LIGHTNING

Design Guide

May, 1994

Revision A

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Section 1 Background Information

1.1 General Description

Lightning is a family of 1 inch high 3.5-inch rigid disk products with capacities of 366 MB and 732 MB. Both SCSI and AT interfaces will be available.

Description	# of Disks	# of Data Surfaces	Capacity
1" SCSI	1	2	366.04MB
1" AT	1	2	365.28MB
1" SCSI	2	4	732.08 MB
1" AT	2	4	730.27 MB

Table 1-1. Summary of Lightning product line

1.2 Basic Development Assumptions

The need to bring Lightning to market within a critical "time window" dictates that Fast Cycle Time methods be used in the product development.

Manufacturing will be done by MKE in Japan, lowering process risk and improving cost competitiveness.

1.2.1 Top Development Priorities

1) Meet capacity point: 365 MB formatted per disk.
2) Time to Market: full specification evaluations by January 1994.
3) Low cost: Meet cost target of < $130 BOM cost at mass pro start.
4) Performance: 10 ms seek.
5) Reliability: same component count as Thunderbolt.
6) Sound: < 4.2 Bels at idle.
7) Power: < 3.2 Watts at idle.

1.2.2 Top Development Risks

1) Making the servo function at 4000 TPI with adequate TMR.
2) Getting the Read Channel to operate at 48.2 Mb/sec.
3) 5 μm heads are not in production at any vendor, process control is difficult.
4) Reducing Seek time to 10 ms for Reads and 12 ms for Writes without mechanical changes.
5) Reducing the idle audible noise to 4.2 Bels.
6) Increasing landing zone so that the head over the innermost track will be clear of head slap footprint.

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Section 2 Specifications

This section provides the physical, electrical, and environmental specifications for the Lightning 365/730 MB hard disk drive.

2.1 General Specification

Specifications	365 MB	730 MB
Interface	AT/SCSI	AT/SCSI
Spindle Speed	4501.80 RPM	4501.80 RPM
Interface Transfer Rate	AT PIO 6MB/Sec DMA up to 13MB/Sec SCSI Asynch 5MB/Sec Synch 10MB/Sec	AT PIO 6MB/Sec DMA up to 13MB/Sec SCSI Asynch 5MB/Sec Synch 10MB/Sec
Servo Method	Embedded	Embedded
Average Seek Time (Read on Arrival)	10 ms	10 ms
Formatted Data	366.04 MB	732.08 MB
ID Radius	0.8310 in (21.107 mm)	0.8310 in (21.107 mm)
OD Radius	1.7992 in (45.7 mm)	1.7992 in (45.7 mm)
Stroke	0.9682 in (25.592 mm)	0.9682 in (25.592 mm)
Code	1,7	1,7
Cylinders	3,673	3,673
User Data Cylinders	3,658	3,658
Tracks per Inch	3,794	3,794
AT Capacity	365.28 MB	730.27 MB
AT Sectors	49	63
AT Logical Cylinders	910	1415
AT Logical Heads	16	16
AT Logical Sectors	49	63
Spare Sectors (per cylinder)	1	2
Total User Sectors	716,470	1,432,940
Data Tracks	7,346	14,692
Flux Changes per Inch (max.)	47,636	47,636
Disks	1	2
Heads	2	4
Zones	16	16
DisCache Buffer Size	96 KByte	96 KByte
ECC	112 bit RS w/ Cross Check	112 RS w/ Cross Check

Table 2-1. General Specifications for the Lightning Drives

2.2 Timing Parameters

	Typical Nominal[1]	Maximum Worst Case
Sequential Cylinder Switch Time[2]	N/A	5.0 ms
Sequential Head Switch Time[3]	N/A	4.0 ms
Random Average (Read or Seek)	11 ms	12 ms
Random Average (Write)	13 ms	14 ms
Full Stroke Seek	19 ms	21 ms
Average Rotational Latency	6.67 ms	
SCSI "Hard" Reset Time[4]	150 ms	
Power On[5] to Drive Ready[6]	12 sec	
Power On to Interface Ready[7]	TBD sec	
Shutdown[8] to Interface Ready	8 sec	
Spin down Time	8 sec	

Table 2-2. Timing Specifications

Notes for Table 2-2.

Quoted seek times include head settling time, but does not include command overhead time or rotational latency.

1. Nominal conditions are defined as 25°C ambient, nominal supply voltages and no applied shock or vibration. Worst case conditions are defined as worst case extremes of "operating" temperature, humidity, and supply voltages.

2. Sequential Cylinder Switch Time is the time from the conclusion of the last sector of a cylinder to the beginning of the first logical sector on the next cylinder.

3. Sequential Head Switch Time is the time from the conclusion of the last sector of a track to the beginning of the first logical sector on the next track of the same cylinder.

4. SCSI "Hard" Reset Time is from SCSI Reset to Selection time.

5. Power On is the time from when the supply voltages reach operating range to the drive being able to accept any command.

6. Drive Ready is when the drive is in the mode with the disks spinning at rated speed, the drive is able to accept and execute commands requiring disk access without further delay.

7. Interface Ready is the mode where the drive is ready to accept any command.

8. Shutdown is the mode where the microprocessor is powered, but not the HDA. When the system sends the drive a shutdown command the drive parks the heads off the data zone and spins down to complete stop.

2.3 Disk Errors

Error Type	
Uncorrected Read Errors[1]	1 Event per 10^8 bits read
Recovered Errors[2]	1 Event per 10^{10} bits read
Double Burst Recovered Errors[3]	1 Event per 10^{12} bits read
Unrecovered Read Errors[4]	1 Event per 10^{14} bits read
Transferred[5]	1.123 e-24
Seek Errors[6]	1 Error per 10^6 seeks

Table 2-3. Error Types and Rates.

Notes to Table 2-3:

1. Uncorrected Read Errors are those read errors with Read on arrival, ECC on the fly and retries are disabled. It's to monitor manufacturing process only.

2. Recovered Read Errors are those which require retries for data correction. Errors corrected by ECC on the fly are not considered recovered read errors. Read on arrival is disabled to meet this specification.

2. Double Burst Recovered Errors are those read errors that require the double burst error correction algorithm to be applied for data correction. This correction is typically applied only after the programmed retry count is exhausted.

3. Unrecovered Read Errors are those that are not correctable using an error correcting code (ECC) or retries. The drive terminates retry reads either when a repeating error pattern occurs or after eight unsuccessful retries and application of double burst error correction.

4. Transferred errors are actually the ones that matter to customers, since they are the ones that are not detected and subsequently corrected by the drive.

5. A seek error occurs when the actuator fails to reach or remain on the requested cylinder, or the drive requires the execution of the full recalibration routine to locate the requested cylinder.

6. A seek error occurs when the actuator fails to reach or remain on the requested cylinder, or the drive requires the execution of the full recailbration routine to locate the requested cylinder.

For further explanation of terms and more detailed information regarding how these numbers were arrived at, please see Section 15.2, ECC.

2.4 Power Requirements

Lightning 365/730 hard disk drive operates using two supply voltages:

+12 V ±10%
+5 V ±5%

The allowable ripple and noise for each voltages:

+12 V	250 mV P-P	60 Hz - 100 MHz
+5 V	150 mV P-P	60 Hz - 100 MHz

2.4.1 Power Sequencing

No damage of loss of data will occur if power is applied or removed in any order or manner, except that data may be lost in the sector being written at the time of a power loss. This includes shorting out or opening up either voltage or return line, and transient voltages of **+10% to -100%** from nominal, while powering up or down.

2.4.2 Power Reset Limits

When powering up, the drive will remain reset (inactive) until both V_{HT} reset limits are exceeded. When powering down, the drive will become reset when either supply voltage drops below the V_{LT} threshold.

Power On Reset (POR) Thresholds

DC Supply	5 V	12 V
V_{LT}	4.65 V (max.)[1] 4.29 V (min.)	10.60 V (max.)[1] 9.37 V (min.)
V_{HT}	4.75 V (max.) 4.29 V (min.)	10.83 V (max.) 9.36 V (min.)
Hysteresis	50 mV (min.)	14 mV (min.)

Table 2-4. Power Reset Limits

Notes to Table 2-4.

1. Includes a 100 mV Peak to Peak ripple on +5 V or 250 mV Peak to Peak ripple on +12 V to maximize or minimize values.

2.4.3 Drive Power Dissipation

1 Disk Power Requirements

Mode of Operation	Maximum Average Current (mA) +12 V	Typical Average Current (mA) +12 V	Maximum Average Current (mA) +5 V	Typical Average Current (mA) +5 V	Maximum Average Power (Watts)	Typical Average Power (Watts)
Start up[1]	943	918	484	469	13.7	13.4
Idle[2]	210	170	224	214	3.6	3.1
Read/ Write/ Seek[3]	293	257	435	422	5.7	5.2
Max. Seeking[4]	428	391	365	352	7.0	6.5
Standby[5]	TBD	TBD	TBD	TBD	TBD	TBD
Read/ Write (On Track)[6]	205	168	486	469	4.9	4.4

Table 2-5. 365 MB Power Dissipation in Various Modes.

2 Disk Power Requirements

Mode of Operation	Maximum Average Current (mA) +12 V	Typical Average Current (mA) +12 V	Maximum Average Current (mA) +5 V	Typical Average Current (mA) +5 V	Maximum Average Power (Watts)	Typical Average Power (Watts)
Start up[1]	980	924	505	476	14.29	13.47
Idle[2]	262	216	231	215	4.3	3.68
Read/ Write/ Seek[3]	339	302	449	428	6.32	5.76
Max. Seeking[4]	475	436	374	356	7.57	7.01
Standby[5]	TBD	TBD	TBD	TBD	TBD	TBD
Read/ Write (On Track)[6]	250	213	502	476	5.51	4.94

Table 2-6. 730 MB Power Dissipation in Various Modes.

Notes for Tables 2-5 and 2-6.

1. START UP: Peak current with duration of 10 microseconds or greater.
2. IDLE is when the drive is not reading, writing, or seeking; but the motor is up to speed and DRIVE READY condition exists. Actuator is residing on last track accessed.

3. READ/WRITE/SEEK is when data is being read from or written to the disk. The head is assumed to be on-track. Implies no more than 40% of the time is spent seeking, 30% reading, and 30% writing.

4. MAX. SEEKING is for continues random seek operations with no controller delay.

5. STANDBY is when the motor is stopped, actuator parked, and all electronics except the interface control is in the sleep state. STANDBY will occur after a programmable time-out since the last host access occurs. Drive Ready and Seek Complete status exists. The drive will leave STANDBY upon receipt of a command which requires disk access or upon receipt of a spin-up command.

6. READ/WRITE ON TRACK is for 50% read operations and 50% write operations on a single physical track.

7. MAXIMUM AVERAGE CURRENT: Mean plus 3 Standard Deviations.

8. Power requirements reflect nominal values for +12V and +5V power supplies and do not include power required for the SCSI termination resistors.

9. Current is RMS (except for START UP).

2.4.4 Power Budget

Idle Mode (Track Follow Mode)

Function	Typical Power (mW)
KONI	430
DRAM	15[1]
MOTOR/VCM/POR	745
READ/WRITE	100
PRE-AMP[2]	15[2]
MOTOR	1680
MICROPROCESSOR	400
Total	3385

Table 2-7. Power Budget in Track Follow Mode.

Notes for Table 2-7.

1. DRAM is in refresh mode.

2. Pre-amp power applied for 9/166 duty cycle.

Read/Write Mode

Function	Typical Power (mW)
KONI	550
DRAM	400
MOTOR/VCM/POR	745
READ/WRITE	750
PRE-AMP	275
MOTOR	1680
MICROPROCESSOR	400
Total	4,800

Table 2-8. Power Budget in Read/Write Mode.

2.5 Environmental

2.5.1 Environmental Conditions

The drive will meet all of its operating performance specifications when operated within its operating environment and will not sustain any damage or permanent performance degradation when subject to the non-operating environment. Where applicable, SI units as well as American Standard units have been given.

Parameter	Operating	Non-Operating
Temperature	0°C to 55°C -32°F to 131°F	-40°C to 65°C -40°F to 149°F
Temp. Gradient	24°C/Hr. Maximum	48°C/Hr. Maximum
Humidity[1]	5% to 85% RH	5% to 95% RH
Max. Wet Bulb Temp.	40°C 104°F	46°C 114.8°F
Humidity Gradient	30% per Hour	30% per Hour
Altitude[2]	-650 to 10,000 ft. -198.12 to 3,048 m	-650 to 40,000 ft. -198.12 to 12,192 m
Altitude Gradient	1.5 k Pa/min.	8 k Pa/min.
Shock No Soft Error No Un-Recovered Errors	 6.0 G's, 11 msec 10.0 G's, 11 msec 1/2 sine 18.0 G's, 3 msec 1/2 sine	 60.0 G's, 11 msec 1/2 sine
Vibration	1.0 G P-P 5-300 Hz 0.5 G P-P 300-500 Hz	2.0 G P-P 5-500 Hz

Table 2-9. Environmental Specifications

Notes for Table 2-9.

1. Humidity figures do not take condensation into account. See Appendix C for humidity charts for low and medium temperatures.
2. Altitude is relative to sea level.

2.5.2 Electromagnetic Conditions

2.5.2.1 EMI/RFI Susceptibility

4 Volts per meter over a range from 20 Hz to 20 MHz.

2.5.2.2 Electrostatic Discharge

The drive shall maintain normal functional operation when subjected to electrostatic discharges from a 150 pF capacitor discharged through a 150 ohm resistor to any part of the face plate at a rate not to exceed 1 discharge every 30 seconds.

0 - 10 KV	Average of <0.3 soft errors per discharge.
10 - 25 KV	No catastrophic failures.

2.5.2.3 Sensitivity to Magnetic Fields

The drives will meet all specifications with less than 6 Gauss field applied in any orientation.

2.6 Mechanical Dimensions

Height	1.00 in	(25.4 mm)
Length	5.75 in	(146.1 mm)
Width	4.00 in	(101.6 mm)
Weight	<1.2 lb.	

2.7 Acoustics

This will be measured in an anechoic chamber, with a background noise less than 30 dbA.

Sound Pressure

	Measured Noise	Distance	No. of Samples
Idle on Track	33 dbA (Average	1 meter	20 (min.)[1]
	36 dbA (Mean + 3 sigma)	1 meter	1[1]
Seeking Random	40 dbA (Average)	1 meter	20 (min.)[1]
	45 dbA (Mean + 3 sigma)	1 meter	1[1]

Table 2-10. Acoustical Specifications (Sound Pressure)

Notes for Table 2-10.

1. Distributions for the 1 Disk and 2 Disk should be determined separately.
2. With no prominent discrete tones. Prominent discrete tones are defined here as the frequency bands (in the 1/3 octave bands) which have a db level higher than the average of the two adjacent bands by more than 5 db.

Sound Power

	Measured Noise 1 Disk	2 Disk
Idle on Track	4.0 bels (Average)	4.0 bels (Average)
	4.2 bels (max.)	4.2 bels (max.)
Seeking Random	4.8 bels (Average)	4.8 bels (Average)
	5.0 bels (Mean + 3 sigma)	5.0 bels (Mean + 3 sigma

Table 2-11. Acoustical Specifications (Sound Power)

Notes for Table 2-11.

1. ISO 7779 and 3745 specifies sound power in bels. The relationship between bels and db for sound power is 1 bel = 10 db.

2.8 Reliability

MTBF[1] at 55°C (Bellcore Issue #3)	150,000 Power On Hours
MTBF[1] (Predicted Field)	300,000 Power On Hours
Component Life	5 Years
Start/Stops[2]	20,000

Table 2-12. Reliability Specifications.

Notes for Table 2-12.

1. The Quantum MTBF numbers represent MTBF predictions per TR-TSY-000332 issue #3 Bell-Core, Sept. 1990 and represents the minimum MTBF that Quantum or a customer would expect from a drive.

2. Determined at the HDA level in a 50°C 50% RH environment.

2.9 Hard Defects During Manufacture

During manufacturing and test, no drive will re-allocate more than 1 block/2 Megabytes with a maximum of 75 blocks per surface.

2.10 Connectors and Jumpers

2.10.1 AT I/O DC 3 IN 1 Power Connector (J1)

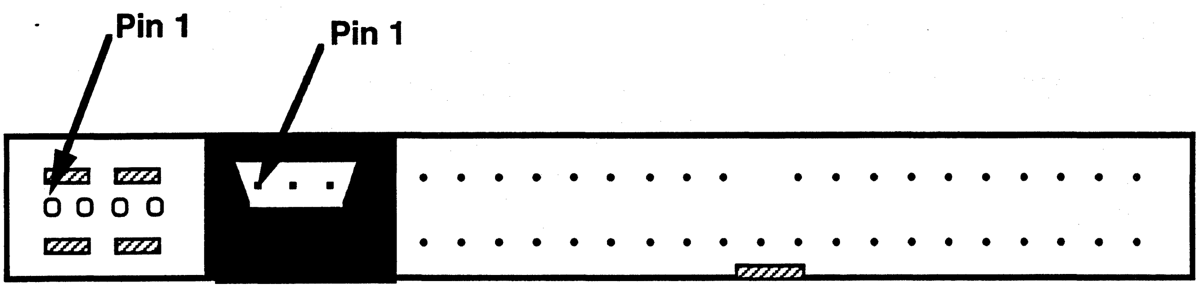

Figure 2-1. AT I/O DC 3 IN 1 Power Connector (J1).

Power Pin Numbers	
3 Pin Connector	
Pin 1	+5.0 V DC
Pin 2	+12.0 V DC
Pin 3	Ground
4 Pin Connector	
Pin 1	+12.0 V DC
Pin 2[1]	+12.0 V Return (Ground)
Pin 3[1]	+5.0 V Return (Ground)
Pin 4	+ 5.0 V DC

Table 2-13. 3 IN 1 Power Connectors Pin Assignments

Notes for Table 2-13:

1. Pins 2 and 3 are interconnected on the drive.

2.10.2 SCSI Power Connector (J1)

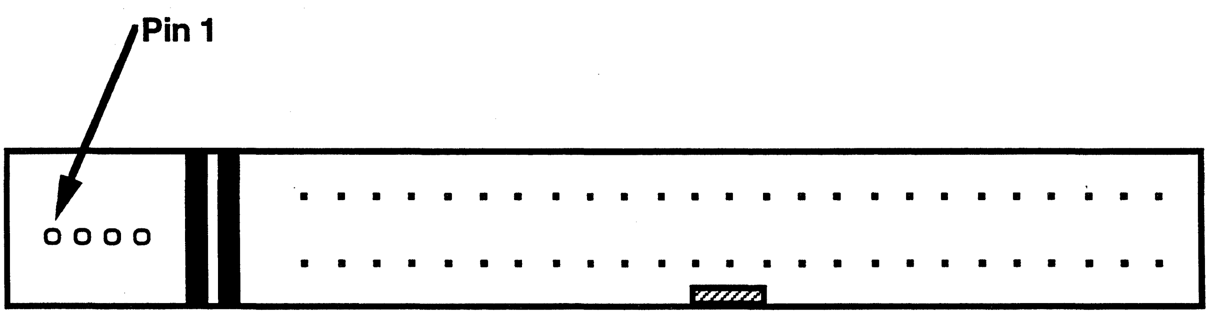

Figure 2-2. SCSI I/O DC Power Connector (J1).

4 Pin Connector	
Pin 1	+12.0 V DC
Pin 2[1]	+12.0 V Return (Ground)
Pin 3[1]	+5.0 V Return (Ground)
Pin 4	+ 5.0 V DC

Table 2-14. 4 Pin Power Connector Pin Assignments

Notes for Table 2-14:

1. Pins 2 and 3 are interconnected on the drive.

The Combination Power/Interface Connector (J1) is mounted on the back edge of the PCB. The recommended mating connector for the 4 Pin Power Connector is AMP P/N 1-480424-0 utilizing AMP Pins P/N VS 61117-4 (strip) or P/N VS 60619-4 (loose piece), or equivalent. For the 3 Pin Power Connector (AT only), the recommended mating connector is MOLEX P/N 5484 39-27-0032 or equivalent.

2.10.3 SCSI 5 Pin Control Connector (J5)

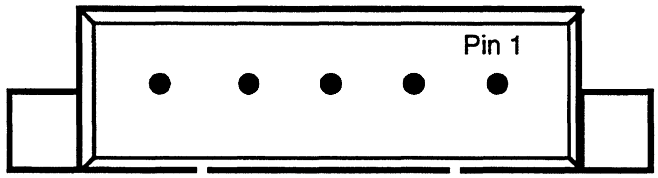

Figure 2-3. SCSI 5 Pin Connector (J5).

5 Pin Connector	
Pin 1	Ground
Pin 2	Address Bit 2
Pin 3	Address Bit 1
Pin 4	Address Bit 0
Pin 5	N/C (Reserved for future Spindle Sync)

Table 2-15. 5 Pin Connector Pin Assignments

Notes for Table 2-15:

1. The 5 Pin Connector is a remote ID selector for SCSI only.

The recommended mating connector for the 5 Pin Control Connector is MOLEX P/N 51021-0500, loose piece pins are MOLEX P/N 50058-8100, or equivalent.

2.10.4 2 Pin LED Connector (J2)

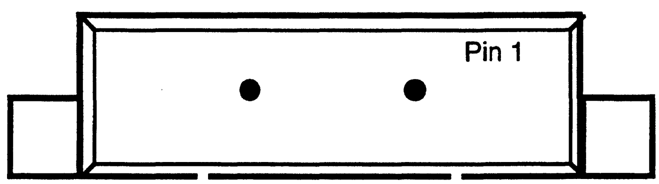

Figure 2-4. 2 Pin LED Connector (J2).

2 Pin Connector	
Pin 1	- LED
Pin 2	+ LED

Table 2.16. 2 Pin LED Connector Pin Assignments.

Notes for Table 2.16:

1. The 2 Pin LED Connector may be used to connect an external LED for monitoring drive activity.

The recommended mating connector for the 2 Pin LED Connector is MOLEX P/N 51021-200, loose piece pins are MOLEX P/N 50058-8100, or equivalent.

2.10.5 AT JUMPERS

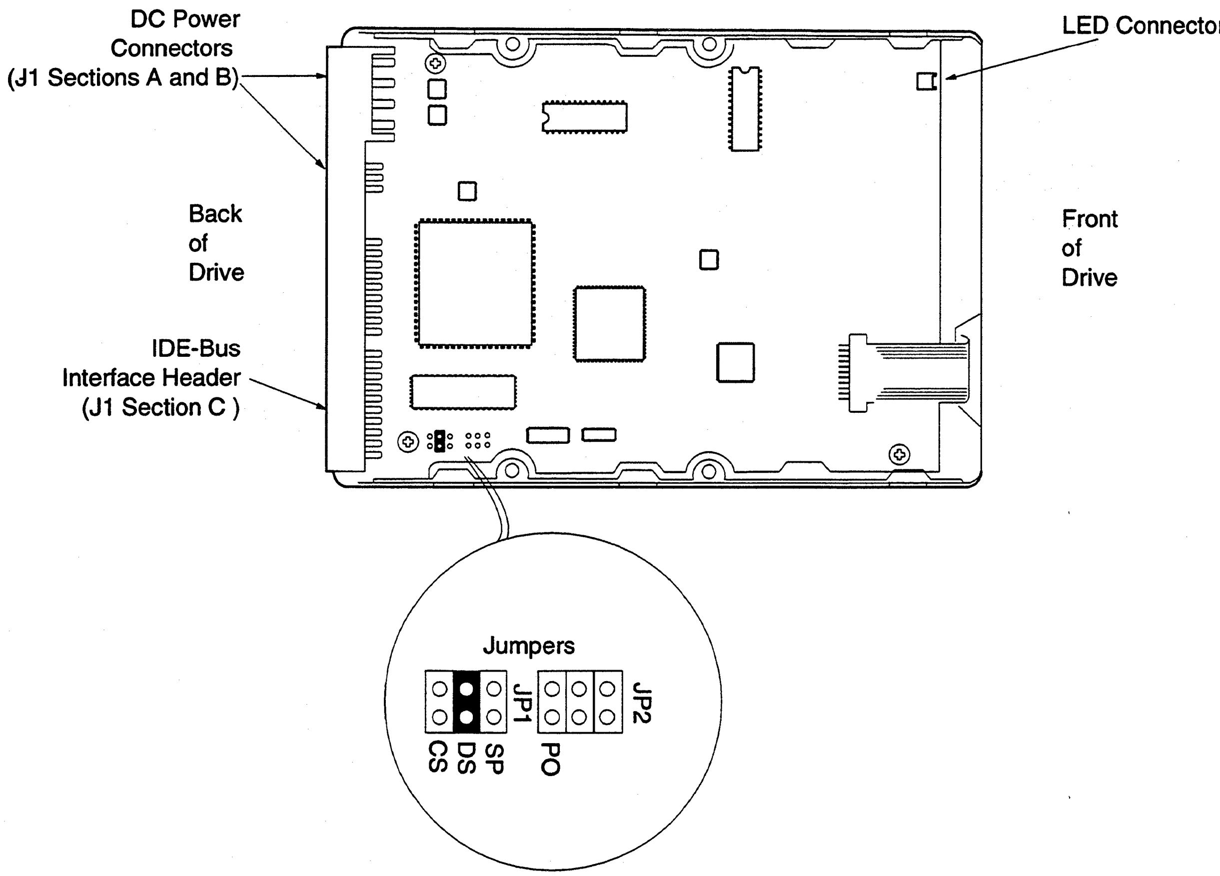

Figure 2-5. Jumper Locations on the AT PCB.

AT Jumper Definitions

CS	Cable Select
DS	Drive Select
SP	Slave Present
PO	Product Option

Table 2-17. AT Jumper Operational Modes.

2.10.5.1 Cable Select Jumper (CS)

When two hard disk drives are daisy-chained together, they can be configured as Master or Slave either by the CS or DS jumpers. Only one jumper may be used at a time. To configure the drive as a Master or Slave with the CS feature, the CS jumper is installed and the DS jumper is removed.

Once the CS jumper is installed, the drive is configured as a Master or Slave by the state of the Cable Select signal at pin 28 on the IDE Bus Connector. If pin 28 is grounded, the drive is configured as a Master. If pin 28 is high, the drive is configured as a Slave. In order to configure two drives in a Master/Slave relationship using the CS jumper, a cable must be used that provides the proper signal level at pin 28 of the IDE Bus Connector.

2.10.5.2 Drive Select Jumper (DS)

Also, two drives can be daisy-chained together on the IDE Bus by using the Drive Select (DS) jumper. If the DS jumper is installed, the CS jumper must be removed. To configure a drive as the Master (Drive 0), a jumper must be installed at the DS pins.

LIGHTNING AT 365/730 Drives are shipped from the factory with the DS jumper installed, that is configured as Drive 0. To configure a drive as Slave (Drive 1), the DS jumper must be removed.

2.10.5.3 Slave Present Jumper (SP)

In combination with the current DS or CS jumper setting, the Slave Present (SP) jumper enables one of the two following configurations:

a) When the drive is configured as a Master with the DS jumper installed or with the CS jumper installed and the Cable Select signal low (Ground), the SP jumper indicates to the drive that a Slave drive is present. The SP jumper should be installed on the Master drive only if the Slave drive does not use the Drive Active/Slave Present (DASP) signal to indicate its presence.

b) When the drive is configured as a Slave without the DS jumper installed, the SP jumper enables the self-seek test. When power is applied to the drive with the self-seek test enabled, the drive executes seeks in a butterfly pattern.

2.10.5.4 Product Option Jumper (PO)

This jumper is reserved for specific customer use, for normal IDE Master/Slave operation, do no install this jumper.

2.10.6 SCSI Jumpers

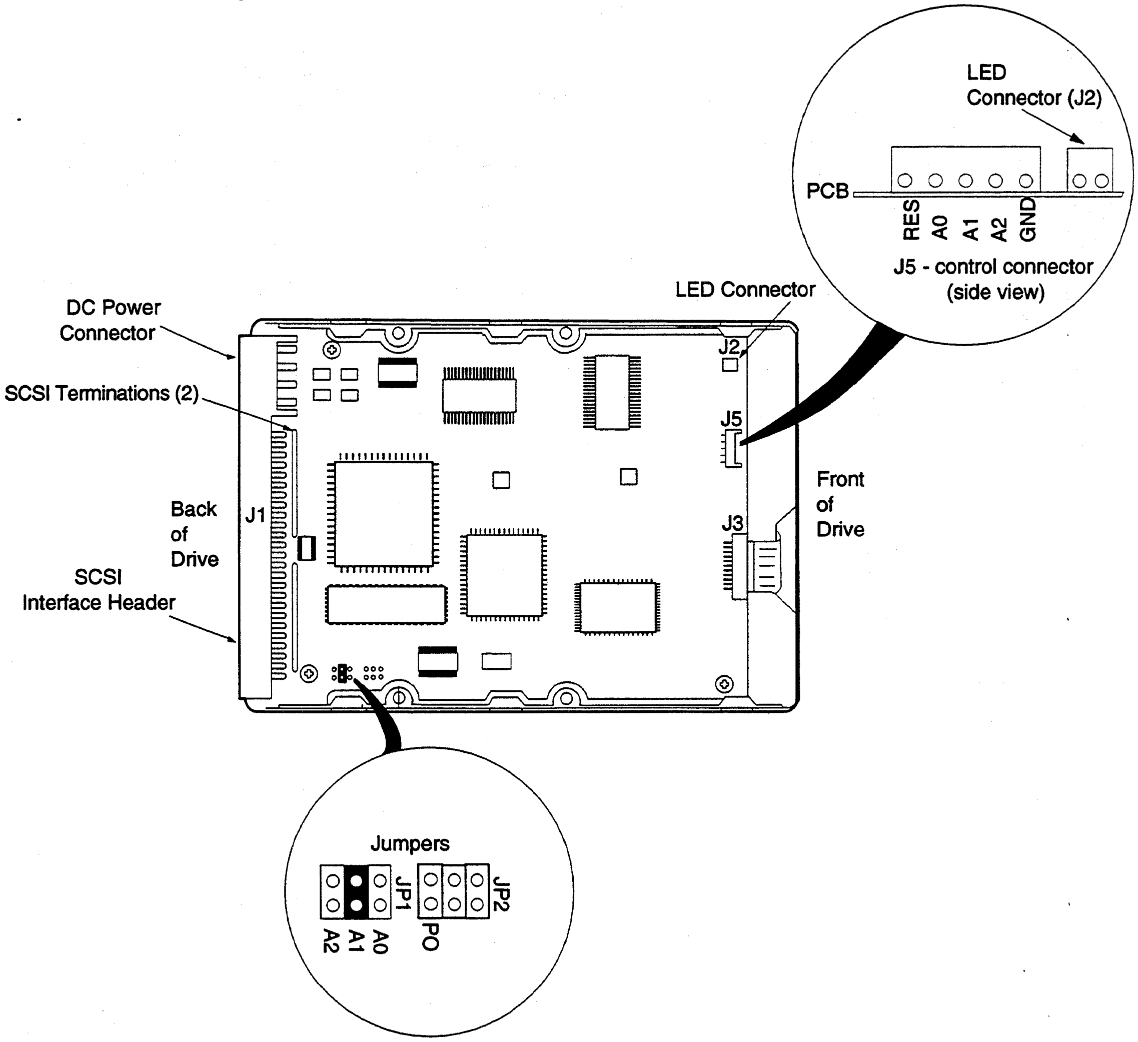

Figure 2-6. Jumper Locations on the SCSI PCB.

SCSI Jumpers

PO	Product Option
A2	Address Bit 2 (SCSI Bus Identification)
A1	Address Bit 1 (SCSI Bus Identification)
A0	Address Bit 0 (SCSI Bus Identification)

Table 2-18. SCSI Jumper Operational Modes

2.10.6.1 Product Option Jumper (PO)

With the PO jumper installed, one of the following functions can be controlled:

Wait Spin

Enable Parity

Self Seek

(For detail information, please see LPS 365/730 Product Manual.)

2.10.7 Connector and Jumper Location (Dimensions)

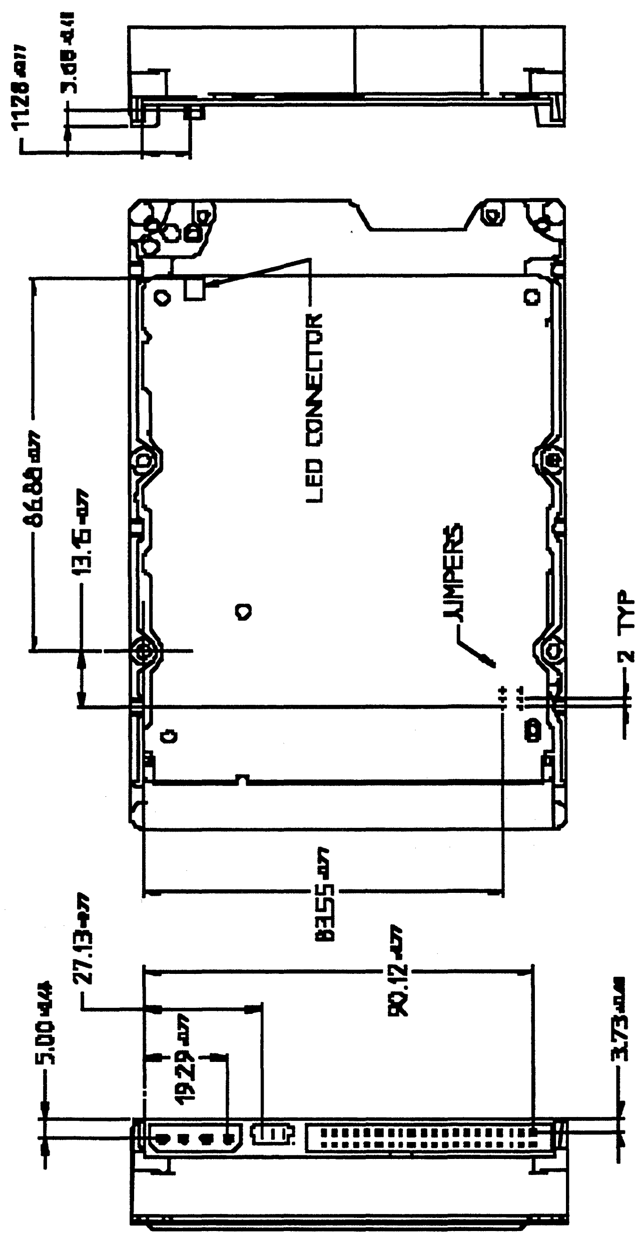

Figure 2-7. Connector and Jumper Locations.

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Section 3 Track Specifications

The Lightning Drives are shipped from the factory as "hard sectored" drives. That is, all physical sector addresses are written on the disks before the drives are shipped. As a result, sector size and number of sectors per track are not selectable. The information given in this section is the physical format of Lightning as it is defined at the factory prior to shipment.

Note that the physical format is in contrast to the logical format of the drive, which is how the drive appears to the host system.

3.1 Track Locations

	Nominal Gap Centerline	Outside Corner of Slider
Disk Edge Radius	1.8700	
Disk Chamfer Radius	1.8550	
Outermost OD Stop Compressed Radius	1.8505	1.8546
Nominal OD Stop Uncompressed Radius	1.8043	
Innermost OD Stop Uncompressed Radius	1.7992	
System Data (Cyl -15)	1.7992	
Zone 1 Outside Radius	1.7952	
Zone 15 Inside Radius	0.8310	
Media Certified Inner Radius	0.8100	
Outermost ID Stop Uncompressed Radius	0.7854	
Nominal ID Stop Uncompressed Radius	0.7815	
Innermost ID Stop Uncompressed Radius	0.7759	
Nominal ID Stop Compressed Radius	0.7415	
Innermost ID Stop Compressed Radius	0.7359	0.6630
Disk Clamp Outside Radius + Tolerance	0.6309	
Spindle Hub Radius + Tolerance (Flange)	0.6309	
Pivot to Spindle Distance	2.4000	
Head Arm Length to Center Gap	2.3410	

Table 3-1. Data Area Location.

The actuator sweeps out an angle of 25.8002° from crash stop to crash stop. This is measured from a line passing through the pivot and the geometric center of the slider gap. From the start of servos to the end of servos the minimum angle is 4.4490°.

LIGHTNING TRACK MAP: 3700 TPI + Air Latch

Disk Radius		Description
1.8700		Disk Outer Radius
1.8505		Outermost OD Stop Compressed
1.8443		Nominal OD Stop Compressed .040 in. Compression
	COMPRESS ZONE	
1.8043		Nominal OD Stop Uncompressed
1.7992		Innermost OD Stop Uncompressed
1.7951	15 System Tracks	First Data Track (gap ctr)

DATA ZONE 3567 Tracks

Disk Radius		Description
.8310		Last Data Track (gap ctr) - Air Latch
	1X LANDING ZONE	
.7854		Outermost ID Stop Uncompressed
.7815		.Nominal ID Stop Uncompressed .040 in. Compression
	COMPRESS ZONE	
.7415		Nominal ID Stop Compressed
.7359		Innermost ID Stop Compressed
.6630		Innermost Slider Corner
.6309	.032 CLEARANCE(worst case)	Spindle Flange Outer Radius

3.2 Track Format

Wedge (70 per Revolution)

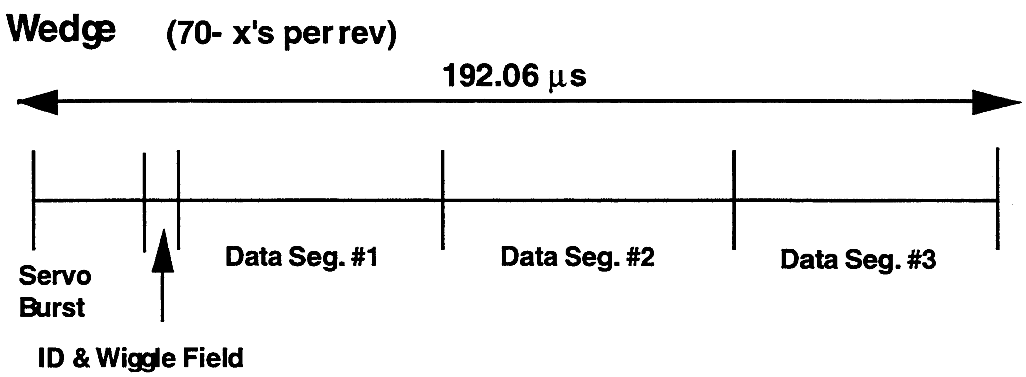


Figure 3-1. Track Wedge Format.

Servo Burst (12.40 s)

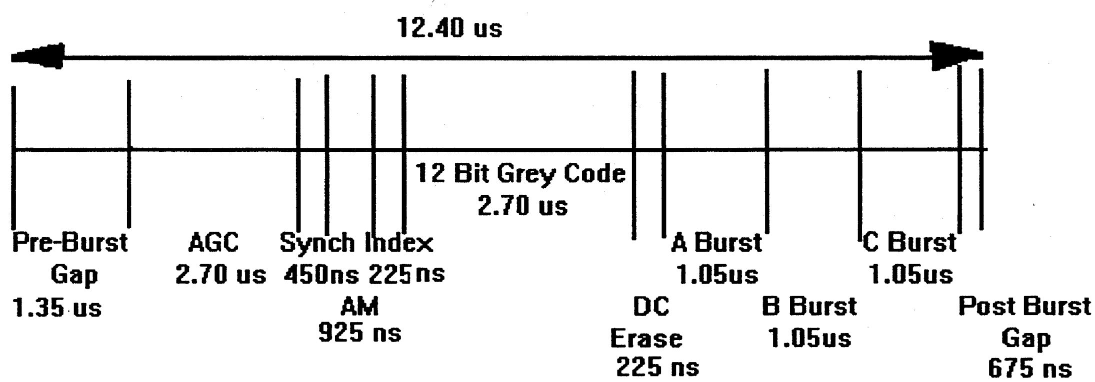


Figure 3-2. Servo Burst Format.

ID Field (26 Bytes)

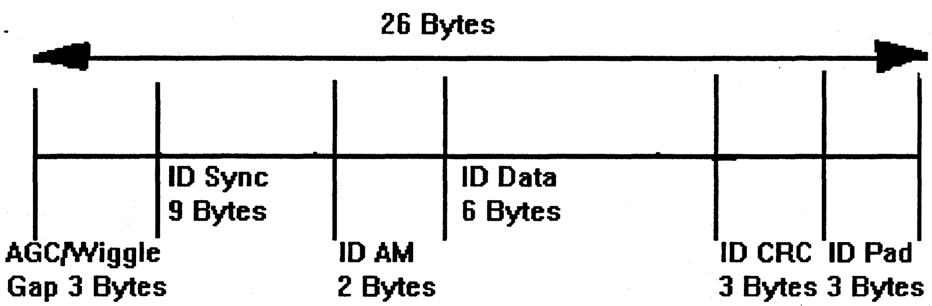


Figure 3-3. ID & Wiggle Field Format.

Data Segment (546 Bytes)

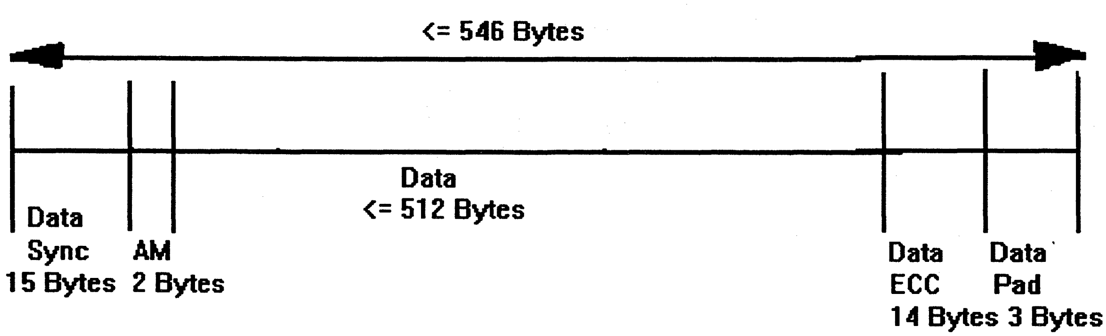


Figure 3-4. Data Segment Format.

Table 3-2. Lightning 365 Zone Specificatins

LIGHTNING Zone Specification

Zone Number	Zone Outside Radius	Zone Inside Radius	No. Cyl.	Sectors Per Track	Sectors Per Zone [1]	Bytes Per Sector	Sector Time uSec	Data Rate Mb/Sec	Write Clock (MHz)	Fmax (Sine) (MHz)	Tw/2 nSec
1	1.7952	1.6687	480	128	61440	512	92.47	47324	70.857	17.714	7.06
2	1.6687	1.5986	266	124	32984	512	95.33	45.82	68.732	17.183	7.27
3	1.5986	1.5306	258	120	30960	512	98.84	44.19	66.286	16.571	7.54
4	1.5306	1.4708	227	114	25878	512	103.84	42.07	63.099	15.775	7.92
5	1.4708	1.4065	244	109	26596	512	108.17	40.38	60.571	15.143	8.25
6	1.4065	1.3543	198	104	20592	512	112.41	38.86	58.286	14.571	8.58
7	1.3543	1.2918	237	99	23463	512	118.67	36.81	55.211	13.803	9.06
8	1.2918	1.2259	250	93	23250	512	125.58	34.78	52.174	13.043	9.58
9	1.2259	1.1690	216	89	19224	512	130.30	33.52	50.286	12.571	9.94
10	1.1690	1.1071	235	83	19505	512	139.83	31.24	46.857	11.714	10.67
11	1.1071	1.0356	271	81	21951	512	143.33	30.48	45.714	11.429	10.94
12	1.0356	0.9726	239	75	17925	512	153.02	28.54	42.817	10.704	11.68
13	0.9726	0.9189	204	71	14484	512	161.53	27.04	40.563	10.141	12.33
14	0.9189	0.8530	250	66	16500	512	171.03	25.54	38.310	9.577	13.05
15	0.8530	0.8311	83	64	5312	512	176.60	24.73	37.101	9.275	13.48

Notes for Table 3-2:

1. Does not include spare sectors, which is one per cylinder per disk.

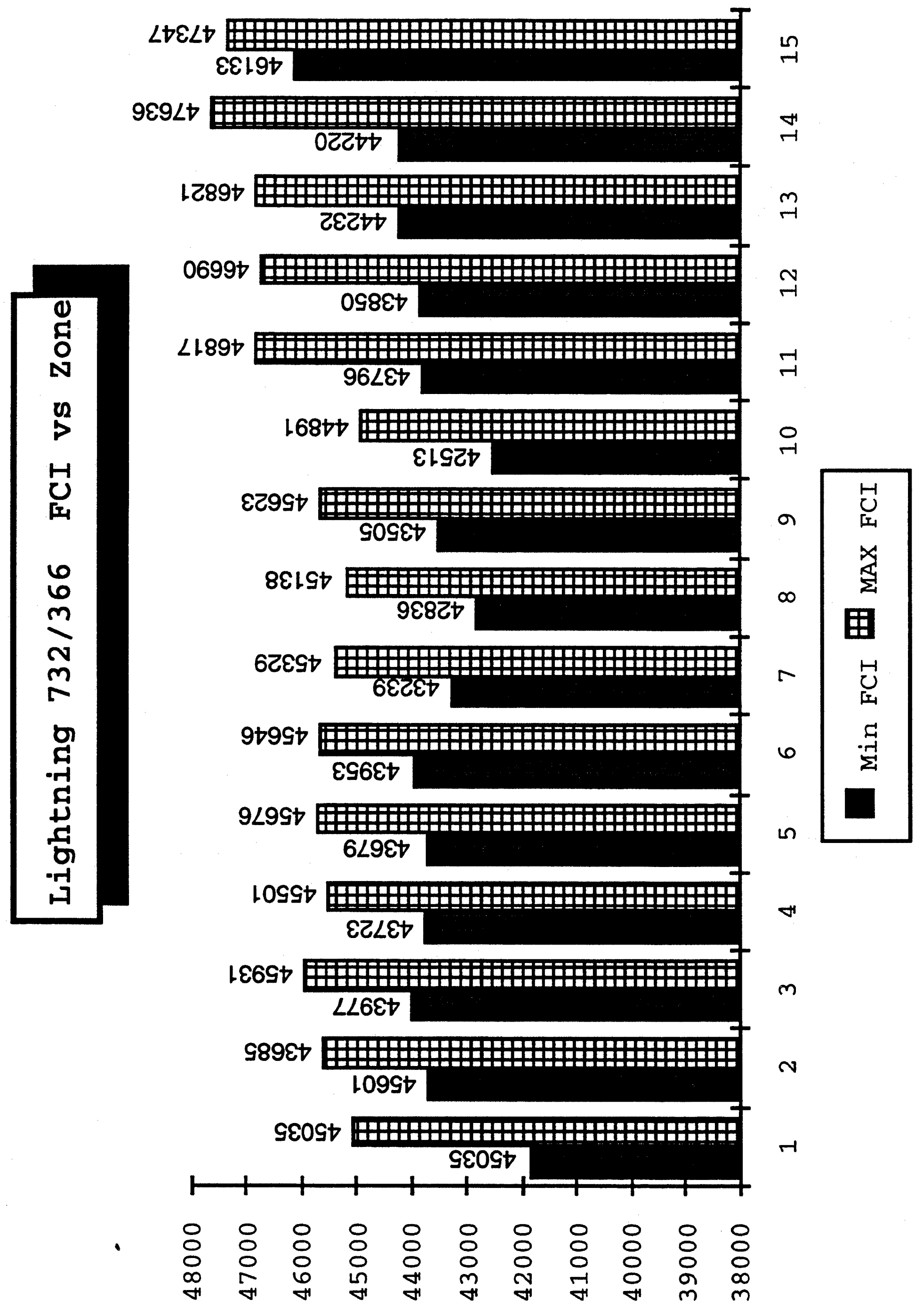


Figure 3-5. FCI per Zone

3.3 Cylinder Contents

Cylinder Contents	Zone[1]	Cylinder Range	Data Rate Mb/Sec	Sectors Per Track
Copy of Cylinder -4	System[2]	-5	37.14	100
DiskWare	System	-4	37.14	100
Copy of Cylinder -2	System	-3	37.14	100
System	System	-2	37.14	100
Test Equipment Data Error Logging	System	-1	37.14	100
User Data	1	0 to 479	47.24	128
	2	480 to 745	45.82	124
	3	746 to 1003	44.19	120
	4	1004 to 1230	42.07	114
	5	1231 to 1474	40.38	109
	6	1475 to 1672	38.86	104
	7	1673 to 1909	36.81	99
	8	1910 to 2159	34.78	93
	9	2160 to 2375	33.52	89
	10	2376 to 2610	31.24	83
	11	2611 to 2881	30.48	81
	12	2882 to 3120	28.54	75
	13	3121 to 3324	27.04	71
	14	3325 to 3574	25.54	66
	15	3575 to 3657	24.73	64

Table 3-3. Cylinder Contents Description.

Notes for Table 3-3:

1. System is outermost, then Zone 1 continuing in to Zone 15, the inner most zone.

2. Five cylinders on all drives are reserved for System, DiskWare, and Test usage. These cylinders contain drive configuration information, drive test information, and DiskWare. Customers cannot access these reserved cylinders. The reserved cylinders are only accessible with physical address commands which are protected diagnostic commands.

3. Data on cylinder -2 is repeated on cylinder -3, also cylinder -4 is repeated on cylinder -5. Data is read from and written to these areas according to firmware redundancy algorithms.

4. The test equipment cylinder is reserved for test equipment usage. This cylinder contains test parameters and data collected during production test. Writing on this cylinder may erase some important information and cause the drive to be rejected and sent back to the servo writer station.

The sector usage is as follows:

Sector	Usage
0	Servo writer test data.
1	Analog scan test data.
2	DiskWare station test data.
3	Post OP - Final test data.
4	Digital scan test data.
5	QA/DA test data.
6 - 13	Self scan results.
14 - 17	Self scan test parameters.
18	Error log.
19 - 26	Analog scan defect list.
27 - 34	Self scan defect list.
35 - 42	Digital scan defect list.
43	Reserved.
44 - 49	Self scan - PRO/NPRO results.
50 - 53	Servo defect map.
54 - 61	QA/DA defect list.
62	Self scan command history.
63 - 78	Self scan overlay (8K).
79 - 94	Not in use.
95 - 98	Reserved for in-line defect sparing.

5. The System cylinder is reserved for system usage. It contains mode page information, configuration information, defect lists, and format information for the drive. Writing on this cylinder may erase some important information and prohibit the drive from operating.

   The sector usage is as follows:

Sector	Usage
0	Saved mode select pages 1, 2, 20h, 37h, 38h, and 39h.
1	Saved mode select pages 3 and 4.
2 - 7	Configuration pages.
8 - 12	Working defect list.
13 - 17	Primary defect list .
18 - 22	Temporary defect list.
23 - 38	Format header bytes zone0-15.
39	Apple system sector for read/write of OS information.
40 - 59	Not in use.
60 - 94	Error log.
95 - 98	Reserved for in-line defect sparing.

6. The DiskWare cylinder is reserved for DiskWare usage. The data is repeated on cylinder -5.

   The sector usage is as follows:

Sector	Usage
0 - 63	DiskWare 16K + 2 *8K overlays. (32 +16 +16=64)
64 - 79	Self scan overlay number 2. (8K = 8*2= 16]
80 - 94	Not in use.
95 - 98	Reserved for in-line defect sparing.
35 - 42	Digital sacn defect list
43	Reserved.
44 - 49	Self scan - PRO/NPRO results.
50 - 53	Servo defect map.
54 - 61	QA/DA defect list.
62	Self scan command history.
63 - 78	Self sacn overlay (8K).
79 - 94	Not in use.
95 - 98	Reserved for in-line defect sparing.

3.4 Track and Cylinder Skewing

Since the Lightning drives are storage subsystems with integrated controllers, the function and design of the controller can be optimized specifically for the drive. One method of optimization employed by Quantum to improve data throughput is skewing sector addresses. The purpose of track and cylinder skewing is to minimize latency time and thus increase data throughput when data is sequentially accessed to or from the disk. The two types of skewing employed, track and cylinder skewing, are described below.

3.4.1 Track Skewing

Track skewing reduces latency time which results when the drive must switch read/write heads to access sequential data. A track skew is employed such that the next logical sector of data to be accessed will be under the read/write head once the head switch is made and data is ready to be accessed. Since head switch times are defined on Lightning, the sector addresses can be optimally positioned across track boundaries to minimize the latency time which results when a head switch has to be performed.

3.4.2 Cylinder Skewing

Cylinder skewing is also used on Lightning to minimize latency time during sequential accessing of data. However, instead of minimizing latency time due to head switching, as with track skewing, cylinder skewing is used to minimize latency time due to a single-cylinder seek. The next logical sector of data which crosses a cylinder boundary is positioned on the drive such that after a single-cylinder seek is performed, and the drive is ready to continue accessing data, the sector to be accessed is positioned directly under the read/write head. Therefore, the cylinder skew takes place between the last sector of data on the last head at a cylinder and the first sector of data on the first head at the next cylinder. Since single-cylinder seek times are defined on the drive, the sector addresses can be optimally positioned across cylinder boundaries to minimize the latency

Head Switch	**4 ms**	**RPM**	**4500.0**	**Worst Case:**	**(+0.9%)**
Single SEEK	**5 ms**	**Period**	**13.333 ms**		

Track and Cylinder Skewing

Zone #	Sect/ Trk	μSec/ Sect	Raw Track Skew	Rounded Track Skew	# Of Cyl	μSec/ Sect	Raw Cyl Skew	Rounded Cyl Skew
System	100	117.60	30.0120	31	15	117.60	37.5150	38
1	128	92.47	38.4154	39	480	92.47	48.0192	49
2	124	95.33	37.2149	38	266	95.33	46.5186	47
3	120	98.84	36.0144	37	258	98.84	45.0180	46
4	114	103.84	34.2137	35	227	103.84	42.7671	43
5	109	108.17	32.7131	33	244	108.17	40.8914	41
6	104	112.41	31.2125	32	198	112.41	39.0156	40
7	99	118.67	29.7119	30	237	118.67	37.1399	38
8	93	125.58	27.9112	28	250	125.58	34.8890	35
9	89	130.30	26.7107	27	216	130.30	33.3884	34
10	83	139.83	24.9010	25	235	139.83	31.1375	32
11	81	143.33	24.3097	25	271	143.33	30.3872	31
12	75	153.02	22.5090	23	239	153.02	28.1363	29
13	71	161.53	21.3085	22	204	161.53	26.6357	27
14	66	171.03	19.8079	20	250	171.03	24.7599	25
15	64	176.60	19.2077	20	83	176.60	24.0096	25

Table 3-4. Track and Cylinder Skews.

Assumptions made:

1. All skew numbers with tenth digit > 0.01 were rounded up to the next integer.

2. Worst case RPM was used to give a slightly larger safety margin.

Section 4 Heads

4.1 General Requirements

Operating Environment

Temperature	0° TO 55°C	(32° TO 131°F)
Maximum Temperature Gradient	24°C/hr	(75.2°F/hr)
Humidity	5 to 85% RH, non-condensing	
Maximum Wet-Bulb Temperature	40°C	(104°F)
Altitude	-200 to 3050 m	
Cleanliness	Class 100	
Stray Magnetic Field	< 25 Oe	

Shipping and Storage Environment

Temperature	-40° TO 75°C	(-104° to 167°F)
Maximum Temperature Gradient	48°C/hr	(118.4°F/hr)
Humidity	5 to 95% RH, non-condensing	
Maximum Wet-Bulb Temperature	46°C (115°F)	
Altitude	-200 to 12,192 m	
Cleanliness	Class 100	
Stray Magnetic Field	< 25 Oe	

Test Environment

Temperature	23 ± 3°C (73 ± 5°F)
Humidity	30 to 70% RH, non-condensing

Acclimatization
Before starting any measurements, the head shall be acclimatized to the test environment for at least 24 hours. During the acclimatization, condensation on the head shall not be allowed to occur.

Altitude	0 to 914 m (0 to 3,000 ft)
Cleanliness	Class 100
Rotational speed	4500 ± 20 rpm
Stray Magnetic Field	< 6.25 Oe

4.2 Testing

Supplier is to test each head for the following parameters, and shall make the data from these tests available to Quantum on request:

- Flying height at the gap, R4 & R19
- Transducer-rail pitch, R4 & R19
- Trailing-edge roll, R4 & R19
- LF amplitude, R4 & R19
- HF amplitude, R4, R13 & R19
- Resolution, R4 & R19
- Overwrite, R4 & R19
- PW_{50}, R4 & R19
- Bit shift, R4 & R19

Data Expected with Each Shipment

Statistically-representative test data with distribution curves and process capability (cpk) will be required with each shipment for the following parameters:

- Gram load
- Rail widths
- Flying height at the gap, R4 & R19
- Pitch, both rails, R4 & R20
- Roll, leading edge and trailing edge, R4 & R 19
- LF amplitude, R4 & R19
- HF amplitude, R4 & R19
- Resolution, R4 & R19
- Overwrite, R4 & R19
- PW_{50}, R4 & R19
- Bit shift, R4 & R19
- Resistance, wafer level or HGA level
- Inductance, wafer level or HGA level
- Pole and gap geometries
- Waveform stability
- Popcorn Noise
- Pole to coil short (storm)

This data shall be furnished in written form and on a floppy diskette in either Macintosh Excel or IBM-PC Lotus 123 format.

Other Data

Supplier will be expected to promptly honor any reasonable request for test data on any parameter specified in this document.

Zone Descriptions of Test Disk

Zone Radii

The applicable zone radii, shown in the table below are referenced to the gap of the active transducer.

Radius	mm	in.	Zone description	Track	Skew
R1	12.50	0.4920	Disk ID		
R2	15.80	0.6220	Clamping Zone OD		
R3	19.53	0.7690	Loading Zone I D		5.24
R4	21.11	0.8311	Recording Zone - Z15 (ID)		6.32
R6	23.39	0.9210	Recording Zone - Z13		7.82
R7	24.99	0.9840	Recording Zone - Z12		8.83
R8	26.59	1.0470	Recording Zone - Z11		9.82
R9	28.19	1.1100	Recording Zone - Z10		10.79
R10	29.77	1.1720	Recording Zone - Z 9		11.74
R11	31.37	1.2350	Recording Zone - Z 8		12.67
R12	32.97	1.2980	Recording Zone - Z 7		13.60
R13	34.57	1.3610	Recording Zone - Z 6		14.52
R14	36.17	1.4240	Recording Zone - Z 5		15.42
R15	37.77	1.4870	Recording Zone - Z 4		16.33
R16	39.37	1.5500	Recording Zone - Z 3		17.23
R17	40.97	1.6130	Recording Zone - Z 2		18.12
R19	42.57	1.6760	Recording Zone - Z 1		19.02
R20	45.67	1.7980	Recording Zone - Z 1(O)	OD 0	20.74
R21	47.00	1.8500	Disk OD		
R3 - R20			Flyable Zone		

4.3 Mechanical Requirements;

Slider Specifications

Transducer , Pole Tip Area, Face View

Primary Pole Width*	5.0 ± 0.6µm	
Primary Pole Thickness	3.5 ± 0.3 µm	
Secondary Pole Width	6.0 ± 0.6 µm	
Secondary Pole Thickness	3.5 ± 0.3 µm	
Gap	0.30 ± 0.05 µm	REF.
Pole inset	≥ 0 and ≤ 3.0 µm	
Pole Wraparound	None permitted	
Undercoat Thickness	≥ 5 µm	REF.
Overcoat Thickness	≥ 8 µm	(≥ 315 µin) (above the top pole) REF.

* Pole width is measured at gap.

Transducer, Pole Tip Area, Profile View

Pole Tip Recession	≤ 10 nm	(≤ 0.4 µin)	REF.
Pole Tip Protrusion	None allowed		

Turns 42 to 54

Leads 2

Slider Dimensions

Length	2.032± 0.025 mm	(0.080 ± 0.001 in)
Width	1.600 ± 0.025 mm	(0.063 ± 0.001 in)
Thickness	0.432 ± 0.028 mm	(0.017 ± 0.001 in)

ABS Rails

Width	305 ± 10 µm	(.012 ± 0.0004 in)	REF
Taper Angle	30 ± 10 minutes		
Taper Length	203 ± 76 µm	(.008 ± 0.003)	
Bleed Slot Depth	≥ 20 µm	(≥ .0007 in)	REF.
Bleed Slot Width	≥ 300 µm	(≥ .007 in)	REF.
Surface Finish	≤ 13 nm	(≤ 0.5 µin)	
Crown	25 to 63 nm	(1 to 2.5 µin)	(HGA level)
Camber	0 to 25 nm	(0 to 1 µin)	(HGA level)
Flatness	≤ 20 nm	(≤ 0.8 µin)	(HGA level)

ABS Blend

Side edge width	25.4 ± 3.81 µm	(1000± 150 µin)	
Side edge rolloff	0.25 ± 0.13 µm	(10 ± 5 µin)	REF.
Trailing edge width	7.1 ± 3.6 µm	(280 ± 140 µin)	REF.
Trailing edge rolloff	0.25 ± 0.13 µm	(10 ± 5 µin)	REF.
Corner width	36 ± 18 µm	(1400 ± 700 µin)	REF.
Corner rolloff	0.40 ± 0.20 µm	(16 ± 8 µin)	REF.

Head Load Force

Preload in nominal flying position 0.070+ 0.005 N (7.0 ± 0.5 grams force)

Z-Height

The z-height is to be 0.86 mm (0.034 in).

Flying Height

Innermost Track

With the transducer at radius R4, the disk rotating at 4500 rpm, and a skew angle of 7.1 degree at the gap, the following flying characteristics shall be achieved:

Nominal transducer rail clearance	76.2 ± 19.1 nm	(3.00 ±0.75 µin)
Slider roll, trailing edges	0 ± 38 nm	(0 ± 1.5 µin)
Slider pitch, both rails	154 ± 76 nm	(6.0 ± 3 µin)

Outermost Track

With the transducer at radius R20, the disk rotating at 4500 rpm, and a skew angle of 21.1 degrees at the gap, the following flying characteristics shall be achieved:

Nominal transducer rail clearance	76.2 ± 19.1 nm	(3.00 ± 0.75µin)
Slider roll, trailing edges	38 ± 38 nm	0 ± 1.5 µin)
Slider pitch, both rails	380 nm	(15 µin) MAX

Minimum Flying Height

The minimum flying height of any point on either rail shall always exceed 57.2 nm (2.25 µin) at any disk radius in the Flyable Zone.

Maximum Flying Height

The flying height at the transducer shall never exceed 95.3 nm (3.75 µin)(REF.) at any disk radius in the Flyable Zone.

Flight-height measurements taken with equipment based on a Photo Research flying height transducer (or equivalent), with a spot size not to exceed 60 µm (0.0024 in), are acceptable when calibrated by a method and schedule approved by the equipment manufacturer.

Suspension

Hutchinson Technology Incorporated (HTI) P/N 96934 and 96935. Prior written approval from Quantum is required to substitute a different part number or supplier.

The first torsion mode should be between TBD Hz, and the gain should be less than 15dB.

Bond Strength

Slider -to-Flexure

The slider-to-flexure bond strength, when measured by a pull test shall be ≥ 150 gm.

Wire-to-Bond Pad

The single-wire wire-to-bond-pad bond strength, when measured by a pull test(before conformal coat is applied) at 30^{0} from the bond-pad plane, shall be ≥ 12 gm.

Durability of the Slider

Start/Stop Test

- Procedure:
  The test shall be performed for a minimum of **30,000 stop/start cycles** using a Test Disk. The head gap shall be positioned over the disk at radius R3 with 4.3^0 skew (at the gap). The disk speed shall be **4500 ± 20 RPM.** The acceleration and deceleration time shall be 25 ± 5 sec, with a minimum stop time between cycles of 3 sec. A 2.5 MHz data pattern shall be written prior to and after the 30,000 start/stop cycles.

  Results:
  The head shall have no apparent signs of wear or degradation. The readback amplitude at the completion of the test shall be > 90% of the original readback amplitude. Slider shall meet electrical performance specifications at all times during the test. The HF ID amplitude (with respect to either zone) shall change no more than 10% at any time during the test. Maximum coefficient of stiction between the disk surface and a head shall not exceed 1.0 after 30,000 start/stop cycles.

Slider Material

Aluminum Titanium Carbide

Wire and Tubing

Tubing to be made of Teflon. The color shall be :

Vendor	up facing head	down facing head
A	TBD	TBD
B	TBD	TBD
C	TBD	TBD
D	TBD	TBD

Wire colors shall be red and green. Wire type to be gold plated copper alloy with triple-layer polyethylene coating.

Wire twist shall be 25 ± 3 turns/inch. The local variation, anywhere over the length, shall not exceed the average variation by more than 10%.

The wire insulation shall withstand temperatures up to 343 ^oC (650 ^oF) with no change in physical properties.

The wire insulation shall withstand wire tinning temperatures up to TBD ^oC (TBD ^oF).

The wire insulation shall not generate static electricity at the low temperatures of the operating, shipping, and storage conditions of Sec. 3.1 and 3.2.

The wire gage shall be 47 or 48.

The wire shall withstand pull test up to 10 gm with no slipping in the tubing.

The tubing outer diameter shall be 0.017 ± 0.0012 inches .

4.4 Static Electrical Characteristics

DC Resistance

DC head resistance, as measured between tinned portions of leads, shall be $\leq 56\Omega$.

Inductance

Inductance at the wire terminals, when measured at 1 MHz, shall be $\leq 1.6\ \mu H$.

Hi-Pot Test

The resistance between the coil winding and any conductive part on the flexure assembly shall be > $10^9\ \Omega$ with 15 V DC applied. This is applicable with the head in either the loaded or unloaded position.

The breakdown voltage between the coil and the pole tips must be greater than 300 v DC.
The resistance between the coil winding and permalloy poles shall be > $1\text{x}10^9\ \Omega$ with 15 v DC applied.

The resistance across the slider-to-flexure bond shall be < 2 kΩ.

4.5 Dynamic and Electrical Characteristics

Test Conditions

DC Erasure
Unless otherwise specified, all write operations shall be preceded by a DC-erase operation.

Test Frequencies

Recording Zone	Radius(inch)(ID)	LF [MHz]	1/3HF	HF [MHz]
Z -15	0.8311	2.30	3.06	9.191
Z -14	0.8549	2.35	3.14	9.412
Z -13	0.9178	2.54	3.38	10.141
Z -12	0.9808	2.69	3.59	10.775
Z -11	1.0438	2.86	3.82	11.449
Z -10	1.1068	2.99	3.99	11.972
Z - 9	1.1697	3.17	4.23	12.681
Z - 8	1.2327	3.32	4.42	13.264
Z - 7	1.2957	3.48	4.64	13.929
Z - 6	1.3587	3.64	4.86	14.577
Z - 5	1.4216	3.79	5.05	15.141
Z - 4	1.4846	3.94	5.25	15.764
Z - 3	1.5476	4.07	5.43	16.28
Z - 2	1.6106	4.24	5.65	16.944
Z - 1	1.6735	4.33	5.77	17.324

Read/Write Electronics

Read/ Write Preamp
The read/write preamp shall be a VTC720H4 with **NO** external dampening resistor across the head. The total lumped and distributed capacitance across the head, excluding the preamp, shall be < 20 pF.

Write Current

The current amplitude measured at the head termination connector shall be 20 ± 2 mA **p-p.**

Waveform Asymmetry
The difference between any two positive and negative current pulses shall be ≤ 1 ns. That is, from Figure 4, $|T1| - |T2| \leq |1 \text{ ns}|$. The risetime T_r and falltime T_f shall be < 10 ns.

Overshoot
5 % of I_W where $I_W = I_{W+} - I_{W-}$

DC Erase Current
The DC erase current shall be 20 ± 2 mA p-p.

Post-Amplification Frequency and Phase Characteristics

The frequency response, of any post-amplifier, shall be flat, to within ± 0.5 dB, to 40 MHz. The -3 dB rolloff point shall be 60 MHz. The attenuation above 60 MHz shall not be less than that given by a line drawn through 0 dB at 60 MHz with a slope of 18 dB/octave. The group delay shall be flat to within ± 2 ns over the range from 150 kHz to 40 MHz.

Transfer Characteristics

For inputs between 0.15 mV and 3 mV, the transfer characteristics shall be linear within ± 3%.

Processing Filters

For parametric measurements, a 5-pole Butterworth filter (f_{co} = 35.0 MHz) is required. For bit shift measurements, a SSI 8000 programmable filters (f_{co} = 25 MHz at Z0 , f_{co} = 22 MHz at Z6 and f_{co} = 11 MHz at Z15) are required .

4.6 Acceptance Requirements

Track Average Amplitude (TAA)

Using a Test Disk, track average amplitude is defined as the average peak-to-peak amplitude over the entire track under test.

Amplitude

$TAA_{HF} \geq 225\ \mu V$ at any track for 42 turn heads and $\geq 250\ \mu V$ at any track for 50 to 54 turn heads.

Resolution

The resolution shall be > 65% for any track.

Overwrite

The overwrite shall be more negative than -25 dB for any radius.

Signal -to-Noise Ratio

The signal to noise ratio shall be more positive than - 28 dB at any radius .

Isolated Pulse Width

The PW_{50} shall be $\leq$ 60 ns at radius R4.

Pulse Asymmetry

TBD

Bit Shift

The bit shift for a 10^{-7} BER, when written with a 80A0 NRZ pattern, shall be $\leq$ 11 ns at radius R4, $\leq$ 7.2 ns at radius R13, and $\leq$ 5.5 ns at radius R19.

Waveform Stability

One of the tests listed in this section should be used.
Sigma Amplitude
The sigma of the TAA_{HF} shall be $\leq$ 3.0% of the mean TAA_{HF} when TAA_{HF} is measured at any radius.

Sigma Bitshift
The sigma of the bitshift shall be less than 15% of the quantity described by (half window - mean bitshift).

Sigma Error Rate
Using a fixed window of 50% of half window, sigma of the log of the error rate shall not exceed 0.12 of the mean of the log of the error rate.

Popcorn Noise
Under the condition described in A 7.11.2, no more than 100 counts shall be recorded.

4.7 Physical Defects

The performance levels and allowable defects contained in this specification represent the minimum acceptable level of performance.

For detailed information please refer to "Head Specs."

4.8 Approved Manufacturers List (AML)

For Approved Manufacturer List, see Quantum P/N (TBD).

4.9 Packaging Requirements

Current Requirements

Head packaging shall provide complete protection against physical damage, electrostatic discharge, or contamination. The packaging surface, both inside and outside, shall not accumulate static charge resulting in greater than 100 v of surface voltage. Any anti-static chemicals used must not degrade the Class 100 environment.

Production Requirements

For Head Packaging Instructions, see Quantum P/N (TBD).

Section 5 Media

Identification

- The disk shall be marked with a unique alphanumeric identification which identifies the manufacturer, the production lot, and the date of manufacturer. This identification shall be placed between the ID and radius R1, and must not affect the disk flatness or clamping load.

5.1 General Requirements

Operating Environment

Temperature	0° to 55° C (40° to 131° F)
Maximum Temperature Gradient	24° C/hr (75.2° F/hr)
Humidity	5 to 85% RH, non-condensing
Maximum Wet-Bulb Temperature	40° C (104° F)
Altitude	-200 to 3048 m (-650 to 10,000 ft)
Cleanliness	Class 100
Stray Magnetic Field	< 25 Oe

Shipping and Storage Environment

Temperature	-40° to 75° C (-40° to 167° F)
Maximum Temperature Gradient	48° C/hr (118.4° F/hr)
Humidity	5 to 95% RH, non-condensing
Maximum Wet-Bulb Temperature	46° C (114.8° F)
Altitude	-200.12 to 12192m (-650 to 40,000 ft)
Cleanliness	Class 100
Stray Magnetic Field	< 25 Oe

Test Environment

Temperature	23 ± 3° C (73 ± 5° F)
Humidity	30 to 70% RH, non-condensing
Altitude	0 to 914 m (0 to 3,000 ft)
Cleanliness	Class 100
Rotational speed	4500 ± 20 rpm

Stray Magnetic Field	< 6.25 Oe

Acclimatization --
Before starting any measurements, the disk shall be acclimatized to the test environment for at least 24 hours. During the acclimatization, condensation on the disk shall not be allowed to occur.

5.2 Mechanical Requirements

Dimensions

Outside Diameter	95.00 ± 0.10mm (3.740 ± 0.004 in)
Inside Diameter	25.00 ± 0.06/-0.00 mm (0.984 ± 0.002/-0.000 in)
Concentricity of OD to ID	≤ 25 μm (0.001 in)
Thickness	0.800 ± 0.0125 mm (0.0315 ± 0.0005 in)
Flatness	≤ 25 μm (0.001 in) diametral ≤ 50 μm (0.002 in) circumferentially
OD Roundness	< 12.5 μm (0.0005 in)

Edge Condition
The outside and inside edges of the disk shall be chamfered to the following dimensions:

Angle:	45 ± 5 degrees
Length:	0.20 ± 0.15 mm (0.008 ± 0.005 in)

Taper
The substrate thickness, measured on any radial line from OD to ID, shall at the OD be the same as the ID to within the tolerance + 12.7/-51 mm (+ 0.0005/-0.002 in)

Dimensions are to be interpreted as per ANSI Y14.5

Measurements are to be made at 23 ± 2 °C (73 ± 4 °F)

Physical Characteristics

Surface Roughness

The axial surface roughness shall be measured with an optical profilometer.

Flyable Zone
The arithmetic-average surface roughness shall be ≤ 5 nm (0.2 μin), with a maximum protrusion height of 76 nm (3 μin) above the average

Clamping Zone
The arithmetic-average surface roughness shall be ≤ 400 nm (16 μin), with a maximum protrusion height of 1.0 μm (39 μin) above the average.

Axial Runout, Velocity and Acceleration

Measurement Method
The axial runout, velocity and acceleration shall be measured within the Flyable Zone, at 4500 ± 20 rpm, with a disk clamping force of 690 ± 68 N (155 ± 15 lb). The measurement method shall use a non-contacting probe with an active diameter d_p, where 1.52 mm (0.060 in) ≤ d_p ≤ 1.70 mm (0.067 in); and a 7.0 kHz low-pass filter with 18 dB/octave attenuation.

Axial Runout
The axial runout shall be ≤ 0.05 mm (0.002 in) TIR and contained within the deflection limits given below.

Axial Deflection
The axial deflection at radius R6 shall be ≤ ± 0.05 mm (0.002 in) from the reference plane defined by the lower clamping surface.

Axial Velocity	≤ 15 mm/sec (0.59 in/sec)
Axial Acceleration	≤15 mm/sec^2 (590 in/sec^2)
Moment of inertia	≤ 0.020 gm-m^2 (0.0028 in-oz-sec^2)

Magnetic Requirements

Magnetic Material	CoCrTa, CoCrPt, CoPtNi or CoNiCrPt
Coercivity	1600 ± 100 Oe (REF)
Circumferential Coercivity Variation	< 50 Oe
Remanence - Thickness Product	2.9 memμ/cm^2 (REF)
Squareness (Br/Bs)	≥ 0.8 (REF)

Glide Height

In the Flyable Zone, there shall be no head-to-disk contacts when the head is flying at the flight heights shown below:

Disk Radii		Glide Height	
mm	in	μm	μin
17.00 - 46.17	0.669 - 1.8177	0.051	2.0

Coefficient of Thermal Expansion

The coefficient of thermal expansion of the disk substrate material shall be 24 ± 1 x 10^{-6}/°C over a range of 10 to 57°C (13.3 ± 0.5 x 10^{-6}/°F over a range of 50 to 135°F)

Maximum Speed

The disk shall be capable of meeting all requirements after withstanding the effect of stress induced at a speed of 6000 RPM for 1 minute.

Substrate Material

The substrate material shall be alloy aluminum.

Clamping Zone

For all points on both surface in the clamping zone, the axial deviation from a flat plane shall be ≤ 5 µm (200 µin).

No identification, part, or serial number, logos, manufacturing identifiers, or similar information shall be placed in the clamping zone and must not affect flatness, load, or durability.

Both sides of the disk shall be electrically conductive.

Durability of the Magnetic Surfaces

Continuous-Running Wear Test

The disk shall withstand the effects of a Test Head gliding on the disk at 100 ± 2 rpm, at radius R4, for 48 hours. After completion of this test, any HF amplitude change due to disk wear shall be less than 10%.

Overcoat and Friction of Magnetic Surfaces

Overcoat of the Magnetic Surface

Overcoat Material
The disk overcoat material shall be sputtered Hydrogenated carbon.

Overcoat Thickness
≥20 nm (0.8 µin) for carbon (REF)

Overcoat Durability
The top coat shall be able to withstand the operating storage, and durability requirements.

Head/Disk Friction

Test Requirements
The coefficient of friction between the disk surface and a head, the test method, and the methods of calculation are described in ANSI X3B7/88-02, and shall be performed over the entire Flyable Zone, and for any operating or storage condition.

Dynamic Friction Coefficient
The dynamic friction coefficient shall not exceed 0.3 using a Test Head with a 7.0 gm load.
Stiction

The measurement shall be made with a Test Head which has a 7.0 gm preload. The static friction coefficient shall not exceed 0.5 after contact for 24 hours , and shall not exceed 1.0 after any time period and after 30,000 contact start/stop cycles with 90% confidence.

5.3 Testing of Magnetic Characteristics and Acceptance Requirements

Track Average Amplitude (TAA)

Using a Test Head, track average amplitude is defined as the Test Head output of the average peak-to-peak amplitude over the entire track under test.

Amplitude

$TAA_{HF} \geq 225\ \mu V$ at radius R4
$TAA_{LF} \leq$ TBD μV at radius RTBD

Resolution

The resolution shall be> 65% for any track.

Overwrite

The overwrite shall be more negative than -26dB at any radius.

Residual Noise

The media residual noise ratio shall not be more positive than -28dB at any radius.

Positive Modulation

Positive modulation shall be less than 20% within the Recording Zones.

Negative Modulation

Negative modulation shall be less than 20% within the Recording Zones.

Pulse Width

The PW_{50} shall be $\leq$ 60 ns at radius R4.

Bit Shift

BS_{Z}-15 $\leq$ 11 ns
BS_{Z}- 7 $\leq$ 7.2 ns
BS_{Z}- 0 $\leq$ 5.5 ns

5.4 Defects

Definition
A defect is a physical imperfection on the disk that causes either an extra or a missing pulse in the Recording Zones.

There shall be ≤ 60 defects per surface and the length of any one defect shall not exceed 15 bytes when using the test frequencies.

There shall be no more than one defect per any single track.

Defect scanning shall be performed at a maximum track-to-track Test-Head step increment of 200 μin.

5.5 Approved Manufacturers List (AML)

For Approved Manufacture List, see Quantum P/N (TBD)

5.6 Packaging Requirements

For Disk Packaging instruction, see Quantum P/N (TBD)

Section 6 Spindle Motor

6.1 General Information

The 3.5" spindle motor to be used in the "Lightning" Hard Disk Drive (Both One Disk & Two Disks Version). The motor is integral to the drive baseplate. Three screws diskclamp design will be implemented. Back-emf commutation technology will be used to drive motor. (Hall-less design concept)

6.1.1 REFERENCE DOCUMENTS

Spindle Motor Assembly	75-101672-01
Spindle Motor Driver	13-102741-01
Disk 95mm X 25mm X 0.8mm	61-101680-01
Disk Clamp (1 Disk)	40-101638-01
Disk Clamp (2 Disk)	40-103637-01

Table 6-1. Reference documents for spindle motor

6.2 General Specifications

Number of Poles	8
Number of Phases	3
Motor Type	Brushless DC
Driving Mode	BiPolar Y, with center tap
Commutation	Back- emf (Hall-less)
Number of Stator Slots	9
Mounting Orientation	Any Orientation
Flex Circuit Pin Descriptions	
Pin 1	u
Pin 2	v
Pin 3	w
Pin 4	center tap

Table 6-2. General specifications for spindle motor

6.3 Operating Specifications

6.3.1 PERFORMANCE

Rotational Speed	4501.8RPM ± 0.5%
Direction of Rotation (hub side view)	Counterclockwise
Rated Torque (measured @ 4500 RPM)	8.3 gf-cm (min)
Start Time	< 5 sec

Table 6-3. Performance specifications for spindle motor.

6.3.2 ELECTRICAL

Supply Voltage Requirements	12 V (DC) ± 10%
Minimum Motor Voltage[1]	9.3 V DC
Coil Resistance (23°C)[2]	9.0 Ω ± 10%
Coil Inductance (f = 1kHz)	1.15 mH ± 10%
Back EMF (23°C, 4500RPM)	2 V (min)
Average Running Current	120 mA
Starting Current	760 mA (min)
Magnetic Flux Leakage[3]	< 3 Gauss
Insulation	Class B

Table 6-4. Electrical specifications for spindle motor.

Notes to Table 6-4:

1. Measured at winding.
2. Measured across any two windings.
3. At 2.06 cm radius. Measured in any direction, non-operational.

6.3.3 MECHANICAL

Dimensions per Drawing Number	75-101672-01
Weight	< 50 gm
Rotor Hub Inertia	< 0.004 gm M^2
Torque Constant (average) @ 4500 RPM	170 gf-cm/A ± 5%
Torque Ripple	30% (Max) P-P
Indent Torque (Cogging Torque)	5gf-cm (Max)
Minimum Start Torque	138 gf-cm/A
Bearing Type	see 6.4.2
Bearing PreLoad	1.5 - 2 Kgf (OZU) 1.7 ± 0.1 Kgf (NIDEC)
Radial Shaft Movement	<20 µin
Non-Repetitive Run-out (NRRO)[1]	< 6 µin (P-P)
Repetitive Run-out with 0.1 gm-cm imbalance	< 400 µin
Imbalance, bare spindle	< 0.1 gm-cm
Acoustic noise[2]	< 30 dBA @ 1m

Table 6-5. Mechanical specifications for spindle motor.

Notes to Table 6-5:

1. NRRO should be measured at spindle assembly level that includes one disk, one diskclamp and three screw, with both ends of the shaft fixed.)

   NRRO measured at bare motor level does not reflect the actual NRRO measured at drive level.

2. Measured in HDA, with no prominent discrete tones. Prominent discrete tones defined as frequency bands (1/3 octave bands) which have a dB level higher than average of the two adjacent bands by 5 dB.

6.3.4 RELIABILITY (L1 LIFE): 44,000 power-on hours (Mini)

L1 LIfe is the life in hours which a group of similar bearings will pass with a 1% maximum failure rate (99% relibility).

6.4 Materials

The materials used in the construction of the spindle motor are to be approved by Quantum Engineering. No changes are to be incorporated without receiving Engineering approval.

6.4.1 ELECTRICAL COMPONENTS

Elastomeric Connector	22-100547

Table 6-6. Electrical components for spindle motor.

6.4.2 MECHANICAL COMPONENTS

Hub	Aluminum
Thermal Expansion on Ø25	11 ~ 14 X 10^{-6}/°F (50°F - 135°F)
Magnets	Neodymium, encapsulated
Shaft	SS
Bearings, double-shielded ball[1] or Non contact seals	11 x 5 x 4 ABEC Class 5 52100
Bearing Lubrication	Andok- C (Filtered to 5 μ particulate size) 15-20% fill

Table 6-7. Mechanical components for spindle motor.

Notes to Table 6-7:

1. Bearings from different manufacturers cannot be mixed in the same motor.

6.5 Testing Conditions

All performance testing will be performed under the following conditions unless otherwise noted.

6.5.1 ELECTRICAL CONNECTIONS

Electrical connections from motor to drive occur in the order U, V, W & N where N is the center tap.

6.5.2 INERTIAL LOAD

Inertial load includes one disk, and a disk clamp.

	1 Disk	2 Disk
Load Inertia	190 gm-cm^2	372 gm-cm^2
Motor Inertia	19 gm-cm^2	19 gm-cm^2
Total Inertia	209 gm-cm^2	391 gm-cm^2

Table 6-8. Inertial load.

6.5.3 FRICTIONAL LOADS (STATIC AND DYNAMIC)

One Disk, Two Heads Version and Two DIsk, Four Heads Version both loaded at 9.5 ± 1 grams.

	1 Disk	2 Disk
Stiction Load (0 RPM)	50gf-cm	81.0 gf-cm
Friction Load (4500 RPM)[1]	8.3gf-cm	8.3gf-cm

Table 6-9. Frictional load, static and dynamic.

Notes to Table 6-9:

1. Viscous drag.

6.5.4 ENVIRONMENTAL RANGE

Over all environmental ranges listed in 6.7.

6.6 Particulate Generation

Particulate generation from the spindle to meet class 10 specification at 4500RPM all temperature extremes allowable particulate per 1.0 cubic foot.

< 10 @ 0.5 mm and larger
< 38 @ 0.3 mm and larger
< 380 @ 0.1 mm and larger

6.7 Environment

	Operating	Non-Operating	Storage
Temperature	0°C to 55°C 32°F to 131°F	-40°C to 75°C -40°F to 167°F	-40°C to 75°C -40°F to 167°F
Humidity[1] Max wet bulb	5% to 85% RH 40°C 104°F	5% to 95% RH 46°C 114.8°F	
Shock	10 G 11 ms Half sine	60 G 11 ms Half sine[2]	
Vibration (peak to peak)	5 - 300 Hz 1 G (P-P)	5 - 500 Hz 2G (P-P)	

Table 6-10. Environment specifications for spindle motor

Notes to Table 6-10:

1. No condensation allowed.
2. With no loss of preload or change in acoustic noise.

6.8 Cleanliness/Contamination

Motors must be free of dirt, chips, and/or any other foreign materials. Motor should be sealed in individual bags, protected from moisture and ready for a class 100 clean room (See Appendix B).

6.9 Quality Assurance Provisions

6.9.1 IDENTIFICATION

All motors must carry a manufacturer's identification, a revision level, a part number, and manufacturing date code on protective bag.

6.9.2 BURN-IN

7 hours at 75°C.

6.10 Packaging

The motor must be packaged so that it can withstand a drop of 36" onto a concrete floor without performance degradation.

Section 7 SCSI Interface

7.1 General Description

All word descriptions have been taken out since they can easily be found elsewhere---specifically, in the ANSI standard, and in the Flash Preliminary Product Manual. In fact, the four tables contained herein was lifted from the GPPM. They are: message codes; synchronous data transfer request; commands; and status byte code bit values.

7.2 Hardware Description

7.2.1 ANSI Conformance

Lightning interface ASIC conforms to ANSI X3T9.2/86-109 Revision 10K(SCSI II): Single-ended drivers and parity implemented, in addition, synchronous data transfer option is implemented with a minimum transfer period of 100 nanoseconds and a maximum offset of 8.

7.2.1.1 Implementation Options

Where the ANSI specification allows more than one option, and only one option was implemented, the option chosen for implementation is as follows:

- During arbitration, if arbitration is lost due to a higher priority SCSI ID bit being driven on the SCSI data bus, all signals will be released without waiting for SEL to become true.
- During arbitration phase, DB(P) will be undriven.
- Offset is calculated based on the leading edges of the synchronous REQ and ACK pulses.
- Active negation drive may be programmed to apply to REQ and /or Data bus disabled.

7.2.2 SCSI ASIC I/0 Cell Specification

7.2.2.1 Output Characteristics:

Low Level Drive Requirements:

Vol (low level output voltage) = 0.0 to 0.5 Vdc at 48 ma sinking.

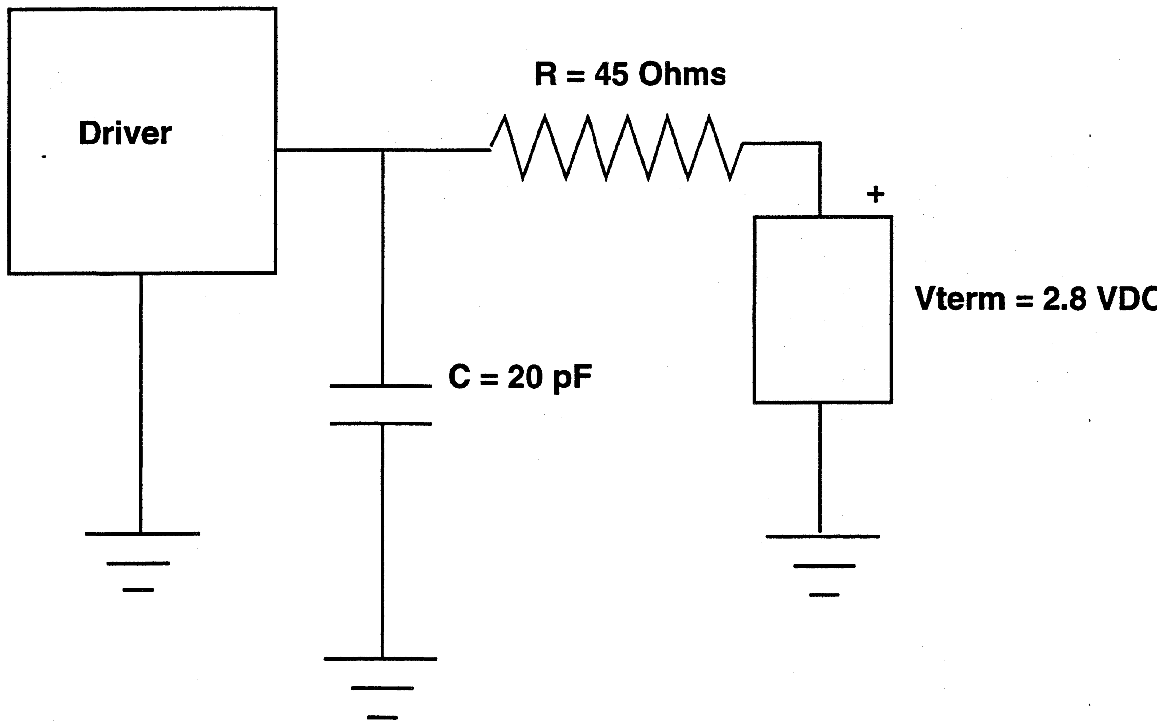
Maximum current (resistive current limit) from external source is

48 ma at Vol = 0.5 VDC

58 ma at Vol = 0.0 VDC

Note: Drivers are subject to elevated transient sink currents of 145 ma sink for up to 40 ns after initial edge assertion.

Driver voltage slew rates shall be maintained in the range of 0.25 to 0.5 V/ns when connected to the following equivalent test circuit.



Active Negation Drive Requirements:

16 ma N-ch type high drive with the following characteristics;

Voh (high level output voltage):

Voh = 3.0 volts dc maximum at IOH $\geq$24 ma

Voh = 3.24 volts dc maximum at 7 ma $\leq$ IOH < 24 ma

Voh = 5.25 volts dc maximum at IOH < 7 mA

High drive mode can be disabled with an internal input to the IO cell.

Note: Drivers are subject to elevated transient source currents of up to 48 ma source for up to 40 ns after initial edge de-assertion.

Driver slew rate limit is the same as for the low level driver.

7.2.2.2 Input Characteristics:

VIL (Low level input voltage) = 0.0 to 0.80 VDC

VIH (High level input voltage) = 2.0 to 5.25 VDC

IIL (Low level input current) = -20 to 0 uA at VI = 0.5 VDC

IIH (High level input current) = 0 to 20 uA at VI = 2.7 VDC

Minimum input hysteresis = 0.3 VDC

Maximum capacitance at pin (incl. output cell) = 10 pF (Measured at 10 Mhz)

IIL and IIH must also be met when the device is powered off, VDD = 0 VDC, and when the input cell is combined with an output buffer to form an IO cell.

These inputs must also tolerate narrow voltage transients that can occur during the assertion and deassertion of these signals that are in excess of the input hysteresis without false triggering. The recommended noise rejection is for the input to not change state on a input swing of less than or equal to 1 volt with a duration of less than or equal to 10 ns. This can be accomodated by the implementation of a series RC filter in the initial input stage.

These inputs will tolerate up to 5.25 VDC input while Vdd ramps up to its operating range, and tolerate Vin greater than vdd by 0.5 VDC in operation without latchup. Additionally the inputs will tolerate a pulse of up to 40 ns duration of up to 10 V or down to -3 V in operation without latchup or damage.
Also the injection of positive or negative current at 400 milliamps into the input must not cause latchup. It is recommended that an epitaxial process be used to insure meeting the above latchup requirements.

The inputs must withstand ESD levels of 2000 volts using the Human body model.

The above limitaions for IIL, IIH, pin capacitance, ESD, and latchup specifications must not be violated when an output buffer is combined with the input buffer to form a bidirectional IO cell.

Each pin will have a pull-up or pull-down or other means to protect against floating inputs implemented such as not to violate any of the above conditions.

7.3 Message Codes

Code	Description	Direction	Supported
00_H	COMMAND COMPLETE	In[1]	
01_H	EXTENDED MESSAGE-SYNCHRONOUS DATA REQUEST	In	Out[2]
02_H	SAVE DATA POINTER	In	
03_H	(Not supported)		
04_H	DISCONNECT	In	
05_H	INITIATOR DETECTED ERROR		Out
06_H	ABORT		Out
07_H	MESSAGE REJECT	In	Out
08_H	NO OPERATION		Out
09_H	MESSAGE PARITY ERROR		Out
$0A_H$	LINKED COMMAND COMPLETE	In	
$0B_H$	LINKED COMMAND COMPLETE (WITH FLAG)	In	
$0C_H$	BUS DEVICE RESET		Out
80_H - FF_H	IDENTIFY	In	Out

Table 7-1. Message codes supported.

Notes to Table 7-1:

1. In: the drive originates a message and sends it to the initiator.

2. Out: the drive supports receiving a message from the initiator.

7.4 Synchronous Data Transfer Request

Byte	Value	Description
0	01_H	Extended Message
1	03_H	Extended-Message Length
2	01_H	SYNCHRONOUS DATA TRANSFER REQUEST code
3	m	Transfer Period (m X 4 nanoseconds)
4	x	REQ/ACK Offset

Table 7-2. Synchronous data transfer request

Requested Period (X4 nSec to determine the actual transfer period)	Transfer Rate Granted
25-0	10.000 MB/Sec
31-26	8.000 MB/Sec
37-32	6.667 MB/Sec
43-38	5.714 MB/Sec
50-44	5.000[1] MB/Sec
62-51	4.000 MB/Sec
75-63	3.333 MB/Sec
86-76	2.857 MB/Sec
100-87	2.500 MB/Sec
112-101	2.222 MB/Sec
125-113	2.000 MB/Sec
137-126	1.818 MB/Sec
150-138	1.667 MB/Sec
162-151	1.538 MB/Sec
174-163	1.429 MB/Sec
187-175	1.333 MB/Sec
255-188	0.625 MB/Sec

Table 7-3. Transfer rate negotiation table.

Notes to Table 7-3:

1. 5.000 MB/Sec transfer rate does not use Fast SCSI Timing, only rates of 5.714MB/Sec and greater use Fast SCSI Timing.

7.5 Drive Status Byte Code Bit Values

Bits of Status Byte								
7	6	5	4	3	2	1	0	Status Represented
R[1]	R[2]	R	0	0	0	0	R	GOOD
R	R	R	0	0	0	1	R	CHECK CONDITION
R	R	R	0	1	0	0	R	BUSY
R	R	R	1	0	0	0	R	INTERMEDIATE/GOOD
R	R	R	1	1	0	0	R	RESERVATION CONFLICT

Table 7-4. Drive status byte code bit values.

Notes to Table 7-4:

1. R: Reserved bit (0).

7.6 Commands

Opcode	Command
00_H	TEST UNIT READY
01_H	REZERO UNIT
03_H	REQUEST SENSE
04_H	FORMAT UNIT
07_H	REASSIGN BLOCKS
08_H	READ
$0A_H$	WRITE
$0B_H$	SEEK
12_H	INQUIRY
15_H	MODE SELECT
16_H	RESERVE
17_H	RELEASE
$1A_H$	MODE SENSE
$1B_H$	START/STOP UNIT
$1D_H$	SEND DIAGNOSTIC
25_H	READ CAPACITY
28_H	READ EXTENDED
$2A_H$	WRITE EXTENDED
$2B_H$	SEEK EXTENDED
$2E_H$	WRITE AND VERIFY
$2F_H$	VERIFY
37_H	READ DEFECT DATA
$3B_H$	WRITE BUFFER
$3C_H$	READ BUFFER
$3E_H$	READ LONG
$3F_H$	WRITE LONG

Table 7-5. Commands supported by Flash.

7.7 Diagnostic Commands

THIS ENTIRE SECTION IS TO BE REMOVED WHEN THE MANUAL IS GIVEN TO ANY PARTIES OUTSIDE OF QUANTUM / MKE

7.7.1 INTRODUCTION

The diagnostic commands are accessible as opcode FF_H along with a one-byte subcode specifying the particular diagnostic function. Subcodes 0 through $3F_H$ are set aside for the Common diagnostic Command Set. The common commands are co-defined by the Gemini and L-series projects in an effort to pave the path for common diagnostic software with standard Command Descriptor Blocks. However, the internal implementation of these commands may be product-dependent.

The diagnostic mode must be enabled prior to executing any diagnostic command. Executing a diagnostic command in normal mode will result in an ILLEGAL COMMAND condition. The SCSI diagnostic commands are enabled by sending a SEND DIAGNOSTIC command to the drive. The diagnostic mode is always disabled on power-up or after a host Reset. Notice that ProDrive can operate only in generic customer mode once diagnostic mode is enabled.

In general, input parameters for the diagnostic commands are sent to the drive as part of the command descriptor block and information is returned via a DATA IN phase.

7.7.2 COMMON COMMANDS

Subcode	Command
00	Read Micro Memory
01	Write Micro Memory
02	Read Configuration
03	Write Configuration
04	Call Subroutine
05	Convert LBA to CHS
06	Compute Starting Sector
07	Read Command History
08	Read Cache Table
09	Read ECC Results
0A	Seek Physical
0B	Seek Verify
0C	Read Physical
0D	Read Long Physical
0E	Write Physical
0F	Write Long Physical
10	Reassign Physical
11	Read Index Time
12	Read ID
13	Read Peak Amplitude
14	Microstep
15	Recalibrate
16	Erase Track
17	Erase Track Data
18	Format Track
19	Write Immediatel
1A	Read Sequencer WCS
1B	Write Sequencer WCS
1C	Peek Buffer
1D	Poke Buffer
1E	Read Variables
1F	Factory Format
20	Start Stop
21	Convert CHS to LBA
22	AT Mode Select
23	AT Mode Sense
24-3F	Reserved for common diagnostic commands
41	Read A B Servo
43	Equalize A B
49	Prediction Control
4A	Read Track to Lock
4C	Read Runout Tables

Subcode	Command
4E	Read Thermistor
4F	Seek and Sample
81	Servo Verify
82	Read Current Cylinder
85	Self Scan
86	Read Perr
60	Write Read Channel
61	Set Write Current
62	Sequencer Trigger
63	Wedge Format
64	Window Margin Test
65	Extended Low Z

Table 7-6. Common commands.

Section 8 AT Interface

8.1 General Information

The following information follows the same general format as the SCSI Interface section: it has none of the descriptive language of the Product Manual and only 3 tables describing the AT-bus interface pin assignments, the command parameters, and the error messages.

8.2 Hardware Description

8.2.1 AT ASIC I/O Cell Specification

8.2.1.1 Output Characteristics:

Three state output drive requirements:

Vol (low level output voltage) = 0.0 to 0.5 Vdc at 24 ma sinking.

Voh (high level output voltage) = 2.4 to 5.25 Vdc at 16 ma sourcing.

Note: Drivers are subject to elevated transient currents of 75 ma sink and 48 ma source for up to 6 ns after initial edge assertion/deassertion.

Driver voltage slew rates shall be a maximum of 0.25 V/ns when connected to the following equivalent test circuit.

```
 ____________
|            |          R = 90 Ohms
|   driver   |__________/\/\/\/\/\___________
|            |     |                    |
 ____________      |                    |
      |           ___    C = 20 pF      *
      |           ___             *     +      *   Vline = 0 or 5 VDC
      |            |              *     -      *
    _____          |                           *
     ___           |                           |
      -          _____                       _____
                  ___                         ___
                   -                           -
```

8.2.1.2 Input Characteristics:

VIL (Low level input voltage) = 0.0 to 0.80 VDC

VIH (High level input voltage) = 2.0 to 5.25 VDC

IIL (Low level input current) = -20 to 0 uA at VI = 0.5 VDC

IIH (High level input current) = 0 to 20 uA at VI = 2.7 VDC

Minimum input hysteresis = 0.3 VDC

Maximum capacitance at pin (incl. output cell) = 10 pF (Measured at 10 Mhz)

IIL and IIH must also be met when the device is powered off, VDD = 0 VDC, and when the input cell is combined with an output buffer to form an IO cell.

These inputs must also tolerate narrow voltage transients that can occur during the assertion and deassertion of these signals that are in excess of the input hysteresis without false triggering. The recommended noise rejection is for the input to not change state on a input swing of less than or equal to 1 volt with a duration of less than or equal to 10 ns. This can be accomodated by the implementation of a series RC filter in the initial input stage.

These inputs will tolerate up to 5.25 VDC input while Vdd ramps up to its operating range, and tolerate Vin greater than vdd by 0.5 VDC in operation without latchup. Additionally the inputs will tolerate a pulse of up to 40 ns duration of up to 10 V or down to -3 V in operation without latchup or damage.
Also the injection of positive or negative current at 400 milliamps into the input must not cause latchup. It is recommended that an epitaxial process be used to insure meeting the above latchup requirements.

The inputs must withstand ESD levels of 2000 volts using the Human body model.

The above limitaions for IIL, IIH, pin capacitance, ESD, and latchup specifications must not be violated when an output buffer is combined with the input buffer to form a bidirectional IO cell.

Each pin will have a pull-up or pull-down or other means to protect against floating inputs implemented such as not to violate any of the above conditions.

8.3 Command Parameters

		Parameter				
Command Name	**Hex Value**	**SC**	**SN**	**CY**	**DS**	**HD**
RECALIBRATE	$1X_H$				V	
READ SECTOR (with retry)	20_H	V	V	V	V	V
READ SECTOR (no retry)	21_H	V	V	V	V	V
READ LONG (with retry)	22_H	V	V	V	V	V
READ LONG (no retry)	23_H	V	V	V	V	V
WRITE SECTOR (with retry)	30_H	V	V	V	V	V
WRITE SECTOR (no retry)	31_H	V	V	V	V	V
WRITE LONG (with retry)	32_H	V	V	V	V	V
WRITE LONG (no retry)	33_H	V	V	V	V	V
READ VERIFY (with retry)	40_H	V	V	V	V	V
READ VERIFY (no retry)	41_H	V	V	V	V	V
FORMAT TRACK	50_H			V	V	V
SEEK	$7X_H$			V	V	V
EXECUTE DIAGNOSTICS	90_H					
INITIALIZE DRIVE PARMS	91_H	V			V	V
READ MULTIPLE	C4H	V	V	V	V	V
WRITE MULTIPLE	C5H	V	V	V	V	V
SET MULTIPLE MODE	C6H	V			V	
READ DMA (with retry)	C8H	V	V	V	V	V
READ DMA (no retry)	C9H	V	V	V	V	V
WRITE DMA (with retry)	CAH	V	V	V	V	V
WRITE DMA (no retry)	CBH	V	V	V	V	V
READ SECTOR BUFFER	$E4_H$				V	
WRITE SECTOR BUFFER	$E8_H$				V	
IDENTIFY DRIVE	EC_H			V	V	
READ DEFECT LIST	$F0_H$	V	V	V	V	V
READ CONFIGURATION	$F0_H$	V	V	V	V	V
SET CONFIGURATION	$F0_H$	V	V	V	V	V

Table 8-1. Command parameters.

Notes to Table 8-1:

Where V = Must contain valid information for this command

The parameters are defined as follows:

SC = SECTOR COUNT register

SN = SECTOR NUMBER register

CY = CYLINDER LOW and CYLINDER HIGH registers

DS = DRIVE SELECT bit (bit 4, DRIVE/HEAD register)

HD = 3 HEAD SELECT bits (bits 0 - 3, DRIVE/HEAD register)

8.4 ATA Interface Timing

8.4.1 Host Interface Timing

PIO

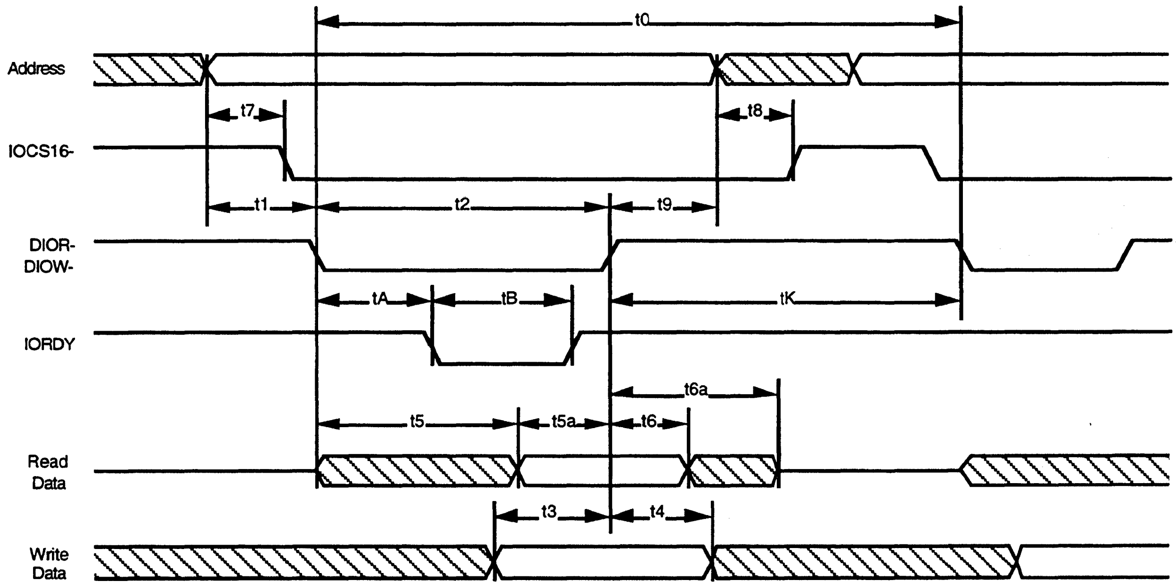


Figure 8-1. PIO Data Transfers (8 and 16 Bit).

SYMBOL	DESCRIPTION	min/max	Mode2	LPS 270/540
t0	Cycle time	min	240	130
t1	Address Valid to DIOR-/DIOW- Setup	min	30	15
t2	DIOR-/DIOW- Pulse width	min	100	80
t3	DIOW- Data Setup	min	30	30
t4	DIOW- Data Hold	min	15	10
t5	DIOR- to Data Valid	max	-	60
t5a	DIOR- Data Setup	min	20	20
t6	DIOR- Data Hold	min	5	5
t6a	DIOR- Data Tristate	max	-	30
t7	Address Valid to IOCS16- Assertion	max	40	30
t8	Address Valid to IOCS16- Deassertion	max	30	30
t9	DIOR-/DIOW- to Address Valid Hold	min	10	10
tA	IORDY Setup	min	35	35
tB	IORDY Pulse Width	max	1250	1250
tK	DIOR-/DIOW- Negated Pulse Width	min	-	50

NOTES:

1 ATA Mode 2 timing listed for reference only.

2 Transfer rates above 6Mbytes/sec requires the use of IORDY.

8.4.2 RESET

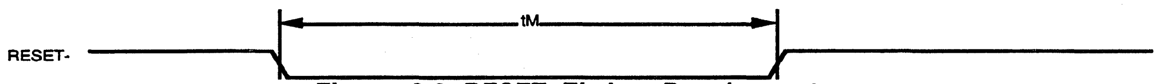


Figure 8-2 RESET Timing Requirements.

SYMBOL	DESCRIPTION	MINIMUM	MAXIMUM
tM	RESET- Pulse Width	300	

8.4.3 Multiword DMA

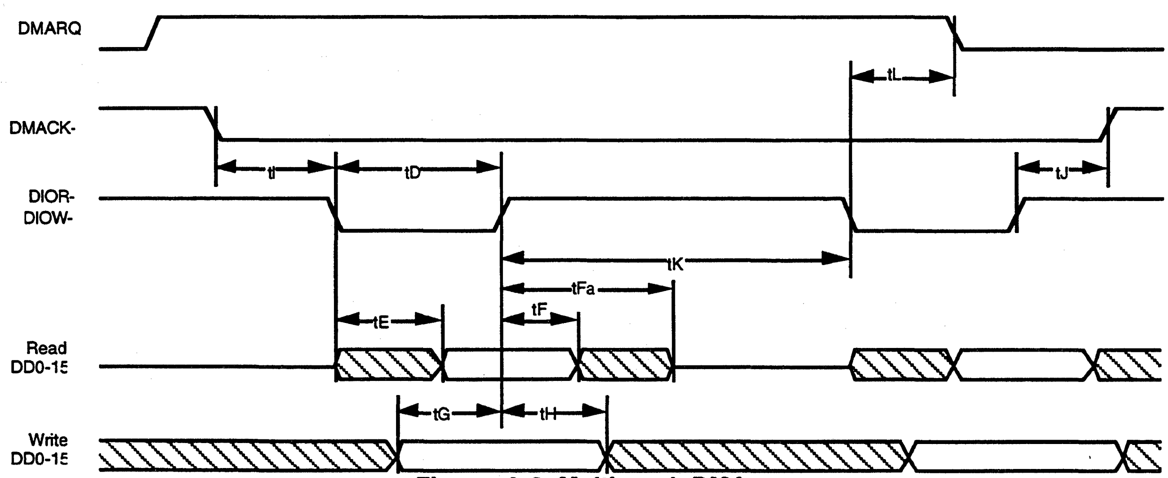


Figure 8-3 Multiword DMA

SYMBOL	DESCRIPTION	min/max	Mode1	LPS 270/540
t0	Cycle time	min	150	150
tD	DIOR-/DIOW- Pulse Width	min	80	60
tE	DIOR- to Data Valid	max	60	60
tF	DIOR- Data Hold	min	5	5
tFa	DIOR- Data Tristate	max	30	30
tG	DIOW- Data Setup	min	30	30
tH	DIOW- Data Hold	min	15	10
tI	DMACK to DIOR-/DIOW- Setup	min	0	0
tJ	DIOR-/DIOW- to DMACK Hold	min	5	0
tK	DIOR-/DIOW- Negated Pulse Width	min	50	50
tL	DIOR-/DIOW- to DMARQ Delay	max	40	40

NOTES:

1 ATA Mode 1 proposed timing listed for reference only.

8.5 AT-Bus Interface Pin Assignments

Disk Connector Pin No.	Disk Connector Signal Name	Direction	AT System Bus Pin No.	AT System Bus Signal Name
1	-HOST RESET	<-- INV	B 2	RESET DRV
2	GROUND	—	—	GROUND
3	HOST DATA 7	<-->	A 2	SD 7
4	HOST DATA 8	<-->	C 11	SD 8
5	HOST DATA 6	<-->	A 3	SD 6
6	HOST DATA 9	<-->	C 12	SD 9
7	HOST DATA 5	<-->	A 4	SD 5
8	HOST DATA 10	<-->	C 13	SD 10
9	HOST DATA 4	<-->	A 5	SD 4
10	HOST DATA 11	<-->	C 14	SD 11
11	HOST DATA 3	<-->	A 6	SD 3
12	HOST DATA 12	<-->	C 15	SD 12
13	HOST DATA 2	<-->	A 7	SD 2
14	HOST DATA 13	<-->	C 16	SD 13
15	HOST DATA 1	<-->	A 8	SD 1
16	HOST DATA 14	<-->	C 17	SD 14
17	HOST DATA 0	<-->	A 9	SD 0
18	HOST DATA 15	<-->	C 18	SD 15
19	GROUND	—	—	GROUND
20	KEY			NO CONNECTION
21	DMARQ	--->	—	HOST DMARQ CHANNEL
22	GROUND	—	—	GROUND
23	-HOST DIOW	<---	B 13	-DIOW
24	GROUND	—	—	GROUND
25	-HOST DIOR	<---	B 14	-DIOR
26	GROUND	—	—	GROUND
27	-HOST IORDY	--->	A 10	-IORDY
28	SPSYNC:CSEL	<-->	—	NO CONNECTION
29	-DMACK	<---	—	HOST -DMACK CHANNEL
30	GROUND	—	—	GROUND
31	HOST INTRQ	--->	D 7	INTRQ
32	-HOST IOCS16	--->	D 2	-IOCS16
33	HOST ADDR 1	<---	A 30	SA 1
34	-PDIAG	—	—	NO CONNECTION
35	HOST ADDR 0	<---	A 31	SA 0
36	HOST ADDR 2	<---	A 29	SA 2
37	-HOST CS 0			CS1FX
38	-HOST CS 1			CS3FX
39	-DASP			NO CONNECTION
40	GROUND	—	—	GROUND

Table 8-2. AT-bus interface pin assignments.

8.6 AT Error Messages

Command	BBK	UNC	IDNF	ABRT	TKO	DRDY	DWF	DSC	CORR	ERR
				Error Message						
RECALIBRATE				V	V	V	V	V		V
READ	V	V	V	V		V	V	V	V	V
READ LONG	V		V	V		V	V	V		V
WRITE	V		V	V		V	V	V		V
WRITE LONG	V		V	V		V	V	V		V
READ VERIFY	V	V	V	V		V	V	V	V	V
FORMAT TRACK			V	V		V	V	V		V
SEEK			V	V		V	V	V		V
EXECUTE DIAGS				V						V
INIT PARAMETERS				V					V	
READ MULTIPLE	V	V	V	V		V	V	V	V	V
WRITE MULTIPLE	V		V	V		V	V	V		V
SET MULTIPLE MODE				V		V	V	V		V
READ DMA	V	V	V	V		V	V	V	V	V
WRITE DMA	V		V	V		V	V	V		V
READ BUFFER				V						V
WRITE BUFFER				V						V
IDENTIFY DRIVE				V		V	V	V		V
INVALID CODES				V						V

Table 8-3. AT error messages.

Notes to Table 8-3:

BBK = Bad block detected
UNC = Uncorrectable data error
IDNF = Requested ID not found
ABRT = Abort command error
TK0 = Track zero not found error
DRDY = Drive not ready error
DWF = Drive write fault detected
DSC = Drive seek complete error
CORR = Corrected data error
ERR = Error bit in the STATUS register
V = Valid error for this command

9 TEST PLAN

9.1 General Description

This is a preliminary Production Test Plan for the Lightning 365 and 730 MB drives. The final test plan will mature from this proposal.

9.2 Servo Writer Station (P1-MP)

The Lightning product will use the push-pin type servo writer; writing the servo with the cover on the HDA. The servo-writer writes wedges on each track of each surface, all heads are written simultaneously. This station verifies the integrity of all the wedges on the top surface only, (plus outer 20 tracks of all heads). In verify mode, the head is positioned at the track center of the outermost track, and then moved in one track increments to each successive track center, using the laser as the position reference. Checks are made of the amplitudes of each servo burst against the minimum and maximum amplitude required for the drive AGC and servo to operate. Also, a check of the encoded track number, and of the Sync and Servo Address Mark (SAM) fields are made. The total stroke of the drive is checked.

A Servo Writer is a complex, very accurate test system consisting of three major blocks:

- A precision mechanical clamping system mounted on a granite plate to achieve high mechanical stability and very low sensitivity to vibration.
- The laser positioning system coupled to a push-pin mechanism used for accurate positioning during the writing and verifying servo bursts.
- The read/write/verify and control electronics.

9.2.1 Servo Writer Station Tests

The tests performed at the servo writer station are as follows:

- Motor Speed.
  This test continuously monitors the motor up to speed signal from the servo writer motor driver board to ensure that the motor speed is operating within the specified limits. The motor speed limits are:

  4500 RPM ± 0.5%

- Parametric.
  Parametric testing is comprised of four parts:

  - Clock Head AGC
    This test verifies the clock head is responding and functional.

  - Track Average Amplitude (TAA)
    The track average amplitude (TAA) test will test each head for an open or short circuit. A high frequency pattern is written at the ID and then read back and compared to a minimum signal value.

    If hf_TAA < min_TAA_limit (50 mV) then FAIL

- Resolution

The head resolution test measures the relative gain at two different frequencies. A high frequency pattern is written at the ID and read back, then followed by a low frequency pattern which is also read back. The ratio of the track average amplitude signal levels, for the two patterns, is compared to a resolution limit.

If ((hf_TAA / lf_TAA) * 100) < resolution _limit (60%) then FAIL

- Positive and Negative Modulation

This test measures the degree of signal modulation for a high frequency pattern written at the ID.

If hf_high > (100 + modulation_limit) (30%) then FAIL
OR
If hf_low < (100 - modulation_limit) (30%) then FAIL

• Measure Stroke

This test measures the actuator stroke from the inner crash stop to the outer inner crash stop in laser counts. The measurement is made by slewing the actuator between crash stops.

If laser count is less than a minimum count, then FAIL

• Airlock

The AirLock test measures the size of the airlock gap; that is, the amount of radial movement of the actuator with the airlock closed. It is used in conjunction with the stroke measurement to determine the amount of usable stroke; that is, the size of the data area.

• DC Erase

The servo writer erases all disk data surfaces by slewing from the outer crash stop to the inner crash stop with a DC erase current. The continued use of this test is under investigation.

• Write Clock Track

A clock track is written, using a separate clock head, to provide timing and synchronization signals for subsequent writing of servo wedges. The clock head is positioned outside of the outer crash stop so as not to impinge on the reserved data area of the media.

If the operation is unsuccessful, then FAIL

• Write Servo Wedges and Serial Number

There are 70 equally spaced servo wedges per track. A servo wedge contains SYNC, servo address mark (SAM), track index, track number and ABC burst information. The relative amplitude of each A, B and C burst provides position information (relative to track center) for each data head. Servo wedges are written at half track intervals on every data surface. The laser positioning system provides the precise position feedback needed for the servo writer/data head positioning servo loop. In addition, if the heads go off track while writing servos, the current track will be rewritten, starting at the previous half track. If timing lock is lost (from the clock track) while writing servos, then the current track will be rewritten. Both excessive off-track errors or lost lock errors will abort and fail the servo writer test process. Serial numbers are also written on the cylinder -6.

If the operation is unsuccessful, then FAIL

- Verify Servo Wedges
  Verify all surfaces for critical cylinders. This includes the system cylinders, as well as some OD cylinders.

  Allow no defective wedges on the system cylinders.
  Verify only the top (worst) surface, for the rest of the tracks.
  Verify servos consists of two parts: track tests and wedge tests.

  - Off Track
    Odd Track #: If B_avg > A_avg OR B_avg > C_avg then ERROR
    Even Track #: If B_avg < A_avg OR B_avg < C_avg then ERROR

    This test measures absolute track location and will generate an error if the track is more than a 1/4 of a track from center.

  - Track PES
    If |PES_avg - prev_PES_avg| > limit (5%) then ERROR

    Where Position Error Signal (PES) is

    Even Track #: PES = C_avg - A_avg
    Odd Track #: PES = A_avg - C_avg

    This test measures track location with respect to the previous track and indicates track squeeze.

  - Average A+C to B:
    If (A_avg + C_avg) - (B_even_avg + B_odd_avg) > limit (10%) then ERROR

    This test was added by FLASH to detect a bit shift between half tracks during a write. A bit shift will cause a small increase in amplitude of the AGC compensated A and C bursts, for which this test is designed to detect.

  - Index
    Check that the index is present.

  - Wedge Error Overflow
    If # of soft errors (wedge errors) > limit then ERROR

  - Wedge
    Wedge tests are performed for each wedge.

  - A/B/C Burst:
    If |A_avg - A| > limit (20 counts) then ERROR
    If |B_avg - B| > limit (20 counts) then ERROR
    If |C_avg - C| > limit (20 counts) then ERROR

  - AGC
    If AGC voltage < limit (80 counts) then ERROR
    This test will detect a low amplitude AGC field.

- A+C to B:
  - If |(A+C) - (B_even_avg + B_odd_avg)| > limit then ERROR

  This test was designed to detect A and C bursts with amplitudes that are too large, and usually indicates a problem with the AGC field.

  This test has been replaced by the following two tests: the Track Average A+C to B test and the Wedge PES test. Therefore, this test may be discontinued to speed up verify.

- TNA SYNC, SAM or ID:
  This test checks the servo wedge TNA status from BISON for missing sync, SAM, index or track number. TNA errors may be caused by media defects or poor S/N ratios.

- Track #:
  This tests checks that the BISON reads the correct track number.

- Wedge PES:
  If |(A - C) - (prev_wedge_A - prev_wedge_C)| < limit (8%) then ERROR
  This test detects wedge errors or servo bump errors.

• Verify Test Fail Criteria

  - Track Errors
    If Track error(s) is(are) reported during verify, then retry track verify 3 times.
    If track errors reported on 2 out of 3 retries, then FAIL VERIFY.

  - Wedge Errors
    If #_of_Bad_Wedges > 1 then FAIL Verify
    If number of soft errors > limit then FAIL.

    A wedge is bad if, and only if, verify reports errors for a wedge (hard wedge error) on 2 out of 3 retries.

9.3 PCB Test (P1-MP)

This is a quick test of the drive board. This test is run on a slave HDA, with pogo pin connectors and an external current detection board. This test is run on every PCB, and therefor time limited. The only things we should test here, are things which can't be tested anywhere else, or features which will screen out potential line failures in a minimum time.

• Power Up.
  The PCB is placed on the slave HDA, and the drive is spun-up.

• PCB Read/Write.
  This test is a brief write/read/compare (full compare), of one cylinder of each zone, to verify the general functionality of the board. Use random data patterns. One write and three reads per track.

- RAM test
  This test performs a write/read/compare for with two complementary data patterns to check for open/shorts, and gross functionality.

- Seek Testing.
  This is a brief test to verify the board's ability to seek and settle. About 50 loops of full stroke seeks are performed.

9.4 Analog Test (Pre Production-Pre MP)

The purpose of the Analog test station is to perform parametric measurements of heads and media, (used to qualify and maintain vendors, as well as debug and disposition failures).

- TAA.
  Track-average-amplitude (TAA), is measured at the HDA flex output. It is measured at both low and high frequencies on each head in each zone. The result is compared against a pass/fail limit.
  TAA is measured by writing the pattern for the entire track and taking as many samples as possible during a read. The read is repeated several times to average the result both for the TAA and Resolution Modulation. This is repeated for both frequencies. The results are reported in mV peak-to-peak.
  For both LF and HF patterns, a minimum and maximum value of peak-to-peak voltages are checked. Each zone potentially has different limits (low and high), and any value outside the range is considered a failure.

- Resolution.
  Resolution is expressed as a percentage and is calculated as $100*(TAA_{HF}/TAA_{LF})$. This is reported as above for every head in each zone.
  Each zone potentially has a lower limit. If the calculated resolution is < min, then FAIL.

- Modulation.
  Measure the TAA envelope once around in all zones; compare with the maximum and minimum amplitudes.

- Overwrite.
  Measure the power spectrum of the highest frequency. First LF is written, and amplitude measured. Second HF is written. Then the amplitude of the remaining LF signal is measured and expressed in dB.

- Window Margin.
  Use an HP TIA tester to gather 10^7 bits and calculate the window margin in percent of full window.

9.5 Digital Scan (Pre Production-Pre MP)

This process is a series of test which are designed to tell us as much about the drives as possible before we get into production. The results of these tests should give us enough information to optimize the drive design, and the test process as we approach mass production.

This test will be eliminated before mass production.

- Nulll.
  Measure actuator current in track following mode and compares to fail limits.
  Number of locations across stroke (number of places to measure) 31

- PERR.
  Measures RRO / NRRO for 200 revs on cylinders 0, 1738, and 3566.

Maximum NRRO	9.5%
Maximum RRO	9.5%

- Wedge Verify.
  Verify servo wedge. Use this data to measure the effectiveness of the verify test in Servo Writer station.

Number of times wedge must pass	4
Number of bad tracks	20
Max number of bad wedges per track	1

- RAM Test.
  This test performs a write/read/compare for with two complementary data patterns to check for open/shorts, and gross functionality.

- Start / Stop - Power Cycle.
  Start / Stop for 5 cycles, waiting 16 seconds after stop and 15 seconds after start.

- Access Time by Stroke Length.
  Measures average access time by seek length for multiple seek lengths across the drive:
  1, 2, 5, 10, 19, 38, 75, 149, 298, 595, 1189, 1538, 3566.

- Random Seek.
  Measure seek time for 5000 random seeks with read on arrival enabled.
  Max 12 ms.

- Sequential Head Switch Time.
  Measure the time it takes for head switch and single track seeks, (head switch from last head to first on next cylinder).

- Servo Dump.
  Reads servo constants. This test is informational only.
  Number of locations across stroke (number of places to measure) TBD

- Window Margin.
  This test writes a pattern, on a defect free track at the ID of each zone, and reads 107 bits per track. The data is checked for early and late window margin.

- Format.
  Format all data tracks. Allow retries on up to 20 tracks.

- Physical Sequential Stress write / read with ECC disabled.
  Defect scan with intelligent scratch-fill which retests adjacent and error tracks. Physical scans are performed with ECC on-the-fly, ECC, and retries disabled for raw error rate.

  Scan defects with 7 patterns (66, 99, 16, 27, 61, 72, and random). For all patterns, do 1 write loop, 3 read loops, 3 read retries, and 3 write/read retries for defective sectors. Read on arrival is disable. All hard and soft defects are logged in the defect list. Soft defects will be changed to hard if found again in the later test patterns.

Limits	**1 Disc**	**2 Discs**
Max hard defects per drive	193	387
Max hard defects per head	129	129
Max hard defects per cylinder	6	12

- Off Track.
  Measures the ID and OD offtrack read capabilities for all heads and all zones of the drive. Measurements are taken at the ID cylinder of each zone. 5 retries in verifying good test track with 2T pattern and high threshold. 1 retry offtrack measurement. Write random patterns on test tracks, and their adjacent tracks. All tracks are written on track.

  Allowed 10 read errors in 10E7 bits transferred. Start from 20% down to 8%.

- Format Inline.
  Format drive with inline spares for all hard defects in selfscan defect list. After inlines, IDs' after inline will be renumbered. Allow 1 inline spare per disk per cylinder. Factory defect list (P list) and working defect list (W list) are created.

  One or more track format error fails the test.

- Logical Sequential write/read with H/W ECC enabled.
  Soft error rate test using sequential seek patterns. Note that ECC on-the-fly (H/W ECC) is considered a hardware function. Hence, for the purpose of counting soft and hard errors, ECC on-the-fly correctable errors are ignored. Soft error is defined as any recoverable (using ECC and retires) error that occurs only once.

  This test is used to make sure no additional hard and non-recoverable defects are found after format inline. Random patterns, 1 sequential write loop, and 4 sequential read loops are done.

- Logical Random write/read with H/W ECC enabled.
  Soft error rate test using random seek patterns. Note that ECC on-the-fly (H/W ECC) is considered a hardware function. Hence, for the purpose of counting soft and hard errors, ECC on-the-fly correctable errors are ignored. Soft error is defined as any recoverable (using ECC and retires) error that occurs only once.

This test is used to make sure no additional hard and non-recoverable defects are found after format inline. 2 Random pattern loops: 1 sequential write loop, and 3 sequential read loops are done with each data pattern.

- ECC Test.
  Perform test on the inner and outer cylinders, sampling 10 times each pattern. Corrupt data byte(s) and verify correction. Verify detection of large ECC errors.

- Sequential Throughput.
  Sequential throughput test using a random data pattern, (256 blocks per transfer for AT products) transferring 10MB data on OD.

Minimum rate for AT	0.1 MB
Minimum rate for SCSI	2.5 MB

- Random Throughput.
  Random throughput test using a random data pattern, 1 block per transfer for 2000 blocks.

Minimum rate for AT	0.001 MB
Minimum rate for SCSI	0.016 MB

- Start / Stop - Power Cycle.
  Start / Stop for 5 cycles, waiting 16 seconds after stop and 15 seconds after start.

9.6 Diskware

The diskware station performs a quick verification of the drive, and then writes and verifies the Diskware blocks and self-scan script.

- Get Drive Type. Model number, and serial number.
- Load RAM Ware.
- Read Servowriter Data.
- Re-read Mode and Serial Number.
- Erase EEPROM. For SCSI drives only, erase the EEPROM, and reload RAM Ware.
- Format System Cylinders.
- Write Disk Ware.
- Write Config Pages. Format table, empty P-list.
- Write Servo write data to negative cylinders.
- Power cycle the drive.

9.7 Self Scan Test

This process is a self-contained series of test which are the core of our testing. All features of the drive which can be tested internally should be tested here.

The 'script' for this station is written on the drives negative cylinders at the Diskware station. The script to automatically run this test is also loaded at Diskware, and the password removed at the end of the Self scan test. The Self scan script is kept on the drive, and the can be invoked at any time by sending the drive the self-scan superset command. Each routine saves data to the negative cylinders. Any additional data required, (defect lists, etc.), will be saved on other locations as directed by software. The data collected in this test is retrieved at the final scan station.

- Start/Stop.
  Start / Stop for 10 cycles, waiting 2 seconds after stop. This test measures the minimum, average, and maximum start / stop times.

  Fail if start-up time is > 7.0 seconds.

- Servo Verify.
  This test scan the entire data area checking the A, B, and C bursts of each servo wedge. Each track is measured 2 times, and retried 7 times if a defect is found.

Bump limit	52
Min Wedge Span	20
Max Errs Per Track	2 bad wedge / track

- Guard-band Erase.
  For each track, on each head, erase on track, and off-track in both directions. This removes any noise from the guard-bands; particularly the 2T pattern left by the servo writer.

- Format.
  This procedure performs a low level format of the data area. Any defect lists are ignored. If a seek error in encountered, retries will be done until error is corrected or the retry count is exhausted (8); if this happens, the drive is failed.

- Adaptive Equalization.
  This procedure is used to interactively optimize the read channel for marginal heads. Several parameters are optimized:

  - Window centering: This procedure finds the center of the read channel window, and writes the value to config page 17. The procedure measures all zones; (from ID to OD, using the value from the pervious zone as a starting point).

  - Threshold Optimization.

  - Adaptive Boost/Cutoff: This procedure is performed on any head not meeting window margin requirements. The firmware goes through a table of boost and cutoff values, trying each combination, and measuring window margin. The best value is saved to RAM.

- Nulll Test.
  Measures actuator current at several locations across the stroke. This value is used to measure the non-linear resistance of the actuator, cause by things like the flex circuit.

- Buffer RAM Test.
  This test checks the drive's RAM, by passing a walking-0 and walking-1; i.e. each bit is set to zero and one independently of all other bits. If a bit is bad, the location is reported.

- Head Switch/ Single Track Seek.
  Measure sequential head switch times from OD to ID, (this includes a seek, when switching from max head to min head).
  5 percent allowed > 3.8 ms for head switch time within the same cylinder.
  5 percent allowed > 4.8 ms for single track seek (head switch across cylinder).

- Third Stroke Seek.
  Measure the seek time for one-third stoke seek, over 500 seeks. (14 ms max.)

- Full Stroke Seek Time.
  Seek from ID to OD, and OD to ID 1000 times, measure maximum minimum and average seek time. (22 ms max.)

- Random Seek.
  Measure seek time, (average and maximum), for 1000 random seeks.

  Max 12 ms.

- Runout.
  Test for repeatable run out (RRO) and non repeatable run out (NRRO), over 100 revolutions on cylinders 0, 609, 1218, 1827, 2436, 3045, and 3657.

  RRO and NRRO limits are 75.

- Wedge to Wedge Scan.
  Several passes are made of the entire data area. The drive is scan with standard thresholds, and offset thresholds. Several data patterns are used; 1 write and 2 read passes are made with each pattern.

- Format.
  This procedure performs a low level format of the data area. Any defect lists are ignored. If a seek error in encountered, retries will be done until error is corrected or the retry count is exhausted (8); if this happens, the drive is failed.

- Physical Sequential Stress write / read with ECC disabled.
  Defect scan of the entire data zone. Physical scans are performed with ECC on-the-fly, ECC, and retries disabled for raw error rate. Scan for defects with several patterns (including random). Scan on track, and off track 7% in each direction.

Limits	1 Disc	2 Discs
Max hard defects per drive	194	300
Max hard defects per head	129	129
Max hard defects per cylinder	6	12
Max seek errors per drive	255	255

- Customer Scan.
  This is a logical scan used to measure soft error rate test using sequential and random seek patterns. Soft error is defined as any recoverable error that occurs only once. Each time a defect is found, it is compared with the self scan defect list; if the defect is not on the self scan list, it is put on a soft error list (if the defect is already on the soft error list, then it is a hard defect, and moved to the self scan list).

- Defect Verify / Scratch Check.
  This procedure is used to supplement the map by doing extensive testing near defects. For every defect encountered during physical sequential defect scans, retest 3 tracks before and after the defective track, and the defective track for possible scratch. Use 5 data patterns. For each pattern, do 2 writes, 5 reads, 8 read retries, and 8 write / read retries on the defective sectors.

- Format Inline.
  Format drive with inline spares for all hard defects in selfscan defect list. After inlines, IDs' after inline will be renumbered. Factory defect list (P list) and working defect list (W list) are created.

- Customer Scan.
  This is a logical test used to make sure no additional hard and non-recoverable defects are found after format inline. Random and sequential passes are run, with random data patterns.

- Start/Stop.
  Start / Stop for 10 cycles, waiting 8 seconds after start. This test measures the minimum, average, and maximum start / stop times.

  Fail if start-up time is > 7.0 seconds.

- Delete Password
  Delete password indicating Self Scan is not to be run during the next power-up.

9.8 Final Station

At this station, we should only be testing the things which can't be tested at self scan. The faster the host system, the more complete the testing we can perform.

- Servowriter Report.
  Reports the results from Servowrite, and displays servo variables.

- Selfscan Report.
  This dumps the results of Selfscan toes to the TEST.OUT file. This routine fails on any selfscan failure, incomplete test, or invalid test code.

- Start/Stop.
  This test is designed to verify that the drive will power up consistently; and is a required by some OEMs. This test powers up the drive, verifies ready, and performs some seeks (in super mode) to verify functionality. Since this test takes 20 to 30 seconds per loop, only five cycles are performed on SCSI drives (two cycles on AT drives)..

- Random Seek Time Test.
  Measure seek time, (average and maximum), for 500 random seeks

- Head Switch Time Test.
  Measure the time it takes for head switch and single track seeks, (head switch from last head to first on next cylinder).

- ECC Test.
  This routine test the error correction code firmware and hardware of the drive. This test verifies the drives ability to detect and correct data errors. A pattern is written to the drive, and read back with ECC syndrome using a read long command. Then, a data byte is modified and written back using a write long command, and read back from the drive; the drive should report an ECC corrected data error. This procedure is repeated with an increased number of modified bytes, until ECC is unable to correct the defect; this should happen at a know defect length.

- FIFO Test.
  Read/writes, with full compare.

- Logical Random Test.
  This is a read/write test designed to verify the integrity of the drives defect list.

- Sequential Throughput Test. (SCSI Only)
  This test measures the time it takes to transfer large sequential blocks to and from the host.

- Random Throughput Test. (SCSI Only)
  This test measures the time it takes to transfer random blocks to and from the host.

- Configuration.
  This operation configures the drive as a generic drive. This should be the last operation run on a drive. This sets the generic SCSI and AT mode and config. parameters.

- Write Results.
  Create TEST.OUT file.

Section 10 Standards

Lightning drives will meet the following regulatory specifications:

10.1 Underwriter Laboratory (UL)

Lightning hard disk drive will meet the current edition of UL 1950, Standard for safety: Information technology equipment including business equipment.

Locked Rotor Test acceptable for UL 1950, No.950 will be included as part of UL Certification.

UL Recognition shall be obtained without any special or unusual conditions of acceptability. A copy of the UL Recognition Report, including Conditions of acceptability, will be provided.

The drive will bear the UL required identification markings which provide proof of UL Recognition. Use of the UL backwards "UR" is preferred.

10.2 Canadian Standards Association (CSA)

Lightning hard disk drive will meet the current edition of CSA - C22.2 No. 950-M89. information technology equipment including business equipment.

Locked Rotor Test acceptable for CSA 22.2, No. 950 will be included as part of CSA Certification.

CSA Certification shall be obtained without any special or unusual conditions of acceptability. A copy of the CSA Certification Report, including Conditions of acceptability, will be provided.

The drive will bear the CSA required identification markings which provide proof of CSA Certification.

10.3 European standards (VDE and TUV)

Verband Deutscher Electroechnier (VDE)
Technisher Uberwachungs Verein (TUV)

Lightning hard disk drive will meet the current edition of EN 60 950. European Community Regulations for safety of Information technology equipment including Electrical business equipment and IEC950, Safety of Information technology equipment including Electrical business equipment.The drive will also meet the requirements of DIN/VDE 0805,Safety specification for business machines.

Locked Rotor Test acceptable for EN60 950 and IEC 950 will be included as part of VDE and TUV approval.

Approval shall be obtained without any special or unusual conditions of acceptability. A copy of the report, License and Construction Data Forms will be provided.

The drive will bear VDE or TUV required identification markings which provide proof of VDE and TUV approval.

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Section 11 Drive Mounting

11.1 Orientation

The Lightning family of drives may be mounted in any orientation and nominal position is PCB face down.

11.2 Physical Characteristics

Outline Dimensions: ±**.010**	**1.00" X 4.00" X 5.750"** 2.54 x 10.16 x 14.6202 cm
Weight	**16 Ounces** 454.00 g
Mounting Dimensions	See Figure 11-1

Table 11-1. Physical dimensions.

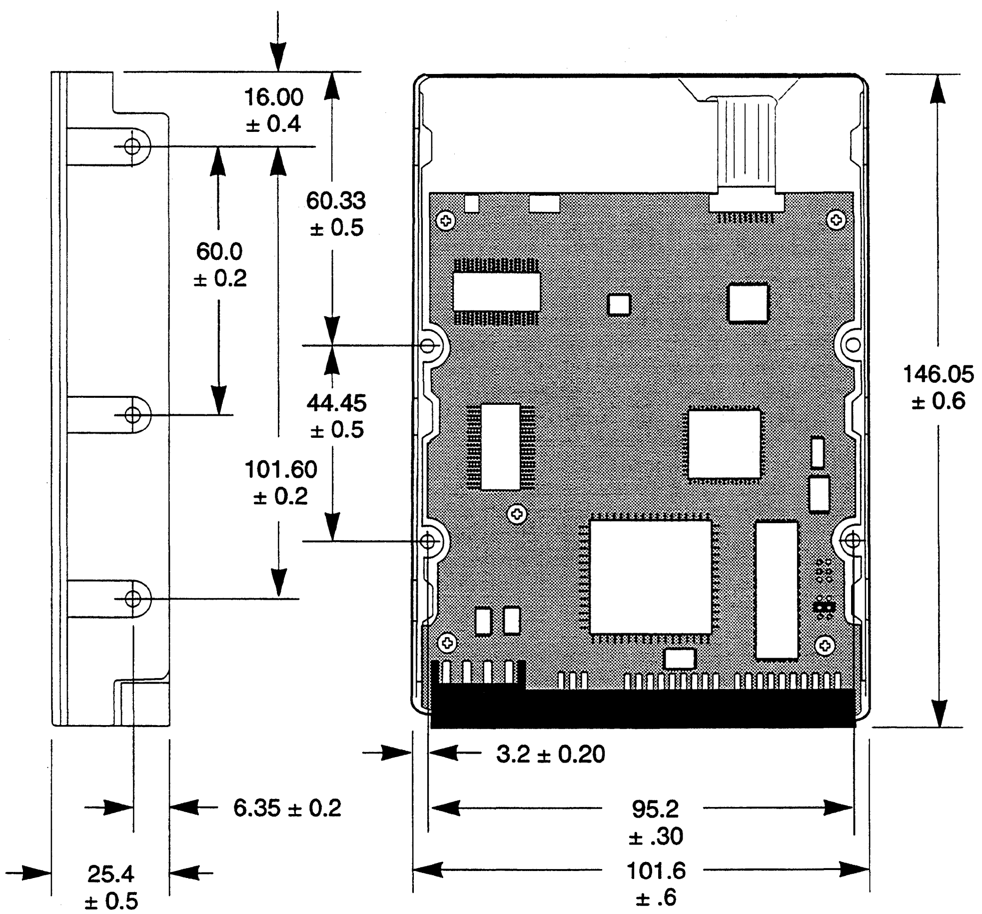

Figure 11-1. Lightning mounting dimensions.

11.3 Mounting Screw Clearance

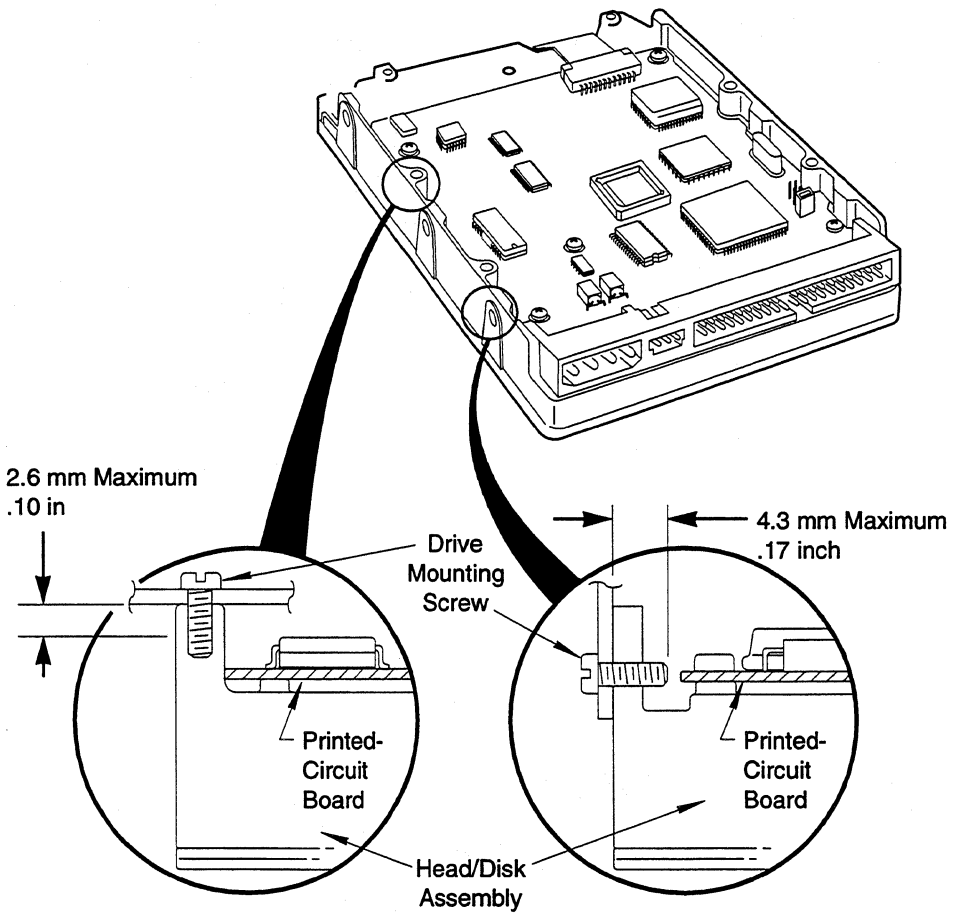

Figure 11-2. Drive Mounting Screw Clearance.

Notes to Figure 11-2:

The Printed-Circuit Board (PCB) is very close to the mounting holes. Do not exceed the specified length for the mounting screws. The specified screw length allows full use of the mounting-hole threads, while avoiding damaging or placing unwanted stress on the PCB. Figure 11-2 specifies the minimum clearance between the PCB and the screws in the mounting hole. To avoid stripping the mounting-hole threads, the maximum torque applied to the screws must not exceed 8 inch-pounds.

Section 12 Packing

12.1 General Information

Quantum seeks not only to ship products that provide the latest in technological features, but also to ensure that these products arrive at the customer's site in the same condition that they left our factories.

12.1.1 SHIPPING CONTAINERS

Two (2) sizes of shipping containers will be required for Lightning products. These are:

1. 1-Pack Shipping Container
2. 12-Pack Shipping Container.

The 1-Pack Container hold one (1) disk drive, and the 12-Pack holds twelve (12).

12.1.1.1. The shipping containers shall be sufficient to protect the parts enclosed, and must comply with the packaging requirements of the latest issue of Uniform Freight Classification Rules, or other applicable carrier requirements.

12.1.1.2. The containers are intended for single-use.

12.1.1.3. Container sizes should be selected such that when arranged upright on a 4-way 40"Wx48"D pallet, the containers do not overhang the edges of the pallet deck. Containers when arranged on the pallet, should maximize utilization of the pallet deck area and the available 48" load height.

12.1.1.4. Closures must permit handling without specific precautions.

12.1.1.5. The corrugation used in these containers must have sufficient strength to prevent collapsing of the container under double stacked pallet loads.

12.1.2 IDENTIFICATION

12.1.2.1 Each shipping container must be identified on sides #3 and #4 (See Figure12-2) with the following basic information:

A. Quantum Logo
B. Symbols to indicate:
   1. The proper orientation of the TOP of the container.
   2. The container contents are FRAGILE.
   3. The container should be protected from water, rain, etc.
   4. The container contents are sensitive to static electricity.

12.1.2.2 The following letters should appear on side #5: "_ of _". This permits identifying each container as part of a group with a marking pen, e.g. 5 of 12.

12.1.3 DOCUMENTATION

12.1.3.1 1-Pack Carton: TBD

12.1.3.2 1-Pack Insert: TBD

12.1.3.3 12-Pack Carton: TBD

12.1.3.4 12-Pack Insert: TBD

12.1.3.6 Anti-Static Bag: TBD

12.1.3.7 Static Warning Label: TBD

12.2 Physical Drive Specifications

12.2.1 DIMENSIONS

Outline Dimensions ±0.01 inches	1.00" X 4.00" X 5.75" (See Figure 12-1)
Weight	16 Ounces (1.0 lbs = 0.44kg)

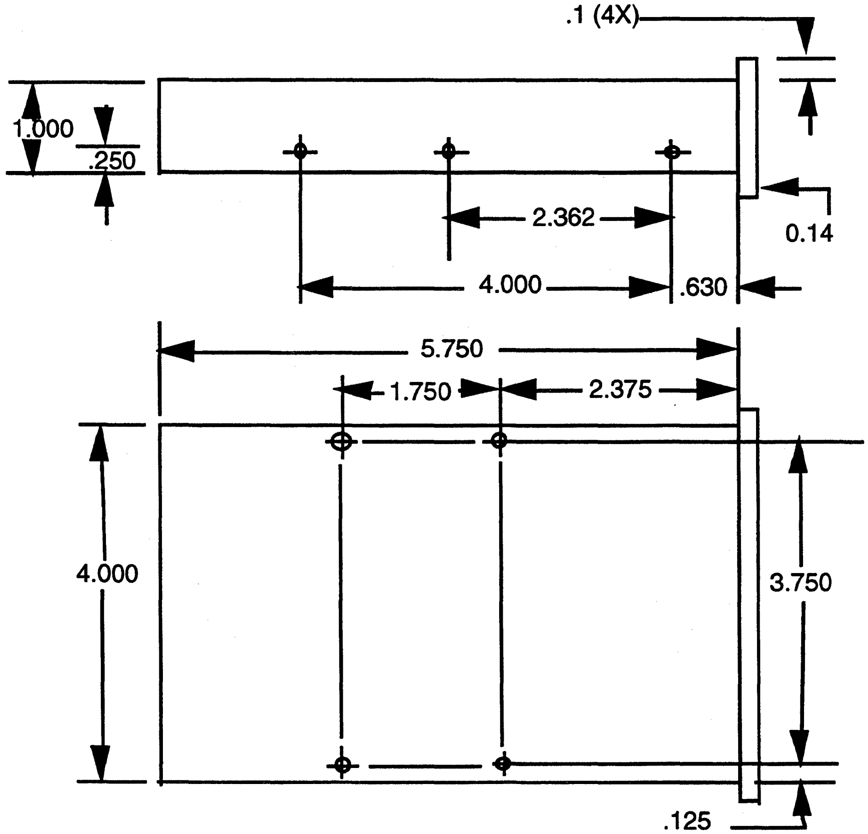

Figure 12-1. Lightning outline dimensions.

12.2.2 NON-OPERATIONAL SPECIFICATIONS

	Non-Operating
Temperature	-40°C to 75°C -40°F to 167°F
Temperature gradient	48°C/hr.
Humidity[1] Max wet bulb	5% to 95% RH 46°C 114.8°F
Altitude[2]	-200 m to 12192 m -650 ft. to 40,000 ft.
Shock[3]	60 Gs
Vibration[4] (peak to peak)	2 Gs

Table 12-1. Non-Operational Specs

Notes to Table 12-1:

1. Humidity: no condensation is allowed. See Appendix E for humidity charts for low and medium temperatures.
2. Altitude: relative to sea level.
3. Shock: 11 msec 1/2 sine wave, 10 hits maximum.
4. Vibration: P-P 5 - 500 Hz, 1 Oct/Min sine sweep.

12.3 Packaged Finished Goods Product Shock & Vibration Test Standards

This section outlines the laboratory test levels required to assure the arrival of Quantum Finished Goods (F/G) products to the end user without damage or loss of performance beyond the published specifications. The packaged products must be tested prior to product release to assure adequate protection against the shipping and handling hazards anticipated in the domestic and international distribution network.

12.3.1 REFERENCE CONDITIONS AND TOLERANCES

Unless otherwise stated, the ambient conditions of the laboratory and tolerances for test conditions are:

Temperature	23 °C ± 5°C
Humidity	30% to 70% RH (not controlled)
Acceleration	+15%, -5% Peak
Velocity Change	+10%, -2%
Frequency	±0.5 Hz

Table 12-2. Assumed ambient conditions and tolerances for test conditions.

12.3.2 APPLICATION

This specification shall apply to all Quantum products which are identified with the name "Quantum" and/or the Quantum logo applied to the product regardless of whether the product was fully or partially manufactured and packaged by Quantum or an outside supplier.

NOTE: This test standard is a procedure to assure the maximum values of shock (Critical Acceleration) are NOT exceeded. Also, this standard details the vibration tests required to assure the packaged cushion resonances will NOT damage the Quantum F/G packaged product.

12.3.3 EXCEPTIONS OR DEVIATIONS

Any exceptions or deviations from the product standards must be approved by the Engineering Product Manager, the Product Marketing Manager and Quality Assurance. Any deviation or exemptions must noted in the Product Plan. Quantum O.E.M. customer and O.E.M. supplier requirements must be reviewed by Quality Assurance prior to contractual finalization by Quantum to avoid both over-packaging and under-packaging of Quantum products.

12.3.4 FINISHED GOODS PRODUCT TESTS

12.3.4.1 Vibration

a. resonance search / Dwell
b. resonance endurance - SINE wave
c. stacked resonance

12.3.4.2 Shock: "Free Fall Drop"

12.3.5 PRE-TEST AND POST-TEST INSPECTION AND FUNCTIONAL TEST

All specimens must be thoroughly functionally tested prior for submission of packaging testing and the characteristic data recorded for comparison with post test data. The product must be visually inspected prior to packaged testing.

All specimens must be tested to determine the sound power, (Lw(A)), during idle. The data is to be recorded for comparison to post-test sound power data.

When testing multiple specimen packing packing, the location of each specimen within the container is to be recorded.

After the shock and vibration tests are performed the specimen must be functionally tested to assure the unit is performing to specification. The specimens must be carefully inspected for structural,cosmetic and mechanical damage after shock and vibration tests. The sound power during idle must also be measured after each test.

The units under test shall be inspected and functionally tested between each segment of the shock and vibration tests series.

12.3.6 PACKAGING ACCEPTANCE

If during any segment of the F/G packaged product test the product fails to meet the required functional specifications, or the product has incurred structural damage, or the unit has been cosmetically blemished (other than fixturing markings), the packaging shall be considered "FAILED".

The packaging is considered to have "FAILED" if the sound power during idle increases by 3dBA, (.3Bel).

The packaging is to be visually inspected. The packaging is considered to have "FAILED" if there is evidence of packaging or cushioning breakdown.

Note: any intermittent problems should be considered "FAILED".

If packaging is considered "FAILED", the system should be rechecked to assure the system under test was not an unreliable sample and more samples must be tested to confirm either an acceptable or non-acceptable sample.

Before final acceptance, the system under test will be "burned-in" for 30 continuous days and retested to assure there are no latent failures introduced in the abuse testing.

12.3.7 CARTON ORIENTATION

The cartons are identified by figure 12-2.

12.3.8 VIBRATION TESTS

12.3.8.1. Resonance Search

Resonance search within a range of 3-200-3 Hz. at a constant acceleration input of 0.5Gs must be performed on three axes of the packaged assembly. An X-Y Log-Log plot must be permanently recorded for each axis tested at each monitoring position. If the packaged unit can conceivable be shipped in a position other than the upright position, all three axes must undergo a resonance search.

12.3.8.2. Resonance Dwell-SINE Wave

Each potential shipping axis must be endurance tested for a total one hour, 15 minutes per resonant frequency at an input of 0.5Gs acceleration. If the requirement of a full one hour cannot be achieved, the balance of the hour must be performed with the vibration system continually sweeping from 3-200-3 Hz. 0.5Gs constant acceleration input.

12.3.8.3. Pallet Stack, Resonance Endurance Test must be performed with the Finished Goods cartons stacked in the normal shipping orientation in a single column to the anticipated maximum height of a pallet load. For safety reasons, the proper fences (lateral support restraints) must be utilized.

After each axis is endurance tested, inspect all products in the column stack for cosmetic and structural damage. Then perform a functional test on the unit checking for intermittent or permanent malfunction.

12.3.9 RESONANCE SEARCH
The vibration system frequency adjusted for stacked resonance (maximum displacement of the top unit) at an input acceleration of 0.5Gs of the table.

12.3.10 RESONANCE DWELL
The endurance test to run a total of 15 minutes at the stacked resonance frequency.

12.3.11 SHOCK TEST: FREE FALL DROP TEST
The free fall drop test must be performed using a drop test mechanism which will provide accurate and repeatable drop heights. Also, the mechanism must be able to assure accurate and repeatable package orientation during impacts.

The acceleration levels must be monitored by the use of accelerometers and the resulting curves permanently recorded on photographs. The levels detected must not exceed the critical acceleration determined by the bare unit damage boundary tests.

12.3.12 TEST SEQUENCE

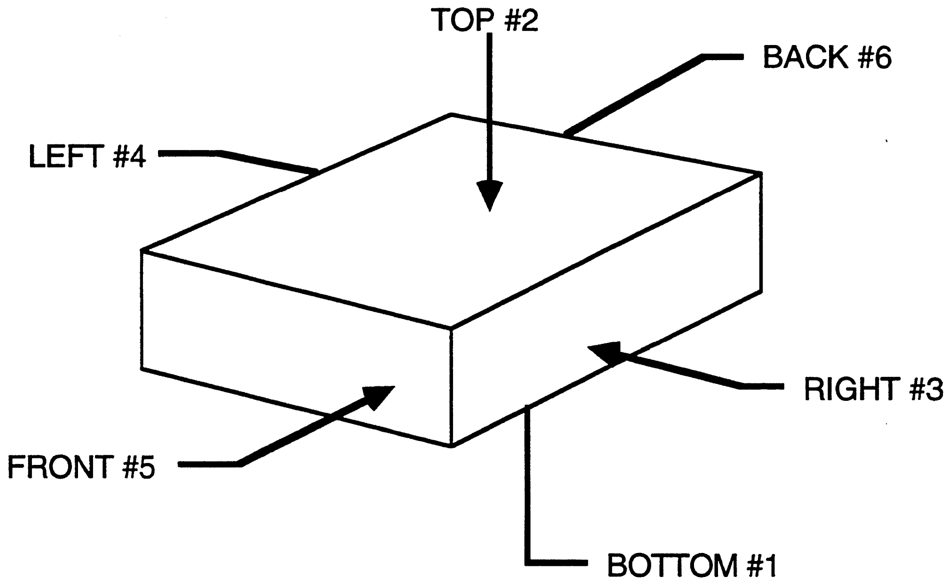

Figure 12-2. Lightning carton face identification.

The package product shall be shock tested by dropping the F/G package in the following sequence:

DROP #	IMPACT
1	bottom (1)
2	top (2)
3	right (3)
4	left (4)
5	front (5)
6	back(6)
7	edge (2-3)
8	edge (5-3)
9	edge (5-2)
10	corner (2-3-5)

Table 12-3. Free fall drop testing sequence.

12.3.13 DROP HEIGHTS

Gross Weight	Drop Height	No. of Drops
0 - 20 lbs.	30 inches	10
21 - 40 lbs.	24 inches	10
41 - 60 lbs.	18 inches	10
61 - 80 lbs.	12 inches	10
81 - 200 lbs.	6 inches	10
200 lbs. and above[1]	15/9 inches[2]	1/5

Table 12-4. Drop heights required for F/G Quantum products

Notes to Table 12-4:

1. If the F/G items are unitized (palletized), 14 impacts at 9 inches are required on the bottom orientation only.

2. First number is the base or bottom drop, second number is the drops on all other surfaces.

After drop testing the product, reinspect for structural and cosmetic damage. Also retest for intermittent and permanent functional malfunction. Retest each drive for sound power during idle. If the sound power has increased by 3dBA, (.3Bel), the packaging is considered to have "FAILED". Subject the units run through the shock tests to a 30 day burn-in test before the final functional test is performed.

12.3.15 COMPRESSION TEST
Floating platen compression test equipment shall be used in this test in accordance with ASTM D-642-76. The test shall be conducted on five (5) identical packages with all internal packaging components and an actual product or dummy load. The average of the five (5) tests shall be used to determine the acceptability of the container/package system.

Compressive forces are to be taken to the maximum required load or to failure. The maximum compressive rate is 0.5 inches per minute.

The minimum acceptable compressive resistance (load) will be based on the HIGHEST value calculated by using the following methods:

A. Four (4) times the greatest expected compressive load during transportation or storage.

B. Ten (10) times the weight of the product intended to be packaged.

C. 300 lbs. compression resistance.

12.3.16 REFERENCE DOCUMENTS
National Safe Transit Association (N.S.T.A.) Test procedures Project 1A.1973

12.3.17 A.S.T.M. DOCUMENTS

D-642-76	Compression Test for Shipping Containers
D-775-61(73)	Drop Test for Shipping Containers
D-880-79	Incline Impact Test For Shipping Containers
D-996-78	Packaging and Distribution Environments def. of terms
D-999-76	Vibration Testing of Shipping Containers
D-1083-53(79)	Testing Large Shipping Containers and Crates
D-3331-77	Assessment of Mechanical-Shock Fragility Using Package Cushioning Materials
D-3332-77	Mechanical-Shock Fragility of Products, Using Shock Machines
D-35680-80	Vibration (Vertical Sinusoidal Motion) Test of Products

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Section 13 PCB

13.1 PCB Layout Consideration

PCB consists of four layers: a component/signal plane, a +5V power plane , a ground plane and a signal plane. PCB has components only on one side. The four layer design provides an opportunity to:

13.1.1 Separate high frequency clock signals and other high current traces from noise-sensitive low amplitude analog signals such as readback signals.

13.1.2 Shield high frequency digital signals so as to reduce the energy dissipated by RFI emissions.

13.1.3 Provide ample ground planes for better ESD protections.

13.1.4 Use wide voltage and ground planes to prevent current loops that creates impedance difference between the power supplies and various parts of the PCB.

13.1.5 Provide adequate heatsinking capability for high current lines (spindle motor and VCM).

13.1.6 Utilize the spacing between the power and ground planes as by-pass capacitors, thereby minimizing the number of capacitors on the PCB.

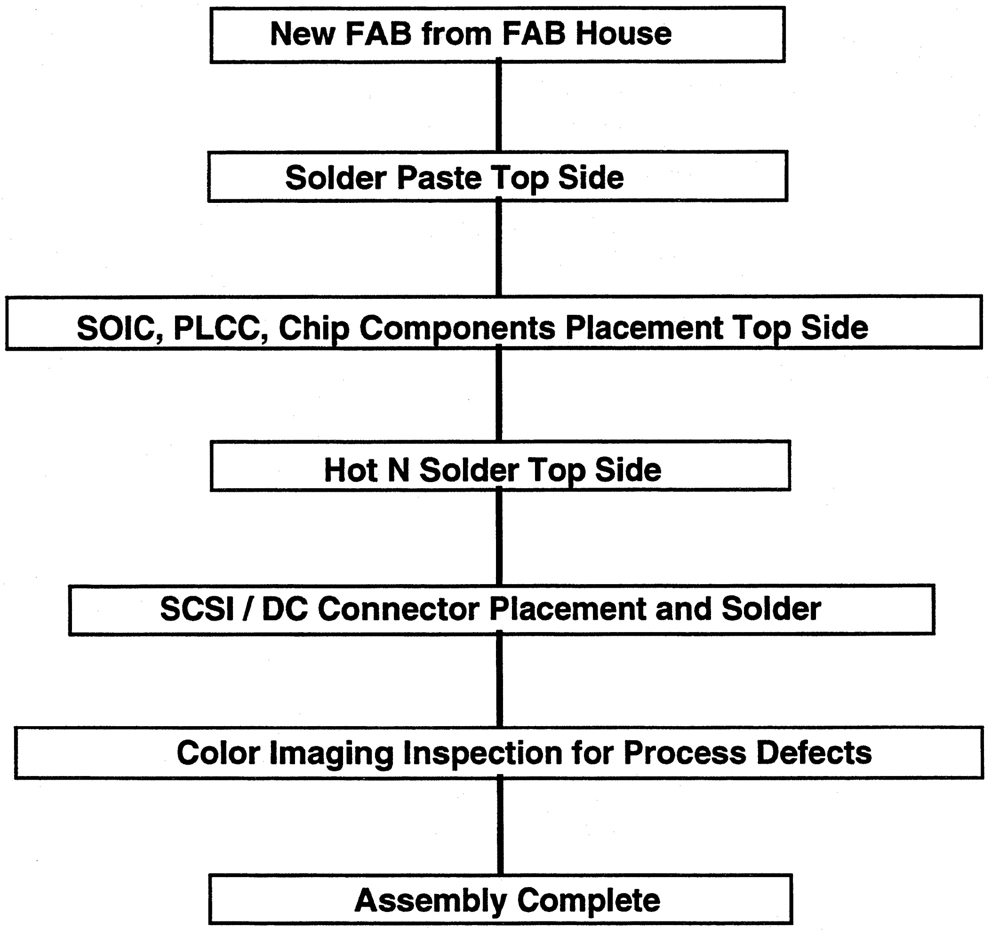
13.1.7 Provide power plane and trace keep out area's where drive mounting screw damage can occur. See Figure 13.3

13.2 Component Selection and Assembly Process

All land sizes were chosen for best placement registration to avoid misalignment, no contact, tombstoning resulting from unequal termination wetting and other SMD parts related solder problems. The fudicial marks at PCB corners help the high resolution vision feedback IC placement machine, especially necessary for fine-pitched QFP placements(TBD mm pin spacing).

PCB components selection was limited, besides performance, price and availability considerations, by package to fit the form factor, automatic placement, solder and other assembly equipment restrictions, ease of testing requirements, etc. The height requirement for the top side is 4.6 mm max, and for the bottom side 0.4 mm max. In order to meet these requirements, all components are mounted only on the top side while traces run on both sides. The current MKE PCB assembly process is illustrated in the next page.

13.3 PCB Assembly Process



13.4 Connector

In the current version of the Lightning design, the following connectors are used:

J1	SCSI/DC COMB 2/1 CONN.	DuPont SMT	QNTM # 22-100599-01
	AT/DC COMB 3/1 CONN.	DuPont SMT	QNTM # 22-100928-01
J2	LED CONN.	Molex SD-53261-0210 RA.	QNTM # 22-102264-01
J3	R/W FLEX CONN.	Molex 1mm FPC 16 pin 52207-1690	QNTM # 22-101366-01
J4	MOTOR CONN.	Elastomeric 4 pin	QNTM # 22-100547-01
J5	ID JUMPER (SCSI ONLY)	Molex SD-53261-0510 RA.	QNTM # 22-103422-01
JP1	ID JUMPER	2 x 3 3mm High Augat Hyper Micro Header	QNTM # 22-100929-01
JP2	QCP JUMPER	2 x 3 3mm High Augat Hyper Micro Header	QNTM # 22-100929-01

13.5 Hardware Review

In the current version of the Lightning design, the following IC's are used:

Spindle Motor Driver	Hitachi HA 13481 AFP
VCM Driver	Hitachi HA 13529 FP
Retract Circuit	Discrete
POR	Fujitsu MB3771
Micro Controller	NEC 78352
R/W ASIC	Hitachi HD153030RF
Controller ASIC	Quantum ASIC, Konishiki
DRAM	64K X16 , multiple sources
EEPROM	1K Serial EIAJ (SCSI Only)

13.6 Adjustments

There are no adjustments done on the PCB.

13.7 PCB Testing and Interchangeability

See Section 9.5 for PCB Test description.
Due to the adaptive equalization done at Self Scan the PCB's are not interchangeable. Any PCB swap will require re-processing the drive through the Self Scan and Final Test process.

13.8 SCSI PCB Block Diagram

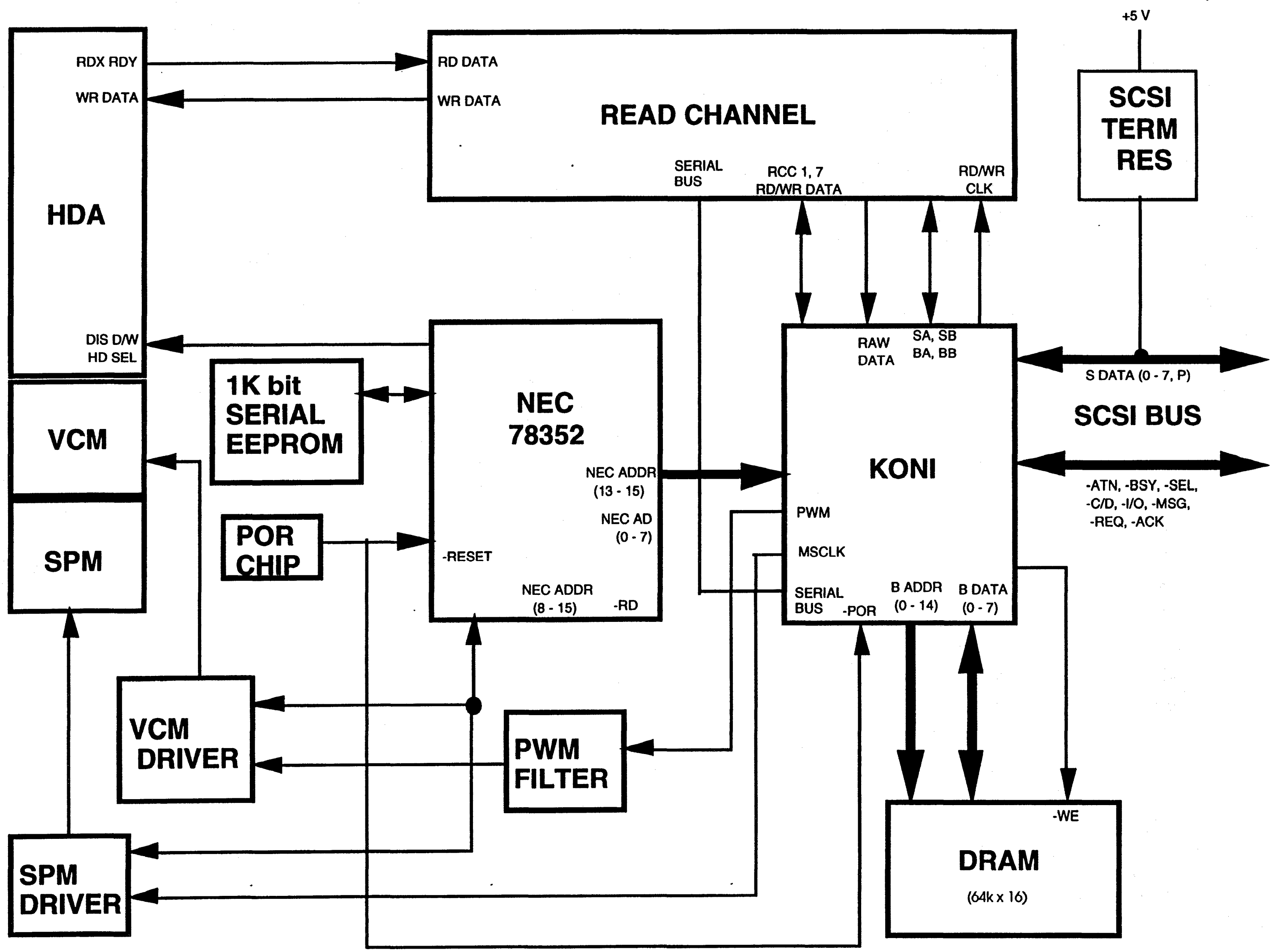


Figure 13-1. Lightning SCSI PCB Block Diagram

13.9 AT PCB Block Diagram

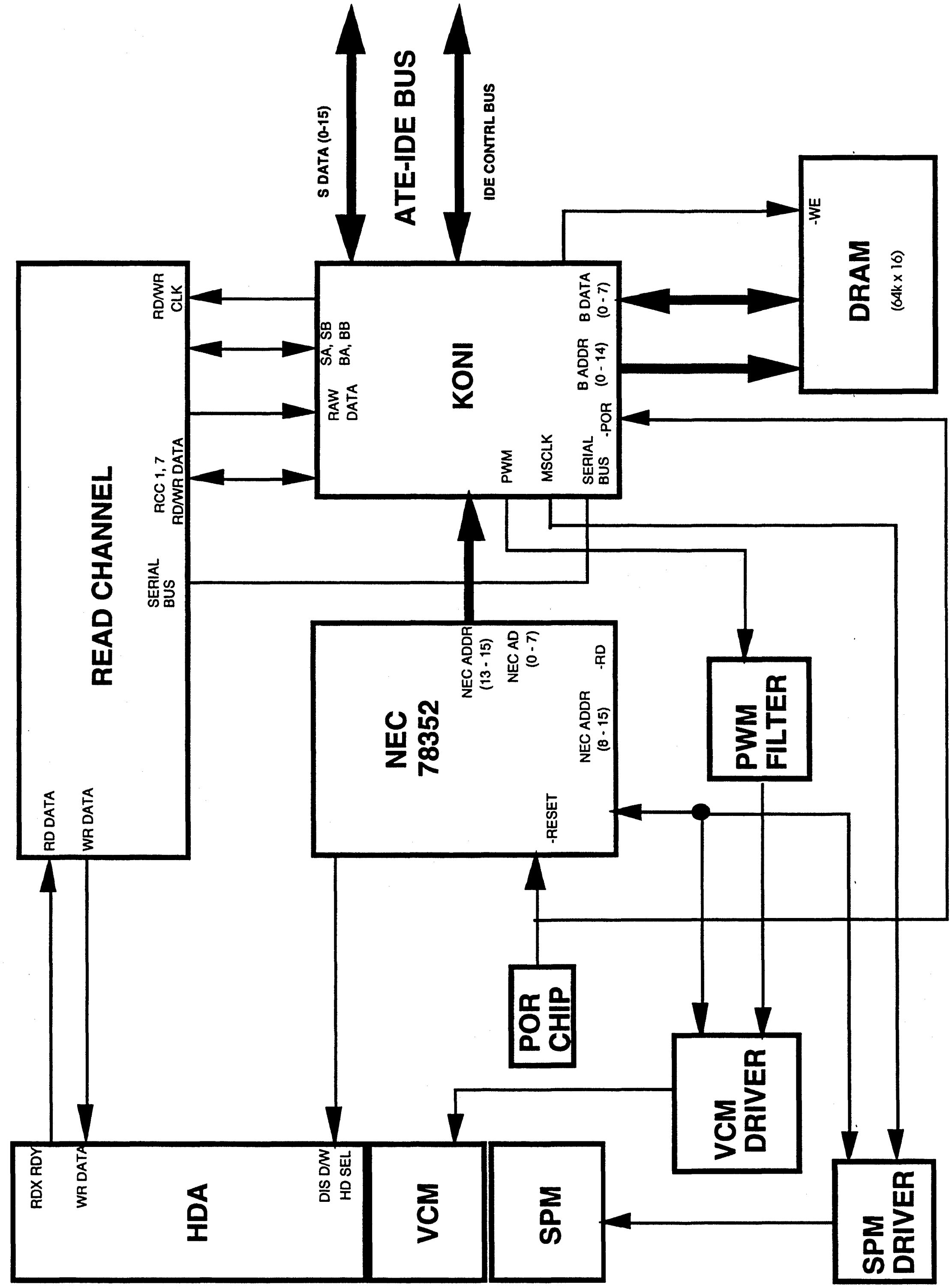


Figure 13-2. Lightning AT PCB Block Diagram

13.10 PCB Non-Component Area

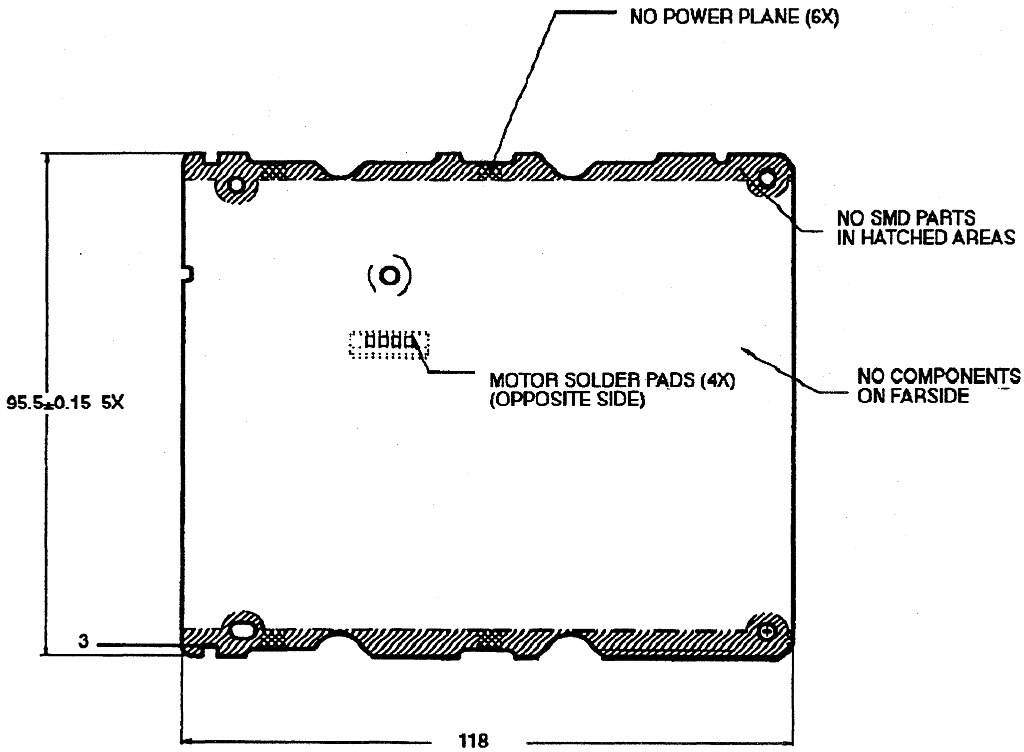


Figure 13-3. Lightning PCB Non-component Area

Section 14 Servo Design

14.1 General Description

Lightning servo is a high performance embedded sector servo system. It is designed to utilize the foremost performance dynamic allowed with adequate self calibration and adaptability to margin parameters and stochastic process variance in the servo system.

The read/write head position feedback transducer system is a scheme of regularly spaced multiple servo sectors embedded into the plural concentric circular data tracks about the rotational axis of the disk. Such servo sectors constitute a constant regular periodic discrete position information feedback to the servo system as the disk is spun at a constant rotational revolution per minute speed.

Any read/write head to position transducer offset is eliminated by the virtue of the transducer position information if derives from the read/write head and part of the data tracks itself.

Since maximizing the data capacity per track by reducing the number of servo sectors per concentric track is contrary to the requirement of the servo to have higher sample rate to improve its TMR performance and to facilitate higher TPI for areal density, the servo design has to utilize all the hardware and microprocessor resources available to achieve the best TMR with the lowest sample rate in conjunction with the rest of the system dynamic limitations.

Also, special considerations are made in the design to minimize the effect of the mechanical resonances, and to minimize the acoustic noise emitted during accessing.

14.2 Modes of Operation

1. The Fast Seek Mode velocity servo
2. The Settle Mode
3. The Track Follow Mode

14.2.1 Fast Seek Mode velocity servo:

The primary objective of Fast Seek Mode is to move the read/write head from one concentric track radial position to another concentric track radial position in a minimum time fashion under the physical constraints of the actuator acceleration factor and power supply. In doing so, it has to accelerate the actuator as quickly as it can and switch to controlled deceleration as soon as it is able to stop just in time when it arrives at the targeted track position.

In order to have the correct acceleration to deceleration switching and controlled deceleration operation for various seek lengths, a phase plane velocity vs. position trajectory guide is employed. Hence, both position and velocity state information of the actuator are vital.

Hence, a computational efficient Kalman state estimator is used for both head position filtering and head velocity estimation.

Control strategy should avoid excessive overshoot of velocity profile trajectory when switching, and should make actuator states adhere to the trajectory profile while decelerating without too much noise in the control by using feed forward. It should also provide consistent final conditions of seek mode for the next servo settle mode initial conditions.

Lightning Fast Seek Mode uses Poweramp high gain mode. It is used for seeks longer than 2 tracks. It combines both nonlinear long seek and linear short seek and seek coarse settling operations into one mode.

During the seek the servo uses only the digitized A and B burst amplitude which has a 90° spatial phase relationship in conjunction with track number from the servo sector. With this information, it constructs the PES by augmenting the track number with the decoded A, B burst amplitude to form the variable with fractional position resolution.

Lightning Fast Seek servo eliminated the need for seek nulli calibration by using the Kalman state estimator to estimate the bias torque continuously.

14.2.2 Settle Mode

Both Settle and Track Follow servo mode use Low poweramp gain for fine resolution current control. The Microprocessor provides loop stability compensation.

Settle Mode is designed with high DC stiffness and high phase margin for good damping and fast settling for seek arrival transients.

Once the actuator has stabilized to within +/- 10 counts of its position for 2 consecutive samples it is "self settled".

Once self settled the integrator is enabled to remove any dc error and 2 consecutive samples are required to settle within +/- 6 counts of the reference " ABSOLUTE SETTLED ".

The integrator (NULLI) initial condition is predicted to minimize time required to eliminate dc error thru integration. Hence, it is necessary to calibrate the nulli in the low gain mode since the low gain mode does not use Kalman state estimator for low microprocessor utilization.

14.2.3 Track Follow Mode

The track Follow Mode is essentially a regulator which keeps the actuator following the repeatable runout of the concentric track. It is designed to have low microprocessor utilization.

14.3 Servo Architecture Block Diagram: Fast Seek Mode

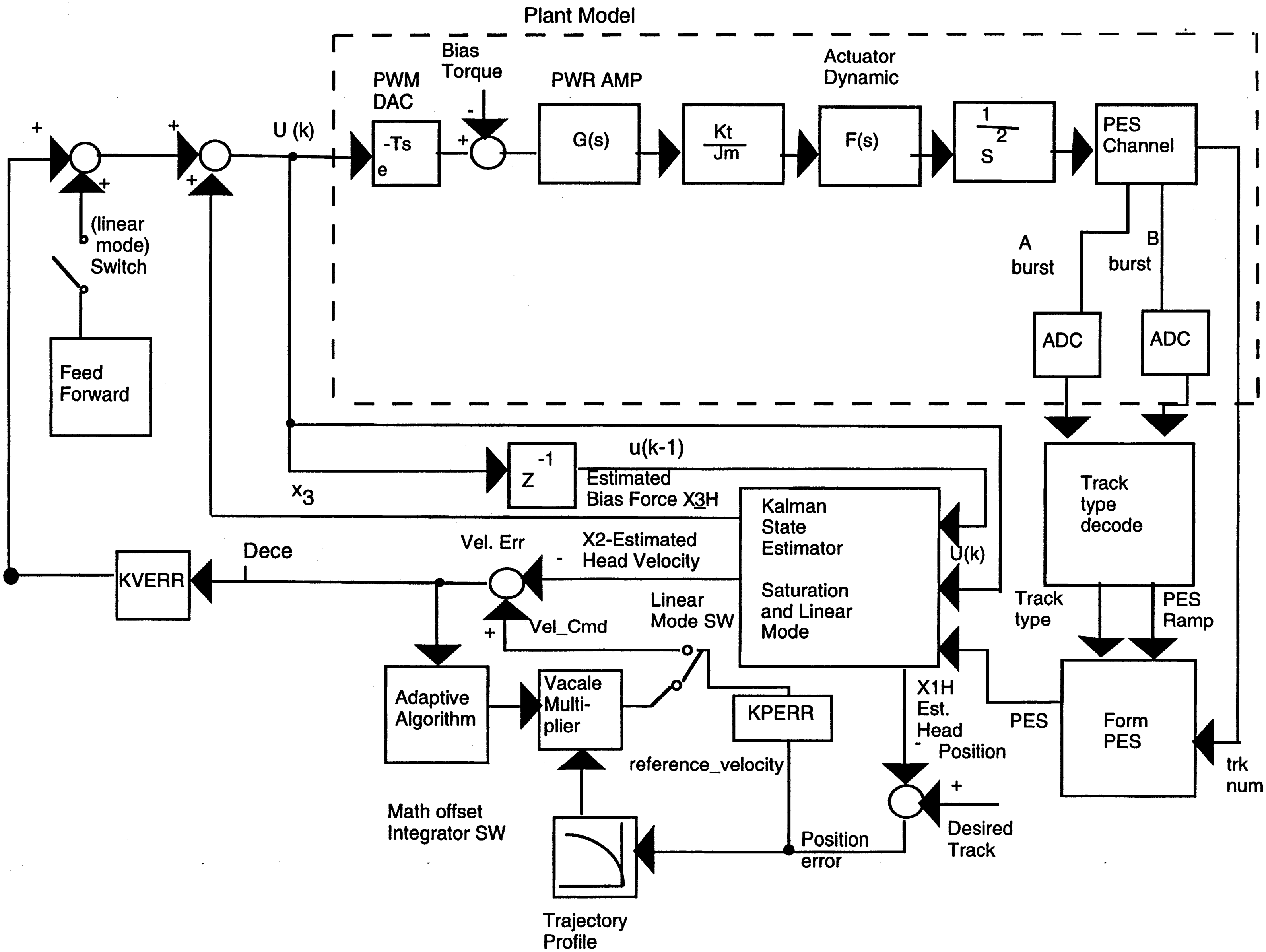


Figure 14-1. Lightning Fast Seek Mode

14.4 Servo Architecture Block Diagram: Settle Mode

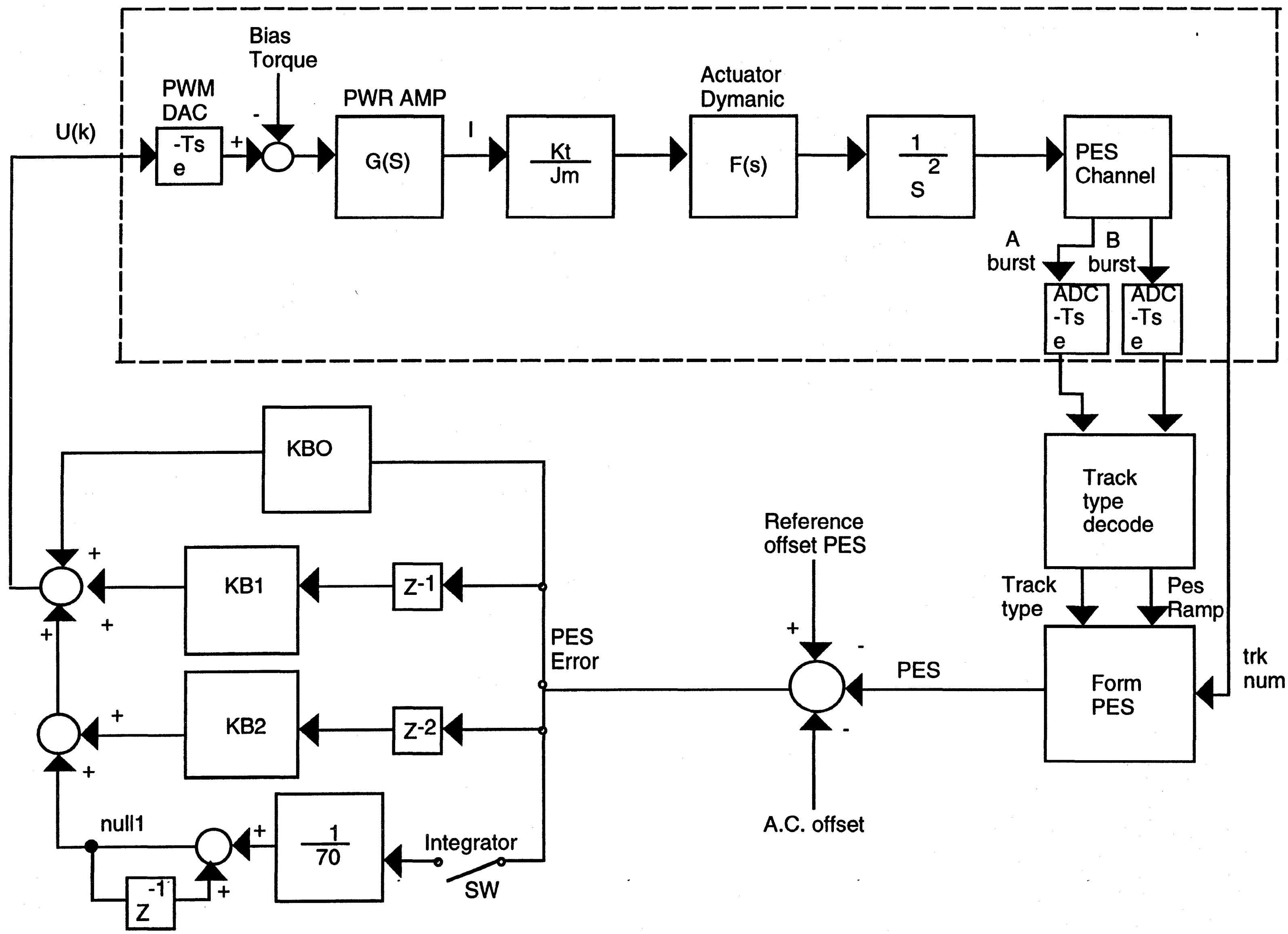


Figure 14-2. Lightning Settle Mode

14.5 Servo Architecture Block Diagram: Track Follow Mode

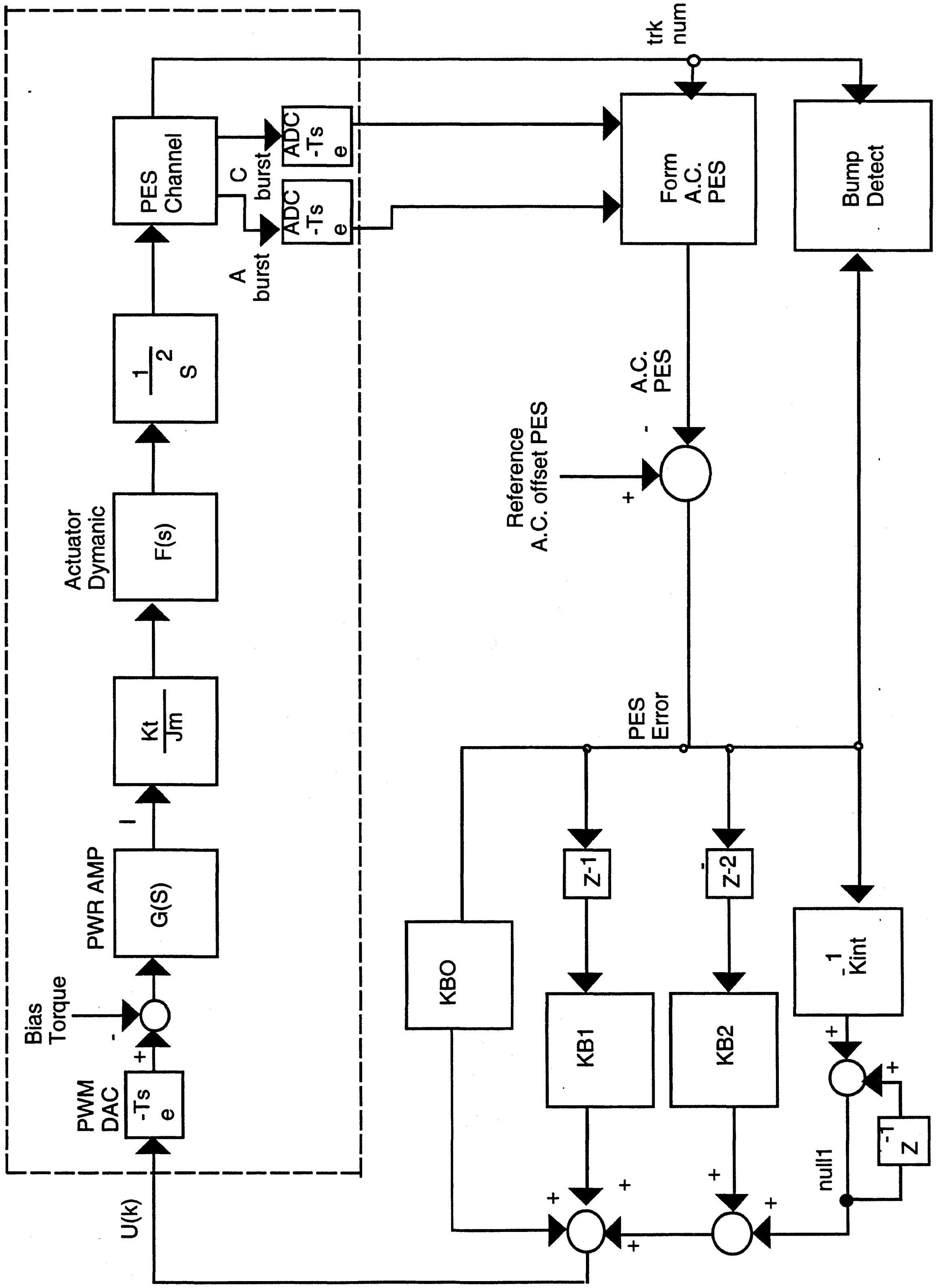


Figure 14-3. Lightning Track Follow Mode

14.6 Servo Error Budget

TMR ITEMS	LIGHTNING	
	-3 SIGMA	+3 SIGMA
NRRO (No vibration)	-6 µin	+6 µin
NRRO(under vibration)	TBD	TBD
NRRO (under shock)	TBD	TBD
Settling, Read Ready	-22.9 µin	+22.9 µin
Settling, Write Ready	-19.0 µin	+15.5 µin
Servo Dither	-8.7 µin	+8.7 µin
Servowriter DC Error	-5.0 µin	+5.0 µin
Servowriter AC Error	-9.7 µin	+9.7 µin
Elastic Thermal Disk Shift	TBD	TBD
Perm.Thermal Disk Shift	TBD	TBD
Actuator Dither (under vibration)	TBD	TBD
Actuator Dither (under shock)	TBD	TBD

Table 14-1. Lightning error budget.

Notes to Table 14-1:

1. All distributions above were approximated from actual data or simulation studies..
2. -3 sigma to + 3 sigma contain (or hold) 99.74% of total histogram, and histogram not necessarily Gaussian distribution.

14.7 Servo System Parameters

Components or parameter	Lightning	Spec
TPI	3794.00	track/inch
# of cylinders	3673.00	cylinder
# of sector/rev	70.00	sector
Spindle speed	4501.80	RPM
Sample period	190.476	µsec
Alias frequency	2625.00	Hz
Arm radius to head[1]	2.356	inch (Pending)
Inertia[2]		
(2 head)	50.00	gm-cm^2 (Pending)
(4 head)	60.00	gm-cm^2 (Pending)
Torque constant[3]		
(2 head)	920.00	gm-cm/amp [Pending]
(4 head)	940.00	gm-cm/amp (Pending)
Acceleration factor		
(1 disk)	18050.00	1/amp-sec^2
(2 disk)	15369.00	1/amp-sec^2
Coil resistance (@ 25°C)[4]	16.00	ohm
Max head velocity	100.00	in/sec
Power amp Lo gain[5]	0.00147	amp/bit
Power amp Hi gain[5]	0.00037	amp/bit
Coil inductance[6]		
(1 disk)	2.00	mH
(2 disk)	2.50	mH
Max voltage[7]	11.00	volt

Table 14-2. Servo related parameters.

Notes to Table 14-2:

1. The distance from actuator pivot to read/write head gap is measured by Quality Assurance X-Y table and caliper measurement.
2. Inertia is measured by means of the Torsion pendulum method.
3. Torque factor is measured by applying a constant current to voice coil and measuring the torque on the actuator across the ID-to-OD band. The currents applied are ± 100 ma, ± 200 ma, and ± 300 ma respectively for each measurement.
4. Coil resistance is measured by means of a Digital ohmmeter.
5. Gain of DAC stage included.
6. Coil inductance is measured by means of a Digital impedance meter.
7. Available @ Power amp outputs w/ nominal 12 volt supply.

14.8 Multi Bursts

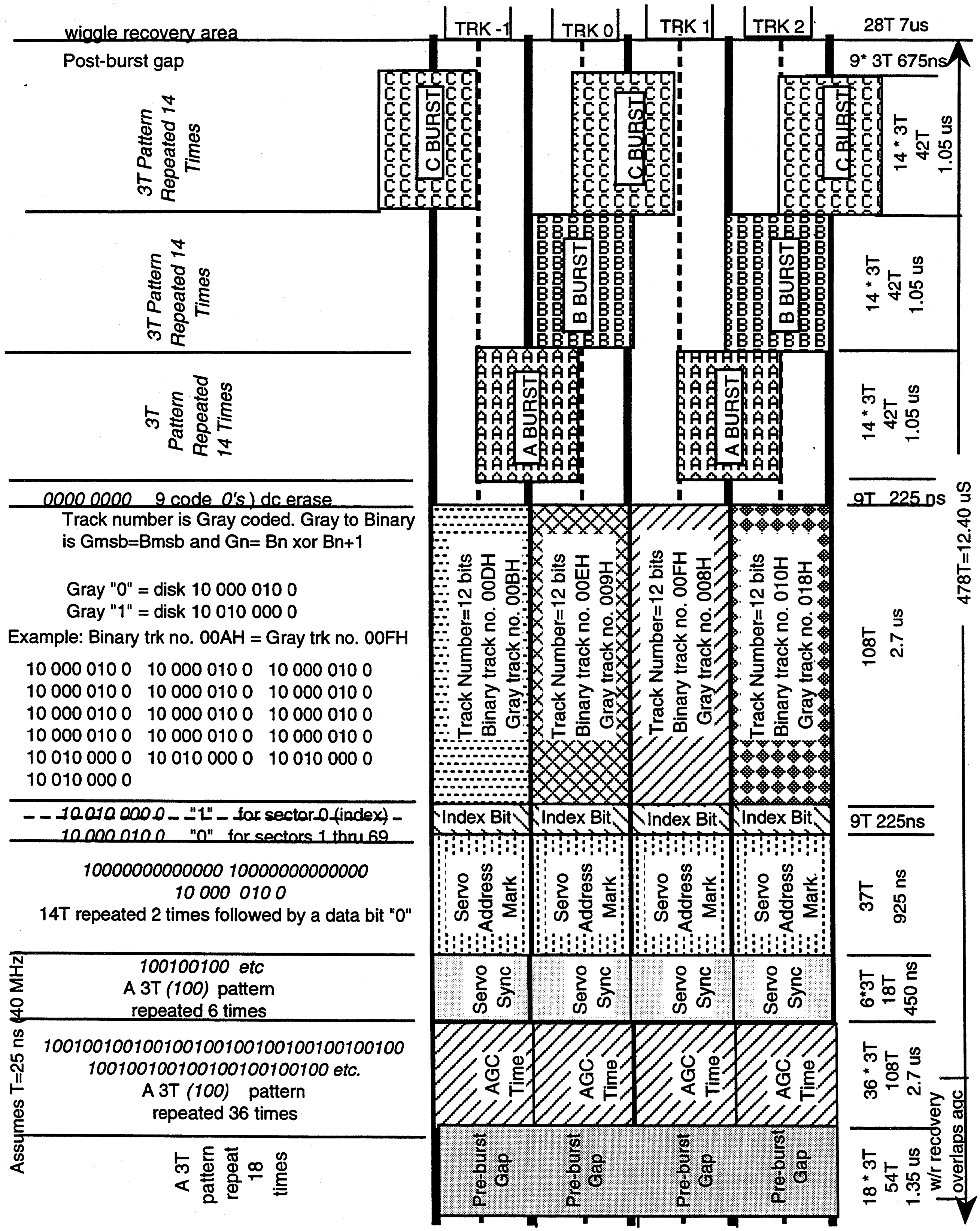


Figure 14-4. Lightning Multi Bursts

Section 15 Firmware Organization

15.1 Caching

Lightning incorporates DisCache, a 96K cache, to enhance drive performance. This integrated feature is user-programmable, using the MODE SELECT command, and can significantly improve system throughput.

15.1.1 READ CACHE DESCRIPTION

DisCache anticipates host-system requests for data and stores that data for faster access. When the host requests a particular segment of data, the caching feature uses a prefetch strategy to "look-ahead" and automatically store the subsequent data from the disk into high-speed RAM (Random Access Memory). If the host requests this subsequent data, the RAM is accessed rather than the disk.

Since typically 50 percent or more of all disk requests are sequential, there is a high probability that subsequent data requested will be in the cache. This cached data can be retrieved in microseconds rather than milliseconds. As a result, DisCache can provide substantial time savings during half or more of all disk requests. In these instances, DisCache may save most of the disk transaction time by eliminating the seek and rotational latency delays that dominate the typical disk transaction. For example, in a 1K-byte data transfer, these delays comprise 90 percent of the elapsed time.

DisCache works by continuing to fill its cache memory with adjacent data after transferring data requested by the host. Unlike a non-caching controller, Quantum's disk controller continues a read operation after the requested data has been transferred to the host system. This read operation terminates after a programmed amount of subsequent data has been read into the cache segment.

The cache memory is a 96K DRAM buffer allocated to hold the data which can be directly accessed by the host via the READ and WRITE commands. The memory functions as a group of segments (ring buffers) with rollover points at the end of each segment (buffer). The unit of data stored is the logical block (i.e., a multiple of the 512 byte sector). Therefore, all accesses to the cache memory must be in multiples of the sector size. In those cases where the cache memory must be used for scratch memory, as in the case of a FORMAT UNIT command, or where the size of the logical block may change, as in the MODE SELECT command, the cache will be emptied. The commands that will force emptying of the cache are:

- FORMAT UNIT
- INQUIRY
- READ DEFECT DATA
- READ LONG
- READ CAPACITY
- WRITE LONG
- MODE SELECT
- MODE SENSE
- REASSIGN BLOCKS
- VERIFY

15.1.2 WRITE CACHE

When a write command is executed with write caching enabled, the drive stores the data to be written in a DRAM cache buffer and immediately sends a COMMAND COMPLETE message to the host before the data is actually written on the disk. The host is then free to move on to the other tasks, such as preparing data for the next data transfer, without having to wait for the drive to seek to the appropriate track or rotate to the specified sector.

While the host is preparing data for the next transfer, the drive immediately writes the cached data to the disk, usually completing the operation in less than 23 ms after issuing COMMAND COMPLETE. With WriteCache, a single-block random write, for example, requires only about 3 ms of host time. Without WriteCache, the same operation would occupy the host for about 27 ms.

WriteCache allows data to be transferred in a continuous flow to the drive rather than as individual blocks of data separated by disk access delays. This is achieved by taking advantage of the ability to write blocks of data sequentially on a disk that is formatted with a 1: 1 interleave. This means that as the last byte of data is transferred out of the write cache, and the head passes over the next sector of the disk, the first byte of the next block of data is ready to be transferred; thus there is no interruption or delay in the data transfer process.

The WriteCache algorithm writes data to the cache buffer while simultaneously transferring data to the disk that was previously written to the cache.

15.1.3 PERFORMANCE BENEFITS

In a drive without DisCache, during sequential reads, there would be a delay due to rotational latency even if the disk actuator were already positioned at the desired cylinder. DisCache eliminates this rotational latency time -- 7 milliseconds on average -- when requested data resides in the cache.

Moreover, the drive often must service requests from multiple processes in a multitasking or multiuser environment. In these instances, while each process may request data sequentially, the disk drive must share time among all these processes. In most disk drives, the heads must move from one location to another. With DisCache, even if another process interrupts, the drive continues to access the data sequentially from its high-speed memory. In handling multiple processes, DisCache achieves it most impressive performance gains, saving both seek and latency time -- 23 milliseconds on average -- when desired data resides in the cache.

15.1.4 FLEXIBILITY, EASE OF USE, SPEED

DisCache was originally designed to be flexible because cache performance is highly application-dependent. Several parameters are automatically adjusted by the drive, this allows the drive to continuously optimize its performance. The remaining options which are still programmable enable users to adjust caching parameters to optimize performance. These options can be specified and subsequently modified using the SCSI MODE SELECT command. Table 16-1 outlines both the programmable and the fixed parameters; the discussion following the table explains the parameters and how they can be used.

Parameter	DisCache function	Input Range	Default Value
Read Cache enable/disable	Activates read cache when set (bit=1)	0,1	1
Write Cache enable/disable	Activates write cache when set (bit=1)	0,1	1
No. of Cache Segments	Sets number of cache segments to be maintained	not changeable	dynamic
Prefetch Only	Allows only prefetch data to be kept in the cache; data from current read is not saved.	0,1	0
Maximum Prefetch			dynamic
Minimum Prefetch			dynamic
Prefetch Enable	Enabled/disabled with cache enable	not changeable	1

Table 15-1. DisCache parameters.

Through the use of these programmable parameters, the caching feature can be tailored to optimize individual system performance. The programmable parameters shown in Table 18-1 can be found on MODE SELECT Page 37H. When the Cache Enable/Disable bit (Byte 2, bit 0), is set to zero, caching is disabled. Disabling the cache reduces command overhead. When disabling the cache, you essentially disable the prefetching and house-keeping required to manage the cache. The default value of this bit is one (Cache enabled).

The Read cache is divided into segments. Each segment contains one cache entry. A cache entry consists of the requested READ data plus its corresponding prefetch data.

The Prefetch Only bit determines whether the drive will retain both prefetch and READ data in the cache or will retain only prefetch data. When this bit (Byte 2, bit 2) is set to one, the drive will only keep prefetch data within a cache segment; the originally requested READ data will be overwritten with prefetch data. If the system anticipates that the requested READ data will not be re-read in the near future (within a certain number of other requests), there is no need to use cache space to store this READ data. Chances for a cache hit on the next READ request will be better if additional prefetch data were stored in place of the READ data in this situation. The default setting is zero (Prefetch Only off).

The requested READ data takes up a certain amount of space in the cache segment so the corresponding prefetch data could essentially occupy the rest of the space within the segment.

15.1.5 NEXT GENERATION IMPROVEMENTS

15.1.5.1 Read Cache

- Dynamic Segmentation
- Dynamic number of segments
- Auto buffer full/empty ratio (SCSI)

15.1.5.2 Write Cache

- Cache multiple Random Writes

15.2 Error Correcting Code

15.2.1 GENERAL INFORMATION

The Reed-Solomon codes are cyclic codes whose symbols are binary m-tuples. These codes have the capability of correcting single to multiple random burst-errors, which is very powerful in data recovery. ECC for Lightning is almost exactly the same as that for the Lethal Series.

All of the following information is taken almost directly from the technical report The Design of A Reed-Solomon Error Correcting Code System, by Hung Nguyen (ext. 4767)

The error correcting code is used to protect the data field of a magnetic disk drive. Data on the disk is written in the fixed block format which consists of 512 data bytes per sector. The data field is arranged in the following orders: 512 data bytes, 2 cross-checking bytes, and 12 ECC bytes (redundancy bytes). The 512 data bytes are interleaved 3 times: interleave 1 has 171 bytes, interleave 2 has 171 bytes, and interleave 3 has 170 bytes. Each interleave is encoded with 4 ECC redundancy bytes; therefore, we have 12 ECC bytes at the end of the data field. Two cross-checking bytes cover all 512 data bytes.

Single-burst error case	
maximum	24 bits (3 consecutive bytes)
minimum (guarantee)	17 bits
Double-burst error case	
maximum	24 bits per burst
minimum (guarantee)	17 bits per burst
Random multiple-burst error case	6 random bursts (maximum)

Table 15-2. Correction by case.

15.2.2 CODE PERFORMANCE EVALUATION

Probability of...	
Uncorrectable errors	3.21e-19
Miscorrection	2.3e-1
Misdetection	1.52e-5
Transferring undetected erroneous data	1.1e-24

Table 15-3. Summary of ECC performance.

15.2.2.1 Assumptions:

1. The algorithm of encoding and decoding is correct.
2. Every symbol (or byte) has equal error probability (uniform distribution).
3. Error bursts are assumed to occur at random intervals.
4. Each error burst is associated with a single byte.

These assumptions might not be very accurate because the characteristics of a read/write channel might be different. However, with the mathematical evaluation model, worst-case result can be predicted at the development stage.

15.2.2.2 Probability of Uncorrectable Errors (P_{ue})

This is the probability of having errors exceeding the correction capability of the code. It is assumed that all symbols have equal probability of being corrupted; hence, the number of error symbols occurred might be from 1 up to 175 per interleave. This is a worst-case scenario, so it is not likely to happen in reality.

P_{ue} has been calculated using the Bernoulli Trials Theorem.

n = number of bytes in an interleave = 175
p = raw symbol error probability (units: symbol errors per symbol) = 8 * raw burst error rate = 8e-8.

$$P_{ue} = \frac{1}{8 * n} \sum_{i>2}^{n} \binom{n}{i} p^{i} (1 - p)^{n-i}$$

15.2.2.3 Probability of Miscorrection (P_{mc})

When the number of errors in an interleave exceeds the correction capability of the code, it is possible that the decoding syndromes might be identical to those produced by the correctable codewords. When miscorrection occurs, the ECC system outputs a set of incorrect error values and error locations.

In an interleave with 4 ECC check bytes, we have a probability P_{mc} = 2.3e-1, almost 1 in 4. This is unacceptably high; thus the reason for using an additional cross-checking code.

Note that this value is only valid when the number of errors in the interleave exceeds the correction capability. When the number of errors is within the correction capability, the value of $P_{mc} = 0$.

15.2.2.4 Probability of Misdetection (P_{md})

The cross-checking code provides the main protection from miscorrection. The misdetection probability of the cross-checking code is $P_{md} = 1.52e-5$.

16.2.2.5 Probability of Transferring Undetected Erroneous Data (P_{bd})

This is the number that the customer is concerned about, since it represents the probability of having bad data escape the ECC. Its value is approximated by

$$\begin{aligned} P_{bd} &= P_{ue} * P_{mc} * P_{md} \\ &= (3.21e-19) * (0.23) * (1.52e-5) \\ &= 1.1e-24 \text{ events/bit.} \end{aligned}$$

This means that within 9.1e+23 bits read, there occurs 1 undetected erroneous data event.

15.2.3 THE ADVERTISING SECTION

Reed-Solomon codes have become popular in both communication and magnetic recording and can be designed in many different forms and have different results depending on the applications. The particular implementation used for Lethal Series and Gemini has kept the circuit size at a minimum; there are still many improvements that could be made. For example, the number of bits in a symbol could be increased to reduce the number of required check bytes, or the code could be implemented into two separate ECC levels.

The use of Reed-Solomon code has permitted specification of raw error rate from 10^{-10} to 10^{-8}. Consequently, it is possible to stretch the design of the R/W channel to its maximum capacity and still preserve data integrity.

Especially for the writers of the product manual, it would be amusing to look at the probability of transferring undetected erroneous data from a different perspective. Suppose the maximum data rate is about 48Mbits/sec. Consider a drive that is used every day with a 10% read-back duty cycle. If P_{bd} is 1.1e-24 as approximated, then it implies that there would exist 1 undetected erroneous event on that drive for every 6.0×10^{9} years. If one million drives were shipped out, then there would occur 1 undetected erroneous event within those drives in about every 6000 years!!

15.3 Microprocessor Memory Map, Diskware and F/W Organization

The Lightning architecture has been designed to support Diskware. Part of the Buffer memory is used to load firmware from disk and the processor is able to execute the firmware directly from the buffer memory.

The firmware is partitioned between the CPU ROM and the Diskware. The CPU ROM code contains all of the routines necessary to power up the drive and read the Diskware into the Buffer. It also contains routines that allow the Diskware to be written to the disk via the host interface. All time critical code is located in the CPU ROM because the processor is able to execute CPU ROM code much faster than Diskware code. The Diskware code contains firmware that is not required for powering up the drive. The Diskware code also contains provisions to allow for possible engineering firmware changes in the CPU ROM code to be corrected by mapping erroneous subroutines from CPU ROM into the Diskware.

The Diskware code space is partitioned into two parts, a resident part and an overlay part. The resident Diskware is loaded during the drive power up initialization and remains in memory while the drive is powered on. The overlay Diskware is loaded on an as needed basis, at present there are two overlay defined, one for Selfscan and one for normal operation.

The Diskware is stored on reserved system cylinders in memory image format. A new configuration page 15 specifies where the overlays are stored on the system cylinders and where the overlays are loaded into the processor memory. Generally system cylinder information is stored in multiple places for redundancy, the overlay configuration page only specifies where the first copy of the Diskware is stored. Redundant copies of the Diskware are stored according to the firmware redundancy algorithm for system cylinder information. The Lightning firmware stores redundant system cylinder information on all physical heads in system cylinder areas.

Configuration Page 15 - Overlay Page

Field Offset	Description
0	00h - Overlay 0 - Resident Diskware.
1	Load address.
3	Number of sectors.
4	Cylinder.
6	Head.
7	Starting sector.
8	01h - Overlay 1 - Normal operating Diskware.
9-15	Same field as above.
16	02h - Overlay 2 - Selfscan Diskware.
17-23	Same field as above.
24	FFh - End marker.

The NEC 78352 microprocessor has a 64K address space. On Lightning, it is organized as follows:

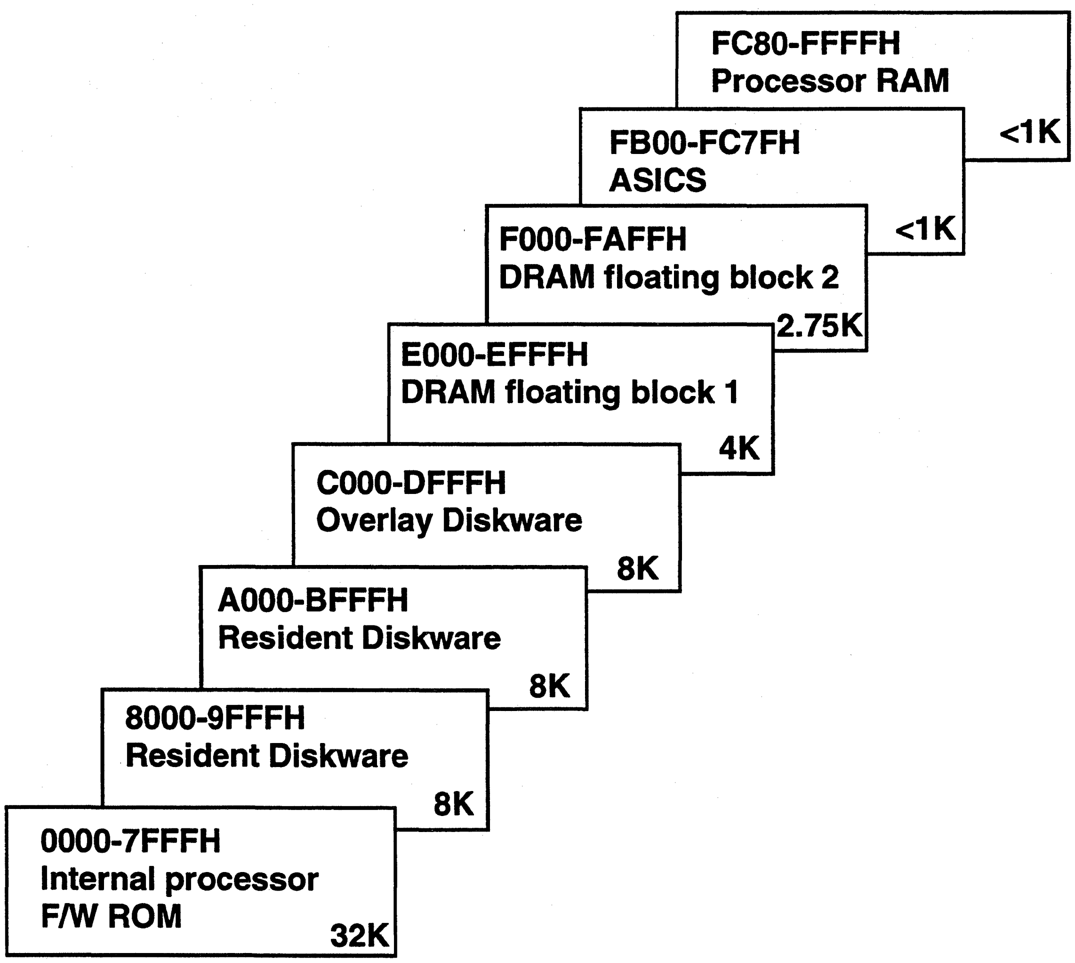


Figure 15-1. Microprocessor memory map.

Firmware Organization

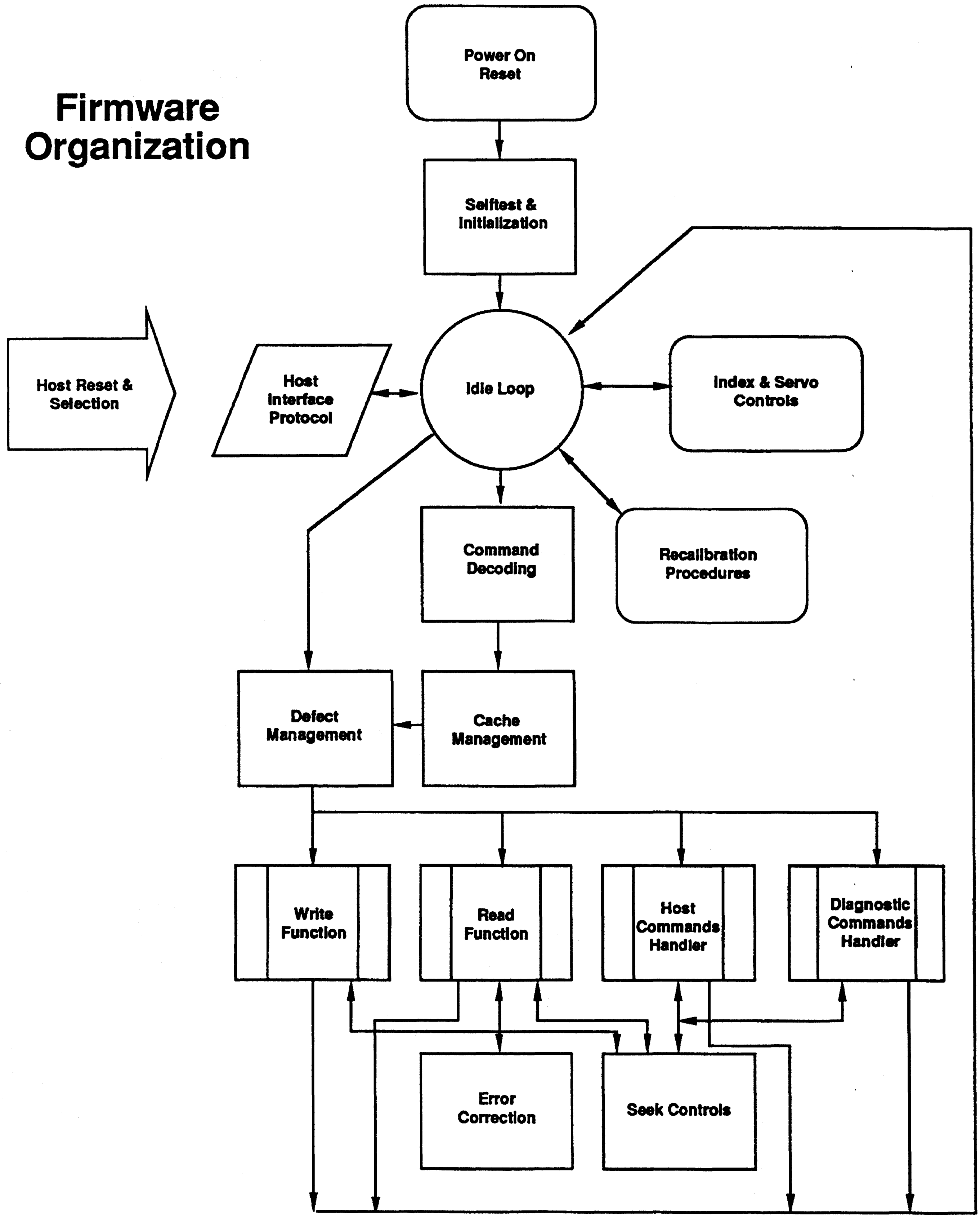


Figure 15-2. Firmware organization.

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Section 16 Read/Write Channel

16.1 General Specifications

Zone	BPI	FCPI	Tw/2 NSEC	DATA RATE	Fmax (Sine) (MHz)	WRITE CLOCK (MHZ)
15	63127	47347	13.48	24.73E+06	9.27	37.10
14	63513	47636	13.05	25.54E+06	9.57	38.31
13	62426	46821	12.33	27.04E+06	10.14	40.56
12	62251	46690	11.68	28.54E+06	10.70	42.81
11	62421	46817	10.94	30.48E+06	11.42	45.71
10	59853	44891	10.67	31.24E+06	11.71	46.85
9	60829	45623	9.94	33.52E+06	12.57	50.28
8	60182	45138	9.58	34.78E+06	13.04	52.17
7	60439	45329	9.06	36.81E+06	13.80	55.21
6	60859	45646	8.58	38.86E+06	14.57	58.28
5	60899	45676	8.25	40.38E+06	15.14	60.57
4	60666	45501	7.92	42.07E+06	15.77	63.09
3	61239	45931	7.54	44.19E+06	16.57	66.28
2	60799	45601	7.27	45.82E+06	17.18	68.73
1	60045	45035	7.06	47.24E+06	17.71	70.85

Table 16-1. Read/write channel specifications.

Note to Table 16-1:

Preliminary Spec. Subject to change

RLL Code	1,7
TPI	2875
Data Zones	15
Data Field (Bytes)	512
Data ECC (Bytes)	14

Table 16-2. Additional read/write channel specifications.

16.2 Lightning Read Channel Features:

- Custom LSI, single chip, 100pin TQFP
- Single +5V supply
- Low power consumption (750 mW typical)
- Zone recording capability up to 15 zones
- Capability of handling up to 48 MBits/sec data rates
- Includes:

AGC -	Closed loop on channel
Filter -	Programmable with equalization for 15 zones Differentiator tracking the zone frequency
Pulse Detector -	Peak detector and qualifier, dual channel Threshold and window skew control via serial port
Data Separator -	Tuned center frequency Zero phase restart
Frequency Synthesizer	
	Frequencies programmable to handle 48Mb/s data rate
Precompensation on write data	
Servo Demod -	To serve embedded servo

16.3 Lightning Preamp Features:

- High gain (300)
- Low Noise (0.7 nV/root Hz max)
- Differential ECL write data inputs
- Low Power (200 mW)

16.4 Lightning Read/Write channel block diagram

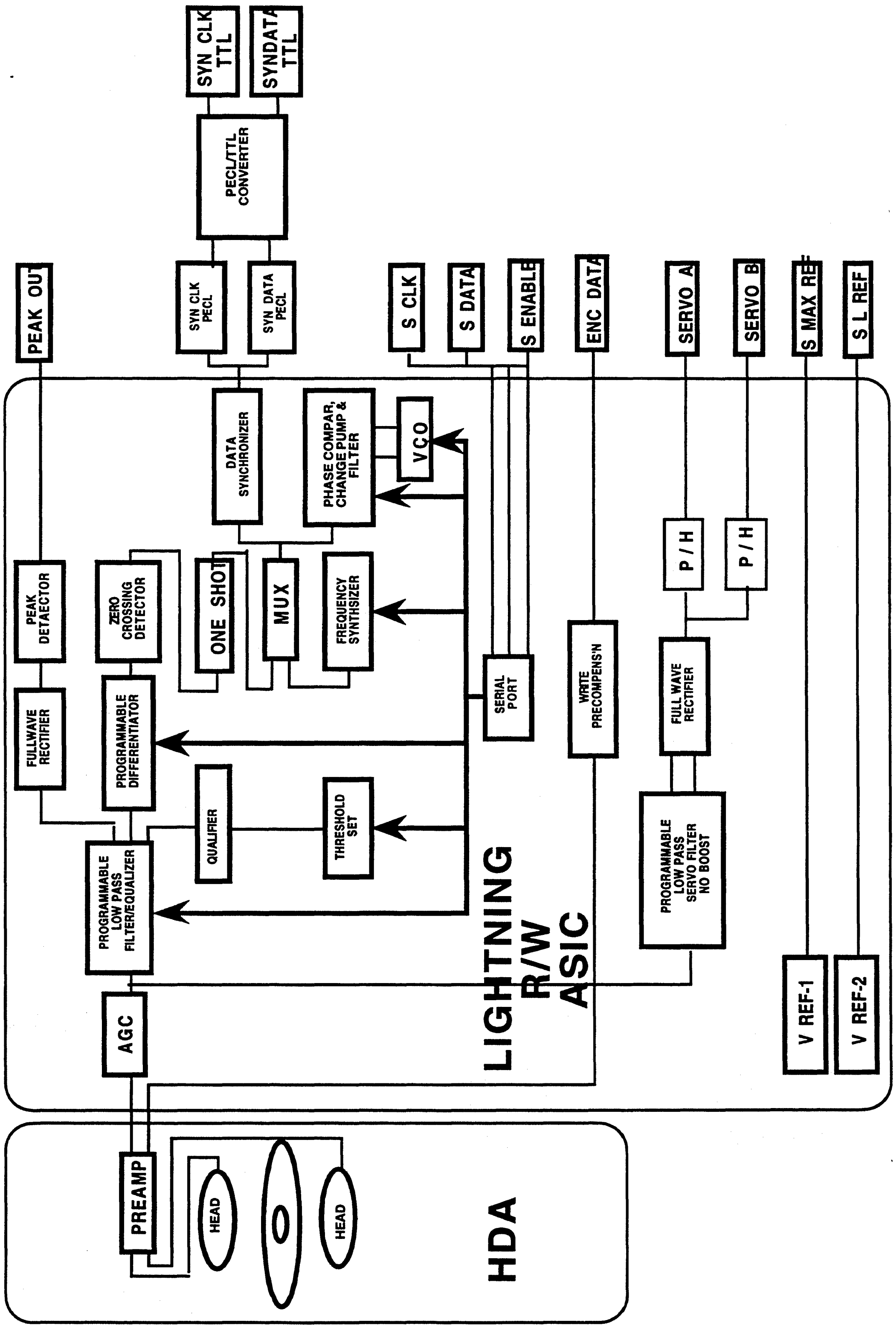

Figure 16-1 Lightning Read/Write Block Diagram

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SECTION 17 ASICs

17.1 Koni

17.1.1 DISK SEQUENCER

- Supports 48 Mbit (51 Mbit during acquisition) data rates.
- 1, 7 ENDEC and Address Mark Logic.
- Programmable Sequencer Writable Control Store (32 x 28 bit).
- Supports split data field for embedded servo ZBR designs.
- Supports Up assigned On-the-Fly ECC using a 96 bit interleaved Reed-Solomon ECC with 2 cross check bytes.

17.1.2 BUFFER MANAGER

- Supports 128/256 KByte buffer using a single1/4 Meg DRAM in a 64/256K x 16 organization.
- Disk and Host rollover and reload address for buffer segmentation.
- 20 MByte/sec Fast page cycles.
- Separate micro access channel usable for diskware in DRAM buffer.
- Auto-write and Auto-read functions on AT version.

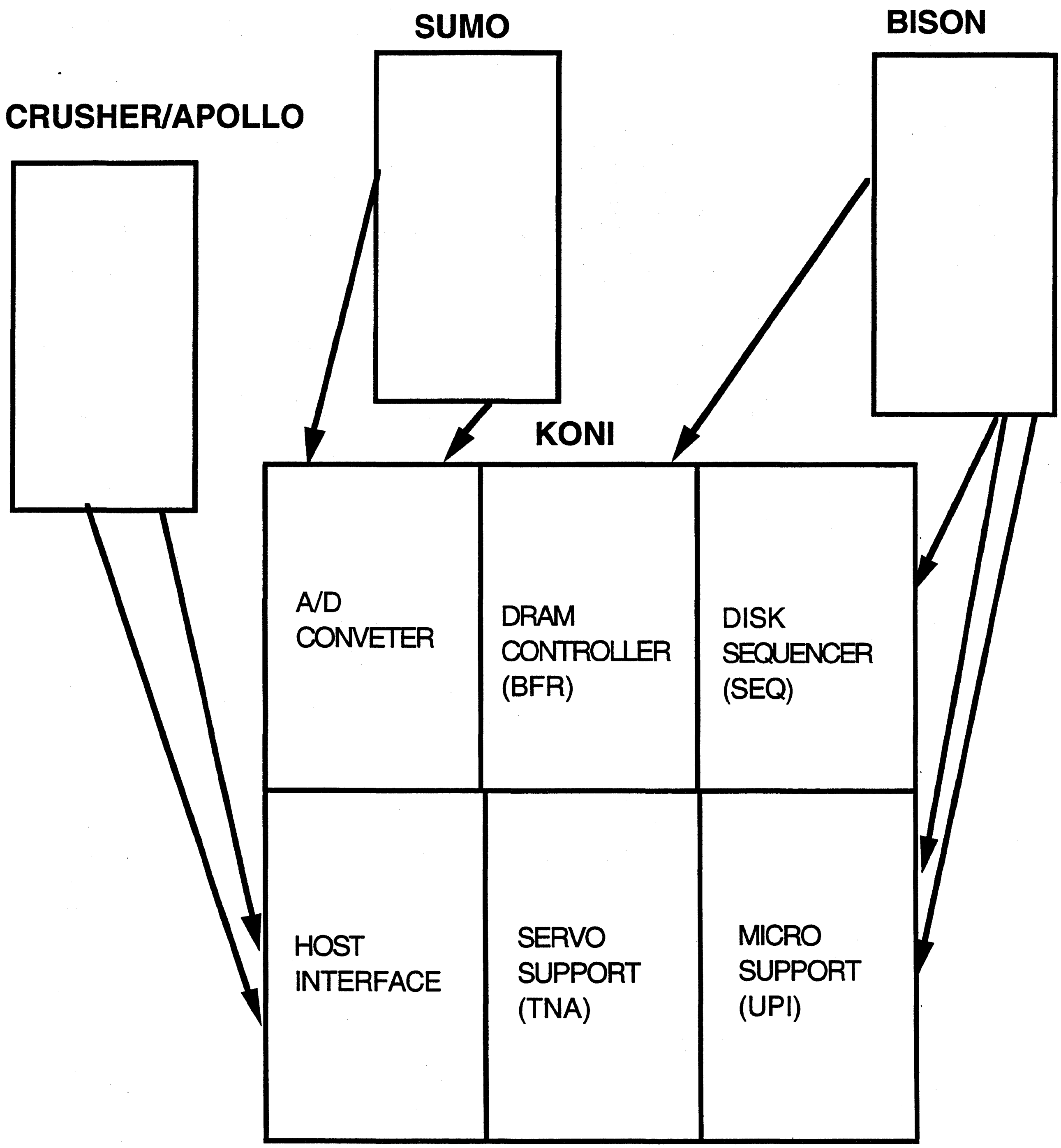
17.1.3 SERVO / MOTOR SUPPORT

- High speed serial port.
- Motor driver interface.
- Track Number Acquisition (TNA) controller.
- A/D converter.
- PWM/DAC.

17.1.4 INTERFACE

- ATA interface same as "CRUSHER" chip.
- SCSI interface same as "APOLLO" chip.

17.1.4 COMPOSITION OF KONI



KONI is based on design blocks from the Bision (E-Series), SUMO (Pioneer), and Crusher/Apollo interface controller. Koni is in an 176 pin TQFP.

Figure 17-1. Composition of Koni.

17.2 Evolution of AT interface chip

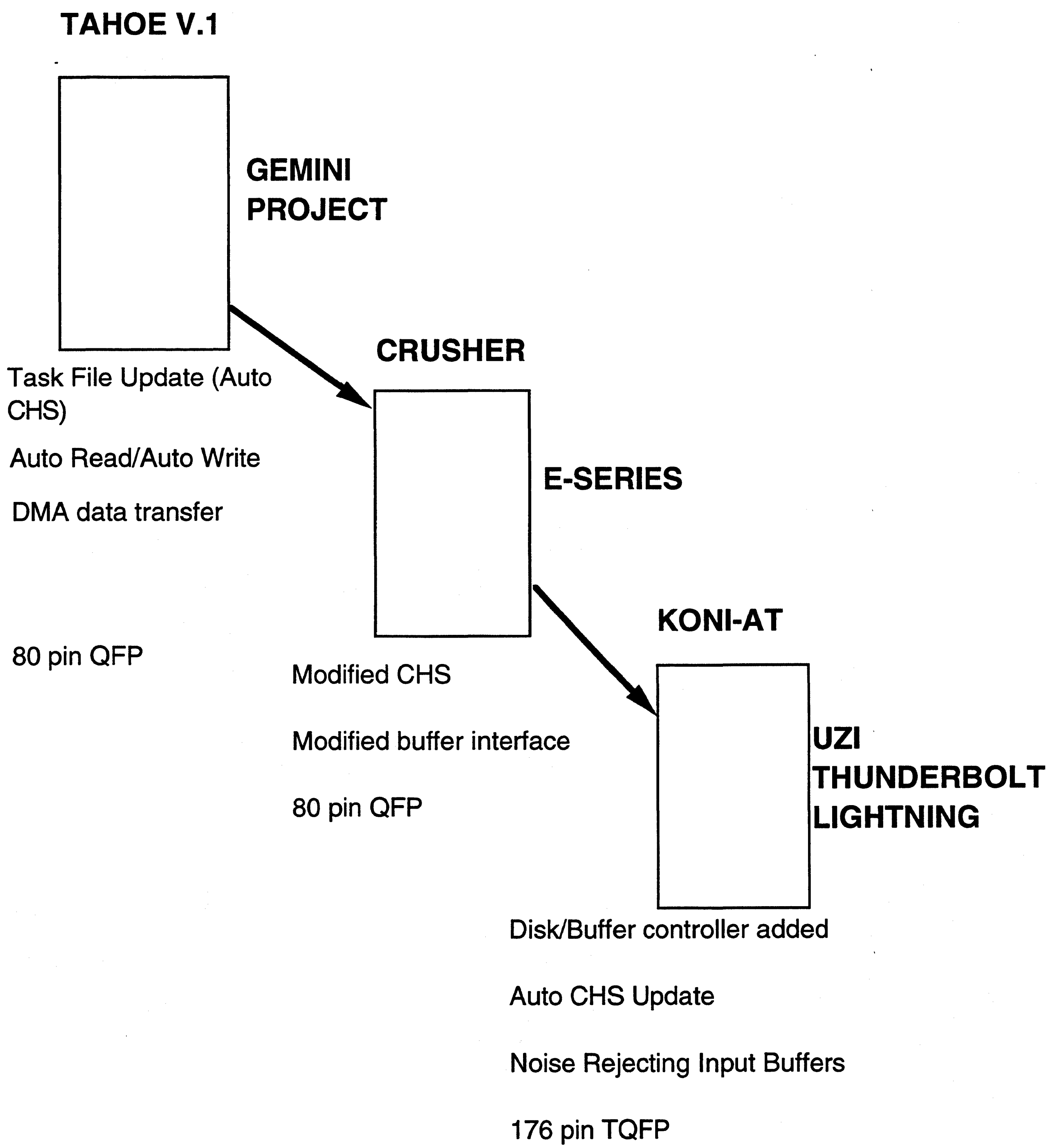


Figure 17-2. Evolution of the AT interface chip.

17.3 Evolution of SCSI Interface Chip

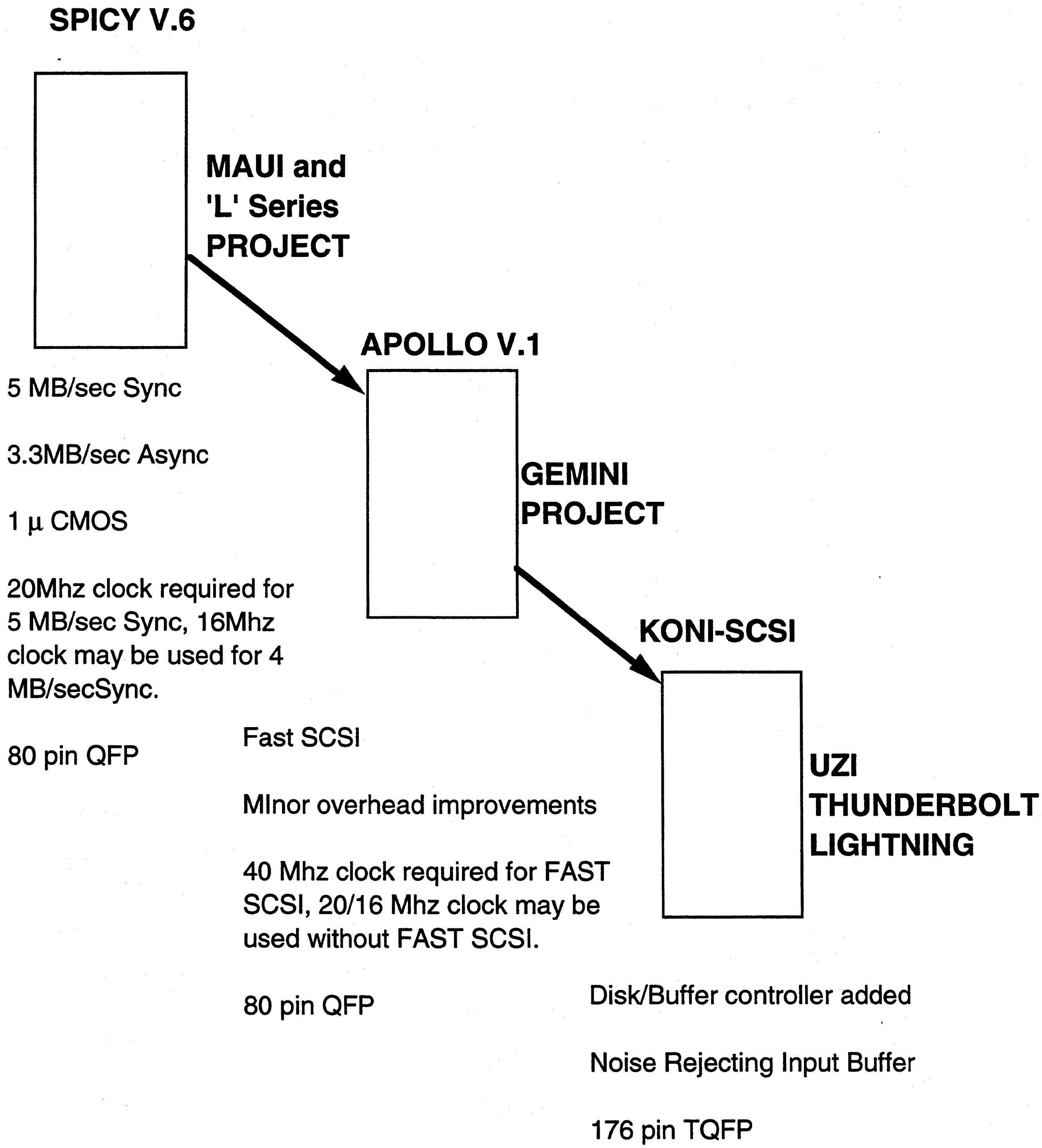


Figure 17-3. Evolution of the SCSI interface chip.

Appendix A Schedule and Major Model Milestones

			Quantity		
	Goal	Location	HDAs	SCSI	AT
June 01/93	E1 build	Quantum/MKE	4		4
July 16/93	E2 build	MKE	50	10	50
Oct. 04/93	E3 build	MKE	60	10	60
Dec. 06/93	P1 build	MKE	546	184	362
Feb. 21/94	P2 build	MKE	610		
Apr 13/94	P2.5	MKE	928	467	461
May 23/94	Pre-Mass production	MKE	large	large	large

Table A-1. Scheduling goals from E0 build through mass production.

	E1	E2-E3	P1	P2- P2.5	PMP
MECH	• Sample Motors. • MECH. Mockup. • Actuator FEM Complete. • CSS/Hall-Less motors.	• Functional HDA. • Fix Resonance.	• Hard Tool HDA. • Soft Tool Motor. • 4.0 BELS Idle.	• Hard Tool HDA. • Hard Tool Motor. • 3.5 BELS Idle. (with damper)	• Documention Release Done. • 3.5 BELS Idle.
F / W	• Download F/W. • Self Scan on Gemini/PNR. • APPLE Diag.CMDS.	• AT error reporting as good as SCSI. • Re-Do error handler. • Read+Write+Seek.	• Drive Boots on PC. • Error logging Functional. • Defect Mgmt. • Sort of Runs on a MAC.	• Runs on a MAC. • CACHE Done. • Self Scan Done.	• It Works! (Sort of) • Debug Done.
R / W	• Channel Integrated on Spin Stand. • Margin Tested & Conf. • 747 & OTC Data. • 1/3 Vendors Dropped.	• Head/Media Spec. Done. • ASIC VendorN Selected with 80% Functionality. • Bit Error Rate 10E-7	• Same as E1. • R/W Channel ASIC V.2. • Bit Error Rate 10E-8.	• BER 10E-9 @ Room Temp.	• BER 10E-9 @ -60° C.
SERVO	• TRK Follow on PNR HDA. • Spindle F/W.	• TRK Follow & Seek. • More Spindle F/W.	• TRK Follow, slow sk 16mS meets error rate. • Sync. Spindle.	• 11mS sk time meets error rate in production. • 4.0 BELS seeking.	• 11mS sk time meets error rate 0-60° c. • 4.0 BEL seeking.
ASIC	• AT Koni V.2			• Altera Programmed	
TEST	• TMR Software. • TMR F/W. • APPLE Diag. CMD set. • Null I.	• ENG. Servo Write 90% Functional.	• A/S 90% Functional. • PCB Function Test. • 1st. Pass D/S.(Self Scan) • Servo Write	• A/S 100% Functional. • PCB Function Test 100%. • D/S, Self Scan. • Servo Write & Test cyl FMT & HDA Parametrics.	
PCB	• Spindle/Actuator Driver 1st Silicon. • PCB Rev 0 • Preliminary Layout Done. • Flex ckt Done.	• PCB Layout Rev 1 (2 Versions) • A/S PCB Rev 0. • First Pass FCC/Noise Eval.	• Spindle/Actuator Driver 2nd Silicon. • PCB Rev 1. • A/S PCB Rev 1 Complete.	• PCB Rev 2.	

Figure A-1. Models defined.

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Appendix B Air Cleanliness (Class 100)

Classification of air cleanliness is based on particle count with maximum allowable number of specified minimum sized particles per unit volume and on statistical average particles size distribution.

DEFINITION OF CLASS 100[1]

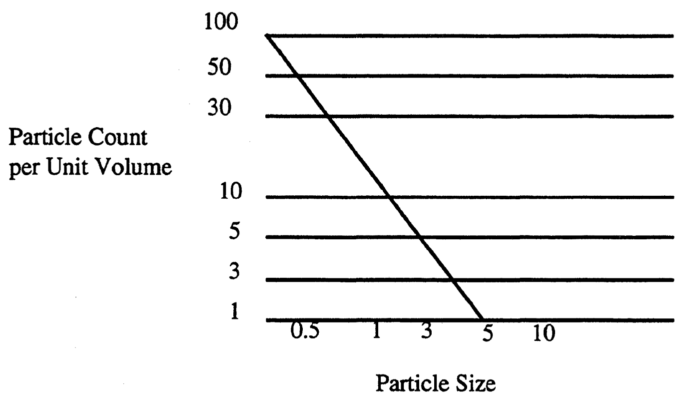
The particle count shall not exceed a total of 100 particles per cubic foot (3.5 particles per liter) of size 0.5 μm or larger.

The statistical average particle size distribution may deviate from this curve because of local or temporary conditions. Counts below 10 particles per cubic foot (0.35 particles per liter) are unreliable except when a larger number of samplings are taken.

TEST METHOD[2]

For particles in the 0.5 to 5.0 μm size range, equipment employing light scattering principles shall be used. The air in the controlled environment is sampled at a known flow rate. Particles contained in the sampled air are passed through an illuminated sensing zone in the optical chamber of the instrument. Light scattered by individual particles is received by a photodetector which converts the light pulses into electrical current pulses. An electronic system relates the pulse height to particle size and counts the pulses such that the number of particles in relation to particle size is registered or displayed.

The count of particles of a given size shall not exceed value shown in the graph below.



1. U.S.A. Federal Standard 209B, available from the General Services Administration; Specifications Activity; Printed Materials Supply Division; Building 197; Naval Weapons Plant; Washington D.C. 20407, U.S.A.

2. American Society for Testing and Materials; Standard ASTM F 50; 1916 Race Street; Philadelphia, Pennsylvania 19103, U.S.A. Society for Testing and Materials; Standard ASTM F

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Appendix C Humidity Charts

These charts are given as reference for any who care to gain a greater understanding of the humidity specifications given in the Environment section. Except for references to specific figure numbers, the explanation is quoted directly from that monster of a book that Don Westwood owns, Marks' Standard Handbook for Mechanical Engineers, McGraw-Hill Book Co., Eighth Edition, New York, © 1978. It's probably a copyright violation, but who's checking?

Psychrometric charts are usually plotted, as indicated by the example Figure C-1, with dry-bulb temperature as abscissa and specific humidity as ordinate. Since the specific humidity is determined by the vapor pressure and the barometric pressure (which is constant for a given chart), and is nearly proportional to the vapor pressure, a second ordinate scale, departing slightly from uniform graduations, will give the vapor pressure. The saturation curve (relative humidity = 100%) gives the specific humidity and vapor pressure for a mixture of air and saturated vapor. Similar curves below it give results for various values of relative humidity. Inclined lines of one set carry fixed values of the wet-bulb temperature, and those of another set carry fixed values of v_a, cubic feet per pound of air. Many charts carry additional scales of enthalpy or Σ function.

Any two values will locate the point representing the state of the atmostphere, and the desired values can be read directly. Figures C-2 and C-3 are psychrometric charts from the General Electric Company and Ellenwood and Mackey, "Thermodynamic Charts," covering a dry-bulb temperature range from 32 to 300°F. They are accurate only for a barometric pressure of 29.92 inHg.

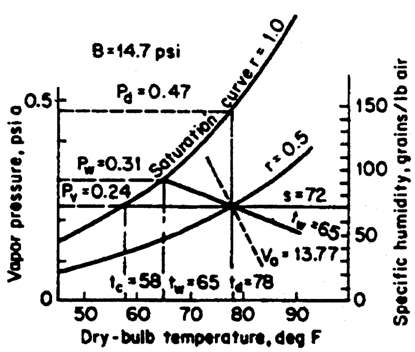

Figure C-1. Skeleton humidity chart.

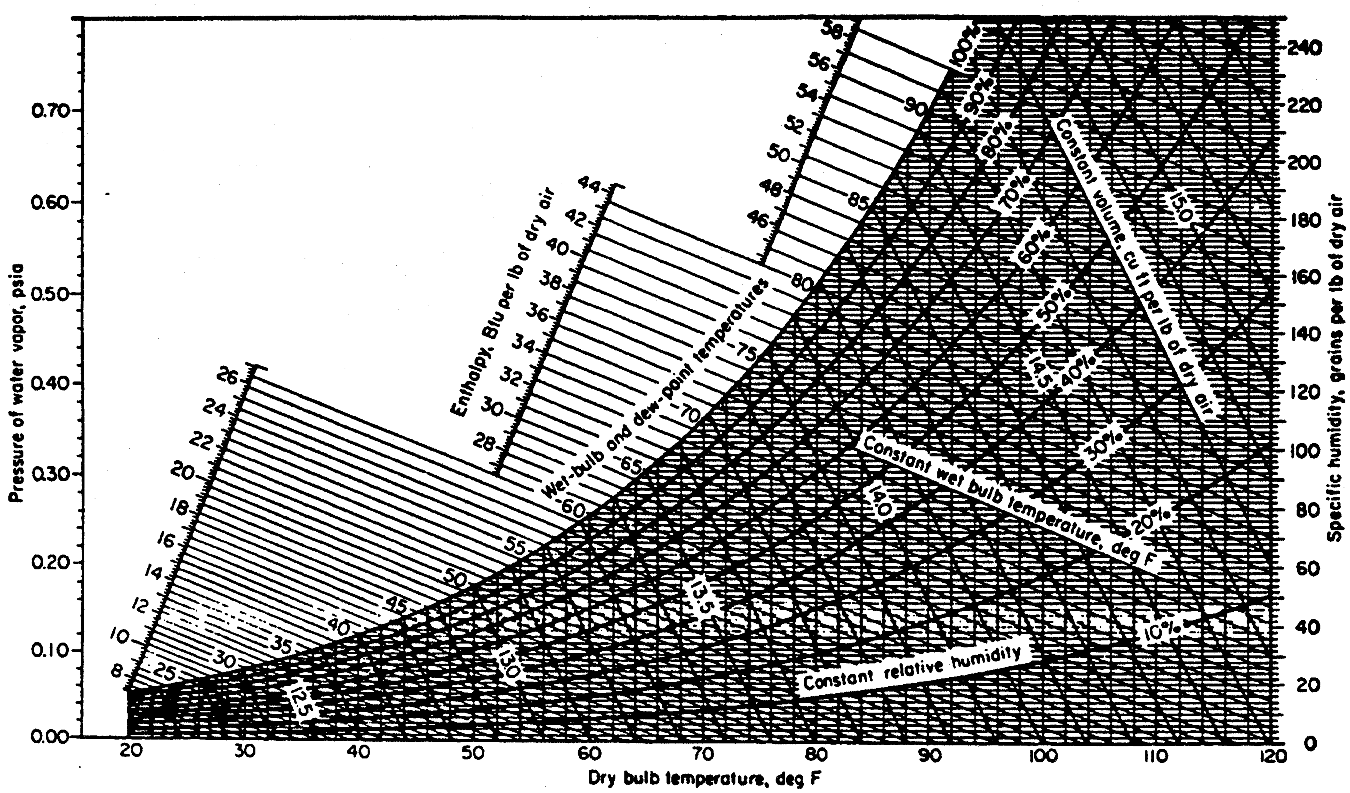

Figure C-2. Humidity chart for low temperatures. Barometric pressure 14.969 psia.
(Copyright by General Electric Co.)

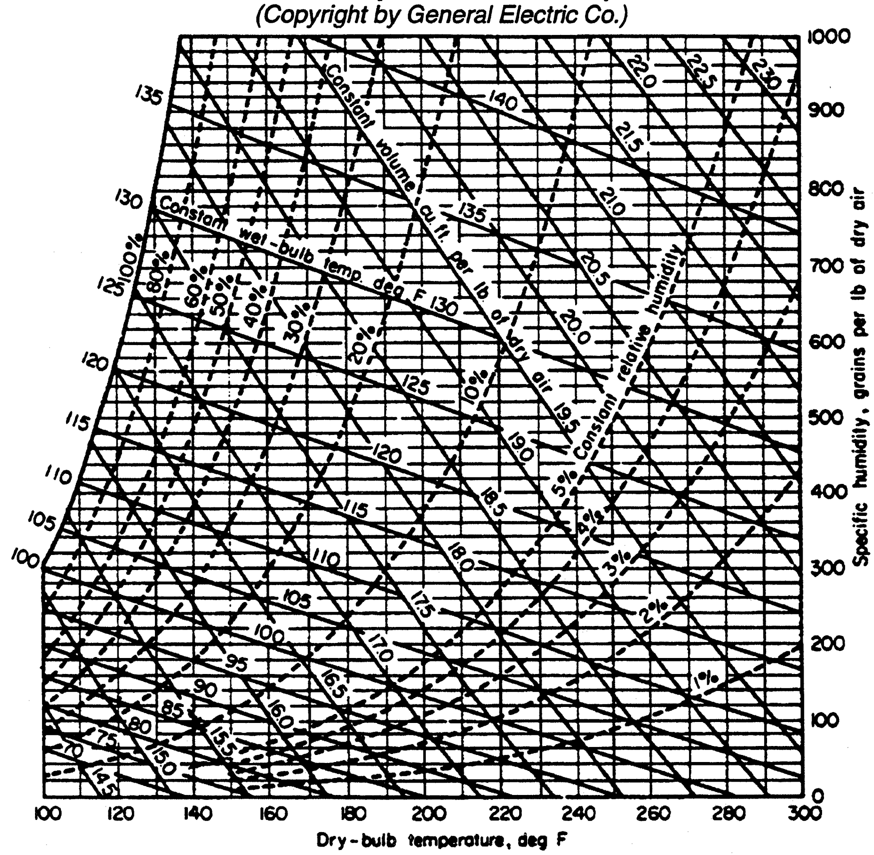

Figure C-3. Humidity chart for medium temperatures.
(From Ellenwood and Mackey, "Vapor Charts," Wiley.)