



ULTRASTAR™ 36XP
Hardware/Functional Specification
36.4 GB, 7200 RPM
FC-AL Type DRHL, Model 36L

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1 Preface

This document contains the Hardware/Functional Specifications for the *Ultrastar 36XP* Fibre Channel High-Capacity Family of 3.5-inch Disk Drives.

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1 Description



Fig. 1. *Ultrastar 36XP* Disk Drive Assembly

1.1 Features

General Features

- 36.4 GB Capacity (512 bytes/sector)
- Industry-standard interface:
 - Dual 1.06 Gb/s Fibre Channel Arbitrated Loops
 - Supports dual-ported operations
 - Supports full-duplex (commands & data only) transfers
 - Login BB Credit = 2
 - Persistent Reservation
 - Enclosure Service Support (SES) Compliant
- FC-AL Standards Supported:
 - FC-AL rev. 4.5
 - Private Loop Direct Attach Profile rev. 1.10
 - FC-PH 4.3 (Physical and Signalling Interface)
 - FLA rev. 2.7 (Public Loop)
 - FC Protocol for SCSI rev. 12
 - SFF-8045/8067
- 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
- 2 MB segmented cache buffer
- LED Driver

Performance Summary

- Average read seek time: 7.5 milliseconds
- Average Latency: 4.17 milliseconds
- Sustained data transfer rate: 11.7 to 19.9 MB/s (16 notches)
- Peak media transfer rate 17.9 to 28.9 MB/s (16 notches)
- Maximum FC-AL interface data transfer rate: 106.25 MB/s
- Read command overhead: < 450 microseconds

FC-AL Interface Controller Features

- Variable logical block lengths (512 to 728 bytes in multiples of 8 bytes)
- Support for up to 16 initiators
- Nearly Contiguous Write
- Nearly Contiguous Read
- Read-ahead caching
- Adaptive caching algorithms
- Write Caching
- Back-to-back writes (merged writes)
- Automatic retry and data correction on read errors
- Automatic sector reallocation
- In-line alternate sector assignment
- Downloadable firmware

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)
- 12 Byte ECC on the fly
- Predictive Failure Analysis™ (PFA™)
- Error Recovery Procedures (ERP)
- Data Recovery Procedures (DRP)
- Probability of not recovering data: 10 in 10¹⁵ bits read
- Event logging and analysis
- Drive-Temperature Indicator Processor (Drive-TIP™) temperature monitoring and logging

1.2 Models

The *Ultrastar 36XP FC-AL* disk drive is available in one capacity of 36.4 GB. Please refer to section 2.3, “Capacities by Format Length” for exact capacities based on user block size.

This model features a 40-pin SCA-2 FC-AL connector. Both the SFF-8045 and SFF-8067 connector standards are supported with the same firmware.

2 Specifications

All specification values are mean population values unless otherwise noted.

2.1 General

The recording band located nearest the disk outer diameter (OD) is referred to as “Notch #0”, the recording band located nearest the inner diameter (ID) is called “Notch #15”. “Average” values are weighted with respect to the number of LBAs per notch when the drive is formatted with 512-byte blocks. Throughout this document 1 MB refers to 1,000,000 bytes and 1 GB refers to 1,000,000,000 bytes.

Data transfer rates (MB/s)

Buffer to/from media	Notch #0	Notch #15	Average
Instantaneous	28.9	17.9	26.0
Sustained	19.9	11.7	17.7

Host - buffer (max.) 106.25 MB/s

Rotational speed 7200 RPM

Average Latency 4.17 ms

Track density 11,550 TPI

	Minimum	Maximum
Recording density	213.647 kbp <i>i</i>	238.793 kbp <i>i</i>
Areal density	2467 Mb/in ²	2758 Mb/in ²

Disks	10
Heads	20

Seek timing Measured at nominal voltage and temperature

Single cylinder	0.30 ms (Read)
	0.90 ms (Write)
Average weighted	7.50 ms (Read)
	8.70 ms (Write)
Full stroke	14.5 ms (Read)
	15.7 ms (Write)

2.2 Notch Details

For the following conditions:

User bytes/Sector: 512
 Sectors/logical block: 1
 User bytes/logical block: 512
 Maximum addressable cylinders: 11494

The following notch data applies:

Notch	Start Cylinder	End Cylinder	User data Cylinders	Reserved Cylinders	Data/servo	User sectors
0	8	4,119	4,112	8	4/1	360
1	4,120	4,770	651	0	23/6	345
2	4,771	5,301	531	0	15/4	337
3	5,302	5,793	492	0	11/3	330
4	5,794	6,159	366	0	18/5	324
5	6,160	6,864	705	0	7/2	315
6	6,865	7,199	335	0	17/5	306
7	7,200	7,643	444	0	10/3	300
8	7,644	8,232	589	0	16/5	288
9	8,233	8,714	482	0	34/11	278
10	8,715	9,588	874	0	3/1	270
11	9,589	10,008	420	0	14/5	252
12	10,009	10,517	509	0	8/3	240
13	10,518	10,757	240	0	13/5	234
14	10,758	11,266	509	0	5/2	225
15	11,267	11,501	235	0	12/5	216

Table 1. Notch Capacities

Valid user bytes/sector: 512 to 728, in multiples of 8 bytes

2.3 Capacities by Block Size

For the following allowable block sizes, the drive capacity is as follows:

User Bytes / Logical Block	User Logical Blocks
512	72,170,880
520	70,061,520
528	69,229,240
536	68,337,680

Table 2. Available User Blocks

Logical block size (bytes)	User bytes / drive
512	36,951,490,560
520	36,431,990,400
528	36,553,038,720
536	36,628,996,480

Table 3. Available User Bytes

Notes:

1. The Maximum Addressable LBA is **User Logical Blocks -1**. The minimum addressable LBA is 0.
2. Capacity = **User Logical Blocks x Block Size**.

2.4 Power Requirements

2.4.1 Specifications

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

Input Voltage

+5 V	5 V ($\pm 5\%$ during run and spin-up)
+12 V	12 V ($\pm 5\%$ 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

Operation Mode	Meas.	Current, Amps		Power, Watts		Total Pwr,
	Type	+5V	+12V	+5V	+12V	Watts
Spindle Start	Peak	1.4	2.7			
Power Save	RMS	1.01	0.72	5.1	8.6	13.7
Idle (OD)	RMS	1.26	0.72	6.3	8.6	14.9
30 IOPS	Peak	1.65	2.3			
30 IOPS	RMS	1.34	0.95	6.7	10.6	17.3
60 IOPS	RMS	1.29	1.13	6.4	12.4	18.8
90 IOPS	RMS	1.26	1.19	6.3	13.2	19.5

Table 4. Ultrastar 36XP Power Requirements

Notes:

1. These values are averages of measurements over a limited sample size of drives. Current and power measurements can vary from these values by $\pm 10\%$.
2. Power measurements were made using a Clarke-Hess Model 259 Wattmeter at nominal supply voltages.
3. Idle measurements were done after a 30 minute warm-up time and while track-following on cylinder 0.
4. For the non-idle measurements an "op" is defined as a read transfer of 4KB over a random distribution of LBAs across the entire LBA range of the drive.
5. "Peak" values are typical maximum values.

2.4.2 Power Supply Graphs

These graphs are actual traces recorded on real drives in a lab environment at nominal power supply voltages. They are intended to be typical examples and do not show worst-case conditions. The results exclude inductive spikes caused by leads or power supplies.

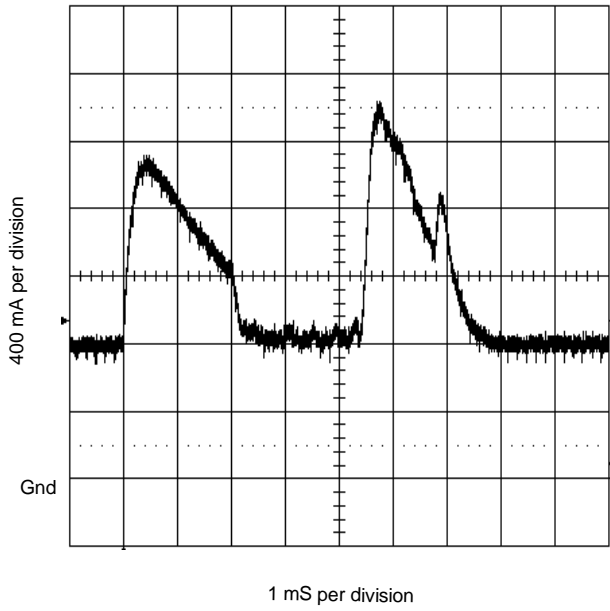


Fig. 2. 12V Seek Profile

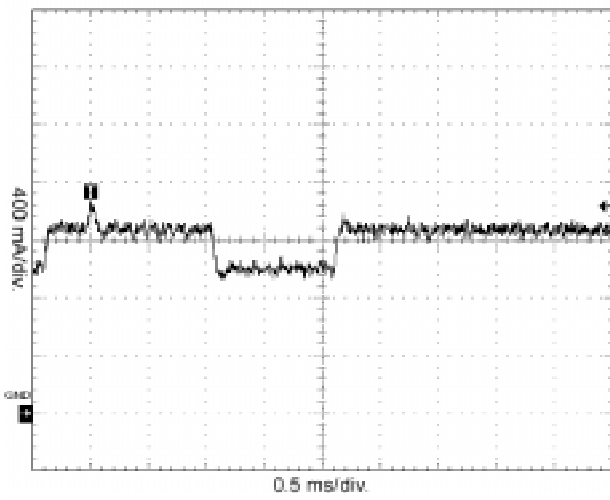


Fig. 3. 5V Read Current Profile

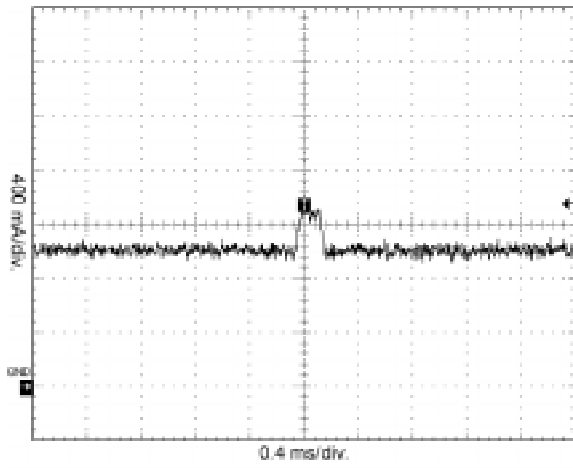


Fig. 4. 5V Write Current Profile

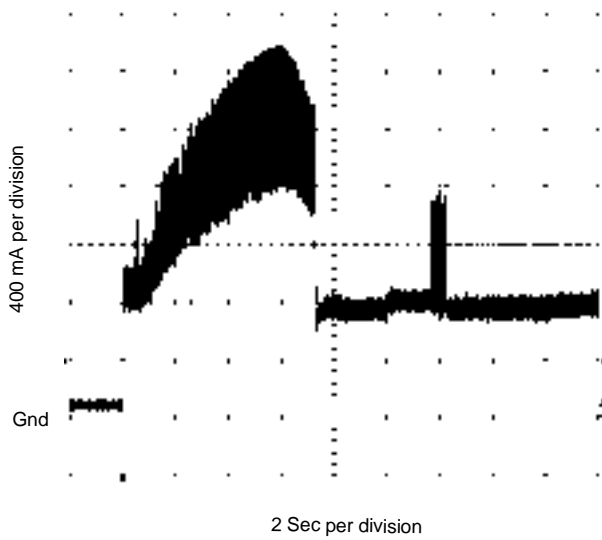


Fig. 5. 12V Start Current Profile

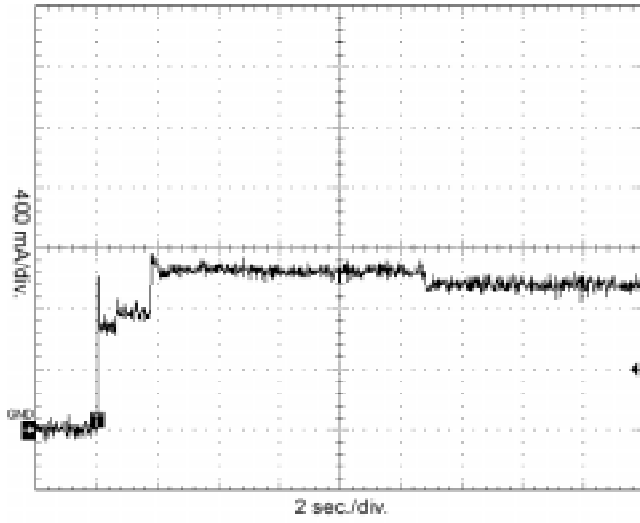


Fig. 6. 5V Start Current Profile

2.4.3 Power Supply Ripple

Externally Generated Ripple as seen at the drive power connector:

	Maximum	Frequency
+5 V DC	250 mV P-P	0-20 MHz
+12 V DC	650 mV P-P	0-100 Hz
	400 mV P-P	100-5 KHz
	250 mV P-P	5 KHz - 20 MHz

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

2.4.4 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 20 mA (150 kHz to 230 MHz).

2.4.5 Input Capacitance

Internal bulk capacitance as seen at the drive power connector:

+5 V DC	63 μ F +/- 20%
+12 V DC	502 μ F +/- 20%

2.4.6 Grounding Requirements of the Disk Enclosure

The disk enclosure is at Power Supply ground potential.

For the best Electromagnetic Compatibility (EMC) performance a common ground connection should be provided between the disk enclosure and the system's mounting frame. The disk enclosure should not become an excessive return current path from the system frame to power supply. The system frame must be within ± 150 mV of the drive's power supply ground. At no time should more than 20 mA of current (0 to 230MHz) be injected into the disk enclosure.

2.4.7 Hot-Plug/Unplug Support

Backplane hot-plug and unplug is allowed for all FC-AL models. It is assumed that port bypasses are active on both FC-AL ports, and that they are both enabled (e.g. the drive is bypassed) during the plug or unplug event.

During a hot plug-in event the drive will draw a large amount of current when it is plugged in because of the charging of the bypass capacitors on the drive. This current pulse may cause the power supply to go out of regulation. If this supply is shared by other drives then a low voltage power-on reset may be initiated on those drives. Never daisy-chain the power leads if hot plugging is planned. Hot plugging should be minimized to prevent wear on the power pins of the connector.

If allowed to do so via the protocol-specific SCSI Mode Page 19, the drive will un-bypass itself on both ports and LIP after a plug-in event.

During hot-plugging, the supplies must not exceed the drive's upper voltage limit. Proper ESD protection must be used during the plugging event.

If the drive's operating shock limit specification can be exceeded during hot-unplugging, then the drive should be spun down completely before it is unplugged.

2.5 Bring-up Sequence (and Stop) Times

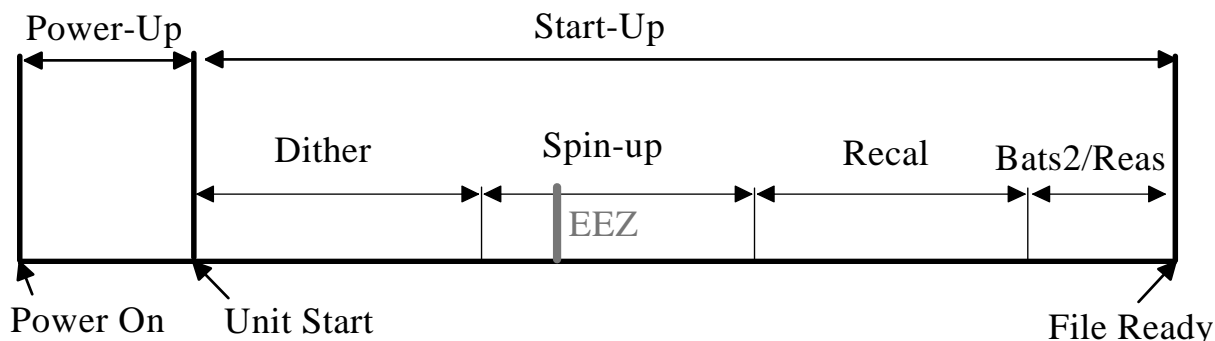


Fig. 7. Start Time Diagram

Definitions:

Power-Up Time: Time for completion of Power-on-Reset, Code load from flash SRAM for IP and SP, BATS1 testing.

Extra Start Attempts: If the drive does not spin-up upon the first attempt, up to two more attempts will take place ¹.

Spin-Up: Time required to go from 0 to 10,000 rpm.

EEZ: Early Exit from landing zone occurs.

Recal: Time required for a complete recal on all heads.

Bats2/Reassign: Time it takes to do the R/W tests and complete any necessary reassigns.

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 *Mako/Hammerhead/Swordfish FC-AL Interface Specification* for additional details on the Startup sequence.

If configured to do so, the drive will enable itself on both FC-AL loops at the end of power-up (auto-start disabled) or at the end of start-up (auto-start enabled).

If a “Target Reset” SCSI Task Management Function 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 “Target Reset” is issued, the present state of the motor is not altered. Reference section 3.8.1.3, “Start/Stop Unit Time” for additional details.

A startup 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 startup sequence increasing by as much as 10 seconds. For example, if a delay of only 3 seconds exists between the two commands, the second command takes 7 seconds longer than if 10 seconds or more had been allowed between the commands.

¹In the unlikely event that the drive fails to spin-up after three start attempts, a dither-sequence will be initiated.

	Nominal (sec)	Worst Case ² (sec)
<i>Power-Up</i>	2.5	3
Start attempts	0	4.6
Spin-Up	10.5	14
Servo Recal	9.9	9.5
Bats2/Reassign	0.5	1
Start-Up Time	20.9	29.1

Table 5. Bring-up Sequence Times

2.5.1 Spin Down Times

After power is removed the drive should be allowed 20 seconds to park the heads and spin down before handling the drive.

² Worst Case represents a 3-sigma event.

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 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 4. The total data buffer length is 671KB. 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". The number of blocks of customer data that can fit into one segment is reduced because 2 bytes of buffer CRC information is stored in the segment for each block of customer data.
- Ten-byte SCSI Read and Write commands are used.
- The FC-AL environment consists of a single initiator and a single target.
- Buffer full/empty ratios are set to their optimum values such that a minimum number of intermediate disconnects occur during the FC-AL data transfer and the overlap of the FC-AL interface and disk data transfer is maximized. This minimizes command execution times with no loop contention.
- All performance-enhancing functions are disabled, except where noted. More specifically,
 - Commands are not queued unless otherwise specified
 - Read Caching and Read Ahead functions are enabled and Write Caching is disabled, except where noted.
- The initiator delay while transferring commands, status, message, and data bytes is assumed to be zero.
- All Current Mode Parameters are set to their Default values except where noted.
- FC-AL raw data transfers are assumed to occur at 106.25 MB/s.
- Averages are based on a sample size of 10,000 operations.

3.2 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 specifications for Command Execution Time with Read Ahead describe exceptions to this restriction. For that scenario all commands are preceded by a Read command, except for sequential write commands.

- The time between the end of an operation and the start of the next operation is the minimum that the test system will support. This is to ensure that the maximum stress is placed on the drive when validating its performance.

3.2.1 Sequential

No Seeks. The target LBA for all operations is the previous LBA + Transfer Length.

3.2.2 Random

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

3.3 Command Execution Time

Command Execution (or Service) times are comprised of the sum of several basic components, which are:

1. Seek
2. Latency
3. Command Execution Overhead
4. Data Transfer to/from Disk
5. Data Transfer to/from FC-AL Loop

The impact or contribution of these Basic Components to Command Execution Time is a function of the workload and the environment in which the drive is being operated.

The following graphs show Command Execution Times for the following four generic workloads vs. transfer length:

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

The data were generated using the following test configuration:

- Dell Precision 410 Workstation (400 MHz Pentium II) w/ 128MB RAM
- IOMeter running on Windows NT4
- Emulex LitePulse 7000E Host Adapter
- WCE=1
- Seg=10

All graphs were generated with queue depth=16.

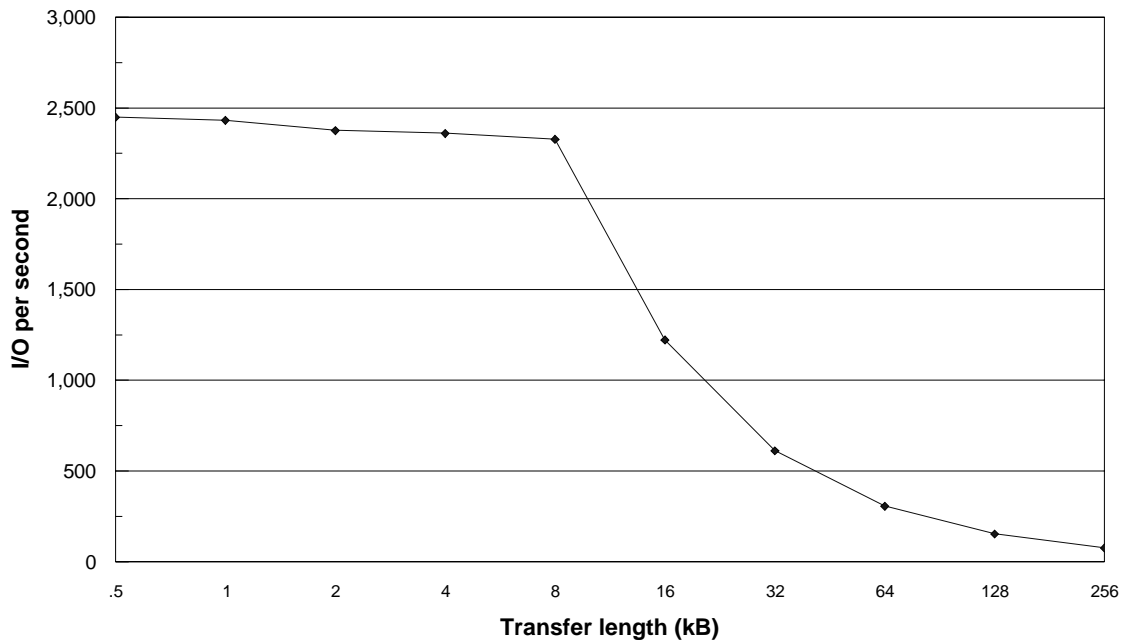


Fig. 8. Sequential Read Performance

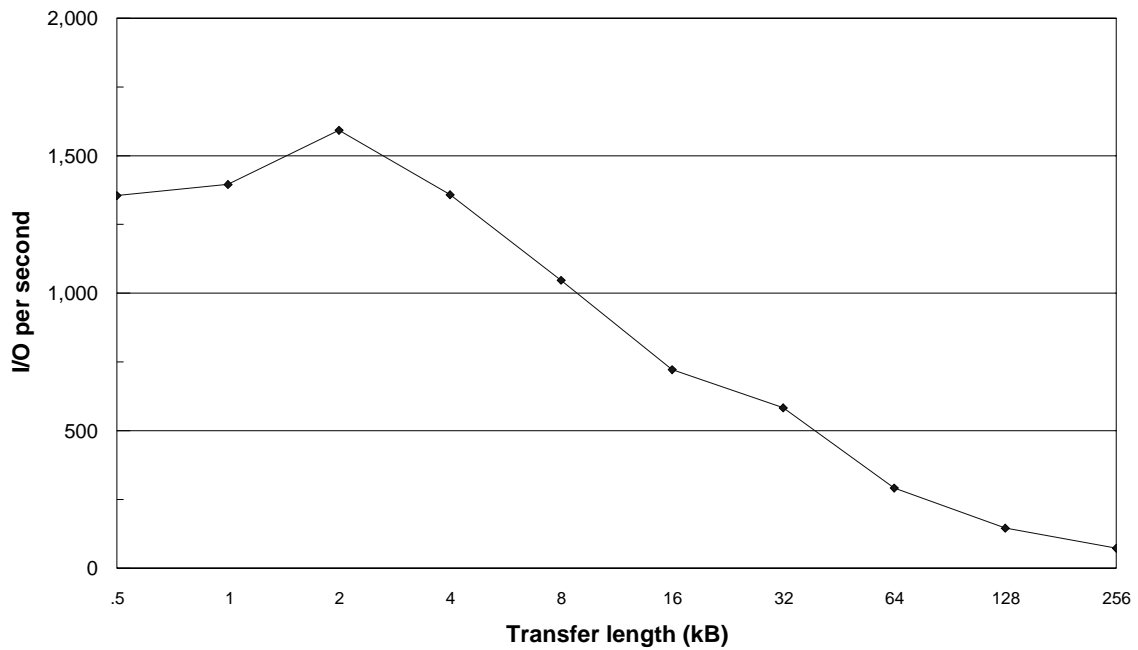


Fig. 9. Sequential Write Performance

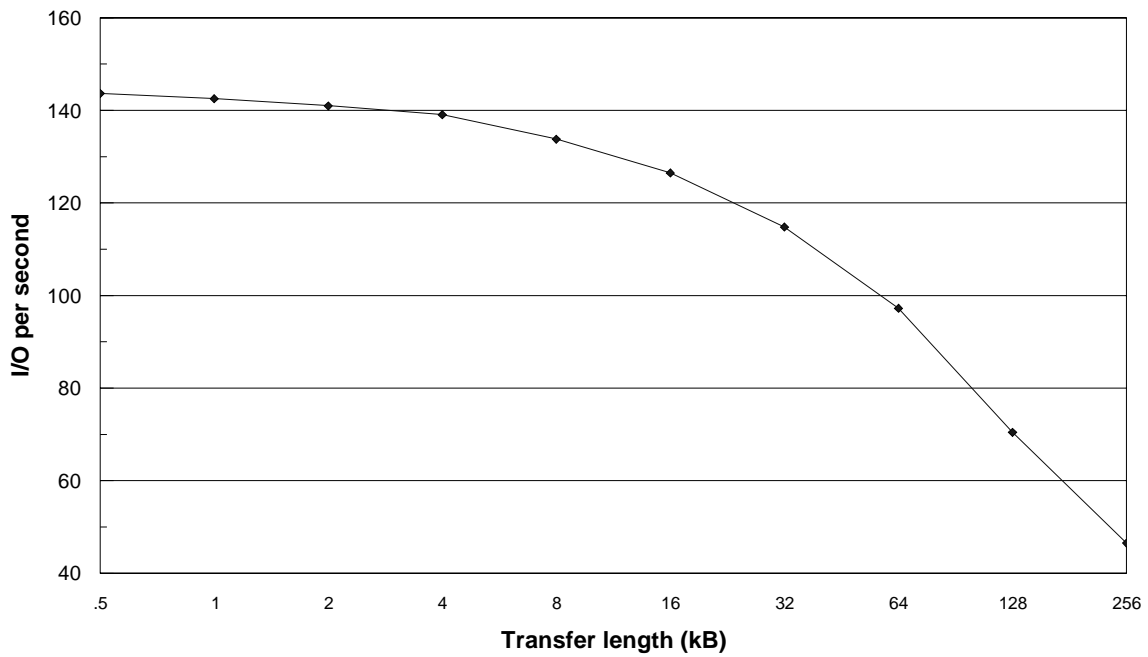


Fig. 10. Random Read Performance

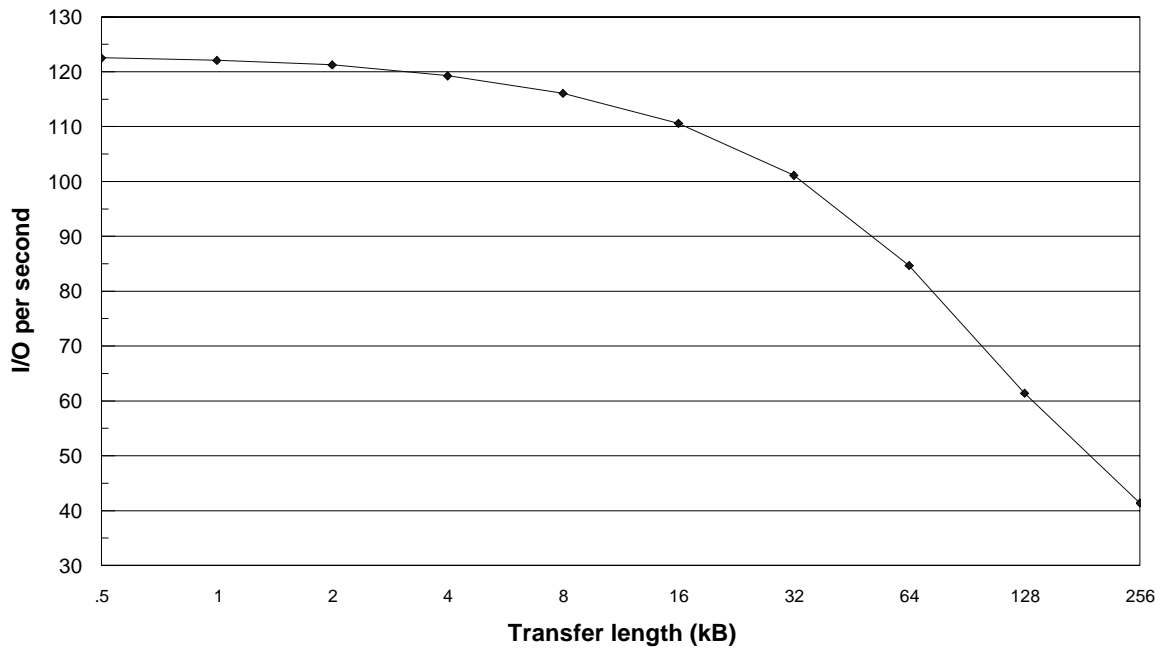


Fig. 11. Random Write Performance

3.3.1 Basic Component Descriptions

3.3.1.1 Seek

Seek Time is 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 2.1 , "General".

3.3.1.2 Latency

Latency is 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.

3.3.1.3 Command Execution Overhead

Command Execution Overhead is the average time added to the Command Execution Time due to the processing of the command. It includes all time the drive spends processing a command while not doing a disk operation or FC-AL data transfer, whether or not it is OPEN/OPENED on the loop. The value of this parameter varies greatly depending upon workloads and environments.

The following values are used when calculating the Command Execution Times. 'RA' means Read Ahead is enabled.

Workload	Command Execution (mS)	FC-AL Loop (mS)
Sequential Read (w/o RA -w/RA)	0.37	0.3
Sequential Write (WCE=0/1)	0.62	0.4
Random Read (w/o RA - w/RA)	0.21 / 0.38	0.3
Random Write	0.21	0.4

Table 6. Overhead Values

A number of initiator-controlled factors affect Command Execution Overhead. These are examined separately in section 3.4 , "Approximating Performance for Different Environments":

FC-AL Loop Overhead is defined as the time required for the device is OPENED on the loop and having transferred all SCSI Command and Response Information Units (i.e. FCP_CMD and FCP_RSP IU's). This includes any processing delays between frames while remaining OPENED on the loop. Initiator delays while transferring information bytes are assumed to be zero. This time does not include actual data transfer (i.e. FCP_DATA frames).

Post Command Processing time of 0.1 ms is defined as the average time required for process cleanup after the command has completed. If a re-instruct period faster than this time is used, the difference is added to the Command Execution Overhead of the next operation.

3.3.1.4 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:

$$\text{(Data Transferred)} / \text{(Media Transfer Rate)}.$$

There are four interpretations of Media Transfer Rate:

1. Instantaneous Data Transfer Rate

This is 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:

$$1/(\text{individual byte time})$$

2. Track Data Sector Transfer Rate

This 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:

$$(\text{user bytes/sector})/(\text{individual sector time})$$

(Contact an IBM Customer Representative for individual sector times of the various formatted block lengths.)

3. Theoretical Data Sector Transfer Rate

This also includes time required for track and cylinder skew and overhead associated with each track. This is calculated from:

$$\text{Data Sector Transfer Rate} = (\text{Bytes/cylinder}) / (\text{time for 1 cyl} + \text{track skews} + \text{1 cyl skew})$$

4. Typical Data Sector Transfer Rates

This also includes the effects of defective sectors and skipped revolutions due to error recovery (see Appendix B of the *Mako/Hammerhead/Swordfish FC-AL Interface Specification* for a description of error recovery procedures.)

Rates for drives formatted at 512 bytes/block are shown in Table 8.

Notch #	Instantaneous	Track	Theoretical	Typical
Average	26.03	19.73	17.77	17.69
0	28.89	22.12	20.01	19.91
1	28.26	21.20	19.14	19.05
2	27.64	20.71	18.66	18.57
3	27.01	20.28	18.29	18.20
4	26.54	19.91	17.92	17.84
5	25.59	19.36	17.43	17.35
6	25.12	18.80	16.88	16.80
7	24.50	18.43	16.57	16.49
8	23.66	17.70	15.89	15.82
9	22.93	17.08	15.29	15.21
10	21.56	16.59	14.85	14.78
11	20.83	15.49	13.76	13.69
12	19.78	14.75	13.08	13.02
13	19.31	14.38	12.71	12.65
14	18.37	13.83	12.27	12.21
15	17.90	13.27	11.73	11.67

Table 7. Data Sector Transfer Rates (MB/s) @ 512 bytes/block

Notes:

- The values for Typical Data Sector Transfer Rates assume a typically worst-case soft error rate of 3×10^9 bits read at nominal conditions.
- Contact an IBM Customer Representative for values when formatted at other block lengths.
- 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.

3.3.1.5 Data Transfer to/from FC-AL Loop

The time required to transfer data between the FC-AL loop 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 an FC-AL loop raw transfer rate of 106.25 MB/s.

3.3.2 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 FC-AL Loop Overhead amount 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 and from the disk.

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 one 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 one revolution less than similar operations with equal inter-op delays and Read-Ahead disabled.

3.4 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 FC-AL or disk data transfers, etc. The following paragraphs describe which parameters are affected by which features.

3.4.1 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 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), the Data Transfer to/from Disk time 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 FC-AL loop 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.

3.4.2 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:

$$\text{Read-Ahead savings} = -(\text{Latency} + (\text{Xfer Size})/(\text{Disk Data Rate}) - (\text{Xfer Size})/(\text{FC-AL Data Rate}))$$

The magnitude of the performance advantage of the Read-Ahead with op delays of 0 to 1 disk revolution 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:

$$\text{Read-Ahead savings} = \text{DELAY} - (\text{time for one revolution})$$

This time also varies with the size of the data transfer due to the difference between the FC-AL data transfer rate and Disk data transfer rate. This time is insignificant for a 0.5KB transfer size and has been ignored in the above equation.

3.4.3 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 FC-AL Loop Time 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 are added to the Post Command Processing Time.

Like Tagged Command Queuing, the potential to reduce Command Execution Overhead exists because of concurrent command processing.

When the WCE bit is set, Back-To-Back write commands are supported. See section 3.1.5.2, "Back-to-Back Write Commands", for more information.

Command completion status is returned when data is completely stored in the buffer. The time to transfer this data to the disk will be added to the performance of any next command that was in the queue.

3.4.4 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 Mode Parameters, with algorithms using the collected workload information.

3.4.5 For Queued Commands

The effects of Command Execution Overhead can be reduced significantly if Tagged Command Queuing is enabled since more than one command can be operated on concurrently. For instance, while a disk operation is being performed for one command another command can be received 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.

3.4.5.1 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 are minimized. The amount of reduction is a function of the location of the first requested block per command and the rate at which the commands are sent to the drive.

A Queue Algorithm Modifier Mode Parameter value of 9 enables an algorithm that gives the using system the ability to place new commands into the drive command queue execution order relative to the outstanding commands in the queue. For example, if a request is sent to the drive that the using system prioritizes such that its completion time is more important than one or more of the outstanding commands, the using system can increase the likelihood that command is executed before those others by using a tag value greater than those outstanding commands.

3.4.5.2 Back-to-Back Write Commands

If all of the requirements are met as stated in the *Mako/Hammerhead/Swordfish FC-AL Interface Specification* section describing Back-To-Back write commands, contiguous data from two or more consecutive write commands can be written to the disk without incurring any disk latency.

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 disk 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.

3.5 Skew

3.5.1 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 number). Cylinder skew is always a fixed minimum amount of 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 2.13 ms.

3.5.2 Track Skew

Track Skew is the time required to perform a head-switch on the same cylinder; it is 0.83 ms.

3.6 Idle-Time Function Considerations

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

1. Predictive Failure Analysis (PFA)
2. Data Logging
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, OPENS, Command phases, and CLOSEs controlled by the drive are not affected by idle-time activities. Command Timeout Limits do not change due to idle-time functions.

Listed below 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.

The following mechanisms can reduce or eliminate performance impacts to an initiator:

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 Rezero Unit commands at known and fixed time intervals) in order to control if and when this function executes.

2. Synchronized operation

Applications which can not accommodate 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.

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 could not be tolerated by the system on any of those commands. This would eliminate drive initiated Idle-Time Function from even 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 *Mako/Hammerhead/Swordfish FC-AL Interface Specification* for details.

3.6.1 Predictive Failure Analysis (PFA)

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. Their impacts 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. The measurements for all heads are taken over a period of 4 hours, therefore the PFA frequency depends on the number of heads. The drive attempts to spread the measurements out evenly in time with each measurement taking about 80 ms. Therefore, *Ultrastar 36XP*, having 20 heads, will perform one PFA measurement every 1.7 minutes (240 / 7*20).

For the last head tested for a particular measurement type (once every 34 minutes), the data is analyzed and stored. The extra execution time for those occurrences is approximately 40 ms.

PFA 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 *Mako/Hammerhead/Swordfish FC-AL Interface Specification* for more details about PFA, PERF and TCC.

3.6.2 Data Logging

The drive periodically saves data in logs in the reserved area of the drive. The information is used by the drive to support various SCSI commands and for 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 new log entries since the last update; in most cases it is less than 30 ms.

3.6.3 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. 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 first disk sweep is reduced back down to 40 seconds. The period is increased back to 9 minutes for subsequent occurrences should no more SCSI commands be received during that time. Execution time is less than one full-stroke seek time

3.6.4 Summary

Idle-Time Function Type	Period (minutes)	Duration (ms)	Mechanism to Delay	Mechanism to Disable
PFA	30/(trk/cyl)	80	Re-instruction period	PERF
Data Logging	26	30	Re-instruction period	
Disk Sweep	2/3 - since last command	17	Re-instruction period	
	9 - since last occurrence			
Note: "Re-instruction period" is the time between consecutive SCSI command requests				

Table 8. Summary of Idle-Time Function Performance Impacts

3.7 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 host if the temperature passes beyond the drives maximum operating range. The sensor is physically mounted on the reverse side of the electronics card but is calibrated to report the DE casting temperature.

The temperature-monitoring algorithm is described below:

- The temperature is first sampled 15 minutes after power-on. If it is below 50C then no further action is taken and the temperature will continued to be sampled at 15-minute intervals.
- If the temperature is between 50C and 65C an internal flag is set to signal a PFA event and the temperature is internally logged by the drive. See the *Mako/Hammerhead FC-AL 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. While the temperature remains in the range 50C to 65C the temperature will be re-sampled every 15 minutes and potentially additional PFA events signaled.
- If the temperature exceeds 65C then action similar to the 50C to 65C range is taken but the sampling interval is decreased 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. it must drop below 60C and 45C respectively.

Measuring the drive's temperature takes approximately 440 microseconds. 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.

3.8 Command Timeout Limits

The "Command Timeout Limit" is defined as the time period from the receipt of a SCSI command through STATUS.

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

3.8.1.1 Reassignment Time

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

3.8.1.2 Format Time

An average of 80 minutes should be allowed to complete a "Format Unit" command for *Ultrastar 36XP*. If the Vendor Unique Mode Page 00h byte 14, bit 3 (FFMT) is set equal to '1'b then the drive should be allowed 30 seconds to complete the command.

3.8.1.3 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 startup 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.

A timeout limit of one minute or more is recommended but not required. The longer host timeout limit allows the host to take advantage of the extensive ERP/DRP that the drive may attempt in order to successfully complete the startup sequence.

3.8.1.4 Medium Access Command Times

The timeout limit for medium access commands that transfer data should be a minimum of 30 sec. These commands are:

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

The 30 sec limit assumes the absence of loop bandwidth contention and assumes data transfers of 64 blocks or less. This time should be adjusted for anticipated contention and for longer data transfer lengths.

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

3.8.1.5 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)
- Test Unit Ready

The command timeout limit for a command that is not located at the head of the command queue should be increased by the sum of all the command timeout limits for the previous commands.

4 Mechanical

4.1 Weight and Dimensions

	SI Metric	US
Weight	1.08 kg	2.38 lb
Height	41.00 mm	1.61 in
Width	101.85 mm	4.00 in
Depth	147.00 mm	5.79 in
Notes: These are nominal weights and dimensions provided for reference only. The dimensional tolerances are shown in the next four figures. The weight tolerance is +/- 10%. Card interface types and disk quantity determine the weight variability.		

Table 9. Weight and Dimensions

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” in section 7.1.1.

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 Figs. 14-16 for the locations of the mounting holes.

The maximum allowable penetration of the mounting screws is 4.0 mm. Screws longer than 4.0 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” in section 7.5.

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 intended to be exhaustive.

1. The SCA-2 connector should not be required to support the weight of the drive
2. Operational vibration occurring between the mating halves of the SCA-2 connector should be avoided.

3. The drive should be firmly secured once the connector has been mated.
4. The connector is designed to allow for some offset during plug-in operation. Excessive offsets between the drive connector and backplane will induce stress on the connector system and card.

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 Side Mounting Holes

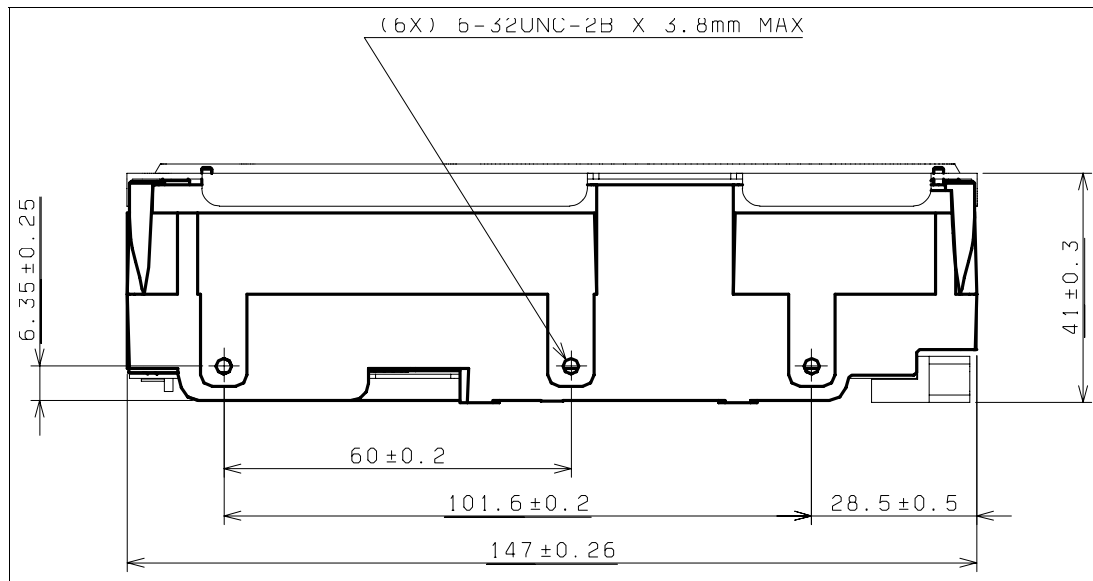


Fig. 12. Locations of Side Mounting Holes

Notes:

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

4.4.2 Bottom Mounts

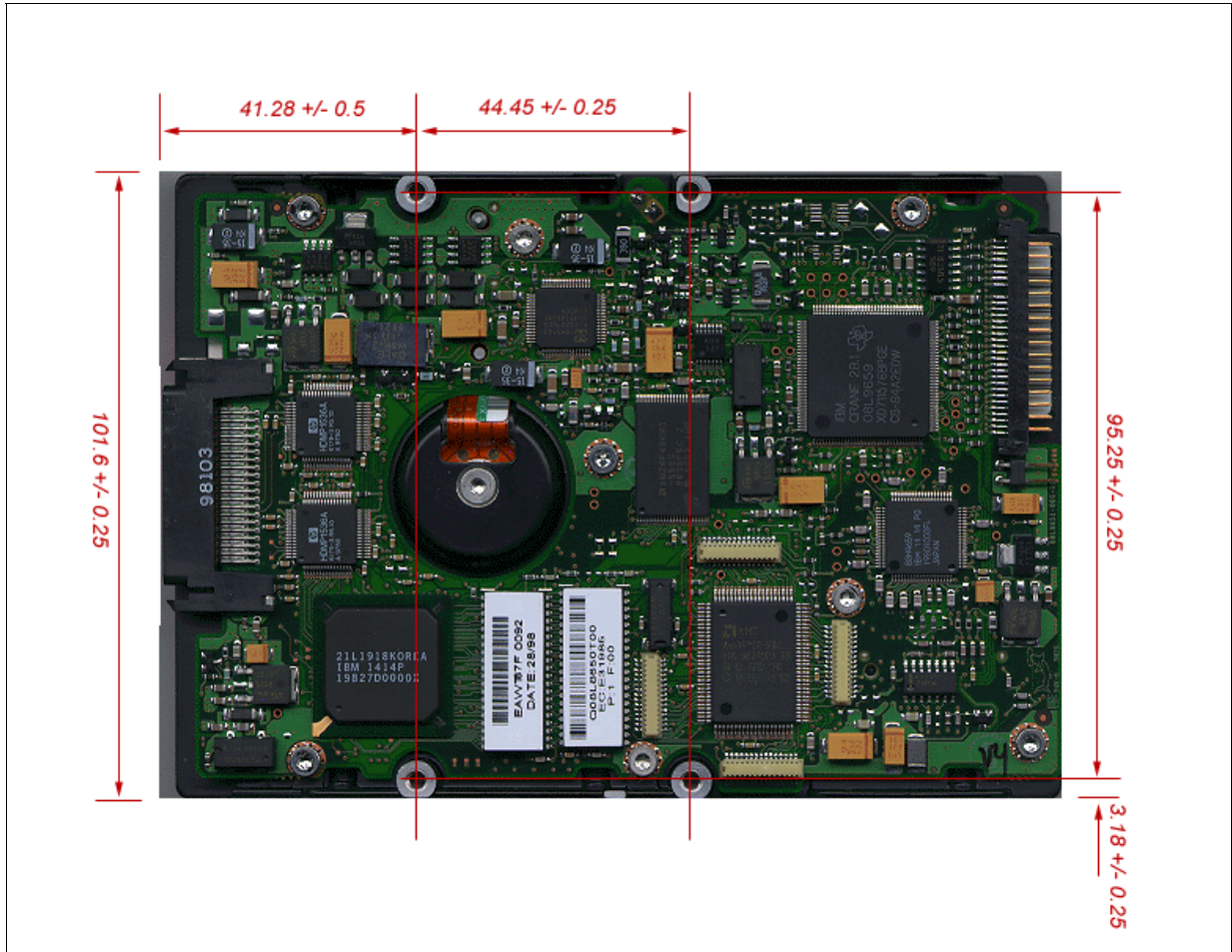


Fig. 13. Locations of Bottom Mounting Holes

4.5 Electrical Connectors

4.5.1 40-Pin FC-AL Connector

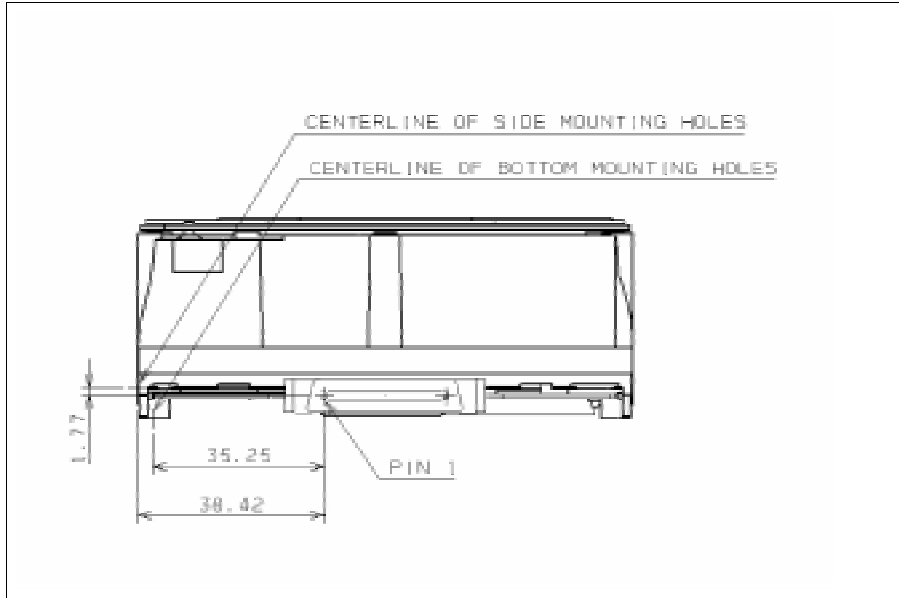


Fig. 14. 40-pin FC-AL Connector

4.5.2 Option Block

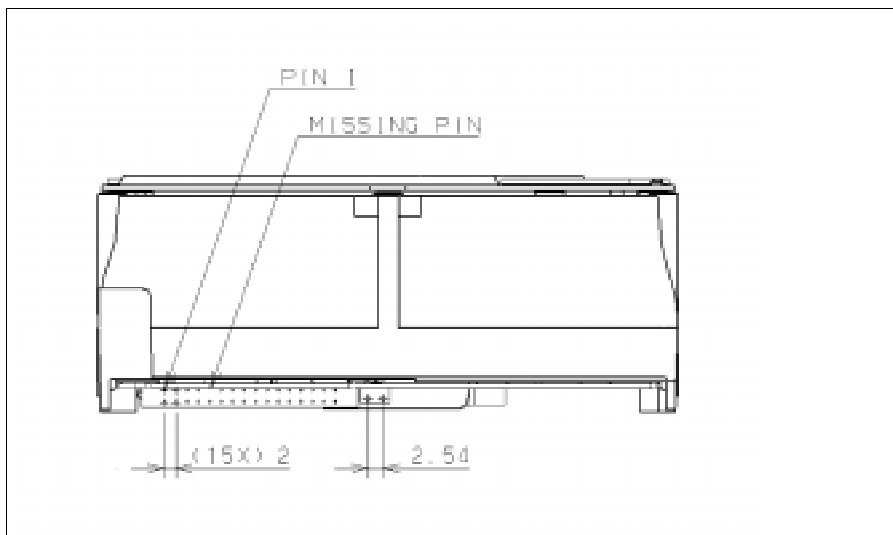


Fig. 15. Option Block

5 Electrical Interface

5.1 FC-AL Connector

Ultrastar 36XP uses the 40 pin SCA-2 connector defined by the ANSI SFF-8045 Specification. SFF-8067 is also supported. The only difference between SFF-8045 and SFF-8067 is the Enclosure Service Interface. The drive will "discover" the level of Enclosure Service Interface supported by the enclosure and use the proper level for all enclosure communication. This "discovery" process is defined in SFF-8067 specification.

It is expected that the drive will be used in an environment which uses a common connector structure for mounting the drives. The connector allows for plugging a drive directly into a backplane by providing the necessary electrical connection. Mechanical stability and device retention must be provided by other mechanisms outside the drive.

The signals defined in this connector include:

- Dual Ported Fibre Channel In/Out signals
- +5V and +12V power and grounds (w/optional 3.3V)
- Port Bypass Control Signals
- Spindle Sync signals
- Motor Start Control
- SEL_ID (translatable to Hard AL_PA)
- Enclosure Service Interface
- LED signals

5.1.1 40-Pin SCA-2 SFF-8045 FC-AL Connector Definition

Ultrastar 36XP uses an AMP C-1123283-5 connector. This connector is compatible with the SFF-8045 connector specifications. The connector contact assignments are shown in Table 11.

The connector is used as specified in the Standard. Definition of these signals are provided here for a convenience. The use of optional pins is also defined here. Please see the latest SFF-8045/SFF-8067 Specifications for a more complete description of this connector.

Signal Name	Connector Contact Number		Signal Name
-ENBL BYP CH1	1	21	12V Charge
12 Volts	2	22	12V Ground
12 Volts	3	23	12V Ground
12 Volts	4	24	+Port 1_In
-Parallel ESI	5*	25	-Port 1_In
-Drive Present	6	26	12V Ground
Ready LED Out	7	27	+Port 2_In
Spindle Sync	8	28	-Port 2_In
Start_1/Mated	9	29	12V Ground
Start_2/Mated	10	30	+Port 1_Out
-ENBL BYP CH2	11	31	-Port 1_Out
Sel_6/ -EFW	12*	32	5V/3.3V Ground
Sel_5/ -P_ESI_5	13*	33	+Port 2_Out
Sel_4/ -P_ESI_4	14*	34	-Port 2_Out
Sel_3/ -P_ESI_3	15*	35	5V/3.3V Ground
Fault LED Out	16	36*	Sel_2/ -P_ESI_2
OPT 3.3 Volts	17	37*	Sel_1/ -P_ESI_1
OPT 3.3 Volts	18	38*	Sel_0/ -P_ESI_0
5 Volts	19	39	OPT 3.3V Charge
5 Volts	20	40	5V Charge
<p>Notes: The 3.3V contacts are not connected in the drive. The Guide Pins are connected to 5V/3.3V ground.</p> <p>* Definition changes for 8067; refer to 5.1.7.3 "P_ESI_n Function".</p>			

Table 10. 40-Pin SCA-2 SFF-8045 Connector Contact Assignments

5.1.2 Voltage and Ground Signals

The 12V and 5V voltage contacts provide all of the Voltages required by *Ultrastar 36XP*. The two voltages share a common ground plane to which all of the ground contacts are connected. The 3.3V contacts are left open.

5.1.3 Spindle Sync

This option is not supported by *Ultrastar 36XP*.

5.1.4 Fault LED Out

As specified in the SFF-8045 Specification, the Fault LED is driven under the following conditions:

- both enable bypass signals are asserted by the drive;
- an internal failure has been detected by the drive;
- the drive has been instructed by the host to turn on the LED.

Ultrastar 36XP provides an open-collector TTL driver with up to 30mA of current sink capability to drive a Fault LED. The cathode of the LED should be connected to this signal. The LED and the current-limiting resistor are provided by the enclosure.

5.1.5 Ready LED Out

As specified in the SFF-8045 Specification, the Ready LED has the following definition (per the Hot Plug implementation):

- **drive not mated:** The signal is de-asserted (i.e. high). The LED is off.
- **drive mated, motor not spinning:** The signal is asserted (i.e. low) for a period long enough to be detected by an observer whenever a SCSI command is received. The LED is mostly off.
- **drive mated, spinning up or down:** The signal is alternately asserted and deasserted for a period of 1/2 second. The LED is flashing.
- **drive mated, motor spinning:** The signal is normally asserted continuously. The signal is de-asserted for a period long enough to be detected by an observer, whenever a SCSI command is received. The LED is mostly on.

Ultrastar 36XP provides an open-collector TTL driver with up to 30mA of current sink capability to drive a Ready LED. The cathode of the LED should be connected to this signal. The LED and the current limiting resistor are provided by the enclosure.

5.1.6 Start x/Mated Controls

The **Start_x Mated** signals are TTL inputs to the drive and have 10K-ohm pullup resistors.

As per the SFF-8045 specification the "Start_x Mated" function is implemented as in the following table. Please refer to SFF-8045 for a more complete definition.

Start_2 Mated	Start_1 Mated	Motor Spin Function
Open	Open	Drive is not mated. No spin-up will occur.
Open	Gnd	The motor will spin up with the SCSI Unit Start Cmd.
Gnd	Open	The motor will spin up after a delay of 12 times the modulo 8 value of Sel_ID (in seconds).
Gnd	Gnd	The motor will spin up after drive initialization.

Table 11. Motor Spin Up Modes vs. Start_X Mated Pin Combinations

5.1.7 SEL_n and Enclosure Service Signals

These signals have different definitions depending on the state of **-Parallel ESI** and the level of enclosure service supported by the backplane. These definitions are described in the following subsections.

5.1.7.1 - Parallel ESI

-Parallel ESI is a TTL open drain output from the drive. It is used to establish the definition of the **SEL_ID/P_ESI** signals. When **-Parallel ESI** is de-asserted (high), the backplane shall present SEL_ID information on these signals (within 1usec). When **-Parallel ESI** is asserted (low), the backplane (if supported) will present enclosure service information on these signals (within 1usec). The drive will then go through a "discovery" phase to determine the level of enclosure services that the backplane supports (i.e. none, SFF-8045, or SFF-8067) and behave accordingly.

5.1.7.2 Sel_n Function

These TTL drive inputs (defined when **-Parallel ESI** is de-asserted) provide a binary value of loop identifier to the drive. These 7 signals define 128 possible values and are directly translated into an 8 bit hard AL_PA via the table below. Only AL_PA's with neutral disparity are valid values. The drive will attempt to acquire this hard AL_PA for its own during the LIHA phase of the loop initialization process (LIP).

SEL_ID	AL_PA	SEL_ID	AL_PA	SEL_ID	AL_PA	SEL_ID	AL_PA
0	EF	20	B2	40	72	60	3A
1	E8	21	B1	41	71	61	39
2	E4	22	AE	42	6E	62	36
3	E2	23	AD	43	6D	63	35
4	E1	24	AC	44	6C	64	34
5	E0	25	AB	45	6B	65	33
6	DC	26	AA	46	6A	66	32
7	DA	27	A9	47	69	67	31
8	D9	28	A7	48	67	68	2E
9	D6	29	A6	49	66	69	2D
A	D5	2A	A5	4A	65	6A	2C
B	D4	2B	A3	4B	63	6B	2B
C	D3	2C	9F	4C	5C	6C	2A
D	D2	2D	9E	4D	5A	6D	29
E	D1	2E	9D	4E	59	6E	27
F	CE	2F	9B	4F	56	6F	26
10	CD	30	98	50	55	70	25
11	CC	31	97	51	54	71	23
12	CB	32	90	52	53	72	1F
13	CA	33	8F	53	52	73	1E
14	C9	34	88	54	51	74	1D
15	C7	35	84	55	4E	75	1B
16	C6	36	82	56	4D	76	18
17	C5	37	81	57	4C	77	17
18	C3	38	80	58	4B	78	10
19	BC	39	7C	59	4A	79	F
1A	BA	3A	7A	5A	49	7A	8
1B	B9	3B	79	5B	47	7B	4
1C	B6	3C	76	5C	46	7C	2
1D	B5	3D	75	5D	45	7D	1
1E	B4	3E	74	5E	43	7E	NA
1F	B3	3F	73	5F	3C	7F	-
Notes: All values are in hex format. An AL_PA value of 0x00 is not valid for an NL-PORT. A SEL_ID of 0x7F forces the drive to obtain a soft address.							

Table 12. SEL_ID to AL_PA Translation Table

5.1.7.3 P_ESI_n Function

These TTL drive I/O's (defined when **-Parallel ESI** is asserted) provide an interface between the enclosure and the drive. When signals are defined as outputs, they are configured as open-drain drivers with 4mA sink capability.

When the drive asserts **-Parallel ESI**, it goes through a "discovery" process (see SFF-8067) to determine the level of enclosure service supported by the backplane. The outcome of the "discovery" process is that the backplane 1) does not support enclosure services, or 2) supports SFF-8045 enclosure services, or 3) supports SFF-8067 enclosure services. The definitions of the signals are summarized in the table below (I=Input, O=Output, I/O=Bi-directional):

-Parallel ESI de-asserted (high)	-Parallel ESI asserted (low)	
	SFF-8045¹	SFF-8067¹
Sel_0 (I)	P_ESI_0 (I)	Data(0) (I/O ²)
Sel_1 (I)	P_ESI_1 (I)	Data(1) (I/O ²)
Sel_2 (I)	P_ESI_2 (I)	Data(2) (I/O ²)
Sel_3 (I)	P_ESI_3 (I)	Data(3) (I/O ²)
Sel_4 (I)	P_ESI_4 (I)	-ENCL_ACK (I)
Sel_5 (I)	P_ESI_5 (I)	-DSK_RD (O)
Sel_6 (I)	-EFW (I)	-DSK_WR (O)
¹ The level of backplane support as established in "discovery".		
² The direction is determined by the state of DSK_RD and DSK_WR.		
Note: all signals are assumed valid 1 μsec after -Parallel ESI changes state		

Table 13. Enclosure Service Interface (ESI) Mode Signal Definitions

The Sel_n function is described in the previous sub-section. The SFF-8045 and SFF-8067 Enclosure Service functions are described in the following sub-sections.

SFF-8045 Enclosure Service Interface

The SFF-8045 Enclosure Service Interface defines 7 bits of enclosure status. This status is read by the drive, and presented to the initiator, upon receipt of the appropriate SCSI Receive Diagnostics command. The definitions of the status bits are vendor specific. The drive does not try to interpret the status. The drive assumes **-EFW** is status and treats it as it does the other P_ESI_n signals.

SFF-8067 Enclosure Service Interface

The SFF-8067 Enclosure Service Interface defines a bidirectional communication path between the backplane and the drive. Read Communications are invoked by the drive upon receipt of the appropriate SCSI Receive Diagnostics command. This has the system level effect of the host reading information from the enclosure. Write Communications are invoked by the drive upon receipt of the appropriate SCSI Send Diagnostics command. This has the system level effect of the host writing information to the enclosure. The meaning of the information is vendor specific. The drive does not try to interpret the information. Please see the SFF-8067 Specification for a detailed description of the communication protocol.

5.1.7.4 -EFW Function

The drive does not implement the optional **-EFW** function. It treats this signal as an additional status bit when in SFF-8045 Enclosure Service Interface mode.

5.1.8 -ENBL BYP CH1, -ENBL BYP CH2

-ENBL BYP CH1 and **-ENBL BYP CH2** are sourced by the drive and control the state of loop Port Bypass Circuits (PBC) on the backplane. **-ENBL BYP CH1** controls the PBC for Port A, and **-ENBL BYP CH2** controls the PBC for Port B. When these Bypass signals are asserted (low), the PBC bypasses the drive on the associated port. The backplane should provide a 1K-ohm pull-down resistor to insure the PBC is active (i.e. the drive is bypassed) if the drive is not plugged into the backplane.

The drive powers up with these signals enabled throughout the hot-plugging process, until the drive has completed its self-initialization process. After a successful power-up, the drive will attempt to enable itself on both loops (if allowed to do so via SCSI mode page 0x19). These signals are also controllable by the host with the LPB (Loop Port Bypass) and LPE (Loop Port Enable) fibre channel primitives.

The Bypass signals will be activated under failing conditions within the drive, on detection of the LPB primitive, or on removal of the drive. In the Bypass state, the drive continues to receive on the inbound port.

Failure modes detected by the drive that enable the Bypass signals include:

- BATs failure
- Loss of Receive clock
- Loss of Transmit clock
- Drive interface hardware errors

Each Bypass signal provides 4mA of sink capability.

5.1.9 - Drive Present

This signal is connected to the drive's ground plane. The backplane can use this signal to detect the presence of a drive.

5.2 Option Block Connector (Jumper Block)

Ultrastar 36XP contains a **Front Option Jumper Block** that can be used to enable optional features. The jumper block provides some useful features not available in SFF-8045, and also provides an alternate means of options access.

The Option Block connector (2x16) is an AMP connector (PN 84156-5) having a pin spacing of 2 mm.

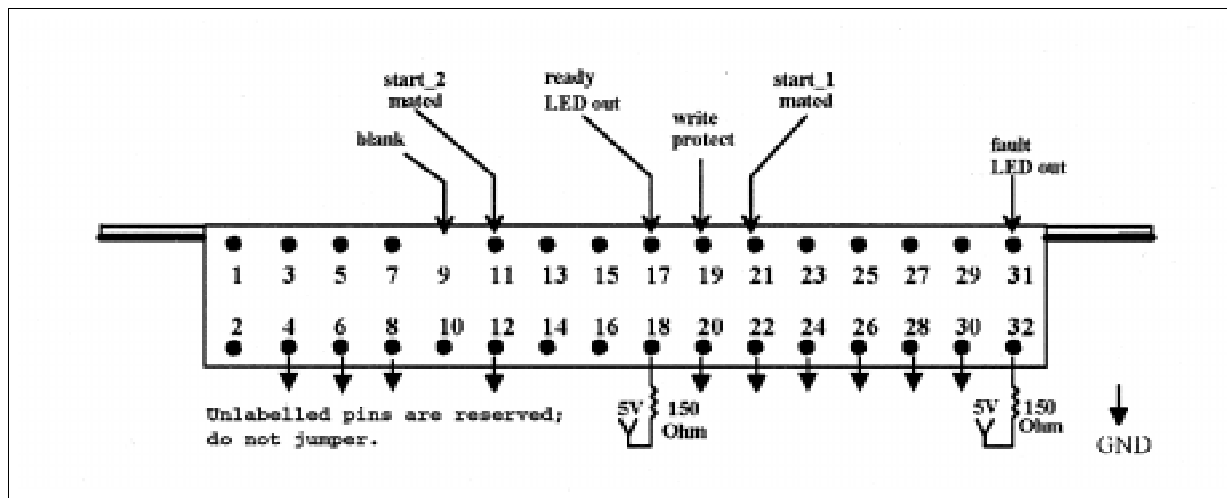


Fig. 16. Front Option Jumper Block

5.2.1 FC-AL SFF-8045 Options

Some of the options from the FC/AL SCA-2 (SFF-8045) connector are also provided at the front option block as a convenience to support legacy systems. The function provided by these pins is the same as defined in SFF-8045, and they are literally the same signals as those wired to the FC/AL SCA-2 connector. For that reason, if these jumpers are used, care must be taken to avoid conflicts on the backplane (via SCA-2). Thus, for these options, either the Front Option Block or the FC/AL SCA-2 option may be used, but not both.

The SFF-8045 options supported on the Front Option Block are:

- Ready LED Out
- Fault LED Out
- Start_1 Mated
- Start_2 Mated

See the following subsections for a more detailed definition of these pins. In addition to the duplicate SCA-2 options, the Front Option Block also provides a "Write-Protect" option as described below.

5.2.1.1 LED Out Options

The LED Out pins can be used to drive an external LED. Please refer to 5.1.5, "Ready LED Out" and 5.1.4, "Fault LED Out" for a detailed functional description of these pins. The LEDs may be connected from either the front option block or the SCA-2 connector. In either case the total LED drive capability is 30mA.

The front option block supports currents up to 33mA (+/- 5%) of TTL level LED sink capability based on the 150 Ohm pull-up values. When using LED OUT options from the jumper block, the LED Anode should be tied to the

+5V source provided on pin 14 (or pin 18) of the Front Option Jumper Block directly adjacent the LED OUT pin. The cathode of the LED can be tied directly to the LED OUT pin 13 (or pin 17) on the jumper block.

When using LEDs via SCA-2 connector, the LED cathode may be connected to either LED OUT, and the LED anode should be connected to the 5V power source on the backplane. In this case it is up to the backplane to supply current limiting so as not to exceed the 30mA LED driver limit.

The LED Out pins can be used to drive an LED located in a bezel connected to the front of the drive or to an external LED in systems where the front of the drive can not be easily seen.

Ultrastar 36XP has two sets of pins for LED access, a set on the front and a set on the back, that are connected to the same LED driver circuit. The combined drive capability is 30mA. It is expected that only one of the access points will be used.

5.2.1.2 Start_1 Mated, Start_2 Mated Options

The motor spin functions of the Start_x Mated Options are summarized in Table 12. Please refer to the SFF-8045 specification for a more complete definition of these pins.

5.2.2 Write-Protect Pin

If the Write-Protect pin is jumpered to ground the drive will prevent the execution of SCSI commands that alter the customer-data portion of the media. The state of this pin is checked at the beginning of each command.

6 Reliability

6.1 Error Detection

Error reporting \geq 99%	All detected errors excluding interface and BATs #1 (Basic Assurance Test) errors.
Error detection \geq 99%	To the device when the “Recommended Initiator Error Recovery Procedures” in the <i>Mako/Hammerhead/Swordfish FC-AL Interface Specification</i> are followed.
FRU isolation = 100%	No isolation to subassemblies within the device are specified.

6.2 Data Reliability

Probability of not recovering data	10 in 10^{15} bits read
Recoverable read errors (mean)	10 in 10^{13} bits read (measured at nominal DC conditions and room environment with default error recovery QPE ³ 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 Start-Stop Cycles

The maximum number of start-stop cycles supported by *Ultrastar 36XP* is 1,800.

³ Please reference QPE (qualify post error) definition in the *Mako/Hammerhead/Swordfish FC-AL 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	5 to 50 °C (41 to 122 °F)
Operating Disk Enclosure	5 to 60 °C (41 to 140 °F)
Storage	1 to 60 °C (34 to 140 °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% non condensing
Storage	5% to 90% non condensing
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)

7.1.1 Storage Requirements

7.1.1.1 Packaging

The drive or option kit must be heat-sealed in a moisture-barrier bag along with a desiccant (either supplied or specified by IBM).

7.1.1.2 Storage Time

At the packaged level, the cumulative storage time for the drive or option kit must not exceed one year. If a longer storage time is required, the drive must be repackaged with a new desiccant or moved to a climate-controlled environment.

One the drive is unpackaged, it must not remain inoperative for longer than six months.

7.1.2 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)" in section 7.1.1 defines where measurements should be made to determine the top disk enclosure temperature during drive operation. "Temperature Measurement Points (bottom view)" also in section 7.1.1 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 across the drive so that the disk enclosure and module temperature maximum limits defined in the following table are not exceeded.

	Absolute Maximum¹	Recommended Maximum
Disk Enclosure Top	60°C (140°F)	50°C (122°F)
Disk Enclosure Bottom	60°C (140°F)	50°C (122°F)
Channel Module²	95°C (203°F)	75°C (167°F)
FC-AL Interface Controller	130°C (266°F)	90°C (194°F)
FC-AL Transceivers	120°C (248°F)	85°C (185°F)
Microprocessor Module	80°C (176°F)	60°C (140°F)
Spindle Motor Controller	90°C (194°F)	70°C (158°F)
DSP Module	95°C (203°F)	75°C (167°F)
¹ Operating the drive above the absolute maximum temperatures may cause permanent damage. ² For continuous-read applications, the Channel module will run at higher temperatures and will require additional cooling.		

Table 14. Operating Case-Temperature Limits

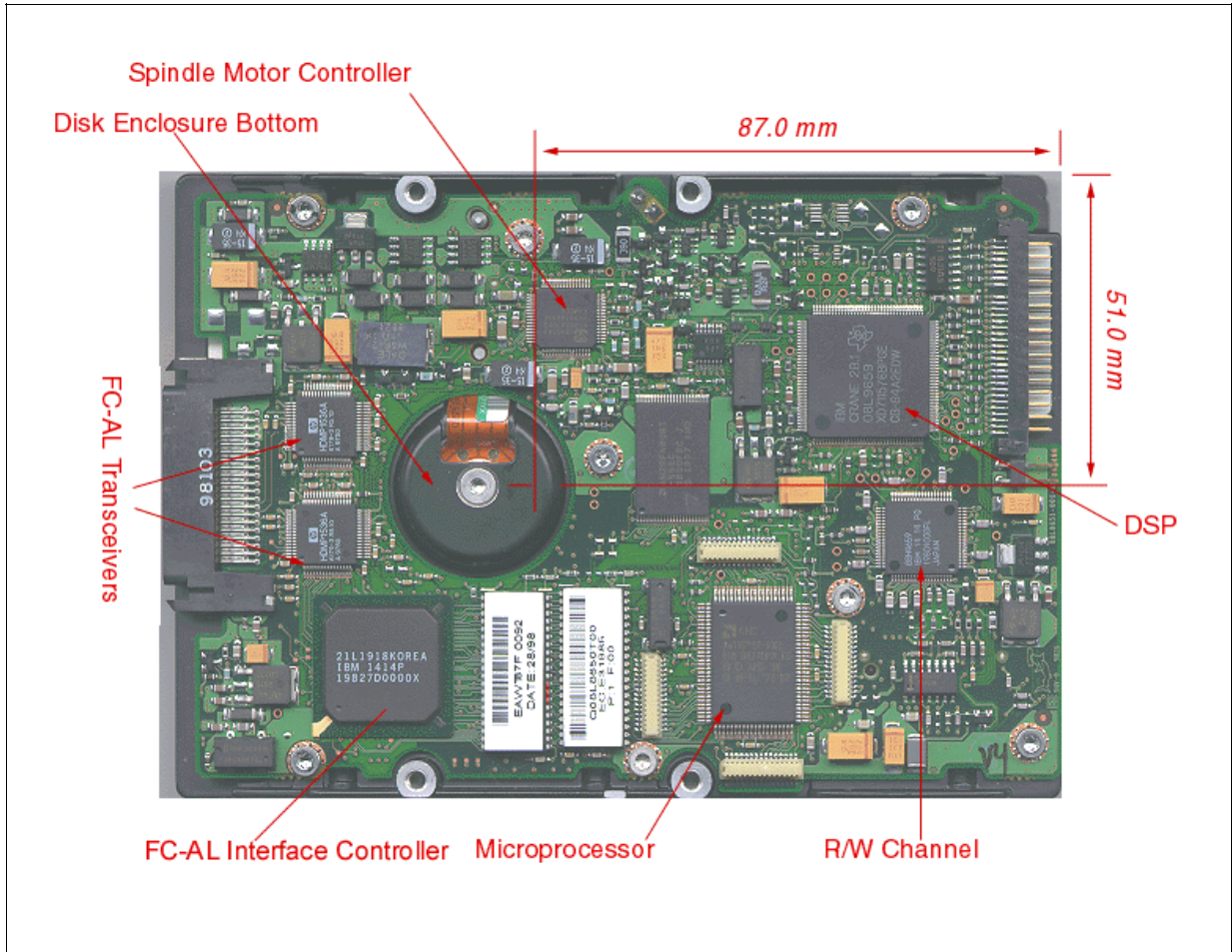


Fig. 17. Temperature Measurement Points (Bottom View)

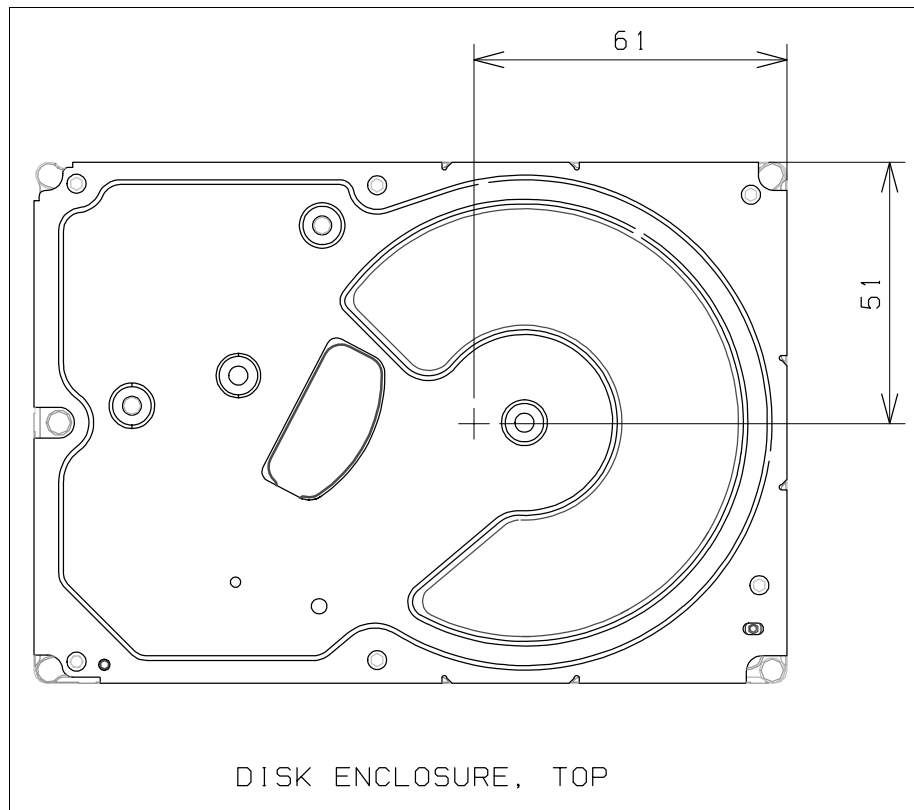


Fig. 18. Temperature Measurement Point (Top View)

7.1.2.1 Module Temperature Measurement Notes

When measuring module temperature,

1. Center the measurement point 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 mounting 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" in section 4.2.
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.

The x-axis of the drive is defined as a line normal to the front/rear faces (see Fig. 1, Ultrastar 36XP Disk Drive Assembly), 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.

7.2.1 Output Vibration Limits

Spindle residual imbalance will not exceed 0.3 gram-millimeters.

7.2.2 Operating Vibration

The vibration is applied in each of the three mutually perpendicular axes, one axis at a time.

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 levels shown in table 32. For excitation in the z-direction, the drive will operate without hard errors when subjected to vibration levels not exceeding the V4S vibration levels shown in table 32.

Note: The RMS value in the table 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-05	1.1E-03	1.1E-03	8.0E-03	8.0E-03	1.0E-03	1.0E-03	8.0E-05	8.0E-05	0.56
V4S	2.0E-05	1.1E-03	1.1E-03	8.0E-03	8.0E-03	1.0E-03	1.0E-03	4.0E-05	4.0E-05	0.55
units					g^2/Hz					g

Table 15. 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, y, and z directions.

This measurement is taken during a frequency sweep from 5 to 300 Hz and back to 5 Hz. The sweep rate is 1 Hz/s.

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

7.2.3 Nonoperating Vibration

7.2.3.1 Random Vibration

No physical damage or degraded throughput 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 2.0 g_{rms} from 5 to 300 Hz of a flat power spectral density of 0.0136 g^2/Hz . The test duration is 30 minutes in each of the three axes.

7.2.3.2 Swept Sine 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 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 16. Swept Sine Vibration Levels

7.2.4 Operating Shock

No hard errors will occur on the drive when it is 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 axes, one axis at a time.

7.2.5 Nonoperating Shock

7.2.5.1 Translational Shock

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

No hard errors will occur if the unpackaged drive is subjected to a 180 in./sec. velocity change square pulse shock of 50 Gs or less to all three axes, one direction at a time.

No hard errors will occur if the unpackaged drive is subjected to a 2 millisecond half sine pulse shock of 120 Gs or less 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)							LwA
	125	250	500	1K	2K	4K	8K	
Idle	4.5	2.6	3.2	3.5	4.4	4.5	4.8	5.0
Operating	4.5	3.3	3.3	4.1	5.1	5.3	4.8	5.5

Table 17. Upper Limit Sound Power Requirements (LwAu 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 dBA.

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 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.

7.4.1 Acoustic Degradation Resulting From Non-Operating Shock

No degradation in A-weighted idle sound power will occur if the unpackaged drive is limited to a 2 ms half sine pulse shock of 70 Gs or less applied in the axial direction (z axis), or 150 Gs or less applied in the radial direction

(x-y plane). The average A-weighted idle sound power will increase by 0.3 Bels if the unpackaged drive is subjected to a 2 ms half sine pulse shock of 110 Gs applied in the axial direction (z axis), or 210 Gs applied in the radial direction (x-y plane).

7.5 Drive Mounting Guidelines

Listed below are summary points for mounting a drive in a user system. Additional information is available from IBM technical support.

1. The drives are sensitive to vibration in the plane of the disk. Vibration in this plane, referred to as rotational vibration, couples directly into offtrack displacement. Mounting within using systems should minimize the rotational input to the drive mounting points due to external vibration.
2. Orient the spindle axis parallel to the direction of minimum shock loading
3. 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.
4. 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 displacement.
5. 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 nonoperational shock.
6. Keep the rigid body resonances of the drive away from harmonics of the spindle speed, which are multiples of 120 Hz.
7. The carrier should be as stiff as possible while allowing room for the isolator mounts (if used). Rather than 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.
8. If isolators are to be used, design them 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.
9. To minimize acoustic radiation, mount drives so there is no "line of sight" between a drive and user.

7.6 Drive/System Compatibility

Ultrastar 36XP 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 2.4, "Power Requirements". 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 section 2.4.8, "Hot Plug/Unplug" support of this specification for requirements and guidelines.

Thermal

The system must supply adequate cooling and air flow to maintain casing and module temperature listed in the section 7.1, "Environmental". 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 nonoperating shock specifications found in section 7.2.4, "Operating Shock" and in section 7.2.5, "Nonoperating Shock". Both operating and nonoperating 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 7.2.2, "Operating Vibration". 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 7.5, "Drive Mounting Guidelines".

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 4.2, "Clearances".

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 protection, care and handling guidelines found in section "ESD Protection" in section 7.10.

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 section 5, "Electrical Interface".

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 section 6.2, "Data Reliability".

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 screwdriver tip or other hard tool.
- Tapping a drive into position when installing into a frame.
- Contact with another drive.

Precautions to take during handling:

- Wear ESD protection at all times.
- Handle drives as you would "Eggs" or "Glass Stemware".
- Handle one drive at a time.
- Handle drive by the sides only.
- Re-use the original packaging for transporting the drive.
- 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.
- Don't stack disk drives, even in ESD bags.
- Don't contact the drive or card with tooling (drivers, etc.).
- Don't rush installation
- Don't slam a drive into a carrier or frame.
- Don't seat a drive into place with tooling.
- Don't stand a drive on its ends or sides.
- Don't allow drives to contact each other.

Shipping Handling Precautions:

- Check for and report shipping damage to a pallet.
- Don't stack more than 2 pallets
- Don't contact pallet package with forklift forks.
- Don't drop a pallet.
- Don't drop drive boxes.

7.8 Filter Breather Opening

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

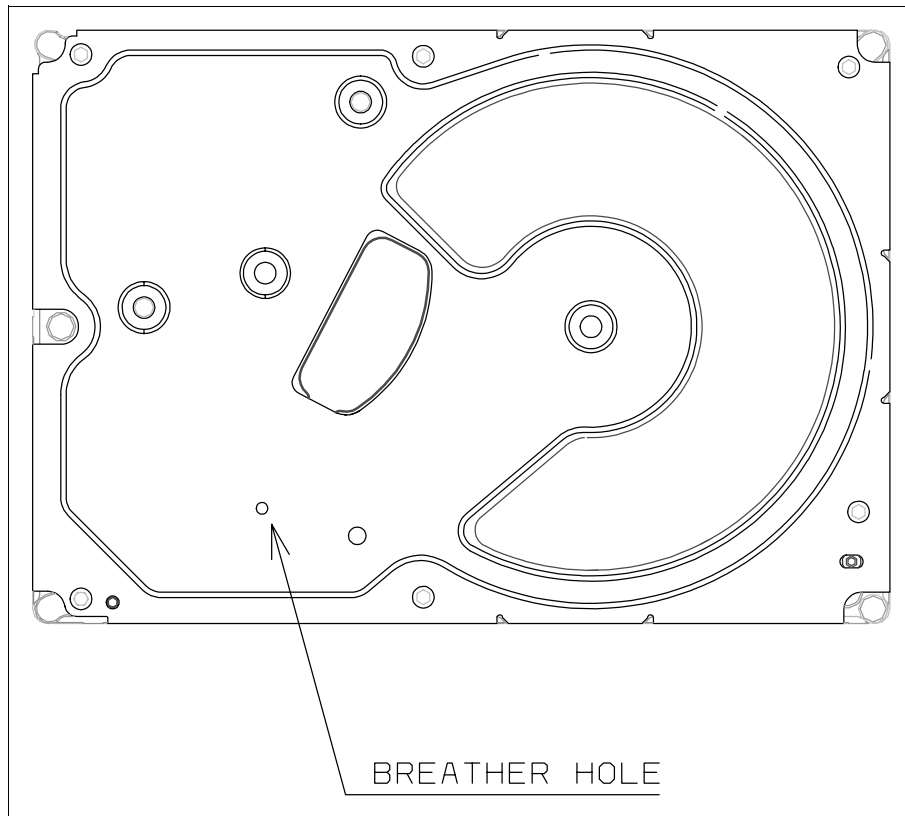


Fig. 19. Filter Breather Opening

7.9 Periodic Maintenance

Ultrastar 36XP drives require no periodic maintenance.

7.10 ESD Protection and Handling

Ultrastar 36XP drives contain electrical components sensitive to damage due to Electrostatic Discharge (ESD). Proper ESD procedures must be followed during handling, installation, and removal, such as the use of ESD mats, wrist straps and the grounding all surfaces that are allowed to touch or come close to the device.

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

7.11 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 magnetic field strength must be equal to or below the values shown at the frequencies shown in the table below where the drive is mounted.

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

Table 18. Stray Magnetic Field Strength Limits

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.

- INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC) STANDARDS

The product is certified to comply to EN60950 by a European test agency Certified Body. The TUV mark is located on the product.

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- 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 with respect 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 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 external circuitry. Current limiting of 10 amps or less should provide sufficient protection.

8.2 Electromagnetic Compatibility (EMC)

- FCC Requirements

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 Limits". Tests for conformance to this requirement are performed with the disk drive mounted in the using system.

- CISPR 22 Requirements

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 Limits" .

- European Declaration of Conformity

The Ultrastar **36XP** disk drive has been tested to comply with the European Council Directive 89/336/EEC and thereby bears the "CE" Mark of Conformity.

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 **36XP** disk drive has been tested to comply with AS/NZS 3548 and thereby bears the "C-Tick" Mark of Conformity.

Producers integrating these drives in alternative enclosures will still need to test the system to ensure it complies with AS/NZS 3548.