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PPC

PERTEC
PERIPHERALS
CORPORATION

DX SERIES
FIXED DISK DRIVE
WITH ANSI INTERFACE
PRODUCT SPECIFICATION

Document No. 84607 (5/84)

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1.0 SCOPE

This Product Specification describes the performance and reliability goals of the Pertec Peripherals Corporation (PPC™) DX Series Fixed Disk Drive and provides a detailed physical description of the drive and a complete electrical description of its interface requirements.

NOTE

PPC reserves the right to change this specification without prior notice.

2.0 REFERENCES

2.1 REGULATORY AGENCY REQUIREMENTS

(1) The DX Series Disk Drives shall be UL recognized as a component under UL 478 and certified under CSA C22.2 Number 154.

(2) The DX Series Disk Drives are designed to comply with IEC Publication Number 435.

(3) The DX Series Disk Drives are designed to minimize conducted and radiated electromagnetic interference.

2.2 DOCUMENTATION

The following documentation is available for field support of the DX Series Fixed Disk Drive.

(1) Operating and Service Manual No. 112952

(2) Installation and Operation Manual No. 112924

(3) Application Note No. 84606

3.0 GENERAL DESCRIPTION

3.1 PRODUCT DESCRIPTION

The DX Series Disk Drive is a random access, fixed media drive comprised of a sealed head/disk assembly (HDA), shock-mounted to an outer chassis with three major printed circuit board assemblies (PCBAs). The HDA houses the heads, media, head amplifiers, rotary-type actuator, spindle and air system components and is sealed to minimize the effects of environmental contamination. With the exception of the head amplifiers, all drive electronics are mounted outside the HDA for easy serviceability.

The Logic PCBA contains a microcomputer which communicates between the interface and the servo control electronics. The Servo PCBA contains voltage regulators, power sensing circuitry and the power devices which drive the spindle and head actuator. Read data recovery circuits are mounted on the Read PCBA.

The drive can be rack-mounted in either European or domestic enclosures and features both fixed and variable (Address Mark) sectoring, phase-locked data separation, 2,7 Run Length Limited (RLL) code data conversion and daisy chain interfacing capability. Large Scale Integration (LSI) is used extensively with ECL technology. See Figure 3-1 for major assembly location.

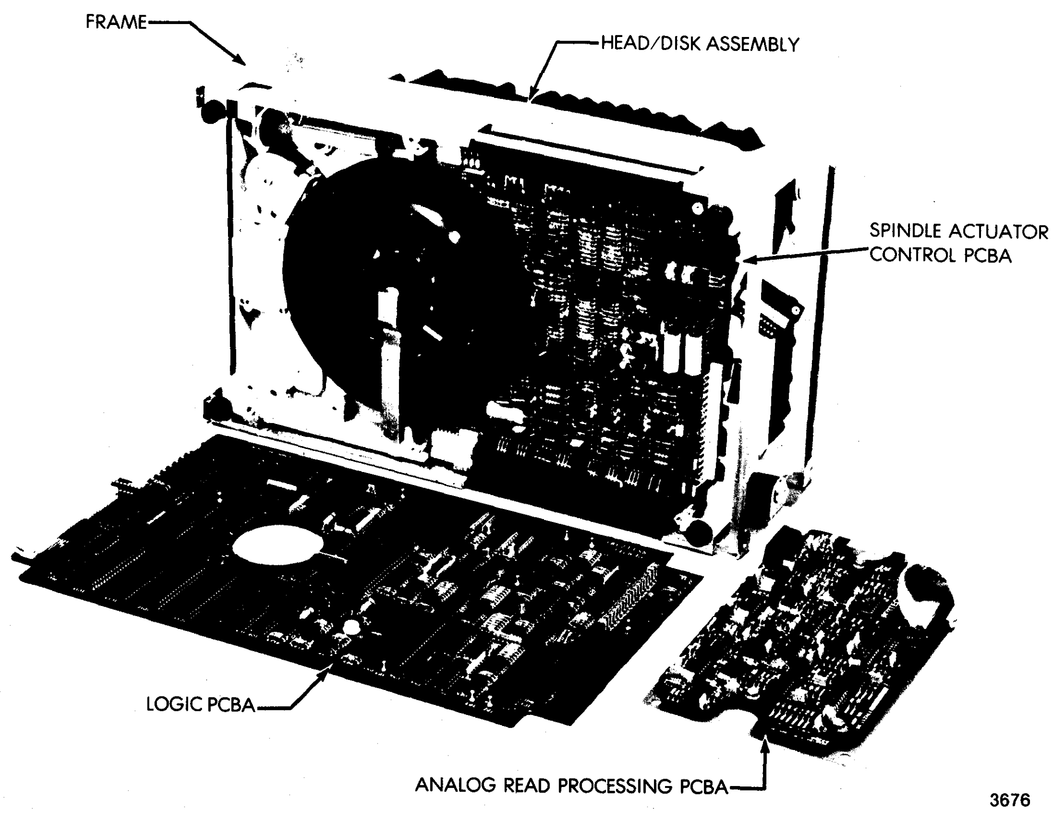

Figure 3-1. Major Assembly Location

3.2 MODEL NUMBER IDENTIFICATION

The model identification is shown in Figure 3-2.

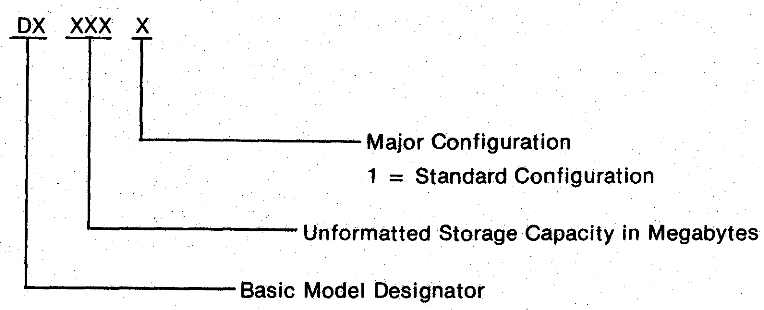

Figure 3-2. Model Number Identification

4.0 FEATURES

4.1 STANDARD FEATURES

The following features are standard equipment on every disk drive.

(1) ANSI interface
(2) Replaceable, shock-mounted HDA
(3) On-board microcomputer control
(4) Custom LSIs for spindle, actuator, read and write control
(5) Selectable hard or soft sector modes from 1 to 127 sectors
(6) Rotary voice coil actuator with automatic shipping lock
(7) Direct drive, brushless dc spindle motor with brake/lock mechanism
(8) Horizontal or side mounting
(9) Installation and Operation Manual
(10) No adjustments or preventive maintenance for life of the unit
(11) ANSI Control Bus Parity Option select switch
(12) Switch selectable spin-up with Power-On

4.2 ACCESSORIES

An Operating and Service Manual can be ordered for the disk drive.

5.0 GENERAL PERFORMANCE SPECIFICATIONS

5.1 MECHANICAL AND ELECTRICAL SPECIFICATIONS

The mechanical and electrical specifications summary is given in Table 5-1.

5.2 UNFORMATTED STORAGE CAPACITY

The nominal unformatted storage capacity of a disk drive is defined as the nominal track capacity times the number of tracks in that drive. The nominal unformatted track capacity is defined as the number of 8-bit bytes which may be recorded on a track when the disk is turning at the nominal spindle speed of 3600 rpm.

The nominal unformatted storage capacity is given in Table 5-1.

5.3 STORAGE MEDIA

The storage media is composed of an aluminum alloy substrate, coated on both surfaces with a layer of ferromagnetic oxide material suspended in a hardened binder. A lubrication overcoating is applied to minimize wear during contact start-stop operation.

5.4 TRACK DENSITY

The nominal track density is 987 tracks per inch.

5.5 ROTATIONAL SPEED

The spindle speed is 3600 rpm ± 1 percent.

5.6 DATA TRANSFER RATE

The data transfer rate is 9.67 megabits (1.21 megabytes) per second ± 2 percent.

5.7 SEEK TIME

Seek time is defined as the time required from the receipt of a seek or position command by the drive until the drive signals the controller is ready to perform another seek or read/write function on the new cylinder.

Average seek time is determined by dividing the total time required to seek between all possible pairs of track addresses by the total number of these ordered pairs.

(1) Adjacent track seek time: 6 milliseconds maximum

(2) Average seek time: 25 milliseconds maximum

(3) Full stroke, 1493 tracks: 48 milliseconds maximum

(4) Zero-track seek time: 40 ± 7.5 microseconds

5.8 LATENCY TIME

Latency time is defined as the time required to reach a target sector after positioning is complete.

(1) The average latency time, based on a nominal disk speed of 3600 rpm, is 8.34 milliseconds.

(2) The maximum latency time, based on a minimum disk speed of 3564 rpm, is 16.84 milliseconds.

Table 5-1
Mechanical and Electrical Specifications (Nominal)

	DX180	DX240	DX300
Recording Parameters			
Capacity (Unformatted MBytes)	180.6	240.8	301.0
Recording Mode on Media		(2,7) RLL	
Interface Data		NRZ	
Media (Note 1)			
Disks	4	5	6
Data Surfaces	6	8	10
Tracks per Surface		1493	
Track Density (tpi)		987	
Track Capacity (bytes)		20,160	
Rotational Speed (rpm)		3,600	
Technology Type			
Head		Composite MgZn	
Media		Oriented Oxide	
Data Transfer Rate (MBits/second)		9.67	
Seek Time (milliseconds)			
Track-to-Track		6	
Average		25	
Maximum		48	
Average Latency Time		8.34	
Zero Track Seek Time (microseconds)		40	
MTBF (Hours)			
Sealed Head/Disk Assembly		25,000	
Complete Unit		12,000	
MTTR (minutes)		30	
Error Rate			
Recoverable Error		1 in 10^{10} read errors	
Non-recoverable Error		1 in 10^{12} read errors	
Seek Error		1 in 10^{6} seeks	
Environmental Error		1 in 8 hours	
Operational Environment			
Temperature		10° to 40°C (50° to 104°F)	
Humidity		10 to 80% (non-condensing)	
Shock		2g (3 axis, both directions)	
Vibration		0.006 inch (5 to 40 Hz), 0.5g, 40 to 500 Hz	
Altitude		– 152 to 2,438m (– 500 to 8,000 feet)	
Power Requirements		+24v dc @ 5.4 amps (average) – 24v dc @ 1.0 amps (average) +5v dc @ 2.2 amps (average) – 5.2v dc @ 2.8 amps (average)	
Power Dissipation (average)		Less than 175 watts	
Start Time (seconds)		60	
Stop Time (seconds)		15	
Physical Dimensions			
Height		118 mm (4.65 inches)	
Width		218 mm (8.58 inches)	
Depth		364 mm (14.31 inches)	
Weight		12.25 kg (27 pounds)	
Planned Certifications		UL, CSA, and IEC	

NOTES:
1. Full, unformatted capacity excluding defects or deallocation schemes.

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5.9 START TIME

The drive will become ready within 60 seconds after application of dc power or, alternatively, after a valid spindle-start command has been received.

5.10 STOP TIME

The spindle will stop within 15 seconds following a valid spin-down command or, alternatively, after dc power is removed.

6.0 ERROR RATE SPECIFICATIONS

The initial error rates stated in this section are guaranteed only when all of the following conditions are met.

(1) The DX disk drive is operated within the environment specified in Paragraphs 8 and 9.

(2) A data format is used which fulfills the requirements of the drive outlined in Paragraph 16.

(3) Media defects, disk drive and host system failures are excluded from the error rate computations.

(4) The power requirements specified in Paragraph 12 are satisfied.

(5) System grounding requirements described in Paragraph 12 are satisfied.

(6) All read/write operations are done with the drive in the same physical orientation.

(7) A correct host/drive operational interface has been implemented to include all interface timings.

(8) All data transfers are performed with nominal strobes and no actuator offset.

6.1 READ ERRORS

Prior to the determination or measurement of read error rates:

(1) The data to be used for measurement of read error rates must be verified as having been correctly written on the media.

(2) All media defect-induced errors must be excluded from error rate calculations.

A read error is defined as recoverable (soft) if the data in question can be read correctly within three attempts at all combinations of head position and strobe timing outlined in Table 6-1.

A read error is defined as nonrecoverable (hard) if the data in question cannot be read correctly within 27 total attempts as outlined in Table 6-1.

The recoverable read error rate is not more than one error in 10^{10} bits transferred.

The nonrecoverable read error rate is not more than one error in 10^{12} bits transferred.

Table 6-1

Read Recovery Attempts

Head Position	Strobe Timing	Number of Attempts
Nominal	Nominal	3
	Early	3
	Late	3
+ Offset	Nominal	3
	Early	3
	Late	3
− Offset	Nominal	3
	Early	3
	Late	3
		27 Total

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6.2 ENVIRONMENTAL INTERFERENCE

When operating at an effective data transfer rate of less than 10^{10} bits over an 8-hour period, the effective error rate may be expected to exceed the specified limits due to environmental interference. In this case, the recoverable read error rate will not exceed one error in 8 hours of operation.

6.3 WRITE ERRORS

Because write errors can be due to write data not being presented correctly, media flaws, environmental interference, or drive malfunction, write errors are not predictable as a function of the number of bits passed.

A write error is defined as unrecoverable if the data in question cannot be written and verified correctly within three attempts.

An unrecoverable write error occurring due to a disk drive malfunction is considered a drive failure affecting the MTBF.

The host system must include sector/track deallocation or skip displacement capabilities to ensure that valid data are not written over defective areas of the media.

6.4 SEEK ERRORS

A seek error is defined as the condition which occurs when the drive fails to position the heads over the addressed cylinder.

A seek error is defined as recoverable if the heads can be positioned over the correct cylinder after one retry preceded by a Return To Zero command.

A seek error is defined as unrecoverable if the heads cannot be correctly positioned after one retry preceded by a Return To Zero command.

The recoverable seek error rate does not exceed one in 10^6 physical seeks. An unrecoverable seek error is considered to be a failure affecting the MTBF.

6.5 DATA SECURITY

Under normal controller I/O operation, the drive will write only that pattern presented on the write data lines. The drive must be selected and on cylinder before a valid write operation can be initiated. Data are protected by internally inhibiting Write Gate during all fault conditions.

7.0 RELIABILITY AND SERVICE

7.1 MEAN TIME BETWEEN FAILURE (MTBF)

MTBF is defined by the following formula.

$$MTBF = \frac{\text{Operating Hours}}{\text{Number of Equipment Failures}}$$

Operating Hours are the total power on hours less any maintenance time. To establish a meaningful MTBF, the number of operating hours must be statistically significant and must include field performance data from all field sites.

Equipment Failure means any stoppage or substandard performance of the disk drive due to hardware malfunction which requires unscheduled repair or replacement. Equipment failures exclude malfunctions caused by operator errors, adverse environmental conditions, power failures, controller failures, cable failures, or other failures not attributable to the disk drive. Failures occurring within the first 200 hours of operation are excluded from the MTBF calculations.

The MTBF shall exceed 7000 hours for units manufactured during the first year of production and 9000 hours for units manufactured during the second year. The MTBF of subsequent units shall exceed 12,000 hours.

7.2 ADJUSTMENTS

No mechanical or electrical adjustments are required.

7.3 PREVENTIVE MAINTENANCE

Preventive maintenance is not required.

7.4 SERVICEABILITY

The disk drive can be serviced in the field at the board replacement level without special tools or fixtures. The HDA may be repaired only at a properly equipped facility. Breaking of the seals or removal of the HDA cover by unauthorized personnel will void the disk drive warranty.

7.5 MEAN TIME TO REPAIR (MTTR)

The field MTTR is defined as the average time required for an adequately trained and equipped serviceperson to diagnose and correct a malfunction external to the HDA while following recommended field service procedures. The MTTR does not include retest time or the time needed to remove and reinstall the drive in the system. The MTTR does not exceed 0.5 hour.

NOTE

Repairs that require opening the sealed HDA must be accomplished in an appropriate clean-room facility and are not included in the MTTR. Removing or breaking the warranty label or defeating the disk chamber seals by unauthorized personnel voids the disk drive warranty.

7.6 SERVICE LIFE

The disk drive has a useful service life of 10 years or 50,000 hours, whichever occurs first, before requiring factory overhaul. Replacement of major parts or depot repair will be permitted during the service life.

8.0 ENVIRONMENTAL LIMITATIONS

The temperature and humidity specifications given in Table 8-1 preclude condensation on or in any part of the disk drive. The temperatures specified are the ambient temperatures measured at any point 12.7 mm (0.5 inch) from the disk drive. When mounted in an enclosure, the user must provide cooling to ensure the temperature specification is not exceeded.

Power should be applied for 30 minutes prior to recording information on the disk drive.

Table 8-1
Environmental Limitations

Parameter	Operating	Shipping and Storage
Temperature	10 °C to 40 °C (50 °F to 104 °F)	– 34 °C to 66 °C (– 9.2 °F to 150.8 °F)
Maximum Rate of Change	7 °C (12 °F) per hour	20 °C (36 °F) per hour
Relative Humidity	10% to 80%	10% to 90%
Altitude	– 152 to 2438 metres (– 500 to 8000 feet)	– 152 to 6096 metres (– 500 to 20,000 feet)

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9.0 SHOCK AND VIBRATION LIMITATIONS

The disk drive can withstand the following shock and vibration conditions without damage to its physical structure or function.

Shock and vibration shall be applied to and measurements shall be taken from the disk drive frame. If the shock or vibration is applied to an enclosure in which the drive is installed, internal resonances may occur within the enclosure which exceed these limits.

9.1 OPERATING SHOCK

The disk drive will withstand a half-sine shock pulse with a peak acceleration of 2g and a duration of 11 milliseconds in 3 axes, in either direction. Testing shall be limited to a maximum of 3 shocks per side (18 total).

9.2 NON-OPERATING SHOCK

The disk drive will withstand a half-sine shock pulse with a peak acceleration of 15g and a duration of 11 milliseconds in 3 axes, in either direction. Testing shall be limited to a maximum of 3 shocks per side (18 total).

9.3 OPERATING VIBRATION

The disk drive will withstand a sinusoidal vibration in each of 3 mutually perpendicular axes at a vibration level of 0.152 mm (0.006 inch) double amplitude from 20 to 40 Hz, and 0.5g peak from 40 to 500 Hz.

9.4 NON-OPERATING VIBRATION

The disk drive will withstand a sinusoidal vibration in each of 3 mutually perpendicular axes at a vibration level of 2.54 mm (0.1 inch) double amplitude from 5 to 17 Hz, and 1.5g peak from 17 to 500 Hz.

NOTE

The test procedure for the vibration frequencies shall be varied logarithmically from low-to-high-to-low. The maximum cycle rate shall be 40 minutes. Dwelling at any resonant frequency shall not be longer than 3 minutes.

9.5 SHIPPING ENVIRONMENT

The DX disk drive, when packaged in the PPC-approved shipping container, will conform to the shipping requirements specified in the National Safe Transit Committee Pre-Shipment Test Procedure.

10.0 DIMENSIONAL SPECIFICATION

The DX disk drive mounts interchangeably into enclosures designed for standard-height 8-inch flexible disk drives.

10.1 MOUNTING ORIENTATION

The drive may be mounted horizontally with the HDA cover on top, or, when facing the rear of the drive (interface connectors visible), with the HDA cover facing towards the right.

10.2 WEIGHT

- 12.25 kg (27 pounds) maximum

10.3 SIZE

The physical dimensions of the drive are illustrated in Figure 10-1.

- Height: 118 mm (4.65 inches) maximum
- Width: 218 mm (8.58 inches) maximum, excluding slides
- Depth: 364 mm (14.31 inches) maximum, measured from the rear of the front panel to the extreme rear of the drive. This dimension excludes cables and connectors.

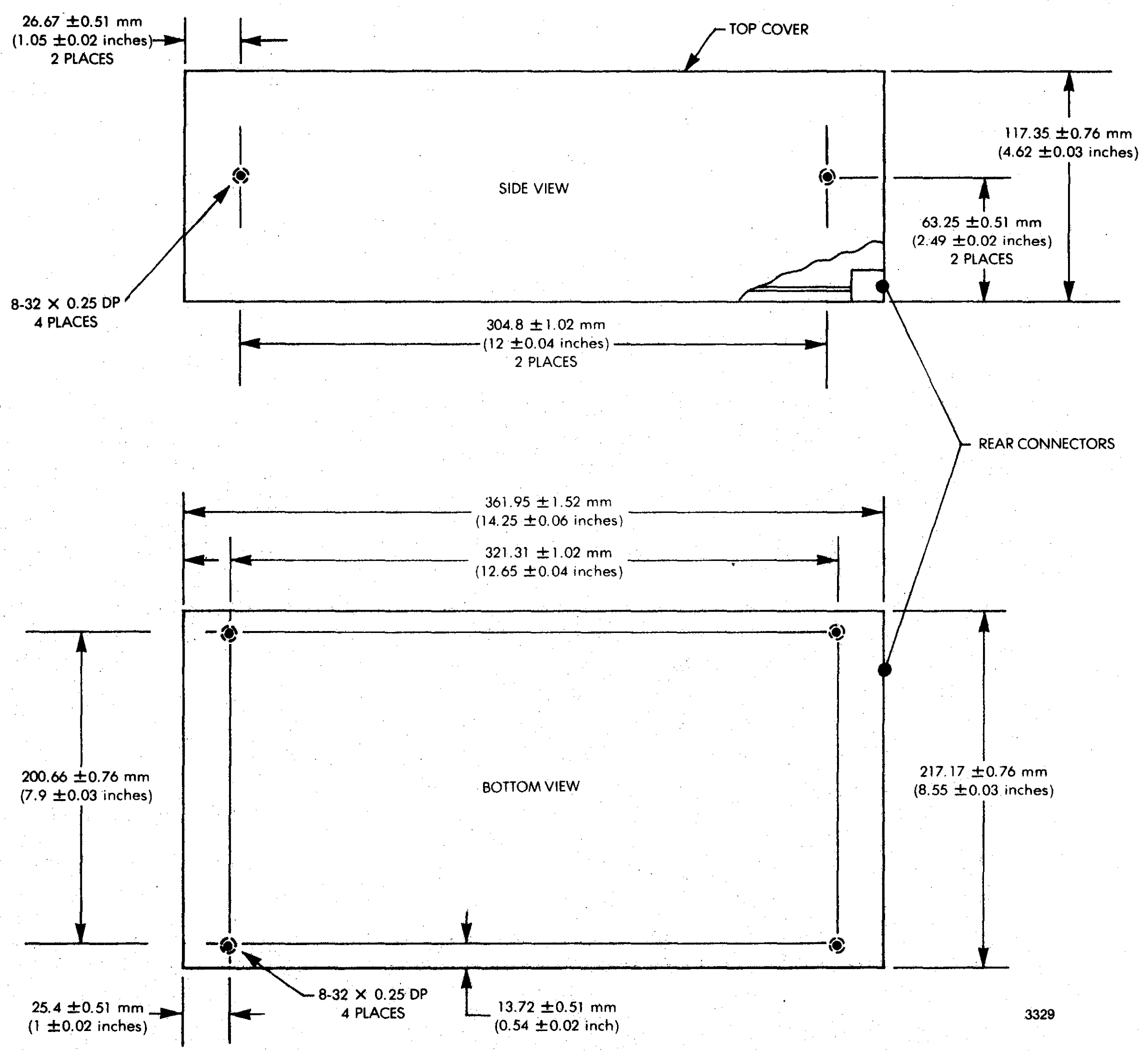

Figure 10-1. Physical Dimensions and Mounting Holes

11.0 AUDIBLE NOISE

The DX disk drive meets the maximum operating level limits defined by the International Organization for Standardization (ISO) noise rating NR-55 curve (31.5 to 8000 Hz range),

11.1 MEASUREMENT PROCEDURES

All measurements on the disk drive are to be conducted in an anechoic chamber. The drive to be tested must be mounted on a wooden surface between 864 and 914 mm (34 and 36 inches) from the floor.

The microphone used during the test must be located 914 mm (36 inches) from the most prominent noise source on the unit under test, and 914 mm from the floor.

12.0 POWER REQUIREMENTS

Table 12-1 lists the voltages and currents required by the DX disk drive as measured at its dc power connector. Ac power is not required.

It is recommended that separate grounds be brought in from the power supply for each voltage to the dc power connector on the disk drive.

It is also recommended that the drive frame be tied to the host cabinet ground with a braided type conductor.

Table 12-1

DC Power Requirements

Voltage	+24v dc	−24v dc	+5v dc	−5.2v dc
Tolerance	±10%	±10%	±3%	±3%
Regulation	±2%	±2%	±1%	±1.5%
Ripple (60 Hz to 25 MHz) peak-to-peak	0.5v	0.5v	0.1v	0.1v
Maximum Current	12A	3A	3A	3A
Average Operating Current	5.4A	1A	2.2A	2.8A
Absolute Maximum Voltage without Physical Damage To Disk Drive	+30v	−30v	+6v	−6v

NOTES:

1. When power is provided to multiple drives from a common supply, average and peak currents must be considered. The maximum current noted must be available to each drive to ensure proper spindle acceleration.
2. Average power dissipation is less than 175 watts.

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13.0 MEDIA DEFECT SPECIFICATION

13.1 MEDIA DEFECTS

A media defect is a physical characteristic of the media which results in a repetitive read error when a properly adjusted drive is operated within the environment specified in this document. Sector/track deallocation or skip displacement techniques should be used to avoid writing data over known media defects.

At the time of shipment from the point of manufacture, the number of media defects per disk drive will not exceed the following:

	DX180	DX240	DX300
Defects	300	400	480

13.2 DEFECTIVE TRACKS

The following conditions may require that the entire track on which they occur be considered defective and therefore define a defective track.

13.2.1 LONG ERROR

A long error is an error whose length is greater than 20 bits and which does not contain any span of error-free data longer than 20 bytes between the first bit in error and the last bit in error.

A long error may cause the read phase lock loop to lose phase lock such that the data following the error would not be properly decoded, even though it may be error-free.

13.2.2 TWO OR MORE SHORT ERRORS ON THE SAME TRACK

An error is defined as short when its length is 20 bits or less and when the preceding and subsequent 20 bytes are error-free. A separation of more than 20 bytes or error-free data between the last bit in error of the first short error to the first bit in error of the second short error defines two short errors.

Two or more short errors occurring in different sectors of a given track would require that the entire track be deallocated if the host system is not capable of deallocating more than one sector per track.

13.2.3 FALSELY DETECTED ADDRESS MARK

In the soft sectored mode, the data integrity of the entire track becomes suspect if a media defect results in the detection of an address mark where none was written. Therefore, a falsely detected address mark anywhere in a track results in a defective track.

NOTE

The length of a defect is defined as the number of bits between the first bit in error and the last bit in error plus the first and last bits in error. The bits between the first and last bits in error may or may not contain an error.

At the time of shipment from the point of manufacture, the number of defective tracks per disk drive will not exceed the following:

	DX180	DX240	DX300
Defects	30	40	48

13.3 DEFECT-FREE AREAS

Cylinder 0, heads 0 and 1, are media defect-free areas.

13.4 DEFECT LOGGING

Each disk drive will be shipped with a hard copy attached to the drive with the following defect information.

(1) Cylinder location
(2) Head
(3) Length of the defect in bits
(4) Location of the defect in bytes from Index

In addition to the hard copy, each disk drive will be formatted at the factory with a Defect Log (Paragraph 13.5).

The Defect Log is provided for those customers who wish to use it as part of their system initialization and track deallocation routines without recertifying the media. Customers so desiring must take precautions to prevent writing over this data until it has been recovered.

13.5 DEFECT LOG

The Defect Log format is shown in Figure 13-1. The Defect Log is written on each track immediately following Index and is divided into two parts. The first part is a hard-sectored format written from byte 00—55. The second part is a soft-sectored format written from byte 56—104. The information in the data fields pertains only to the track on which the information was written.

(1) If a defect is sensed between the start of byte 15 and the end of byte 55, GAP 1 is increased from 30 bytes to 90 bytes and all subsequent information is shifted down track by 60 bytes.

(2) If a defect is sensed between the start of byte 56 and the end of byte 104, 60 bytes of zeros are inserted immediately preceding the address mark. The address mark and all subsequent information are shifted down track by 60 bytes.

(3) The first four errors on each track are logged. If the track is defective, the most significant bit of the first cylinder address byte will be set to 1. The information remaining on that track may or may not be valid.

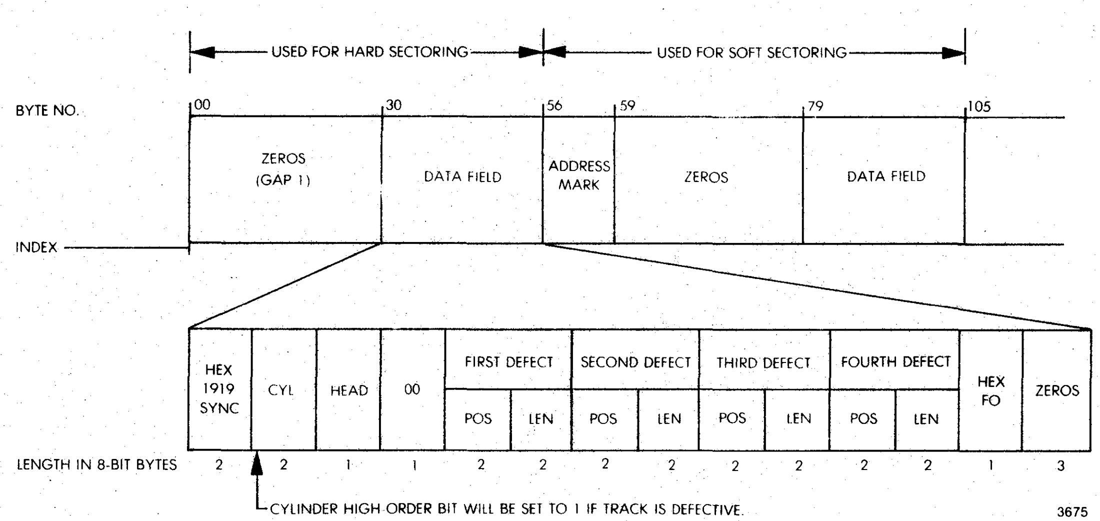

Figure 13-1. Defect Log Format

14.0 PHYSICAL INTERFACE SPECIFICATION

Cables and mating connectors are to be supplied by the user.

14.1 DC POWER CONNECTION

The dc power connector on the drive is an AMP MATE-N-LOK 8-pin connector, AMP Part No. 640588-1. The correct mating connector is AMP Part No. 640586-1, or equivalent, using contacts AMP Part No. 350536-3, or equivalent.

The power connection is made to the Logic PCBA. Refer to Table 14-1 for connector pin assignments.

14.2 INTERFACE CONNECTOR REQUIREMENTS

The ANSI interface signal/data connector mounted on the rear of the disk drive is a polarized, 50-pin 2-row, inline, flat-ribbon, rectangular type, AMP No. 1-102160-0. The mating connector is AMP No. 88393-8 (or equivalent). The mating connector must be provided by the customer on each drive when the daisy-chain configuration is used. Connector configurations are shown in Figures 14-1 and 14-2.

14.3 INTERFACE CABLE CHARACTERISTICS

The DX disk drive accepts a flat ribbon cable consisting of 50 conductors of 28 AWG. The characteristic impedance of the lines is 100 ohms ± 10 percent. Conductor spacing is 1.27 mm (0.05 inch) center-to-center to provide for mechanical termination. Additionally, the flat ribbon cable is marked in such a way as to identify line number one (pin 1).

If the cable contains a shield ground, it must be connected to pin 1 of the interface connector.

The length of the interface cable must not exceed 3 metres (9.8 feet), measured from the host connector to the furthest drive connector on the cable.

14.4 INTERFACE CABLE PIN ASSIGNMENTS

Table 14-2 lists the pin assignments for the ANSI interface cable.

Table 14-1

DC Power Connections (J2)

Pin 1	+5.0v dc Return	Pin 5	−24v dc
Pin 2	+5.0v dc	Pin 6	−24v dc Return
Pin 3	−5.2v dc	Pin 7	+24v dc
Pin 4	−5.2v dc Return	Pin 8	+24v dc Return

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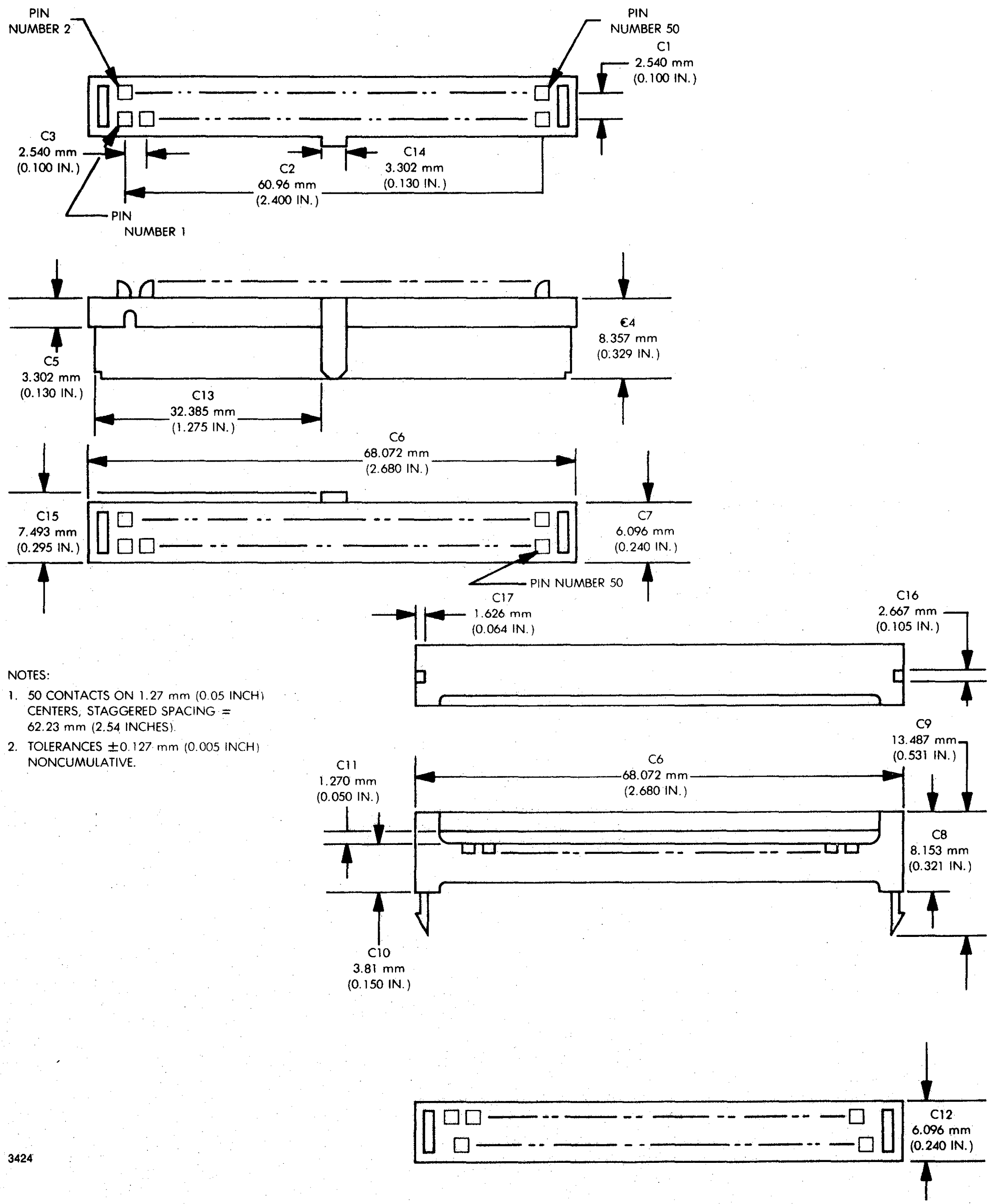

NOTES:

1. 50 CONTACTS ON 1.27 mm (0.05 INCH) CENTERS, STAGGERED SPACING = 62.23 mm (2.54 INCHES).
2. TOLERANCES ±0.127 mm (0.005 INCH) NONCUMULATIVE.

Figure 14-1. Interface Cable Connector

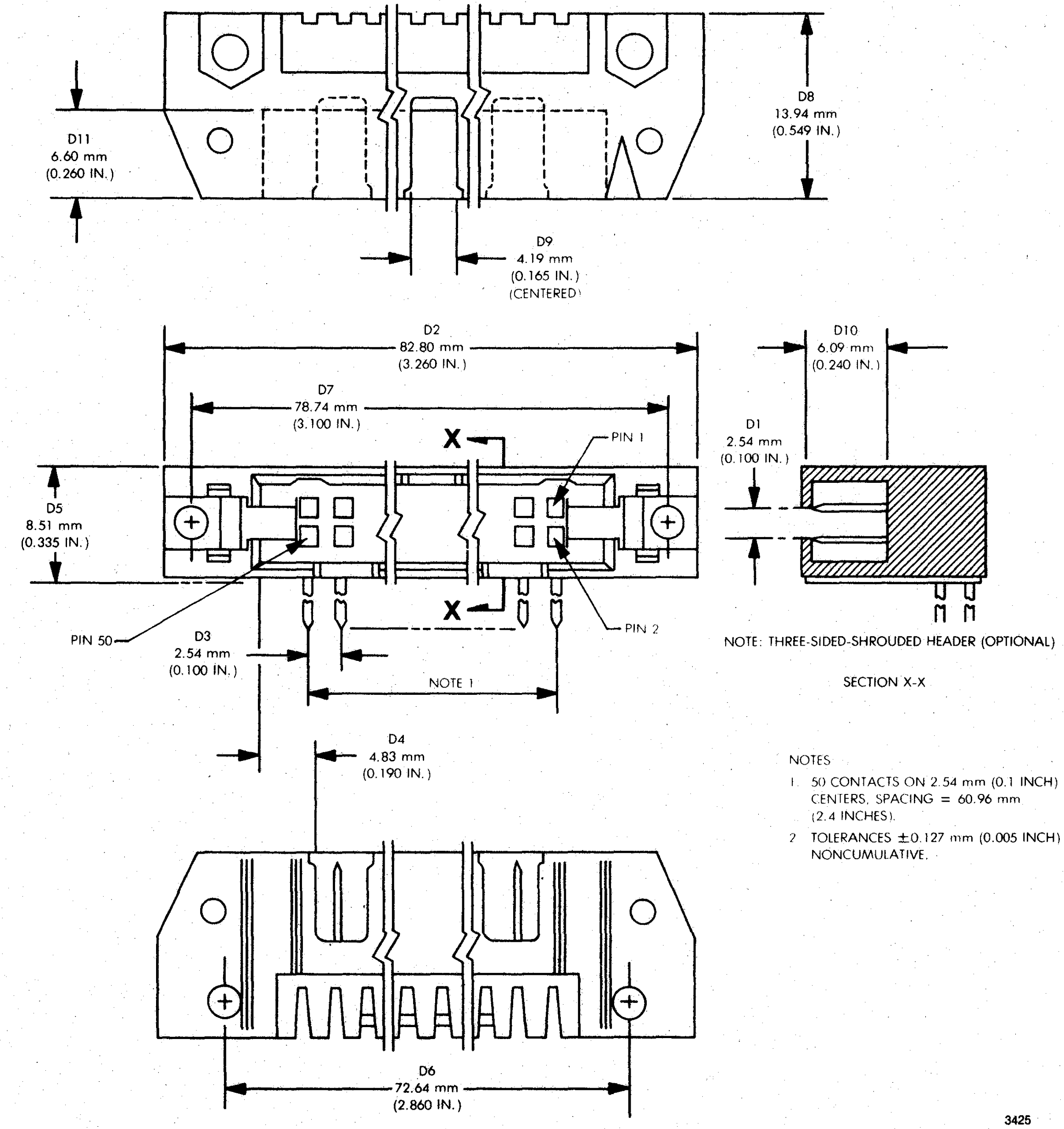

Figure 14-2. Interface Connector on Logic PCBA

Table 14-2
ANSI Interface Cable Pin Assignment

Signal Pin	Ground Pin	Signal Name	Signal Source
1		Ground	—
		Bidirectional Control Bus Lines	
2	10	Bit 0, Select/Attention Disk Drive 0 (ISAD0)	Disk Drive/Controller
3	10	Bit 1, Select/Attention Disk Drive 1 (ISAD1)	Disk Drive/Controller
4	10	Bit 2, Select/Attention Disk Drive 2 (ISAD2)	Disk Drive/Controller
5	10	Bit 3, Select/Attention Disk Drive 3 (ISAD3)	Disk Drive/Controller
6	10	Bit 4, Select/Attention Disk Drive 4 (ISAD4)	Disk Drive/Controller
7	10	Bit 5, Select/Attention Disk Drive 5 (ISAD5)	Disk Drive/Controller
8	10	Bit 6, Select/Attention Disk Drive 6 (ISAD6)	Disk Drive/Controller
9	10	Bit 7, Select/Attention Disk Drive 7 (ISAD7)	Disk Drive/Controller
11	12	Parity (IPAR) (Optional)	
		Unidirectional Lines	
13	14	Select Out/Attention In Strobe (ISOAIS)	Controller
15	16	Command Request (ICOMRQ)	Controller
17	18	Parameter Request (IPARQ)	Controller
19	20	Bus Direction Out (IBUSDO)	Controller
21	22	Port Enable (IPRTEN)	Controller
23	24	Address Mark Control (IADMC)	Controller
25	26	Read Gate (IRDGT)	Controller
27	28	Write Gate (IWRGT)	Controller
29	30	Bus Acknowledge (IBUSAK)	Disk Drive
31	32	Index (IINDEX)	Disk Drive
33	34	Sector Pulse/Address Mark Detected (ISP/IADMD)	Disk Drive
35	36	Attention (IATTN)	Disk Drive
37	36	Busy (IBUSY)	Disk Drive
39	38	Read Data + (IRDATP)	Disk Drive
40	38	Read Data − (IRDATM)	Disk Drive
42	41	Read/Reference Clock + (IRCKP)	Disk Drive
43	41	Read/Reference Clock − (IRCKM)	Disk Drive
45	44	Write Clock + (IWCKP)	Controller
46	44	Write Clock − (IWCKM)	Controller
48	47	Write Data + (IWDATP)	Controller
49	47	Write Data − (IWDATM)	Controller
	50	Ground	—

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15.0 ELECTRICAL CHARACTERISTICS

15.1 BIDIRECTIONAL CONTROL BUS LINES

The bidirectional Control Bus is used in two different modes: Daisy Chain Mode and Radial Mode.

In the Daisy Chain Mode, eight bits of information and an optional parity bit shall be transferred between the host and the selected device.

In the Radial Mode, each of the eight Control Bus lines shall be used separately for communication with one specific disk drive. In this way, one bit of information is transferred to or from all disk drives simultaneously. Each disk drive has switches that connect its individual radial line to any one of the eight Control Bus lines. The optional Control Bus Parity Bit shall not be used in the Radial Mode. The configuration of the bidirectional Control Bus is shown in Figure 15-1.

15.1.1 CONTROL BUS DRIVERS

The Control Bus driver/receiver for the parallel information is tri-state (74LS245 or equivalent). The driver for the radial signal in the disk drive will have an open collector (7438 or equivalent) in combination with a single-ended device (74LS14 or equivalent).

All Control Bus driver outputs at the low level sink 24 milliamps minimum. The low-level output voltage is 0.5v dc maximum. Tri-state driver outputs have a high-level output voltage of 2.4v dc minimum, 5.25v dc maximum. A 10 milliamps source current is provided by the 470 ohms terminator (refer to Paragraph 15.1.3).

The leakage current in the high impedance state (Off state for open-collector drivers) does not exceed 0.25 milliamp for either high or low level on the Control Bus.

The total number of drivers connected to any Control Bus line cannot exceed ten (one in the controller, one in each of the eight disk drives for the parallel lines, and one for the disk drive radial line).

15.1.2 CONTROL BUS RECEIVERS

For the receivers, the maximum low-level input current is −400 microamps. The maximum high-level input current is 80 microamps. The maximum low-level input voltage is 0.9v dc. The minimum high-level input voltage is 2v dc.

The total number of receivers connected to any Control Bus line cannot exceed ten (one in the controller, one in each of the eight disk drives for the parallel lines, and one for the disk drive radial line).

15.1.3 CONTROL BUS TERMINATION

A 470 ohms resistor, ±10 percent, shall be installed at the controller end of each Control Bus (Control Bus bits 0—7 and Control Bus parity) connected to +5v dc (see Figure 15-1).

(TRI-STATE DRIVERS FOR PARALLEL LINES AND OPEN COLLECTOR DRIVERS FOR RADIAL LINES)

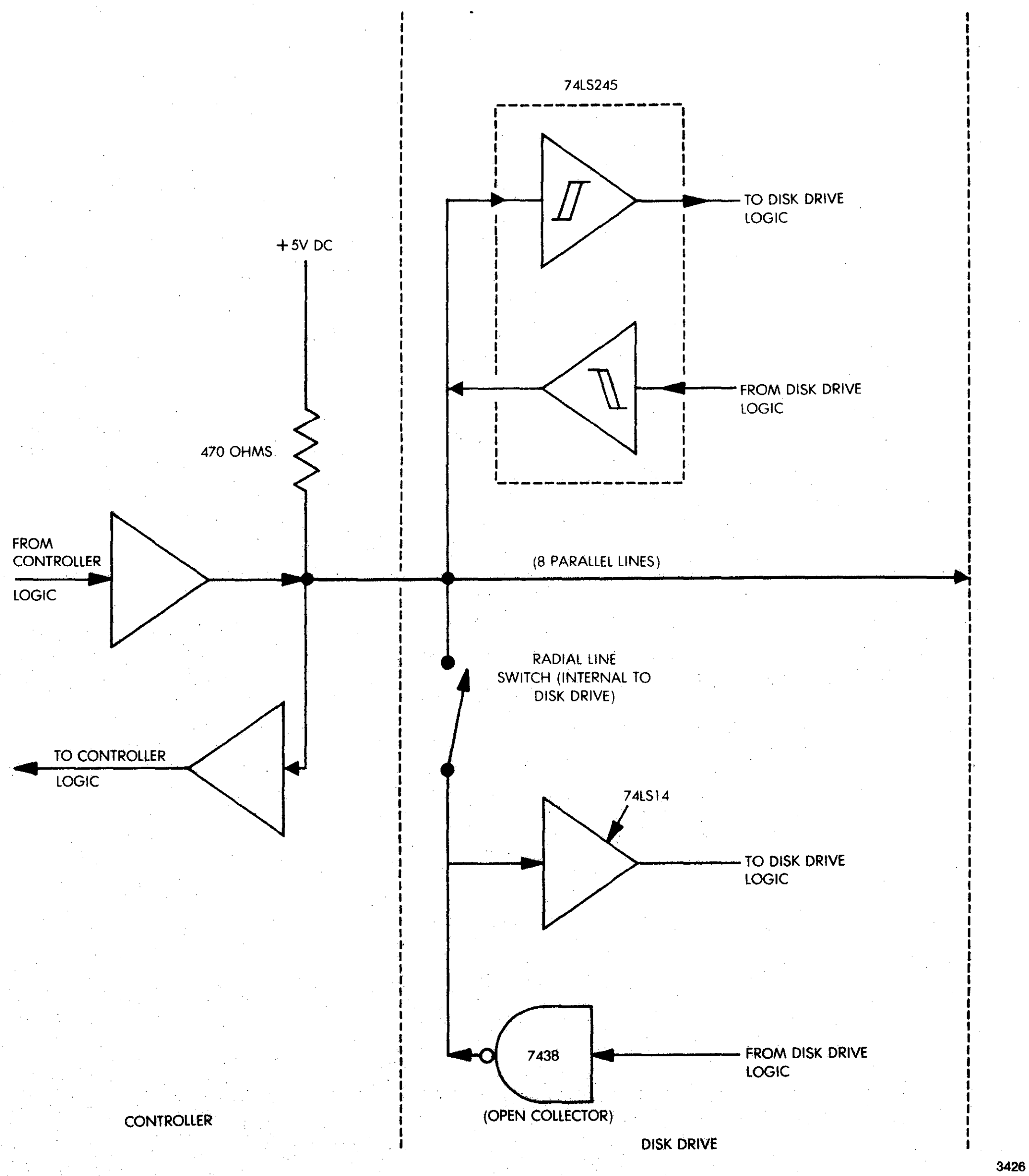

Figure 15-1. Cable Configuration for Bidirectional Control Bus Signals

15.2 SINGLE-ENDED LINES

The cable configuration of the single-ended lines is as shown in Figures 15-2 through 15-4.

15.2.1 Single-Ended Line Drivers (7438 or equivalent)

The drivers are open-collector outputs capable of sinking 40 milliamps at a low level. Low-level output voltage shall not exceed +0.4v dc as measured at the driver. The high-level leakage current shall not exceed 250 microamps.

15.2.2 SINGLE-ENDED LINE RECEIVERS (74LS14 or Equivalent)

The receivers accept TTL logic levels. For noise immunity, the receivers have an input hysteresis of 0.4v dc minimum, with a positive-going threshold voltage between 1.4 and 2v dc and a negative-going threshold voltage between 0.5 and 1.1v dc. Low-level input current is −1.2 milliamps or less. The high-level input current is 40 microamps (maximum).

15.2.3 SINGLE-ENDED LINE TERMINATION

All single-ended lines originating at the controller are terminated at the last disk drive with 330 ohms, ±5 percent, to ground, and 220 ohms, ±5 percent, to +5v dc. The termination is provided via a single in-line package (SIP) resistor network that is removable depending on the system configuration. All single-ended lines originating at the disk drive must be terminated in the same way at the controller.

15.2.4 PORT ENABLE TERMINATION

The Port Enable line is pulled up to +5v dc through a 10K ohm, ±5 percent, resistor in each disk drive. This will assure an inactive state whenever the disk drive is not connected.

15.3 DIFFERENTIAL LINES

The differential line drivers and receivers operate from a single +5v dc supply. The cable configuration of the differential lines is shown in Figures 15-5 and 15-6. An active signal is defined as the + LINE being equal to or more positive than the − LINE. An inactive signal is defined as the − LINE being more positive than the + LINE.

15.3.1 DIFFERENTIAL LINE DRIVERS (75113 or equivalent)

The differential line drivers are capable of sinking or sourcing a minimum of 20 milliamps in the ON state. In the OFF or high impedance state, leakage current does not exceed ±20 microamps.

15.3.2 DIFFERENTIAL LINE RECEIVERS (26LS32 or equivalent)

The common mode input range capability of the receivers are at least +7v dc to −7v dc. The differential input voltage is −0.2v dc (minimum) and +0.2v dc (maximum). The input hysteresis is 140 millivolts (minimum).

15.3.3 DIFFERENTIAL LINE TERMINATION

Each line of all pairs of differential lines is terminated with 100 ohms, ±10 percent, to ground at the controller and the last disk drive.

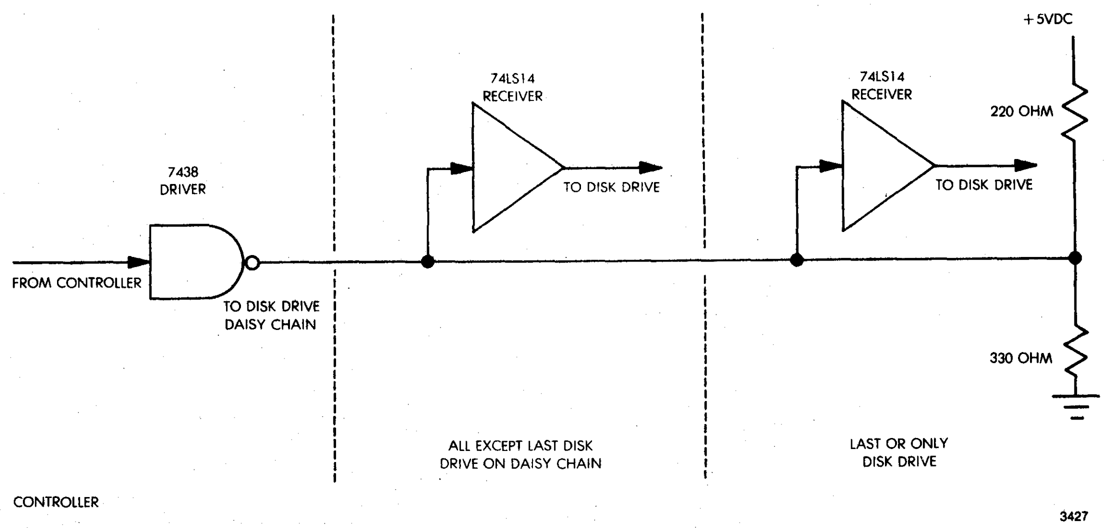

Figure 15-2. Cable Configuration for Unidirectional Single-Ended Lines from Controller (except Port Enable)

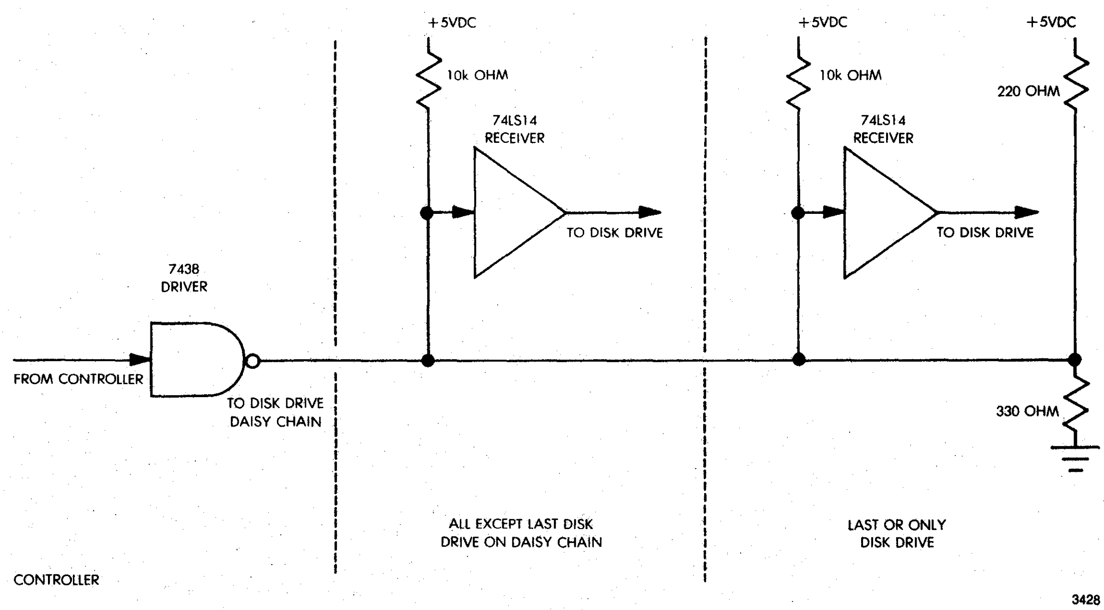

Figure 15-3. Cable Configuration for Port Enable

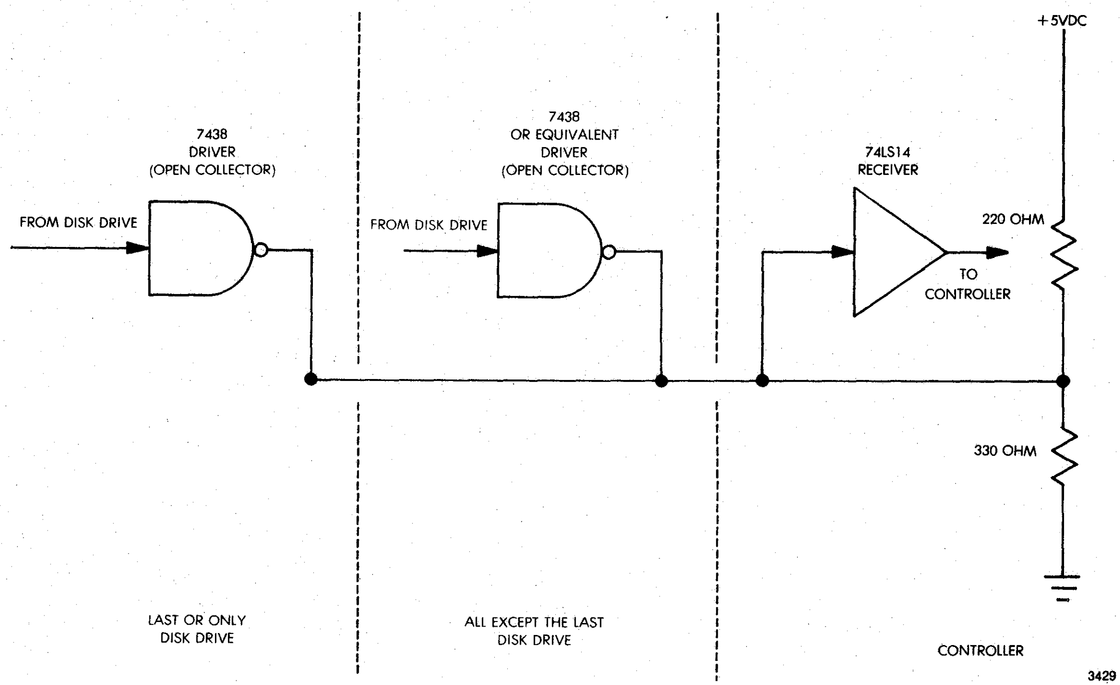

Figure 15-4. Cable Configurations for Unidirectional Single-Ended Lines from Disk Drive

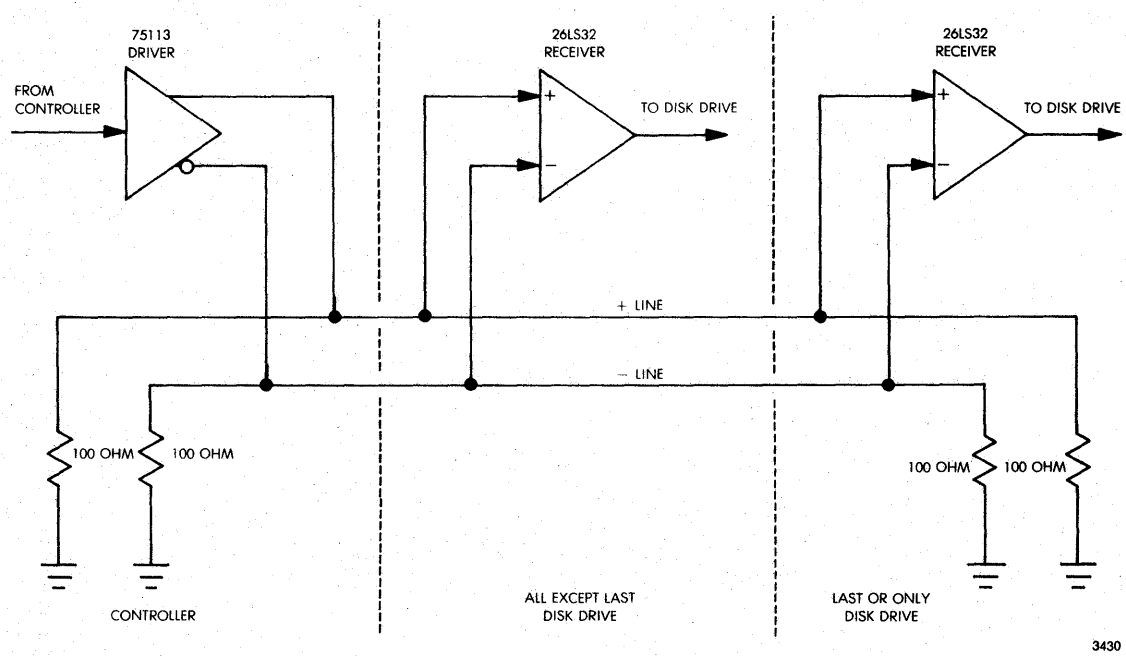

Figure 15-5. Cable Configuration for Differential Lines from Controller

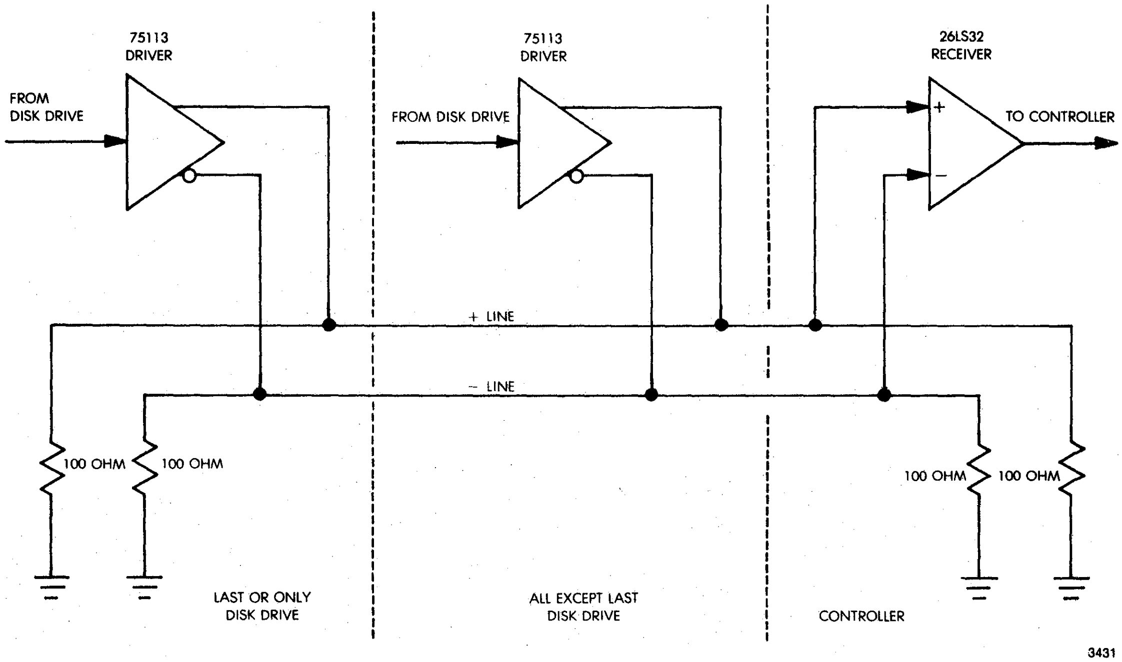

Figure 15-6. Cable Configuration for Differential Lines from Disk Drive

16.0 ELECTRICAL CHARACTERISTICS, CLASS B CONFIGURATION

Not implemented.

17.0 SIGNAL DEFINITIONS

The following paragraphs provide signal definitions, functional operations and/or status of the disk drive. Relative signal timing and tolerance is defined in Section 19.

NOTE

The timing diagrams in Section 5 take precedence over all other timing definitions.

17.1 CONTROL BUS

The Control Bus consists of 8 lines (ISAD0—ISAD7) that are used for bidirectional transfer of information. The direction of transfer is determined by the Bus Direction Out signal (IBUSDO).

Electrical characteristics of the Control Bus signals are defined in Paragraph 15.1. All Control Bus signals are identified by true (low) for active signals, and false (high) for inactive signals.

Throughout this interface specification, the controller is in control of the Control Bus lines. All communication between the controller and selected disk drive is determined by the controller.

The Control Bus lines are used in two modes. When Select-Out/Attention-In Strobe (ISOAIS) is true (low), the Control Bus is in Radial Mode; otherwise, the Control Bus is in the Daisy Chain Mode.

17.1.1 RADIAL MODE

Each disk drive shall be assigned a unit number (0—7) when radially attaching one of the Select/Attention Disk Drive lines as shown in Table 14-4.

17.1.1.1 Select-Out Mode

When both Bus Direction Out (IBUSDO) and Select-Out/Attention-In (ISOAIS) lines are true (low), each radial line transfers the selection information to the corresponding disk drive.

17.1.1.2 Attention-In Mode

When Bus Direction Out (IBUSDO) is false (high) and Select Out/Attention-In Strobe (ISOAIS) is true (low), each disk drive gates its internal attention condition onto its corresponding Control Bus line.

17.1.2 DAISY CHAIN MODE

When in the Daisy Chain Mode, all Control Bus transfers consist of a two-byte sequence. The transfer is asynchronous and controlled with a handshake protocol. The first byte is transferred using a handshake between the Command Request (ICOMRQ) signal and the Bus Acknowledge (IBUSAK) signal. The second byte is transferred using handshake between the Parameter Request (IPARQ) signal and the IBUSAK signal. Refer to Section 18.0 for the command definitions.

17.1.2.1 Command Out

When both the Bus Direction Out (IBUSDO) and Command Request (ICOMRQ) lines are true (low), the controller transfers a Command Byte to the selected disk drive.

When bit 6 in the Command Code (first byte) is a 1, the second byte is a Parameter-Out command (refer to Paragraph 17.1.2.2 and Table 18-1).

When bit 6 in the Command Code (first byte) is a 0, the second byte is a Parameter-In command (refer to Paragraph 17.1.2.3 and Table 18-2).

When the state of the Bus Direction-Out (IBUSDO) signal for the transfer of the parameter (second byte) does not comply with the definition of bit 6 of the Command Code, an error condition exists and the disk drive sets the attention condition and the Control Bus Error bit in the General Status Byte (refer to Paragraph 18.4.1.2).

It is a violation of protocol if the Bus Direction-Out (IBUSDO) is false (high) at the same time the Command Request (ICOMRQ) is true (low). The disk drive sets the attention condition and the Control Bus Error bit in the General Status Byte (refer to Paragraph 18.4.1.2).

17.1.2.2 Parameter Out

When both Bus Direction Out (IBUSDO) and Parameter Request (IPARQ) are true (low), the controller transfers a Parameter Byte to the selected disk drive (see Table 18-1).

17.1.2.3 Parameter In

When the Bus Direction-Out (IBUSDO) signal is false (high) and the Parameter Request (IPARQ) signal is true (low), the controller requests that a Parameter Byte (status) be transferred from the selected disk drive to the controller (see Table 18-2).

17.1.3 CONTROL BUS BITS 0—7, SELECT/ATTENTION DRIVE 0—7 (ISAD0—7)

The eight Control Bus Line signals are used for communication between the controller and the selected disk drive as defined in Paragraphs 17.1.1 and 17.1.2. Control Bus bit 0 is the least significant bit.

17.1.4 CONTROL BUS PARITY (IPAR) (OPTIONAL)

When the Control Bus is used in a Daisy Chain Mode, the bidirectional Control Bus Parity bit (IPAR) will be odd parity (odd number of 1s) of the eight Control Bus bits and the Control Bus Parity bit.

When the Control Bus is used in the Radial Mode, the Control Bus Parity signal is not used.

The user may select the Parity option via a switch on the Logic Control PCBA on the disk drive.

17.2 CONTROL INTERFACE

This group of signals is unidirectional in nature. The electrical characteristics of the control interface lines are defined in Paragraph 15.2. All control interface signals are true (low) for active signals and false (high) for inactive signals.

17.2.1 PORT ENABLE (IPRTEN)

This signal is normally held true (low) by the controller. When IPRTEN is true (low), all disk drives attached to the interface respond to the interface protocol as follows.

IPRTEN going false (high) returns all disk drives to the Initial State (spin down). If the interface cable is disconnected, the disk drive is returned to the Initial State by the true-to-false (low-to-high) transition on this line.

When IPRTEN changes from true (low) to false (high), all disk drives are deselected within 1 microsecond. The disk drive remains deselected while Port Enable is high.

Upon detecting IPRTEN going false, each disk drive goes to its Initial State defined as follows. After IPRTEN changes from false to true (high to low) and after the Initial State is reached, the disk drive sets the attention condition.

Initial State is the state each disk drive reaches after being powered up and IPRTEN is true (low). The conditions are:

(1) The disk drive is deselected.

(2) The disk drive responds to the Select Out/Attention-In Strobe (ISOAIS) signal.

(3) All parameters of commands with Parameters Out (Table 18-1) are 0.

(4) The Device Attribute Table shall be set to its initial value.

(5) All resettable error conditions are reset. If the cause of the error still exists, the error condition is set again.

(6) The Initial State bit in Sense Byte 2 is set.

(7) The spindle's initial condition is determined by user-selected spin-up optional switch setting. This switch is mounted on the Logic Control PCBA of the disk drive.

17.2.2 BUS DIRECTION OUT (IBUSDO)

The IBUSDO signal is transferred from the controller to all attached disk drives. IBUSDO controls the direction of transfer on the Control Bus lines. When the IBUSDO signal is true (low), it indicates a transfer from the controller to the disk drive.

17.2.3 SELECT OUT/ATTENTION-IN STROBE (ISOAIS)

The ISOAIS signal is transferred from the controller to all attached disk drives. ISOAIS has two different functions depending on the true/false state of IBUSDO.

When IBUSDO is true (low), the signal becomes the Select-Out Strobe. When IBUSDO is high (false), the signal becomes the Attention-In Strobe.

17.2.3.1 Select-Out Strobe

Only one disk drive must be selected at any one time. When the IBUSDO signal is true (low), the true (low)-going edge of the ISOAIS signal is used for selecting/deselecting the disk drive.

When any Control Bus signal is true (low) and ISOAIS transitions to true (low), the disk drive connected to that specific Control Bus line becomes selected.

When any Control Bus signal is false (high) and ISOAIS transitions to true (low), the disk drive connected to that specific Control Bus line becomes deselected.

When all Control Bus signals are false (high) and the ISOAIS transistions to true (low), all attached disk drives become deselected. Note that only one Control Bus line must be true (low) during the selection process.

17.2.3.2 Attention-In Strobe

When the IBUSDO signal is false (high), ISOAIS gates the disk drive's attention condition (refer to Paragraph 17.2.8) onto the corresponding Control Bus line connected to that disk drive.

17.2.4 COMMAND REQUEST (ICOMRQ)

ICOMRQ initiates the handshake control from the controller to the selected disk drive. The true (low) state of this signal signifies the transfer of the first byte of each two-byte transfer. Until the receipt of Bus Acknowledge (IBUSAK), ICOMRQ must remain true (low).

17.2.5 PARAMETER REQUEST (IPARQ)

IPARQ is a handshake control line from the controller to the selected disk drive. The true (low) state of this signal for a Parameter Out command indicates that the output parameter byte is valid on the Control Bus. The true (low) state of this signal for a Parameter In command requests the selected disk drive to place the parameter byte on the Control Bus lines. Until the receipt of Bus Acknowledge (IBUSAK) signal, IPARQ must remain true (low).

17.2.6 BUS ACKNOWLEDGE (IBUSAK)

IBUSAK is returned from the selected disk drive to the controller and has two functions.

When the Control Bus lines are used in the Radial Mode (Select Out/Attention-In Strobe [ISOAIS] true), the selected disk drive makes IBUSAK true (low) to acknowledge its selection.

When the Control Bus lines are used in the Daisy Chain Mode, IBUSAK performs the asynchronous handshake with the Command Request signal (ICOMRQ) or the Parameter Request (IPARQ) signal.

17.2.7 BUSY (IBUSY)

IBUSY is held true (low) by the selected disk drive when the selected disk drive is unable to accept additional commands. The IBUSY signal changes to the true (low) state before the true (low)-going edge of IBUSAK of a time-dependent command (refer to Paragraph 18.0) that causes the disk drive to become busy. The busy condition occurs during power up and down sequencing, seeking operations, or execution of a diagnostic. The IBUSY signal is not true (low) if the disk drive can accept commands.

The busy-to-not-busy transition within the disk drive sets the attention condition (refer to Paragraph 17.2.8).

If the ICOMRQ signal is true (low) when the IBUSY signal is true (low), the disk drive will not respond with IBUSAK before the sequence is completed and IBUSY goes false (high). The IBUSY Interface Signal is different from the Busy Executing Status bit (refer to Paragraph 18.4.1.7).

17.2.8 ATTENTION (IATTN)

This signal is a party line signal from all disk drives to the controller, independent of the selection of a disk drive.

The IATTN signal is made true (low) by the disk drive, if the disk drive's internal attention condition is set to a 1, and if the attention circuitry is enabled (refer to Paragraph 18.1.1.1, Attention Control).

The attention condition is set if the disk drive requires service from the controller. The detailed situations that set the attention condition are defined in Paragraph 18.0.

The attention condition of the selected disk drive can only be reset by the Clear Attention command or the Clear Fault command. Issuing the Clear Fault command resets only those error status bits and the resulting attention condition if the error condition can be reset. A Clear Attention command resets the attention condition independent of error conditions.

17.2.9 INDEX (IINDEX)

The IINDEX signal from the disk drive indicates to the controller that a reference point or index area is passing under the heads of the selected drive. One IINDEX pulse is generated by the selected disk drive per revolution of the recording media. Whenever the disk drive is ready, a valid IINDEX signal is transferred from the selected disk drive to the controller.

17.2.10 SECTOR PULSE/ADDRESS MARK DETECTED (ISP/ADMD)

The ISP/ADMD signal establishes rotational reference points on the recording media's surface. Two sectoring methods may be used for subdividing the data to be stored on the disk and, as a result, this line serves a dual function. In the event that the user has selected Hard Sectoring, the ISP/IADMD signal represents the division of each track into sectors. Each track is divided into sectors with the initial sector (0) starting coincident with the Index (IINDEX) Pulse. All subsequent sectors start coincident with the false-to-true (high-to-low) transition of ISP/ADMD. When IINDEX is true (low), the sector pulse is omitted.

If the disk drive has been configured for soft-sectored operation, the ISP/ADMD signal indicates the disk drive's detection of a previously recorded address mark when Read Gate (IRDGT) and Address Mark Control (IADMC) are both true (low). Only one false-to-true (high-to-low) transition of IADMD is made for each assertion by the controller of an Address Mark Control signal when IRDGT is true (low).

Whenever the disk drive is ready, an ISP/ADMD signal can be transferred from the selected disk drive to the controller.

17.2.11 READ GATE (IRDGT)

The IRDGT signal is transferred from the controller to the selected disk drive. IRDGT enables and synchronizes the read circuitry to transfer the serialized data on the Read Data lines (IRDATP and IRDATM) decoded from the recording medium. When an address mark method is used, IRDGT and IADMC enable the disk drive to search for a previously recorded address mark. It is recommended that the IRDGT signal be active, once asserted, until the controller detects a valid sync byte or is assured that synchronization is accomplished.

17.2.12 WRITE GATE (IWRGT)

The IWRGT signal is transferred from the controller to the selected disk drive. IWRGT enables the write circuitry in the disk drive to transfer the serialized information on the Write Data lines through an encoder to the recording medium. The disk drive records an address mark on the medium when IWRGT and IADMC are true (low). Note that a write operation cannot take place unless a write enable condition has been established by a previous Write Control command.

17.2.13 ADDRESS MARK CONTROL (IADMC)

The IADMC signal is transferred from the controller to the selected disk drive. IADMC is used in conjunction with IRDGT and IWRGT for detecting or writing an address mark on the recording medium.

The controller must maintain the IADMC signal false if the Address Mark option is not used. Termination will be provided at the last disk drive attached.

17.3 READ/WRITE SIGNALS

The following subparagraphs describe the signals used when transferring data to and from the controller. These signals are valid only if a disk drive is selected. All read/write signals are driven differentially (refer to Paragraph 15.3). All data exchanged between the controller and the disk drive is Non-Return-to-Zero (NRZ).

17.3.1 READ DATA + (IRDATP) AND READ DATA – (IRDATM) LINES

When Read Gate (IRDGT) is true, the Read Data lines (IRDATP and IRDATM) transfer the serial NRZ read data from the selected disk drive to the controller. These data are synchronized with Read Clock. The Read Data signal will be static when Read Gate is false.

17.3.2 READ/REFERENCE CLOCK + (IRCKP) AND READ/REFERENCE CLOCK – (IRCKM) LINES

The Read/Reference Clock signals are transferred from the selected disk drive to the controller. These signals transfer Read Clock only when IRDGT is true (low). Read Clock is synchronous with the serial NRZ read data. These lines transfer Reference Clock signals at all other times.

17.3.3 WRITE DATA + (IWADTP) AND WRITE DATA – (IWDATM) LINES

When Write Gate (IWRGT) is true (low), the Write Data lines (IWDATP and IWDATM) transfer the serial NRZ write data from the controller to the selected disk drive for encoding and subsequent recording. The serial write data are synchronized with the Write Clock. The Write Data signals are held static at all times except when IWRGT is true (low).

17.3.4 WRITE CLOCK + (IWCKP) AND WRITE CLOCK – (IWCKM) LINES

The Write Clock is used by the selected disk drive to properly phase the Write Data lines during the encoding and subsequent recording. Write Clock shall be generated by the controller by returning the Reference Clock signal (refer to Paragraph 17.3.2) back to the selected disk drive at the same frequency with constant phase shift. This signal must be held static at all times except when used to precede the false- to true-going edge of Write Gate by at least one bit cell but not more than sixteen bit cells and when Write Gate is true (low).

18.0 COMMAND STRUCTURE

All command, status, and parameter information passed between the selected disk drive and the controller is transferred via the Control Bus lines and conforms to the command protocol defined in the following subparagraphs.

The command protocol requires that each command sequence consists of two byte transfers. The first byte, the Command byte, is always transferred from the controller to the selected disk drive. The second byte, the Parameter byte, may be transferred from the controller to the selected disk drive or from the selected disk drive to the controller. The direction of the transfer of the Parameter byte is determined by the state of the Bus Direction-Out (IBUSDO) signal.

The Command byte indicates the particular function that the selected disk drive is requested to perform and also conditions the disk drive as to the direction of the transfer of the Parameter byte portion of the command sequence.

The Parameter byte completes the command sequence by providing the parameter or status information demanded by the Command byte. In cases where the Command byte is sufficient to indicate the complete nature of the command, the General Status byte is transferred as a Parameter byte to complete the command sequence.

The Command sequence is divided into two groups: one which requires the Parameter byte transferred to the disk drive (Parameter Out as listed in Table 18-1), and one which requires the Parameter byte transferred to the controller (Parameter In as listed in Table 18-2).

There are two kinds of commands: Immediate commands and Time-Dependent commands.

For Immediate commands, the true (low)-going edge of the second Bus Acknowledge (IBUSAK) is not generated until the required function has been performed. In the case that the function is not performed, the Attention Condition is set prior to the true (low)-going edge of the IBUSAK signal that is returned as a response to Parameter Request (IPARQ).

For Time-Dependent commands, the Attention Condition is set when the Time-Dependent command function is completed. The resetting of the Attention Condition by the Immediate command, Clear Fault or Clear Attention, completes the Time-Dependent command.

All commands, once in progress, proceed to completion using parameters established prior to the issuance of the command. While a command is in progress, another command is not accepted.

While all commands are defined individually, there are logical groups of commands that represent functional operations, for example, the loading of parameter information (cylinder address) and the execution of a particular operation (seek). Unusual command sequences within such groups may result in violations of an implied protocol.

Note that some protocol violations can cause loss of data or a functional error, with or without an error indication.

18.1 COMMANDS WITH PARAMETER OUT

All commands defined in Paragraphs 18.1.1.1—18.2.2.4 require a Parameter byte to be transferred to the disk drive. These commands are summarized in Table 18-1.

Table 18-1
Commands With Parameter Out

Function	Command Code[1,2]	Parameter
Attention Control	40 Hex	Bit 7 0 = Enable Attention 1 = Disable Attention
Write Control	41 Hex	Bit 7 1 = Write Enable 0 = Write Disable
Set Upper Cylinder Address	42 Hex	MSB of Cylinder Address
Set Lower Cylinder Address	43 Hex	LSB of Cylinder Address
Select Moving Head	44 Hex	Head Number
Select Moving Head[3]	45 Hex	Head Number
Load Attribute Number	50 Hex	Address Byte
Load Device Attribute	51 Hex	Information Byte
Read Control	53 Hex	Bits 7,6 0X = Nominal Strobe 10 = Strobe Early 11 = Strobe Late
Offset Control[3]	54 Hex	Bits 7,6 0X = No Offset 10 = Offset Forward 11 = Offset Reverse
Spin Control[3]	55 Hex	Bit 7 1 = Spin Up 0 = Spin Down
Load Bytes Per Sector High	56 Hex	MSB of Bytes Per Sector
Load Bytes Per Sector Medium	57 Hex	MedSB of Bytes Per Sector
Load Bytes Per Sector Low	58 Hex	LSB of Bytes Per Sector
Load Sector Pulses Per Track High	59 Hex	MSB of Sector Pulses Per Track
Load Sector Pulses Per Track Medium	5A Hex	MedSB of Sector Pulses Per Track
Load Sector Pulses Per Track Low	5B Hex	LSB of Sector Pulses Per Track
Load Read Permit High	6B Hex	MSB of Cylinder Address
Load Read Permit Low	6C Hex	LSB of Cylinder Address Read Enabled only on cylinder equal to or greater than the above
Load Write Permit High	6D Hex	MSB of Cylinder Address
Load Write Permit Low	6E Hex	LSB of Cylinder Address Write Enabled only on cylinder equal to or greater than the above
Load Test Byte	6F Hex	Test Byte

NOTES:
1. Commands with codes 40 Hex through 45 Hex are mandatory commands. Commands with codes 50 Hex to 6F Hex are optional and implemented with exception of 52 Hex (Select Fixed Head).
2. The code range of 70—7F Hex (not shown) is reserved for unique applications. All unused bits in parameter bytes must be 0.
3. Time dependent commands that generate an Attention Condition upon completion.

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Table 18-2
Commands With Parameter In

Function	Command Code[1,2]	Parameter
Report Illegal Command	00 Hex	General Status
Clear Fault	01 Hex	General Status
Clear Attention	02 Hex	General Status
Seek[3]	03 Hex	General Status
Rezero[3]	04 Hex	General Status
Report Sense Byte 2[4]	0D Hex	Sense Byte 2
Report Sense Byte 1[4]	0E Hex	Sense Byte 1
Report General Status[4]	0F Hex	General Status
Report Device Attribute	10 Hex	Device Attribute Byte
Set Attention[3]	11 Hex	General Status
Selective Reset[3]	14 Hex	General Status
Partition Track[3]	16 Hex	General Status
Report Cylinder High	29 Hex	MSB of Cylinder Address
Report Cylinder Low	2A Hex	LSB of Cylinder Address
Report Read Permit High	2B Hex	MSB of Cylinder Address
Report Read Permit Low	2C Hex	LSB of Cylinder Address
Report Write Permit High	2D Hex	MSB of Cylinder Address
Report Write Permit Low	2E Hex	LSB of Cylinder Address
Report Test Byte	2F Hex	Echo byte

NOTES:
1. Commands with codes 00 Hex through 0F Hex are mandatory commands. Commands with codes 10 Hex to 2F Hex are optional and those listed, implemented.
2. Code range of 30—3F Hex (not shown) is reserved for unique applications. All unused bits in parameter bytes must be 0.
3. Time dependent command that sets an Attention Condition upon completion.
4. This byte can set an Attention Condition without a preceding command.

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18.1.1 MANDATORY COMMANDS

18.1.1.1 Attention Control (Command Code 40 HEX)

This command conditions the selected disk drive to enable or disable its attention circuitry based on the value of the Parameter Byte as follows.

	MSB							LSB
Bit Number	7	6	5	4	3	2	1	0
Value		0	0	0	0	0	0	0

0 = Enable Attention
1 = Disable Attention

This command allows the controller to selectively ignore attention requests from any disk drive on the interface. This might be done in response to a disk drive that generates spurious attention requests due to a malfunction.

The Enable Attention command causes the selected disk drive to gate its internal Attention Condition onto the party line (wired OR) Attention (IATTN) signal. The Disable Attention command causes the selected disk drive to disable the gating of the internal Attention Condition onto the party line IATTN signal. This command has no impact on the function of the radial status returned with the Attention-In Strobe signal (refer to Paragraph 17.2.3.2).

The disk drive is initialized with the Attention Condition circuitry enabled.

18.1.1.2 Write Control (Command Code 41 Hex)

This command conditions the selected disk drive to enable or disable its write circuitry, based on the value of the Parameter byte as follows.

	MSB							LSB
Bit Number	7	6	5	4	3	2	1	0
Value		0	0	0	0	0	0	0

1 = Write Enable
0 = Write Disable

This command is also used in conjunction with the Write Gate signal and therefore enables the selected disk drive's write circuitry while the Write Gate signal activates the circuitry at the proper time. A true Write Gate signal, while the disk drive's write circuitry is disabled, results in no data being recorded, and activates the Attention condition (IATTN).

The disk drive is initialized with the write circuitry disabled.

A Write Control command executed during a write operation is a violation of protocol.

18.1.1.3 Set Upper Cylinder Address (Command Code 42 Hex)

This command conditions the selected disk drive to accept the Parameter byte as the most significant byte of a cylinder address.

The command is also used in conjunction with the Seek command (refer to Paragraph 18.2.1.4) and is a means of supplying the most significant byte of a target cylinder address.

This command will not cause any head motion. Loading an illegal cylinder address outside the range of a disk drive will not cause an error unless a subsequent Seek command is issued to that illegal cylinder.

The disk drive is initialized with the cylinder address equal to 0.

18.1.1.4 Set Lower Cylinder Address (Command Code 43 Hex)

This command conditions the selected disk drive to accept the Parameter byte as the least significant byte of a cylinder address.

The command is also used in conjunction with the Seek command (refer to Paragraph 18.2.1.4) and is a means of supplying the least significant byte of a target cylinder address.

This command will not cause any head motion. Loading an illegal cylinder address outside the range of a disk drive will not cause an error unless a subsequent Seek command is issued to that illegal cylinder.

The disk drive is initialized with the target cylinder address equal to 0.

18.1.1.5 Select Moving Head

There are two Select Moving Head commands; one is time dependent, the other is immediate (not time dependent).

This command conditions the selected disk drive to accept the Parameter byte as the binary address of the head selected for read or write operations.

A Select Moving Head command issued during a read or write operation is a violation of protocol. The disk drive sets the Attention Condition and the Illegal Parameter bit in the General Status byte upon receipt of a head address outside the head address range of the disk drive.

The disk drive is initialized with moving head zero selected.

18.1.1.5.1 *Select Moving Head (Command Code 44 Hex) (Immediate)*

This command is used when the time to select a moving head is less than the normal command cycle of the interface.

18.1.1.5.2 *Select Moving Head (Command Code 45 Hex) (Time Dependent)*

This command is used when the time to select a moving head is longer than the normal command cycle of the interface. The command is, in effect, a Seek command and as such, shall set the Attention Condition upon the completion of the Select Moving Head operation.

The Select Moving Head command is a time dependent command and sets the Busy Executing bit in the General Status Byte (refer to Paragraph 18.4.1.7) while command execution is in progress. Also, the Busy signal at the interface is activated (refer to Paragraph 17.2.7).

18.1.1.6 Reserved Mandatory Commands

(N/A)

18.1.2 OPTIONAL COMMANDS

If an optional command, which is not implemented, is issued to the disk drive, the disk drive sets the Attention Condition and the Illegal Command bit in the General Status byte.

18.1.2.1 Load Attribute Number (Command Code 50 Hex)

This command conditions the selected disk drive to accept the Parameter byte as the hex number of a disk drive attribute as defined in Table 18-3. This command prepares the disk drive for a subsequent Report Disk Drive Attribute command or Load Disk Drive Attribute command. This command may be issued at any time.

Table 18-3
Disk Drive Attributes

Attribute	Number[1]	Parameter[2]
User ID	00 Hex	User Defined
Model ID High	01 Hex	MSB of model used
Model ID Low	02 Hex	LSB of model used
Revision ID	03 Hex	Firmware Revision
Disk Drive Type ID	0D Hex	01 Hex
Table Modification	0E Hex	Action Dependent
Table ID[3]	0F Hex	01 Hex
Bytes per Track High	10 Hex	MSB of number of Bytes
Bytes per Track Medium	11 Hex	MedSB of number of Bytes
Bytes per Track Low	12 Hex	LSB of number of Bytes
Bytes per Sector High	13 Hex	MSB of number of Bytes
Bytes per Sector Medium	14 Hex	MedSB of number of Bytes
Bytes per Sector Low	15 Hex	LSB of number of Bytes
Sector Pulses per Track High	16 Hex	MSB of number of Sector Pulses
Sector Pulses per Track Medium	17 Hex	MedSB of number Sector Pulses
Sector Pulses per Track Low	18 Hex	LSB of number of Sector Pulses
Sectoring Method	19 Hex	Sectoring Method
Number of Cylinder High	20 Hex	MSB of number of cylinders
Number of Cylinder Low	21 Hex	LSB of number of cylinders
Number of Moving Heads	22 Hex	Number of heads
Head Select Mode	24 Hex	Selection Mode
Encoding Method number 1	30 Hex	Encoding Method
Preamble number 1 Length	31 Hex	Number of Bytes
Preamble number 1 Pattern	32 Hex	Preamble Pattern
Sync number 1 Pattern	33 Hex	Sync Pattern
Postamble number 1 Length	34 Hex	Number of Bytes
Postamble number 1 Pattern	35 Hex	Postamble Pattern
Gap number 1 Length	36 Hex	Number of Bytes
Gap number 1 Pattern	37 Hex	Gap Pattern
Encoding Method number 2	40 Hex	Encoding Method
Preamble number 2 Length	41 Hex	Number of Bytes
Preamble number 2 Pattern	42 Hex	Preamble Pattern
Sync number 2 Pattern	43 Hex	Sync Pattern
Postamble number 2 Length	44 Hex	Number of Bytes
Postamble number 2 Pattern	45 Hex	Postamble Pattern
Gap number 2 Length	46 Hex	Number of Bytes
Gap number 2 Pattern	47 Hex	Gap Pattern

NOTES:
1. All unused numbers are reserved for future use.
2. All unused bits in parameters are set to 0.
3. See Paragraph 4.3.8 for validity of this byte.

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18.1.2.2 Load Disk Drive Attribute (Command Code 51 Hex)

This command conditions the selected disk drive to accept the Parameter byte as the new value of a disk drive attribute. The number of the disk drive attribute must have been previously defined by the Load Attribute Number command (refer to Paragraph 18.1.2.1).

18.1.2.3 Select Fixed Head

(N/A)

18.1.2.4 Read Control

This command conditions the selected disk drive to modify its read timing. The modification of the timing is defined by the value of the Parameter byte as follows.

	MSB							LSB
Bit Number	7	6	5	4	3	2	1	0
Value			0	0	0	0	0	0

0 X = Nominal Strobe
1 0 = Strobe Early
1 1 = Strobe Late
X = Don't Care

When set, the read control remains in the 1 logic state. It returns to the Nominal Strobe state by a new Read Control command, Rezero Command or Initial State.

The disk drive is initialized with Nominal Strobe timing.

18.1.2.5 Offset Control (Command Code 54 Hex)

This command conditions the selected disk drive to modify the position of the moving heads. The offset modification is defined by the value of the Parameter byte as follows.

	MSB							LSB
Bit Number	7	6	5	4	3	2	1	0
Value			0	0	0	0	0	0

0 X = No Offset
1 0 = Offset Forward
1 1 = Offset Reverse
X = Don't Care

The Offset Control is reset to the No Offset position by every Seek command (refer to Paragraph 18.2.1.4) and Rezero command or when the disk drive reaches its initial state. Furthermore, the setting of any offset has the effect of disabling the write circuitry and any Write Control command attempted sets the Attention Condition and the Command Reject bit in Sense byte 1 (refer to Table 18-5).

The Offset Control command is, in effect, a Seek command and sets the Attention Condition upon the completion of the offset operation.

The Offset Control command is a time dependent command and as such sets the Busy Executing bit in the General Status byte (refer to Paragraph 18.4.1.7) while command execution is in process. Also, the disk drive activates the Busy signal at the interface (refer to Paragraph 17.2.7).

The device disk drive is initialized with no offset.

18.1.2.6 Spin Control (Command Code 55 Hex)

This command conditions the selected disk drive to enter a spin-up or spin-down cycle, based on the value of the Parameter byte as follows.

	MSB							LSB
Bit Number	7	6	5	4	3	2	1	0
Value		0	0	0	0	0	0	0

1 = Spin Up
0 = Spin Down

A spin-up cycle consists of starting the rotation of the spindle. A spin-down cycle consists of stopping the rotation of the spindle.

Upon completion of a spin cycle, the disk drive sets the Attention Condition. Issuing a spin-up command to the disk drive whose spindle is already at full speed or issuing a spin-down command to the disk drive whose spindle has already stopped also sets the Attention Condition. The disk drive is initialized dependent on an option select switch on the Logic Control PCBA.

The Spin Control command is a time dependent command and, as such, sets the Busy Executing bit in the General Status byte (refer to Paragraph 18.4.1.7) while command execution is in process. Also, the disk drive activates the Busy signal at the interface (refer to Paragraph 17.2.7).

18.1.2.7 Load Bytes per Sector, High (Command Code 56 Hex)

This command conditions the selected disk drive to accept the Parameter byte as the most significant byte of a 24-bit number. This represents the total number of bytes that occur between active-going edges of sector pulses, and between the active-going edge of the Index pulse and the active-going edge of the first Sector pulse when a Partition Track command (refer to Paragraph 18.2.2.6) is executed.

This command, used in conjunction with the Partition Track command, is a means of supplying the most significant byte of the Bytes Per Sector value.

Upon completion of the execution of the Partition Track command, the contents of this byte are set into the Bytes Per Sector High Attribute (13 Hex) (refer to Table 18-3 and Paragraph 18.3.12).

This command functions in conjunction with the Load Bytes Per Sector Medium and Low Commands (refer to Paragraphs 18.1.2.8 and 18.1.2.9) and operates in the same way.

18.1.2.8 Load Bytes per Sector, Medium (Command Code 57 Hex)

This command conditions the selected disk drive to accept the Parameter byte as the medium significant byte of a 24-bit number. This represents the total number of bytes that occur between active-going edges of sector pulses, and between the active-going edge of the Index pulse and the active-going edge of the first Sector pulse when a Partition Track command (refer to Paragraph 18.2.2.6) is executed.

This command, used in conjunction with the Partition Track command, is a means of supplying the medium significant byte of the Bytes Per Sector value.

Upon completion of the execution of the Partition Track command, the contents of this byte are set into the Bytes Per Sector Medium Attribute (14 Hex) (refer to Table 18-3 and Paragraph 18.3.13).

This command functions in conjunction with the Load Bytes Per Sector High and Low Commands (refer to Paragraphs 18.1.2.7 and 18.1.2.9) and operates in the same way.

18.1.2.9 Load Bytes per Sector, Low (Command Code 58 Hex)

This command conditions the selected disk drive to accept the Parameter byte as the least significant byte of a 24-bit number. This represents the total number of bytes that occur between active-going edges of sector pulses, and between the active-going edge of the Index pulse and the active-going edge of the first Sector pulse when a Partition Track command (refer to Paragraph 18.2.2.6) is executed.

This command, used in conjunction with the Partition Track command, is a means of supplying the least significant byte of the Bytes Per Sector value.

Upon completion of the execution of the Partition Track command, the contents of this byte are set into the Bytes Per Sector Low Attribute (15 Hex) (refer to Table 4-3 and Paragraph 18.3.14).

This command functions in conjunction with the Load Bytes Per Sector High and Medium commands (refer to Paragraphs 18.1.2.7 and 18.1.2.8) and operates in the same way.

18.1.2.10 Load Sector Pulses per Track, High (Command Code 59 Hex)

This command conditions the selected disk drive to accept the Parameter byte as the most significant byte of a 24-bit number. This represents the total number that controls the number of sector pulses between (but excluding) Index pulses generated by disk drives selected for hard-sectored operation when a Partition Track command (refer to Paragraph 18.2.2.6) is executed.

This command, used in conjunction with the Partition Track command, is a means of supplying the most significant byte of the Sector Pulses Per Track value.

Upon completion of the execution of the Partition Track command, the contents of this byte are set into the Sector Pulses Per Track High Attribute (16 Hex) (refer to Table 18-3 and Paragraph 18.3.15).

This command functions in conjunction with the Load Sectors Per Track Medium and Low commands (refer to Paragraphs 18.1.2.11 and 18.1.2.12) and operates in the same way.

18.1.2.11 Load Sector Pulses per Track, Medium (Command Code 5A Hex)

This command conditions the selected disk drive to accept the Parameter byte as the medium significant byte of a 24-bit number. This represents the total number that controls the number of sector pulses between (but excluding) Index pulses generated by disk drives selected for hard-sectored operation when a Partition Track command (refer to Paragraph 18.2.2.6) is executed.

This command, used in conjunction with the Partition Track, command is a means of supplying the medium significant byte of the Sector Pulses Per Track value.

Upon completion of the execution of the Partition Track command, the contents of this byte are set into the Sector Pulses Per Track Medium Attribute (17 Hex) (refer to Table 18-3 and Paragraph 18.3.16).

This command functions in conjunction with the Load Sectors Per Track High and Low commands (refer to Paragraphs 18.1.2.10 and 18.1.2.12) and operates in the same way.

18.1.2.12 Load Sector Pulses per Track, Low (Command Code 5B Hex)

This command conditions the selected disk drive to accept the Parameter byte as the least significant byte of a 24-bit number. This represents the total number that controls the number of sector pulses between (but excluding) Index pulses generated by disk drives selected for hard-sectored operation when a Partition Track command (refer to Paragraph 18.2.2.6) is executed.

This command, used in conjunction with the Partition Track command, is a means of supplying the least significant byte of the Sector Pulses Per Track value.

Upon completion of the execution of the Partition Track command, the contents of this byte are set into the Sector Pulses Per Track Low Attribute (18 Hex) (refer to Table 18-3 and Paragraph 18.3.17).

This command functions in conjunction with the Load Sectors Per Track High and Medium commands (refer to Paragraphs 18.1.2.10 and 18.1.2.11) and operates in the same way.

18.1.2.13 Load Read Permit, High (Command Code 6B Hex)

This command conditions the selected disk drive to accept the Parameter byte as the most significant byte of a 16-bit cylinder address defining a programmable read permit area on the disk drive.

The disk drive will allow read operations to occur only on cylinders with an address equal to or greater than the cylinder address programmed in the disk drive via this command.

Issuing this command while Read Gate is active is a violation of protocol.

The disk drive will be initialized with Read Permit, High to zero.

18.1.2.14 Load Read Permit, Low (Command Code 6C Hex)

This command conditions the selected disk drive to accept the Parameter byte as the least significant byte of a 16-bit cylinder address defining a programmable read permit area on the disk drive.

This command also functions in conjunction with the Load Read Permit High command (refer to Paragraph 18.1.2.13) and operates in the same way.

The disk drive will be initialized with Read Permit, Low to zero.

18.1.2.15 Load Write Permit, High (Command Code 6D Hex)

This command conditions the selected disk drive to accept the Parameter byte as the most significant byte of a 16-bit cylinder address defining a programmable write permit area on the disk drive.

The disk drive will allow write operations to occur only on cylinders with an address equal to or greater than the cylinder address programmed in the disk drive via this command.

Issuing this command while Write Gate is active is a violation of protocol.

The disk drive will be initialized with Write Permit, High to zero.

18.1.2.16 Load Write Permit, Low (Command Code 6E Hex)

This command conditions the selected disk drive to accept the Parameter byte as the least significant byte of a 16-bit cylinder address defining a programmable write permit area on the disk drive.

This command functions in conjunction with the Set Write Permit, High command (refer to Paragraph 18.1.2.15) and operates in the same way.

The disk drive will be initialized with Write Permit, Low to zero.

18.1.2.17 Load Test Byte (Command Code 6F Hex)

This command conditions the selected disk drive to accept the Parameter byte as a special test byte that is returned to the controller as part of the Report Test Byte command (refer to Paragraph 18.2.2.13).

This pair of commands allows the controller to test the integrity of data transfer over the Control Bus.

18.1.2.18 Reserved Optional Commands

(N/A)

18.1.2.19 Vendor Unique Commands

(N/A)

18.2 COMMANDS WITH PARAMETER IN

The commands defined in this paragraph (including all subparagraphs) require a Parameter byte to be transferred to the controller. These commands are summarized in Table 18-2.

18.2.1 MANDATORY COMMANDS

18.2.1.1 Report Illegal Command (Command Code 00 Hex)

This command sets the Illegal Command bit in the General Status byte (refer to Paragraph 18.4.1). The General Status byte, with the Illegal Command bit set to 1, is returned to the controller by the Parameter byte of the command sequence.

18.2.1.2 Clear Fault (Command Code 01 Hex)

This command causes all fault status bits of the selected disk drive to be reset, provided the fault condition has passed. If the fault condition persists, the appropriate status bit continues to be set. The General Status byte, cleared of previous fault status, is returned by the Parameter byte of the command sequence.

The Clear Fault command also resets the Attention Condition caused by the fault condition only if the fault condition no longer exists.

18.2.1.3 Clear Attention (Command Code 02 Hex)

This command causes the Attention Condition to be reset in the selected disk drive. The General Status byte is returned by the Parameter byte of the command sequence.

If the error or other condition that causes the Attention Condition persists, the Attention Condition is not set again. However, if the condition is reset and then the error reoccurs, the Attention Condition is set again.

18.2.1.4 Seek (Command Code 03 Hex)

This command causes the selected disk drive to seek to the cylinder identified as the target cylinder by the Set Cylinder Address commands (refer to Paragraphs 18.1.1.3 and 18.1.1.4). The General Status byte is returned to the controller by the Parameter byte of the command sequence with the Busy Executing bit set (refer to Paragraph 18.4.1.7).

The Seek command sets the Attention Condition and the Illegal Parameter bit in the General Status byte if the cylinder address is outside the cylinder address range of the disk drive.

Upon the completion of any Seek (including a zero length Seek), the disk drive clears the Busy Executing bit in the General Status byte and sets the Attention Condition.

This command resets the Offset Control to No Offset.

18.2.1.5 Rezero (Command Code 04 Hex)

This command causes the selected disk drive to position the moving heads over cylinder zero and reset Read Control to nominal strobe and the Offset Control to No Offset. The General Status byte is returned to the controller by the Parameter byte of the command sequence with the Busy Executing bit set (refer to Paragraph 18.4.1.7).

Upon completion of positioning the moving heads over cylinder zero, the disk drive clears the Busy Executing bit in the General Status byte and sets the Attention Condition.

18.2.1.6 Report Sense Byte 2 (Command Code 0D Hex)

This command causes the selected disk drive to return Sense Byte 2 via the Parameter byte portion of the command sequence; no other action is taken in the disk drive.

18.2.1.7 Report Sense Byte 1 (Command Code 0E Hex)

This command causes the selected disk drive to return Sense Byte 1 via the Parameter byte of the command sequence. No other action is taken in the disk drive.

18.2.1.8 Report General Status Byte (Command Code 0F Hex)

This command causes the selected disk drive to return the General Status byte via the Parameter byte of the command sequence. This command does not perform any other function in the disk drive but can be used as a *no-op* to allow the controller to monitor the disk drive's General Status byte without changing any disk drive condition. The contents of the byte are defined later in Table 18-4.

18.2.1.9 Reserved Mandatory Commands

(N/A)

18.2.2 OPTIONAL COMMANDS

18.2.2.1 Report Disk Drive Attribute (Command Code 10 Hex)

This command causes the selected disk drive to return a byte of information that is the Disk Drive Attribute whose number was defined in the Load Attribute Number command (refer to Paragraph 18.1.2.1). The contents of the byte are defined in Table 18-3 and Paragraph 18.3.

18.2.2.2 Set Attention (Command Code 11 Hex)

This command causes the selected disk drive to set the Attention Condition only. No other function is performed.

The General Status byte is transferred to the controller by the Parameter byte of the command sequence.

18.2.2.3 Multiported Devices

The disk drive does not implement any multiport configurations.

18.2.2.4 Selective Reset (Command Code 14 Hex)

This command causes the selected disk drive to reach Initial State (refer to Paragraph 17.2.1). This is a time dependent command and, as such, sets the Busy Executing bit prior to the assertion of the acknowledge-to-parameter request and is reflected in the returned General Status byte. Upon completion of the parameter byte transfer, the disk drive goes to the Initial State. When the Initial State is reached, bit 0 of Sense Byte 2 is set. This causes the setting of the Attention Condition.

18.2.2.5 Seek To Landing Zone (Command Code 15 Hex)

The disk drive contains failure detect circuitry that automatically causes the positioner to seek to landing zone upon detection of failure or a Spin-Down command. Response to this command is therefore not implemented.

18.2.2.6 Partition Track (Command Code 16 Hex)

The Sector signal is derived, in the disk drive, from the servo clocks recorded on the servo surface. Upon disk drive initialization, the disk drive microprocessor determines hard/soft sector operation and the number of decimal sectors per revolution.

This command causes the selected disk drive to activate the hard sector option regardless of the option switch setting. It also reconfigures the arrangement of Sector Pulse generation according to parameters received via the Load Bytes Per Sector and the Load Sector Pulses Per Track commands (refer to Paragraphs 18.1.2.7 to 18.1.2.12). The General Status byte shall be returned to the controller by the Parameter byte of the command sequence.

The following are the requirements for the number of sector pulses and the maximum number of bytes per sector that may be specified when configuring the disk drive.

(1) The minimum number of bytes per sector is 4.

(2) The range of the number of sector pulses (not the number of sectors) is 0 through 3,358.

(3) When the number of sector pulses is 0, the maximum number of bytes per sector is 20,160.

(4) When the number of sector pulses is between 1 and 3,358, the following formula is used to calculate the maximum number of bytes per sector:

$$B = \text{Integer of } \left[1.5 \left(\text{Integer of } [(S-3) / (P+1)] \right) \right]$$

Where: B = maximum number of bytes allowed with the specified number of sector pulses, Integer is the integer value of the term calculated.

S = number of sector pulses (13,440).

P = number of sector pulses required.

The Partition Track command is a time-dependent command and sets the Busy Executing bit in the General Status byte returned by this command (refer to Paragraph 18.4.1.7) and it remains set while this command execution is in process.

Upon the completion of execution of this command, the Bytes Per Sector and the Sector Pulses Per Track are updated in the Attribute Table, bit 6 of Attribute Byte 0E Hex is cleared and the Attention Condition is set.

The Partition Track command sets the Attention Condition and the Illegal Parameter bit in the General Status byte if the Bytes Per Sector and the Sector Pulses Per Track create a set that is outside the range of the disk drive. Issuing this command while Read Gate or Write Gate is active, or activating Read Gate or Write Gate while this command is executing, is a violation of protocol.

18.2.2.7 Report Cylinder, High (Command Code 29 Hex)

This command causes the selected disk drive to return the most-significant byte of a 16-bit number that indicates the cylinder address of the current position of the moving heads. This number does not reflect the most recent cylinder address set by the Set Cylinder Address commands (refer to Paragraphs 18.1.1.3 and 18.1.1.4) unless an intervening Seek command has been completed (refer to Paragraph 18.2.1.4). The information is transferred by the Parameter byte of the command sequence.

18.2.2.8 Report Cylinder, Low (Command Code 2A Hex)

This command causes the selected disk drive to return the least-significant byte of a 16-bit number that indicates the cylinder address of the current position of the moving heads. This number does not reflect the most recent cylinder address set by the Set Cylinder Address commands (refer to Paragraphs 18.1.1.3 and 18.1.1.4) unless an intervening Seek command has been completed (refer to Paragraph 18.2.1.4).

The information is transferred by the Parameter byte of the command sequence.

18.2.2.9 Report Read Permit, High (Command Code 2B Hex)

This command causes the selected disk drive to return a byte of information that is the most-significant byte of a 16-bit number that indicates the minimum cylinder address accessible for read operations. This number is programmed by the Load Read Permit commands (refer to Paragraphs 18.1.2.13 and 18.1.2.14).

The information is transferred by the Parameter byte of the command sequence.

18.2.2.10 Report Read Permit, Low (Command Code 2C Hex)

This command causes the selected disk drive to return a byte of information that is the least-significant byte of a 16-bit number that indicates the minimum cylinder address accessible for read operations. This number is programmed by the Load Read Permit commands (refer to Paragraphs 18.1.2.13 and 18.1.2.14).

The information is transferred by the Parameter byte of the command sequence.

18.2.2.11 Report Write Permit, High (Command Code 2D Hex)

This command causes the selected disk drive to return a byte of information that is the most-significant byte of a 16-bit number that indicates the minimum cylinder address accessible for write operations. This number is programmed by the Load Write Permit commands (refer to Paragraphs 18.1.2.15 and 18.1.2.16).

The information is transferred by the Parameter byte of the command sequence.

18.2.2.12 Report Write Permit, Low (Command Code 2E Hex)

This command causes the selected disk drive to return a byte of information that is the least-significant byte of a 16-bit number that indicates the minimum cylinder address accessible for write operations. This number is programmed by the Load Write Permit commands (refer to Paragraphs 18.1.2.15 and 18.1.2.16).

The information is transferred by the Parameter byte of the command sequence.

18.2.2.13 Report Test Byte (Command Code 2F Hex)

This command causes the selected disk drive to return a copy of the Test byte transferred to the disk drive via the Load Test Byte command (refer to Paragraph 18.1.2.17).

The Report Test Byte is transferred by the Parameter byte of the command sequence.

18.2.2.14 Reserved Optional Commands

(N/A)

18.2.2.15 Vendor Unique Commands

(N/A)

18.3 DISK DRIVE ATTRIBUTE COMMANDS

The Disk Drive Attribute commands are: Load Attribute Number, Load Disk Drive Attribute, and Report Disk Drive Attribute. They are used to load or report disk drive attributes but they do not cause any operation that affects the characteristic of the disk drive.

The Parameter byte transferred with the Load Attribute Number command is used as a number to select a disk drive attribute (refer to Table 18-3). This number remains valid for all subsequent Load Disk Drive Attribute and Report Attribute Number commands until changed by another Load Attribute Number command. If for a received number no attribute is assigned or the function is not implemented, the Attention Condition and the Illegal Command bit in the General Status byte are set.

The Load Disk Drive Attribute command sets the selected attribute to the value transferred with the Parameter byte. If the selected attribute can be read only and not be altered, the Attention Condition, and the Illegal Command bit in the General Status byte are set. If an illegal value is loaded, the Attention Condition and the Illegal Parameter bit in the General Status byte are set.

The Report Disk Drive Attribute command causes the disk drive to return the current value of the selected attribute. The Report Disk Drive Attribute command is used for all implemented attributes.

18.3.1 USER ID (00 Hex)

This attribute is a user settable and readable byte that can be used by the user for any purpose. It is used to identify the characteristics of the disk drive with which the controller is communicating.

18.3.2 MODEL ID HIGH (01 HEX)

This attribute is a read-only byte that identifies a specific disk drive model.

MSB LSB

Value	0	0	0	0	0	0	1	1

Example: MSB of Model Used (03 Hex)

18.3.3 MODEL ID LOW (02 HEX)

This attribute is a read-only byte that identifies a specific disk drive model.

MSB LSB

Value	0	0	0	0	0	0	0	0

Example: LSB of Model Used (00 Hex)

18.3.4 REVISION ID (03 HEX)

This attribute is a read-only byte that identifies the revision level of a specific disk drive operating firmware.

MSB LSB

Value	0	0	0	0	0	0	0	0

Example: Software Revision (00 Hex)

18.3.5 RESERVED

(N/A)

18.3.6 DISK DRIVE TYPE ID (0D HEX)

This attribute is a read-only byte that identifies the disk drive as follows.

MSB LSB

Value	0	0	0	0	0	0	0	1

Example: Non-Removable Disk (01 Hex)

18.3.7 ATTRIBUTE TABLE MODIFICATION (0E HEX)

The purpose of this attribute is to permit an orderly modification of the Attribute Table (refer to Table 18-3).

When the disk drive goes to the Initial State, bit 7 of this attribute is set. After or during the Initial State generation, the disk drive initializes the Attribute Table. When the Table is initialized by the disk drive, bit 7 is reset and bit 6 is set. The controller may, at its option, modify attributes and if it does, the disk drive resets bit 6. After all attributes have been modified, the controller sets bit 5.

When any subsequent byte, except 0E Hex, is modified, bits 5 and 6 are reset and bit 4 is set. After a controller has modified the attributes, it must execute a Load Disk Drive Attribute command with 0E Hex selected. This resets bit 4 and sets bit 5.

When either bit 6 or bit 5 is equal to 1, the Table is safe to use. As long as bit 6 remains set, the Table contains the initial values set by the disk drive.

This attribute is defined as follows:

7	6	5	4	3	2	1	0
				0	0	0	0

Bit 7 = 1:
The Attribute Table is being modified by the disk drive. This bit is set by the disk drive and is reset by the disk drive upon completion of the modification process.

Bit 6 = 1:
The initial disk drive attribute values have not been modified. This bit is set by the disk drive upon attaining the Initial State and is reset when any Load Disk Drive Attribute Command (except to 0E Hex) is executed or the Partition Track Command is executed.

Bit 5 = 1:
This bit, which is set by the controller, is used to signify that the Attribute Table is complete and ready for use. This bit is reset on any Load Disk Drive Attribute command except to 0E (Hex). This bit can be set only by executing a Load Disk Drive Attribute command to 0E (Hex).

Bit 4 = 1:
This bit is set by the disk drive after a Load Disk Drive Attribute command is executed. This bit can be reset only by executing a Load Disk Drive Attribute command to 0E (Hex).

The setting of this bit causes bit 5 of Sense Byte-2 to be set.

Bits 0, 1, 2, and 3 are 0.

18.3.8 TABLE ID (0F HEX)

This attribute defines the meaning of numbers 10—FF Hex.

When the value of this attribute is equal to 01 Hex, then Paragraphs 18.3.9—18.3.39 define the attributes for numbers 10—FF (Hex).

18.3.9 BYTES PER TRACK, HIGH (10 HEX)

This attribute is the most-significant byte of a 24-bit binary number that represents the total number of unformatted bytes that occur between active-going edges of Index pulses.

18.3.10 BYTES PER TRACK, MEDIUM (11 HEX)

This attribute is the medium-significant byte of a 24-bit binary number that represents the total number of unformatted bytes occurring between true (low)-going edges of Index pulses.

18.3.11 BYTES PER TRACK, LOW (12 HEX)

This attribute is the least-significant byte of a 24-bit binary number that represents the total number of unformatted bytes occurring between true (low)-going edges of Index pulses.

18.3.12 BYTES PER SECTOR, HIGH (13 HEX)

This attribute is the most-significant byte of a 24-bit number that represents the total number of bytes that occur between active-going edges of Sector pulses, and between the active-going edge of the Index pulse and the active-going edge of the first Sector pulse.

18.3.13 BYTES PER SECTOR, MEDIUM (14 HEX)

This attribute is the medium-significant byte of a 24-bit number that represents the total number of bytes that occur between active-going edges of Sector pulses, and between the active-going edge of the Index pulse and the active-going edge of the first Sector pulse.

18.3.14 BYTES PER SECTOR, LOW (15 HEX)

This attribute is the least-significant byte of a 24-bit number that represents the total number of bytes that occur between active-going edges of Sector pulses, and between the active-going edge of the Index pulse and the active-going edge of the first Sector pulse.

18.3.15 SECTOR PULSES PER TRACK, HIGH (16 HEX)

This attribute is the most-significant byte of a 24-bit number that indicates the number of Sector pulses between but excluding Index pulses generated by hard-sectored disk drives. The Sector pulses are used to divide a track into sectors. The length of the sectors (distance between Sector pulses) is defined by the Bytes Per Sector attribute.

18.3.16 SECTOR PULSES PER TRACK, MEDIUM (17 HEX)

This attribute is the medium-significant byte of a 24-bit number that indicates the number of Sector pulses (excluding Index pulses) generated by hard-sectored disk drives. The Sector pulses are used to divide a track into sectors. The length of the sectors (distance between Sector pulses) is defined by the Bytes Per Sector attribute.

18.3.17 SECTOR PULSES PER TRACK, LOW (18 HEX)

This attribute is the least-significant byte of a 24-bit number that indicates the number of Sector pulses (excluding Index pulses) generated by hard-sectored disk drives. The Sector pulses are used to divide a track into sectors. The length of the sectors (distance between Sector pulses) is defined by the Bytes Per Sector attribute.

18.3.18 SECTORING METHOD (19 HEX)

This attribute defines the sectoring method used in the disk drive. The attribute may allow either loading and reporting if the disk drive provides two sectoring methods which are switch selectable by the user.

	MSB							LSB
Value	0	0	0	0	0	0	1	1

- Bit 0: Hard Sectoring (01 Hex)
- Bit 1: Soft sectoring with dc-erased Address Marks (02 Hex)

18.3.19 NUMBER OF CYLINDERS, HIGH (20 HEX)

This attribute is the most-significant byte of a 16-bit binary number that represents the number of cylinders implemented in the disk drive. This number, when combined with the Number-of-Cylinders, Low byte, is one greater than the maximum allowable cylinder address that can be addressed.

18.3.20 NUMBER OF CYLINDERS, LOW (21 HEX)

This attribute is the least-significant byte of a 16-bit binary number that represents the number of cylinders implemented in the disk drive. This number, when combined with the Number-of-Cylinders, High byte, is one greater than the maximum allowable cylinder address that can be addressed.

18.3.21 NUMBER OF MOVING HEADS (22 HEX)

This attribute represents the number of moving heads implemented in the disk drive. This number is one greater than the maximum allowable moving-head address that can be addressed.

18.3.22 NUMBER OF FIXED HEADS

(Indicated as 0.)

18.3.23 HEAD-SELECT MODE (24 HEX)

This attribute defines the mode of selecting heads implemented in the disk drive (refer to Paragraph 18.1.1.5).

7	6	5	4	3	2	1	0
0	0	0	0	0	0	1	0

	Bit 1	Bit 0
Immediate Mode =	0	0
Time Dependent =	0	1
Both Modes =	1	X (don't care)

Bits 2—7 shall be zeros

18.3.24 HEADER ENCODING METHOD NUMBER 1 (30 HEX)

This attribute represents the header encoding method used for all fields labeled NUMBER 1 in the disk drive and is defined as follows:

Value	Encoding Method
00 Hex	Modified Frequency Modulation (MFM)
01 Hex	ANSI Group Code Recording (GCR)
02 EF Hex	Reserved for Future Standardization
F0 FF Hex	Unique Vendor Method

The definition of formatting requirements as defined by Attributes 30—37 (Paragraphs 18.3.24—18.3.31) is based on the initial value set at F1 Hex and represents the use of a (2, 7) Run Length Limited code (see Figure 18-1).

18.3.25 PREAMBLE NUMBER 1 LENGTH (31 HEX)

This attribute represents the minimum number of header preamble bytes required by the disk drive. The initial value is set at 1B Hex.

18.3.26 PREAMBLE NUMBER 1 PATTERN (32 HEX)

This attribute represents the pattern to be recorded in the header preamble bytes. The pattern is recorded starting with the most-significant bit. The initial value is set at 00 Hex.

18.3.27 SYNCHRONIZATION NUMBER 1 PATTERN (33 HEX)

This attribute represents the pattern to be recorded in a 1-byte header synchronization field following the preamble. The pattern is recorded starting with the most-significant bit. The initial value is set at FF Hex.

18.3.28 POSTAMBLE NUMBER 1 LENGTH (34 HEX)

This attribute represents the minimum number of header postamble bytes required by the disk drive. A value of zero, as initialized, indicates that no postamble is required.

18.3.29 POSTAMBLE NUMBER 1 PATTERN (35 HEX)

This attribute represents the pattern to be recorded in the header postamble bytes. The pattern is recorded starting with the most-significant bit. The initial value is set at 00 Hex.

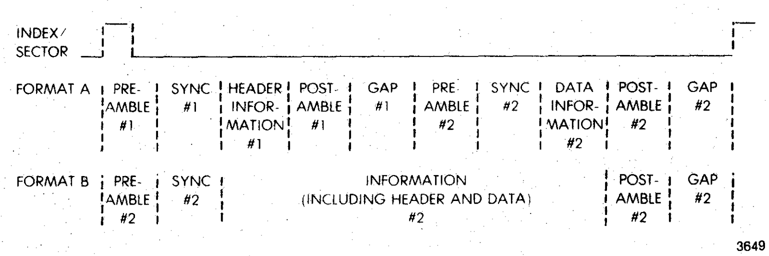

Figure 18-1. Sector Formats for Attributes 30—47 (Hex)

18.3.30 GAP NUMBER 1 LENGTH (36 HEX)

This attribute represents the minimum number of bytes in the header gap (splice area) between postamble and the next preamble. The initial value is set at 01 Hex.

18.3.31 GAP NUMBER 1 PATTERN (37 HEX)

This attribute represents the pattern to be recorded in the header gap bytes. The pattern is recorded starting with the most-significant bit. The initial value is set at 00 Hex.

18.3.32 DATA ENCODING METHOD NUMBER 2 (40 HEX)

This attribute represents the encoding method used for all fields labeled NUMBER 2 in the disk drive and is defined as follows:

Value	**Encoding Method**
00 Hex	Modified Frequency Modulation (MFM)
01 Hex	ANSI Group Code Recording (GCR)
02-EF Hex	Reserved for Future Standardization
F0-FF Hex	Unique Vendor Method

The definition of formatting requirements as defined by Attributes 40—47 (Paragraphs 18.3.32—18.3.47) is based on the initial value set at F1 Hex and represents the use of a (2, 7) Run Length Limited code.

18.3.33 PREAMBLE NUMBER 2 LENGTH (41 HEX)

This attribute represents the minimum number of preamble bytes required by the disk drive. The initial value is set at 0B Hex.

18.3.34 PREAMBLE NUMBER 2 PATTERN (42 Hex)

This attribute represents the pattern to be recorded in the preamble bytes. The pattern is recorded starting with the most-significant bit. The initial value is set at 00 Hex.

18.4 STATUS REPORTING

18.4.1 GENERAL STATUS BYTE

The contents of the General Status byte are defined in Table 18-4.

Table 18-4
General-Status Byte

Bit Number	Function	Method of Clearing
0	Not Ready	Self Clearing (Spin-up)
1	Control-Bus Error*	Clear Fault Command
2	Illegal Command*	Clear Fault Command
3	Illegal Parameter*	Clear Fault Command
4	Sense Byte 1**	**
5	Sense Byte 2**	**
6	Busy Executing	Self Clearing
7	Normal Complete*	Clear Attention Command

*A 0-to-1 transition of this bit sets the Attention Condition.
**See Sense Byte 1 and Sense Byte 2 in Tables 18-5 and 18-6, respectively.

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Table 18-5
Sense Byte 1

Bit Number	Function	Method of Clearing
0	Seek Error*	Clear Fault Command
1	Read/Write Fault*	Clear Fault Command
2	Power Fault*	Clear Fault Command
3	R/W Permit Violation	Clear Fault Command
4	Speed Error*	Clear Fault Command
5	Command Reject*	Clear Fault Command
6	0 (zero)	N/A
7	0 (zero)	N/A

*A 0-to-1 transition of this bit sets the Attention Condition.

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Table 18-6
Sense Byte 2

Bit Number	Function	Method of Clearing
0	Initial State*	Clear Attention Command
1	Ready Transition	Clear Attention Command
2	0 (zero)	N/A
3	0 (zero)	N/A
4	0 (zero)	N/A
5	Disk Drive Attribute Table Modified*	Clear Attention Command
6	Positioned Within Write Protected Area	Self Clearing
7	0 (zero)	N/A

*A 0-to-1 transition of this bit sets the Attention Condition.

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18.4.1.1 Bit 0 — Not Ready

The Not-Ready bit is set when the disk drive is unable to perform any head motion or read/write operation.

Index (IINDEX) and Sector/Address Mark Detected (ISP/IADMD) signals are invalid when the disk drive is not ready.

The Not-Ready bit is reset when the disk drive becomes ready.

The ready-to-not ready and not ready-to-ready transition sets the Attention Condition. Refer to Table 18-7 for the Busy/Not Ready Relationship.

18.4.1.2 Bit 1 — Control Bus Error

This bit is set when the disk drive detects a protocol or parity error (if parity option has been selected) during the transfer of a command or parameter when:

(1) A Control Bus Parity Error is detected.

(2) The Command Request (ICOMRQ) is transferred and the Bus Direction Out (IBUSDO) signal is false (high).

Table 18-7
Command Busy/Not Ready Relationships

Function	Busy Signal	Not Ready	Busy Executing Status
No Power	N/A	N/A	N/A
Spinning Up[1]	1	1	1
Spinning Down[1]	1	1	1
Motor Stopped	0	1	0
Idle Condition	0	0	0
Seeking[1]	1	0	1
Offsetting[1]	1	0	1
Power Fault[2]	1[3]	0	0
Read/Write Operation	0[2]	0	0

NOTES:
1. Indicates time-dependent operation.
2. Status is as indicated for non-catastrophic power faults. Catastrophic power faults result in undefined state for the three signals.
3. A power fault causes an immediate spin down. The Busy signal is active during the spin down operation and becomes inactive upon completion.

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(3) The level of the IBUSDO signal for the transfer of the Parameter byte (second byte) does not comply with the Command Code.

The disk drive does not act upon the command transferred during a Command/Parameter byte cycle resulting in a Control Bus Error. When the IBUSDO signal is false for the second byte and a Control Bus Error has been detected, the disk drive returns the General Status Byte.

18.4.1.3 Bit 2 — Illegal Command

This bit is set when the disk drive detects an illegal command such as when the command received is not implemented in the disk drive or the disk drive detected a parity error in the Command byte which also sets the Control Bus Error bit. The Illegal Command bit is reset by the Clear Fault Command. The transition of 0-to-1 in this bit sets the Attention Condition.

18.4.1.4 Bit 3 — Illegal Parameter

This bit is set when the disk drive detects an illegal parameter or part of a parameter when:

(1) The parameter is an address that exceeds the valid range (illegal head address).

(2) Any illegal parameter value is detected.

(3) The disk drive detects a parity error in the Parameter byte which will set the Control Bus Error Bit.

The Illegal Parameter bit is reset by the Clear Fault command.

The transition of 0-to-1 in this bit sets the Attention Condition.

18.4.1.5 Bit 4 — Sense Byte 1

This bit is generated by an OR function of all bits in the Sense Byte 1 status byte. Sense Byte 1 is reset if all bits of Sense Byte 1 are 0.

18.4.1.6 Bit 5 — Sense Byte 2

This bit is generated by an OR function of all bits in the Sense Byte 2 status byte. Sense Byte 2 bit is reset if all bits of Sense Byte 2 are 0.

18.4.1.7 Bit 6 — Busy Executing

This bit is set during the the execution of all Time Dependent commands and is set prior to the return of the General Status for those commands with Parameters-In that return the General Status as the parameter (refer to Tables 18-1, 18-2, and Paragraph 18.2).

NOTE

This status bit is different from the Busy Interface signal (refer to Paragraph 17.2.7).

18.4.1.8 Bit 7 — Normal Complete

This bit is set when the disk drive has successfully completed the execution of a time-dependent command (refer to Tables 18-1 and 18-2).

The Normal Complete bit is reset by the Clear Attention Command.

The 0-to-1 transition in this bit sets the Attention Condition.

18.4.2 SENSE BYTE 1

The contents of Sense Byte 1 are listed in Table 18-5.

18.4.2.1 Bit 0 — Seek Error

The Seek Error bit is set when a head positioning command (Seek, Rezero, or Offset) cannot be completed successfully.

The Seek Error bit is reset by a successful Rezero operation or by the Clear Fault command.

The 0-to-1 transition in this bit sets the Attention Condition.

18.4.2.2 Bit 1 — Read/Write Fault

This bit is set when the disk drive cannot execute a Read command or a Write command or detects a fault during reading or writing. Two kinds of faults are distinguished:

(1) Bit 1 and Bit 5 are set when the execution of a read/write function requested by making Read Gate (IRDGT) or Write Gate (IWRGT) true (low) is prevented by one of the following conditions:
   - when IWRGT is true (low) and writing is disabled with a Write Control command (see Paragraph 18.1.1.2).
   - when IWRGT is true (low) and the heads are offset (see Paragraph 18.1.2.5).

(2) Bit 1 only is set when the disk drive detects a fault in its Read/Write circuitry, for example:
   - when IWRGT is true (low) but there is no write current, bit 1 will set.
   - when the disk drive detects a simultaneous IWRGT and IRDGT in the true (iow) state.

The Read/Write Fault bit is reset by the Clear Fault command.

The 0-to-1 transition in this bit sets the Attention Condition.

18.4.2.3 Bit 2 — Power Fault

This bit is set when the disk drive tests for and detects a failure or undervoltage in one of the dc supply voltages.

This bit is reset by the Clear Fault command when the power failure no longer exists.

The 0-to-1 transition in this bit sets the Attention Condition.

18.4.2.4 Bit 3 — Read/Write Permit Violation

This bit is set if writing to the currently accessed track is not permitted (refer to Paragraphs 18.1.2.15 and 18.1.2.16) and Write Gate (IWRGT) is true (low). This bit is set if reading from the currently accessed track is not permitted (refer to Paragraphs 18.1.2.13 and 18.1.2.14) and Read Gate (IRDGT) is true (low).

This bit is reset by the Clear Fault command.

The 0-to-1 transition in this bit sets the Attention Condition.

18.4.2.5 Bit 4 — Speed Error

This bit is set when the disk drive detects that the spindle speed is not within ±5 percent of 3600 rpm.

This bit is reset by the Clear Fault command when the spindle speed remains within the specified tolerance.

The 0-to-1 transition in this bit sets the Attention Condition.

18.4.2.6 Bit 5 — Command Reject

This bit is set when the disk drive receives a command which it cannot execute at this time because of some interlocking condition or command sequence error.

This status bit may be set in combination with another status bit that defines the reason why the command was rejected, e.g., when the disk drive is not ready and has received a command that cannot be executed (such as a Seek command when the disk is not rotating).

The Command Reject bit is reset by the Clear Fault command.

The 0-to-1 transition in this bit sets the Attention Condition.

18.4.2.7 Bit 6 — Other Errors

This bit is set to zero.

18.4.2.8 Bit 7 — Unique Errors

This bit is set to zero.

18.4.3 SENSE BYTE 2

The contents of Sense Byte 2 are listed in Table 18-6.

18.4.3.1 Bit 0 — Initial State

This bit is set if an initialize procedure has been entered and the procedure has been completed.

The Initial State bit is reset by a Clear Attention command.

The 0-to-1 transition in this bit sets the Attention Condition.

18.4.3.2 Bit 1 — Ready Transition

This bit is set if a 0-to-1 or a 1-to-0 transition of the Not Ready bit (refer to Paragraph 18.4.1.1) has occurred.

The Ready Transition bit is reset by a Clear Attention command.

The 0-to-1 transition in this bit sets the Attention Condition.

18.4.3.3 Bit 2 — Device Reserved to This Port

(N/A)

18.4.3.4 Bit 3 — Forced Release

(N/A)

18.4.3.5 Bit 4 — Device Reserved to Alternate Port

(N/A)

18.4.3.6 Bit 5 — Device Attribute Table Modified

This bit is set if bit 4 of the Table Modification Attribute Number 0E Hex is set to a 1 (refer to Paragraph 18.3.7).

This bit is reset by a Clear Attention command.

The 0-to-1 transition in this bit sets the Attention Condition.

18.4.3.7 Bit 6 — Positioned Within Write Protected Area

This bit is set by the disk drive whenever Write Control (refer to Paragraph 18.1.1.2) has placed the disk drive in the write disabled state.

This bit is set by the disk drive whenever the heads are positioned within an area that has been defined as Write Protected (refer to Paragraphs 18.1.2.15 and 18.1.2.16) and the disk drive is write enabled.

This bit is cleared whenever the heads are positioned outside the Write Protected area.

This bit is not defined during head movement.

18.4.3.8 Bit 7 — PPC Unique Attentions

None.

19.0 TIMING SPECIFICATION

The timing characteristics described in the following paragraphs are referenced to the signals at the disk drive interface connector. The controller timing must be designed to accommodate cable delays and signal skew within the cables.

NOTE

This section takes precedence, with respect to functions and timing, over all preceding sections. All waveforms in the timing diagrams show the voltage levels of the signals. A – (minus) in front of a signal name indicates a low (active), high (inactive) signal. A + (plus) in front of a signal name indicates a high (active), low (inactive) signal.

19.1 CONTROL BUS TIMING

19.1.1 SELECTION TIMING

The true (low) going edge of the Select Out/Attention-In Strobe (ISOAIS) is used to clock the selected information on the dedicated Control Bus line into the disk drive. A successful selection is acknowleded by making Bus Acknowledge (IBUSAK) true (low). In the controller, the false (high) going edge of ISOAIS is used to sample the IBUSAK signal. If IBUSAK is not true (low) within the specified time, the controller assumes that the desired disk drive does not exist or is inoperable. The state of the Busy (IBUSY) signal indicates to the controller if the selected disk drive will accept commands and respond to the Control Bus handshake.

Deselecting all disk drives is accomplished by a true (low) going edge of the ISOAIS signal with all of the Control Bus lines false (high).

The select timing is shown in Figure 19-1.

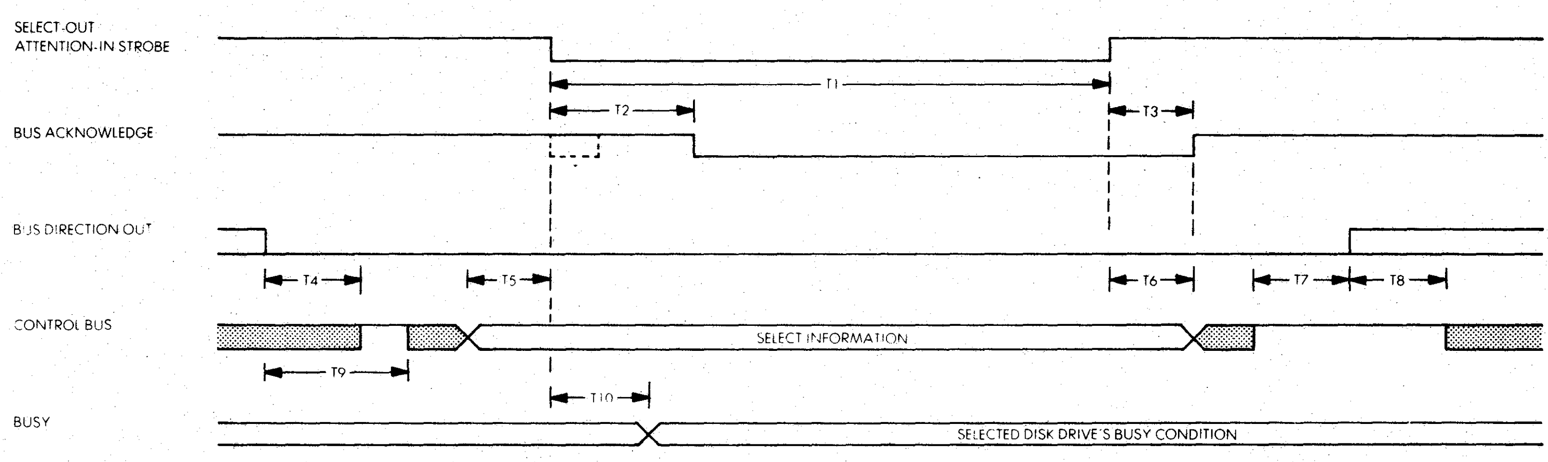
19.1.2 ATTENTION TIMING

In general, timing of the party line Attention (IATTN) signal (refer to Paragraph 17.2.8) is asynchronous to the Control Bus signals. However, if a command error or parameter error is detected, the attention condition is set and if enabled, the IATTN signal goes true (low) prior to the true (low) going edge of IBUSAK, which is returned as a response to the Parameter Request (IPARQ). All other events (completion or errors) cause the IATTN line to go true (low) immediately, when they occur.

The IATTN signal goes false (high) prior to the true (low) going edge of IBUSAK, which is returned as a response to the parameter request of a Clear Attention command or Clear Fault command. IATTN will not go false (high) in response to the Clear Fault Command if the error that caused IATTN to go true (low) still exists.

To determine which one of the attached disk drives has caused the party line IATTN signal to go true (low), the controller polls all disk drives simultaneously by making the Bus Direction-Out (IBUSDO) signal false (high) and changing the ISOAIS signal from false to true (high to low). Each disk drive then immediately gates its internal attention condition onto its dedicated Control Bus line. Additionally, the selected disk drive, if any, makes IBUSAK true (low). Note that if no disk drive is selected, IBUSAK will not be sent from the disk drive.

The IATTN line timing is shown in Figure 19-2.



*GLITCH POSSIBLE DUE TO PREVIOUSLY SELECTED DISK DRIVE. TO AVOID GLITCH, DESELECT ALL DISK DRIVES AND THEN SELECT.

NOTES:

FUNCTION		TIMING (NANOSECONDS) MIN	MAX
T1	= SELECT/ATTENTION STROBE WIDTH	500	
T2	= BUS ACKNOWLEDGE INVALID	0	300
T3	= BUS ACKNOWLEDGE HOLD TIME	0	100
T4	= DISK DRIVE CONTROL BUS RELEASE TIME	0	100
T5	= CONTROL BUS DATA SETUP TIME	100	
T6	= CONTROL BUS DATA HOLD TIME	0	
T7	= CONTROLLER CONTROL BUS RELEASE TIME	100	
T8	= DISK DRIVE CONTROL BUS ACCESS TIME	0	
T9	= CONTROLLER CONTROL BUS ACCESS TIME	100	
T10	= BUSY INVALID	0	300

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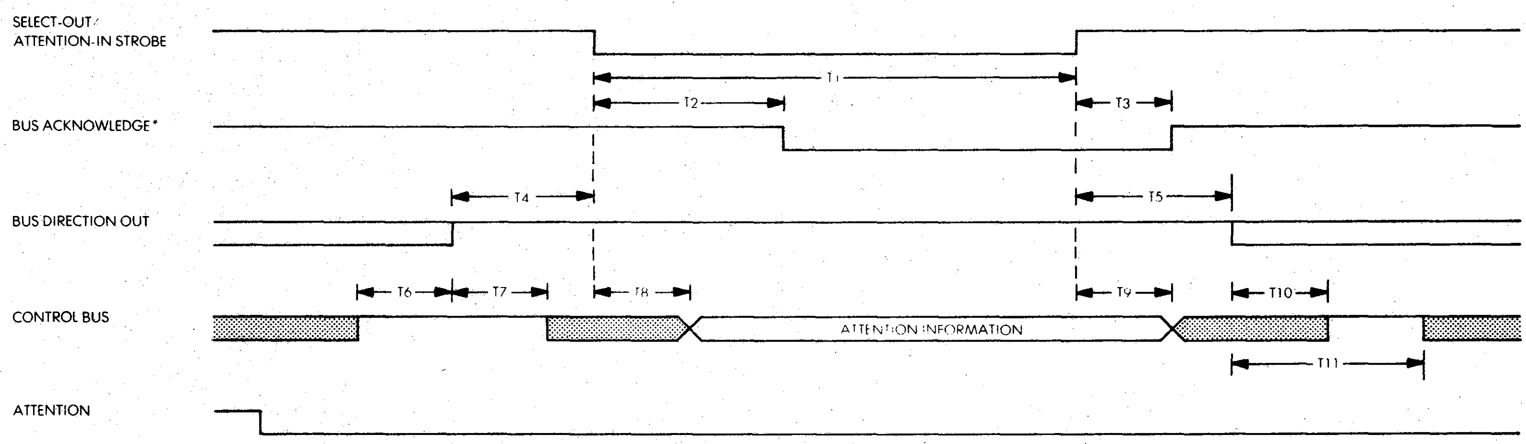
Figure 19-1. Select Timing



NOTES:

1. *ACTIVE ONLY IF THERE IS A PREVIOUSLY SELECTED DISK DRIVE. INACTIVE IF ALL DISK DRIVES ARE DESELECTED.

2.

	FUNCTION	TIMING (NANOSECONDS) MIN	MAX
T1	= SELECT/ATTENTION STROBE WIDTH	500	
T2	= BUS ACKNOWLEDGE INVALID**	0	300
T3	= BUS ACKNOWLEDGE HOLD TIME	0	100
T4	= BUS DIRECTION OUT SETUP TIME	100	
T5	= BUS DIRECTION OUT HOLD TIME	0	
T6	= CONTROLLER CONTROL BUS RELEASE TIME	100	
T7	= DISK DRIVE CONTROL BUS ACCESS TIME	0	
T8	= ATTENTION INFORMATION INVALID	0	100
T9	= ATTENTION INFORMATION HOLD TIME	0	
T10	= DISK DRIVE CONTROL BUS RELEASE TIME	0	100
T11	= CONTROLLER CONTROL BUS ACCESS TIME	100	

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Figure 19-2. Attention Timing

19.1.3 CONTROL BUS HANDSHAKE TIMING

The Control Bus handshake is performed by three interface signals: Command Request (ICOMRQ), Parameter Request (IPARQ), and Bus Acknowledge (IBUSAK).

The Control Bus handshake timing is shown in Figures 19-3 and 19-4.

19.2 INDEX AND SECTOR MARK TIMING

One Index pulse is generated per revolution of the disk. Sector pulses are used to divide each track into discrete sections. The disk drive inhibits the Sector pulse each time is synchronizes with the generated Index pulse. The Index and Sector pulses are enabled when the disk drive selection is made. The Index and Sector pulses should not be considered valid until 500 nanoseconds after the false-to-true (high-to-low) transition of the Select Out/Attention-In strobe signal that caused the selection of the disk drive.

The Index/Sector pulse timing is shown in Figure 19-5.

19.3 REFERENCE CLOCK TIMING

The Reference Clock timing is shown in Figure 19-6.

19.4 READ TIMING

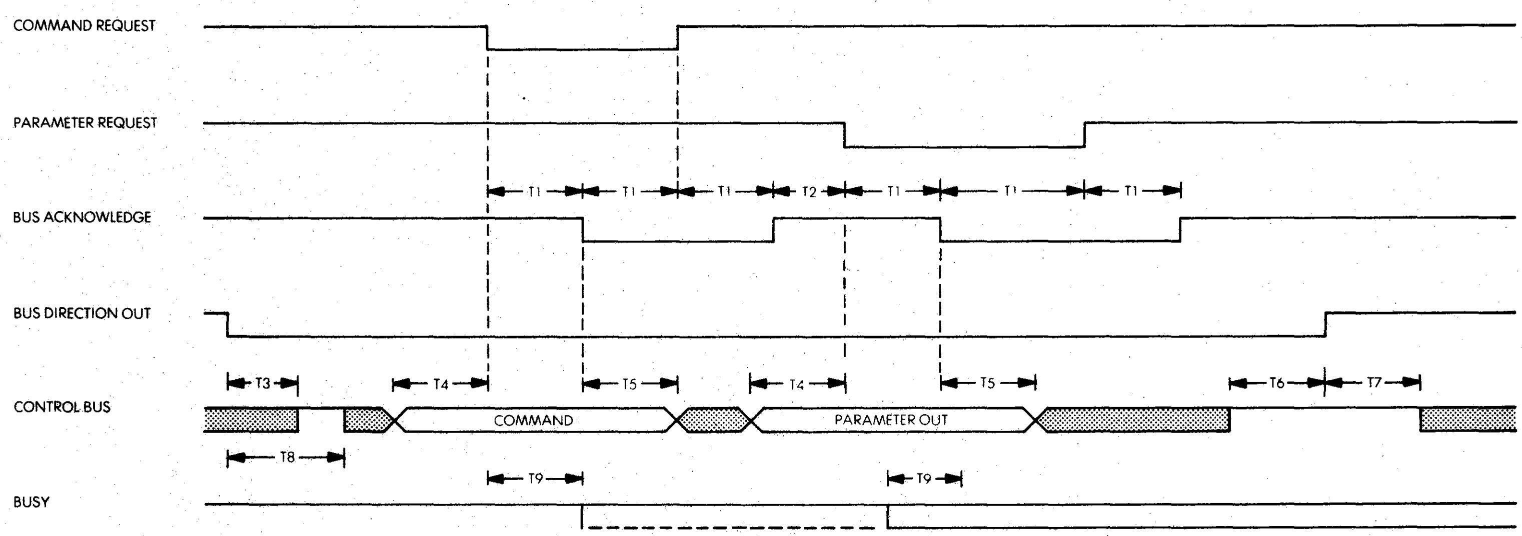
The read timing is shown in Figure 19-7.

19.5 WRITE TIMING

The write timing is shown in Figure 19-8. The Write Clock is generated in the controller from the Reference Clock. The delay time from the Reference Clock to Write Clock is a function of cable length and circuit delays. The phase difference between the two signals is constant during the complete write operation. The Write Data and Write Clock signals are synchronized as shown in Figure 19-8. The Read Data is static during a write operation.

19.6 READ ADDRESS MARK TIMING, AND WRITE ADDRESS MARK TIMING

The Read Address Mark timing is shown in Figure 19-9. The Write Address Mark timing is shown in Figure 19-10.



NOTES:

FUNCTION	TIMING* MIN	MAX
T1 = HANDSHAKE RESPONSE TIME	0	10**
T2 = SPACING	0	10**
T3 = DISK DRIVE CONTROL BUS RELEASE TIME	0	100
T4 = CONTROL BUS DATA SETUP TIME	100	
T5 = CONTROL BUS DATA HOLD TIME	0	
T6 = CONTROLLER CONTROL BUS RELEASE TIME	100	
T7 = DISK DRIVE CONTROL BUS ACCESS TIME	0	
T8 = CONTROLLER CONTROL BUS ACCESS TIME	100	
T9 = BUSY SETUP TIME	0**	

*T1 AND T2 TIMING IS IN MILLISECONDS. ALL OTHER VALUES ARE IN NANOSECONDS.
**THIS VALUE IS VALID ONLY IF THE BUSY SIGNAL IS NOT TRUE (LOW) AT THE BEGINNING OF A COMMAND SEQUENCE.

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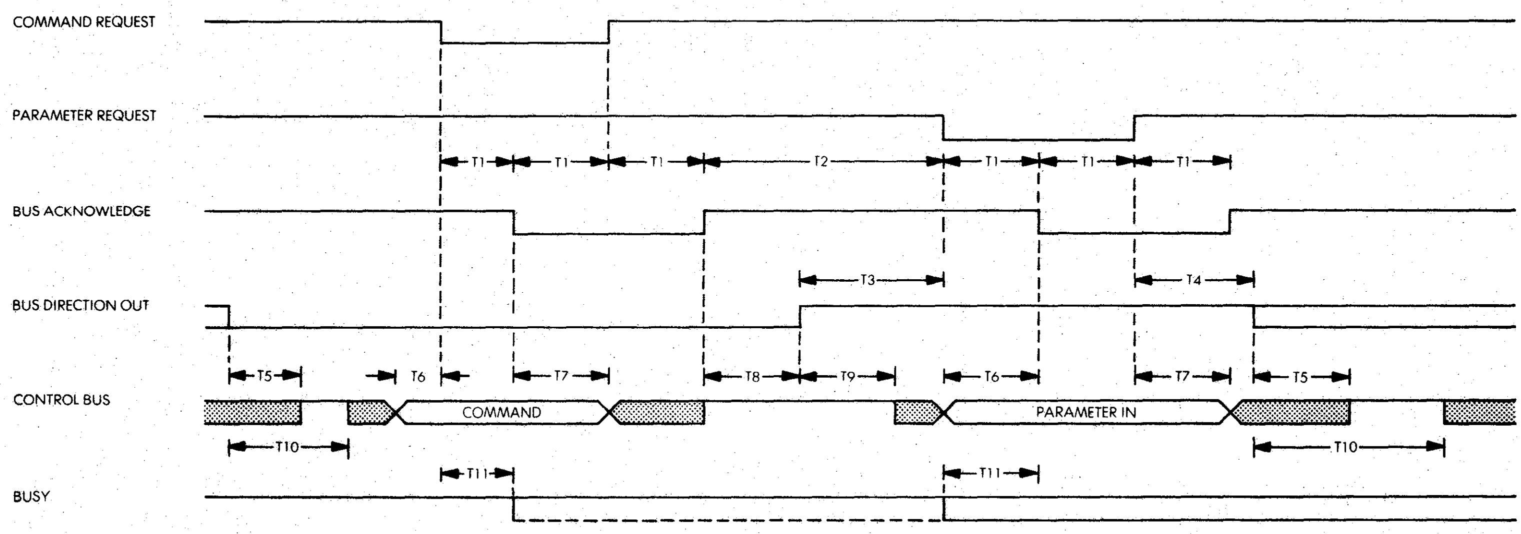
Figure 19-3. Command/Parameter-Out Sequence



NOTES:

FUNCTION		TIMING* MIN	MAX
T1	= HANDSHAKE RESPONSE TIME	0	10**
T2	= SPACING	0	10**
T3	= BUS DIRECTION OUT SETUP TIME	100	—
T4	= BUS DIRECTION OUT HOLD TIME	0	—
T5	= DISK DRIVE CONTROL BUS RELEASE TIME	0	100
T6	= CONTROL BUS DATA SETUP TIME	100	—
T7	= CONTROL BUS DATA HOLD TIME	0	—
T8	= CONTROLLER CONTROL BUS RELEASE TIME	100	—
T9	= DISK DRIVE CONTROL BUS ACCESS TIME	0	—
T10	= CONTROLLER CONTROL BUS ACCESS TIME	100	—
T11	= BUSY SETUP TIME	0**	—

*T1 AND T2 TIMING IS IN MILLISECONDS. ALL OTHER VALUES ARE IN NANOSECONDS.
**THIS VALUE IS VALID ONLY IF THE BUSY SIGNAL IS NOT TRUE (LOW) AT THE BEGINNING OF A COMMAND SEQUENCE.

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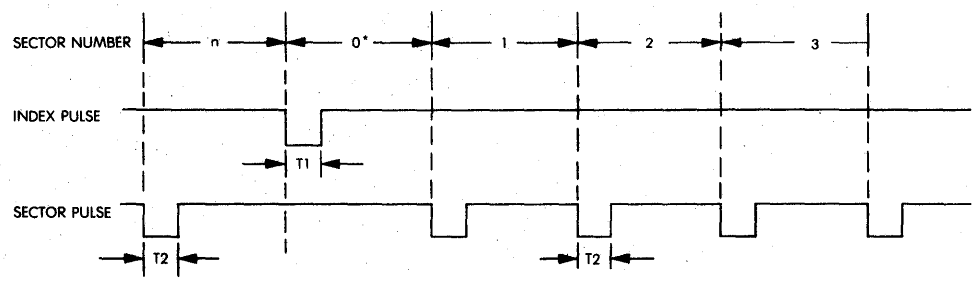
Figure 19-4. Command/Parameter-In Sequence



NOTES:

1. *THE FIRST SECTOR, SECTOR ZERO, IS 3.72 MICROSECONDS LONGER THAN THE REST OF THE SECTORS. ALL OTHER SECTORS ARE EQUAL IN LENGTH.

2.

FUNCTION	TIMING (MICROSECONDS) MIN	MAX
T1 = INDEX PULSEWIDTH	2.2	2.8
T2 = SECTOR PULSEWIDTH	1.0	1.5

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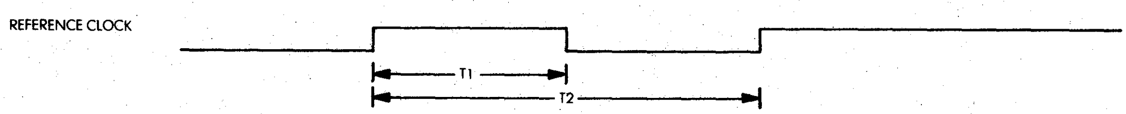
Figure 19-5. Index/Sector Timing (Hard Sectoring)

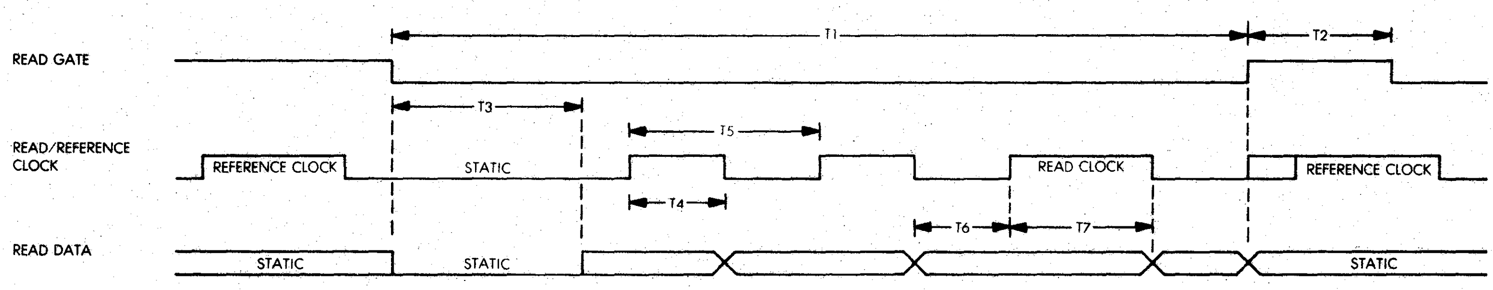


NOTES:

FUNCTION	TIMING (NANOSECONDS) MIN	MAX
T1 = REFERENCE CLOCK ACTIVE TIME	0.4 × TP	0.6 × TP
T2 = REFERENCE CLOCK PERIOD	0.95 × TP	1.05 × TP
TP = NOMINAL REFERENCE CLOCK PERIOD, 103.4 NSEC		

3437

Figure 19-6. Reference Clock Timing

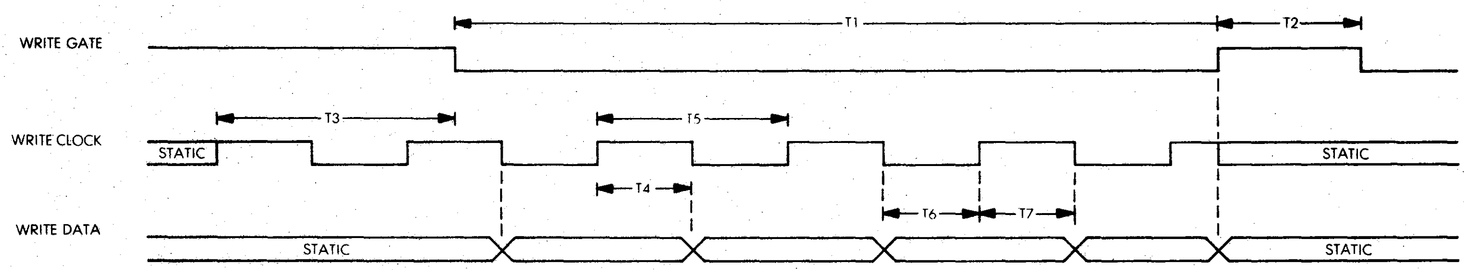


NOTES:

FUNCTION		TIMING (NANOSECONDS) MIN	MAX
T1	= READ GATE TRUE (LOW)	0	—
T2	= READ GATE FALSE (HIGH)	2 × TP	—
T3	= READ GATE TO VALID READ DATA AND READ CLOCK	64 × TP	
T4	= READ CLOCK ACTIVE TRUE (LOW) TIME	0.4 × TP	0.6 × TP
T5	= READ CLOCK PERIOD	0.95 × TP	1.05 × TP
T6	= READ DATA SETUP TIME	0.25 × TP	—
T7	= READ DATA HOLD TIME	0.25 × TP	—
TP	= NOMINAL REFERENCE CLOCK PERIOD		

3438

Figure 19-7. Read Timing



NOTES:

FUNCTION	TIMING (NANOSECONDS) MIN	TYP	MAX
T1 = WRITE GATE TRUE (LOW)	0		
T2 = WRITE GATE FALSE (HIGH)	88 × TP		
T3 = WRITE CLOCK VALID	TP		16 × TP
T4 = WRITE CLOCK TRUE (LOW) TIME	0.4 ×		0.6 × TP
T5 = WRITE CLOCK PERIOD		TP	
T6 = WRITE DATA SETUP TIME	0.25 × TP		
T7 = WRITE DATA HOLD TIME	0.25 × TP		
TP = NOMINAL REFERENCE CLOCK PERIOD			

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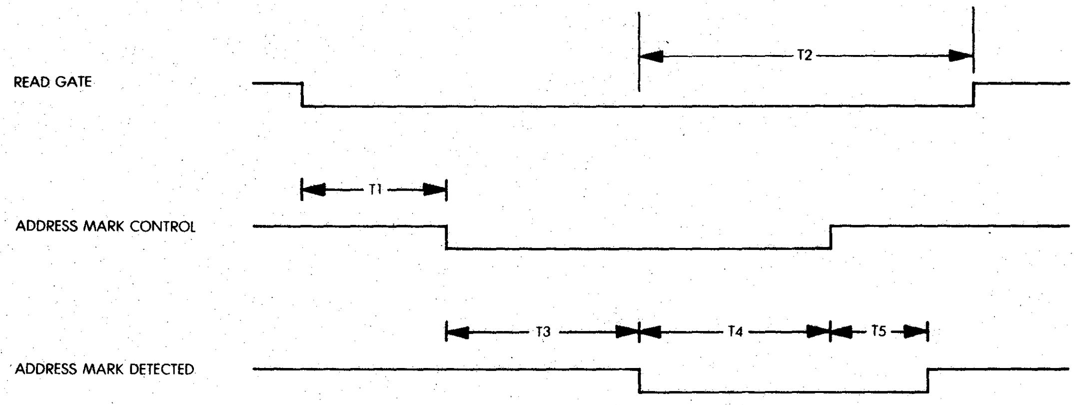
Figure 19-8. Write Timing



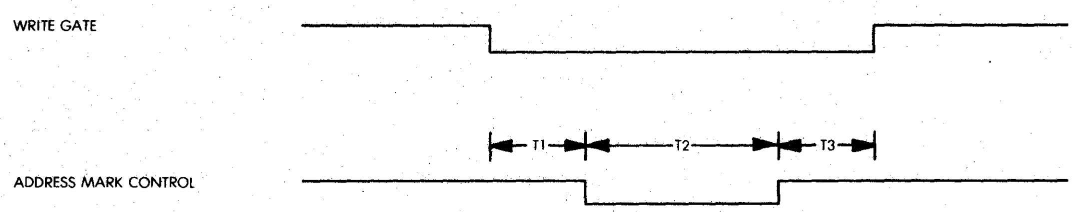
NOTES:

FUNCTION	TIMING (NANOSECONDS) MIN	MAX
T1 = READ GATE SETUP TIME	0	100
T2 = READ GATE HOLD TIME	88 × TP	—
T3 = ADDRESS MARK CONTROL SETUP TIME	24 × TP	—
T4 = ADDRESS MARK CONTROL HOLD TIME	0	—
T5 = ADDRESS MARK DETECTED HOLD TIME*	0	100
TP = NOMINAL REFERENCE CLOCK PERIOD		

*THIS HOLD TIME APPLIES TO THE EARLIEST LOSS OF READ GATE OR ADDRESS MARK CONTROL.

3440

Figure 19-9. Read Address Mark Timing



NOTES:

FUNCTION	TIMING (NANOSECONDS) MIN	MAX
T1 = WRITE GATE SETUP TIME	0	
T2 = ADDRESS MARK CONTROL WIDTH	24 × TP	
T3 = WRITE GATE HOLD TIME	0	
TP = NOMINAL REFERENCE CLOCK PERIOD		

3441

Figure 19-10. Write Address Mark Timing