OEM
Ultrastar 2XP Model DCHS
Hardware/Functional Specification
4.55GB and 9.11GB Models., 7200 RPM
Version 5.51

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1.0 Description

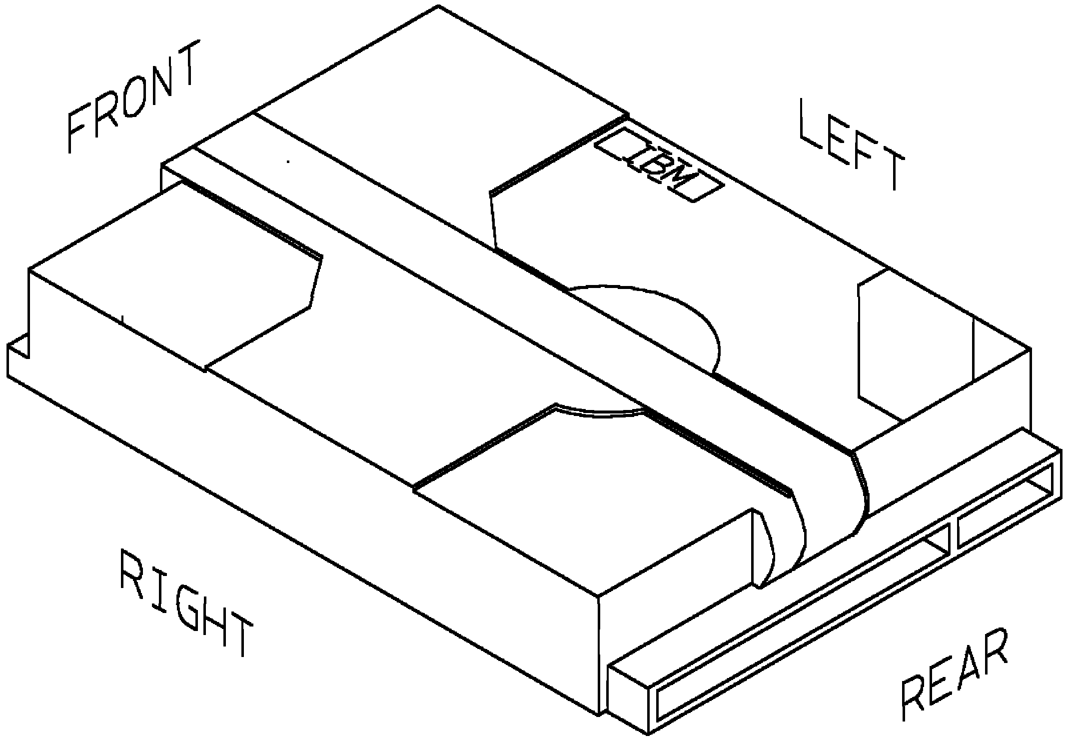


Figure 1. *Ultrastar 2XP* Disk Drive Assembly

1.1 Features

General Features

- 4.55GB/9.11GB (512 bytes/sector)
- Industry-standard interface:
  - 50 pin ANSI SCSI-2 Single-Ended
  - 68 pin ANSI SCSI-3 Single-Ended or Differential
  - Single Connector Attachment (SCA-2/ 80-pin)
- Rotary voice coil motor actuator
- Closed-loop digital actuator servo
- Embedded sector servo
- Magnetoresistive (MR) heads
- 8/9 rate encoding
- Enhanced Partial Response Maximum Likelihood (EPRML) data channel with digital filter
- No-ID® sector format
- All mounting orientations supported
- Jumperable auto spindle motor start
- Jumperable drive supplied terminator power on some models
- Jumperable on board active SCSI terminators (Optional on some models)
- Jumperable write protection
- Spindle synchronization

- LED Driver
- 512KB segmented cache buffer, 1MB (Optional on some models)
- Bezel (Optional on some models)

Performance Summary

- Average read seek time 4.55GB : 7.5 milliseconds
- Average read seek time 9.11GB, : 8.5 milliseconds
- Average Latency: 4.17 milliseconds
- Media data transfer rate: 10.2881 to 15.4321 MegaBytes/second (8 bands)
- SCSI data transfer rate: 10 MegaTransfers/second (sustained synchronous)
- Fast-20 SCSI data transfer rate: 20 MegaTransfers/second (sustained synchronous)
- SCSI Bus Overhead: < 40 microseconds

Interface Controller Features

- SCSI bus parity
- SCSI disconnect and reconnect capability
- Multiple initiator support
- Fast SCSI supported
- Fast-20 SCSI supported
- Wide SCSI models
- Integrated differential tranceivers (Optional on some models)
- Variable logical block lengths (*512 - 740 supported*)

  NOTE: Please see 2.3, “Capacities by Format Length” on page 14 for more detail.

- Read-ahead caching
- Adaptive caching algorithm
- Write Caching
- Tagged and untagged command queuing
- Command reordering
- Back-to-back writes (merged writes)
- Automatic retry and data correction on read errors
- Automatic sector reallocation
- In-line alternate sector assignment for high-performance
- Down-loadable firmware
- SCSI behavior customizing jumpers

  For example:-
  - Disable Target Initiated Synchronous Negotiation
  - Disable Unit Attention
  - Disable SCSI Parity
  - Auto Start Delay

Reliability Features

- Self-diagnostics on power up
- Dedicated head landing zone
- Magnetic actuator latch
- Embedded Sector Servo
- Entire Read/Write data path protected by a 16 Bit LRC polynomial
- ECC on the fly
- 18 Byte Error Correcting Code (ECC)
- Predictive Failure Analysis. (PFA) ®
- Data Recovery Procedures (DRP)
- Probability of not recovering data: **10 in 10^{15}** bits read

1.2 Models

The ***Ultrastar 2XP*** disk drive is available in the following models:

- 4.55GB capacity
- 9.11GB capacity

50 pin SCSI connector models offer an 8 bit SCSI bus using the SCSI 'A' connector. 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.

All models support Fast SCSI data transfers

Fast-20 models supports Fast-20 SCSI data transfers

Please refer to section 2.3, “Capacities by Format Length” on page 14 for exact capacities based on user block size.

The following options are also available:

– 512kB or, 1MB cache

– Jumperable active terminators on 50, 68-pin single-ended models.

4.55GB Models	HDA Type 1"	Capacity GB	SCSI Pins/Connector Type	SCSI Electrical Signal Type
DCHS 04F	P9	4.55GB	50/'A' Connector	Single Ended Fast
DCHS 04Z	P9	4.55GB	50/'A' Connector	Single Ended F20
DCHS 04W	P9	4.55GB	68/Unitized Connector	Single Ended Fast/Wide
DCHS 04D	P9	4.55GB	68/Unitized Connector	Differential Fast/Wide
DCHS 04S	P9	4.55GB	80 SCA-2	Single Ended Fast/Wide
DCHS 04U	P9	4.55GB	68/Unitized Connector	Single Ended Fast/Wide F20
DCHS 04X	P9	4.55GB	68/Unitized Connector	Differential Fast/Wide F20
DCHS 04Y	P9	4.55GB	80 SCA-2	Single Ended Fast/Wide F20

9.11GB Models	HDA Type 1.6"	Capacity GB	SCSI Pins/Connector Type	SCSI Electrical Signal Type
DCHS 09F	PI	9.11GB	50/'A' Connector	Single Ended Fast
DCHS 09Z	P9	4.55GB	50/'A' Connector	Single Ended F20
DCHS 09W	PI	9.11GB	68/Unitized Connector	Single Ended Fast/Wide
DCHS 09D	PI	9.11GB	68/Unitized Connector	Differential Fast/Wide
DCHS 09S	PI	9.11GB	80 SCA-2	Single Ended Fast/Wide
DCHS 09U	PI	9.11GB	68/Unitized Connector	Single Ended Fast/Wide F20
DCHS 09X	PI	9.11GB	68/Unitized Connector	Differential Fast/Wide F20
DCHS 09Y	PI	9.11GB	80 SCA-2	Single Ended Fast/Wide F20
Note: Please refer to section 2.3, “Capacities by Format Length” on page 14 for exact capacities based on user block size.				

2.0 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 #8'. '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 #8	Average	
Buffer to/from media	15.4321	10.2881	13.2281	MB/s (instantaneous)

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

Rotational speed (RPM): 7202.7

Average latency (milliseconds): 4.17

Track Density (TPI): 6160

	Minimum	Maximum
Recording density (BPI)	116,585	134,544
Areal density (Megabits/square inch)	758.4	828.7

Models	4.55GB	9.11GB
Disks	5	9
Heads	9	18

Seek Timing in milli seconds (measured at nominal voltage and temperature)

Single cylinder (Read)	0.7	0.7
(Write)	2.0	2.0
Average weighted (Read)	7.5	8.5
(Write)	9.5	10.5
Full Stroke (Read)	14.5	18.0
(Write)	16.5	20.0

2.2 Notch Details

User bytes/Sector (ub/sct) 512

Sectors/logical block (sct/lba) 1

User bytes/logical block (ub/lba) 512
Maximum addressible cylinders 6076

2.2.1 Models 4.55GB and 9.11GB

Notch	*Start Cylinder*	*User Data cylinders*	*Media Data Rate*	*Sectors Per Track*
1	0	1876	15.4321	184
2	1890	1400	14.2504	176
3	3290	300	13.9028	165
4	3590	700	12.9296	154
5	4290	450	12.4430	146
6	4740	250	11.8869	140
7	4990	600	10.9832	132
8	5590	500	10.2881	120

Table 1. LBA and cylinder notch table for 512 Byte Format

Notch	*Last Cylinder*	*User Data cylinders*	*Media Data Rate*	*Sectors Per Track*
8	6092	500	10.2881	120

Table 2. Maximum LBA's and cylinders

User bytes/Sector (ub/sct) 512 to 740 (even byte numbers only)

2.3 Capacities by Format Length

	Maximum User Logical Block Address / drive	
User bytes / logical block	**4.55GB Model**	**9.11GB Model**
512	8,888,543	17,796,077
514	8,871,650	17,762,201
520	8,639,864	17,298,449
522	8,612,171	17,242,973
524	8,555,471	17,129,573
528	8,493,749	17,005,769
536	8,400,149	16,818,569
688	6,696,665	13,408,181
740	6,263,171	12,540,473

Table 3. User LBA capacity

	User bytes / drive	
User bytes / logical block	**4.55GB Model**	**9.11GB Model**
512	4,550,934,528	9,111,591,936
514	4,560,028,614	9,129,771,828
520	4,492,729,800	8,995,194,000
522	4,495,553,784	9,000,832,428
524	4,483,067,328	8,975,896,776
528	4,484,700,000	8,979,046,560
536	4,502,480,400	9,014,753,520
688	4,607,306,208	9,224,829,216
740	4,634,747,280	9,279,950,760

Table 4. User byte capacity

Note: The table refers to Logical Block Address (LBA). Minimum is 0 and Maximum is specified.

The capacity is calculated as the maximum LBA PLUS 1; 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. For Differential SCSI models see: 2.4.8, “Additional 5V Current Requirements for Differential SCSI” on page 21.

Input Voltage
+5 Volts Supply 5V (± 5% during run and spin-up)
+12 Volts Supply 12V (± 5% during run) (+5% / -7% during spin-up)

Power Supply On/Off Requirements

+5V 4.5 V/sec Minimum Slew.
The +5 Volt supply must maintain a minumum of 0.20 volts for a period of 200 milli seconds after either the +5 volts decays below 4.1 volts or the +12 volts decays below 9.25 volts during power off.

+12V 7.4 V/sec Minimum Slew. 200 V/sec Max Slew.

Power Supply Current 4.55GB Model		Population Mean	Range
+5VDC (idle avg)		1.068 Amps[1]	+/- 10%
+5VDC (R/W baseline)	Typical	1.094 Amps	+/- 10%
+5VDC (R/W pulse)	Peak	1.30 Amps	+/- 10%
+12VDC (Idle)		0.486 Amps	+/- 10%
+12VDC (seek peak)	Peak	2.07 Amps	Max
+12VDC (Start Current)	Maximum	1.71 Amps[2]	+/- 0.3

Power Supply Current 9.11GB Model			
+5VDC (idle avg)		1.085 Amps[1]	+/- 10%
+5VDC (R/W baseline)	Typical	1.133 Amps	+/- 10%
+5VDC (R/W pulse)	Peak	1.37 Amps	+/- 10%
+12VDC (Idle)		0.850 Amps	+/- 10%
+12VDC (seek peak)	Peak	2.43 Amps	Max
+12VDC (Start Current)	Maximum	2.71 Amps[2]	+/- 0.3

Energy Consumption (Japanese Requirement Only)
4.55GB 0.002 per MB
9.11GB 0.001 per MB

Note: Energy Consumption Index = Idle Power/Capacity (W/MB)

[1] 5 Volt Current is given with termination power provided by the using system.

[2] The Start Current is the total 12 volt current required by the drive.

2.4.2 RMS Power Measurements

DCHS	**4.55GB**	**9.11GB**
Idle	11.03 Watts	15.6 Watts
15 ops/second	11.73 Watts	17.4 Watts
30 ops/second	12.38 Watts	17.8 Watts
60 ops/second	13.25 Watts	18.6 Watts

Table 5. Power Measurements made using Clarke Hess Model 259 Digital Wattmeter

Note: For the purpose of calculations 0.036Watts per op can be used for the 4.55GB and 0.038 Watts per op for 9.11GB This is not completely accurate because of the non linear scale but can be used for approximations.

Example

If 4.55GB power was required for 90 ops per second the calculation would be as follows

Idle power = 11.03 Watts

90 ops/second = 90 * 0.036 = 3.24 Watts

Total Power = 11.03 + 3.24 = 14.27 Watts

DCHS Fast-20	**4.55GB**	**9.11GB**
Idle	10.95 Watts	16.04 Watts
15 ops/second	11.50 Watts	16.55 Watts
30 ops/second	12.41 Watts	17.42 Watts
60 ops/second	13.75 Watts	18.64 Watts

Table 6. Power Measurements made using Clarke Hess Model 259 Digital Wattmeter

2.4.2.1 Differential Models

The power increase for differential models will be between 0.5 watts at idle to 1.0 watts for 60 ops/s.

2.4.3 Power Supply Graphs

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

All power supplies are nominal.

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

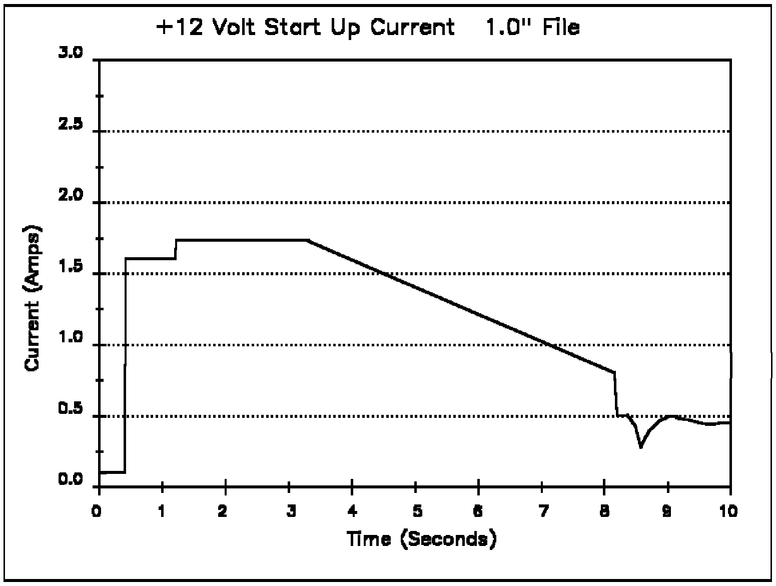


Figure 2. 12 Volt Start Current 1.0" Models

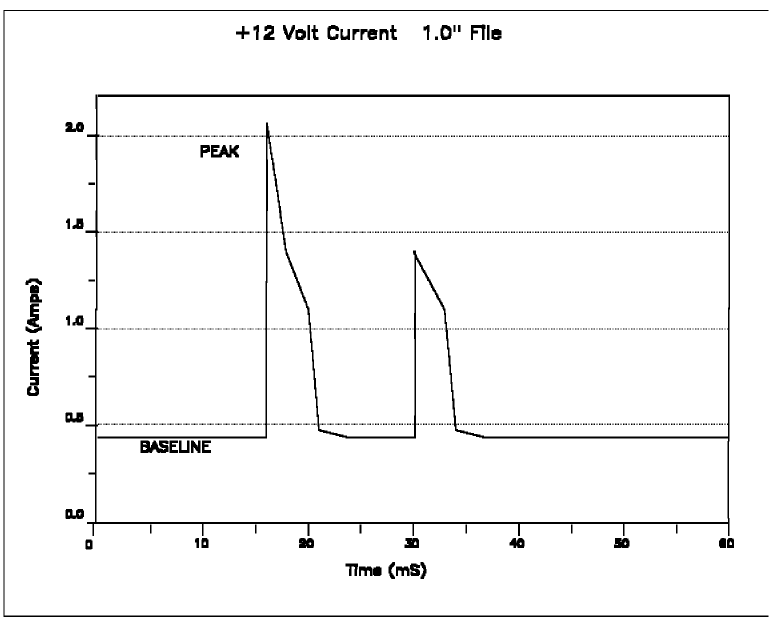


Figure 3. Typical Seek with Read 12 Volt Current 1.0" Models

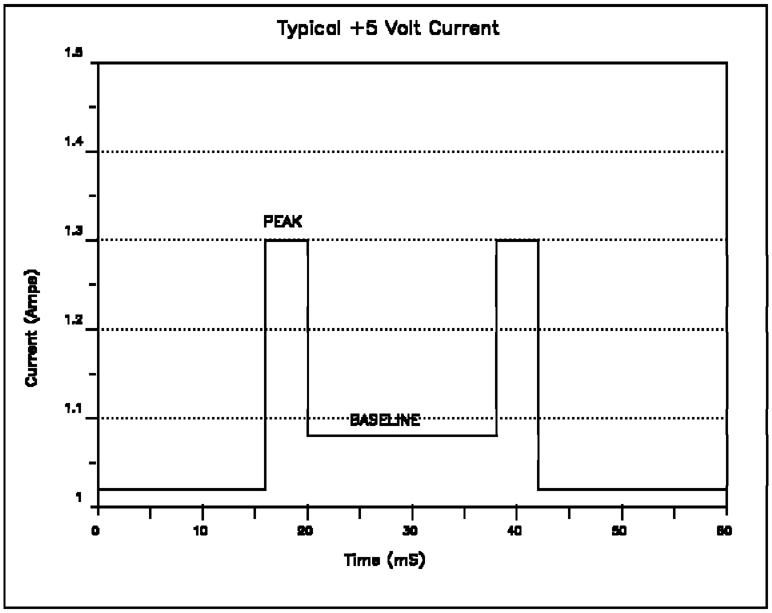


Figure 4. Typical Seek with Read 5 Volt Current all Models

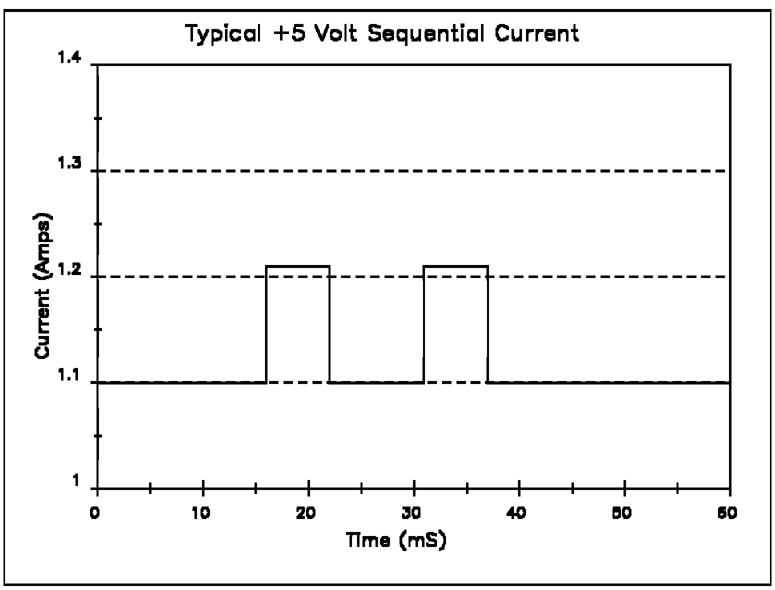


Figure 5. Typical Sequential Read Operation 5 Volt Current all Models

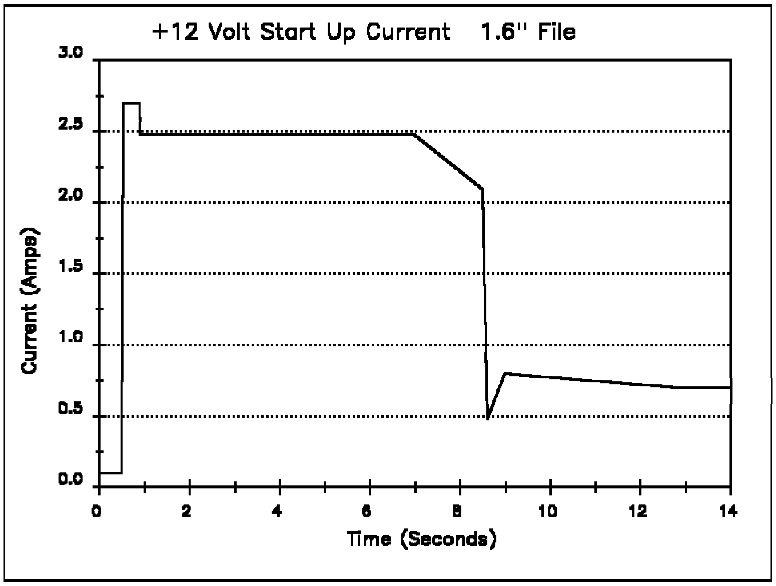


Figure 6. 12 Volt Start Current 1.6" Models

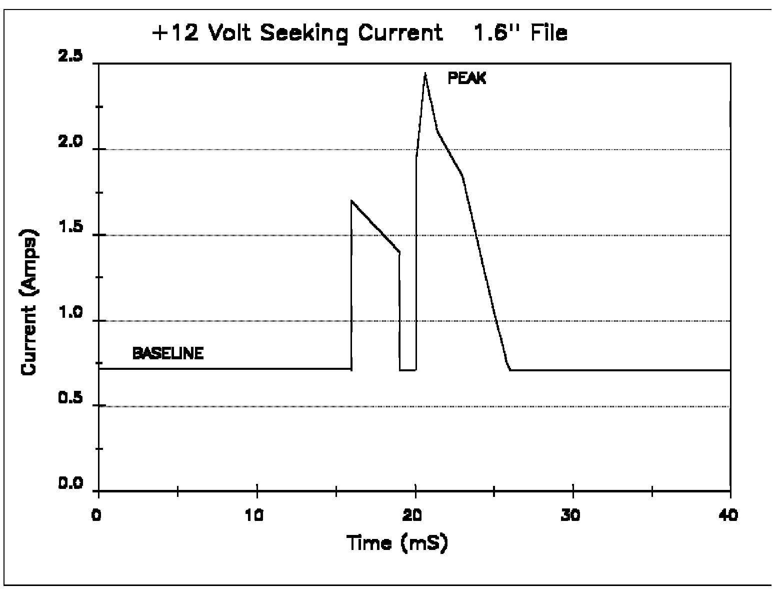


Figure 7. Typical Seek with Read 12 Volt Current 1.6" Models

2.4.4 Power Supply Ripple

Externally Generated Ripple
as seen at drive power connector

	Maximum	Notes
+5VDC	200 mV peak-to-peak	0-20 MHz
+12VDC	200 mV peak-to-peak	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

+5VDC	82 microfarad
+12VDC	60 microfarad

2.4.6 Grounding Requirements of the Disk Enclosure

The disk enclosure is at Power Supply ground potential. It is allowable for the user mounting scheme to common the Disk Enclosure to Frame Ground potential or to leave it isolated from Frame Ground.

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 SCSI 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 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 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.

Reference section 7.2, “Vibration and Shock” on page 72 for the Operating and Non-Operating Shock limits.

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 (SCA-2 models)

Based on this classification, the ***Ultrastar 2XP*** 80pin SCA-2 drive is designed to be 'Case 4' compliant when the system has properly implemented the SFF-8046 guidelines.

2.4.7.2 (50,68 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 affecting an 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 recommended to minimize the chance of interfering with the SCSI Bus:

Plug

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

Un-Plug

1. Power down device (no special sequencing of 5 or 12 volts)
2. Un-plug device from the bus
3. Remove common ground

2.4.8 Additional 5V Current Requirements for Differential SCSI

Additional Power Supply Current	Notes	Population Mean
+5VDC (idle avg)		0.10 Amps
+5VDC (R/W baseline)	Typical	0.06 Amps
+5VDC (R/W pulse)	Base-to-peak	1.0 Amps

2.5 Bring-up Sequence (and Stop) Times

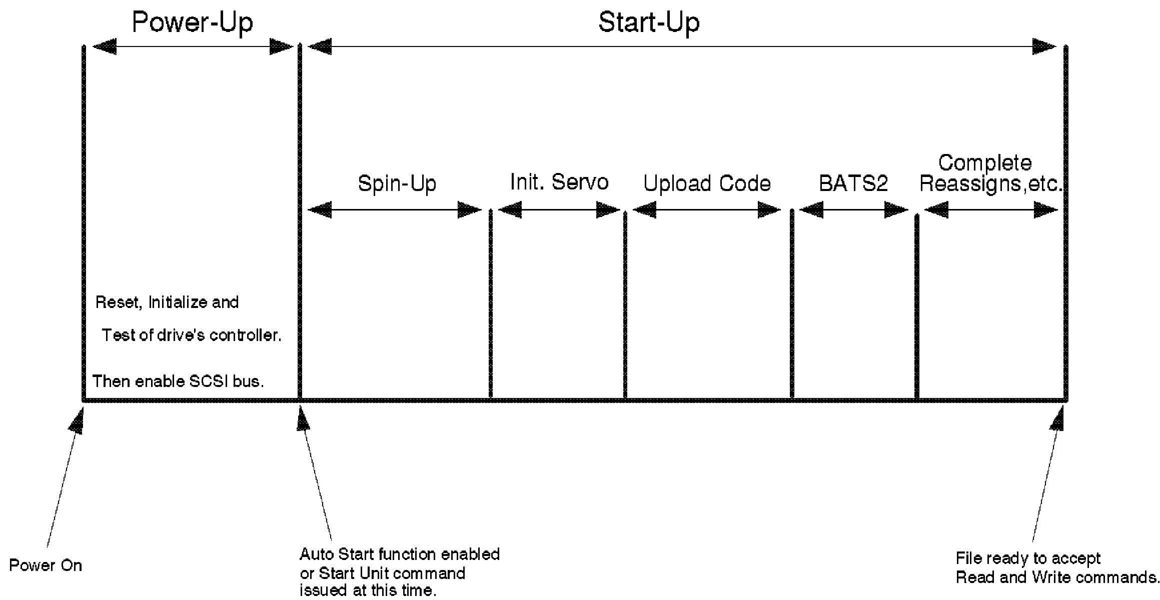


Figure 8. Start Time Diagram

Note: BATS is the abbreviation for Basic Assurance Tests. Start-up sequence spins up the spindle motor, initializes the servo subsystem, uploads code, performs BATS2 (verifies read/write hardware), resumes "Reassign in Progress" operations, and more. For more information see **UltraStar2-XP Interface Specification** for additional details.

Note: If a TOTAL RESET is issued before the drive comes ready, the power on sequence will start again. In all other cases when a TOTAL RESET is issued the present state of the motor is not altered.

Note: Reference 3.10.1.3, “Start/Stop Unit Time” on page 39 for additional details.

Note: See 5.4, “Spindle Synchronization for ***Ultrastar 2XP*** Drives Only” on page 65

Note: There is a 10 second delay between a "Unit Stop" and "Unit Start". back to back commands.

Event	Nominal	Maximum	Notes
Power-up	1.5 sec	2.0 sec	*See Figure 8 on page 22
Start-up	25 sec	60 sec	*See Figure 8 on page 22
Spin-up	9 sec	25 sec	*See Figure 8 on page 22
Spindle Stop	6.0 sec	15.0 sec	

Table 7. Bring-up Sequence Times and Stop Time. 4.55GB

Event	Nominal	Maximum	Notes
Power-up	1.5 sec	2.0 sec	*See Figure 8 on page 22
Start-up	30 sec	90 sec	*See Figure 8 on page 22
Spin-up	11 sec	27 sec	*See Figure 8 on page 22
Spindle Stop	9.0 sec	15.0 sec	

Table 8. Bring-up Sequence Times and Stop Time. 9.11GB

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. Depending on the duration of the glitch the drive may spin down and then spin back up or may reset itself. 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.

3.0 Performance

Drive performance characteristics are dependent upon the workloads run and the environments in which they are run.

All times 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.

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.

- Block lengths are formatted at 512 bytes per block.
- The number of data buffer segments is 16. The total data buffer length is 512K bytes. Of the 16 segments in the buffer, at least one segment is allocated for the NO-ID tables, and probably more. This number is dependent on the number of defects found on the drive.

  The number of blocks of customer data that can fit into one segment is reduced because 2 bytes of buffer CRC information is also stored in the segment for each block of customer data stored in the segment.

  The number of segments is also reduced by at least one. This segment is used to store the defect information for the NO-ID architecture. In some cases more than one segment may be needed to store this information. This varies on a drive to drive basis due to defect population distributions. This size is also affected by the capacity of the drive. Larger capacity drives have more defects and thus require more space.

  There is also the pontential to have a partially used or runt segment for the maximum use of all available memory.
- Ten byte SCSI Read and Write commands are used.
- SCSI environment consists of a single initiator and single target with no SCSI Bus contention.
- Buffer full/empty ratios are set to their optimum values such that a minimum number of intermediate disconnects occur during the SCSI data transfer and the overlap of the SCSI and disk data transfer is maximized. This minimizes Command Execution Times with no bus contention.
- Read Caching and Read Ahead functions are enabled except where noted.
- The initiator delay while transferring SCSI command, status, message, and data bytes is assumed to be zero.
- The media is formatted with the skew definition that optimizes the disk data transfer rate for unsynchronized spindle operation.
- Tagged Command Queuing is not used, unless otherwise specified.
- All Current Mode Parameters are set to their Default values except where noted.
- SCSI data transfers are successfully negotiated to be 20 MB/sec.
- 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 when the next operation is issued is 50 msec, +/- a random value of 0 to 50 msec, unless otherwise noted.

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 LBAs. The average seek is an average weighted seek.

3.3 Command Execution Time

Command Execution, or Service, Times are the sum of several Basic Components. Those Components are -

1. Seek
2. Latency
3. Command Execution Overhead
4. Data Transfer to/from Disk
5. Data Transfer to/from SCSI Bus

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

The following graphs show Command Execution Times for four generic workloads

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

with several different requested Transfer Lengths while running in various environments whose key factors are identified within each graph.

Note: Times are calculated with Typical Data Sector Transfer Rates for 4.55GB models and are averaged over the entire drive.

Note: In the following Graphs, "TCQing" means Tagged Command Queueing and "Qd" is the average number of commands queued by the drive at one time.

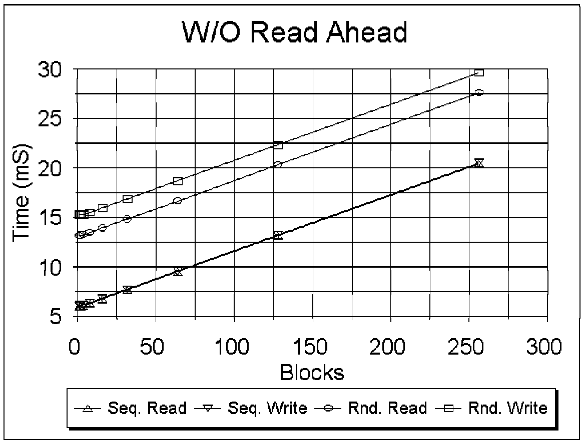


Figure 9. All caching disabled, Re-instruction Times = 0-100ms, no TCQing

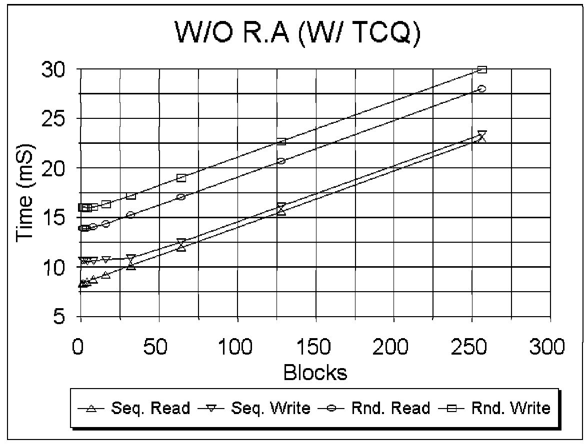


Figure 10. All Caching disabled, Re-instruction Times = 50-150ms, with TCQing

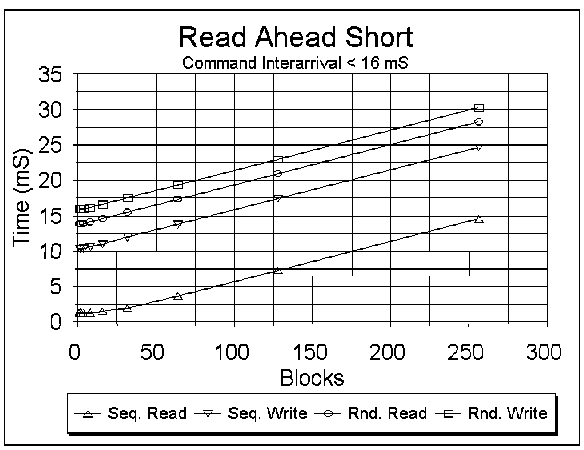


Figure 11. Read Caching enabled, no TCQing

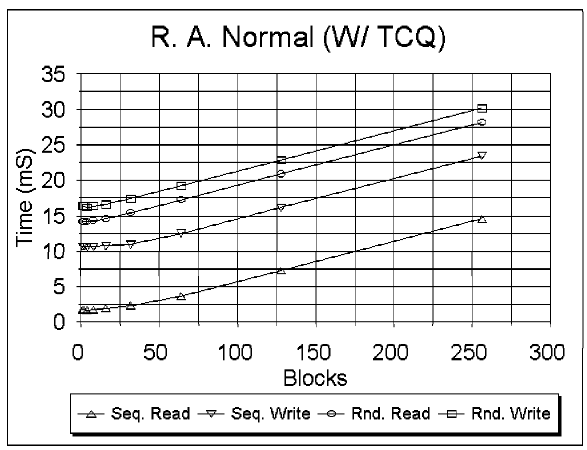


Figure 12. Read Caching enabled, With TCQing

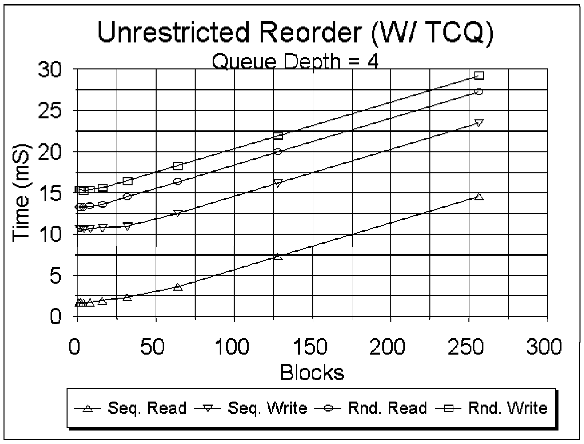


Figure 13. Read Ahead, With TCQing used (Queue Depth = 4)

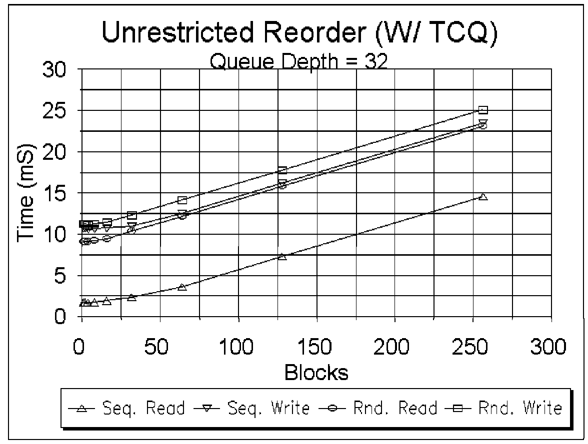


Figure 14. Read Ahead, With TCQing used (Queue Depth = 32)

3.3.1 SCSI Data Transfer Rate

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

When the drive is configured for an 8 bit wide transfer a synchronous data transfer rate of 10 MB/sec can be realized. The 16 bit wide maximum synchronous data transfer rate is 20 MB/sec.

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

3.3.2 Basic Component Descriptions

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. 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 2.0, “Specifications” on page 12.

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 4.17 ms.

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 not doing a disk operation or SCSI data transfer, whether or not it is connected to the bus. (See 3.6, “Read Command Performance” on page 33

and 3.7, “Write Command Performance” on page 35 for examples of detailed descriptions of the components of Command Execution Overhead.)

The Command Execution Overhead specification is based on a normal operation with the Read Ahead function disabled. The value of this parameter varies greatly depending upon workloads and environments.

When Read Ahead is enabled, overhead for random commands immediately following a read command is increased by approximately .24 msec.

Overhead for sequential read commands immediately following a read command is decreased by approximately .89 msec.

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

Workload	**Command Execution**	**SCSI Bus**
Sequential Read	1.20	.03
Sequential Write	1.06	.04
Random Read	.25	.03
Random Write	.40	.04

Table 9. Overhead Values. (All times are in 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 3.6, “Read Command Performance” on page 33 and 3.7, “Write Command Performance” on page 35 for more detailed descriptions of the components of SCSI Bus Overhead.)

Post Command Processing time of 0.40 ms 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.

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.

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)

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. (See 3.6.1.3, "Theoretical Data Sector Transfer Rate" on page 34 for a description on how to calculate it.)

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 2XP SCSI Interface Specification Release 2.03* for a description of error recovery procedures.)

Rates for drives formatted at 512 bytes/block are located in Table 10.

Model Type	**9.11GB**		**4.55GB**	
Notch #	**Theoretical**	**Typical**	**Theoretical**	**Typical**
Average	9.201	9.191	9.127	9.117
1	10.178	10.168	10.098	10.088
2	9.736	9.726	9.659	9.649
3	9.127	9.118	9.055	9.046
4	8.519	8.510	8.452	8.443
5	8.076	8.068	8.013	8.004
6	7.744	7.737	7.683	7.676
7	7.302	7.295	7.244	7.237
8	6.638	6.631	6.586	6.579
Note: The values for Typical Data Sector Transfer Rates assume a typically worst case value of 1 error in 10^8 bits read at nominal conditions for soft error rate.				

Table 10. Data Sector Transfer Rates. (All rates are in MB/sec)

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 20.0 MB/sec.

3.3.3 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 3.6, "Read Command Performance" on page 33 and 3.7, "Write Command Performance" on page 35 for details.)
- The Post Command Processing times are not components of the Command Execution time therefore they are not included in the calculation of environments where the re-instruct period exceeds the Post Command Processing time.

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

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

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

The effects of idle time functions are not included in the above examples. The sections 3.2.1, “Sequential” on page 25 and 3.2.2, “Random” on page 25 both define environments where the effects due to increased command overhead of Idle Time Functions upon Command Execution time are less than 0.01%.

3.4 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 20 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 intermediate disconnect causes a pause of approximately 0.24 msec during the Data phase. This disconnection requires approximately 33 µsec and the subsequent reconnection requires approximately 20 µsec.

3.5 Approximating Performance for Different Environments

3.5.1 For Different Transfer Sizes

The primary performance change due to a change of the Transfer Size, is the Data Transfer to/from Disk component. See 3.3.2, “Basic Component Descriptions” on page 27, Data Transfer to/from Disk, for an explanation of the calculation of this parameter.

The values for several other Basic Components may also change if the transfer size is reduced to the point where certain internal control functions can no longer be overlapped with either the SCSI or disk data transfer. The components changed vary based on the type of environment and workload.

The following four sections, give an approximation of performance changes for read, write, sequential and random workloads with a 0.5KByte transfer size.

3.5.1.1 0.5 KByte Sequential Read

For this workload, the Data Transfer to/from SCSI Bus is reduced by 0.104 msec (since a single block of data is transferred). The Command Execution Overhead increases by approximately 0.28 msec since the starting of the SCSI data transfer can no longer be overlapped with the disk data transfer.

The magnitude of the performance advantage with the Read Ahead function enabled and op delays between 50 and 150 ms is reduced due to the smaller transfer size. The Command Execution time is reduced by approximately 0.5 msec.

Note: This time difference can be approximated for other transfer sizes 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 the Read Ahead with op delays of 0-8 msec 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: This time also varies with the size of the data transfer due to the difference between the SCSI data transfer rate and Disk data transfer rate. This time is insignificant for a 0.5KByte transfer size and has been ignored in the above equation.

3.5.1.2 0.5 KByte Sequential Write

For this workload the Data Transfer to/from SCSI Bus is reduced by 0.05 msec (since a single block of data is transferred). The Command Execution Overhead increases by approximately 0.068 msec.

3.5.1.3 0.5 KByte Random Read

For this workload, the Data Transfer to/from SCSI Bus is reduced by 0.104 msec (since a single block of data is transferred). The Command Execution Overhead increases by approximately 0.28 msec since the starting of the SCSI data transfer can no longer be overlapped with the disk data transfer.

3.5.1.4 0.5 KByte Random Write

For this workload, only the Data Transfer to/from Disk changes as described in 3.5.1, “For Different Transfer Sizes” on page 30.

3.5.2 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) 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.

3.5.3 When Write Caching is Enabled

For write commands with the Write Caching Enabled (WCE) Mode parameter bit set, Command Execution time can be approximated by deleting Seek, Latency and Data Transfer to/from Disk times from those shown in the graphs. The contribution of the Data Transfer to/from SCSI Bus to the Command Execution time may increase since a larger, or entire, portion of the transfer may no longer be overlapped with the components that were reduced.

The reduced times effectively are added to the Post Command Processing Time.

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

Like Tagged Command Queuing, when the WCE bit is set Back-To-Back write commands are supported. See 3.5.5.2, “Back-To-Back Write Commands” on page 32 for more information.

3.5.4 When Adaptive Caching is Enabled

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

3.5.5 For Queued Commands

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

3.5.5.1 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 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.

3.5.5.2 Back-To-Back Write Commands

If all of the requirements are met as stated in the *Ultrastar 2XP SCSI Interface Specification Release 2.03* 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.

3.6 Read Command Performance

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

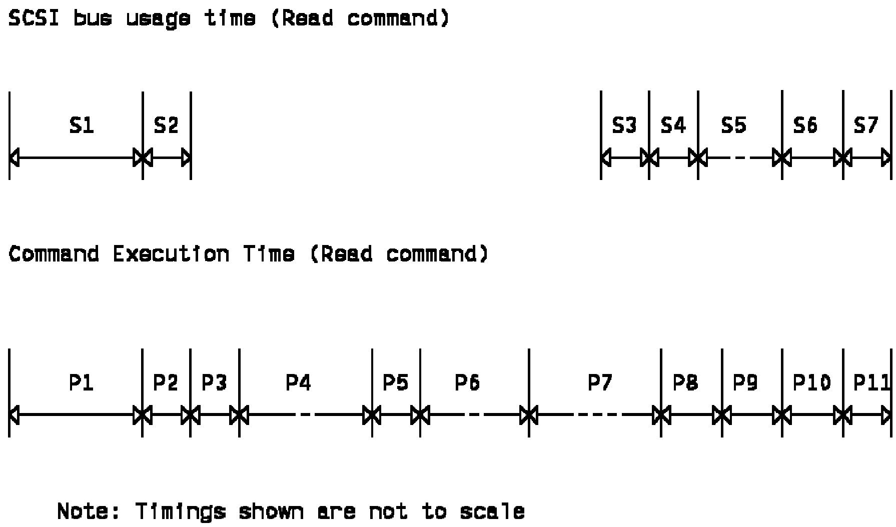


Figure 15. SCSI Read command performance measurements

3.6.1.1 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)**	10 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**	3 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).

3.6.1.2 Command Execution Overhead

P1 Selection, Identify Msg., CDB	10 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 = 7.5 or 8.5 msec)
P5 Set up read disk transfer	0 µsec
P6 Latency (for example, half revolution)	(latency = 4.17 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

Use the following formula to approximate the Typical Data Sector Transfer Rate.

3.6.1.3 Theoretical Data Sector Transfer Rate

This Rate does not account for time required for error recovery or defective sectors. (The Typical Data Sector Transfer Rate described in 3.3.2, “Basic Component Descriptions” on page 27 does include those effects.) Each group of cylinders with a different number of gross sectors per track is called a notch. The following shows values for notch #1 of 4.55GB models. The "Average" values used in this specification are sums of the individual notch values weighted by the number of LBAs in the associated notches. For the other notches and block lengths use values that correspond to those notches and block lengths.

Data Sector Transfer Rate =

$$\frac{\text{Bytes/cylinder}}{\text{time for 1 cyl} + \text{track skews} + \text{1 cyl skew}}$$

Bytes/cylinder = (tracks/cyl)(gross sectors/track) (bytes/sector)
= (9)(184)(512)
= 847,872 Bytes/cyl

time for 1 cyl of data = (tracks/cyl)(revolution time)
= (9)(8.333)
= 75.000 msec/cyl

time for track skews = (tracks/cyl - 1)(track skew time)
= (9-1)(8.333*9/88)
= 6.818 msec/cyl

time for 1 cyl skew = (cylinder skew time)
= (8.333*23/88)
= 2.178 msec/cyl

Data Sector Transfer Rate =

$$\frac{\text{847,872 Bytes}}{\text{75.000msec} + \text{6.818 msec} + \text{2.178 msec}}$$

= 10.094 MB/sec (Notch #1)

3.7 Write Command Performance

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

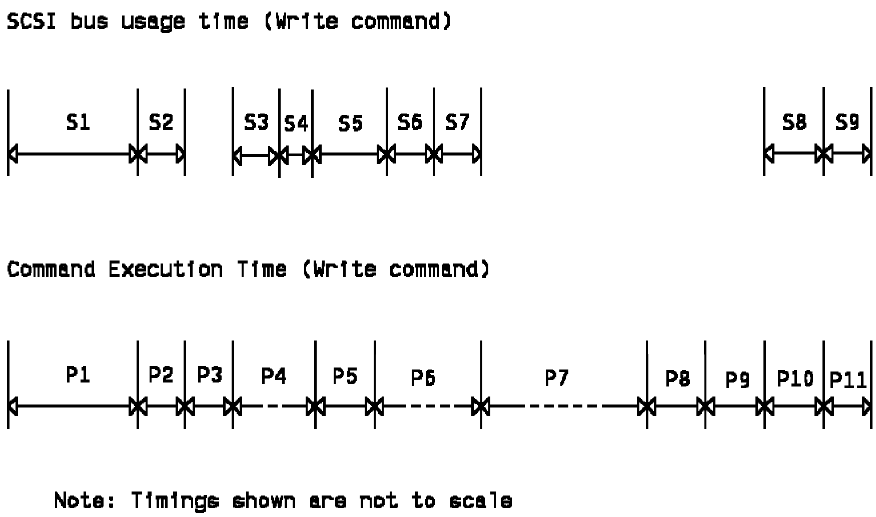


Figure 16. SCSI Write command performance measurements

3.7.1.1 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	10 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	3 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. (0.04 msec total).

3.7.1.2 Command Execution Overhead

P1 Selection, Identify Msg., CDB	10 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 = 9.5 or 10.5 msec)
P5 Set up write disk transfer	0 µsec
P6 Latency (for example, half revolution)	(Latency = 4.17 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

Note: Use the 3.6.1.3, “Theoretical Data Sector Transfer Rate” on page 34 for an approximation of the Typical Data Sector Transfer Rate.

3.8 Skew

3.8.1 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. Cylinder skew is based on the number of SIDs required to accomplish the physical movement. There are 88 SIDs on a track, and cylinder skew requires 23 SIDs. Therefore the amount of time required for a cylinder switch is 2.17 mS (8.33*23/88).

3.8.2 Track to Track Skew

Track skew is the time required to perform a switch between heads on the same track. The concept is exactly the same as cylinder skew, except it can be performed more quickly. The track skew value is 9 SIDs. Therefore the track skew time is .85 mS (8.33*9/88).

3.9 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. Channel Calibration
3. Save Logs and Pointers
4. 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. Mechanisms to lessen performance impacts, and in some cases virtually eliminate those impacts from an Initiator's point of view, are also mentioned.

Following the descriptions is a summary of the possible impacts to performance.

3.9.1 Performance considerations for Predictive Failure Analysis

This is an idle time function.

Predictive ***F***ailure ***A***nalysis measures drive parameters and can predict if a drive failure is imminent.

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 a particular model has. The drive attempts to spread the measurements evenly in time and each measurement takes about 80 milliseconds.

```
For example, a model with 9 heads will perform one PFA measurement
every 3.8 minutes (240 / 7*9).
```

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 0h Mode Parameter LITF = 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 2XP SCSI Interface Specification Release 2.03* for more details about PFA, LITF and TCC.

3.9.2 Channel Calibration

The drive periodically calibrates the channel to insure that the read and write circuits function optimally, thus reducing the likelihood of soft errors.

Channel calibration is done once every 4 hours and typically completes in 20 milliseconds, but may take up to 64 milliseconds per measurement.

The measurement will only be 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 function also makes use of the mechanism to alter the idle detection period to limit execution for critical response time periods of operation, if needed.

3.9.3 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.

If the Page 0h Mode Parameter LITF = 1, the saving will only be 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 function also makes use of the mechanism to alter the idle detection period to limit execution for critical response time periods of operation, if needed.

3.9.4 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, the heads are moved to another position. Execution time is less than 1 full stroke seek.

3.9.5 Summary

Idle Time Function Type	Period of Occurance (minutes)	Duration (ms)	Mechanism to Delay/Disable
PFA	30/(trk/cyl)	80	LITF, TCC
Channel Calibration	240	64	Re-instruction Period
Save Logs & Pointers	26	30	LITF & Re-instruction Period
Note: "Re-instruction Period" is the time between consecutive SCSI command requests.			

Table 11. Summary of Idle Time Function Performance Impacts

3.10 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.

3.10.1.1 Reassignment Time

The drive should be allowed a minimum of 25 sec to complete a "Reassign Blocks" command.

The drive is capable of substantial consecutive reassigns to maintain performance however greater than 25 consecutive reassigns may take longer than 60 seconds. Hardware resets should not be issued when reassigns are in progress.

3.10.1.2 Format Time

9.11GB models should be allowed an average of 60 minutes to complete a "Format Unit" command. The maximum format time is 120 minutes

4.55GB models should be allowed an average of 30 minutes to complete a "Format Unit" command. The maximum format time is 60 minutes

3.10.1.3 Start/Stop Unit Time

The drive should be allowed a minimum of 90 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.

3.10.1.4 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.

3.10.1.5 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.

4.0 Mechanical

4.1 Weight and Dimensions

	4.55GB Models		9.11GB Model	
	U.S.	S.I. Metric	U.S.	S.I.Metric
Weight	1.12 pounds	0.506 kilograms	1.79 pounds	0.812 kilograms
Height	1.00 inches	25.4 millimeters	1.63 inches	41.3 millimeters
Width	4.00 inches	101.6 millimeters	4.00 inches	101.6 millimeters
Depth	5.75 inches	146.0 millimeters	5.75 inches	146.0 millimeters

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. Figure 19 on page 43 shows the clearance requirements

There should be 7 mm of clearance between these 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 7.1.1, “Temperature Measurement Points” on page 70.

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 Figure 17 on page 41, Figure 19 on page 43 and Figure 18 on page 42 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 perminent damage to the drive.

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

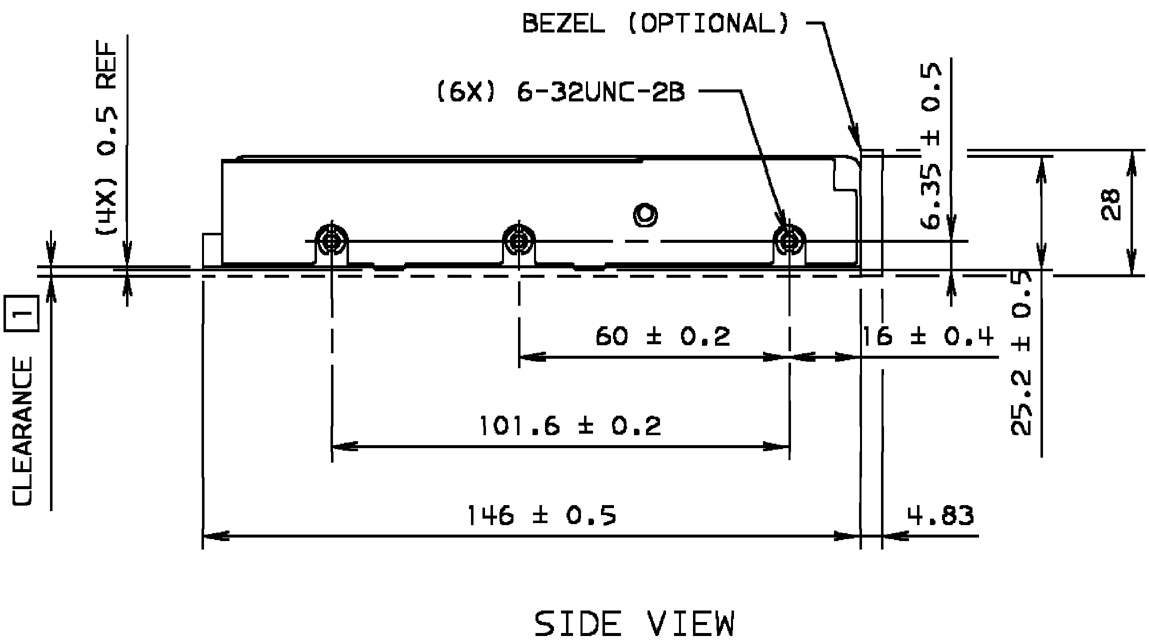
For more information on mounting guidelines see section 7.5, “Drive Mounting Guidelines” on page 75

4.3.1 SCA Mounting Guidelines

Since the SCA mounting system lacks the compliant cabling of alternate connectors (50/68), 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.

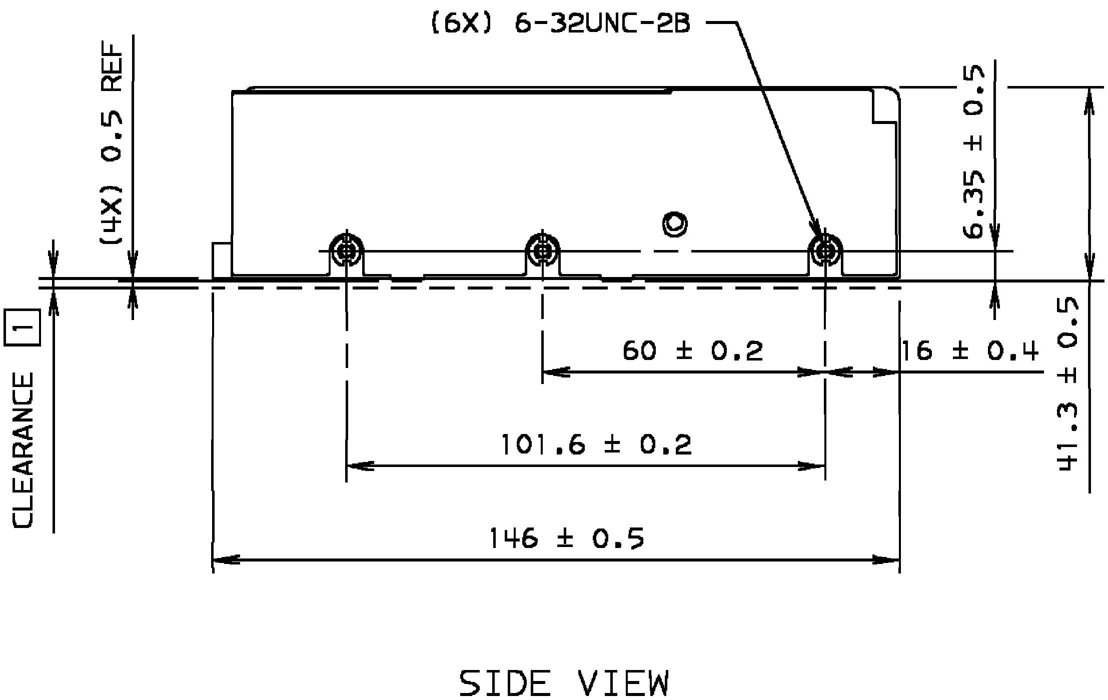
1. The SCA-2 connector should not be required to support the weight of the drive.
2. Operational vibration occurring between the mating halves of the SCA connector should be avoided.
3. The drive should be firmly secured once the connector mate has occured.
4. The connector was designed to allow for 'mismate' or offset during the plugging operation. Excessive offsets between the drive connector and the 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. The manufacturer will provide technical support to assist users to overcome mounting sensitivity.



Note: Clearance = 7 mm

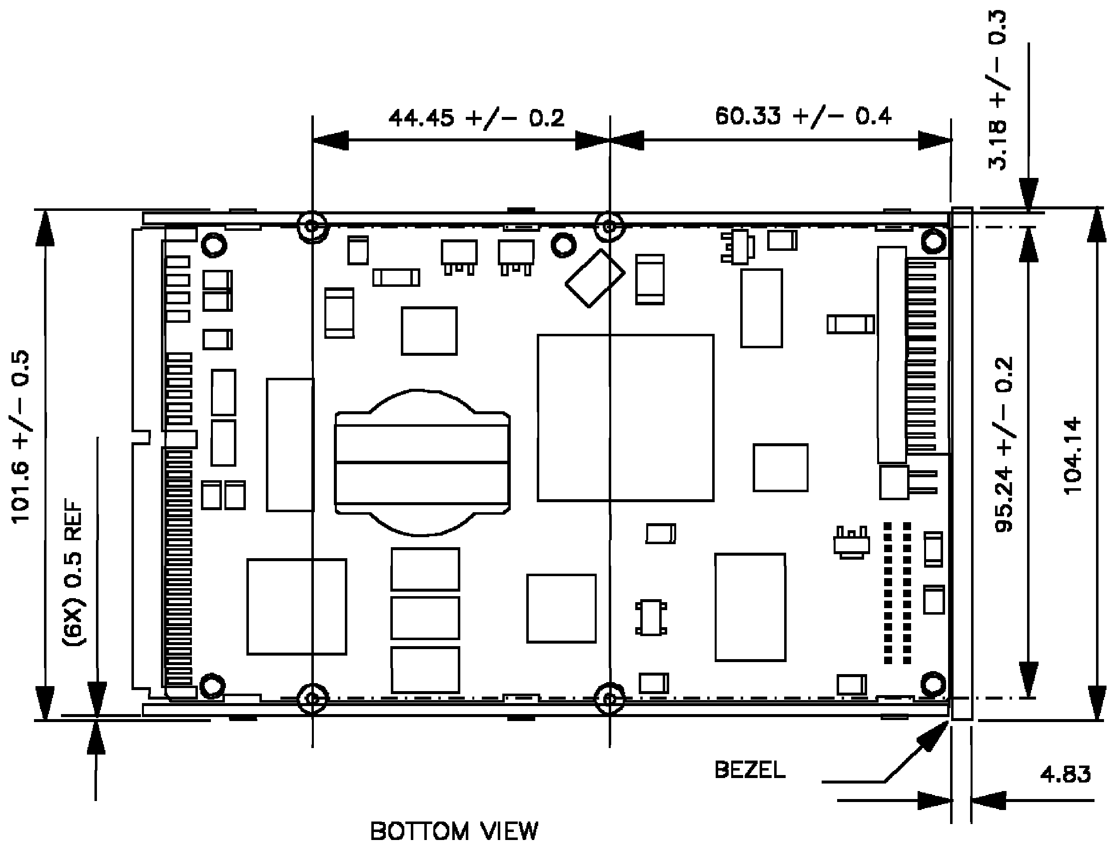
Figure 17. Location of Side Mounting Holes of 4.55GB Model



Note: Dimensions are in millimeters.

Note: Clearance = 7 mm

Figure 18. Location of Side Mounting Holes of 9.11GB Model



Note: Dimensions are in millimeters.

Figure 19. Location of Bottom Mounting Holes for 68 Pin Models

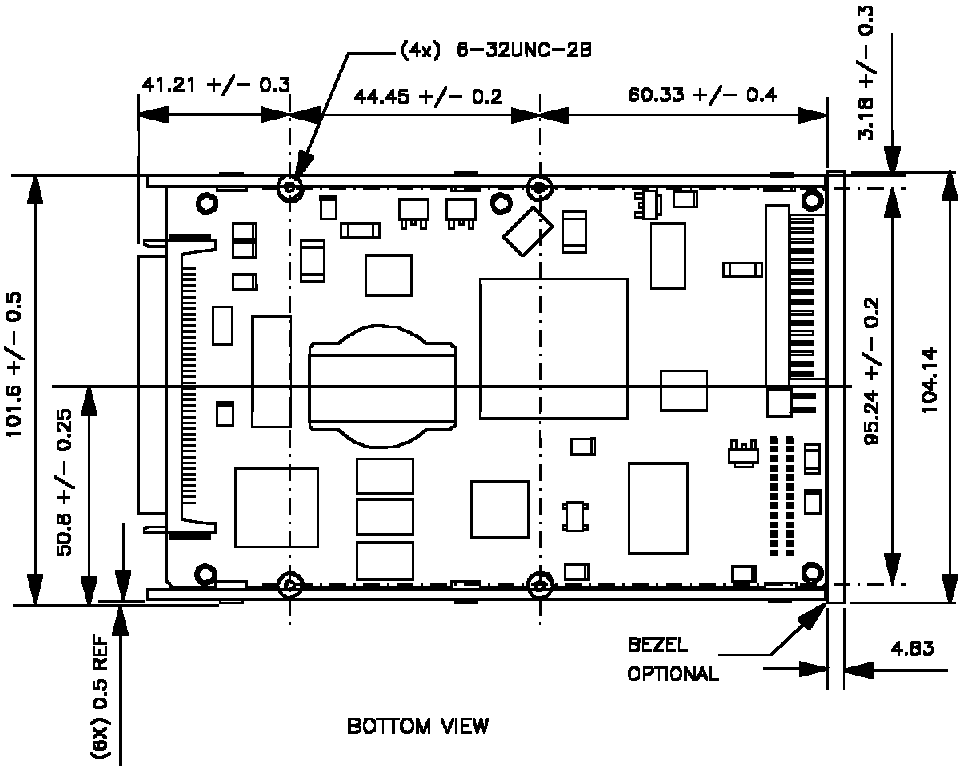


Figure 20. Location of Bottom Mounting Holes for 80 pin SCA-2 models.

4.4 Electrical Connector Locations

The electrical connectors are located as shown in Figure 21 on page 45, Figure 22 on page 46, Figure 23 on page 47, and Figure 24 on page 48.

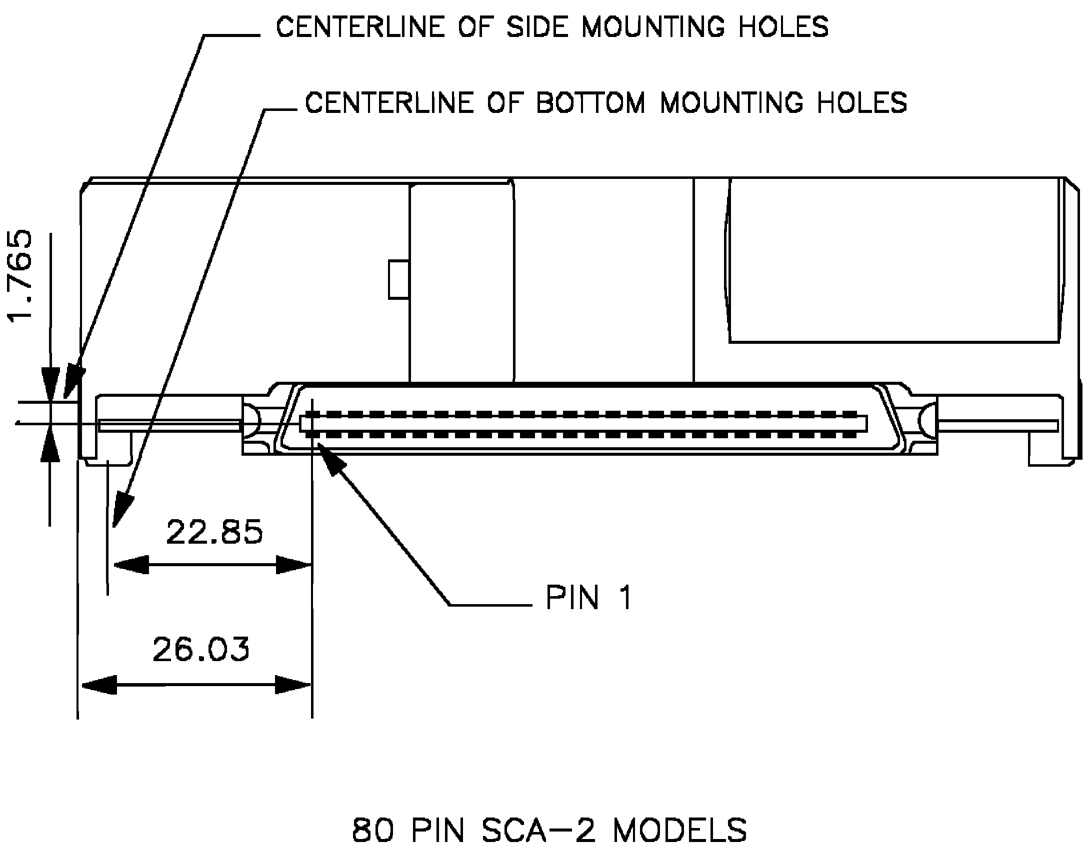
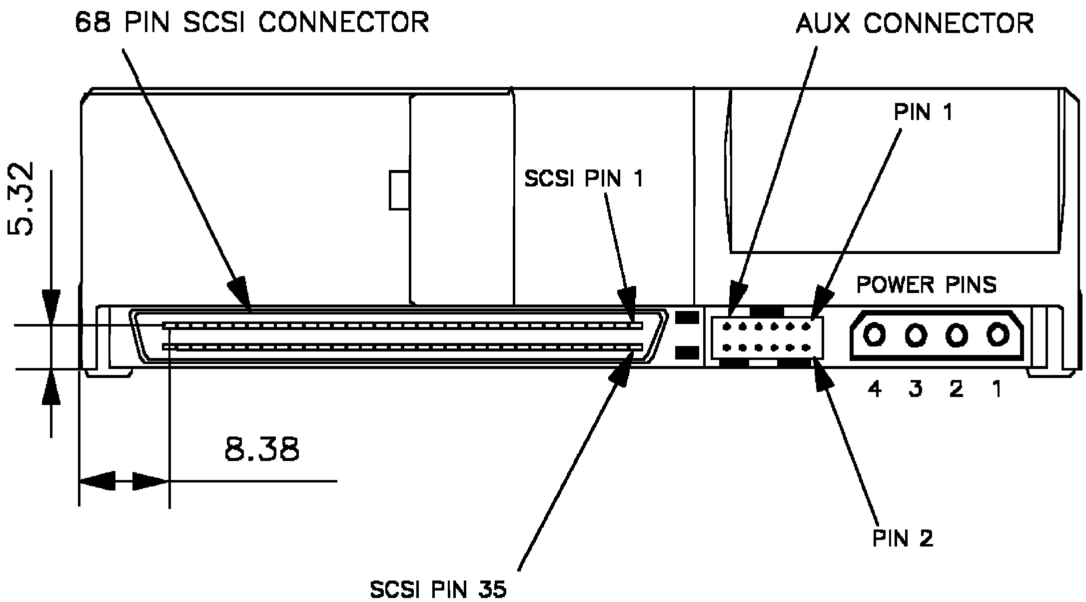
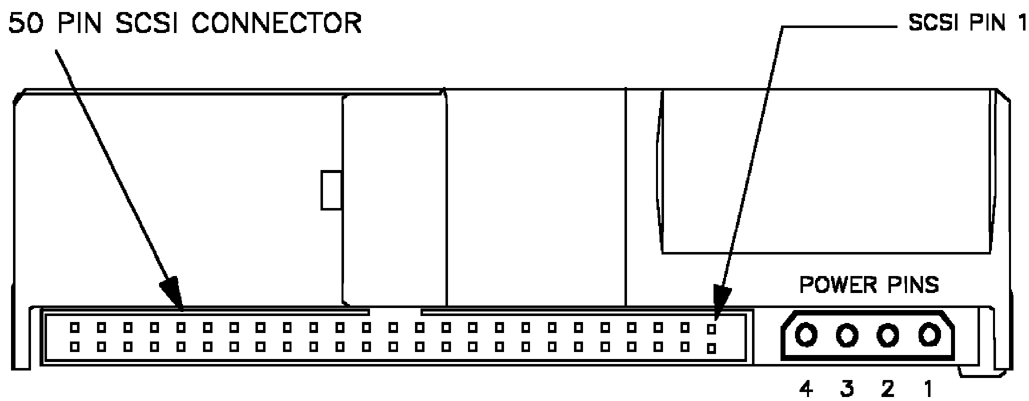


Figure 21. Electrical connectors (rear view) -- 80 pin SCA-2 models.



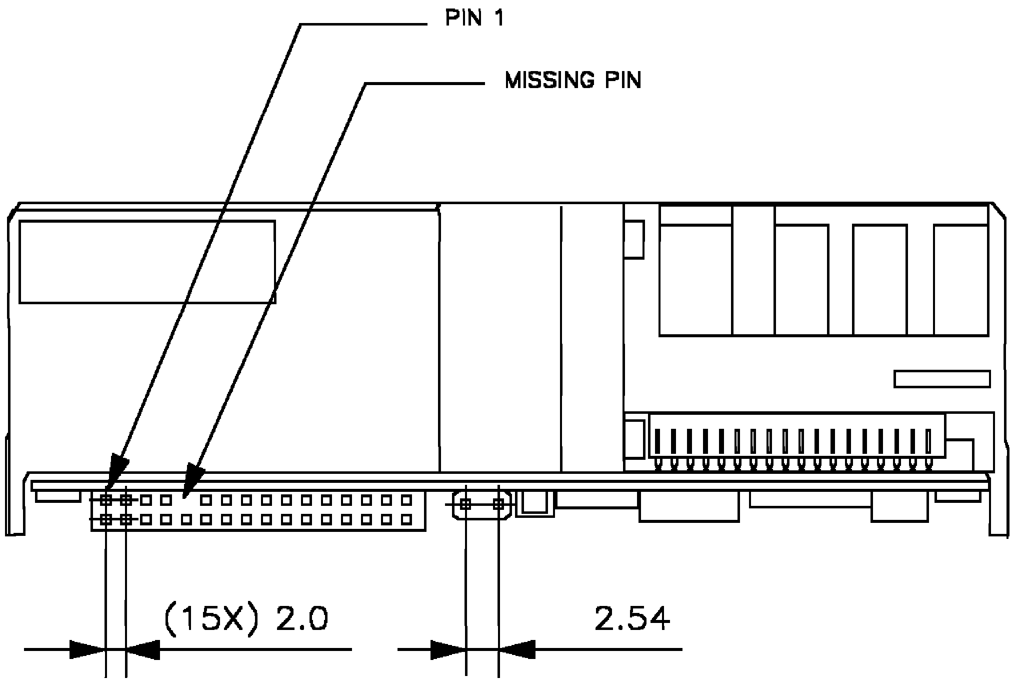
POWER PIN ASSIGNMENTS	
PIN	VOLTAGE
1	+ 12V
2	GND
3	GND
4	+ 5V

Figure 22. Electrical connectors (rear view) -- 68 pin models.



POWER PIN ASSIGNMENTS	
PIN	VOLTAGE
1	+ 12V
2	GND
3	GND
4	+ 5V

Figure 23. Electrical connectors (rear view) -- 50 pin models.



Note: Dimensions are in millimeters.

Figure 24. Jumper pin locations (front view)

5.0 Electrical Interface

5.1 Power Connector

The DC power connectors used on all models (50, 68 and 80 pin SCA-2) are an integral portion of the 50/68 pin SCSI 'Unitized' Connectors or the 80 pin 'Single Connector Attachment' (SCA-2) Connector.

50 pin models use an AMP connector (PN 84160-1) that is compatible with the ANSI SCSI "A" connector specifications.

68 pin models use a Molex connector (PN 87360-0001) that is compatible with the ANSI SCSI "P" connector specifications.

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 50 and 68 pin models are shown in Table 12.

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

Table 12. Power connector pin assignments

Refer to the section entitled 2.4, “ Power Requirements” on page 15 and 2.4.8, “Additional 5V Current Requirements for Differential SCSI” on page 21, for details on drive power requirements.

5.2 SCSI Bus Connector

Ultrastar 2XP has different model types that support 50 or 68 pin Single-Ended or 68 pin Differential configurations. Also supported is the 80 pin SCA-2 in a Single-Ended configuration. This section describes the signal assignments of the ***Ultrastar 2XP*** SCSI connectors.

These connectors use 30 micro-inch Gold plating for high reliability.

5.2.1 50 Pin Signal Connector

50 pin models use an AMP PN 84160-1 connector. The connector is compatible with the ANSI SCSI "A" connector specifications. It is limited to 8 bit data transfers only. Refer to Figure 23 on page 47 for a rear view of the 50 pin model connector.

The SCSI connector contact assignments for the 50 pin single-ended model is shown in Table 13 on page 50.

Signal Name	Connector Contact Number		Signal Name
GROUND	1	2	-DB(0)
GROUND	3	4	-DB(1)
GROUND	5	6	-DB(2)
GROUND	7	8	-DB(3)
GROUND	9	10	-DB(4)
GROUND	11	12	-DB(5)
GROUND	13	14	-DB(6)
GROUND	15	16	-DB(7)
GROUND	17	18	-DB(P)
GROUND	19	20	GROUND
GROUND	21	22	GROUND
GROUND	23	24	GROUND
OPEN	25	26	TERMPWR
GROUND	27	28	GROUND
GROUND	29	30	GROUND
GROUND	31	32	-ATN
GROUND	33	34	GROUND
GROUND	35	36	-BSY
GROUND	37	38	-ACK
GROUND	39	40	-RST
GROUND	41	42	-MSG
GROUND	43	44	-SEL
GROUND	45	46	-C/D
GROUND	47	48	-REQ
GROUND	49	50	-I/O

Table 13. 50 Pin Single-Ended SCSI Connector Contact Assignments

5.2.2 68 Pin Signal Connector

68 pin models use an AMP connector (PN 786963-1) 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 Figure 22 on page 46 for a rear view of a 68 pin model.

The SCSI connector contact assignments for the 68 pin single-ended models are shown in Table 14 on page 51.

The SCSI connector contact assignments for the 68 pin differential models are shown in Table 15 on page 52.

Signal Name	**Connector Contact Number**		**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)
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 14. 68 Pin Single-Ended SCSI Connector Contact Assignments

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

5.2.3 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 uses 30 micro-inch Gold plating for high reliability.

Data transfers in both 8 bit (narrow) and 16 bit (wide) modes are supported. Refer to Figure 21 on page 45 for a rear view of an 80 pin model.

The SCSI connector contact assignments for the 80 pin single-ended models are shown in Table 16 on page 53.

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
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	SCSI ID(3)
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 "ENABLE NARROW MODE" on the Front Option Jumper Block and 'float' the same signals. All other signals shall be connected as defined.			

Table 16. 80 Pin SCA-2 Connector Contact Assignments

5.2.4 SCSI Bus Cable

Single-ended 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.

Fast-20 models permit cable lengths of up to 3 meters (3.25 feet)

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.

Differential models permit cable lengths of up to 25 meters (82.02 feet). Cables must meet the requirements for differential cables as set forth in the ANSI SCSI standard under "Cable Requirements - Differential Cable".

The ANSI SCSI standard states that any stub from main cable must not exceed 0.1 meters for single-ended cables and 0.2 meters for differential cables. ***Ultrastar 2XP*** has a maximum internal stub length of 0.05 meters on all 'single ended' SCSI signals, and 0.1 meters on all 'differential' 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.

5.2.5 SCSI Bus Terminators (Optional)

Upon request, Single Ended 50 and 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 Figure 25 on page 57, Figure 26 on page 58, and Figure 29 on page 61.) The using system is responsible for making sure that all required signals are terminated at both ends of the cable. See 5.2.7, "SCSI Bus Electrical Characteristics" on page 55 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: .

50 Pin Model Terminators	68 Pin Model Terminators
Data Mate DM2000-02-R	Data Mate DM2050-02-68S
Data Mate DM500-06-R	Data Mate DM2050-02-68R

Table 17. Single Ended SCSI Terminators

Differential models do not have internal SCSI bus terminators. Some external terminator possibilities are listed below: .

50 Pin Model Terminators	68 Pin Model Terminators
Data Mate DM550-05-0	Data Mate DM2050-01-68D
Data Mate DM1050-02-0	

Table 18. Differential SCSI Terminators

5.2.6 SCSI Bus Termination Power

Termination power is optionally provided for systems that desire to use it. In order to use the termination power, the user needs to install a jumper between pins 1 and 2 of the TermPower Block. (Refer to Figure 25 on page 57, Figure 26 on page 58.) 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. 50 pin models can source up to 1.5 Amps of current at 5.0 Volts (+- 5%) for termination power.

5.2.6.1 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 2XP*** drive limits current to 5.0 Amps thru the use of a permanent 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.

5.2.7 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
Vil	low level input voltage	-0.2	0.8	V	
	Fast-20		1.0	V	
Vih	high level input voltage	2.0	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	0.3		V	
Ci	input capacitance		25	pF	w/terminators disabled, Typ. = 19 pF
Ci	input capacitance		19	pF	w/o terminators, Typ. = 14 pF

Table 19. Single-Ended Bus Electrical Characteristics

Differential models meet all electrical requirements as defined in the ANSI SCSI-2 standard under "Electrical Description - Differential Alternative".

5.3 Option Block Connector (Jumper Blocks)

Ultrastar 2XP 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 (50, 68, Differential, SCA-2).

The Option Block connector (2x16) used on 50,68 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 -- 30Uin Gold
- Supplier -- METHODE 9608-202-35, or approved equivalent.

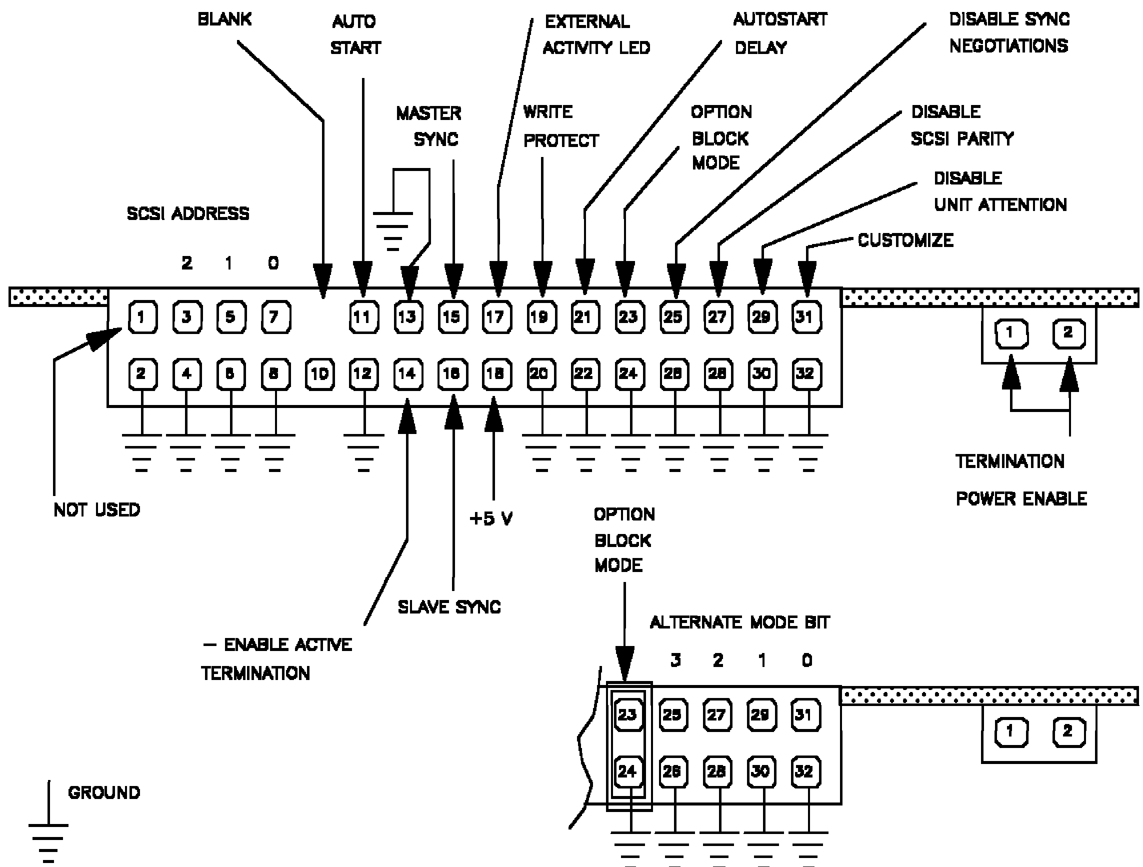


Figure 25. 50 pin Single Ended Front Option Jumper Block and TermPower Block

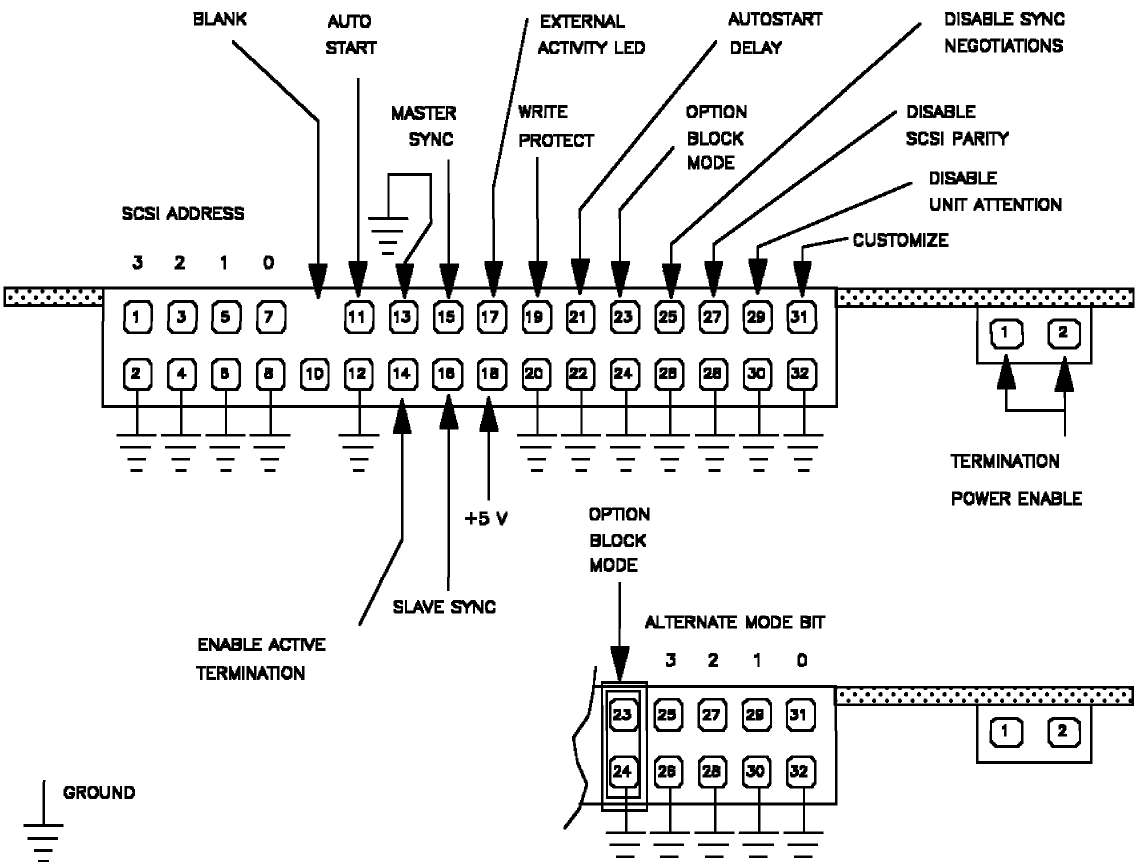


Figure 26. 68 pin Single Ended Front Option Jumper Block and TermPower Block

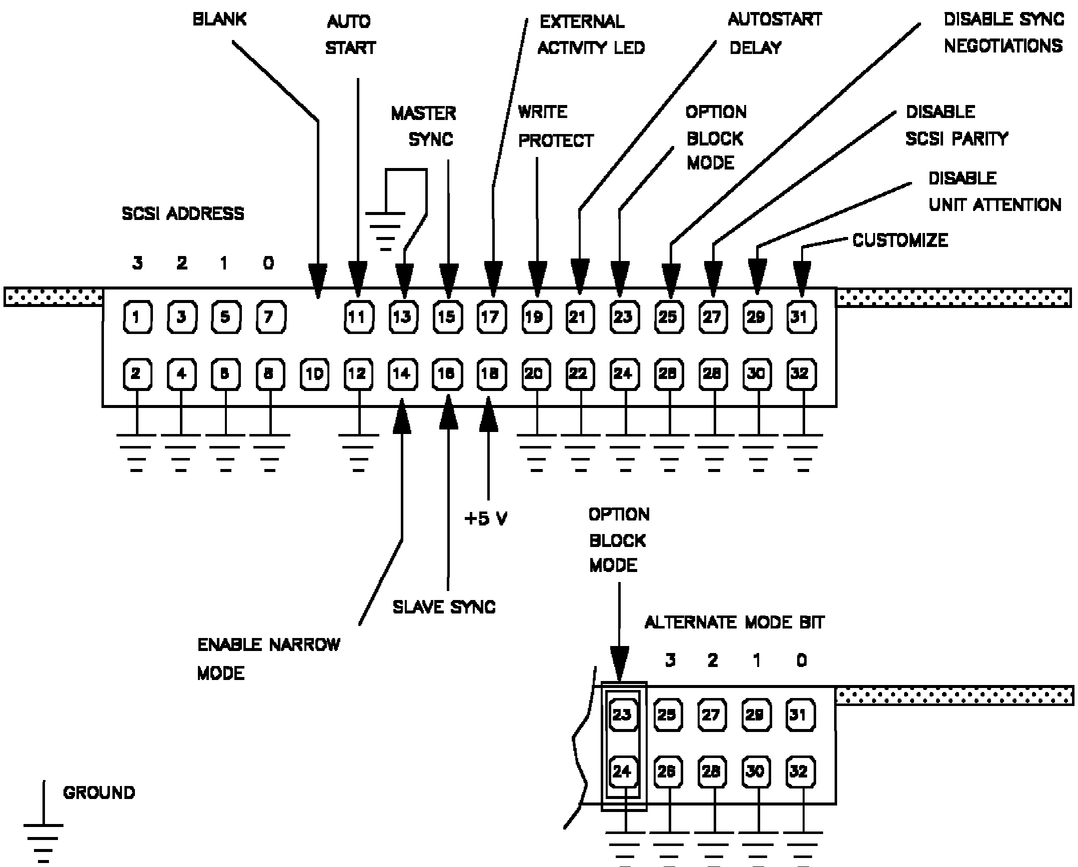


Figure 27. SCA-2 Front Option Jumper Block

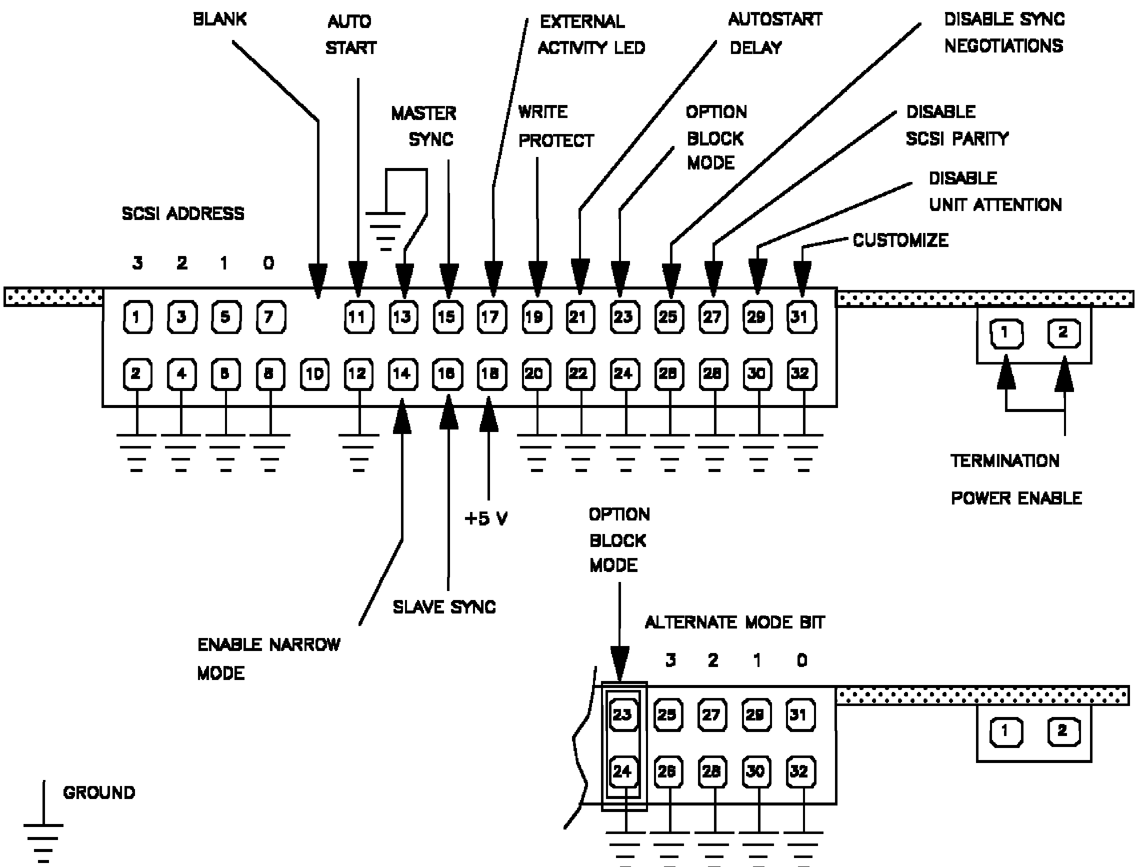


Figure 28. 68 pin Differential Front Option Jumper Block

5.3.1 68 Pin Auxiliary Connector

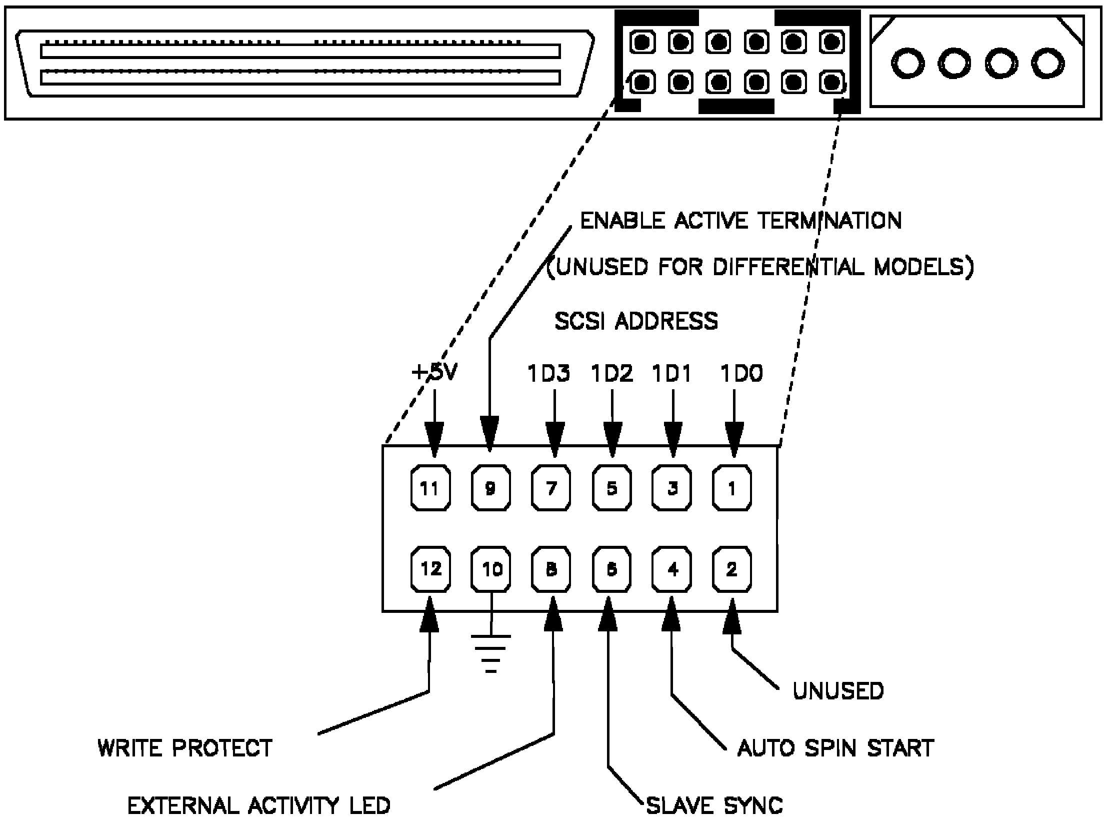


Figure 29. Auxiliary Connector on the 68 pin Connector

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:

   a. tied to ground (auto spin start enabled)
   b. allowed to 'float' (no connection)
   c. driven with an open collector driver (>1mA sink capability)

The Auxiliary Connector is shown in figure Figure 29.

5.3.2 SCSI ID (Address) Pins

Information on how to select a particular address for the SCSI device ID is given in Table 20 and Table 21.

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 20. Address Determination of 68 and 80 Pin Models

BIT 2	BIT 1	BIT 0	ADDRESS
off	off	off	0
off	off	on	1
off	on	off	2
off	on	on	3
on	off	off	4
on	off	on	5
on	on	off	6
on	on	on	7

Table 21. Address Determination of 50 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. Table 22 on page 63 and Table 23 on page 63 show whether or not Auto-Startup mode is active and the delay periods, where applicable, for all combinations of the pins.

Pins (50 & 68 interface pin models)		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 22. Auto-Startup Modes selectable by Auto-Start/Delay Pin Combinations

Pins (80 interface pin models)		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 23. 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 **Ultrastar2 XP 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.

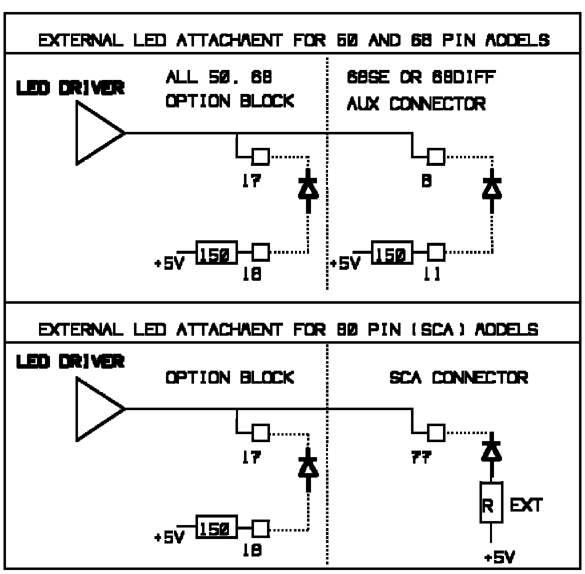


Figure 30. LED Circuit Diagram

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 **Ultrastar2 XP Interface Specification** for functional details. detailed functional d

5.3.6 Option Block Mode Pin

The Option Block Mode pin is used to modify the function of the Front Option Jumper Block. When the Option Block Mode Pin is not grounded (refer to Figure 25 on page 57, Figure 26 on page 58 and Figure 27 on page 59) the pin function of the Front Option Jumper Block will be as defined by the upper portion of the referenced figures. When the Option Block Mode Pin is grounded the pins (25,27,29,31) will be redefined to control what is referred to as 'ALTERNATE MODE'. ALTERNATE MODE allows tailoring of SCSI options such as 'boot up' characteristics and other operational features on a per customer basis.

The state of these pins immediately after power is applied to the drive will determine their function.

5.3.7 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 **Ultrastar2 XP Interface Specification** for more details on this feature.

5.3.8 Disable SCSI Parity Pin

Grounding this pin will disable SCSI Parity checking.

5.3.9 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.

5.3.10 Customizing Pin

The customizing pin is currently reserved for future use.

5.3.11 Enable Narrow Mode

Jumpering pin 14 to pin 13 (refer to Figure 27 on page 59), will cause the 68 pin Differential or the 80 pin SCA-2 to operate in a Single Byte mode. The drive will not negotiate for 'Wide' (Double Byte) operation. The drive will terminate the unused upper byte and upper byte parity on the SCSI bus.

5.3.12 Enable Active Termination

Upon request, Single Ended 50 and 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 Figure 25 on page 57, Figure 26 on page 58, and Figure 29 on page 61.)

5.4 Spindle Synchronization for *Ultrastar 2XP* Drives Only

5.4.1 Spindle Synchronization Overview

There are four modes of spindle synchronization. Reference Figure 31 for a list of how the -MASTER SYNC and -SLAVE SYNC pins on the Option Jumper Block are used for the different modes. The following paragraphs give a short description of each spindle synchronization mode:

- The Slave drive (Slave Sync mode) receives the index from the Master drive on the -SLAVE SYNC line and synchronizes its INDEX (Slave index) to it.
- Should the drive be the Master drive, (Master Sync mode), it outputs its INDEX on the -MASTER SYNC and the -SLAVE SYNC lines. The Master drive does not synchronize its index to any other device. It simply outputs its INDEX.
- In the Master Sync Control mode, a drive will synchronize its spindle to the signal it receives on the -SLAVE SYNC input. It outputs to -MASTER SYNC a pulse that has the same period as the drive INDEX, but is not synchronized to the drive INDEX generated from the disk.
- In the non-sync mode, the drive will receive the -SLAVE SYNC signal, but it is not used by the drive.

Reference the Ultrastar2 XP Interface Specification for further information on the different synchronization modes.

Spindle Synchronization Control Lines		Functional Mode
-MASTER SYNC	-SLAVE SYNC	
released	receive	Slave sync
drive	drive	Master Sync.
drive	receive	Master Sync Control
released	receive	non sync

Figure 31. Spindle Synchronization Functional Modes

- Drive Synchronization with Offset.

  The drive electronics receives the Master Index and creates the delayed Slave Index from the drive INDEX. The delay is determined by using the SCSI Mode Select command, Rigid Disk Drive Geometry Parameters (Page 4). A rotational offset of 0/256 of a revolution up to 255/256 of a revolution may be selected in increments of 1/256 of a revolution. Reference the Ultrastar2 XP Interface Specification for further information on the rotational offset of synchronized spindles.

- Synchronization Time

  The SCSI Mode Select command is used to select the Spindle Sync. It could take up to 5.0 seconds (2.5 sec. nominally) to synchronize the Slave drive to the Master drive. While the Slave drive is synchronizing to the Master, it will not be able to read and write data. Once synchronized, the drive will maintain +/- 20 usec synchronization tolerance.

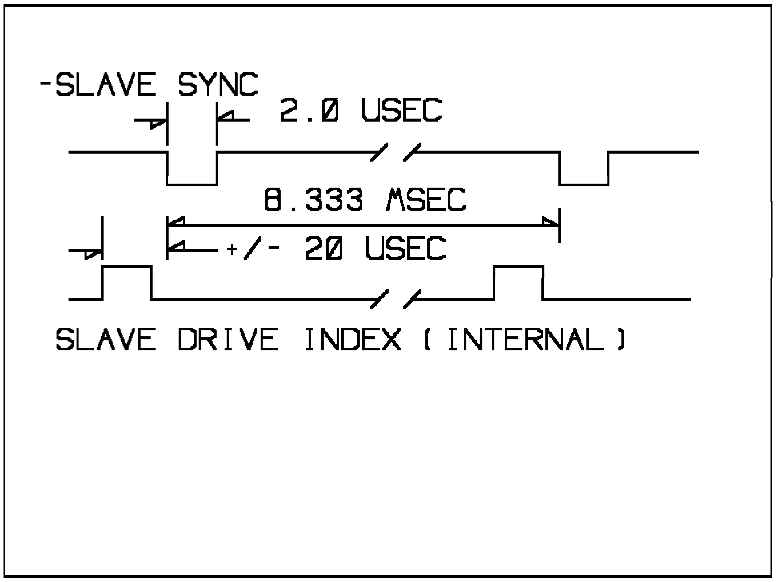


Figure 32. Slave-Sync to Slave-Index Timing

5.4.2 Spindle Synchronization Bus

The spindle synchronization Bus consists of the two signal lines, -MASTER SYNC and -SLAVE SYNC. which show the location of these signal lines on the Option Jumper Block connector. One potential configuration of this bus for drives that are to be used in a synchronized mode is shown in the following figure. This example requires the -SLAVE SYNC lines to be daisy chained together.

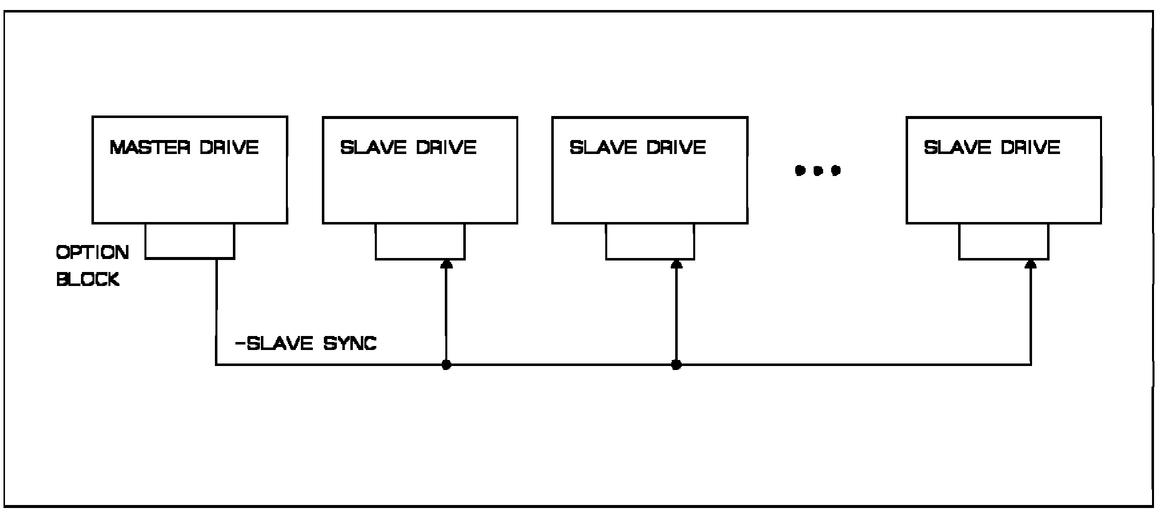


Figure 33. Daisy-Chain Connection of Synchronization Bus

- Termination

  Bus termination of the -MASTER SYNC and -SLAVE SYNC signals is internal to the drive. These two signals each have a 5K ohm pullup to the +5 volt supply. A maximum of 30 drives can have their -MASTER SYNC or -SLAVE SYNC lines daisy chained together. Violating this could damage the Master drive line driver on the -MASTER SYNC and/or -SLAVE SYNC line.

  It is the using system's responsibility to provide the cable to connect to the -SLAVE SYNC lines, and -MASTER SYNC lines where needed, of the synchronized drives.

- Bus Characteristics

  - maximum Bus length = 6 meters
  - 2 micro-second negative active pulse (when sourced by drive)
  - minimum of 1 micro-second negative active pulse when externally sourced
  - 0.8 volts = max valid low input
  - 2.2 volts = min valid high input
  - 0.4 volts = low output
  - Vcc volts = High output
  - 60 milli-amps = maximum output low level sink current

  The driver used for these two signal lines is an open collector.

- -SLAVE SYNC Input Timing Requirements

  If the input to -SLAVE SYNC is supplied by an external source other than a ***Ultrastar 2XP*** drive, the period of the input signal must be 8.333 msec with a tolerance of +/-.025%.

6.0 Reliability

6.1 Error Detection

Error reporting ≥ 99%

All detected errors excluding interface and BATs #1 (Basic Assurance Test) errors

Error detection ≥ 99%

FRU isolation = 100%

To the device when the "Recommended Initiator Error Recovery Procedur Procedures" in the Ultrastar2 XP 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 the Population)

10 in 10^{13} bits read (Measured at nominal DC conditions and room environment with default error recovery - QPE* enabled.)

With QPE enabled and the default thresholds, error reporting only occurs after step 17.[3]

6.3 SPQL (Shipped product quality level)

All units are functionally tested immediately prior to packaging and shipment from the manufacturer. 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.

[3] * Please reference QPE (qualify post error) definition in the Ultrastar2 XP Interface Specification.

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 drive is designed to support 1800 start stop cycles at 50˚C base casting temperature with a failure probability of 0.11% or less.

7.0 Operating Limits

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

7.1 Environmental

- Temperature

Operating Ambient	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) See Note
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 95% noncondensing
Shipping	5% to 100% (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)

Note: Guidelines for storage below 1˚C are given in IBM Technical Report TR 07.2112.

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: Figure 35 on page 72 defines where measurements should be made to determine the top disk enclosure temperature during drive operation. Figure 34 on page 71 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 Table 24 on page 71 are not exceeded.

Table 24. Maximum and Reliable Operating Temperature Limits		
	Maximum	**Maximum Recommended**
Disk Enclosure Top	149˚F (65˚C)	122˚F (50˚C)
Disk Enclosure Bottom	149˚F (65˚C)	122˚F (50˚C)
Channel Module[4]	194˚F (90˚C)	176˚F (80˚C)
SCSI Module	176˚F (80˚C)	140˚F (60˚C)
Microprocessor Module	203˚F (95˚C)	167˚F (75˚C)
Controller Module	212˚F (100˚C)	167˚F (75˚C)
Spindle Motor Driver Module	194˚F (90˚C)	176˚F (80˚C)
Voice Coil Driver	221˚F (105˚C)	176˚F (80˚C)
Note: - Operating the drive above the maximum temperatures may cause permanent damage.		

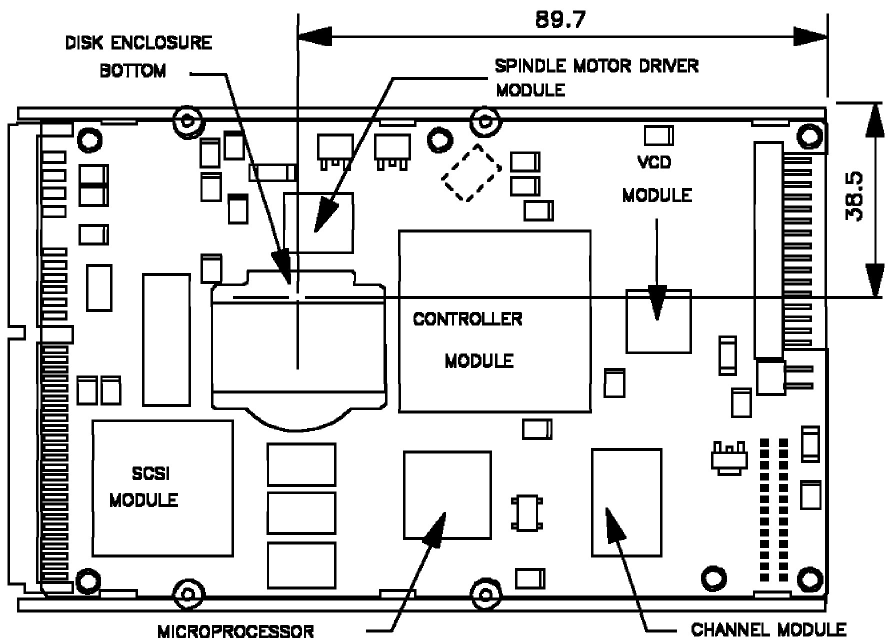


Figure 34. Temperature Measurement Points (bottom view)

4 For continuous read applications the channel module will run at higher temperatures and will require additional cooling.

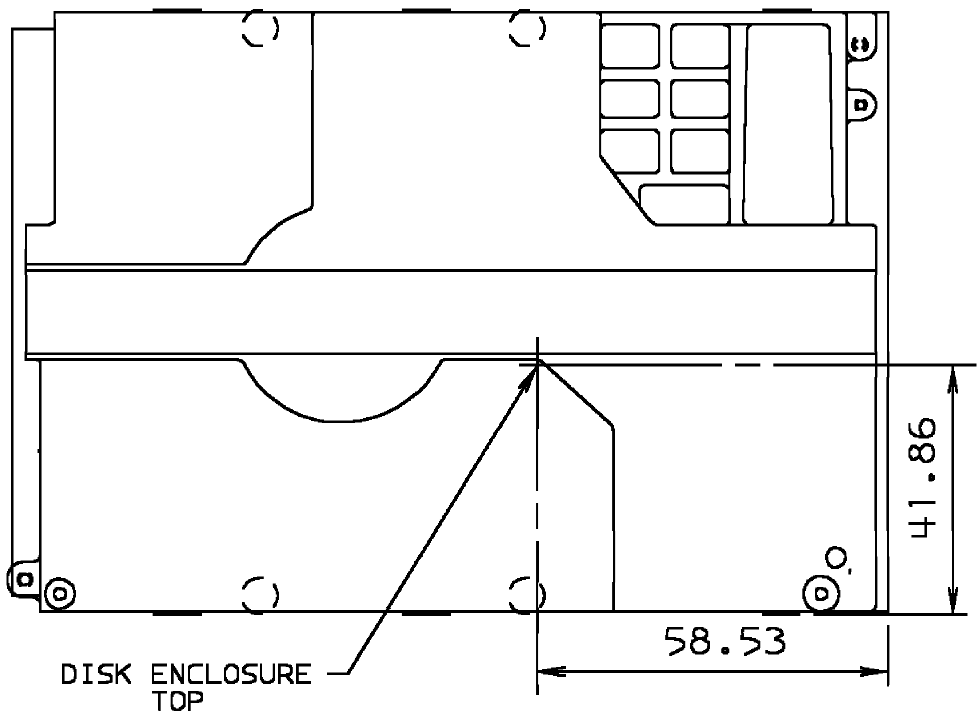


Figure 35. Temperature Measurement Points (top view)

7.1.1.1 Module Temp. Measurement Notes

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 4.2, “Clearances” on page 40
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 imbalance	1.0 gram-millimeters maximum 4.55GB
spindle imbalance	1.5 gram-millimeters maximum 9.11GB

7.2.2 Operating Vibration

The vibration is applied in each of the three mutually perpendicular axis, one axis at a time. Referring to Figure 1 on page 9, the x-axis is defined as a line normal to the front/rear faces, the y-axis is defined as a line normal to the left side/right side faces, and the z-axis is normal to the x-y plane.

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

Random Vibration

For excitation in the x-direction and the y-direction, the drive meets the required throughput specifications when subjected to vibration levels not exceeding the V4 vibration level defined below.

For excitation in the z-direction, the drive meets the required throughput specifications 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.

Table 25. Random Vibration Levels

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	g^2/hz									g

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. For input in the z-direction, an input of 1.0 G peak amplitude can be applied from 5 hz to 250 hz, the amplitude at 300 hz is 0.5 G peak. Linear interpolation is used to determine the acceleration levels between 250 hz and 300 hz.

The test will consist of a sweep from 5 to 300 hz and back to 5 hz. The sweep rate will be one hz per second.

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

7.2.3 Nonoperating Vibration

No damage 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 200 hz and back to 5 hz at a sweep rate of eight decades per hour.

Table 26. Non-operating Vibration Levels

Frequency	5 hz to 7 hz	7 hz to 200 hz
Amplitude	0.8 inch DA	2.0 G peak

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.

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

7.2.5 Non-Operating Shock

Translational Shock

No damage will occur if the unpackaged drive is subjected to a square wave shock less than 35 Gs applied to all three axis for a period of 20 milliseconds, one direction at a time.

No damage will occur if the unpackaged drive is subjected to a 11 millisecond half sine wave shock less than 70 Gs applied to all three axis, one direction at a time.

Rotational Shock

No damage will occur if the unpackaged drive is subjected to a 11 millisecond half sine wave shock less than 7,000 radians per second squared applied to all three axis, one direction at a time.

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

Upper Limit Sound Power Requirements (Bels) for 25mm Models							
	Octave Band Center Frequency (Hz)						A-weighted
	125	250	500	1K	2K	4K	8K	Bel
Idle	4.5	3.5	3.3	3.5	4.5	4.5	4.7	5.0
Operating	4.5	4.0	3.6	4.5	4.8	5.0	4.7	5.4

Additionally, the population average of the sound pressure measured one meter above the center of the drive in idle mode will not exceed 36 dBA.

Upper Limit Sound Power Requirements (Bels) for 41mm Models								
	Octave Band Center Frequency (Hz)							A-weighted
	125	250	500	1K	2K	4K	8K	Bel
Idle	4.6	3.5	3.3	3.5	4.5	4.8	4.8	5.0
Operating	4.6	4.0	3.6	4.1	5.1	5.3	4.8	5.5

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 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.

7200 RPM harmonics: 120Hz, 240Hz, 360Hz, 480Hz....

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 2XP 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” 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 and differential drive/system designs. Refer to 2.4.7, “'Hot Plug/Unplug' support” on page 20 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 Table 24 on page 71. Operating Limits in accordance with the Temperature measurement points shown Figure 35 on page 72. 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 7.2.4, “Operating Shock” on page 74 and 7.2.5, “Non-Operating Shock” on page 74. 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 7.2.2, "Operating Vibration" on page 73 . Random vibration must be measured in all three planes and found to be compatible with the vibration level in Table 25 on page 73. Swept Sine Vibration must also be measured and be compatible with 7.2.2, "Operating Vibration" on page 73.

To achieve system compatibility for vibration, it is recommended that the system conform to section 7.5, "Drive Mounting Guidelines" on page 75 .

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" on page 40.

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 7.10, "ESD Protection" on page 79.

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 5.0, "Electrical Interface" on page 49.

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 6.2, "Data Reliability" on page 68.

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 G's in the manufacturing environment. The following are things to consider in the handling and protection of the disk drive.

Damage may be caused by:

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

Precautions to take during handling:

- Wear ESD protection at all times
- Treat drives as you would "Eggs" or "Glass Stemware"
- Handle one drive at a time
- Handle drive by the sides only, avoid grasping the card
- Replace drive into original packaging for transport
- Pad ALL drive work areas (1" foam under 1/4" ESD pad)
- Pad ALL drive transport areas (1" foam under 1/4" ESD pad)
- Pad All drive holding areas (1" foam under 1/4" ESD pad)
- Clear work areas of potential metal contact
- Remove / Install drives separately
- Report any drive that may have been dropped or mishandled
- Do Not stack disk drives (Even in ESD Bags)
- Do Not contact drive or card with tooling (drivers, etc)
- Do Not rush installation
- Do Not "Slam" a drive into a carrier or frame
- Do Not "Seat" a drive into place with tooling
- Do Not stand a drive on end or side (Tipping Hazard)
- Do Not allow drives to contact each other

Shipping Handling Precautions:

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

7.8 Breather Filter Hole

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

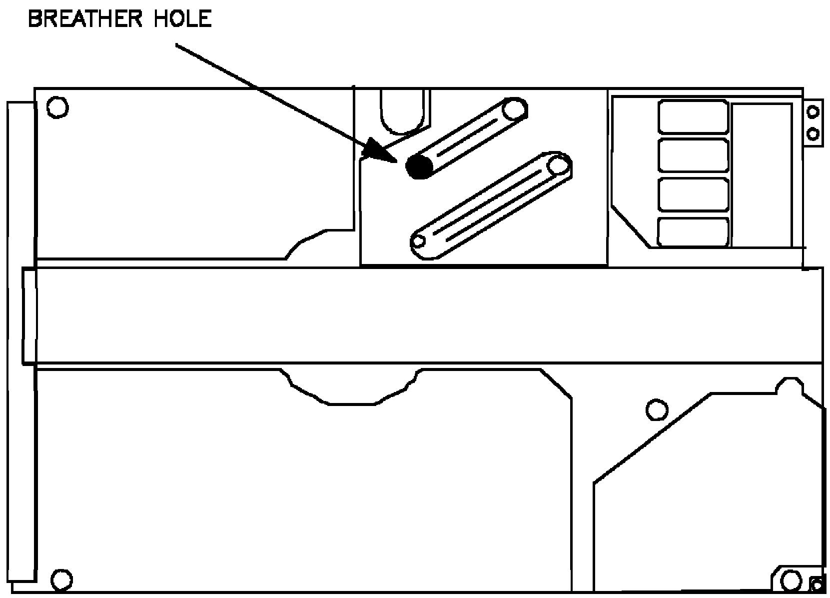


Figure 36. Breather Hole for Filter

7.9 Periodic Maintenance

None required

7.10 ESD Protection

The ***Ultrastar 2XP*** 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.

7.11 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.

7.12 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.

8.0 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.

  UL E133560 Vol 16 Section 1

- 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.

  LR-34074C

- 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.

  TUV R 9371775 Page 7

- 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 2XP*** disk drive, IBM will provide technical support to assist users in complying with the **United States Federal Communications Commission (FCC) Rules and Regulations, Part 15, 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 2XP*** 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 2XP*** 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. Products integrating these drives in alternative enclosures will still need to test the system to ensure it complys with the European Directive.