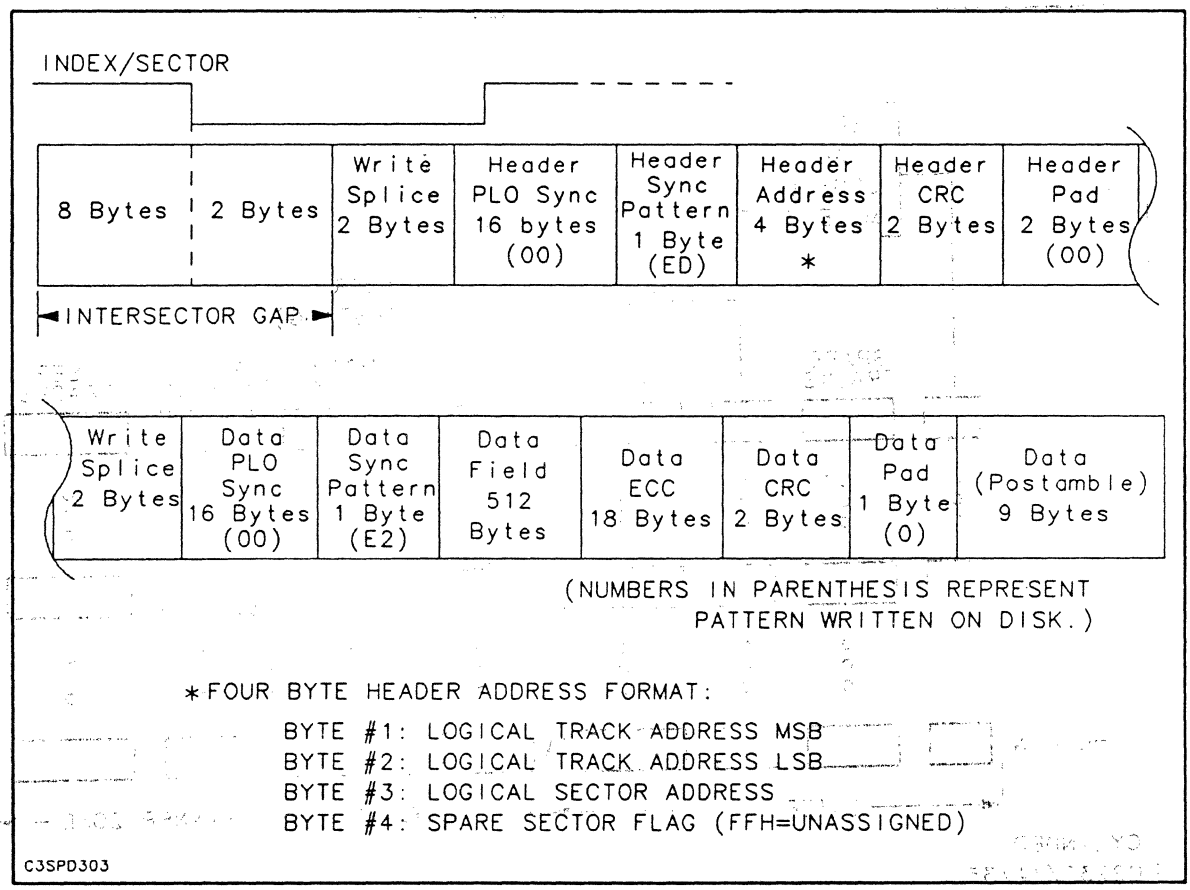


Figure 3-4. Disk Drive Block Diagram.