Ultrastar 9ZX™
Hardware/Functional Specification
9.11GB Model, 10020 RPM
Version 1.01

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1 Preface

This document details the Hardware/Functional Specifications for the Ultrastar 9ZX High Capacity Family of 3.5-inch Disk Drives.

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1.1.1.1 Revision Codes and Dates Applied

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

Version	Date	Change
1.00	11/3/97	Product release
1.01	11/5/97	Removed in appropriate confidentaility statements

1.1.1.2 Trademarks

IBM, Ultrastar 9ZX, No-ID, and Predictive Failure Analysis are trademarks of International Business Machines Corporation in the United States are/or other countries.

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1 Description

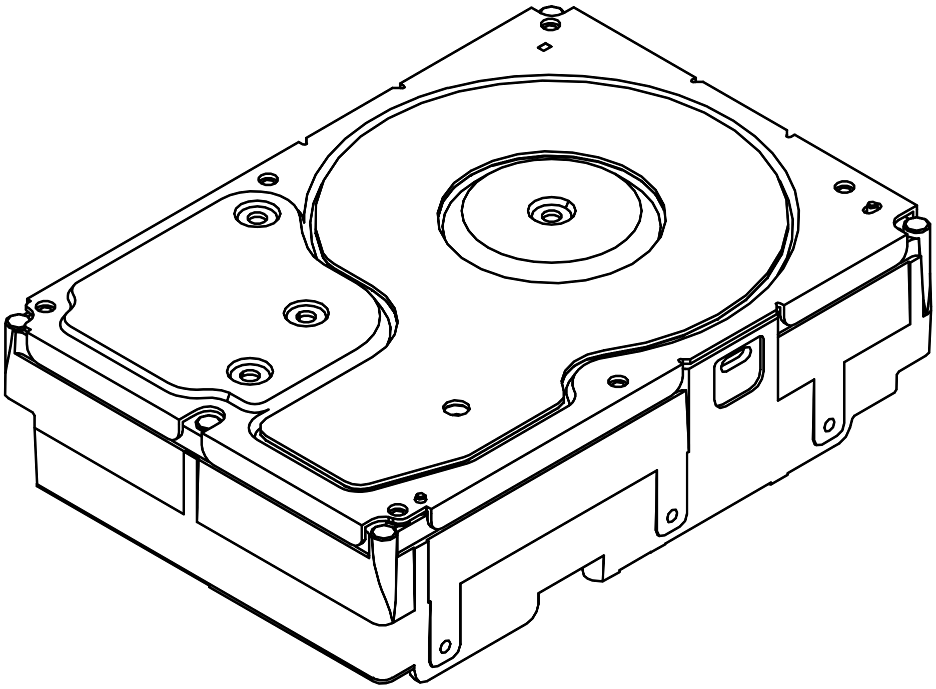

Fig 1. Ultrastar 9ZX Disk Drive Assembly

1.1 Features

General Features

- 9.11GB. (512 bytes/sector)
- Industry-standard interface:
  - 68 pin ANSI SCSI-3 Single-Ended
  - Single Connector Attachment (SCA-2/80 pin)
- Rotary voice coil motor actuator
- Closed-loop digital actuator servo
- Embedded sector servo
- Magnetoresistive (MR) heads
- 16/17 rate encoding
- Partial Response Maximum Likelihood (PRML) data channel with analog filter
- No-ID™ sector format
- All mounting orientations supported
- 1 MB segmented cache buffer
- Jumperable drive supplied terminator power (on some models)
- Jumperable on board active SCSI terminators (optional on some models)
- LED Driver
- Bezel (Optional on some models)

Performance Summary

- Average read seek time: 6.3 milliseconds
- Average write seek time: 7.7 milliseconds
- Average Latency: 3 milliseconds

- Sustained data transfer rate: 10.5 to 17.0 MegaBytes/second (16 bands)
- Peak media transfer rate 16.1 to 25.6 MegaBytes/second (16 bands)
- Fast-20 SCSI data transfer rate: 20 MegaTransfers/second (sustained synchronous)
- SCSI bus overhead: < 40 microseconds
- Read command overhead: < 350 microseconds

SCSI Interface Controller Features

- Multiple initiator support
- Variable logical block lengths (512 - 732 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

Reliability Features

- Self-diagnostics on power up
- Dedicated head landing zone
- Magnetic actuator latch
- Entire Read/Write data path protected by a 32 Bit CRC
- 24 Byte Error Correcting Code (ECC)
- 9 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 during an operation shock event
- High temperature monitoring and logging

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[1] Please see “Capacities by Format Length” on page 14 for more details.

1.2 Models

The Ultrastar 9ZX disk drive is available in the following models:

- 9.11GB capacity

  68 pin SCSI connector models offer an 8/16 bit SCSI bus using the SCSI 'P' connector which supports Wide data transfers.

  80 pin SCSI connector models offer an 8/16 bit SCSI bus using the SCA-2' connector.

  Please refer to “Capacities by Format Length” on page 14 for exact capacities based on user block size.

Models	HDA Type	Capacity GB	SCSI Pins/Connector Type	SCSI Electrical Signal Type
DGVS09U	1.6”	9.11GB	68/Unitized Connector	SCSI Single Ended Fast/Wide-20
DGVS09Y	1.6”	9.11GB	80 SCA-2	SCSI Single Ended Fast/Wide-20

Table 1. Available Models

The following options, which are not identified in the table include:

- Bezel (on some models).
- Jumperable active terminators (on 68 pin only)

2 Specifications

All specification numbers are mean population values unless otherwise noted.

2.1 General

Note: The recording band located nearest the disk outer diameter (OD) is referred to as 'Notch #1', the recording band located nearest the inner diameter (ID) is called 'Notch #16'. 'Average' values are weighted with respect to the number of LBAs per notch when the drive is formatted with 512 byte blocks.

Data transfer rates

	Notch #1	Notch #16	Average	
Buffer to/from media	16.1	25.6		MB/S instantaneous
	10.5	17	15	MB/S sustained

Host to/from buffer up to 20.0 MB/s (synchronous sustained - SCSI)
up to 40.0 MB/s (synchronous sustained - SCSI Fast-20)

Rotational speed 10,020 RPM
Average Latency 3 ms
Track density 7528 TPI

	Minimum	Maximum
Recording density	118 KBPI	151 KBPI
Areal density	888 Mb/sq inch	1136 Mb/sq inch

Disks 6
Heads 12

Seek timing in ms Measured at nominal voltage and temperature

Single cylinder	0.7 (Read)
	1.8 (Write)
Average weighted	6.3 ms (Read)
	7.7 ms (Write)
Full stroke	17 (Read)
	18.8 (Write)

2.2 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	7400

The notch table is as follows

Notch	**Start Cylinder**	**End Cylinder**	**User data Cylinders**	**Reserved Cylinders**	**Data/ servo**	**User sectors**
1	0	1,118	1,108	11	37/11	228
2	1,119	2,318	1,200	0	10/3	226
3	2,319	2,746	428	0	23/7	223
4	2,747	3,143	397	0	13/4	221
5	3,144	3,697	554	0	19/6	215
6	3,698	4,048	351	0	34/11	210
7	4,049	4,732	684	0	3/1	204
8	4,733	4,970	238	0	20/7	194
9	4,971	5,337	367	0	11/4	187
10	5,338	5,640	303	0	8/3	181
11	5,641	6,014	374	0	28/11	173
12	6,015	6,282	268	0	5/2	170
13	6,283	6,514	232	0	12/5	163
14	6,515	6,744	230	0	7/3	158
15	6,745	7,110	366	0	11/5	149
16	7,111	7,399	286	3	23/11	142

Table 2. Notch capacities

Allowed user bytes/Sector (ub/sct) 512 to 732 (even byte numbers only)

2.3 Capacities by Format Length

For the allowable sector lengths the drive capacity is as follows

User bytes / logical block	User Logical Blocks
512	17,829,870
514	17,634,522
520	17,457,330
522	17,394,702
524	17,339,946
528	17,254,746
536	17,014,674
688	13,642,014
732	12,910,242

Table 3. Available user blocks

User bytes / logical block	User bytes / drive

512	9,128,893,440
514	9,064,144,308
520	9,077,811,600
522	9,080,034,444
524	9,086,131,704
528	9,110,505,888
536	9,119,865,264
688	9,385,705,632
732	9,450,297,144

Table 4. Available user bytes

Note:

1. The maximum addressable LBA User Logical Blocks -1. Minimum is 0.
2. The capacity is calculated as the User Logical Blocks multiplied by the block size.

2.4 Power Requirements

2.4.1 Specifications

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

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, 200 V/sec maximum slew

Power Supply Current

		Population Max	Population Mean	Population Std. Dev.
+5 V DC (Idle)	RMS		0.58 A[2]	0.024 A
+5 V DC (R/W baseline)	RMS		0.72 A	0.026 A
+5 V DC (R/W pulse)	Peak	1.11 A		
+12 V DC (Idle)	RMS		1.12 A	0.028 A
+12 V DC (Seek peak)	Peak	3.3 A		
+12 V DC (Start)	Peak	3.5 A[3]		

Energy Consumption (Japanese Requirement)[4]
0.0019 watts/MB

2.4.2 RMS Power Measurements

	Population mean	Population Sigma

[2] 5 V current is given with termination power provided by the using system if required.
[3] The start current is the total 12 V current required by the drive.
[4] Energy consumption idex = Idle power/Capacity (W/MB)

Idle	16.35 Watts	0.26 Watts
15 ops/second	17.94 Watts	0.38 Watts
30 ops/second	18.83 Watts	0.38 Watts
60 ops/second	20.69 Watts	0.38 Watts
90 ops/second	22.32 Watts	0.38 Watts

Note:

1. Non-idle measurements are for a fully random distribution of commands across the drive.
2. Power Measurements made using Clarke Hess Model 259 Digital Wattmeter
3. For the purpose of calculations 0.67 Watts per op can be used. This is not completely accurate because of the non linear scale but can be used for approximations.

   Example

   If power was required for 90 ops per second the calculation would be as follows

   Idle power = 16.35 Watts

   90 ops/second = 90 * 0.067 = 6.03 Watts

   Total Power = 16 + 6.03 = 22.38 Watts

2.4.3 Power Supply Graphs

These graphs are actual traces recorded on real drives in a lab environment. They are intended to be typical examples and do not show worst case 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.

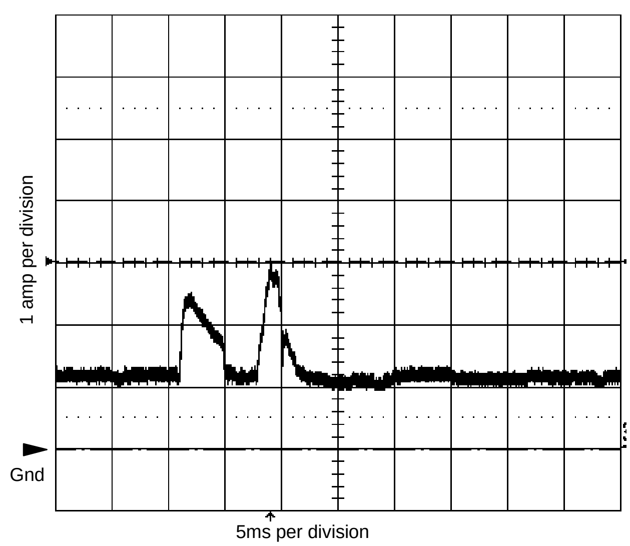


Fig 2. Typical 12V seek profile (followed by data writing)

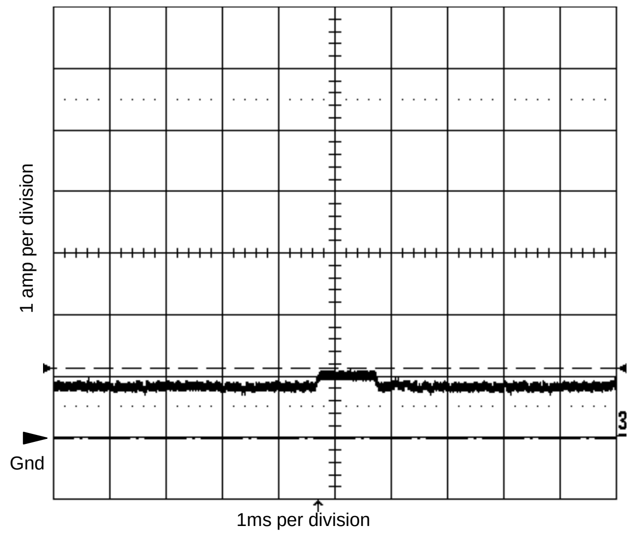


Fig 3. Typical 5V seek with write current profile

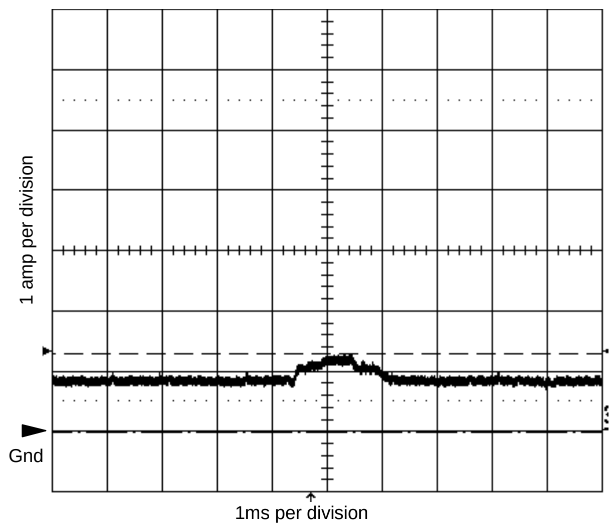


Fig 4. Typical 5V seek with read current profile

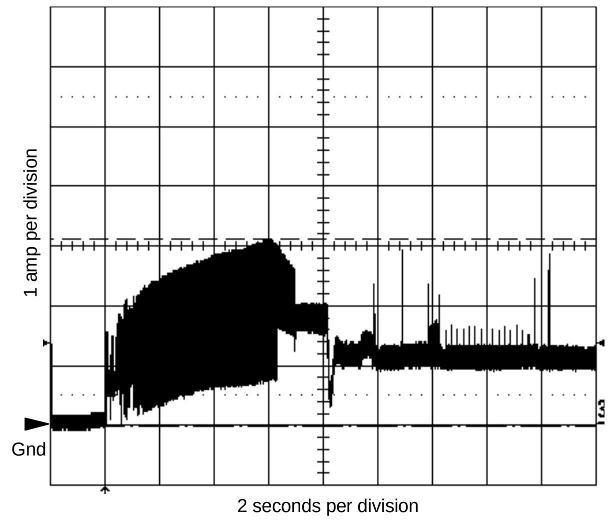


Fig 5. Typical 12V start current profile

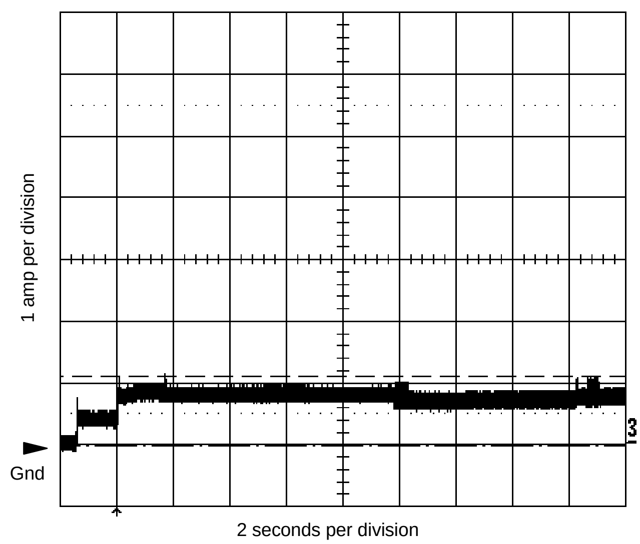


Fig 6. Typical 5V start current profile

2.4.4 Power Supply Ripple

Externally Generated Ripple as seen at drive power connector

	Maximum	Frequency
+5 V DC	200 mV P-to-P	0-20 MHz
+12 V DC	200 mv P-to-P	0-20 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.

2.4.5 Input Capacitance

Internal bulk capacitance as seen at drive power connector

+5 V DC	72 µF +/- 20%
+12 V DC	510 µF +/- 20%

2.4.6 Grounding Requirements of the Disk Enclosure

The disk enclosure is at Power Supply ground potential.

From a 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. The drive's mounting frame must be within +/- 150 millivolts of the drive's power supply ground. At no time should more than 35 milliamps of current (0 to 100Mhz) be injected into the disk enclosure.

2.4.7 'Hot Plug/Unplug' support

The term 'Hot Plug', refers to the action of mechanically engaging a device to 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, Annex 'A'.

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 (as a result of a UNIT STOP or Un-Plug) the operational shock limits are in effect. Once the drive has completely stopped (15 seconds max) 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 Unplug events the power supply ripple on adjacent operational drives should not go outside of the +/-5 % regulation tolerance.

2.4.7.1 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 cannot afford to quiesce the SCSI bus but can meet the requirements of voltage regulation, operational and non-operational shock, the following guidelines are recommeded 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

2.4.7.2 SCSI SCA-2 Models

Based on connector classification called out in SF-8046, the SCA-2 connector drive is designed to be ‘Case 4’ compliant when the system has properly implemented the SFF-8046 guidelines.

2.5 Bring-up Sequence (and Stop) Times

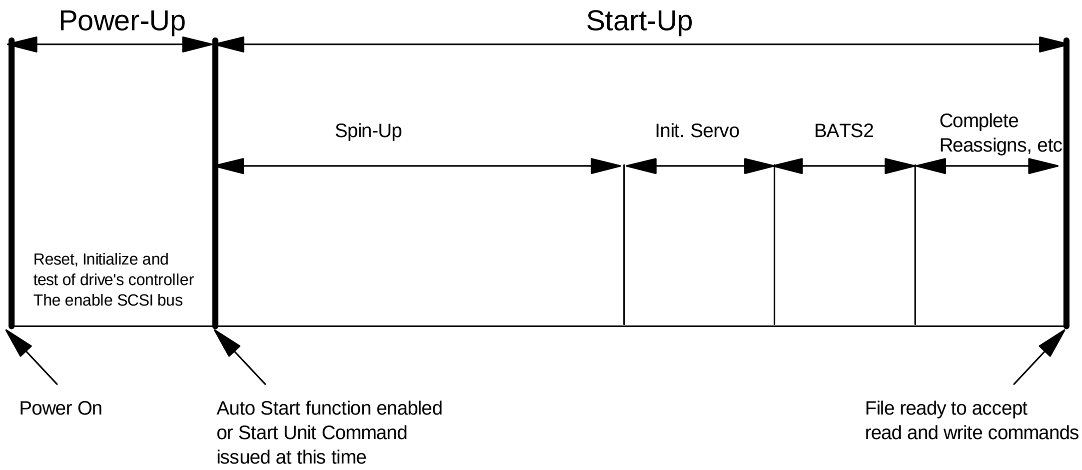


Fig 7. Start Time Diagram

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

“Power On” is defined as 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) verifying the read/write hardware, resumes “Reassign in Progress” operations and more. See the *Ultrastar 9ZX 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.

Reference “Start/Stop Unit Time” on page 33 for additional details.

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.

Event	Nominal	Maximum
Power-up	2.5 sec	3.0 sec
Start-up	16.5 sec	30 sec
Spin-up	10.5 sec	15 sec
Spindle Stop	15 sec	15 sec

Table 5. Bring-up Sequence Times

2.5.1 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.

It is recommended that after power is removed a period of 2 seconds should be allowed before DC is reapplied to the drive.

In the event of a power glitch the drive will normally issue a Power On Reset and then go through it’s Power-Up sequence. Depending on the duration of the glitch the drive may spin down and then spin back up or may reset itself in which case the spindle motor is turned off. If the host system detects a power glitch it is recommended that a reset is issued to all attached drives. This allows the drive to be brought up in a controlled manner from a known state.

3 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.

3.1 Environment

3.1.1 Basic Component Descriptions

3.1.1.1 Seek

The average time from the initiation of the seek, to the acknowledgement that the R/W head is on the track that contains the first requested LBA. The values used for sequential command calculations should be 0 ms and the values for random commands are shown in “General” on page 13.

3.1.1.2 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 1/2 of a revolution of the disk, or 3 ms.

3.1.1.3 Command Execution Overhead

The average time added to the Command Execution Time due to the processing of the SCSI command. It includes all 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 28 and “Write Command Performance” on page 29 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 operation (ie not a skip operation) with the Read Ahead function disabled. The value of this parameter varies greatly depending upon workloads and environments.

The following values are used when calculating the Command Execution Times.

Workload	**Command Execution**	**SCSI Bus**
Sequential Read	0.72	0.03
Sequential Read with Read Ahead	0.20	0.03
Sequential Write	0.82	0.04
Sequential Write with Write Cache	0.23	0.04
Random Read	0.22	0.03
Random Read with Read Ahead	0.32	0.03
Random Write	0.35	0.03

Table 6. Overhead Values (milliseconds)

Other Initiator controlled factors such as use of disconnects, Tagged Command Queueing and the setting of Mode Parameters like DWD, DRD, 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 28 and “Write Command Performance” on page 29 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.

3.1.1.4 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 9ZX SCSI Logical Interface Specification* for a description of error recovery procedures.)

Rates for drives formatted at 512 bytes/block are shown below:

Notch#	Theoretical	Typical

Notch#	Theoretical	Typical
Average	15.3	15.23
1	16.97	16.89
2	16.86	16.78
3	16.62	16.54
4	16.45	16.37
5	16.02	15.94
6	15.67	15.59
7	15.23	15.16
8	14.47	14.4
9	13.95	13.88
10	13.51	13.45
11	12.91	12.85
12	12.66	12.6
13	12.15	12.09
14	11.8	11.74
15	11.11	11.06
16	10.6	10.55

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

Note

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 a different 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.

3.1.1.5 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 40.0 MB/sec.

The SCSI data transfer rate is dependant on the mode, either synchronous or asynchronous. It also depends upon the width of the data path used, 8 and 16 bit transfer are supported.

When the drive is configures for an 8 bit wide transfer a synchronous data transfer rate of 20 MB/s can be realized. The 16 bit wide maximum synchronous data transfer rate is 40 MB/s.

The asynchronous data transfer rate is dependant 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 5 MegaTransfer/second (MT/s) asynchronous data transfer rates.

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.

3.1.2 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 it's 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 28 and "Write Command Performance" on page 29 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.

3.2 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.

3.3 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.

3.3.1 When Read Caching is Enabled

For read commands with Read Caching Enabled Command Execution time can be approximated by deleting Seek, Latency and Data Transfer to/from Disk times from the normal drive performance timings 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.

3.3.2 When Read Ahead is Enabled

The reduction in sequential (contiguous and non-contiguous) read workload with long inter-op delays command execution times 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.

3.3.3 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 the normal drive performance times. 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 27 for more information.

3.3.4 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.

3.3.5 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.

3.3.6 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 portion 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.

3.3.7 Back-To-Back Write Commands

If all of the requirements are met as stated in the *Ultrastar 9ZX SCSI 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 can not 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.

3.4 Read Command Performance

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

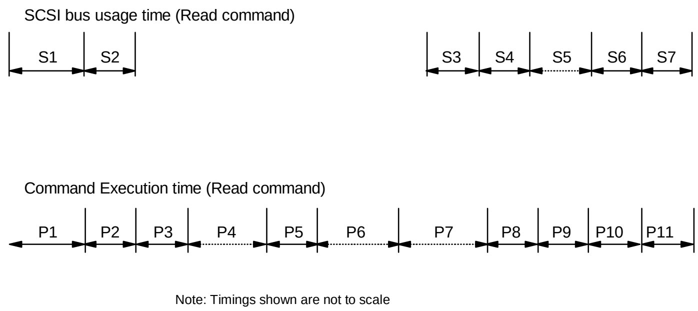


Fig 8. SCSI Read command performance measurements

3.4.1.1 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 (CDB)	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).

3.4.1.2 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 = 6.5 msec)
P5	Set up read disk transfer	0 µsec
P6	Latency (for example, half revolution)	(latency = 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 read 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
```

3.5 Write Command Performance

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

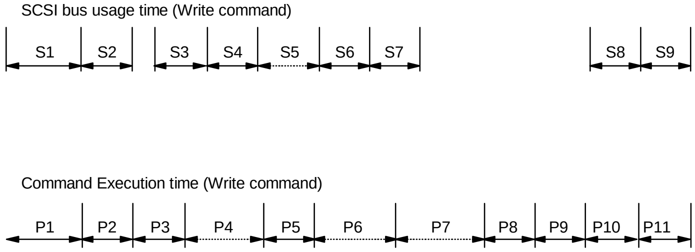


Fig 9. SCSI Write Command Performance Measurements

3.5.1.1 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).

3.5.1.2 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 = 8.3 msec)
P5	Set up write disk transfer	0 µsec
P6	Latency (for example, half revolution)	(Latency = 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
```

3.6 Skew

3.6.1 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 ms.

3.6.2 Track to Track Skew

Track skew is the time required to perform a switch between heads on the same cylinder. That time is 0.83 ms.

3.7 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:

1. Predictive Failure Analysis (PFA)
2. Save Logs and Pointers
3. 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. 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. This mechanism has the benefit of not requiring special system software (such as issuing SCSI Rezreo Unit commands at known & fixed time intervals) in order to control if and when this function executed.

2. Synchronized operation

   Applications which cannot accomodate interruptions at all may consider synchronizing idle activities to the system needs through use of the TCC bit in Mode Page 0h and the Rezero Unit command.

   Note: An example of this limiting mechanism's use would be if a system is known to issue SCSI commands for an application greater than 5 seconds apart and an idle time function delay cannot be tolerated by the system on any of these commands. This would eliminate drive idle time function from ever starting while the system/application is in a critical response time period of operation.

3. No PFA operation

   Idle time initiated PFA can be disabled by setting the "Perf" bit in Mode Page 1Ch. See the *Ultrastar 9ZX SCSI Logical Interface Specification* for details.

3.7.1 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".

Ther 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 12 heads one PFA measurement will be made every 2.8 minutes (240/(7*12)).

For the last head tested for a particular measurement type (once every 1/2 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. The using system also has the option of forcing execution at known times by issuing the SCSI Rezero Unit command if the Page 0h Mode Parameter TCC = 1. All tests for all heads occur at those times. See the *Ultrastar 9ZX SCSI Logical Interface Specification* for more details about PFA, LITF and TCC.

3.7.2 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.

3.7.3 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 9 minutes 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 9 minutes thereafter. As soon as a SCSI command is received, the period for the 1st occurance is reduced back down to 40 seconds. The period is increased back to 9 minutes for subsequent occurances should no more SCSI commands be received during that time. Execution time is less than 1 full stroke seek.

3.7.4 Summary

Idle Time Function Type	Period of Occurance (minutes)	Duration (ms)	Mechanism to delay	Mechanism to disable
PFA	30/(trk/cyl)	80	Re-instruction period, TCC	PERF
Save Log & Pointers	26	30	Re-instruction period, TCC	
Disk Sweep	2/3 - since last command 9 - since last occurance	17	Re-instruction period	
Note: “Re-instruction period” is the time between consecutive SCSI command requests				

Table 8. Summary of Idle Time Functions

3.8 Temperature Monitoring

The drive is equipped with an internal temperature sensor which is used to log the drives operating environment and optionally notify the using system if the temperature passes beyond the drives maximum operating range. The sensor is pysically mounted on the reverse side of the electronics card but is calibated to report the HDA casting temperature.

The algorithm used is as follows:

- Starting 25 minutes after power on the temperature is sampled. If it is below 56C then no further action is taken and the temperature will continued to be sampled at 25 minute intervals.
- If the temperature is between 56C and 71C an internal flag is set to signal a PFA event and the temperature is internally logged by the drive. See the *Ultrastar 9ZX SCSI Logical Interface Specification* for the actions which may be taken when a PFA event is signalled and how they may be controlled by the host system. While the temperature remains in the range 56C to 71C the temperature will be re-sampled every 15 minutes and potentially additional PFA events signalled.
- If the temperature exceeds 71C then action similar to the 56C to 71C range is taken but the sampling interval is shortened to 10 minutes.
- Once either of the thresholds above has been crossed hysteresis is applied to the sensor so that to exit the state the drive temperature must drop 5C below the point that triggered the activity, i.e. drop below 66C and 51C respectively.

Measuring the drive’s temperature takes approximately 440 microseconds. The internal logging of this temperature by the drive, ie 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.

3.9 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.

3.9.1.1 Reassignment Time

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

3.9.1.2 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.

3.9.1.3 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.

3.9.1.4 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
- Skip Mask (Read)
- Skip Mask (Write)
- 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.

3.9.1.5 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 Ready

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.

4 Mechanical

4.1 Weight and Dimensions

	US	SI Metric
Weight	1.91 pounds	0.87 Kilograms
Height	1.63 inches	42.0 millimetres
Width	4.00 inches	101.85 millimetres
Depth	5.75 inches	147.0 millimetres

4.2 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 51.

4.3 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 " on page 36, "Location of bottom mounting holes (68 pin SCSI version)" on page 37 and "Location of bottom mounting holes (80 pin SCA-2 SCSI version)" on page 38 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 "Drive Mounting Guidelines" on page 55.

4.3.1 SCA-2 Mounting Guidelines

Since the SCA-2 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 interned to be exhaustive.

1. The SCA-2 connector should not be required to support the weight of the drive
2. Operational vibration occuring between the mating halves of the SCA-2 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 pluggin operation. Excessive offsets between the drive connector and backplane 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.

4.4 Mounting Drawings

4.4.1 Bottom Mounts (All)

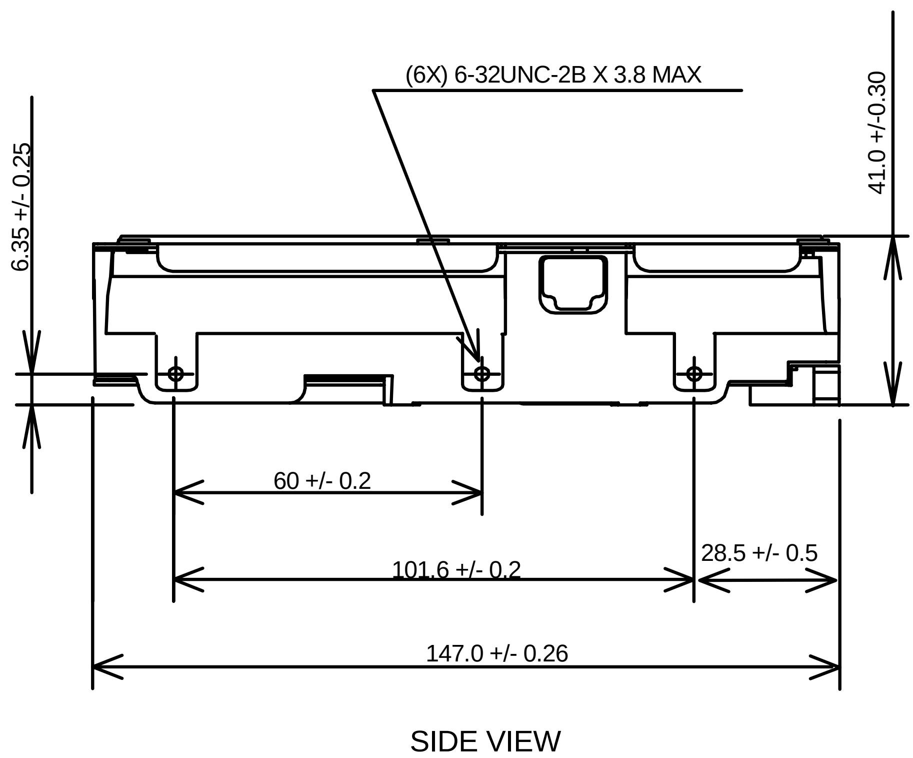


Fig 10. Location of side mounting holes

Note:

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

4.4.2 68 Pin SCSI Bottom Mounts

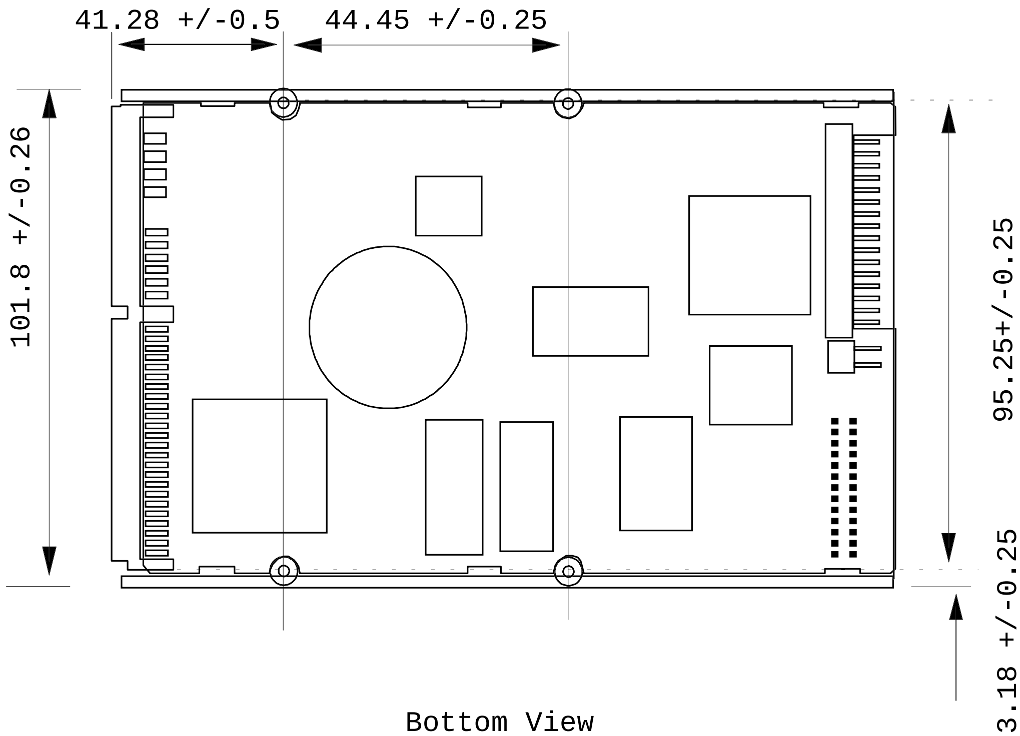


Fig 11. Location of bottom mounting holes (68 pin SCSI version)

4.4.3 80 Pin SCA-2 SCSI Bottom Mounts

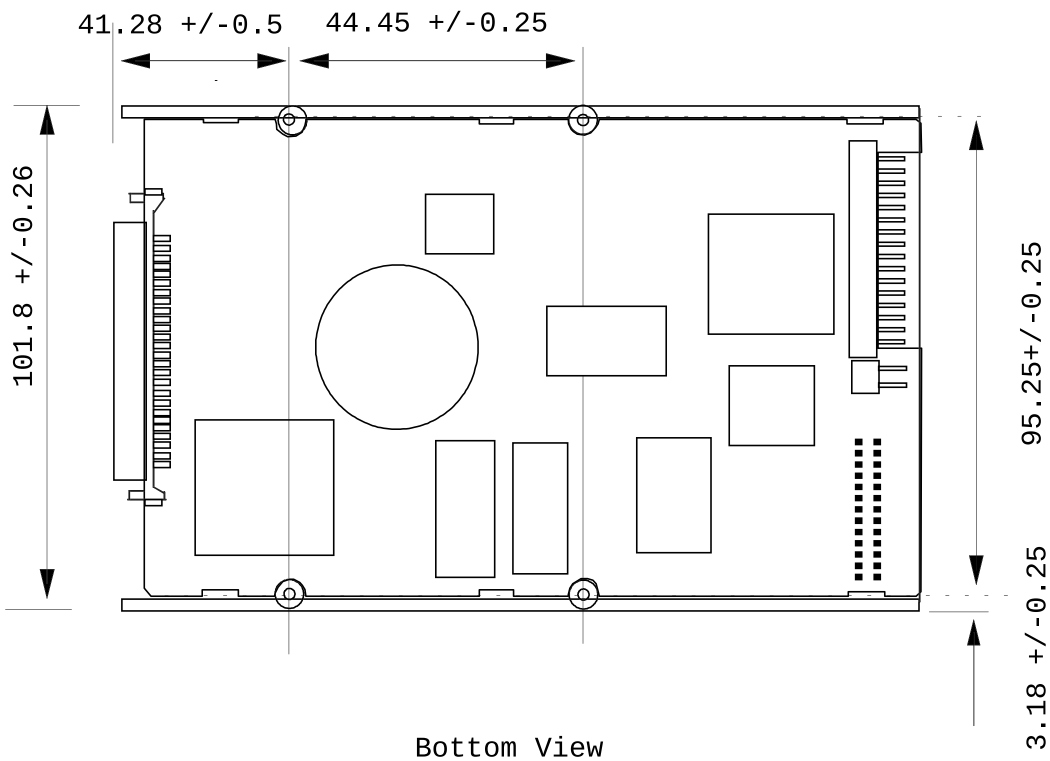


Fig 12. Location of bottom mounting holes (80 pin SCA-2 SCSI version)

4.5 Electrical Connectors

4.5.1 68 Pin SCSI

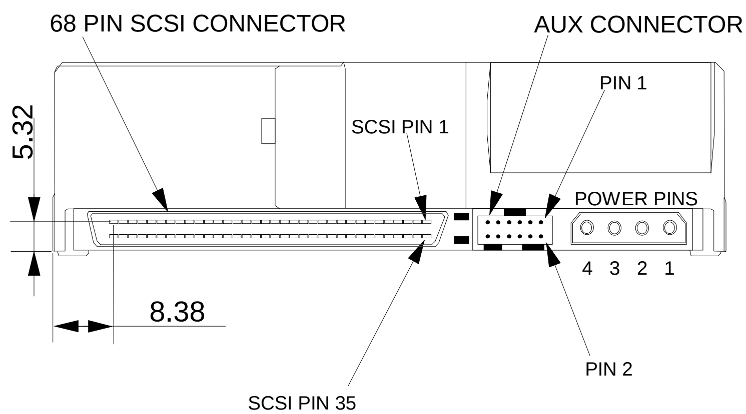


Fig 13. 68 pin SCSI Electrical Connector

4.5.2 80 Pin SCSI

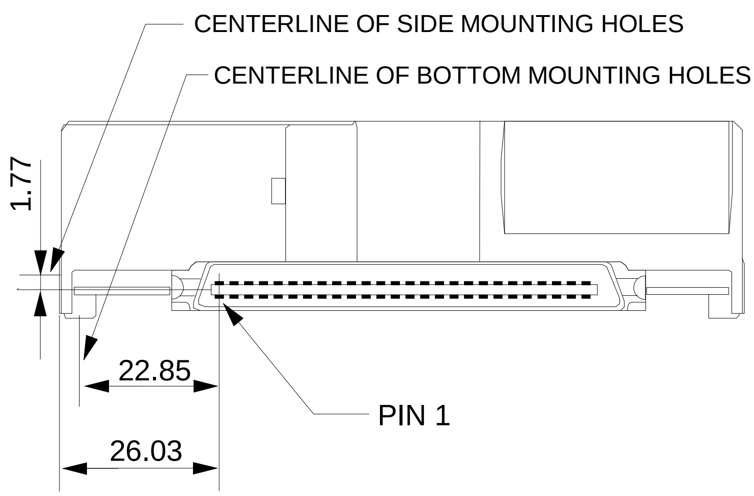
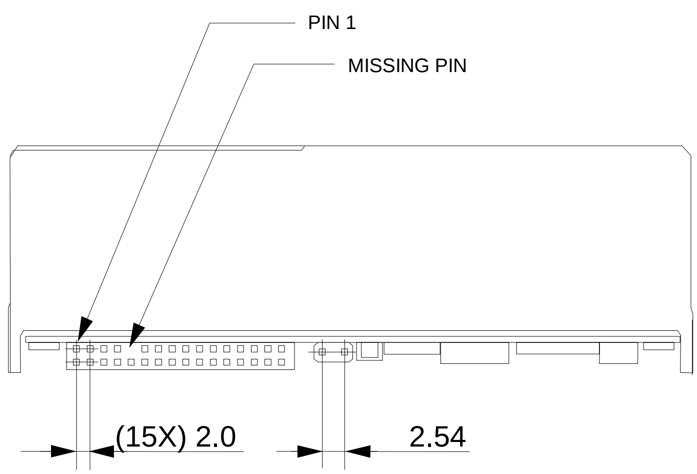


Fig 14. 80 pin SCSI Connector

4.5.3 Jumper Pins



5 Electrical Interface

5.1 Power Connector

The DC power connectors used on all models (68 and 80 pin SCA-2 and SSA) are an integral portion of the 68 pin SCSI 'Unitized' Connectors, 80 pin 'Single Connector Attachment' (SCA-2) Connector and 34 pin SSA connector.

- 68 pin models use a Molex connector (PN 87360-0001) that is compatible with the ANSI SCSI "P" connector
- The 80 pin SCA-2 models use a AMP connector (PN 5-917593-9) that is compatible with the Specification of: 'Single Connector Attachment for Small SCSI Disk Drives' SFF-8046 draft document, revision 2.3, dated Dec 2, 1995. Placement of the connector is in compliance with the SFF-8337, revision 1.2, dated July 27, 1995.This connector uses 30 micro-inch Gold plating for high reliability.

Pin assignments for the 68 pin power connector are shown below.

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

Table 9. Power connector pin assignments

Refer to the section entitled “Power Requirements” on page 15 for details on drive power requirements.

5.2 SCSI Bus Connector

This section describes the varying connectors offered on models of the Ultrastar 9ZX file. These connectors have a finish metallurgy 30 micro-inch gold plating.

5.2.1 68 Pin Signal Connector

The 68 pin models use an AMP connector (PN -187360-0001) 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 39 for a rear view of a 68 pin model.

Signal Name	Connector Contact		Signal Name
GROUND	1	35	-DB(12)
GROUND	2	36	-DB(13)
GROUND	3	37	-DB(14)
GROUND	4	38	-DB(15)
GROUND	5	39	-DB(P1)
GROUND	6	40	-DB(0)
GROUND	7	41	-DB(1)
GROUND	8	42	-DB(2)
GROUND	9	43	-DB(3)
GROUND	10	44	-DB(4)
GROUND	11	45	-DB(5)
GROUND	12	46	-DB(6)
GROUND	13	47	-DB(7)
GROUND	14	48	-DB(P)

Signal Name	Connector Contact		Signal Name
GROUND	15	49	GROUND
GROUND	16	50	GROUND
TERMPWR	17	51	TERMPWR
TERMPWR	18	52	TERMPWR
OPEN	19	53	OPEN
GROUND	20	54	GROUND
GROUND	21	55	-ATN
GROUND	22	56	GROUND
GROUND	23	57	-BSY
GROUND	24	58	-ACK
GROUND	25	59	-RST
GROUND	26	60	-MSG
GROUND	27	61	-SEL
GROUND	28	62	-C/D
GROUND	29	63	-REQ
GROUND	30	64	-I/O
GROUND	31	65	-DB(8)
GROUND	32	66	-DB(9)
GROUND	33	67	-DB(10)
GROUND	34	68	-DB(11)
Note: 8 bit devices which connect to the P-cable should tie the following signals inactive: -DB(8), -DB(9), -DB(10), -DB(11), -DB(12), -DB(13), -DB(14), -DB(15), -DB(P1). All other signals shall be connected as defined.			

Table 10. 68 Pin Single-Ended SCSI Connector Contact Assignments

5.2.2 80 Pin (Single Connector Attachment) Connector

The 80 pin SCA-2 models use a AMP connector (PN 5-917593-9) that is compatible with the Specification of: 'Single Connector Attachment for Small SCSI Disk Drives' SFF-8046 draft document, revision 2.3, dated Dec 2, 1995. Placement of the connector is in compliance with the SFF-8337, revision 1.2, dated July 27, 1995.

This connector has a finish metallurgy of 30 micro-inch gold plating.

Data transfers in both 8 bit (narrow) and 16 bit (wide) modes are supported. Refer to “80 pin SCSI Connector” on page 39 for a rear view of an 80 pin model.

Signal Name	Connector Contact Number		Signal Name
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	Ground
DB(11)	7	47	Ground
DB(10)	8	48	Ground
DB(9)	9	49	Ground
DB(8)	10	50	Ground
I/O	11	51	Ground
REQ	12	52	Ground
C/D	13	53	Ground

Signal Name	Connector Contact Number		Signal Name
SEL	14	54	Ground
MSG	15	55	Ground
RST	16	56	Ground
ACK	17	57	Ground
BSY	18	58	Ground
ATN	19	59	Ground
DB(P0)	20	60	Ground
DB(7)	21	61	Ground
DB(6)	22	62	Ground
DB(5)	23	63	Ground
DB(4)	24	64	Ground
DB(3)	25	65	Ground
DB(2)	26	66	Ground
DB(1)	27	67	Ground
DB(0)	28	68	Ground
DB(P1)	29	69	Ground
DB(15)	30	70	Ground
DB(14)	31	71	Ground
DB(13)	32	72	Ground
DB(12)	33	73	Ground
5 Volt	34	74	Mated 2
5 Volt	35	75	5 V Ground
5 V Charge	36	76	5 V Ground
SLAVE SYNC	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	0
Note : 8bit devices which connect to the SCA connector should tie the following signals inactive high: DB(8), DB(9), DB(10), DB(11), DB(12), DB(13), DB(14), DB(15), DB(P1) or select "Disable Wide Negotiation" on the Front Option Jumper Block and 'float' the same signals. All other signals shall be connected as defined.			

Table 11. 80 Pin SCA-2 Connector Contact Assignments

5.2.3 SCSI Bus Cable

Single-ended SCSI models permit cable lengths of up to 6 meters (19.68 feet). 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.

SCA-2 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 cables. Ultrastar 9ZX has a maximum internal stub length of 0.05 meters on all 'single ended' SCSI signals. To remain compliant with the standard the SCSI bus cable must not add more than 0.05 meters additional stub length to any of the single-ended SCSI signals or 0.1 meters to any differential SCSI signals.

5.2.4 SCSI Bus Terminators (Optional)

Upon request, Single Ended 68 pin models are available with on card SCSI bus Active terminators.

For those cards having the Active Termination feature, this function can be enabled by installing a jumper between pins 13 and 14 of the Front Option Jumper Block or connecting pins 9 and 11 of the Auxiliary Connector on 68 SCSI models. The using system is responsible for making sure that all required signals are terminated at both ends of the cable. See “SCSI Bus Electrical Characteristics” on page 43 for input capacitance values when terminators are disabled and when terminators are not populated on the card.

80 pin SCA-2 Models do not have internal SCSI bus terminators.

Some external terminator possibilities for single ended cabled systems are listed below: .

68 Pin Model Terminators
Data Mate DM2050-02-68S Data Mate DM2050-02-68R

Table 12. Single Ended SCSI Terminators

5.2.5 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.

5.2.5.1 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 9ZX drive limits current to 2.0 Amps thru 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.

5.2.6 SCSI Bus Electrical Characteristics

The following DC operating characteristics pertain to the single-ended SCSI bus transceivers. All of these parameters meet the ANSI SCSI-2 requirements.

- Ta = 0 to 70 deg. C

Symbol	**SCSI I/O Parameters**	**min**	**max**	**Units**	**Notes**
Vol	low level output voltage		0.4	V	Iout = 48 mA
	Fast-20 Models		0.5	V	
Voh	high level output voltage	2.5		V	Iout = -400 uA

Symbol	SCSI I/O Parameters	min	max	Units	Notes
Vil	low level input voltage	-0.2	0.8	V	
	Fast-20		1	V	
Vih	high level input voltage	2	5.5	V	
	Fast-20	1.9		V	
Iil	low level input current		10	uA	
Iih	high level input current		50	uA	
Vihys	input hysteresis	0.33		V	
Ci	input capacitance		25	pF	w/terminators disabled, Typ. = 15 pF
Ci	input capacitance		19	pF	w/o terminators, Typ. = 14 pF

Table 13. Single-Ended Bus Electrical Characteristics

5.3 Option Block Connector (Jumper Blocks)

Ultrastar 9ZX 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 refered 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-2).

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

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

The 45G9800 PN is:-

- 2mm 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, wo/tab connector is 5.08 mm long
- Contact -- 30micro-inch gold plating with nickel underplate
- Supplier -- METHODE 9608-202-35, or approved equivalent.

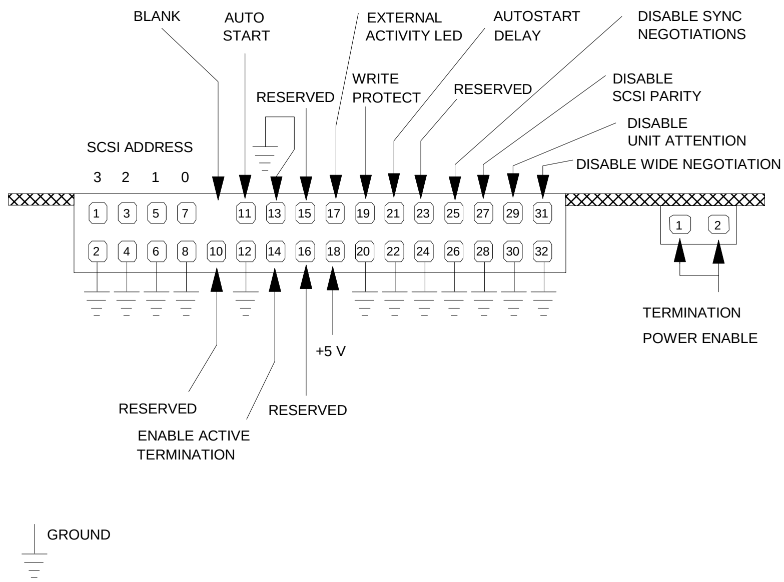


Fig 15. 68 pin Single Ended Front Option Jumper Block and TermPower Block

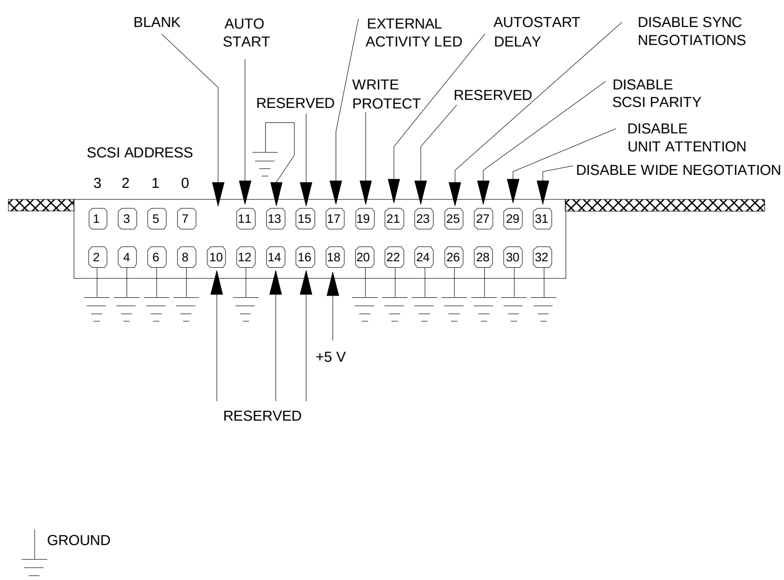


Fig 16. SCA-2 Front Option Jumper Block

5.3.1 68 Pin Auxiliary Connector

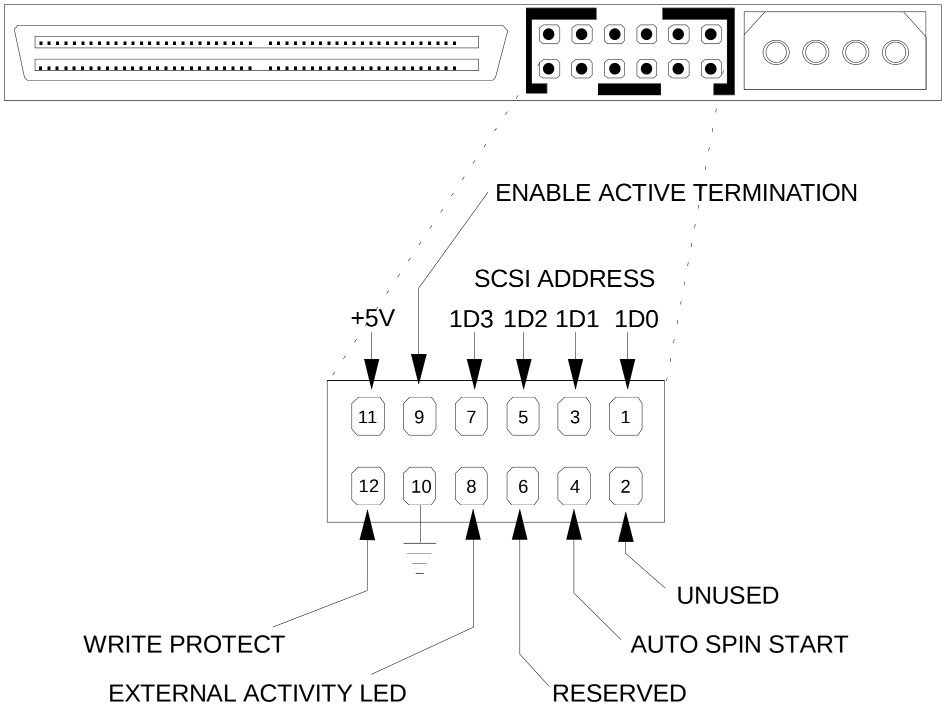


Fig 17. Auxiliary Connector on the 68 pin Connector

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 2.0 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 SCSI spec (SCSI 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)
   -

The Auxiliary Connector is shown in “Auxiliary Connector on the 68 pin Connector” on page 46.

5.3.2 SCSI ID (Address) Pins

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

Note: In the address determination tables, "off" means jumper is not in place and "on" means jumper is in place.

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 14. Address Determination of 68 and 80 Pin Models

5.3.3 Auto Start (& 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 Start Unit command. For no Auto-Startup, a SCSI Start Unit command is required to make the drive spin 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 (sec) Multiplier
off	off	NO	na
off	on	YES	0
on	off	YES	10
on	on	YES	4

Table 15. Auto-Startup Modes selectable by Auto-Start/Delay Pin Combinations

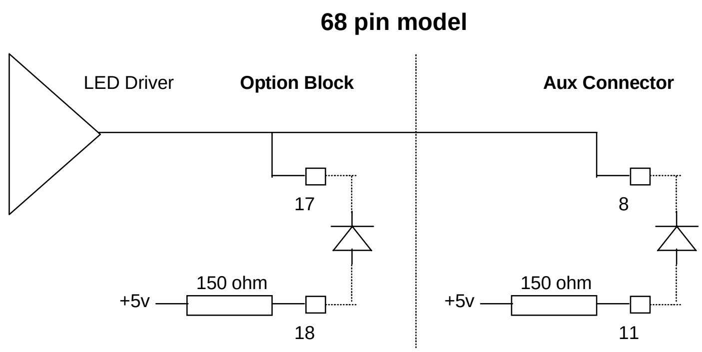
Pins (80 pin model)		Drive Behavior	
AUTO START DELAY	AUTO START	Auto-Startup Mode ?	Delay (sec) Multiplier
off	off	YES	0
off	on	NO	na
on	off	YES	10
on	on	NO	na

Table 16. Auto-Startup Modes selectable by Auto-Start/Delay Pin Combinations

5.3.4 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 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.



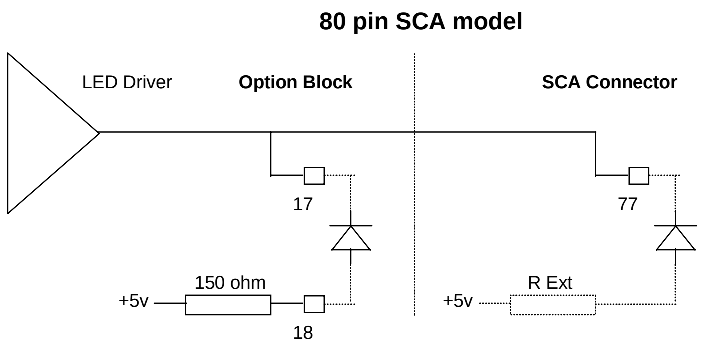


Fig 18. LED Circuit Diagram

5.3.5 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 9ZX SCSI Logical Interface Specification* for functional details.

5.3.6 Disable Sync. 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 9ZX SCSI Logical Interface Specification* for more details on this feature.

5.3.7 Disable SCSI Parity Pin

Grounding this pin will disable SCSI Parity checking.

5.3.8 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.

5.3.9 Disable Wide Negotiations

Jumpering thee pins will cause the drive to operate in single byte mode. The drive will not negotiate ‘wide’ (double byte) operation.

5.3.10 Enable Active Termination

Upon request, Single Ended 68 pin models are available with on card SCSI bus Active terminators.

For those cards having the Active Termination feature, this function can be enabled by installing a jumper between pins 13 and 14 of the Front Option Jumper Block or connecting pins 9 and 11 of the Auxiliary Connector on 68 SCSI pin models (refer to “68 pin Single Ended Front Option Jumper Block and TermPower Block” on page 45 and “Auxiliary Connector on the 68 pin Connector” on page 46)

5.4 Spindle Synchronization

Spindle Synchronization is not a feature of the Ultrastar 9ZX drive.

6 Reliability

6.1 Error Detection

Error reporting ⩾ 99%	All detected errors excluding interface and BAT's #1 (Basic Assurance Test) errors.
Error detection ⩾ 99%	
FRU isolation = 100%	To the device when the 'Recommended Initiator Error Recovery Procedures' in the *Ultrastar 9ZX Interface Specification* are followed.
	No isolation to sub-assemblies within the device are specified.

6.2 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 conditions and room environment with default error recovery - QPE[5] enabled).
	With QPE enabled and the default thresholds, error reporting only occurs after step 18.

6.3 SPQL (Shipped product quality level)

All units are functionally tested immediately prior to packaging and shipment from IBM. When subsequently installed and functionally tested in an approved system, some drives may not pass. In general, the percentage of drives that fail will depend upon adherence to shipping and handling guidelines, functional test criteria and system design compatibility. Contact your technical support representative for further information and assistance.

6.4 Failure Rate

This product is designed for use in applications where high reliability and availability are critical. In general, actual failure rates will depend on usage conditions and system design compatibility.

Parameters such as ambient temperature, cooling air flow rate, relative humidity, ambient pressure (altitude), applied voltage, shock, vibration, on/off cycles and duty cycle will affect failure rates. Failure rate projections may only be determined from drive system testing. Contact your technical support representative for further information and assistance.

6.5 Shelf Life

It is recommended that the drive does not remain inoperative for longer than 180 days especially if the shelf environment is at high temperature and humidity.

6.6 Start Stop Cycles

The maximum number of start stop cycles supported by the drive is 1800.

[5] Please reference QPE (qualify post error) definition in the interface specification.

7 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	41 to 122 °F (5 to 50 °C)
Operating Disk Enclosure	41 to 149 °F (5 to 65 °C)
Storage	34 to 149 °F (1 to 65 °C) [6]
Shipping	-40 to 149 °F (-40 to 65 °C)

- Temperature Gradient

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

- Humidity

Operating	5% to 90% noncondensing
Storage	5% to 90% noncondensing
Shipping	5% to 95% (Applies at the packaged level)

- Wet Bulb Temperature

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

- Elevation

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

7.1.1 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 Point (top view)” on page 53 defines where measurements should be made to determine the top disk enclosure temperature during drive operation. “Temperature Measurement Points (bottom view)” on page 52 defines the modules that are located on the bottom side of the card and the measurement location on the bottom of the disk enclosure.

There must be sufficient air flow through the drive so that the disk enclosure and module temperature maximum limits defined in the following table are not exceeded.

[6] Guidelines for storage below 1 °C are given in IBM Technical Report TR 07.2112.

	Absolute Maximum	Recommended Maximum
Disk Enclosure Top	149 °F (65°C)	122 °F (50 °C)
Disk Enclosure Bottom	149 °F (65 °C)	122 °F (50 °C)
Channel Module[7]	203 °F (95 °C)	167 °F (75 °C)
SCSI Module	194 °F (90 °C)	158 °F (70 °C)
Microprocessor Module	176 °F (80 °C)	140 °F (60 °C)
Controller Module	194 °F (90 °C)	158 °F (70 °C)
Motor Driver Module	194 °F (90 °C)	158 °F (70 °C)
Note: Operating the drive above the absolute maximum temperatures may cause permanent damage		

Table 17.Absolute Maximum and Recommended Maximum Operating Case Temperature Limits

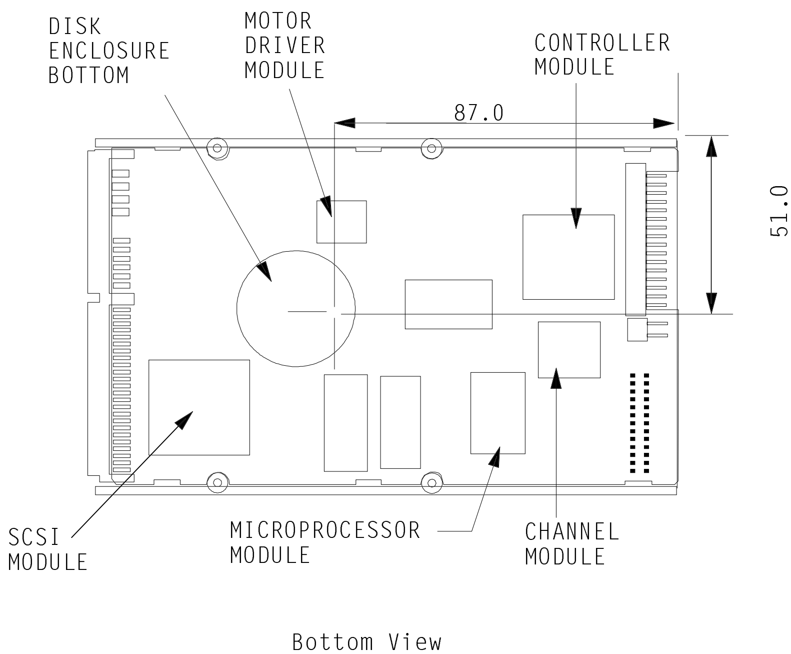


Fig 19. Temperature Measurement Points (bottom view)

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

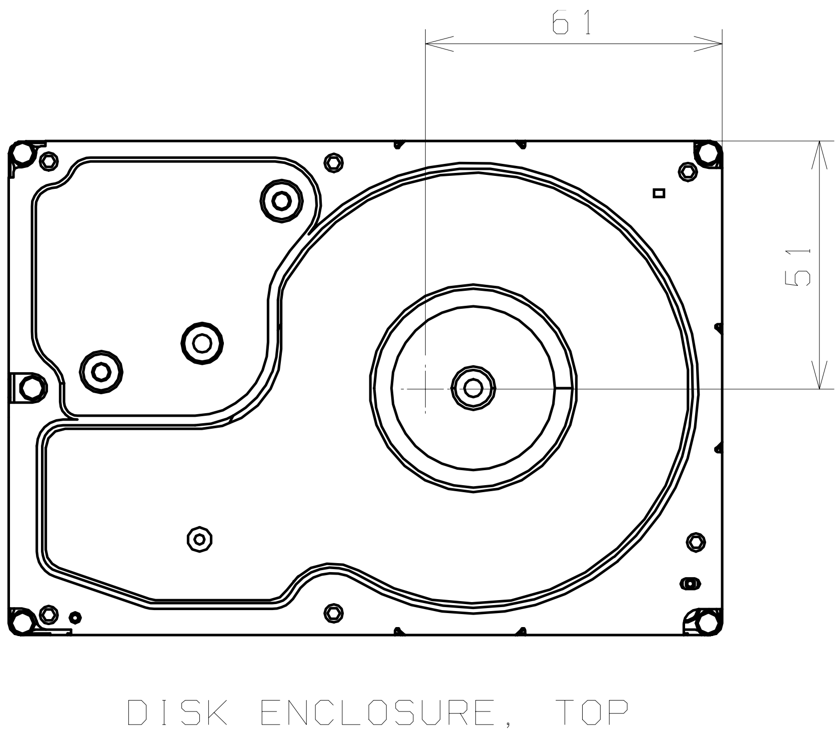


Fig 20. Temperature Measurement Point (top view)

7.1.1.1 Module Temp. 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.

7.2 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 35.
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.

7.2.1 Output Vibration Limits

Spindle residual imbalance not to exceed 0.5 gram-millimeters.

7.2.2 Operating Vibration

The vibration is applied in each of the three mutually perpendicular axis, one axis at a time. Referring to the figure “Ultrastar 9ZX Disk Drive Assembly” on page 10, 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.

7.2.2.1 Random Vibration

For excitation in the x-direction and the y-direction, the drive will operate without hard errors when subjected to vibration levels not exceeding the V4 vibration level defined below.

For excitation in the z-direction, the drive will operate without hard errors when subjected to vibration levels not exceeding the V4S vibration level defined below.

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.

Class	5 Hz	17 Hz	45 Hz	48 Hz	62 Hz	65 Hz	150 Hz	200 Hz	500 Hz	RMS
V4	2.0E-5	1.1E-3	1.1E-3	8.0E-3	8.0E-3	1.0E-3	1.0E-3	8.0E-5	8.0E-5	0.56
V4S	2.0E-5	1.1E-3	1.1E-3	8.0E-3	8.0E-3	1.0E-3	1.0E-3	4.0E-5	4.0E-5	0.55
Units	g2/Hz									g

Table 18. Random Vibration Levels

7.2.2.2 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 300 hz in the x- and y direction.

This measurement is taken during a frequency sweep from 5 to 300 Hz and back to 5Hz. The sweep rate will be one Hz per second.

Note: 1.0 G acceleration at 5 hz requires 0.78 inch double amplitude displacement.

7.2.3 Nonoperating Vibration

No Physical damage or degraded throughput 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 300 Hz and back to 5 Hz at a sweep rate of eight decades per hour.

Frequency	5 Hz to 7 Hz	7 Hz to 300 Hz
Amplitude	0.8 inch DA	2.0 G peak

Table 19. Non-operating Vibration Levels

7.2.4 Operating Shock

No permanent damage will occur to the drive when subjected to a 10 G half sine wave shock pulse of 11 milliseconds duration.

No permanent damage will occur to the drive when subjected to a 10 G half sine wave shock pulse of 2 milliseconds duration.

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

7.2.5 Non-Operating Shock

7.2.5.1 Translational Shock

No hard error or acoustic degredation will occur if the unpackaged drive is subjected to a 20 millisecond square pulse shock of 35 Gs or less applied to all three axes, one direction at a time.

No hard error or acoustic degredation will occur if the unpackaged drive is subjected to a 2 millisecond half sine pulse shock of 140 Gs or less applied to all three axes, one direction at a time.

7.2.5.2 Rotational Shock

The actuator will remain latched in the disk landing zone if the unpackaged drive is subjected to a 2 millisecond half sine wave shock less than 15,000 radians per second squared applied to the XY plane.

7.3 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).

7.4 Acoustic Levels

	Octave Band Center Frequency (Hz)								A-weighted
	125	250	500	1	2	4	8	16	Bel
Idle	3.45	2.2	3.3	3.88	4.35	4.92	4.09	3.64	5.08
Operating	3.43	2.34	3.38	3.89	4.49	5.37	4.32	3.88	5.53

Table 20. Upper Limit Sound Power Requirements (Bels)

Additionally, the population average of the sound pressure measured one meter above the center of the drive in idle mode will not exceed 41 dB.

Notes:

1. The above octave band and A-weighted sound power levels are statistical upper limits of the sound power levels. See C-B 1-1710-027 and C-S 1-1710-006 for further explanation.
2. The drives are tested after a minimum of 20 minutes warm-up in idle mode.
3. The operating mode is simulated by seeking at a rate at 32 seeks per second.
4. The values for a sample size of 5 or greater will be less than or equal to the stated upper limits with 90% confidence.

7.5 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 axis 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.

10020 RPM harmonics: 167Hz, 334Hz, 501Hz, 668Hz....

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.

7.6 Drive/System Compatibility

Ultrastar 9ZX 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” on page 15. 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 to hot plug, Refer to “'Hot Plug/Unplug' support” on page 19 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 51. 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 54 and “Non-Operating Shock” on page 54. Both operating and non-operating shock should be measured in all 3 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 53.This must include random vibration must be measured in all three planes and Swept Sine Vibration.

To achieve system compatibility for vibration, it is recommended that the system conform to section “Drive Mounting Guidelines” on page 55.

Also, drives are sensitive to rotary vibration. Mounting within using systems must minimize the rotational input to drive mounting points due to external vibration.

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 35.

Electrostatic Discharge (ESD)

The drive contains electrical components sensitive to ESD. System design and assembly process, must protect the drive and must be verified to conform the the protection, care and handling guidelines found in section “ESD Protection” on page 59

Interface Compatability

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 40.

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, reference “Data Reliability” on page 50.

7.7 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 Gs 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)

7.8 Breather Filter Hole

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

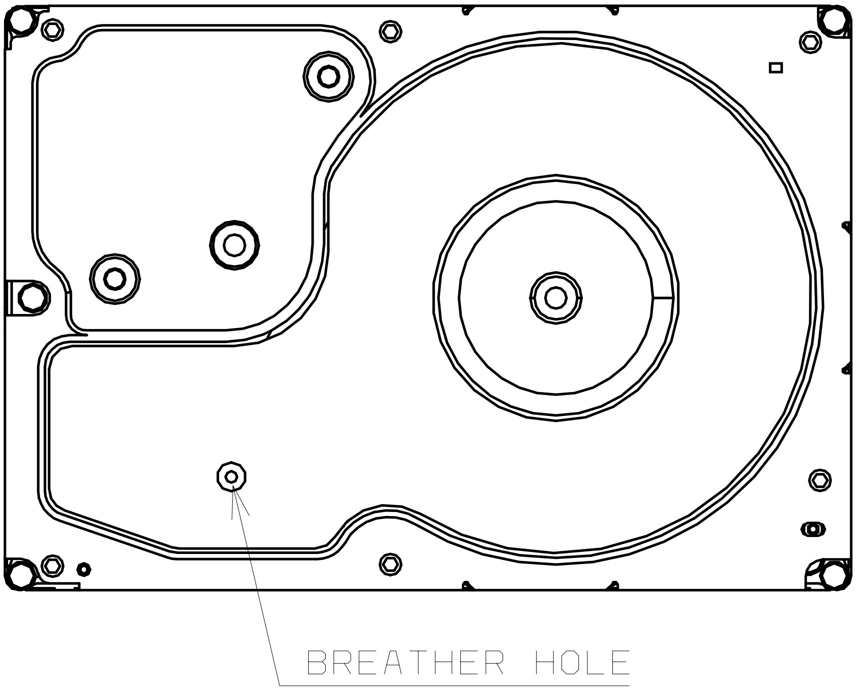


Fig 21. Breather Hole for Filter

7.9 Periodic Maintenance

None required.

7.10 ESD Protection

The Ultrastar 9ZX disk drives contain electrical components sensitive to damage due to electrostatic discharge (ESD). Proper ESD procedures must be followed during handling, installation, and removal. This includes the use of ESD wrist straps and ESD protective shipping containers.

7.10.1 ESD Handling

This product is sensitive to Electro Static Discharge.

Precautions such as using 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 device should be avoided. It is recommended that the device is always stored in its anti-static package until it is ready for installation.

7.10.2 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 device.

Stray field magnetic susceptibility is as follows. Field strength must be equal to or below the values shown at these frequencies where the drive is mounted.

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 21. Stray Magnetic Field Strength

8 Standards

8.1 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)

- 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 overcurrent 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. Overcurrent limits of the voltage into the file of 10 amps or less should be sufficient protection.

8.2 Electromagnetic Compatibility (EMC)

- FCC Requirements

  Pertaining to the Ultrastar 9ZX 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 9ZX 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.

  Pertaining to the Ultrastar 9ZX 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 complys with the European Directive.