Ultrastar 36ZX and 18LZX
Hardware/Functional Specification
36, 18 and 9 GB Models 10,000 RPM

Including ‘Ultra 160’ Parallel SCSI Models

Version 2.01

September 24, 1999

Preface

This document details the Hardware/Functional Specifications for the ULTRASTAR 36ZX/18LZX High Capacity Family of 3.5-inch Disk Drives. Product capable of supporting the Parallel SCSI Fast-40 interface and product capable of supporting the Ultra 160 interface are detailed here.

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a. Revision Codes and Dates Applied

Following is a list of dates that revisions have been applied.

Version	Date	Change
1.93	06/9/99	LA level specification (Fast-40 / SE)
2.0	09/18/99	LA level specification (include Ultra 160 support)
2.01	09/24/99	LA level specification (update wording to say ‘Ultra ‘160’, update nonop shock

b. Reviewers

The following areas are responsible for reviewing the accuracy of this specification. The review is documented by a note from each functional area manager and is kept in the program project file.

Development Manager
Mechanical Design Manager
Servo Architecture Manager
Interface Microcode Manager
PAE Manager
Component Integration Manager
Mechanical Integration Manager
Card/Electronics Manager:
Product Assurance Manager
RAS Manager

c. Approvers

Approval for this document is the responsibility of the Program Manager. The approval is documented by a note from the Program manager and is kept in the program project file.

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1.0 Description

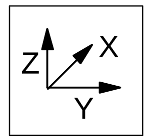

Fig 1. Ultrastar 36ZX, 18LZX Disk Drive Assembly

1.1 General

This is an overview of the general features of the disk drive.

- 36,703/18,351/9,173 MB formatted capacity. (512 Bytes per Sector)
- ECC correction and detection.
- Internal data protection from SCSI bus to media.
- Write splice protection across resets.
- Automatic data sector reallocation with power fault protection.
- Power on and self-diagnostics.
- Rotational speed of 10000 rpm.
- Multimode SE/LVD SCA & 68 pin P connector.
- *Burst data rate, up to 160 MB/s wide in Fast-80 (*Ultra 160 *LVD mode)*
- *Backward compatible design for SE and Fast-40 operation*
- 2MB segmented cache buffer.
- Non-volatile error logs.
- Tagged queuing, maximum queue depth of 64 commands.
- Inquiry Pages to hold operating system's mode information.
- Predictive Failure Analysis (SMART) Support.
- No-ID® sector format.
- All mounting orientations supported.

1.2 Performance Summary

- Average read seek time: 4.9 & 5.4 milliseconds (18LZX)
- Average write seek time: 5.9 & 6.4 milliseconds (36ZX)
- Average Latency: 3 milliseconds
- Sustained data transfer rate: 14.79 to 28.00 MegaBytes/second (15 bands)
- Peak media transfer rate 23.27 to 44.31 MegaBytes/second (15 bands)
- Maximum SCSI Bus data transfer rate: *160* MegaBytes/Second
- SCSI bus overhead: < 32 microseconds
- Read command overhead: < 283 microseconds

1.3 SCSI Interface Controller Features

- Multiple initiator support
- Variable logical block lengths (512 - 688 supported)[1]
- Nearly Contiguous Read
- Read-ahead caching
- Adaptive caching algorithm
- Write Caching
- Back-to back writes (merged writes)
- Tagged and untagged command queuing
- Command reordering (4 user selectable algorithms)
- Automatic retry and data correction on read errors
- Automatic sector reallocation
- In-line alternate sector assignment for high-performance
- Down-loadable firmware
- Customizing controller jumpers, for example:-
  - Auto spindle motor start
  - Auto start delay
  - Disable Target Initiated Synchronous Negotiation
  - Disable Unit Attention
  - Disable SCSI Parity
  - Write protection

[1] Please see **Capacities by Format Length** on page 20 for more details.

1.4 Reliability Features

- Self-diagnostics on power up
- Ramp Load and Unload for all heads
- Inertia actuator latch
- Entire Read/Write data path protected by a 32 Bit CRC
- 24 Byte Error Correcting Code (ECC)
- 12 Byte on the fly ECC
- Predictive Failure Analysis. (PFA) ®
- Error Recovery Procedures (ERP)
- Data Recovery Procedures (DRP)
- Probability of not recovering data: **10 in 10^{15}** bits read
- No preventative maintenance required
- Event logging and analysis
- Enhanced write protection
- Temperature monitoring, logging and adaptation

1.5 Models

- The 68 pin SCSI connector models offer an 8/16 bit SCSI bus using the SCSI 'P' connector which supports wide data transfers.
- The 80 pin SCSI connector models offer an 8/16 bit SCSI bus using the 'SCA-2' connector which supports wide data transfers.

Models	HDA Type	Capacity GB	SCSI Pins/Connector Type	SCSI Electrical Signal Type
DMVS 09	1.0"	9.11GB	68/SCA Connector	SCSI SE/LVD Multimode
DMVS 18	1.0"	18.35GB	68/SCA Connector	SCSI SE/LVD Multimode
DMVS 36	1.6"	36.70GB	68/SCA Connector	SCSI SE/LVD Multimode

Model Suffix (example DMVS 09 **-V**) defines the type of SCSI connector and the SCSI Interface capability.

Model Suffix	Description
V	68 pin connector , Fast-40 / SE
D	80 pin connector , Fast-40 / SE
N	68 pin connector , Ultra 160 capable / SE
M	80 pin connector , Ultra 160 capable / SE

Table 1. Available Models

2.0 Power Requirements

The following voltage specifications apply at the drive power connector. No special power on/off sequencing is required.

2.1 Input Voltage

Input Voltage	
+5 V	5 V (± 5% during run and spin-up)
+12 V	12 V (± 5% during run, +5%/-7% during spin-up)
Power Supply On/Off Requirements	
+5 V	4.5 V/sec Minimum slew
+12 V	7.4 V/sec Minimum slew

2.2 Power Supply Current and Drive Power Measurements

18LZX 9.1 GB

Operation Mode	Measurement	Current (Amps)		Power (Watts)		**Total Power (Watts)**
	Type	+5V	+12V	+5V	+12V	
Spindle Start	MAX		1.60			
Standby	RMS	0.40	0.38	2.00	4.60	6.51
Idle	RMS	0.39	0.44	2.00	5.30	7.24
Seek Peak			1.65			
Energy Consumption (Japanese Requirement)[2]				0.001		
30 Ops	RMS	0.57	0.61	2.81	7.30	10.10
60 Ops	RMS	0.58	0.70	2.84	8.36	11.20
90 Ops	RMS	0.58	0.81	2.87	9.62	12.50

18LZX 18 GB

Operation Mode	Measurement Type	Current (Amps)		Power (Watts)		**Total Power (Watts)**
		+5V	+12V	+5V	+12V	
Spindle Start	MAX		1.60			
Standby	RMS	0.55	0.52	2.73	6.24	8.98
Idle	RMS	0.58	0.71	2.90	8.58	11.48
Seek Peak			2.10			
Energy Consumption (Japanese Requirement)[3]				0.0006		
30 Ops	RMS	0.60	0.83	3.03	10.00	13.02
60 Ops	RMS	0.61	0.93	3.07	11.21	14.27
90 Ops	RMS	0.62	1.02	3.10	12.30	15.40

[2]Energy consumption Index = Idle Power/Capacity (Watts/MB)
[3]Energy consumption Index = Idle Power/Capacity (Watts/MB)

36ZX 36 GB

Operation Mode	Measurement Type	Current (Amps)		Power (Watts)		**Total Power (Watts)**
		+5V	+12V	+5V	+12V	
Spindle Start	MAX		2.90			
Standby	RMS	0.58	0.82	2.92	9.80	12.72
Idle	RMS	0.63	1.19	3.13	14.31	17.41
Seek Peak			3.25			
Energy Consumption (Japanese Requirement)[4]				0.0004		
30 Ops	RMS	0.65	1.34	3.24	16.03	19.27
60 Ops	RMS	0.66	1.44	3.28	17.33	20.61
90 Ops	RMS	0.66	1.57	3.32	18.84	22.16

Note 1: Power Measurements were made using a Clarke Hess Model 259 Digital Wattmeter. The tester configuration and operation may vary and cause a 10% variation in the results.

2.3 Supply Graphs

These graphs were obtained by measuring a population of drives from the normal manufacturing process. The results are the average from this population taken at nominal voltage conditions.

All power supplies are nominal.

The results exclude inductive spikes caused by leads, power supplies and components that will vary with different setup configurations.

These graphs are actual traces recorded on real drives in a lab environment. They are intended to be typical examples.

[4] Energy consumption Index = Idle Power/Capacity (Watts/MB)

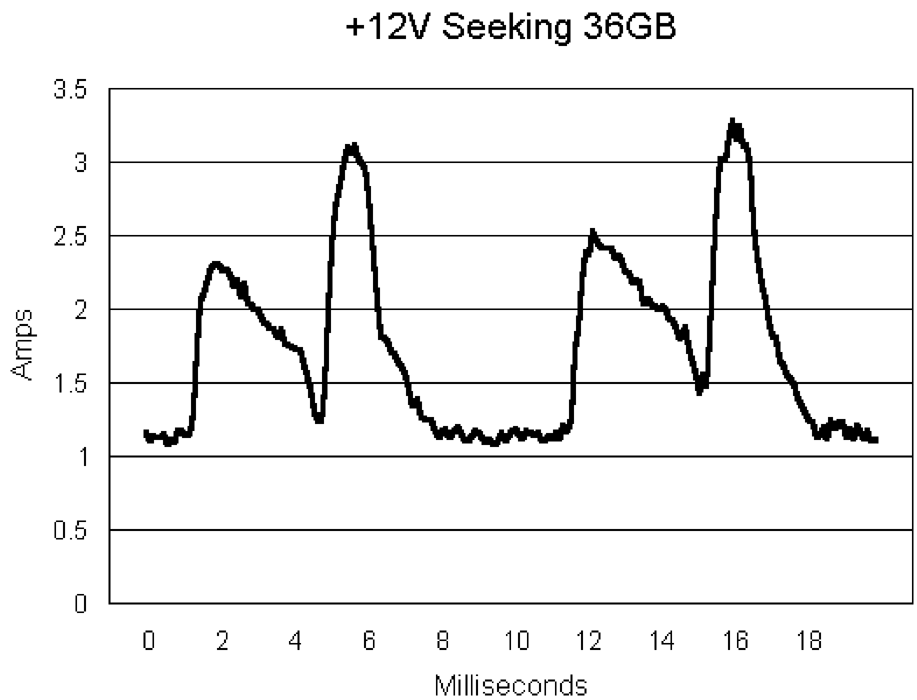

Fig 2. 36ZX +12 Volt Current during a Forward and Reverse seek

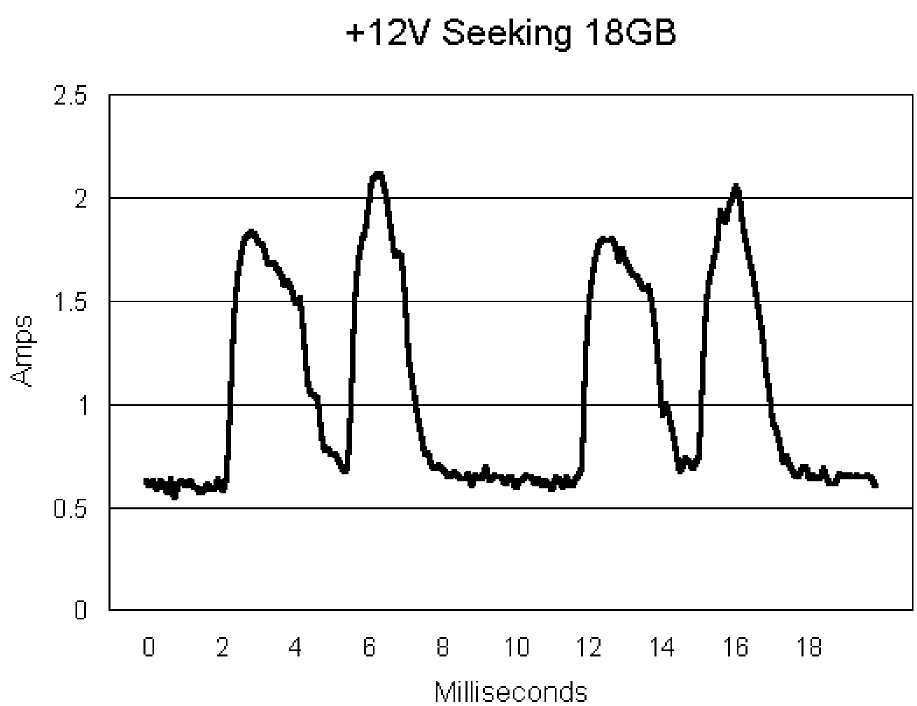

Fig 3. 18LZX +12 Volts Current during a Forward and Reverse seek

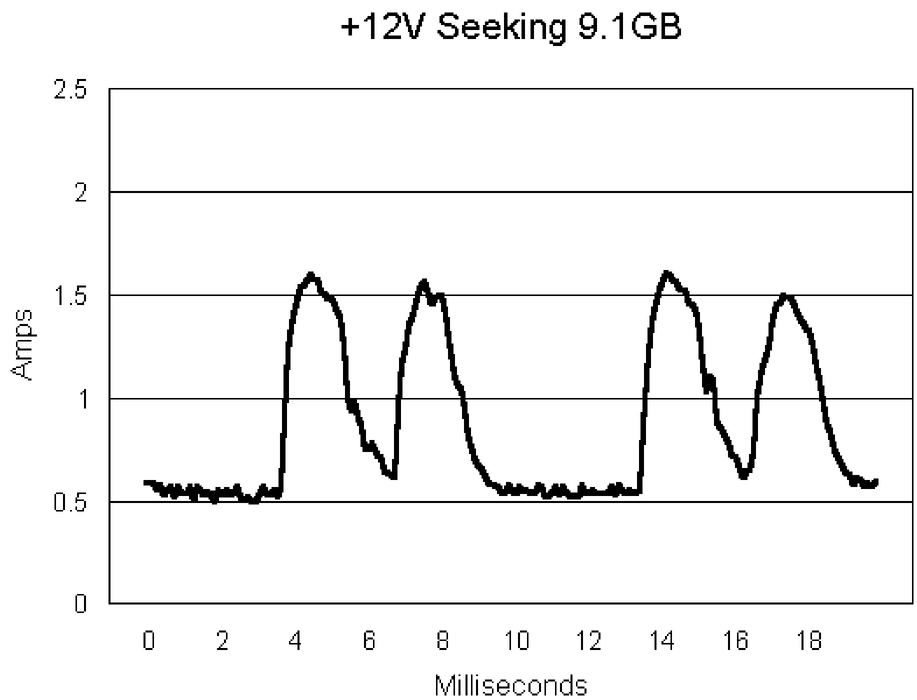

Fig 4. 18LZX (9.1GB) +12 Volts Current during a Forward and Reverse seek

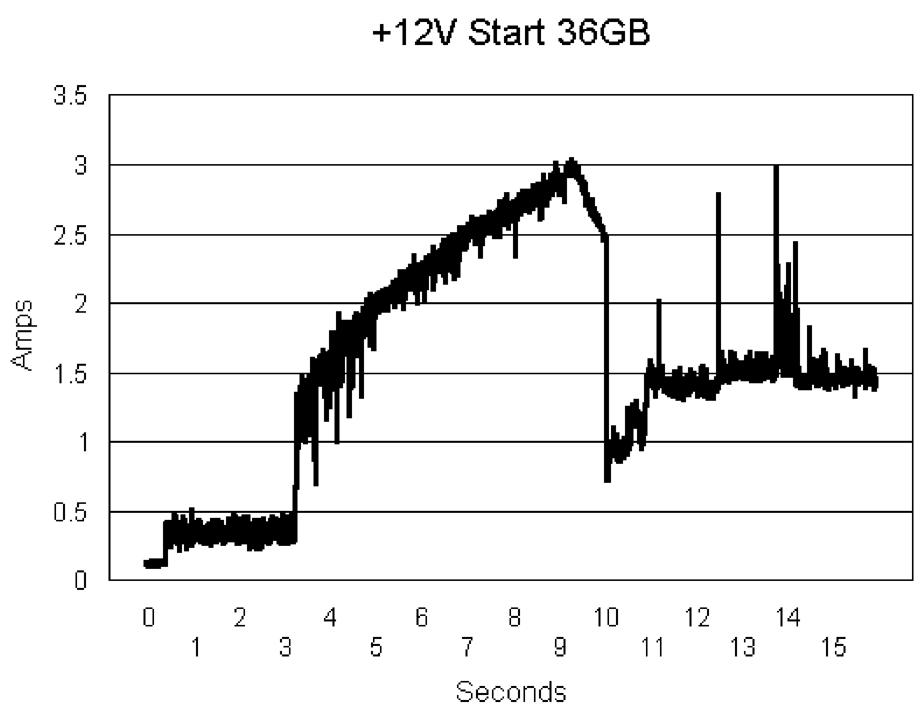

Fig 5. 36ZX Typical 12V Start Current Profile

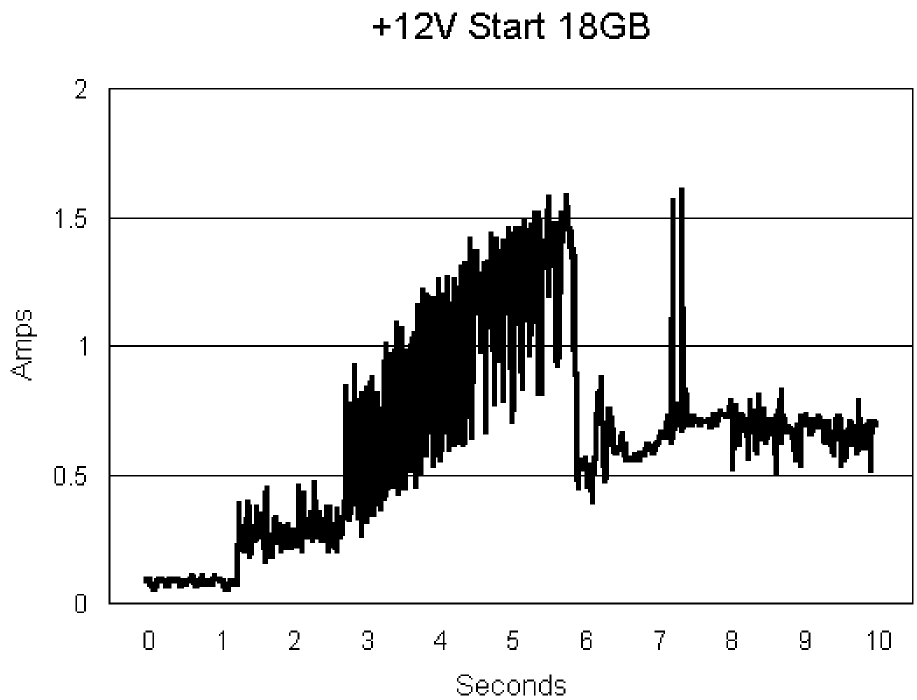

Fig 6. 18LZX Typical +12V Start Current Profile

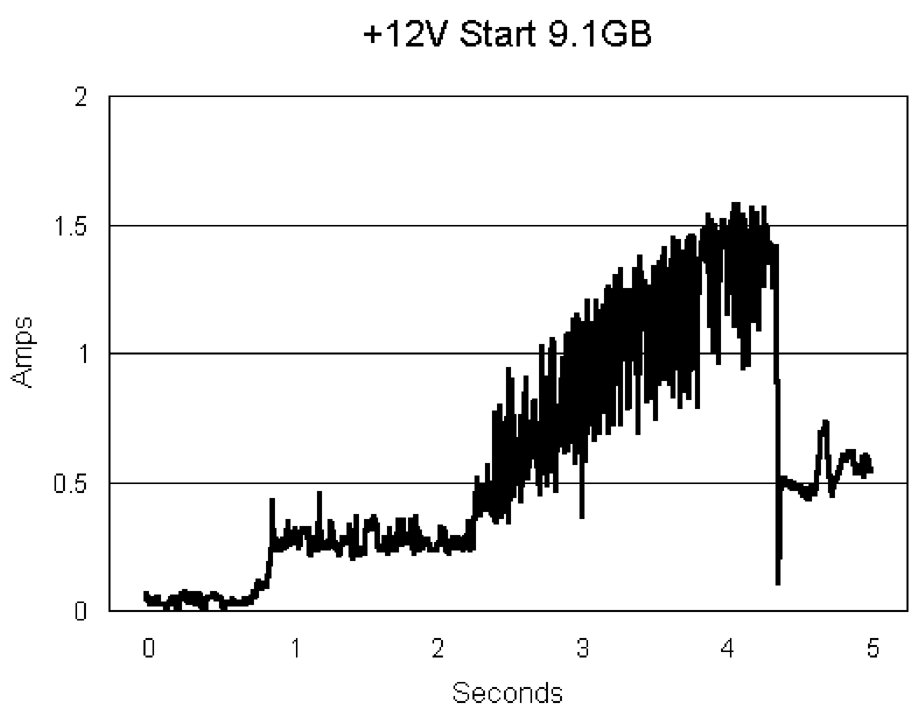

Fig 7. 18LZX (9.1GB) Typical +12V Start Current Profile

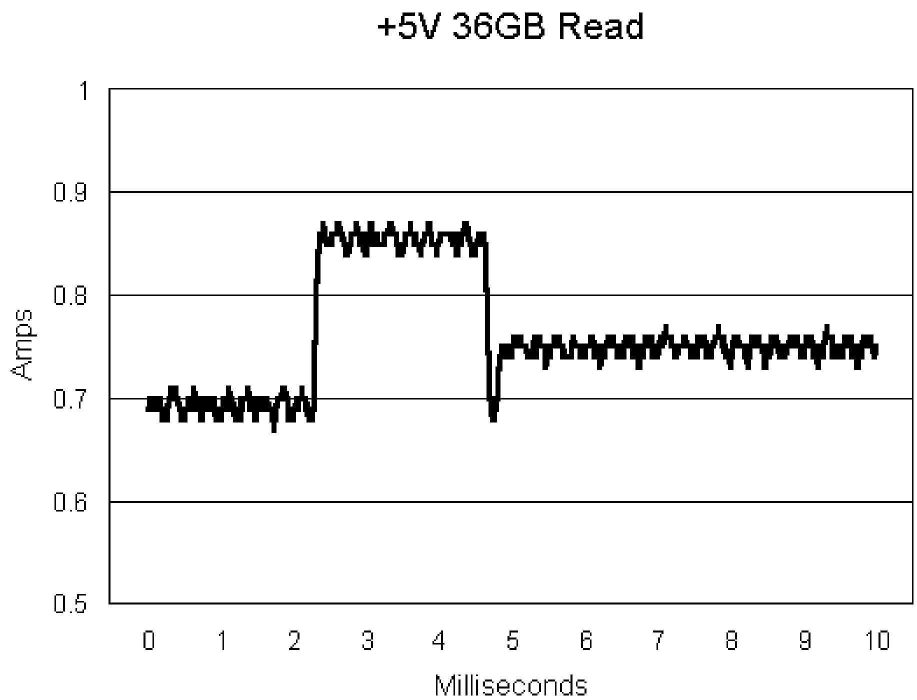

Fig 8. 36ZX Typical +5V current during a Read

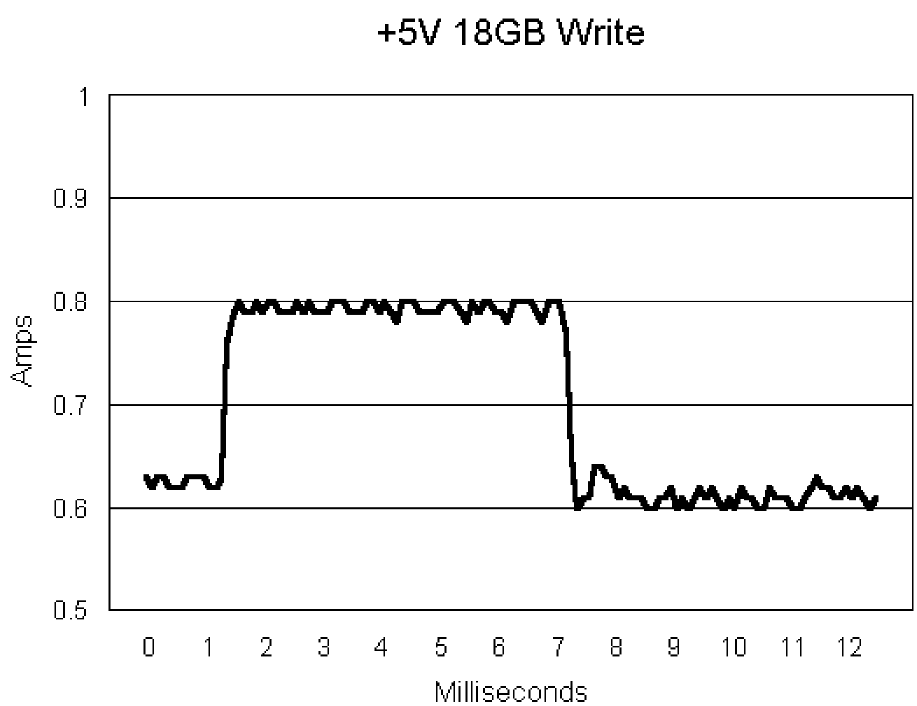

Fig 9. 18LZX Typical +5V current during a Write

2.4 Power Supply Ripple

Externally Generated Ripple as seen at drive power connector

	Maximum	Frequency
+5 Volts DC	250 mV P-to-P	0 - 20 MHz
+12 Volts DC	650 mV P-to-P	0 - 100 Hz
	400 mV P-to-P	100 - 5,000 Hz
	250 mV P-to-P	5 Khz - 20 MHz

During drive start up and seeking, 12 volt ripple is generated by the drive (referred to as dynamic loading). If several drives have their power daisy chained together then the power supply ripple plus other drive's dynamic loading must remain within the regulation tolerance window of +/- 5%. A common supply with separate power leads to each drive is a more desirable method of power distribution.

2.5 Power Supply Common Mode Noise

The drive is sensitive to common mode noise on the power supply cable. Common Mode Noise current on the power supply cable should not exceed 20mA (150KHz to 230MHz)

2.6 Input Capacitance

Internal bulk capacitance as seen at drive power connector

+5 V DC	140 µF +/- 20%
+12 V DC	510 µF +/- 20%

2.7 Grounding Requirements of the Disk Enclosure

The disk enclosure is at power supply ground potential. From an electromagnetic compatibility (EMC) standpoint it will, in most cases, be preferable to common the disk enclosure to the system's mounting frame. With this in mind, it is important that the disk enclosure not become an excessive return current path from the system frame to power supply. At no time should more than 20 milliamps of current (0 to 230 MHz) be injected into the disk enclosure.

3.0 Specifications

All specification numbers are mean population values unless otherwise noted.

3.1 General

Data transfer rates			
Buffer to/from media (MB/s)	23.27 to 44.31		
Host to/from buffer	up to 40.0 MB/s (Fast - 20) up to 80.0 MB/s (Fast - 40) LVD *Up to 160 MB/s (Fast- 80) '160M' LVD*		
Rotational speed	10,000 RPM		
Average Latency	3 ms		
Track density	13,595 TPI		
Recording density (KBPI)	260 to 235		
Areal density (Mb/sq inch)	3,535 to 3,197		
	9.1 GB model	18 GB model	36 GB model
Disks	3	5	10
Heads	5	10	20
Seek timing in ms (Measured at nominal voltage & temperature)			
Single cylinder	0.4 (Read)	0.4 (Read)	0.4 (Read)
	0.7 (Write)	0.7 (Write)	0.7 (Write)
Average weighted	4.9 (Read)	4.9 (Read)	5.4 (Read)
	5.9 (Write)	5.9 (Write)	6.4 (Write)
Full stroke	10.6 (Read)	10.6 (Read)	11.4 (Read)
	11.4 (Write)	11.4 (Write)	12.4 (Write)

3.2 Notch Details

For the following conditions

User bytes/sector (ub/sct)	512
Sectors/logical block (sct/lbs)	1
User bytes/logical block (ub/lba)	512
Maximum addressable cylinders	11748

3.3 Data Zones

Zone	*M*Byte Rate	Sectors per SID	Sectors per Track	Cylinder Start	Cylinder End	No. of Cylinders	Radius mm	bpi
0	44.31	17/4	382	**[5]	1684	1672	36.56	235.18
1	41.18	4/1	360	1685	3930	2246	32.36	246.85
2	39.61	19/5	342	3931	4813	883	30.71	250.21
3	38.82	26/7	334	4814	5232	419	29.93	251.67
4	38.04	29/8	326	5233	5644	412	29.16	253.09
5	36.86	7/2	315	5645	6235	591	28.06	254.92
6	35.29	37/11	302	6236	6980	745	26.66	256.81
7	34.51	23/7	295	6981	7334	354	26.01	257.49
8	33.73	16/5	288	7335	7683	349	25.35	258.12
9	30.85	3/1	270	7684	8909	1226	23.06	259.56
10	29.80	17/6	255	8910	9340	431	22.26	259.82
11	28.24	8/3	240	9341	9975	635	21.07	260.03
12	26.41	5/2	225	9976	10691	716	19.73	259.65
13	24.84	7/3	210	10692	11288	597	18.62	258.85
14	23.27	13/6	195	11289	11748[6]	460	17.75	254.34

Table 2. Data Zone Table

3.4 Capacities by Format Length

Block Size	9.1 GB	18 GB	36 GB
512	17,916,240	35,843,670	71,687,340
514	17,779,500	35,570,150	71,140,300
520	17,429,580	34,870,150	69,740,300
522	17,334,100	34,678,990	69,357,980
524	17,264,020	34,538,830	69,077,660
528	17,207,800	34,426,390	68,852,780
536	17,012,010	34,034,810	68,069,620
688	13,630,100	27,268,830	54,537,660

Table 3. User **Blocks** (Generic Factory Settings)

[5] Number will change with different models
[6]

Block Size	9.1 GB	18 GB	36 GB
512	9,173,114,880	18,351,959,040	36,703,918,080
514	9,138,663,000	18,283,057,100	36,566,114,200
520	9,063,381,600	18,132,478,000	36,264,956,000
522	9,048,400,200	18,102,432,780	36,204,865,560
524	9,046,346,480	18,098,346,920	36,196,693,840
528	9,085,718,400	18,177,133,920	36,354,267,840
536	9,118,437,360	18,242,658,160	36,485,316,320
688	9,377,508,800	18,760,955,040	37,521,910,080

Table 4. User **Capacity** (Generic Factory Settings)

Note: The total number of LBA's is the maximum LBA + 1

3.5 'Hot Plug/Unplug' support

The term 'Hot Plug' refers to the action of mechanically engaging a device to the power and/or bus when other devices may be active on the same bus. A comprehensive classification of the state of the SCSI bus during this event is located in the SCSI-3 Parallel Interface Standard.

Note:

- Case 3 is defined as 'Current I/O processes not allowed during insertion or removal'
- Case 4 is defined as 'Current I/O processes allowed during insertion or removal'

While every effort was made to design the drive not to influence the SCSI bus during these events, it is a system responsibility to insure voltage regulation and conformance to operational and non-operational shock limits.

During Hot Plug events the non-operational shock levels should not be exceeded. The operational shock levels of adjacent drives should not be exceeded as well. The recommended procedure is to prohibit write operations to adjacent drives during the HOT PLUG and during the HOT UN-PLUG actions.

During Hot Un-plug the operational shock limit specifications should not be exceeded. If this cannot be guaranteed then the drive should be issued a SCSI Stop Unit command that is allowed to complete before un-plugging. The basic requirement is that while the drive is operational or spinning down the operational shock limits are in effect. Once the drive has completely stopped the non-operational shock limits are in effect. The recommended procedure is to allow the un-plugged drive to rest in the drive bay for a minimum of 15 seconds and then complete the removal.

During Hot Plug or Un-plug events the power supply ripple on adjacent operational drives should not go outside of the +/-5 % regulation tolerance.

3.6 SCSI 68 pin Models

Based on the SCSI Parallel Interface classification, it is recommended that the using system comply with 'Case 3' guidelines to eliminate the chance of effecting the active bus.

In systems that can not afford to quiesce the SCSI bus, but can meet the requirements of voltage regulation, operational and non-operational shock, the following guidelines are recommended to minimize the chance of interfering with the SCSI bus.

Plug

1. Common ground should be made between device and power supply ground
2. Plug device onto the bus
3. Power up device (no special sequencing of +5 V and +12 V required).
4. Device is read to be accessed

Unplug

1. Power down device (no special sequencing of +5V and +12V required).
2. Unplug device from bus
3. Remove common ground

3.7 SCSI SCA Models

Based on this classification the SCA connector drive is designed to be 'Case 4' compliant when the system has properly implemented *SPI-3* Annex guidelines.

3.8 Bring-up Sequence (and Stop) Times

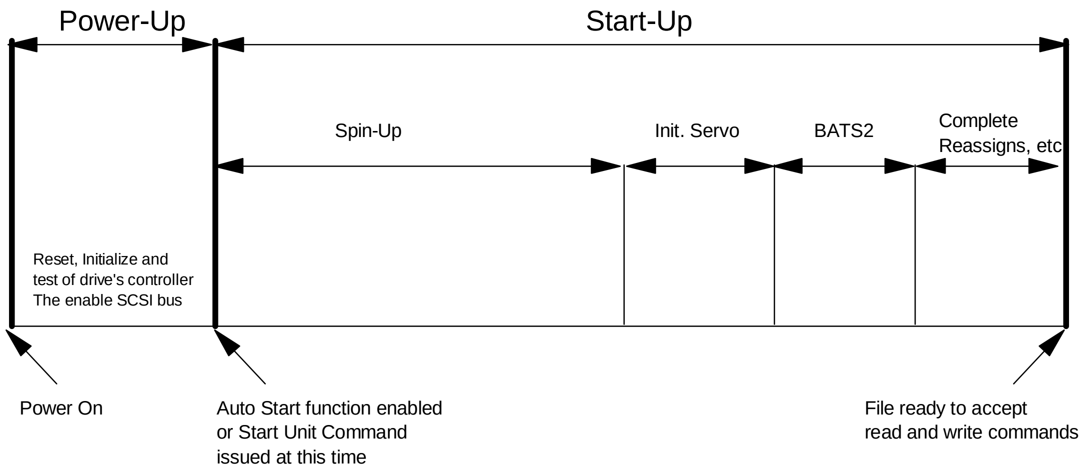

Fig 10. Start Time Diagram

A full Bring-up sequence consists of a Power-up sequence and Start-up sequence as shown above.

“Power On” is defined to be when the power at the drive meets all of the power specifications as defined in this document.

The Start-up sequence spins up the spindle motor, initializes the servo subsystem, performs the Basic Assurance Tests 2 (BATS2) to verify the read/write hardware, resumes “Reassign in Progress” operations and more. See the *Ultrastar 36ZX,18LZX SCSI Logical Interface Specification* for additional details on the Start-up sequence.

If a SCSI Reset is issued while the drive is in either a Power-up or Start-up sequence, that same sequence starts again. In all other cases when a SCSI Reset is issued the present state of the motor is not altered.

A Start-up sequence initiated by SCSI “Start/Stop Unit” command that follows a spindle stop initiated by a SCSI “Start/Stop Unit” command by less than 10 seconds may result in the Start-up sequence increasing by as much as 10 seconds. For example, if a delay of only 3 seconds exists between the two command the second command takes 7 seconds longer than if 10 seconds or more had been allowed between the commands.

	18LZX		36ZX	
	Nominal	Sigma	Nominal	Sigma
Power-up (seconds)	*3.25*	0.25	*3.25*	0.25
Start-up (seconds)	16.5	1.5	26	1.5
Spin-up (seconds)	12	2	15	2
Spindle Stop (seconds)				
Coast	45	10	85	10
Active Brake	12	3	15	3

Table 5. Bring-up Sequence Times

3.9 Spin Down Times

After power is removed the drive should be allowed 15 seconds to park the heads and spin down before any attempt is made to handle the drive. When power is removed from the drive active braking is engaged. If a unit stop command is issued, then the drive will coast down.
It is recommended that after power is removed a period of 2 seconds should be allowed before DC is reapplied to the drive.

4.0 Performance

Drive performance characteristics listed in this chapter are typical values provided for information only, so that the performance for environments and workloads other than those shown as examples can be approximated. Actual minimum and maximum values will vary depending upon factors such as workload, logical and physical operating environments and manufacturing process variations.

4.1 Environment Definition

Drive performance criteria is based on the following operating environments. Deviations from these environments may cause deviations from values listed in this specification.

- Nominal physical environment (voltage, temperature, vibration, etc.) as defined elsewhere in this specification.
- Block lengths are formatted at 512 bytes per block.
- The number of data buffer segments is 8. The total data buffer length available for customer use is 1778 KB. The size of each equally sized segment, in either bytes or blocks, is determined via the SCSI Mode Page 8h parameter called “Cache Segment Size”.
- Ten byte SCSI Read and Write commands are used.
- SCSI environment consists of a single initiator and single target with no SCSI bus contention.
- Buffer full/empty ratios are set to their optimum values such that a minimum number of intermediate disconnects occur during the SCSI data transfer and the overlap of the SCSI and disk data transfer is maximized. This minimizes command execution times with no bus contention.
- Read Caching and Read Ahead functions are enabled except where noted.
- The initiator delay while transferring SCSI command, status, message, and data bytes is assumed to be zero.
- Tagged command queuing is not used, unless otherwise specified.
- All current mode parameters are set to their default values except where noted.
- SCSI data transfers are successfully negotiated to be 160 MB/sec.
- Averages are based on a sample size of 10,000 operations.

4.2 Workload Definition

The drive’s performance criteria is based on the following command workloads. Deviations from these workloads may cause deviations from this specification.

- Operations are either all reads or all writes.
- The time between the end of an operation, and when the next operation is issued is 50 msec, +/- a random value of 0 to 50 msec, unless otherwise noted.

4.1.1 Sequential

No Seeks. The target LBA for all operations is the previous LBA + transfer length.

4.2.1 Random

All operations are to random LBA/s. The average seek is an average weighted seek.

4.3 Command Execution Time

Command execution, or service times, are the sum of several basic components. Those components are:

- Seek
- Latency
- Command Execution Overhead
- Data Transfer to/from Disk
- Data Transfer to/from SCSI Bus

The impact or contribution of these basic components to command execution time is a function of the workload being sent to the drive and the environment in which the drive is being operated.

The following graphs show command execution times for four generic workloads, with several different requested transfer lengths, while running in various environments whose key factors are identified within each graph. The generic workloads are:

- Sequential Reads
- Sequential Writes
- Random Reads
- Random Writes

Notes:

1. Times are calculated with typical data sector transfer rates for ULTRASTAR 36ZX/18LZX models and are averaged over the entire drive.
2. In the following graphs, “TCQing” means tagged command queuing.

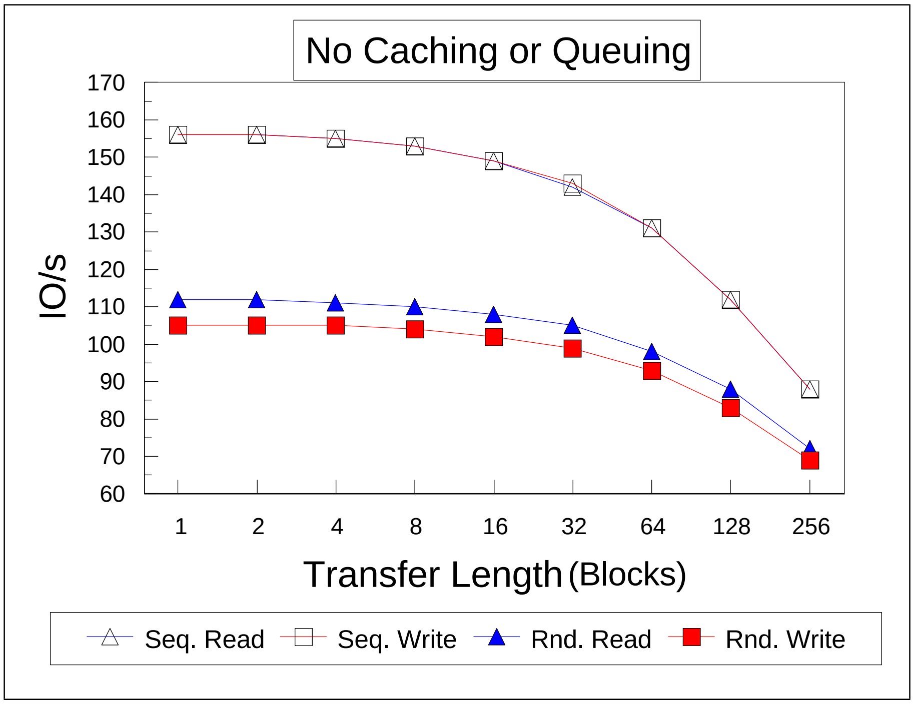

Fig 11. 18LZX: Re-instruction times = 0 ms, with no caching or queuing

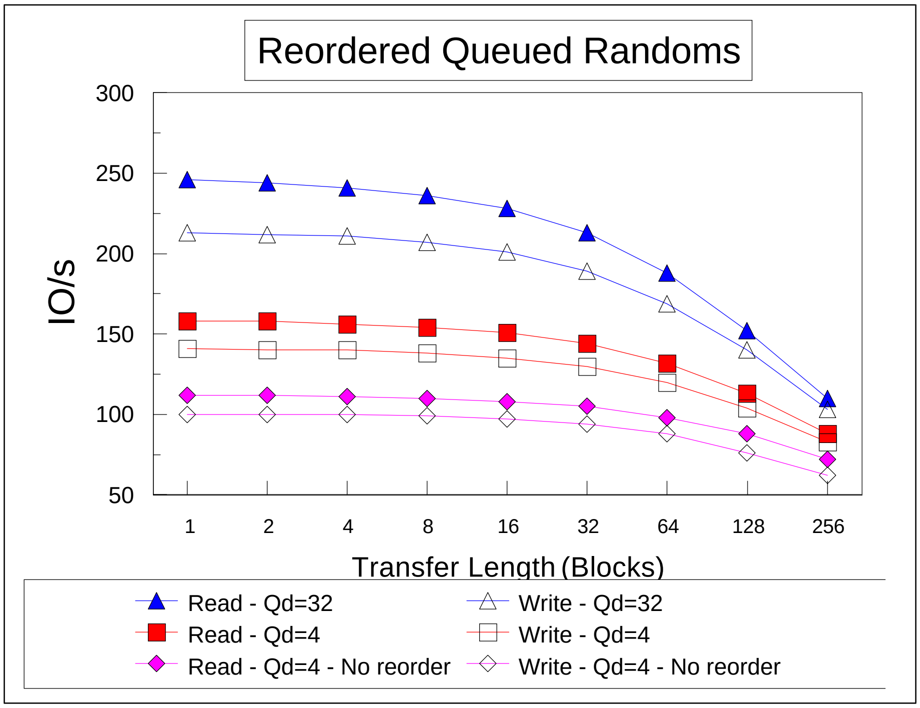

Fig 12. 18LZX: Random reads and writes with and without reordering

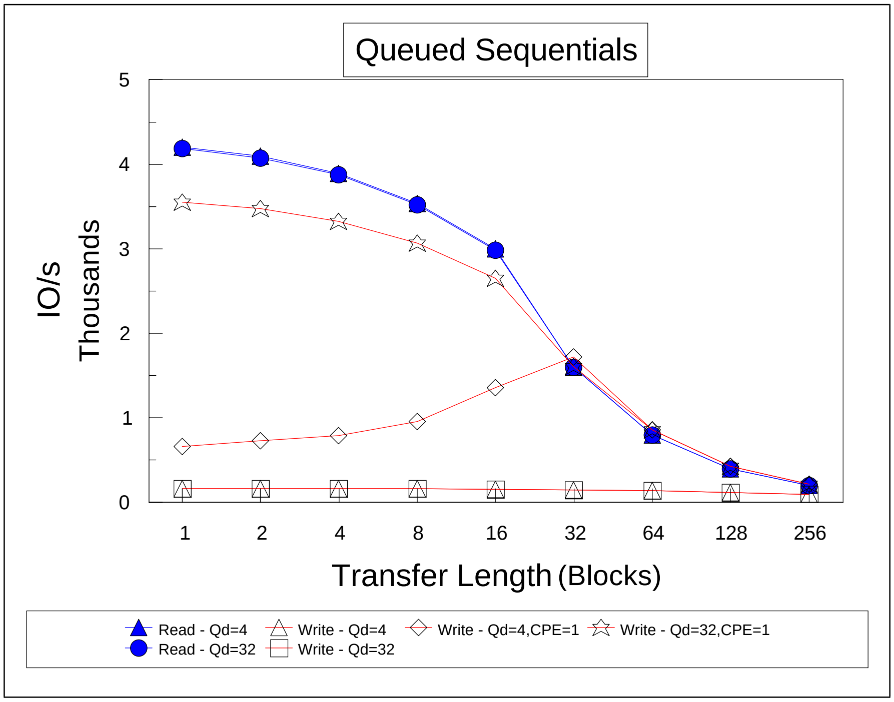

Fig 13. 18LZX: Queued sequential performance

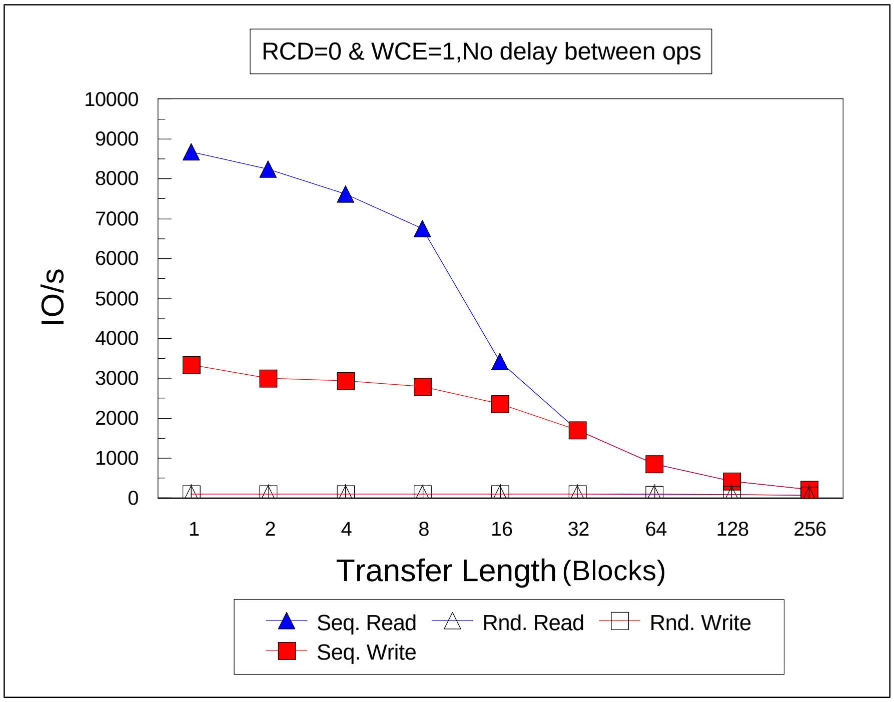

Fig 14. 18LZX: *Write Cache on and Read Cache on*

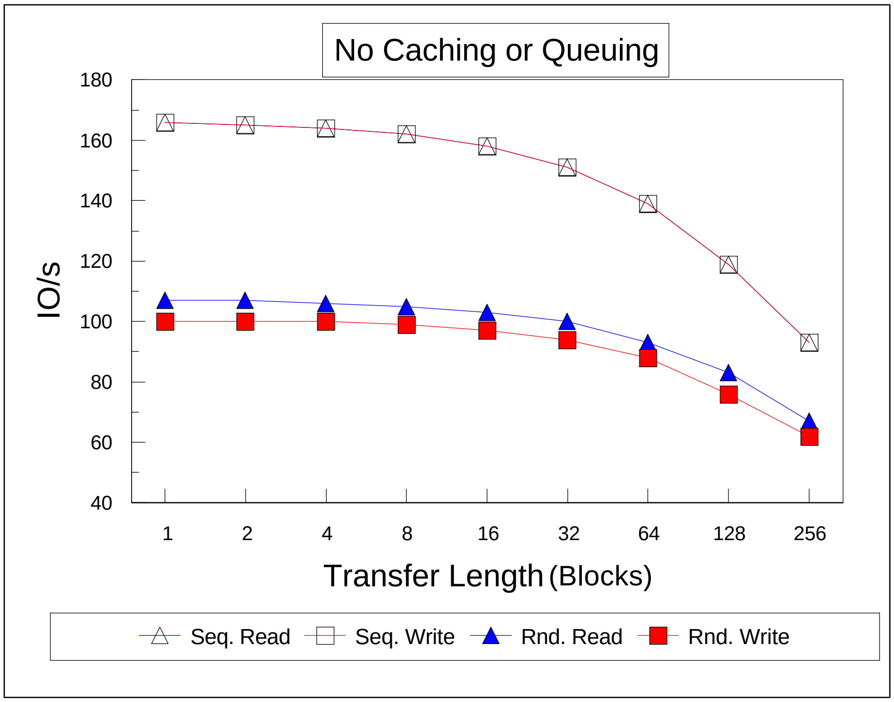

Fig 15. 36ZX: Re-instruction times = 0 ms, with no caching or queuing

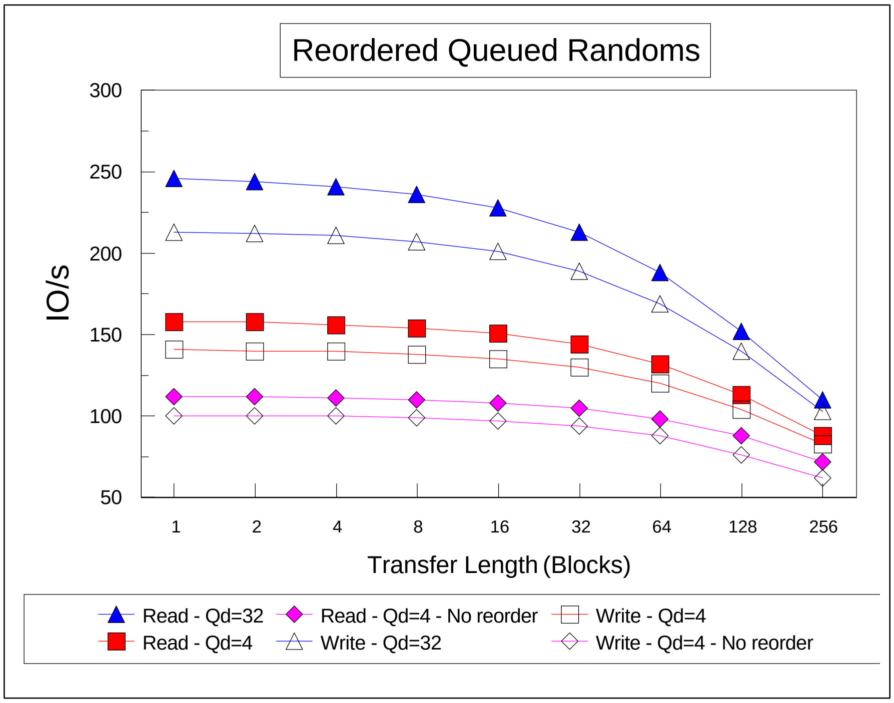

Fig 16. 36ZX: Random reads and writes with and without reordering

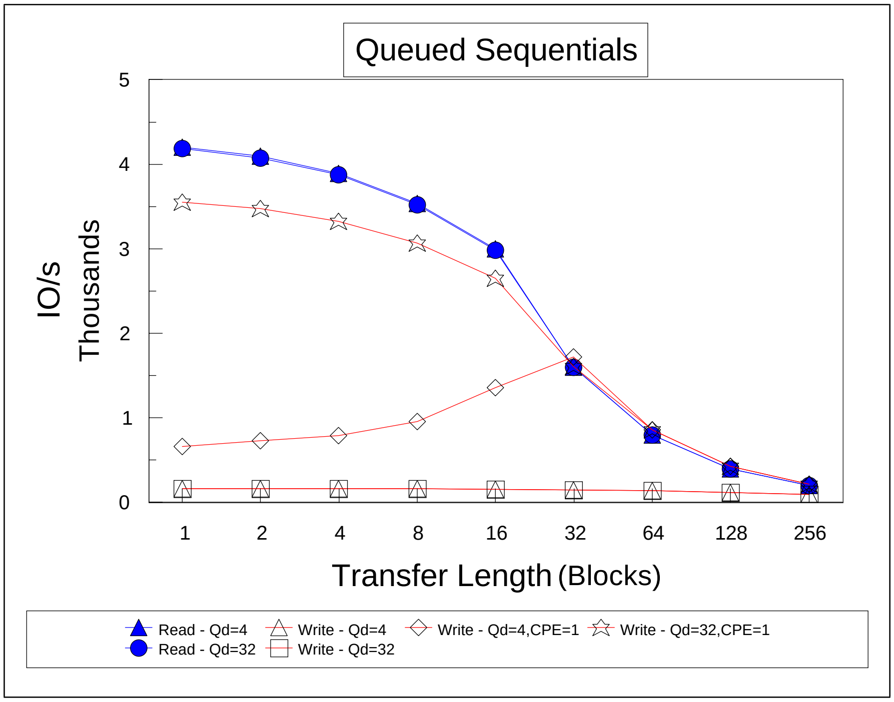

Fig 17. 36ZX: Queued sequential performance

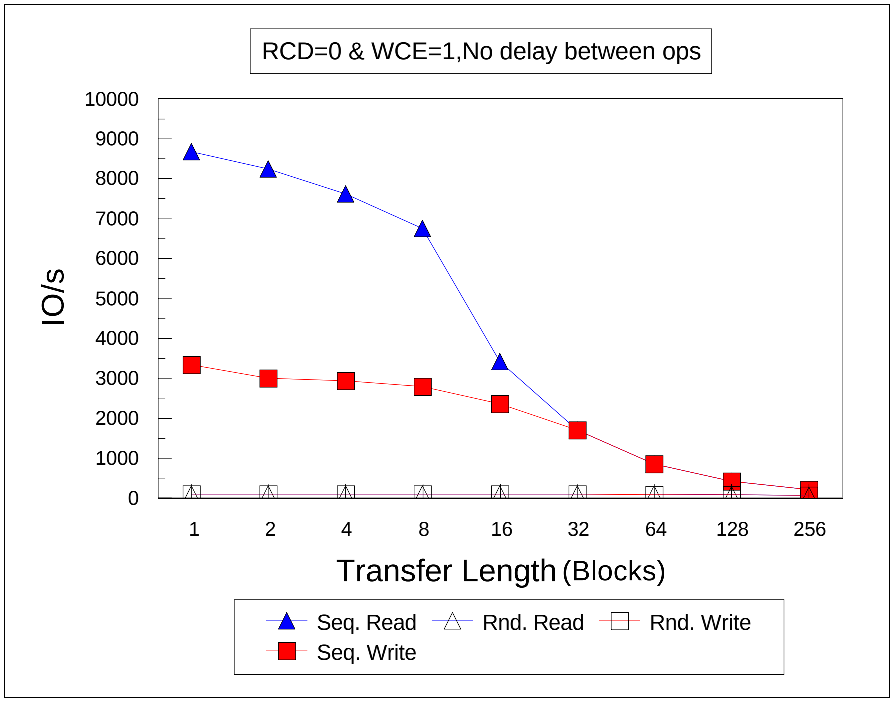

Fig 18. 36ZX: *Write Cache on and Read Cache on*-

4.4 Basic Descriptions

4.4.1 Seek

The average time from the initiation of the seek to the acknowledgment that the R/W head is on the track that contains the first requested LBA. Values are population averages and vary as a function of operating conditions. The values used in the graphs showing command execution times for sequential commands is 0 ms and the values for random commands are shown in section Random" on page 25.

4.4.2 Latency

The average time required from the activation of the read/write hardware until the target sector has rotated to the head and the read/write begins. This time is ½ of a revolution of the disk, or 3 ms.

4.4.3 Command Execution Overhead

The average time added to the command execution time due to the processing of the SCSI command. It includes all the time the drive spends processing a command while not doing a disk operation or SCSI data transfer, whether or not it is connected to the bus. (See " **Read Command Performance**" on page 36 and " **Write Command Performance**" on page 37 for examples of detailed descriptions of the components of command execution overhead.) The value of this parameter varies greatly depending upon workloads and environments.

The command execution overhead specification is based on a normal operations with the Read Ahead function disabled. The following values are used when calculating the command execution times.

Workload	**Command Execution**	**SCSI Bus**
Sequential Read	0.29	0.03
Sequential Read with Read Ahead	0.10	0.03
Sequential Write	0.15	0.04
Sequential Write with Write Cache	0.09	0.04
Random Read	0.16	0.03
Random Read with Read Ahead	0.17	0.03
Random Write	0.15	0.03

Table 6. Overhead Values (milliseconds)

Other initiator controlled factors such as use of disconnects, tagged command queuing and the setting of mode parameters like DIMM, DPSDP and ASDPE also affect command execution overhead. They also affect SCSI bus overhead which is partially a subset of command execution overhead.

SCSI Bus Overhead is defined as the time the device is connected to the bus transferring all SCSI Command, Status and Message phase information bytes. This includes any processing delays between SCSI bus phases while remaining connected to the SCSI bus. Initiator delays while transferring information bytes are assumed to be zero. This time does not include the SCSI Data phase transfer. (See " **Read Command Performance**" on page 36 and " **Write Command Performance**" on page 37 for more detailed descriptions of the components of SCSI bus overhead.)

Post Command Processing time of 0.1ms is defined as the average time required for process cleanup after the command has completed. This time indicates the minimum re-instruct time which the device supports. If a re-instruct period faster than this time is used, the difference is added to the command execution overhead of the next operation.

4.4.4 Data Transfer to/from Disk

The average time used to transfer the data between the media and the drive's internal data buffer. This is calculated from:

(Data Transferred)/(Media Transfer Rate).

There are four interpretations of Media Transfer Rate. How it is to be used helps decide which interpretation is appropriate to use.

1. Instantaneous Data Transfer Rate

   The same for a given notch formatted at any of the supported logical block lengths. It varies by notch only and does not include any overhead. It is calculated from:

   1/(individual byte time)

2. Track Data Sector Transfer Rate

   Varies depending upon the formatted logical block length and varies from notch to notch. It includes the overhead associated with each individual sector. This is calculated from: (user bytes/sector)/(individual sector time). (Contact an IBM Customer Representative for individual sector times of the various formatted block lengths.)

   Note: These rates are used to help estimate optimum SCSI Buffer Full/Empty Ratios.

3. Theoretical Data Sector Transfer Rate

   Also includes time required for track and cylinder skew and overhead associated with each track. Use the following to calculate it.
   Data Sector Transfer Rate = Bytes per cylinder/(Time for 1 cyl + track skew + 1 cyl skew)

4. Typical Data Sector Transfer Rates

Also includes the effects of defective sectors and skipped revolutions due to error recovery. (See Appendix B. of the *ULTRASTAR 36ZX/18LZX Parallel SCSI Disk Drive Logical Interface Specification* for a description of error recovery procedures.)

Rates for drives formatted at 512 bytes/block are shown in the following table.

Model Type	36ZX		18LZX		18LZX (9GB)	
Notch #	**Theoretical**	**Typical**	**Theoretical**	**Typical**	**Theoretical**	**Typical**
Average	23.45	23.35	23.20	23.09	22.70	22.60
	Theoretical	**Typical**	**Theoretical**	**Typical**	**Theoretical**	**Typical**
1	28.14	28.00	27.83	27.70	27.24	27.11
2	26.56	26.44	26.27	26.15	25.71	25.59
3	25.80	25.68	25.52	25.40	24.98	24.86
4	25.20	25.08	24.93	24.81	24.40	24.28
5	24.52	24.40	24.25	24.13	23.73	23.63
6	23.22	23.11	22.96	22.85	22.48	22.37
7	22.35	22.24	22.10	21.99	21.62	21.52
8	21.75	21.64	21.51	21.41	21.06	20.95
9	21.23	21.13	21.00	20.90	20.55	20.45
10	19.87	19.77	19.65	19.55	19.23	19.14
11	18.81	18.72	18.60	18.51	18.20	18.11
12	17.70	17.61	17.50	17.42	17.13	17.05
13	16.58	16.50	16.40	16.32	16.05	15.98
14	15.46	15.39	15.29	15.22	14.96	14.89
15	14.86	14.79	14.70	14.63	14.38	14.31

Table 7. Data Sector Transfer Rates (MB/s)

Notes:

1. The values for typical data sector transfer rate assume a typically worst case value of 3 errors in 10^9 bits read at nominal conditions for the soft error rate.
2. Contact an IBM customer representative for values when formatted at other block lengths.
3. Each group of cylinders with the same number of gross sectors per track is called a notch. “Average” values used in this specification are sums of the individual notch values weighted by the number of LBAs in the associated notches.

4.4.5 **Data Transfer to/from SCSI Bus**

The time required to transfer data between the SCSI bus and the drive’s internal data buffer, that is not overlapped with the time for the seek, latency or data transfer to/from disk. This time is based on a SCSI synchronous data transfer rate of 160.0 MB/sec.

For Fast-80 drives, synchronous data transfer rates of 160MB/sec are achieved for 16 bit wide transfers. Slower transfer rates are possible. *Please refer to Table 181 of the SCSI Message System portion of the ULTRASTAR 36ZX/18LZX Parallel SCSI Disk Drive Logical Interface Specification for details.*

The asynchronous data transfer rate is dependent on both the initiator and target delays to the assertion and negation of the SCSI REQ and ACK signals. It is also dependent on the SCSI cable delays. The drive is capable of supporting asynchronous data transfer rates of 5 MegaTransfer/second (MT/s).

The SCSI data transfer rate specification only applies to the Data phase for logical block data for Read, Write, Write and Verify, etc.… commands. The data rate for parameter/sense data for Request Sense, Mode Select, etc. commands is not specified.

Comments

Overlap has been removed from the command execution time calculations. The components of the command execution times are truly additive times to the entire operation. For example:

- The SCSI bus overhead data is not included in the calculation since some of its components are also components of command execution overhead and the remaining components overlap the data transfer to/from disk. (See “ **Read Command Performance**” on page 36 and “ **Write Command Performance**” on page 37 for details.)
- The post command processing times are not components of the command execution time therefore they are not included in the calculation of environments where the re-instruct period exceeds the post command processing time.

With Read Ahead enabled, this specification measures a read or write command when the immediately preceding command is a read command (which starts up the Read Ahead function). If the preceding command is a write command, then the time difference due to Read Ahead is zero.

Longer inter-op delay, or low re-instruction rate, environments are such that the Read Ahead function has filled the drive’s internal data cache segment before the next read or write command is received.

Environments with inter-op delays less than 1 revolution period, or high re-instruction rates, are such that the Read Ahead function is still in the process of filling the drive’s internal data cache segment when the next read or write command is received. For sequential reads, command execution time is 1 revolution less than similar operations with equal inter-op delays and Read Ahead disabled.

The effects of idle time functions are not included in the above examples. The sections “Sequential” on page 25 and “ Random” on page 25 both define environments where the effects due to increased command overhead of idle time functions upon command execution time are less than 0.01%.

4.4.6 Disconnection During Read/Write Data Phase

If a nonzero maximum burst size parameter is specified, the drive disconnects after transferring the number of blocks specified by the maximum burst size parameter. This disconnection requires approximately 33 µsec and the subsequent reconnection requires approximately 15 µsec.

The drive also disconnects prior to completion of the data phase if the drive’s internal data buffer cache segment becomes empty during a read command or full during a write command. This disconnection occurs regardless of the maximum burst size parameter. This disconnection requires approximately 6 µsec and the subsequent reconnection requires approximately 15 µsec.

4.5 Approximating Performance for Different Environments

The values for several basic components may change based on the type of environment and workload. For example, command overhead may change because certain internal control functions may no longer be overlapped with either the SCSI or disk transfers, etc.. The following paragraphs describe which parameters are effected by which features.

4.5.1 When Read Caching is Enabled

For read commands with Read Caching Enabled the command execution time can be approximated by deleting Seek, Latency and Data Transfer to/from Disk times from those shown on the graphs if all of the requested data is available in a cache segment (cache hit). When some, but not all, of the requested data is available in a cache segment (partial cache hit) Data Transfer to/from Disk will be reduced but not eliminated. Seek and Latency may or may not be reduced depending upon the location of requested data not in the cache and location of the read/write heads at the time the command was received. The contribution of the Data Transfer to/from SCSI Bus to the Command Execution time may increase since a larger, or entire, portion of the transfer may no longer be overlapped with the components that were reduced.

4.5.2 When Read Ahead is Enabled

When Read Ahead is enabled the reduction in command execution times for sequential read workloads (contiguous and noncontiguous) with long inter-op delays can be approximated by using the following equation:

-(Latency + (Xfer Size)/(Disk data rate) - (Xfer size)/(SCSI data rate) = Read ahead savings

The magnitude of the performance advantage of Read Ahead with op delays of 0 to 1 rev varies with the size of the delay. Since the range of delays is less than the time for one revolution, the operation is “synchronized to the disk”. The Read Ahead savings can be roughly approximated by :

DELAY - (time for one revolution) = Read Ahead savings

Note: The time also varies with the size of the data transfer due to the difference between the SCSI data transfer rate and disk data rate. This time is insignificant for a 0.5KByte transfer size and has been ignored in the above equation.

4.5.3 When Write Caching is Enabled

For write commands with the Write Caching Enabled (WCE) Mode parameter bit set, Command execution time can be approximated by deleting seek, latency and data transfer to/from disk times from those shown in the graphs. The contribution of the data transfer to/from SCSI Bus to the command execution time may increase since a larger, or entire, portion of the transfer may no longer be overlapped with the components that were reduced. The reduced times effectively are added to the post command processing time.

Like tagged command queuing, the potential to reduce command execution overhead exists due to concurrent command processing.

Like tagged command queuing, when the WCE bit is set back-to-back write commands are supported. See “ **Back-To-Back Write Commands**” on page 36 for more information.

4.5.4 When Adaptive Caching is Enabled

The Adaptive Caching feature attempts to increase Read Cache hit ratios by monitoring workload and adjusting cache control parameters, normally determined by the using system via the SCSI Mode Parameters, with algorithms using the collected workload information.

4.5.5 For Queued Commands

The effects of Command Execution Overhead can be reduced significantly if Tagged Command Queuing is enabled since more than 1 command can be operated on concurrently. For instance, while a disk operation is being performed for one command another command can be received via the SCSI bus and placed in the device command queue. Certain environments may cause Command Execution Overhead to increase if the added function to process the queue and the messages associated with queuing is not permitted to overlap with a disk operation.

4.5.6 Reordered Commands

If the Queue Algorithm Modifier Mode Parameter field is set to allow it, commands in the device command queue may be executed in a different order than they were received. Commands are reordered so that the seek and latency portions of Command Execution time is minimized. The amount of reduction is a function of the location of the 1st requested block per command and the rate at which the commands are sent to the drive.

4.5.7 Back-To-Back Write Commands

If all of the requirements are met as stated in the *ULTRASTAR 36ZX/18LZX Parallel SCSI Disk Drive Logical Interface Specification* section describing Back-To-Back write commands, contiguous data from 2 or more consecutive write commands can be written to the disk without requiring any disk Latency.

Note: There is a minimum write command transfer length for a given environment where continuous writing to the disk cannot be maintained without missing a motor revolution. When Write Caching is enabled the likelihood is increased that shorter transfer write commands can fulfill the requirements needed to maintain continuous writing to the disk.

4.6 Read Command Performance

Note: This case is for Random SCSI read commands, with Read Ahead disabled.

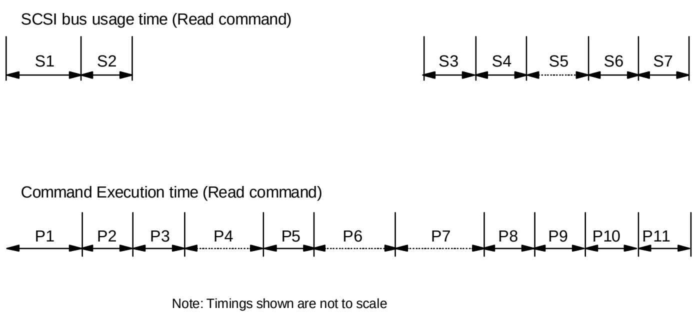

Fig 19. SCSI Read command performance measurements

4.7 SCSI Bus Overhead

Note: All times listed in this section are provided for information only so that the performance for other environments/workloads can be approximated. These component times should not be measured against the specification.

S1	Selection, Identify Msg, Command Descriptor Block	15 µsec
S2a	Save Data Pointers (SDP) Msg	1 µsec
S2b	Disconnect Msg, Bus Free	1 µsec
S3	Arbitrate, Reselect, Identify Msg	6 µsec
S4	Start SCSI transfer in	4 µsec
S5	SCSI bus data transfer in	(Transfer size)/(SCSI Data Transfer Rate)

S6	SCSI read ending processing	2 µsec
S7	Status, Command Complete Msg, Bus Free	3 µsec

Note: The SCSI bus overhead for a read command is composed of S1,S2(a&b),S3,S4,S6 and S7. (0.03 msec total).

4.8 Command Execution Overhead

P1	Selection, Identify Msg, CDB	15 µsec
P2a	SDP Msg	1 µsec
P2b	Disconnect Msg, Bus Free	1 µsec
P3	Start seek or head switch	258 µsec
P4	Seek or head switch (for example, average seek)	(Read Seek = 4.9 or 5.4 msec)
P5	Set up read disk transfer	0 µsec
P6	Latency (for example, half revolution)	3 msec
P7	Disk data transfer	(Data transferred)/(Typical Data Sector Transfer Rate)
P8	End read disk transfer	(Sector size)/(SCSI Data Transfer Rate)
P9	Transfer last few SCSI blocks in	(5)(Sector size)/(SCSI Data Transfer Rate)
P10	SCSI red ending processing	2 µsec
P11	Status, Command Complete Msg, Bus Free	3 µsec

Note: The Command execution overhead for a read command is composed of P1, P2(a&b), P3, P5, P10 and P11. (0.28 msec total).

```
Time to Read data =P1+P2+P3+P4+P5+P6+P7+P8+P9+P10+P11
```

4.9 Write Command Performance

Note: This case is for Random SCSI Write commands, with Read Ahead disabled.

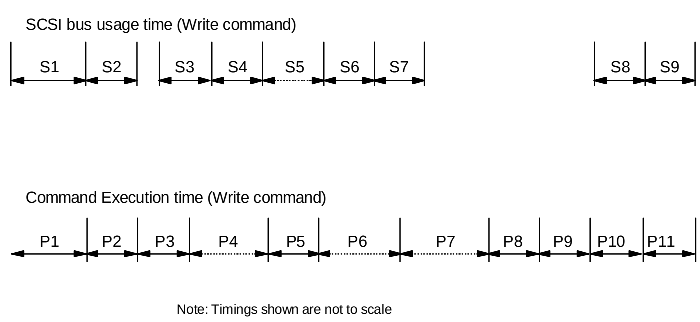

Fig 20. SCSI Write Command Performance Measurements

4.10 SCSI Bus Overhead

Note: All times listed in this section are provided for information only so that the performance for other environments can be approximated. These component times should not be measured against the specification.

S1	Selection, Identify Msg, CDB	15 µsec
S2a	SDP Msg	1 µsec
S2b	Disconnect Msg, Bus Free	1 µsec
S3	Arbitrate, Reselect, Identify Msg	6 µsec
S4	Start SCSI transfer out	4 µsec
S5	SCSI bus data transfer out	(Transfer size)/(SCSI Data Transfer Rate)
S6	End SCSI transfer out	4 µsec
S7a	SDP Msg	1 µsec
S7b	Disconnect Msg, Bus Free	1 µsec
S8	Arbitrate, Reselect, Identify Msg	6 µsec
S9	Status, Command Complete Msg., Bus Free	3 µsec

Note: The SCSI bus overhead for a write command is composed of S1,S2(a&b),S3,S4,S6,S7,S8 and S9. (0.4 msec total).

4.11 Command Execution Overhead

P1	Selection, Identify Msg, CDB	15 µsec
P2a	SDP Msg	1 µsec
P2b	Disconnect Msg, Bus Free	1 µsec
P3	Start seek	258 µsec
P4	Seek (for example, average seek)	(Write Seek = 5.9 or 6.4 msec)
P5	Set up write disk transfer	0 µsec
P6	Latency (for example, half revolution)	3 msec
P7	Disk data transfer	(Data transferred)/(Typical Data Sector Transfer Rate)
P8	End write disk transfer	75 µsec
P9	SCSI Write ending processing	25 µsec
P10	Arbitrate, Reselect, Identify Msg	6 µsec
P11	Status, Command Complete Msg, Bus Free	3 µsec

Note: The Command execution overhead for a write command is composed of P1, P2(a&b), P3, P5, P8, P9, P10 and P11. (0.38 msec total).

```
Time to Write data = P1+P2+P3+P4+P5+P6+P7+P8+P9+P10+P11
```

4.12 Cylinder to Cylinder Skew

Cylinder skew is the sum of the sectors required for physically moving the heads, which is a function of the formatted block length and recording density (notch #). Cylinder skew is always a fixed time and therefore the number of sectors varies depending on which notch is being accessed and the block length. The minimum amount of time required for a cylinder switch is 2.0 ms.

4.13 **Track to Track Skew**

Track skew is the time required to perform a switch between heads on the same cylinder. That time is 0.80 ms.

4.14 **Idle Time Functions**

The execution of various functions by the drive during idle times may result in delays of commands requested by SCSI initiators. 'Idle time' is defined as time spent by the drive not executing a command requested by a SCSI initiator. The functions performed during idle time are:

- Predictive Failure Analysis (PFA)
- Save Logs and Pointers
- Disk Sweep

The command execution time for SCSI commands received while performing idle time activities may be increased by the amount of time it takes to complete the idle time activity. Arbitration, Selection, Message and Command phases, and disconnects controlled by the drive are not affected by idle time activities.

Note: Command timeout limits do not change due to idle time functions.

Following are descriptions of the various types of idle functions, how often they execute and their duration. Duration is defined to be the maximum amount of time the activity can add to a command when no errors occur. When idle functions have become due to be executed and there are SCSI commands to be performed, no more than one idle function will be interleaved with each SCSI command. Following the descriptions is a summary of the possible impacts to performance.

There are mechanisms to lessen performance impacts and in some cases virtually eliminated those impacts from an initiator's point of view.

1. Normal recommended operation

   Idle time functions are only started if the drive has not received a SCSI command for at least 5 seconds. This means that multiple SCSI commands are accepted and executed without delay if the commands are received by the drive within 5 seconds after the completion of a previous SCSI command.

2. No PFA operation

   Idle time initiated PFA can be disabled by setting the "PERF" bit in Mode Page 1Ch. See the *ULTRASTAR 36ZX/18LZX Parallel SCSI Disk Drive Logical Interface Specification* for details.

4.14.1 Predictive Failure Analysis

PFA monitors drive parameters and can predict if a drive failure is imminent. There are “symptom driven” PFA processes which occur during error recovery procedures. The impacts of these upon perceived performance are not included here since they are included in the normal error recovery times, which are taken into account by the “Typical Data Sector Transfer Rate”.

There are also “measurement driven” PFA processes which occur during idle time. Seven different PFA measurements are taken for each head. All measurements for all heads are taken over a period of 4 hours, therefore the frequency of PFA is dependent on the number of heads. The drive attempts to spread the measurements evenly in time and each measurement takes about 80 milliseconds. For example, with 10 heads one PFA measurement will be made every 3.4 minutes (240/(7*10)).

For the last head tested for a particular measurement type (once every ½ hour), the data is analyzed and stored. The extra execution time for those occurrences is approximately 40 milliseconds.

This measurement/analysis feature can be disabled for critical response time periods of operation by setting the Page 1Ch Mode Parameter PERF = 1. See the *ULTRASTAR 36ZX/18LZX Parallel SCSI Disk Drive Logical Interface Specification* for more details about PFA.

4.14.2 Save Logs and Pointers

The drive periodically saves data in logs in the reserved area of the disks. The information is used by the drive to support various SCSI commands and for the purpose of failure analysis.

Logs are saved every 26-35 minutes. The amount of time it takes to update the logs varies depending on the number of errors since the last update. In most cases, updating those logs and the pointers to those logs will occur in less than 30 milliseconds..

4.14.3 Disk Sweep

The heads are moved to another area of the disk if the drive has not received a SCSI command for at least 40 seconds. After flying in the same spot for *40 seconds* without having received another SCSI command, the heads are moved to another position. If no other SCSI command is received, the heads are moved every *40 seconds* thereafter. Execution time is less than 1 full stroke seek.

Idle Time Function Type	Period of Occurrence (minutes)	Duration (ms)	Mechanism to delay	Mechanism to disable
PFA	30/(trk/cyl)	80	Re-instruction period,	PERF
Save Log & Pointers	26	30	Re-instruction period,	
Disk Sweep	2/3 - since last command 2/3 - since last occurrence	17	Re-instruction period	
Note: "Re-instruction period" is the time between consecutive SCSI command requests				

Table 8. Summary of Idle Time Functions

4.15 Temperature Monitoring

The drive is equipped with an internal temperature sensor which is used to log the drive's operating environment and optionally notify the using system if the temperature passes beyond a user selectable temperature value. The sensor is physically mounted on the reverse side of the electronics card but is calibrated to report the DE casting temperature.

The algorithm used is as follows:

Temperature is taken at power on during the Hardware Initialization. The temperature is periodically sampled after power on depending on the initial temperature value.

Value	Polling Period	Comments
If the temperature sensed is below 0 ° Celsius, the value logged will be 0.		
No temperature logging is done for temperatures below Threshold 1, but error log entries will have the temperature sensed at the time of the error included in the error record.		
Less than Threshold 1	**5 minutes**	Threshold 1 is set by the value in mode page 0, byte 9 if between 6 and 65. If the mode page byte is zero or out of range, then the default threshold 1 value is 54 ° Celsius. Warning messages are contingent on the temperature exceeding threshold
Greater than Threshold 1 but Less than Threshold 2	**15 Minutes**	Threshold 2 is set at 65 ° Celsius.
Greater than Threshold 2	**10 Minutes**	This period is designed to allow 3 days of testing above threshold 2 without overflowing the error log.

- If the temperature is above Threshold 1 an internal flag is set to signal a PFA event and the temperature is internally logged by the drive. See the *ULTRASTAR 36ZX/18LZX Parallel SCSI Disk Drive Logical Interface Specification* for the actions which may be taken when a PFA event is signaled and how they may be controlled by the host system.

- Once either of the thresholds has been crossed**,** hysteresis is applied to the sensor so that to exit the state the drive temperature must drop 5°C below the point that triggered the activity, i.e. drop below 60 ° and (threshold 1 ° - 5 °) , respectively.

Measuring the drive's temperature takes between 200 and 440 microseconds (depending upon the sensor type). The internal logging of this temperature by the drive, i.e. writing the value to a reserved area of the drive, is done as a part of saving of logs and pointers described under **Idle Time Functions** on Page 39.

4.16 Command Timeout Limits

The 'Command Timeout Limit' is defined as the time period from the SCSI Arbitration phase through the SCSI Command Complete message, associated with a particular command.

The following times are for environments where Automatic Reallocation is disabled and there are no queued commands.

4.16.1 Reassignment Time

The drive should be allowed a minimum of 45 sec to complete a "Reassign Blocks" command.

4.16.2 Format Time

An average of 60 minutes should be allowed to complete a "Format Unit" command. If the vendor unique mode page 00h bit named "FFMT" is set equal to '1'b then the drive should be allowed 30 seconds to complete.

4.16.3 Start/Stop Unit Time

The drive should be allowed a minimum of 30 sec to complete a "Start/Stop Unit" command (with Immed bit = 0). Initiators should also use this time to allow start-up sequences initiated by auto start ups and "Start/Stop Unit" commands (with Immed bit = 1) to complete and place the drive in a "ready for use" state.

Note: A timeout of one minute or more is recommended but NOT required. The larger system timeout limit allows the system to take advantage of the extensive ERP/DRP that the drive may attempt in order to successfully complete the start-up sequence.

4.16.4 Medium Access Command Time

The timeout limit for medium access commands that transfer user data and/or non-user data should be a minimum of 30 sec. These commands are:

- Log Sense
- Mode Select (6)
- Mode Sense (6)
- Pre-Fetch
- Read (6)
- Read (10)
- Read Capacity
- Read Defect Data
- Read Long
- Release
- Reserve
- Rezero Unit
- Seek (6)
- Seek (10)
- Send Diagnostic
- Write (6)
- Write (10)
- Write and Verify
- Write Buffer
- Write Long
- Write Same
- Verify

Note: The 30 sec limit assumes the absence of bus contention and user data transfers of 64 blocks or less. This time should be adjusted for anticipated bus contention and if longer user data transfers are requested.

When Automatic Reallocation is enabled add 45 sec to the timeout of the following commands; Read (6), Read (10), Write (6), Write (10), Write and Verify, and Write Same.

4.16.5 Timeout Limits for Other Commands

The drive should be allowed a minimum of 5 sec to complete these commands:

- Inquiry
- Request Sense
- Read Buffer
- Start/Stop Unit (with Immed bit = 1)
- Synchronize Cache
- Test Unit

The command timeout for a command that is not located at the head of the command queue should be increased by the sum of command timeouts for all of the commands that are performed before it is.

5.0 Mechanical

5.1 Weight and Dimensions

	9.0 GB Model		18 GB Model		36 GB Model	
	SI Metric	**US (reference)**	**SI Metric**	**US (reference)**	**SI Metric**	**US (reference)**
Weight +/- 10%	**696 g**	*1.53 lbs*	**713 g**	*1.57 lbs*	**1138 g**	*2.51 lbs*
Height	25.6 mm	*1.008 in*	25.6 mm	*1.008 in*	42.0 mm	*1.63 in*
Width	101.85 mm	*4.00 in*	101.85 mm	*4.00 in*	101.85 mm	*4.00 in*
Depth	147.0 mm	*5.75 in*	147.0 mm	*5.75 in*	147.0 mm	*5.75 in*

5.2 Clearances

A minimum of 2 mm clearance should be given to the bottom surface except for a 10 mm maximum diameter area around the bottom mounting holes.

There should be 7 mm of clearance between the IBM drives that are mounted with their top sides facing each other. Drives from other manufactures may require additional spacing due to stray magnetic fields.

Note: For proper cooling it is suggested that a minimum clearance of 7 mm be provided under the drive and on top of the drive. For further information see **Temperature Measurement Points** on page 70.

5.3 Mounting Guidelines

The drive can be mounted with any surface facing down.

The drive is available with both side and bottom mounting holes. Refer to “Location of side mounting holes (68 pin SCSI version)” on page 46 and “Location of bottom mounting holes (80 pin SCA SCSI version)” on page 46 for the location of these mounting holes for each configuration.

The maximum allowable penetration of the mounting screws is 3.8 mm. Screws longer than 3.8 mm may cause permanent damage to the drive.

The recommended torque to be applied to the mounting screws is 0.8 Newton-meters +/- 0.2 Newton-meters. IBM will provide technical support to users that wish to investigate higher mounting torques in their application.

For more information on mounting guidelines see **Mounting Guidelines** on page 45.

5.4 SCA Mounting Guidelines

Since the SCA mounting system lacks the compliant cabling of alternate connectors the system designer must now consider the following mounting situations and design the system appropriately for long term reliability. This list of guidelines is not intended to be exhaustive.

1. The SCA connector should not be required to support the weight of the drive.
2. Operational vibration occurring between the mating halves of the SCA connector should be avoided.
3. The drive should be firmly secured once the connector mate has occurred.
4. The connector was designed to allow for ‘mismate’ or offset during plugging operation. Excessive offsets between the drive connector and back plane will induce stress on the connector system and card.

WARNING: The drive may be sensitive to user mounting implementation due to frame distortion effects. IBM will provide technical support to assist users to overcome mounting sensitivity.

Note: For all drawings:

1. Dimensions are in millimeters.
2. Clearance = 7 mm

5.5 Mounting Drawings

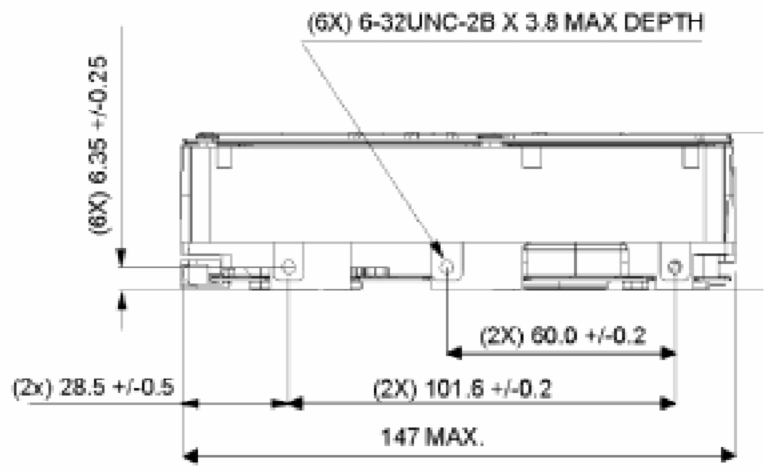

Fig 21. Location of side mounting holes (68 pin SCSI version)

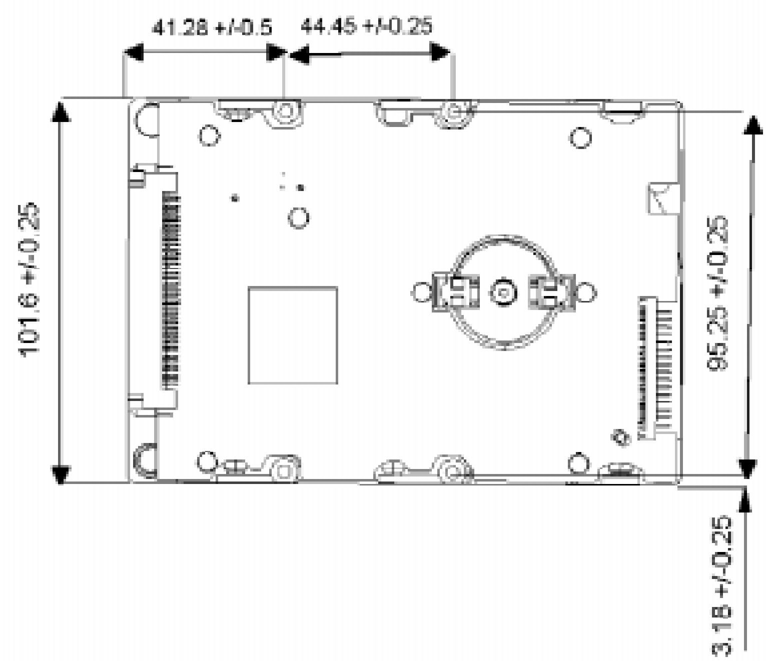

Fig 22. Location of bottom mounting holes (80 pin SCA SCSI version)

5.6 Electrical Connector

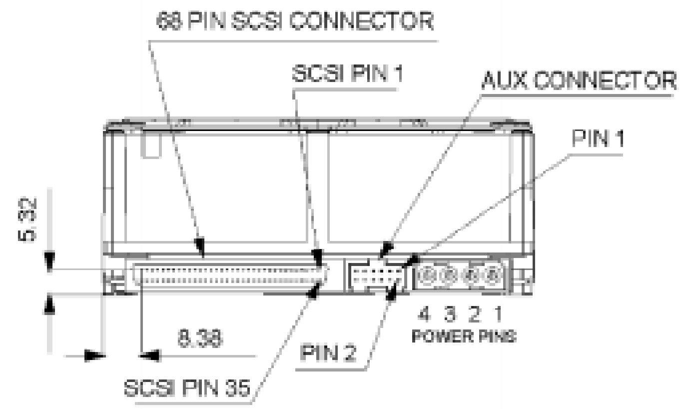

Fig 23. 68 pin SCSI Electrical Connector

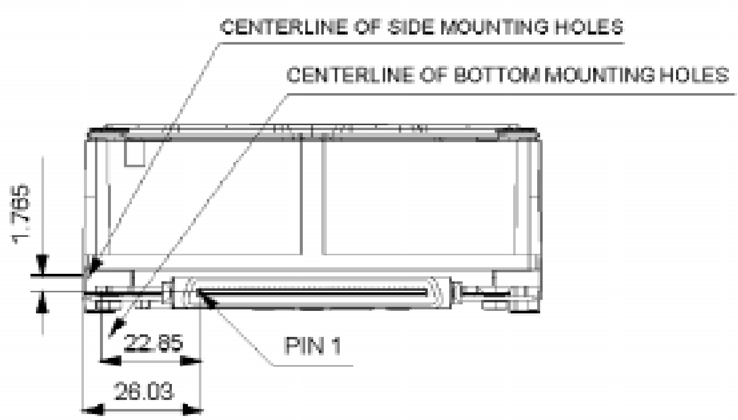

Fig 24. 80 pin SCSI Connector

6.0 Electrical Interface

6.1 Power Connector

The DC power connectors used on all models (68 and 80 pin SCA) are an integral portion of the 68 pin SCSI 'Unitized' Connectors and 80 pin 'Single Connector Attachment' (SCA) Connector.

- 68 pin models use a Molex connector (PN 87583-0001) that is compatible with the ANSI SCSI "P" connector.
- The 80 pin SCA models use a Berg connector (PN6169-001) that is compatible with Annex *C* of the SCSI Parallel Interface **3** (SPI- **3**) specification. Placement of the connector is in compliance with the Small Form Factor Committee document, 'SFF-8337 Specification for SCA Connector Location' Revision 1.2.

Pin #	Voltage Level
1	+12 V
2	Ground
3	Ground
4	+5 V

Table 9. 68 Pin Power Connector Pin Assignments

Refer to section **Power Requirements** on page 12 for details on drive power requirements.

6.2 SCSI Bus Connector

This section describes the varying connectors offered on models of the ULTRASTAR drive. These connectors have a finish metallurgy of 30 micro-inch gold plating.

6.2.1 68 Pin Connector

The 68 pin models use a Molex connector (PN 87583-0001) that is compatible with the ANSI SCSI "P" connector specifications. It can transfer data in both 8 bit (narrow) and 16 bit (wide) modes. Refer to 68 pin SCSI Electrical Connector on page 47 for a rear view of a 68 pin model.

6.2.2 80 Pin Connector

The 80 pin SCA models use a BERG connector (PN 6169-001) that is compatible with Annex '*C*' of the SCSI Parallel Interface-**3** (SPI- **3**) specification. Placement of the connector is in compliance with the SFF-8337, revision 1.2. Data transfers in both 8 bit (narrow) and 16 bit (wide) modes are supported. Refer to 80 pin SCSI Connector on page 47 for more details.

This connector is rated for 500 plug / unplug cycles.

Signal Name(LVD (SE))	Connector Contact		Signal Name
+DB(12) (GROUND)	1	35	-DB(12)
+DB(13) (GROUND)	2	36	-DB(13)
+DB(14) (GROUND)	3	37	-DB(14)
+DB(15) (GROUND)	4	38	-DB(15)
+DB(P1) (GROUND)	5	39	-DB(P1)
+DB(0) (GROUND)	6	40	-DB(0)
+DB(1) (GROUND)	7	41	-DB(1)
+DB(2) (GROUND)	8	42	-DB(2)
+DB(3) (GROUND)	9	43	-DB(3)
+DB(4) (GROUND)	10	44	-DB(4)
+DB(5) (GROUND)	11	45	-DB(5)
+DB(6) (GROUND)	12	46	-DB(6)
+DB(7) (GROUND)	13	47	-DB(7)
+P_CRCA(GROUND)	14	48	-P_CRCA
GROUND	15	49	GROUND
DIFFSENS	16	50	GROUND
TERMPWR	17	51	TERMPWR
TERMPWR	18	52	TERMPWR
OPEN	19	53	OPEN
GROUND	20	54	GROUND
+ATN (GROUND)	21	55	-ATN
GROUND	22	56	GROUND
+BSY (GROUND)	23	57	-BSY
+ACK (GROUND)	24	58	-ACK
+RST (GROUND)	25	59	-RST
+MSG (GROUND)	26	60	-MSG
+SEL (GROUND)	27	61	-SEL
+C/D (GROUND)	28	62	-C/D
+REQ (GROUND)	29	63	-REQ
+I/O (GROUND)	30	64	-I/O
+DB(8) (GROUND)	31	65	-DB(8)
+DB(9) (GROUND)	32	66	-DB(9)
+DB(10) (GROUND)	33	67	-DB(10)
+DB(11) (GROUND)	34	68	-DB(11)

Notes:

For 8 bit LVD devices in LVD or SE mode the following signals must be tied inactive (+ = inactive low, **-** = inactive high). +/-DB(8), +/-DB(9), +/-DB(10), +/-DB(11), +/-DB(12), +/-DB(13), +/-DB(14), +/-DB(15), +/-DB(P1). Floating these signals is not sufficient.

All other signals shall be connected as defined.

Table 10. 68 Pin Connector Contact Assignment

Signal Name	Connector Contact Number		Signal Name (LVD (SE))
12 V Charge	1	41	12V Ground
12 Volt	2	42	12V Ground
12 Volt	3	43	12V Ground
12 Volt	4	44	Mated 1
Reserved /NC	5	45	Reserved/NC
Reserved /NC	6	46	DIFFSENS
-DB(11)	7	47	+DB(11) (Ground)
-DB(10)	8	48	+DB(10) (Ground)
-DB(9)	9	49	+DB(9) (Ground)
-DB(8)	10	50	+DB(8) (Ground)
-I/O	11	51	+I/O (Ground)
-REQ	12	52	+REQ (Ground)
-C/D	13	53	+C/D (Ground)
-SEL	14	54	+SEL (Ground)
-MSG	15	55	+MSG (Ground)
-RST	16	56	+RST (Ground)
-ACK	17	57	+ACK (Ground)
-BSY	18	58	+BSY (Ground)
-ATN	19	59	+ATN (Ground)
-P_CRCA	20	60	+P_CRCA(Ground)
-DB(7)	21	61	+DB(7) (Ground)
-DB(6)	22	62	+DB(6) (Ground)
-DB(5)	23	63	+DB(5) (Ground)
-DB(4)	24	64	+DB(4) (Ground)
-DB(3)	25	65	+DB(3) (Ground)
-DB(2)	26	66	+DB(2) (Ground)
-DB(1)	27	67	+DB(1) (Ground)
-DB(0)	28	68	+DB(0) (Ground)
-DB(P1)	29	69	+DB(P1) (Ground)
-DB(15)	30	70	+DB(15) (Ground)
-DB(14)	31	71	+DB(14) (Ground)
-DB(13)	32	72	+DB(13) (Ground)
-DB(12)	33	73	+DB(12) (Ground)
5 Volt	34	74	Mated 2
5 Volt	35	75	5 V Ground
5 V Charge	36	76	5 V Ground
Reserved	37	77	Active LED Out
AUTO START	38	78	AUTO START DELAY
-SCSI ID 0	39	79	-SCSI ID 1
-SCSI ID 2	40	80	-SCSI ID 3
Note : For 8 bit LVD devices in LVD or SE mode, the following signals must be tied inactive (+ = inactive low, - = inactive high). +/-DB(8), +/-DB(9), +/-DB(10), +/-DB(11), +/-DB(12), +/-DB(13), +/-DB(14), +/-DB(15), +/-DB(P1). Floating these signals is not sufficient. All other signals shall be connected as defined.			

Table 11. 80 Pin SCA Connector Contact Assignments

6.3 MATED 1,2 Pin Function

The ANSI SPI- **3** specification Annex **C** defines the drive (SCSI device) and backplane requirements for the SCA pins called MATED 1,2. The Annex also defines optional feature support for this signal pair. This signal pair is used to determine if the SCSI device is fully inserted into the mating connector.

This product supports the MATED 1,2 signaling as follows:

1) The MATED 2 pin is attached to signal ground on the SCSI device side.
2) The MATED 1 pin is sensed by the SCSI device and will respond as follows:

This product will delay normal power up procedures until after the MATED 1 signal is detected to be at GND potential. In addition, this product will delay capture of the SCSI ID until approx. 0.5 sec after Mated 1 is at GND potential and all power supplies are within tolerance.

This product detects an open or opening condition on MATED 1 (change from GND to OPEN) and responds with an immediate spin down sequence. These attributes are not Mode Selectable. There is no provision for Synchronization of the Cache.

6.4 SCSI Bus Cable

Low Voltage Differential models permit cable lengths of up to 12 meters (39.37 feet) when operating in LVD mode. Cables must meet the requirements for LVD cables as set forth in the Information Technology SCSI Parallel- **3** (SPI- **3**) standard under “Cable Requirements”.

In Single-Ended SCSI mode, cable lengths of up to 6 meters (19.69 feet) are permitted. It should be noted however that users who plan to use "Fast" data transfers with Single-Ended models should follow all of the ANSI SCSI guidelines for Single-Ended "Fast" operations. This may include a cable length of less than 6 meters.

When operating in Fast-20 mode cable lengths of 3 meters (9.84 feet) are supported.

The SCA connector models are not designed for direct cable attachment due to the combination of power and SCSI bus signals. "Fast" data transfers with SCA models should follow all of the ANSI SCSI guidelines for Single-Ended "Fast" operations.

The ANSI SCSI standard states that any stub from main cable must not exceed 0.1 meters for Single-Ended or LVD cables. ULTRASTAR drives have a maximum internal stub length of 0.056 meters on all LVD and 'Single-Ended' SCSI signals. To remain compliant with the standard the SCSI bus cable must not add more than 0.044 meters additional stub length to any of the LVD and Single-Ended SCSI signals.

6.5 SCSI Bus Terminators

The using system is responsible for making sure that all required signals are terminated at both ends of the cable. There is no active termination supplied on the ULTRASTAR drives. Termination must be provided externally.

Some external terminator possibilities for 68 pin models are listed below:

68 pin model Terminators
Data Mate DM2750-01-LVD (LVD Only) Amphenol 497040001 (Multimode)

Table 12. LVD Terminators

6.6 SCSI Bus Termination Power

Termination power is optionally provided for systems that desire to use it. In order to use the termination power, the user needs to install a jumper between pins 1 and 2 of the TermPower Block. The jumper should only be installed on one device, which should be the last device on the SCSI bus (i.e. the drive that is physically closest to a terminator). 68 pin models can source up to 2.0 Amps of current at 5.0 Volts (+/- 5%) for termination power.

6.7 SCSI Bus Termination Power Short Circuit Protection

The ANSI SCSI specification recommends for devices that optionally supply TERMPWR, to include current limiting protection for accidental short circuits. It also recommends that the maximum current available for TERMPWR should be 2 Amps. UL has a different requirement that they call the 8 Amp rule. This rule states that when a power source leaves an enclosure (like SCSI TERMPWR in the SCSI cable), it must trip 8 Amps of current within 1 minute.

The ULTRASTAR drives limit current to 2.0 amps through the use of a resettable fuse mounted on the electronics card.

Systems may also provide short circuit protection for drive supplied TERMPWR by limiting the current of the 5 Volt power it supplies to the drive.

6.8 (Fast-40 Version) Single-Ended SCSI Bus Electrical Characteristics

The following DC operating characteristics pertain to the LVD SCSI bus transceivers when operating in Single-Ended (SE) mode. All of these parameters meet the SCSI Parallel Interface-2 (SPI-2) requirements.

- Ta = 0 to 70 ^{o}C

Symbol	SCSI I/O Parameters	min	typ	max	Units	Notes
Vol	low level output voltage			0.5	V	Iout = 48 mA
Voh	high level output voltage	2.5			V	
Vil	low level input voltage	1.0		1.3	V	
Vih	high level input voltage	1.6		1.9	V	
Iil	low level input current			20	uA	Vi = 0.5
Iih	high level input current			20	uA	Vi = 2.7
Vihys	input hysteresis	0.3	0.54	0.9	V	
Ci	input capacitance			11.5	pF	

Table 13. (Fast-40 Version) Single-Ended Bus Electrical Characteristics

6.9 (Fast-40 Version) Low Voltage Differential SCSI Bus Electrical Characteristics

The following DC operating characteristics pertain to the Low Voltage Differential SCSI bus tranceivers.

6.9.1 Stub Length

Minimum and maximum trace lengths, between the SCSI connector and the SCSI controller die pad, on the ULTRASTAR ZX SCSI product card are defined in the table below.

Measurement Parameter	**Minimum**	**Maximum**	**Spec Limit (Maximum)**	**Unit**
SCA Stub Length	46	56	100	mm
68 pin Stub Length	26	38	100	mm

Table 14. LVD SCSI Controller to SCSI Connector Stub Length

6.9.2 Capacitive Loading

The test system used for capacitance measurements is calibrated such that total capacitance of the system is zero at the mating connector without a drive plugged into the test system. The test conditions used for measurement purposes are those defined in the SCSI Parallel Interface-2 (SPI-2) specification. The test data provided is based on a small number of lab sample**s.**

6.9.3 LVD SCSI Single-Ended (SE) Test Results

Measurement Parameter	Maximum Measured	Spec Limit (Maximum)	Unit
68-Pin Connector (No Active Termination)			
C1 (-sig/gnd)	9.3	25	pf
80-Pin Connector (No Active Termination)			
C1 (-sig/gnd)	11.5	25	pf

Table 15. LVD SCSI Controller Single-Ended Capacitive Load Data

6.1.1 LVD SCSI Differential Test Results

Measurement Parameter	Maximum Measured	Spec Limit (Maximum)	Unit
68-Pin Connector (No Active Termination)			
C1 (-sig/gnd)	9.3	20	pf
C2 (+sig/gnd)	7.9	20	pf
C3 (-sig/+sig)	9.8	10	pf
C1-C2 (Data,Parity,REQ,ACK)	1.4	1.5	pf
C1-C2 (All Other Signals)	1.8	3.0	pf
C1(i)-C1(REQ) (Data,Parity)	0.8	2.0	pf
C2(i)-C2(REQ) (Data,Parity)	0.9	2.0	pf
C1(i)-C1(ACK) (Data,Parity)	1.4	2.0	pf
C2(i)-C2(ACK) (Data,Parity)	1	2.0	pf
80-Pin Connector (No Active Termination)			
C1 (-sig/gnd)	11.5	20	pf
C2 (+sig/gnd)	10.5	20	pf
C3 (-sig/+sig)	9.8	10	pf
C1-C2|(Data,Parity,REQ,ACK)	1.2	1.5	pf
C1-C2|(All Other Signals)	1.8	3.0	pf
C1(i)-C1(REQ) (Data,Parity)	1.2	2.0	pf
C2(i)-C2(REQ) (Data,Parity)	1.3	2.0	pf
C1(i)-C1(ACK) (Data,Parity)	2	2.0	pf
C2(i)-C2(ACK) (Data,Parity)	1.5	2.0	pf

Table 16. LVD SCSI Controller Differential Capacitive Load Data

6.10 Driver Slew Rates

The Slew Rates (t_{Rise}, t_{Fall}) for Data and REQ are measured on a synchronous data transfer. The test conditions and load circuits used for measurement purposes are those defined in the SCSI Parallel Interface-2 (SPI-2) specification. The test data provided is based on a small number of lab samples.

6.10.1 LVD SCSI Single-Ended (SE) Test Results

Measurement Parameter	Maximum Measured	Spec Limit (Maximum)	Unit
80-Pin Connector (No Active Termination)			
t_{Rise} (Data)	234	520	mV/ns
t_{Fall} (Data)	251	520	mV/ns
t_{Rise} (REQ)	272	520	mV/ns
t_{Fall} (REQ)	273	520	mV/ns

Table 17. LVD SCSI Controller Single-Ended Slew Rate Data

6.1.1 6.10.2 LVD SCSI Differential Test Results

Measurement Parameter	Minimum Measured	Spec Limit (Minimum)	Unit
80-Pin Connector (No Active Termination)			
t_{Rise} (Data)	2.33	1.0	ns
t_{Fall} (Data)	2.84	1.0	ns
t_{Rise} (REQ)	1.65	1.0	ns
t_{Fall} (REQ)	1.98	1.0	ns

Table 18. LVD SCSI Controller Differential Slew Rate Data

6.1 6.11 Assertion/Negation Periods

The Assertion/Negation Periods for the REQ signal are measured on a synchronous data transfer. The test conditions and load circuits used for measurement purposes are those defined in the SCSI Parallel Interface-2 (SPI-2) specification. The test data provided is based on a small number of lab samples.

6.11.1 LVD SCSI Single-Ended (SE) Test Results

Measurement Parameter	Minimum Measured	Spec Limit (Minimum)	Unit
80-Pin Connector (No Active Termination)			
Assertion Period (REQ)	26.3	15	ns
Negation Period (REQ)	18.5	15	ns

Table 19. LVD SCSI Controller Fast-20 Single-Ended Assertion/Negation Data

6.11.2 LVD SCSI Differential Test Results

Measurement Parameter	Minimum Measured	Spec Limit (Minimum)	Unit
80-Pin Connector (No Active Termination)			
Assertion Period (REQ)	10.2	8.0	ns
Negation Period (REQ)	12.4	8.0	ns

Table 20. LVD SCSI Controller Fast-40 Differential Assertion/Negation Data

6.12 Data Setup/Hold Time

The Data Setup/Hold Times with respect to the REQ signal are measured on a synchronous data transfer. The test conditions and load circuits used for measurement purposes are those defined in the SCSI Parallel Interface-2 (SPI-2) specification. The test data provided is based on a small number of lab samples.

6.12.1 LVD SCSI Single-Ended (SE) Test Results

Measurement Parameter	Minimum Measured	Spec Limit (Minimum)	Unit
80-Pin Connector (No Active Termination)			
Setup Time (Data to REQ)	17.7	11.5	ns
Hold Time (REQ to Data)	23.4	16.5	ns

Table 21. LVD SCSI Controller Fast-20 Single-Ended Setup and Hold Time Data

6.12.2 LVD SCSI Differential Test Results

Measurement Parameter	Minimum Measured	Spec Limit (Minimum)	Unit
80-Pin Connector (No Active Termination)			
Setup Time (Data to REQ)	10.6	9.25	ns
Hold Time (REQ to Data)	11.5	9.25	ns

Table 22. LVD SCSI Controller Fast-40 Differential Setup and Hold Time Data

6.13 Receiver Hysteresis

Single-Ended Receiver Hysteresis is a measurement of the voltage levels at which the receiver changes state as defined in the SCSI Parallel Interface-2 (SPI-2) specification. The test data provided is based on a small number of lab samples.

6.13.1 LVD SCSI Single-Ended (SE) Test Results

Measurement Parameter	Minimum Measured	Spec Limit (Minimum)	Unit
80-Pin Connector (No Active Termination)			
Hysteresis	540	300	mV

Table 23. LVD SCSI Controller Single-Ended Hysteresis Data

6.14 (Ultra 160 Version) Single-Ended SCSI Bus Electrical Characteristics

The following DC operating characteristics pertain to the LVD SCSI bus transceivers when operating in Single-Ended (SE) mode. All of these parameters meet the SCSI Parallel Interface **3** (SPI- **3**) requirements.

- Ta = 0 to 70 ºC

Symbol	SCSI I/O Parameters	min	typ	max	Units	Notes
Vol	low level output voltage			0.5	V	Iout = 48 mA
Voh	high level output voltage	2.5			V	
Vil	low level input voltage	1.0		1.3	V	
Vih	high level input voltage	1.6		1.9	V	
Iil	low level input current			20	uA	Vi = 0.5
Iih	high level input current			20	uA	Vi = 2.7
Vihys	input hysteresis	0.3	0.34	0.9	V	
Ci	input capacitance			12.1	pF	

Table 24. (Ultra 160 version) Single-Ended Bus Electrical Characteristics

6.15 (Ultra 160 Version) Low Voltage Differential SCSI Bus Electrical Characteristics

The following DC operating characteristics pertain to the Low Voltage Differential SCSI bus transceivers.

6.15.1 Stub Length

Minimum and maximum trace lengths, between the SCSI connector and the SCSI controller die pad, on the ULTRASTAR SCSI product card are defined in the table below.

Measurement Parameter	**Minimum**	**Maximum**	**Spec Limit Maximum)**	**Unit**
SCA Stub Length	46	56	100	mm
68 pin Stub Length	26	38	100	mm

Table 25. LVD SCSI Controller to SCSI Connector Stub Length

6.15.2 Capacitive Loading

The test system used for capacitance measurements is calibrated such that the total capacitance of the system is zero at the mating connector without a drive plugged into the test system. The test conditions used for measurement purposes are those defined in the SCSI Parallel Interface **3** (SPI- **3**) specification. The test data provided is based on a small number of lab samples**.**

6.15.3 LVD SCSI Single-Ended (SE) Test Results

Measurement Parameter	Maximum Measured	Spec Limit (Maximum)	Unit
80-Pin Connector (No Active Termination)			
C1 (-sig/gnd)	12.1	25	pf

Table 26. LVD SCSI Controller Single-Ended Capacitive Load Data

6.15.4 LVD SCSI Differential Test Results

Measurement Parameter	Maximum Measured	Spec Limit (Maximum)	Unit
80-Pin Connector (No Active Termination)			
C1 (-sig/gnd) (REQ, ACK, Data, Parity)	10.4	15	pf
C2 (+sig/gnd) (REQ, ACK, Data, Parity)	9.4	15	pf
C3 (-sig/+sig) (REQ, ACK, Data, Parity)	10	8	pf
C1 (-sig/gnd) (all other signals)	12	25	pf
C2 (+sig/gnd) (all other signals)	10.4	25	pf
C3 (-sig/+sig) (all other signals)	11.3	13	pf
C1-C2|(Data,Parity,REQ,ACK)	1.7	1.5	pf
C1-C2|(All Other Signals)	2.5	3.0	pf
C1(i)-C1(REQ) (Data,Parity)	0.7	2.0	pf
C2(i)-C2(REQ) (Data,Parity)	1.4	2.0	pf
C1(i)-C1(ACK) (Data,Parity)	1.6	2.0	pf
C2(i)-C2(ACK) (Data,Parity)	1.5	2.0	pf

Table 27. LVD SCSI Controller Differential Capacitive Load Data

6.16 Driver Slew Rates

The Slew Rates (t_{Rise}, t_{Fall}) for Data and REQ are measured on a synchronous data transfer. The test conditions and load circuits used for measurement purposes are those defined in the SCSI Parallel Interface **3** (SPI-**3**) specification. The test data provided is based on a small number of lab samples.

6.16.1 LVD SCSI Single-Ended (SE) Test Results

Measurement Parameter	Maximum Measured	Spec Limit (Maximum)	Unit
80-Pin Connector (No Active Termination)			
t_{Rise} (Data)	252	520	mV/ns
t_{Fall} (Data)	306	520	mV/ns
t_{Rise} (REQ)	234	520	mV/ns
t_{Fall} (REQ)	287	520	mV/ns

Table 28. LVD SCSI Ultra 160 Controller Single-Ended Slew Rate Data

6.16.2 LVD SCSI Differential Ultra 160 Test Results

Measurement Parameter	Minimum Measured	Spec Limit (Minimum)	Unit
80-Pin Connector (No Active Termination)			
t_{Rise} (Data)	2.19	1.0	ns
t_{Fall} (Data)	2.08	1.0	ns
t_{Rise} (REQ)	1.92	1.0	ns
t_{Fall} (REQ)	1.74	1.0	ns

Table 29. LVD SCSI Ultra 160 Controller Differential Slew Rate Data

6.17 Assertion/Negation Periods

The Assertion/Negation Periods for the REQ signal are measured on a synchronous data transfer. The test conditions and load circuits used for measurement purposes are those defined in the SCSI Parallel Interface **3** (SPI-**3**) specification. The test data provided is based on a small number of lab samples.

6.17.1 LVD SCSI Single-Ended (SE) Test Results

Measurement Parameter	Minimum Measured	Spec Limit (Minimum)	Unit
80-Pin Connector (No Active Termination)			
Assertion Period (REQ)	27.6	15	ns
Negation Period (REQ)	17.9	15	ns

Table 30. LVD SCSI Ultra 160 Controller Fast-20 Single-Ended Assertion/Negation Data

6.17.2 LVD SCSI Differential Ultra 160 Test Results

Measurement Parameter	Minimum Measured	Spec Limit (Minimum)	Unit
80-Pin Connector (No Active Termination)			
Assertion Period (REQ)	12.4	11.5	ns
Negation Period (REQ)	12	11.5	ns

Table 31. LVD SCSI Ultra 160 Controller Fast- 80 Differential Assertion/Negation Data

6.18 Data Setup/Hold Time

The Data Setup/Hold Times with respect to the REQ signal are measured on a synchronous data transfer. The test conditions and load circuits used for measurement purposes are those defined in the SCSI Parallel Interface **3** (SPI- **3**) specification. The test data provided is based on a small number of lab samples.

6.18.1 LVD SCSI Single-Ended (SE) Test Results

Measurement Parameter	Minimum Measured	Spec Limit (Minimum)	Unit
80-Pin Connector (No Active Termination)			
Setup Time (Data to REQ)	18.6	11.5	ns
Hold Time (REQ to Data)	23.4	16.5	ns

Table 32. LVD SCSI Ultra 160 Controller Fast-20 Single-Ended Setup and Hold Time Data

6.18.2 LVD SCSI Differential Ultra 160 Test Results

Measurement Parameter	Minimum Measured	Spec Limit (Minimum)	Unit
80-Pin Connector (No Active Termination)			
Setup Time (Data to REQ_{Rise})	6.6	4.8	ns
Hold Time ($REQ_{Rise}$to Data)	5.4	4.8	ns
Setup Time (Data to REQ_{Fall})	6.2	4.8	ns
Hold Time (REQ_{Fall} to Data)	5.4	4.8	ns

Table 33. LVD SCSI Ultra 160 Controller Fast 80 Differential Setup and Hold Time Data

6.19 Receiver Hysteresis

Single-Ended Receiver Hysteresis is a measurement of the voltage levels at which the receiver changes state as defined in the SCSI Parallel Interface **3** (SPI- **3**) specification. The test data provided is based on a small number of lab samples.

6.19.1 LVD SCSI Single-Ended (SE) Test Results

Measurement Parameter	Minimum Measured	Spec Limit (Minimum)	Unit
80-Pin Connector (No Active Termination)			
Hysteresis	320	300	mV

Table 34. LVD SCSI Controller Single-Ended Hysteresis Data

6.20 Option Block Connector (Jumper Blocks)

ULTRASTAR models contain a jumper block that can be used to enable certain features and select the SCSI ID of the drive. This jumper block is referred to as the 'Front' Option Jumper Block due to its location on the drive (opposite the SCSI connector). This jumper block varies in pin definition based on interface type (68, SCA).

The Option Block connector (2x16) used on both the 68 and 80 pin models is an AMP connector (PN 84156-5) having a pin spacing of 2 mm.

The IBM part number for the 2 mm jumpers is 45G9800 and the Termination Power Enable jumper part number is 21H0793.

The 45G9800 PN is:-

- 2 mm spacing, w/tab 8.5mm long, connector is 3.5 mm long
- Contact -- 30micro-inch gold plating with nickel underplate
- Supplier -- HIROSE A3-SP(B)(13), or approved equivalent.

The 21H0793 PN is:-

- 2.54mm spacing, w/o tab connector is 5.08 mm long
- Contact -- 30micro-inch gold plating with nickel underplate
- Supplier -- METHODE 9608-202-35, or approved equivalent.

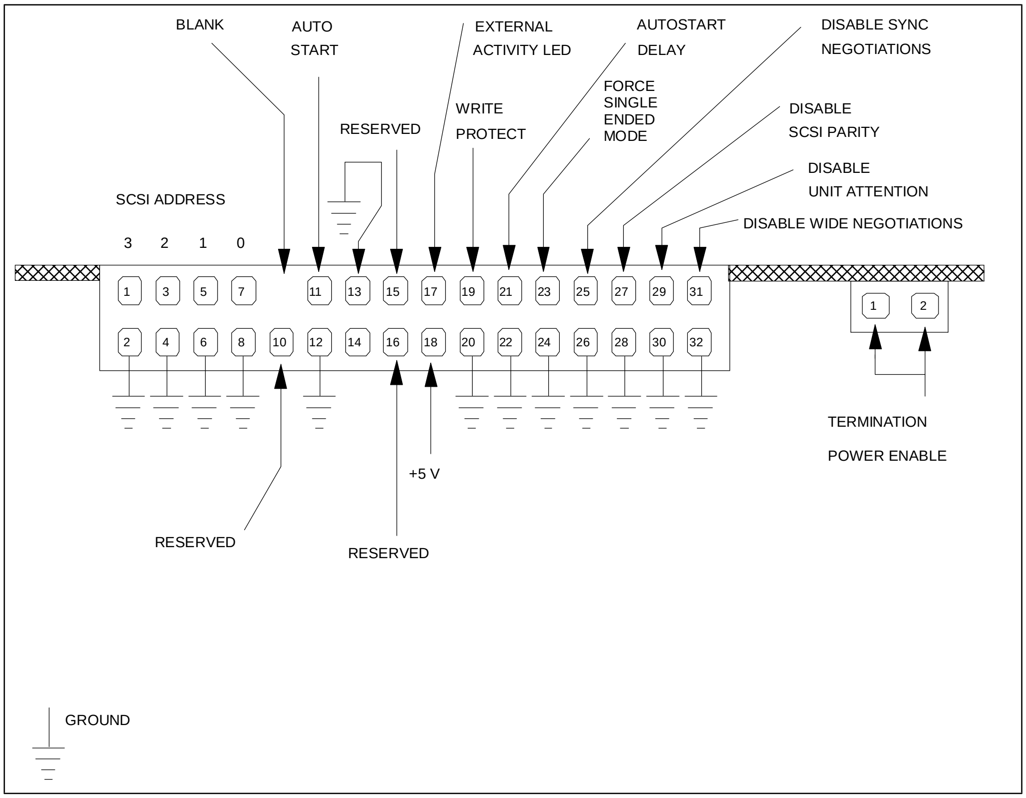

Fig 25. 68 pin Front Option Jumper Block and TermPower Block

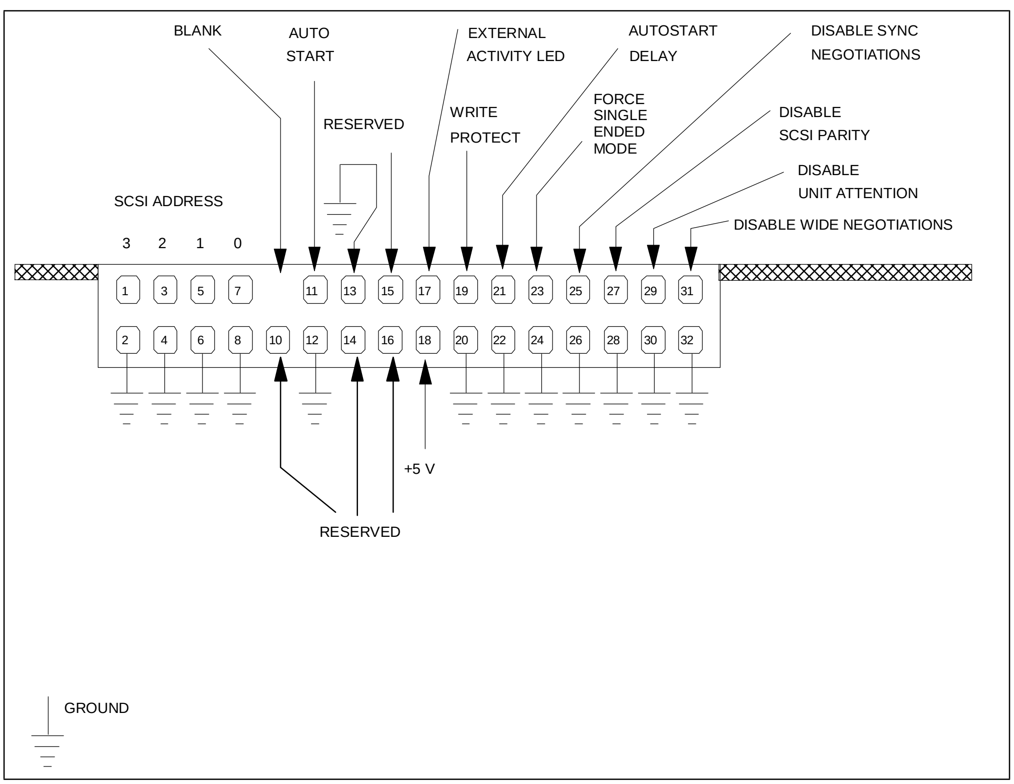

Fig 26. SCA Front Option Jumper Block

6.21 68 Pin Auxiliary Connector

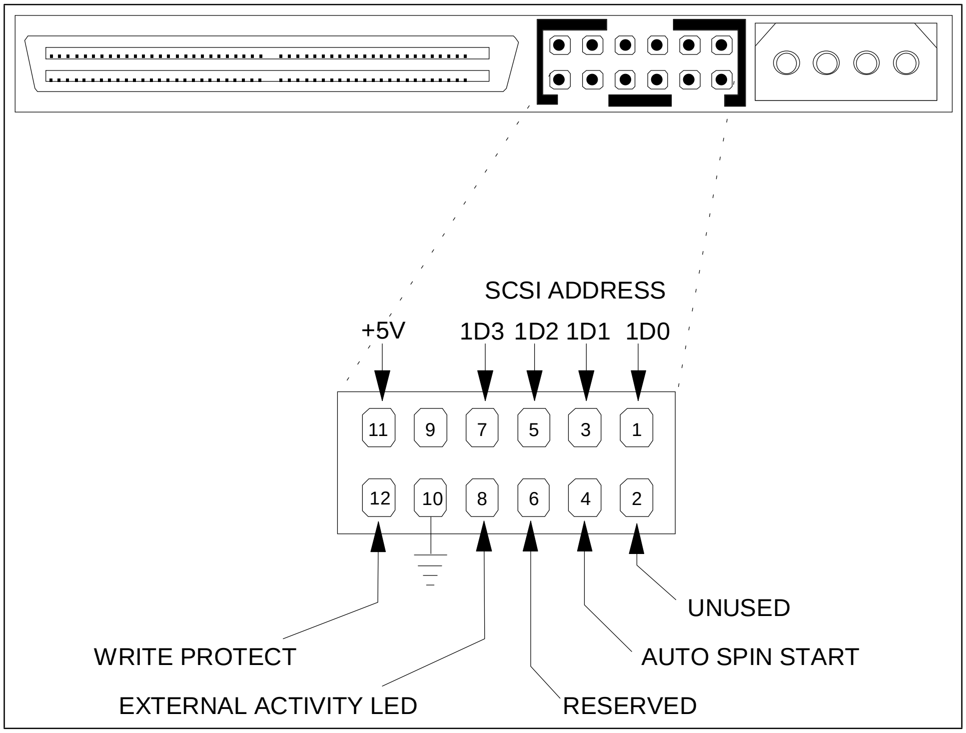

Fig 27. Auxiliary Connector on the 68 pin Connector

Note : Either the Front Option Block or the Auxiliary block may be used but not both.

The 68 pin models contain an 'Auxiliary' connector that replicates some of the functions contained in the Front Option Jumper Block. The Auxiliary connector signal definition conforms to the SCSI document: SFF-8009 Rev 4.1 definition with the following exceptions:

1. EXTERNAL FAULT (XTFALT-) is not supported on pin 2
2. AUTO SPIN START was chosen as the 'vendor unique' signal assignment (on pin 4.) (This signal is an input to the drive. The Small Form Factor spec (SFF-8009) specifies this pin as an output.) This signal should be useful for those applications that want to "auto-start" the drive based on location dependent SCSI ID.
   This pin should be handled in one of the following ways:
   - tied to ground (auto spin start enabled)
   - allowed to 'float' (no connection)
   - driven with an open collector driver (>1mA sink capability)

6.22 SCSI ID (Address) Pins

Information on how to select a particular address for the SCSI device ID is given in the following table.

The SCSI ID can be set via:
a) the Front Option Block
b) the SCA connector
c) the 68 pin ‘auxiliary’ connector

Note: In the address determination table, "off" means either that the jumper is not in place or equivalently that the signal is driven to a CMOS High voltage level. Likewise the term "on" means either that the jumper is in place or that the signal is driven to a CMOS Low voltage level (i.e. Ground).

BIT 3	BIT 2	BIT 1	BIT 0	ADDRESS
off	off	off	off	0
off	off	off	on	1
off	off	on	off	2
off	off	on	on	3
off	on	off	off	4
off	on	off	on	5
off	on	on	off	6
off	on	on	on	7
on	off	off	off	8
on	off	off	on	9
on	off	on	off	10
on	off	on	on	11
on	on	off	off	12
on	on	off	on	13
on	on	on	off	14
on	on	on	on	15

Table 35. Address Determination of 68 and 80 pin Models

6.22.1 Auto Start (and Delay) Pins

The Auto Start and Auto Start Delay pins control when and how the drive can spin up and come ready. When configured for Auto-Startup, the motor spins up after power is applied without the need of a SCSI Unit Start command. For no Auto-Startup, a SCSI Unit Start command is required to make the drive spin up and be ready for media access operations. When in Auto-Startup mode, the drive will delay its start time by a period of time multiplied by its own SCSI address. The following tables shows whether or not Auto-Startup mode is active and the delay periods, where applicable, for all combinations of the pins.

Pins (68 pin model)		Drive Behavior	
AUTO START DELAY	AUTO START	Auto-Startup Mode ?	Delay (s) Multiplier
off	off	NO	NA
off	on	YES	0
on	off	YES	10
on	on	YES	4

Table 36. Selectable by Auto-Start/Delay Pin Combinations (68 pin)

Pins (80 pin model)		Drive Behavior	
AUTO START DELAY	AUTO START	Auto-Startup Mode ?	Delay (s) Multiplier
off	off	YES	0
off	on	NO	NA
on	off	YES	10
on	on	NO	NA

Table 37. Selectable by Auto-Start/Delay Pin Combinations (80 pin)

6.22.2 External Activity (LED) Pins

The LED pins can be used to drive an external Light Emitting Diode. Please refer to the LED pin section of the *ULTRASTAR 36ZX/18LZX Parallel SCSI Disk Drive Logical Interface Specification* for a detailed functional description of this pin.

Up to 33 mA (+/- 5%) of TTL level LED sink current capability is provided. Current limiting for the LED is as shown in the following diagram.

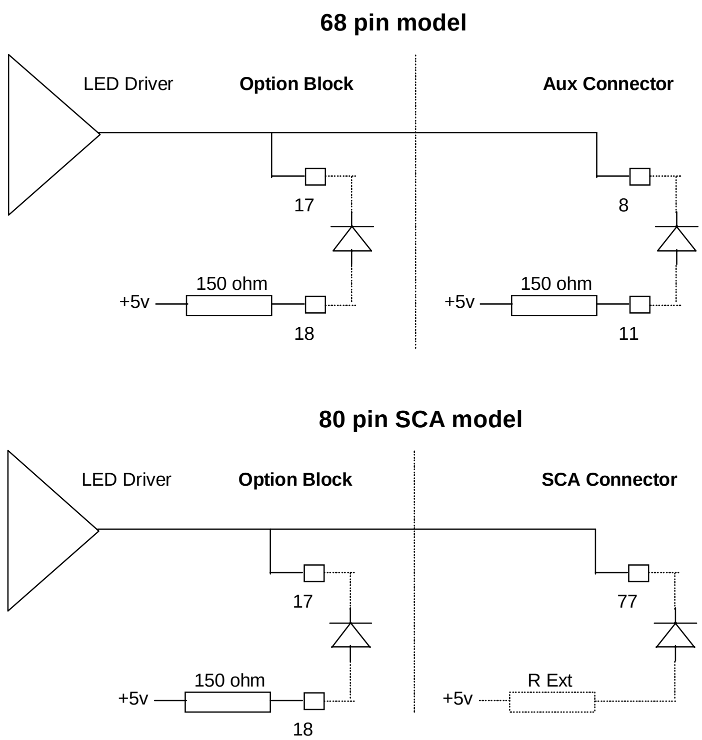

Fig 28. LED Circuit Diagram

6.1.1 6.22.3 Write Protect Pin

If the Write Protect pin is jumpered to ground the drive will prohibit SCSI commands that alter the customer data area portion of the media from being performed. The state of this pin is monitored on a per command basis. See the *ULTRASTAR 36ZX/18LZX Parallel SCSI Disk Drive Logical Interface Specification* for functional details.

6.22.4 Disable Synchronous Negotiation Pin

If a Disable Target Initiated Synchronous Negotiation pin is grounded then an Initiator is required to start a negotiation handshake if Synchronous and/or 'Wide' (Double Byte) SCSI transfers are desired. Please refer to the *ULTRASTAR 36ZX/18LZX Parallel SCSI Disk Drive Logical Interface Specification* for more details on this feature.

6.22.5 Disable SCSI Parity Pin

Grounding this pin will disable SCSI Parity checking.

6.22.6 Disable Unit Attention Pin

Grounding this pin will disable the drive from building Unit Attention Sense information for commands immediately following a Power On Reset (POR) or SCSI Bus Reset. Any pending Unit Attention conditions will also be cleared at POR or SCSI Reset times.

6.22.7 Disable Wide Negotiations

Jumpering pin 31 to pin 32 will cause the drive to operate in single byte mode. The drive will not negotiate ‘wide’ (double byte) operation. Refer to the notes included with table ‘68 Pin Connector Contact Assignment’ and 80 Pin SCA Connector Contact Assignments’ on page 49 and page 50 when using this option jumper. The customer must provide termination for the upper data bus (DB8 - DB15) and upper parity bit (DBP1) when using the drive in a narrow bus configuration.

6.22.8 Force Single-Ended Mode

Jumpering pin 23 to pin 24 (refer to the figures 19 and 20) will cause all models to operate in Single-Ended mode only. The drive will not use the DIFFSENS line to determine SE or LVD modes.

7.0 Operating Limits

The IBM Corporate specifications and bulletins, such as C-S 1-9700-000 in the contaminants section, that are referenced in this document are available for review.

7.1 Environmental

- Temperature

Operating Ambient	5 to 50 °C (41 to 122 °F)
Operating Disk Enclosure	5 to 60 °C (41 to 140 °F)
Storage	1 to 65 °C (34 to 149 °F)
Shipping	-40 to 65 °C (-40 to 149 °F)

- Temperature Gradient

Operating	20 °C (36 °F) per hour
Shipping and storage	below condensation

- Humidity

Operating	5% to 90% (Average over 1 month)
Storage	5% to 90% (Average over 1 month)
Shipping	5 to 95% (Applies at the packaged level

- Wet Bulb Temperature

Operating	26.7 °C (80 °F) maximum
Shipping and Storage	29.4 °C (85 °F) maximum

- Elevation

Operating and Storage	-304.8 to 3048 meters (-1000 to 10,000 feet)
Shipping	-304.8 to 12,192 meters (-1000 to 40,000 feet)

7.2 Storage Requirements

7.2.1 Packaging

The drive or option kit must be heat-sealed in a moisture barrier bag, with desiccant inside the bag, supplied or specified by IBM.

7.2.2 Storage Time

- On the packaged level, cumulative storage time for the drive or option kit must not exceed one year. If longer storage time is required, the drive must be repackaged with new desiccant or moved to a climatically controlled environment.
- Once the drive is unpackaged, it must not remain inoperative for longer than six months.

7.3 Temperature Measurement Points

The following is a list of measurement points and their temperatures. Maximum temperatures must not be exceeded at the worst case drive and system operating conditions with the drive reading and writing at the maximum system operations per second rate.

Note: "Temperature Measurement Points (bottom view)" on page 70 defines the modules that are located on the bottom side of the card and the measurement location on the bottom of the disk enclosure. "Temperature Measurement Points (top view)" on page 72 defines where measurements should be made to determine the top disk enclosure temperature during drive operation. There must be sufficient air flow through the drive so that the disk enclosure and module temperature maximum limits defined in below are not exceeded.

	Maximum	Maximum Recommended
Disk Enclosure Top	60 °C (140 °F)	50 °C (122 °F)
Disk Enclosure Bottom	60 °C (140 °F)	50 °C (122 °F)
Channel Module[7] (Harp)	95 °C (203 °F)	75 °C (167 °F)
Hard Disk Controller (Sloop/ Ketch)	90 °C (194 °F)	70 °C (158 °F)
Microprocessor Module (uP)	80 °C (176 °F)	60 °C (140 °F)
Motor Driver Module (Tomcat)	90 °C (194 °F)	70 °C (158 °F)
Note: Operating the drive above the maximum temperatures may cause permanent damage		

Table 38. Maximum and Reliable Operating Temperature Limits

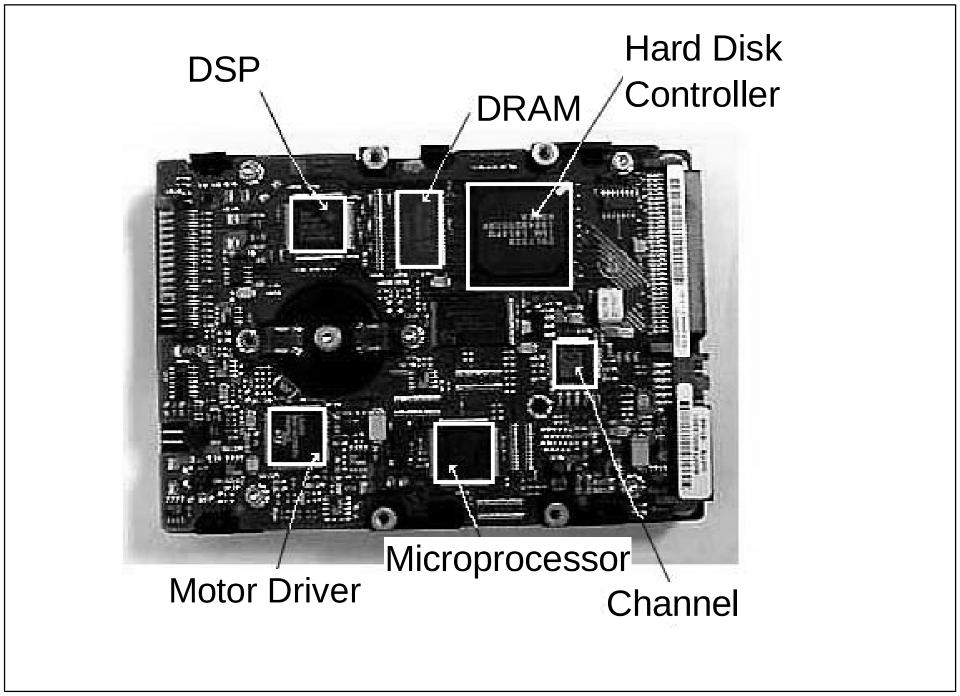

Fig 29. Temperature Measurement Points (bottom view)

[7] For continuous read applications the channel module will run at higher temperatures and will require additional cooling

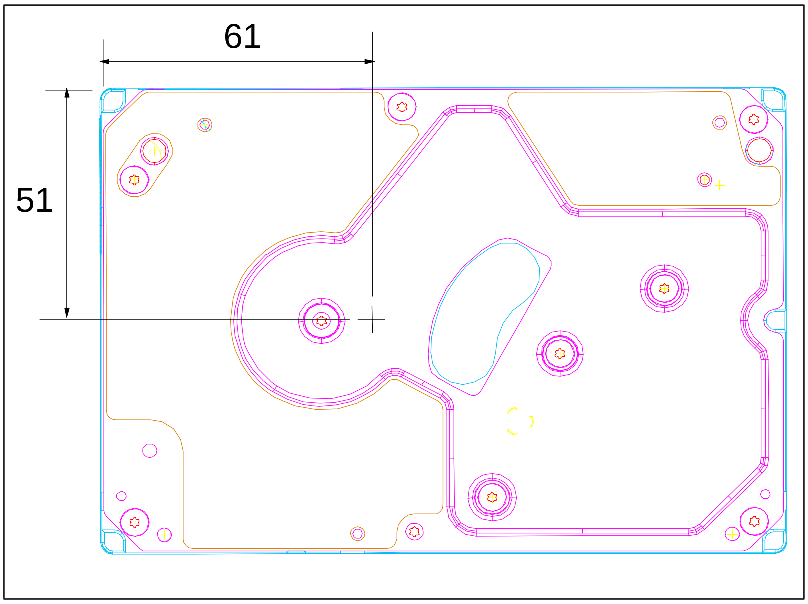

Fig 30. Temperature Measurement Points (top view)

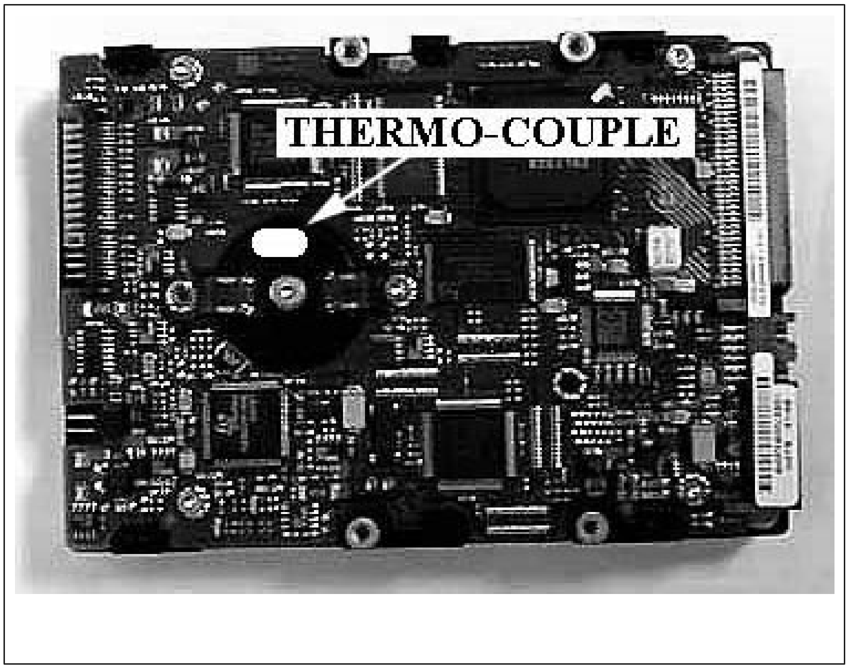

Fig 31. Temperature Measurement Points (bottom View)

7.3.1 Module Temperature Measurement Notes

When measuring module temperature

1. Center on the top surface of the module.
2. If copper tape is used to attach temperature sensors, it should be no larger than 6 mm square.

7.4 **Vibration and Shock**

The operating vibration and shock limits in this specification are verified in two mount configurations:

1. By mounting with the 6-32 bottom holes with the drive on 2 mm high by 10 mm diameter spacers as required by section " **Clearances**" on page 44.
2. By mounting on any two opposing pairs of the 6-32 side mount holes.

Other mount configurations may result in different operating vibration and shock performance.

7.4.1 Output Vibration Limits

Spindle residual imbalance not to exceed 0.3 gram-millimeters.

7.4.2 Operating Vibration

The vibration is applied in each of the three mutually perpendicular axes, one axis at a time. Referring to the figure "Ultrastar 36ZX, 18LZX Disk Drive Assembly" on page 9, the x-axis is defined as a line normal to the front/rear faces, the y-axis is defined as a line normal to the left side/right side faces, and the z-axis is normal to the x-y plane.

WARNING : The drives are sensitive to rotary vibration. Mounting within using systems should minimize the rotational input to the drive mounting points due to external vibration. IBM will provide technical support to assist users to overcome problems due to vibration.

7.4.2.1 Random Vibration

For excitation in the x, y, and z directions, the drive will operate without hard errors when subjected to vibration levels not exceeding those defined in the following table.

Note: The RMS value in the table below is obtained by taking the square root of the area defined by the g^2/Hz spectrum from 5 to 500 Hz.

	5 Hz	500 Hz	RMS
Random Vibration	4.6E-03	4.6E-03	1.5
Units	g^2/Hz		g

Table 39. Random Vibration Levels

7.4.2.2 Swept Sine Vibration

The drive will operate without hard errors when subjected to the swept sine vibration of 1.0 G peak from 5 to 500 Hz in the x, y, and z directions.

This measurement is taken during a frequency sweep from 5 to 500 Hz and back to 5 Hz. The sweep rate will be one Hz per second.

Note: 1.0 g acceleration at 5 Hz requires 0.78 inch double amplitude displacement.

7.4.3 Nonoperating Vibration

No physical damage or degraded performance will occur as long as the vibration at the unpackaged drive, in the x, y and z directions (as defined in section 7.2, “Vibration and Shock”), does not exceed the levels defined in the following table. The test duration is 30 minutes in each direction.

Class	5 Hz	500 Hz	RMS
Random Vibration	1.0E-02	1.0E-02	2.23
Unites	g^2/Hz		g

Table 40. Random Vibration Levels

7.4.3.1 Random Vibration

No physical damage or degraded performance will occur as long as vibration at the unpackaged drive in all three directions defined above does not exceed the levels defined in the table below. The test will consist of a sweep from 5 Hz to 500 Hz and back to 5 Hz at a sweep rate of eight decades per hour.

Frequency	5 Hz to 7 Hz	7 Hz to 500 Hz
Amplitude	0.8 inch DA	2.0 g peak

Table 41. Swept Sine Vibration Levels

7.5 **Shock**

7.5.1 Operating Shock

No permanent damage will occur to the drive when subjected to a 20 G half sine wave shock pulse of 2 milliseconds duration for the 1.0” models and 10G half sine wave shock pulse of 2 milliseconds duration for the 1.6” model.

The shock pulses are applied in each of three mutually perpendicular axes, one axis at a time.

7.6 Non-Operating Shock

7.6.1 Translational Shock

For both the 1.0” and the 1.6” models, no hard error or acoustic degradation will occur if the unpackaged drive is subjected to a 20 millisecond square pulse shock of 35G’s or less to all three axes, one direction at a time.

For both the 1.0” and the 1.6” models, no hard error or acoustic degradation will occur if the unpackaged drive is subjected to a 180 in/sec velocity change square pulse shock of 50 Gs or less applied to all three axes, one direction at a time.

For the 1.0” models, no hard error or acoustic degradation will occur if the unpackaged drive is subjected to a 2 millisecond half sine pulse shock of *250* Gs or less applied to all three axes, one direction at a time.

For the 1.6” models, no hard error will occur if the unpackaged drive is subjected to a 2 millisecond half sine pulse shock of 175 Gs or less applied to all three axes, one direction at a time. The typical degradation in A-weighted idle sound power is 1 dB when the unpackaged drive is subjected to a 2 millisecond half sine pulse of 175 G.

7.6.2 Rotational Shock

The actuator will remain latched on the ramp if the unpackaged drive is subjected to a 2 millisecond half sine wave shock less than 15,000 radians per second squared applied to all three axes, one direction at a time.

7.7 Contaminants

The corrosive gas concentration expected to be typically encountered is Subclass G1; the particulate environment is expected to be P1 of C-S 1-9700-000 (1/89).

7.8 Acoustic Levels

Mode of operation	Typical 1.0" A-Weighted	Typical 1.6" A-Weighted
Idle (Bel)	4.09	4.17
Operating (Bel)	5.14	5.28

Table 42. Sound Power Requirements (Bels)

Notes:

1. The drives are tested after a minimum of 20 minutes warm-up.
2. The operating mode is simulated by seeking at a rate at 50 seeks per second for the 1.0" model and 47 seeks per second for the 1.6" model.

7.9 Drive Mounting Guidelines

1. Use of the extreme side mounts will align the drive Center of Gravity (CG) closer to the center of stiffness. This will minimize off axis coupling and in-plane yaw rotation about the spindle axis.
2. Orient the spindle axis parallel to the direction of minimum shock loading.
3. The carrier should not allow the drive to rotate in the plane of the disk. If any isolation between the device and the frame is to be used, it can be soft in the x ,y, z, pitch and roll axes but should be stiff for the yaw axis. Yaw motion is rotation about the spindle axis which couples directly into offtrack.

   If isolators are used, they should provide natural frequencies about 25% lower than the motor speed. The idea is to place the rigid body modes below primary excitation frequencies and drive structural modes. Isolators must be well damped and of sufficient strength so they will not be torn by high non operational shocks.

   Otherwise, keep the rigid body resonances of the drive away from harmonics of the spindle speed. 10000 RPM harmonics: 167Hz, 333Hz, 499Hz, 666Hz....

4. It is desirable that the carrier be as stiff as possible while allowing room for the isolator mounts (if used). Rather then creating a weak carrier that flexes to fit the drive, hold the mounting gap to

tighter tolerances. A flexible carrier may contain resonances that cause operational vibration and/or shock problems.

5. If isolators are to be used, design for maximum sway. Adequate clearance around all edges are necessary for cooling and shock impacts. Maximum sway is usually determined by geometry and compressibility limits of the isolator grommet plus some carrier/rack flexibility. Metal to metal impacts must be avoided because they result in short duration, high impacts loads; such waveforms can excite high frequency modes of the components inside the drive.
6. To minimize acoustic radiation, mount drives so there is no "line of sight" between a drive and user.

7.10 Drive/System Compatibility

Ultrastar 36ZX, 18LZX drives are supplied to using systems that demonstrate a level of drive/system compatibility to this specification.

Verification prior to a formal system qualification is recommended to determine whether the drive/system is capable of achieving the quality and reliability requirements found in this specification.

Preliminary testing to verify compatibility may be performed using common laboratory instrumentation equipped with the appropriate transducer (thermal, power, shock, vibration and acoustics). Final verification must be performed by measuring functional performance (error rates) of the drive when installed within the system.

The following sections describe the parameters to be verified prior to and as a part of the system qualification test in order to achieve the quality and reliability requirements set forth by this specification.

Power

The system must be capable of providing adequate power to the drive as described in section **Power Requirements** found on page 12. In addition to voltage, current and capacitance, the system must be capable of remaining within regulation when the maximum number of drives are installed in the system.

Special consideration must be given for systems designing for hot-plug capabilities. Refer to **'Hot Plug/Unplug' support** on page 21 of this specification for requirements and guidelines.

Thermal

The system must supply adequate cooling and air flow to maintain casting and module temperature listed in the “**Environmental**” section on page 69. The system must demonstrate sufficient cooling to operate below the recommended temperatures for any given location that the drive may be installed within the system.

Special consideration for minimum clearances must be given to achieve adequate cooling of the drive.

Shock (Operating and Non-operating)

The system must maintain an environment that is compatible with operating and non-operating shock specifications found in sections “Operating Shock” on page 73 and “ Non-Operating Shock” on page 73. Both operating and non-operating shock should be measured in all three planes and found to be within the limits set in this specification.

Vibration (Operating and Non-operating)

The system must maintain an environment that is compatible with the operating vibration specification found in section “ Operating Vibration” on page 72. This must include both random and swept sine vibration and the vibration must be measured in all three planes. The drives are sensitive to rotary vibration. Mounting within the using systems must minimize the rotational input to drive mounting points due to external vibration.

To achieve system compatibility for vibration, it is recommended that the system conform to section "**Drive Mounting Guidelines**" on page 74.

Electromagnetic Compatibility (EMC)

The system must be designed to insure that stray fields are not placed close to the device. Minimum clearances must be maintained. Clearance guidelines are found in section " **Clearances**" on page 44.

Electrostatic Discharge (ESD)

The drive contains electrical components sensitive to ESD. System design and assembly processes, must protect the drive and must be verified to conform to the protection, care and handling guidelines found in section " **ESD Protection**" on page 77

Interface Compatibility

The drive/system, in conjunction with associated operating software, must be capable of conforming to the pin configurations, cabling, command and timing parameters found in "**Electrical Interface**" on page 48.

Verification of the preceding parameters is recommended prior to starting a system test or qualification. Most parameters may be verified by using common laboratory instrumentation or simple inspection of design, handling and process. For further information regarding verification testing, please contact your technical support representative.

Final verification of drive/system compatibility must be determined through functional testing. Adequate system testing must be performed to demonstrate conformance to the Data Reliability requirements, page79 .

7.11 Recommendations for Handling of Disk Drives

Disk Drives are very fragile and can be damaged if dropped or impacted against another object. Amount of damage to the drive will depend on magnitude and duration of the impact. People handling the disk drive should be trained in the proper handling procedures. Manufacturing processes, equipment, and Disk Drive holding containers/fixtures should be characterized and qualified to less than 50 G's in the manufacturing environment. The following are things to consider in the handling and protection of the disk drive.

Damage may be caused by:

- Dropping a drive onto a hard surface, even over small distances
- Drives may fall over after being set on edge
- Tapping a drive with a screw driver tip or other hard implement
- Tapping a drive into position when installing into a user frame
- Clicking 2 drives together metal to metal

Precautions to take during handling:

- Wear ESD protection at all times
- Treat drives as you would "Eggs" or "Glass Stemware"
- Handle one drive at a time
- Handle drive by the sides only, avoid grasping the card
- Replace drive into original packaging for transport
- Pad all drive work areas (1" foam under 1/4" ESD pad)
- Pad all drive transport areas (1" foam under 1/4" ESD pad)
- Pad all drive holding areas (1" foam under 1/4" ESD pad)
- Clear work areas of potential metal contact
- Remove / Install drives separately
- Report any drive that may have been dropped or mishandled

- Do Not stack disk drives (Even in ESD Bags)
- Do Not contact drive or card with tooling (drivers, etc)
- Do Not rush installation
- Do Not "Slam" a drive into a carrier or frame
- Do Not "Seat" a drive into place with tooling
- Do Not stand a drive on end or side (Tipping Hazard)
- Do Not allow drives to contact each other

Shipping Handling Precautions:

- Check for and report shipping damage to a Pallet
- Do Not stack more than 2 pallets
- Do Not contact pallet package with Forklift Forks
- Do Not drop a Pallet
- Do Not drop Drive Boxes (Singles or Multiples)

7.12 Breather Filter Hole

Under no circumstances should the Filter Breather Hole be obstructed or labels placed over the hole.

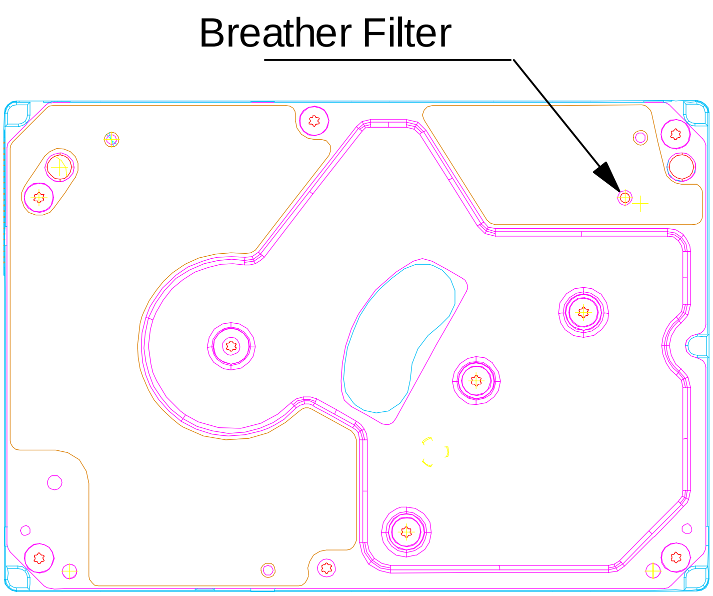

Fig 32. Breather Hole for Filter

7.13 Periodic Maintenance

None required.

7.14 ESD Protection and Handling

The Ultrastar 36ZX, 18LZX disk drives contain electrical components sensitive to damage due to electrostatic discharge (ESD). Proper ESD procedures must be followed during handling, installation and removal of the drives.

Precautions such as using ESD protective shipping containers, ESD mats, wrist straps and grounding all surfaces that are allowed to touch or come close to the device are recommended.

Known ESD dangers such as walking across a carpet carrying the drive should be avoided. It is recommended that the device is always stored in its anti-static package until it is ready fro installation.

7.15 Stray Magnetic Fields

This device is sensitive to strong magnetic fields. Magnets and other sources of magnetic fields must not be placed close to the drive. To avoid problems associated with stray field magnetic susceptibility the field strength, at these frequencies, at the drive mounting location, must be equal to or below the values shown.

Frequency	DC (Static Field)	47 Hz to 400 Hz	400 Hz to 5KHz	5 Khz to 50 KHz	50 Khz to 200 KHz
Magnitude (Gauss)	5	5	2	0.5	0.1

Table 43. Stray Magnetic Field Strength

8.0 Reliability

8.1 Error Detection

Error reporting ⩾ 99%	All detected errors excluding interface and BATs1 (Basic Assurance Test) errors.
Error detection ⩾ 99%	
FRU isolation = 100%	To the device when the 'Recommended Initiator Error Recovery Procedures' in the *Ultrastar 36ZX, 18LZX Interface Specification* are followed. No isolation to subassemblies within the device are specified.

8.2 Data Reliability

Probability of not recovering data	10 in 10^{15} bits read
Recoverable read errors (Mean of population)	10 in 10^{13} bits read (measured at nominal DC voltage conditions and room ambient environment with default error recovery - QPE[8] enabled). With QPE enabled at the default thresholds, error reporting across the SCSI bus occurs after step 24.

8.3 Start/Stop Cycles

The drive is designed to support 50,000 start/stop cycles at 50 °C base casting temperature.

8 Please reference QPE (qualify post error) definition in the interface specification.

9.0 Standards

9.1 Safety

- UNDERWRITERS LABORATORY (UL) APPROVAL:
  The product is approved as a Recognized Component for use in Information Technology Equipment according to UL 1950 Standard, third edition (without any D3 deviations). The UL Recognized Component marking is located on the product.
- CANADIAN STANDARDS ASSOCIATION (CSA) APPROVAL:
  The product is certified to CAN/CSA-C22.2 No. 950-M95 Third Edition (without any D3 deviations). The CSA certification mark is located on the product.
- FLAMMABILITY REQUIREMENTS
  Printed circuit boards and all foam and other plastic materials are UL Recognized V-1, HF-1, or VTM-1 or better. Small plastic parts that will not contribute to a fire will meet V-2 flame class.
- SAFE HANDLING:
  The product is conditioned for safe handling in regards to sharp edges and corners.
- ENVIRONMENT:
  IBM will not knowingly or intentionally ship any units which during normal intended use or foreseeable misuse, would expose the user to toxic, carcinogenic, or otherwise hazardous substances at levels above the limitations identified in the current publications of the organizations listed below.

❖ International Agency for Research on Cancer (IARC)
❖ National Toxicology Program (NTP)
❖ Occupational Safety and Health Administration (OSHA)
❖ American Conference of Governmental Industrial Hygienists (ACGIH)
❖ California Governor's List of Chemical Restricted under California Safe Drinking Water and Toxic Enforcement Act 1986 (Also known as California Proposition 65)
❖ IBM Environmental Design Engineering Specification 46G3772

- SECONDARY CIRCUIT PROTECTION REQUIRED IN USING SYSTEMS
  Care has been exercised to not use any unprotected components or constructions that are particularly likely to cause fire. However, adequate secondary over current protection is the responsibility of the user of the product. Additional protection against the possibility of sustained combustion due to circuit or component failure may need to be implemented by the user with circuitry external to the product. Over current limits of the voltage into the drive of 10 amps or less should be sufficient protection Electromagnetic Compatibility (EMC).

9.2 Electromagnetic Compatibility (EMC)

- FCC Requirements
  Pertaining to the ULTRASTAR 18LZX & 36ZX disk drive, IBM will provide technical support to assist users in complying with the United States Federal Communications Commission (FCC) Rules and Regulations, Subpart B Digital Devices "Class A and B Limits". Tests for conformance to this requirement are performed with the disk drive mounted in the using system.
- CISPR 22 Requirements
  Pertaining to the ULTRASTAR 18LZX & 36ZX disk drive, IBM will provide technical support to assist users in complying with the Comite International Special des Perturbations Radio Electriques (International Special Committee on Radio Interference) CISPR 22 "Class A and B Limits" .
- European Declaration of Conformity.
  The ULTRASTAR 18LZX & 36ZX disk drive has been tested to comply with the European Council Directive 89/336/EEC and thereby bears the "CE" Mark of Conformity.
  Pertaining to the ULTRASTAR 18LZX & 36ZX disk drive, IBM will provide technical support to assist users in complying with the European Council Directive 89/336/EEC so the final product can thereby bear the "CE" Mark of Conformity.
  This is obtained by integrating the drives in an IBM product. Producers integrating these drives in alternative enclosures will still need to test the system to ensure it complies with the European Directive.

- Australian Declaration of Conformity

  The ULTRASTAR 18LZX & 36ZX disk drives have been tested to comply with AS/NZS 3548 and thereby bears the "C-Tick" Mark of Conformity.

  Pertaining to the ULTRASTAR 18LZX & 36ZX disk drives, IBM will provide technical support to assist users in complying with AS/NZS 3548, so the final product can thereby bear the "C-Tick" Mark of Conformity.

  This is obtained by integrating the drives in an IBM product. Producers integrating these drives in alternative enclosures will still need to test the system to ensure it complies with AS/NZS 3548.

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