



OEM
***Ultrastar 2XP* SSA Model DCHC**
Hardware/Functional Specification
4.55GB and 9.11GB Models., 7200 RPM
Version 5.16

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1.0 Description

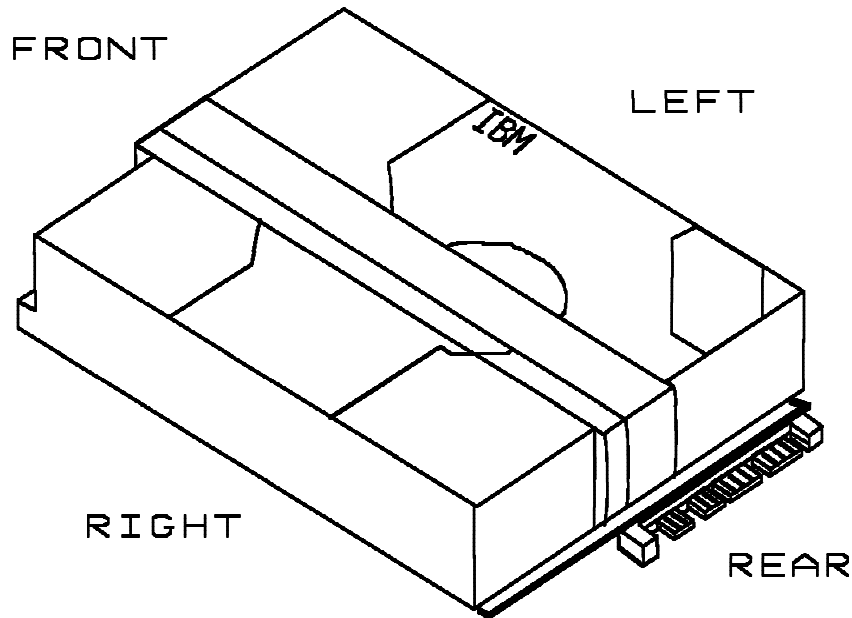


Figure 1. *Ultrastar 2XP* Disk Drive Assembly

1.1 Features

General Features

- 4.55GB/9.11GB (512 bytes/sector)
- Industry-standard interface:
 - Serial Storage Architecture (SSA) attachment (dual port)
- 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 write protection
- Spindle synchronization
- x2 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)

Interface Controller Features

- UIG-95 SSA Compliant
- Split Read/Write
- Nearly Contiguous Read/Write
- Multiple (up to 16) initiators

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

- Read-ahead caching
- Adaptive caching algorithm
- Write Caching
- 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
- Customizing controller jumpers

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 10¹⁵** bits read

1.2 Models

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

- 4.55GB capacity
- 9.11GB capacity

4.55GB Models	HDA Type 1"	Capacity GB	SSA Pins/Connector Type
DCHC 04	P9	4.55GB	38-Pin Unitized

9.11GB Models	HDA Type 1.6"	Capacity GB	SSA Pins/Connector Type
DCHC 09	PI	9.11GB	38-Pin Unitized

Note: For exact capacities refer to 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 (sustained)			

Buffer Size (Bytes) 512K
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

<i>Notch</i>	<i>Start Cylinder</i>	<i>User Data cylinders</i>	<i>Media Data Rate</i>	<i>Sectors Per Track</i>
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

<i>Notch</i>	<i>Last Cylinder</i>	<i>User Data cylinders</i>	<i>Media Data Rate</i>	<i>Sectors Per Track</i>
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

User bytes / logical block	Maximum User Logical Block Address / drive	
	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 / logical block	User bytes / drive	
	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 Common to All Models

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

Input Voltage

+5 Volts Supply	5V ($\pm 5\%$ during run and spin-up)
+12 Volts Supply	12V ($\pm 5\%$ during run) (+5% / -7% during spin-up)

Power Supply Current

	Population Mean	Population Stand. Dev.
Minimum voltage slew rate = 4.5 V/sec		
Maximum voltage slew rate = 100 V/sec		
4.55GB Models		
+5VDC (idle avg)	1.24 Amps	0.025 Amps
+5VDC (R/W baseline)	Typical 1.26 Amps	0.010 Amps
+5VDC (R/W pulse)	Peak 1.448 Amps	0.032 Amps
Minimum voltage slew rate = 7.4 V/sec		
+12VDC (Idle)	0.41 Amps	0.025 Amps
+12VDC (seek peak)	Peak 1.40 Amps	0.012 Amps
+12VDC (Start Current)	Maximum 1.71 Amps ¹	0.10 Amps

Power Supply Current

9.11GB Model		
+5VDC (idle avg)	1.242 Amps	0.030 Amps
+5VDC (R/W baseline)	Typical 1.260 Amps	0.030 Amps
+5VDC (R/W pulse)	Peak 1.468 Amps	0.030 Amps
Minimum voltage slew rate = 7.4 V/sec		
+12VDC (Idle)	0.850 Amps	0.025 Amps
+12VDC (seek peak)	Peak 2.05 Amps	0.052 Amps
+12VDC (Start Current)	Maximum 2.71 Amps ¹	0.10 Amps

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 The Start Current is the total 12 volt current required by the file.

2.4.2 RMS Power Measurements

	4.55GB	9.11GB
Idle	11.2 Watts	15.6 Watts
15 ops/second	12.1 Watts	16.7 Watts
30 ops/second	12.7 Watts	17.7 Watts
60 ops/second	13.7 Watts	19.0 Watts

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

Note: For the purpose of calculations 0.036 Watts per op can be used for and 4.55GB, 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

$$\text{Idle power} = 11.2 \text{ Watts}$$

$$90 \text{ ops/second} = 90 * 0.036 = 3.24 \text{ Watts}$$

$$\text{Total Power} = 11.2 + 3.24 = 14.44 \text{ Watts}$$

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.

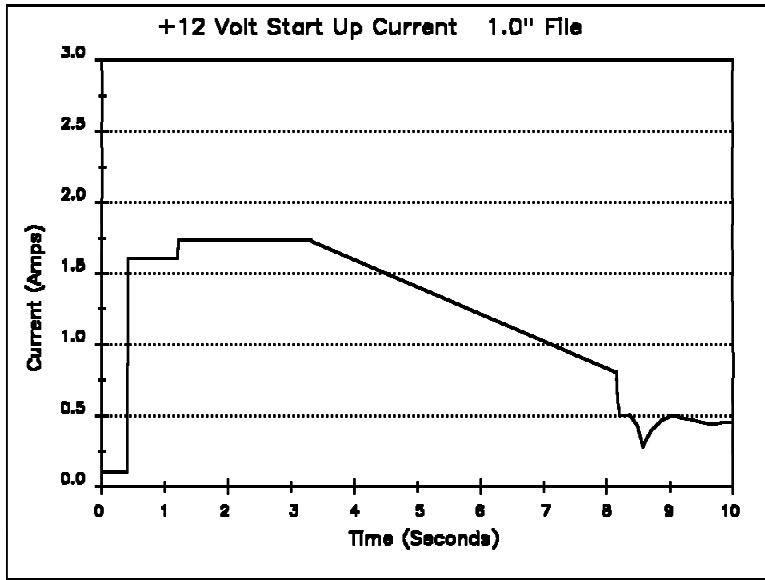


Figure 2. 12 Volt Start Current 1.0" Models

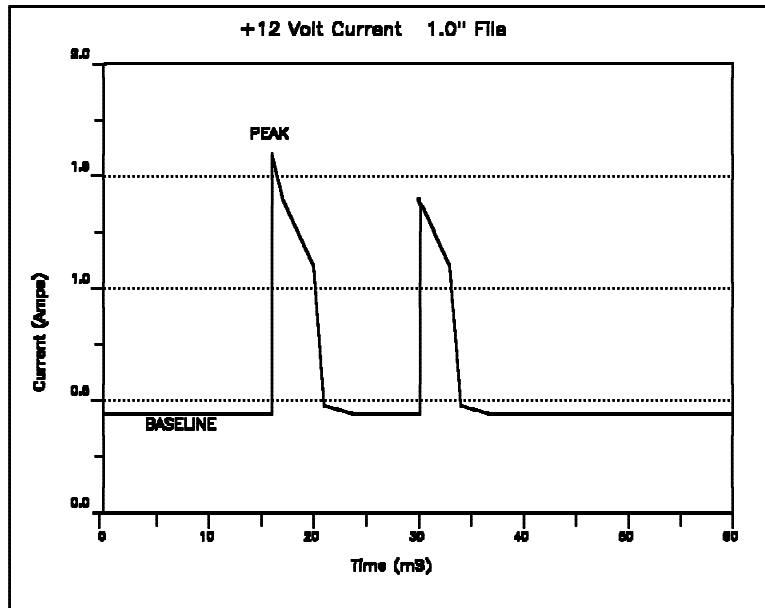


Figure 3. Typical Seek with Read 12 Volt Current 1.0" Models

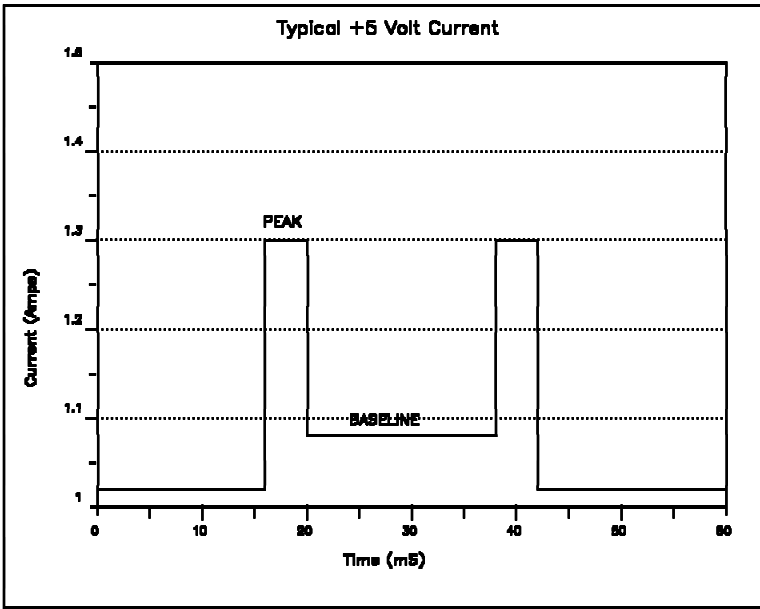


Figure 4. Typical Seek with Read 5 Volt Current all Models

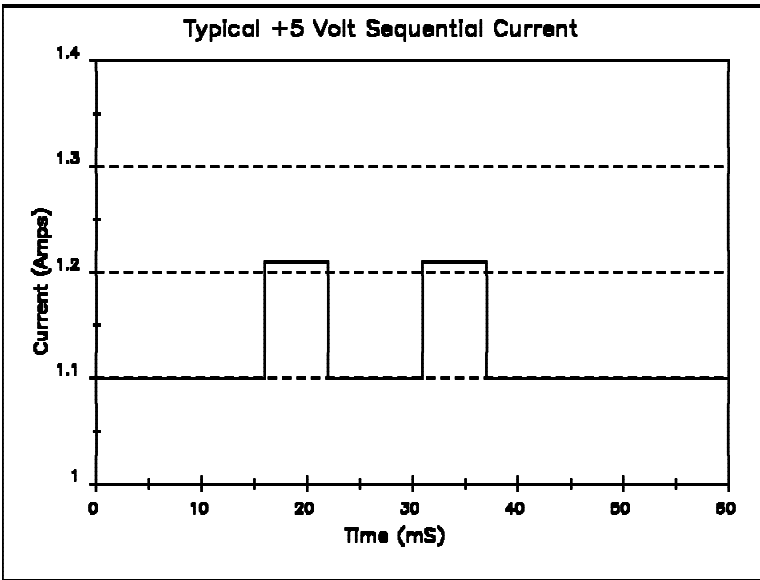


Figure 5. Typical Sequential Read Operation 5 Volt Current all Models

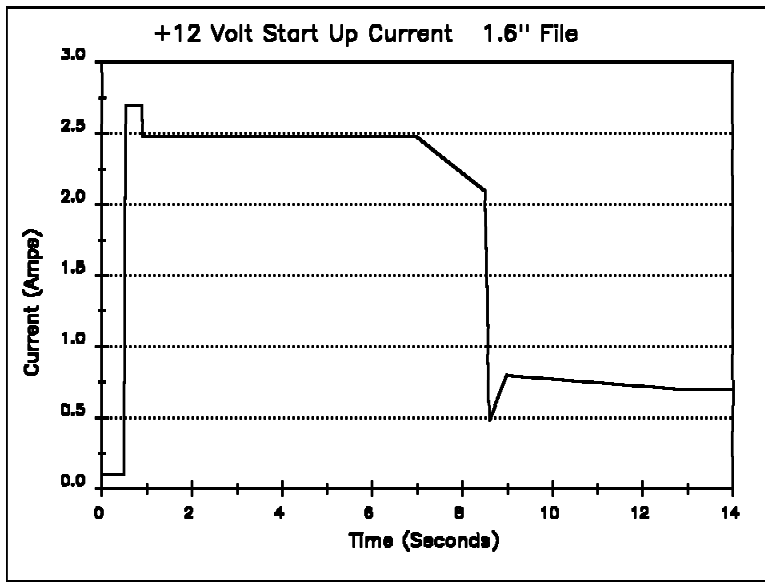


Figure 6. 12 Volt Start Current 1.6" Models

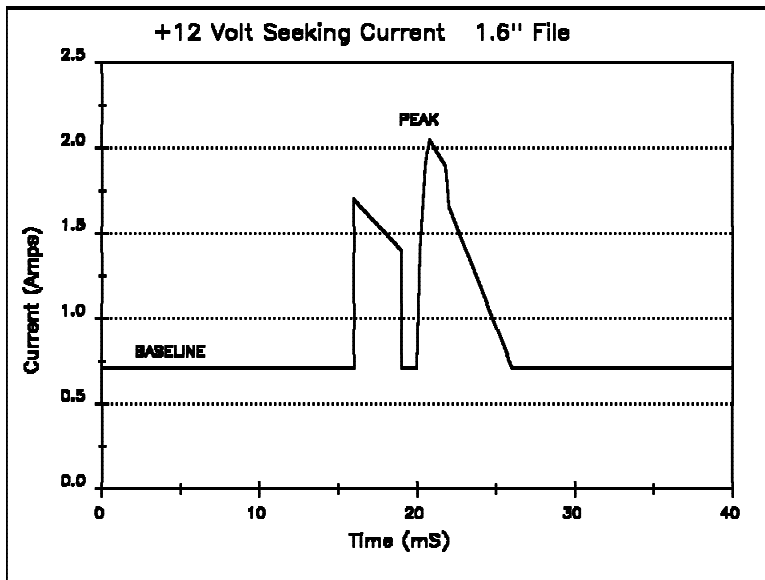


Figure 7. Typical Seek with Read 12 Volt Current 1.6" Models

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

Power supply and SSA link hot plug and un-plug is allowed for all SSA models.

For Form Factor models, there is no special sequence required for connecting 5 volt, 12 volt, or ground. During a hot plug-in event the drive being plugged will draw a large amount of current at the instant of plug-in. This current spike is due to charging the bypass capacitors on the drive. This current pulse may cause the power supply to go out of regulation. If this supply is shared by other drives then a low voltage power on reset may be initiated on those drives. Therefore the recommendation for hot plugging is to have one supply for each drive. Never daisy chain the power leads if hot plugging is planned. Hot plugging should be minimized to prevent wear on the power connector.

Hot plugging the SSA link will be recognized by the next node which will cause a configuration process to be started by the Initiators.

During hot plugging, the supplies must not go over the upper voltage limit. This means that proper ESD protection must be used during the plugging event.

During hot un-plugging if the operating shock limit specification can be exceeded then the drive should be issued a Start/Stop Unit command (spin down) that is allowed to complete before un-plugging.

2.5 Bring-up Sequence (and Stop) Times

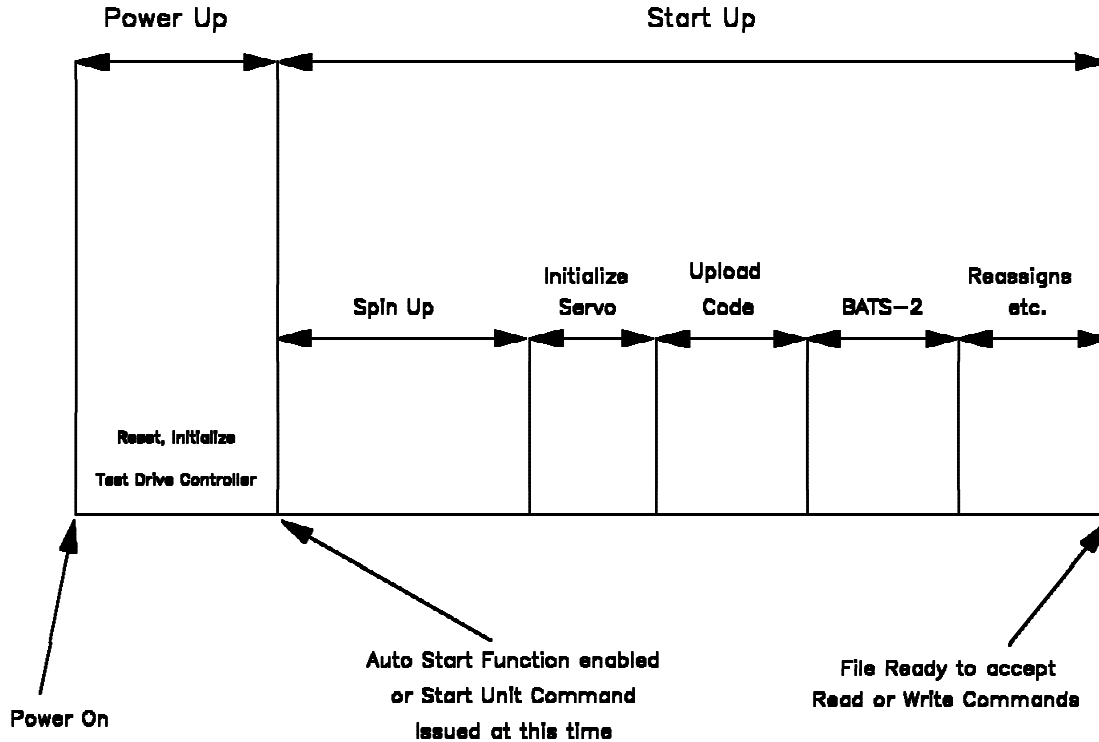


Figure 8. Start Time Diagram

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 3.7.1.3, "Start/Stop Unit Time" on page 33 for additional details.

Note: See 5.6, "Spindle Synchronization" on page 45

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 6. 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 7. 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 environment. Deviations from this environment 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 8. The total data buffer length is 512K bytes. Of the 8 segments in the buffer, at least one segment is allocated for the NO-ID tables, and probably more. This number is dependant 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 LRC 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 potential to have a partially used or runt segment. This allows for the maximum use of all available memory.

- Ten byte Read and Write commands are used.
- SSA environment consists of a single initiator and single target with no SSA link contention.
- The Initiator delay in responding to messages from the Target is assumed to be zero.
- All performance enhancing functions are disabled, except where noted. More specifically,
 - Commands are not queued
 - Data Ready/Reply messages are exchanged for Read (DDRM=0)
 - Caching is disabled (RCD=1, WCE=0)
 - Out of order transfers are not allowed (OOT=0)
- The media is formatted with the skew definition that optimizes the disk data transfer rate for un-synchronized spindle operation.
- All Current Mode Parameters are set to their Default values except where noted.
- 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 Data Transfer size is set to 64 Blocks.
- 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 + 64.

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:

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

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.

3.3.1 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 to determine Command Execution Times for sequential commands is 0 milliseconds 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 milliseconds.

Command Execution Overhead

The average time added to the Command Execution Time due to the processing of the command. It includes all time the drive spends not doing a disk operation or SSA link data transfer.

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

Workload	Command Execution
Sequential Read	1.30 ms
Sequential Write	1.60 ms
Random Read	.26 ms
Random Write	.30 ms

Table 8. Overhead Values

A number of Initiator controlled factors affect Command Execution Overhead. These are examined separately in 3.4, "Approximating Performance for Different Environments" on page 28.

The *Post Command Processing* time of .26 ms is defined as the average time required for process cleanup after the command has completed. If a re-instruct period faster than this time is used, the difference is added to the Command Execution Overhead of the next operation.

Data Transfer to/from Disk

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

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

There are four interpretations of Media Transfer Rate. 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:

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

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

3. Theoretical Data Sector Transfer Rate

Also includes time required for track and cylinder skew and overhead associated with each track. (See 3.3.2.1, "Theoretical Data Sector Transfer Rate" on page 28 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 (DCHC) SSA Models Interface Specification* for a description of error recovery procedures.

Rates for drives formatted at 512 bytes/block are located in Table 9 on page 27.

Model Type	ALL		9.11GB		4.55GB	
Notch #	Instant.	Track	Theoretical	Typical	Theoretical	Typical
Average	13.796	10.002	9.201	9.191	9.127	9.117
1	15.432	11.309	10.391	10.380	10.307	10.297
2	14.250	10.817	9.939	9.929	9.859	9.849
3	13.902	10.141	9.035	9.026	8.963	8.954
4	12.930	9.465	8.584	8.575	8.515	8.506
5	12.443	8.974	8.075	8.067	8.010	8.002
6	11.887	8.605	7.624	7.616	7.562	7.555
7	10.983	8.113	7.228	7.221	7.170	7.163
8	10.288	7.376	6.777	6.770	6.722	6.715
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.						
Note: Contact an IBM Customer Representative for values when formatted at other block lengths.						

Table 9. Data Sector Transfer Rates. (All rates are in MB/sec)

Data Transfer to/from SSA Link

The time required to transfer data between the SSA link and the drive's internal data buffer, that is not overlapped with the time for the Seek, Latency or Data Transfer to/from Disk.

When the drive is reading, data is transferred from the medium to its data buffer and from the buffer across the SSA link simultaneously. However, data transfer to the link from the data buffer lags transfer from the medium to the buffer by one block. At the end of the transfer from the medium, one block still has to be transferred across the link.

For a write operation, the data is normally transferred to the data buffer during the seek and latency time. In the rare case that these are both zero, the write cannot begin until one sector is transferred, and the time to do this becomes part of the overhead.

Each block of data is transferred as one or more frames on the SSA Link. Each frame requires 10 bytes of overhead and may contain up to 128 bytes of data. The time to transfer one block depends on the number of frames required. For example, a 740 byte block needs 6 frames (5 x 128 byte, 1 x 100). This adds 60 bytes of overhead making 800 bytes total. At an instantaneous transfer rate of 20MB/s, that is 40 microseconds per block (18.5MB/s sustained).

3.3.2 Comments

Overlap has been removed from the Command Execution Time calculations. The components of the Command Execution Times are truly additive times to the entire operation. For example,

- The 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.

The effects of idle time functions are not included in the above examples. The 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 0.15%.

3.3.2.1 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 3.3.1, "Basic Component Descriptions" on page 25 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 =

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

$$\begin{aligned} \text{Bytes/cylinder} &= (\text{tracks/cyl})(\text{gross sectors/track}) (\text{bytes/sector}) \\ &= (9)(184)(512) \\ &= 847,872 \text{ Bytes/cyl} \end{aligned}$$

$$\begin{aligned} \text{time for 1 cyl of data} &= (\text{tracks/cyl})(\text{revolution time}) \\ &= (9)(8.333) \\ &= 75.000 \text{ msec/cyl} \end{aligned}$$

$$\begin{aligned} \text{time for track skews} &= (\text{tracks/cyl} - 1)(\text{track skew time}) \\ &= (9-1)(8.333*9/88) \\ &= 6.818 \text{ msec/cyl} \end{aligned}$$

$$\begin{aligned} \text{time for 1 cyl skew} &= (\text{cylinder skew time}) \\ &= (8.333*23/88) \\ &= 2.178 \text{ msec/cyl} \end{aligned}$$

Data Sector Transfer Rate =

$$\begin{aligned} &\frac{1,085,440 \text{ Bytes}}{130.815 \text{ msec} + 6.818 \text{ msec} + 2.178 \text{ msec}} \\ &= 10.094 \text{ MB/sec (Notch \#1)} \end{aligned}$$

3.4 Approximating Performance for Different Environments

3.4.1 For Different Transfer Sizes

The primary performance change due to a change of transfer size is the Data Transfer to/from Disk parameter. See 3.3.1, "Basic Component Descriptions" on page 25 for an explanation of the calculation of this parameter.

The Command Execution Overhead 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 SSA Link or Disk data transfer.

For example, a short read may incur up to .65ms extra overhead if the Data Ready/Reply exchange does not overlap the disk transfer.

3.4.2 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 components if all of the requested data is available in a cache segment (cache hit). Command Execution Overhead increases by approximately .1ms in this case as there is no overlap with seek/latency.

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 SSA link to the Command Execution time may increase since a larger, or entire, portion of the transfer may no longer be overlapped with the components that were reduced.

3.4.3 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 components. The contribution of the Data Transfer to/from SSA link 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.

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

3.4.4 When Adaptive Caching is Enabled

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

3.4.5 When Read-ahead is Enabled

If read-ahead is active, the service time is affected in several ways:

- If the data requested by a read command is all in the data buffer already, the command can be serviced very quickly.
- If the beginning of the requested data is in the buffer, and the read-ahead is still in progress, data transfer for the command can start immediately. This effectively avoids latency time for read operations sequential on a previous read.
- If the data requested by a read operation is **not** in the read-ahead buffers, there is an increase in the command overhead time due to the time spent searching the buffers. This time depends on the number of buffer segments selected by the Mode Select command.
- If read-ahead is still in progress when the next command is received and the data requested is not sequential, the drive aborts read-ahead and starts the command. The time to perform this abort increases the Command Execution Overhead by .24ms.

3.4.6 When No Seek is Required

For a Read command, the additional Command Execution Overhead when no seek is required is approximately .50ms. For a Write, it is approximately .70ms.

3.4.7 For Queued Commands

If commands are sent to the drive when it is busy performing a previous command, they can be queued. In this case, some of the command processing is performed during the previous command and the overhead for the queued command is reduced by approximately .20 milliseconds.

3.4.7.1 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.

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

3.4.7.2 Back-To-Back Commands

If consecutive read/write commands access contiguous data, they can be serviced without incurring disk latency between commands.

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

3.4.8 Disable Data Ready Message (DDRM)

This bit in the SCSI Command message applies only to Read commands. When set, the Data Ready/Data Reply message exchange does not take place and the Data Channel supplied by the SCSI Command message is used for the transfer.

For most operations, DDRM does not affect the Command Execution Overhead as the message exchange takes place in parallel with the disk transfer. However, if the disk transfer is short or non-existent (eg. a cache hit), up to .70ms can be saved by setting DDRM=1.

The primary reason for setting DDRM=1 is to minimize the time between receiving the first block of data into the buffer and starting to transfer it on the SSA Link.

Note: When using DDRM=1, the number of Data Channels available to the Initiator will become a limiting factor in the number of commands that it may have queued in the Target(s).

3.4.9 Out of Order Transfers

Two bits in the SCSI Command message control out of order transfers. OOT applies to transfers to/from the media and OOT applies to transfers to/from the interface (SSA Link).

The benefit from setting OOT increases as the transfer length approaches one disk revolution. This affects both reads and writes and is due to the reduction in latency.

The full benefit of out of order transfers is only achieved if OOT is also set. Read data is transferred on the interface in the same order as it was read from the media.

3.5 Skew

3.5.1 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 ($8.33 \times 23 / 88$).

3.5.2 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 ($8.33 \times 9 / 88$).

3.6 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.

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.

3.6.1 Performance considerations for Predictive Failure Analysis

This is an idle time function.

Predictive Failure Analysis 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 ($240 / 7 \times 9$).

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 (DCHC) SSA Models Interface Specification* for more details about PFA, LITF and TCC.

3.6.2 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.

3.6.3 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.

3.6.4 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.

3.6.5 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 10. Summary of Idle Time Function Performance Impacts

3.7 Command Timeout Limits

The 'Command Timeout Limit' is defined as the time period from receipt of the SCSI command through STATUS, associated with a particular command.

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

3.7.1.1 Reassignment Time

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

3.7.1.2 Format Time

9.11GB models should be allowed an average of 60 minutes to complete a "Format Unit" command. The maximum format time is 100 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.

3.7.1.3 Start/Stop Unit Time

The drive should be allowed a minimum of 30 sec to complete a "Start/Stop Unit" command (with Immed bit = 0).

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

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

3.7.1.4 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 | • Read Long | • Skip Mask (Write) |
| • Mode Select (6) | • Release | • Write (6) |
| • Mode Sense (6) | • Reserve | • Write (10) |
| • Pre-Fetch | • Rezero Unit | • Write and Verify |
| • Read (6) | • Seek (6) | • Write Buffer |
| • Read (10) | • Seek (10) | • Write Long |
| • Read Capacity | • Send Diagnostic | • Write Same |
| • Read Defect Data | • Skip Mask (Read) | • 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.

3.7.1.5 Timeout limits for other commands

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

- Inquiry
 - Request Sense
 - Read Buffer
- | |
|--|
| <ul style="list-style-type: none">• Start/Stop Unit (with Immed bit = 1)• Synchronize Cache• Test Unit Ready |
|--|

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.

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	1.00 pounds	0.46 kilograms	1.87 pounds	0.82 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 11 on page 38 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 50.

4.3 Mounting Guidelines

The drive can be mounted with any surface facing down.

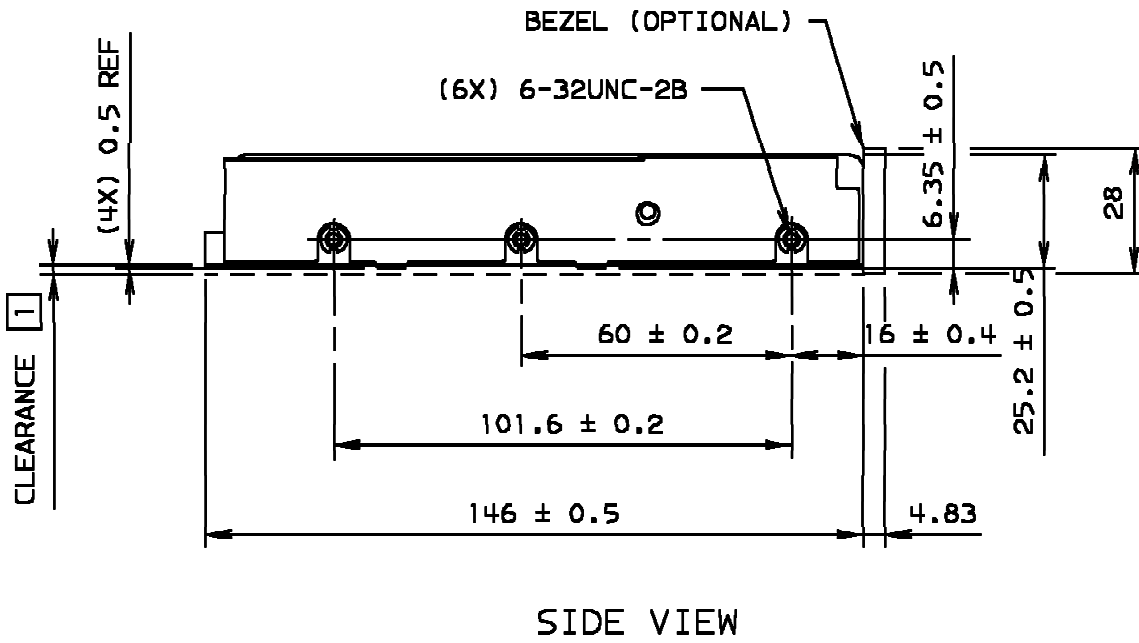
The drive is available with both side and bottom mounting holes. Refer to Figure 9 on page 36, Figure 11 on page 38 and Figure 10 on page 37 for the location of these mounting holes for each configuration.

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

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

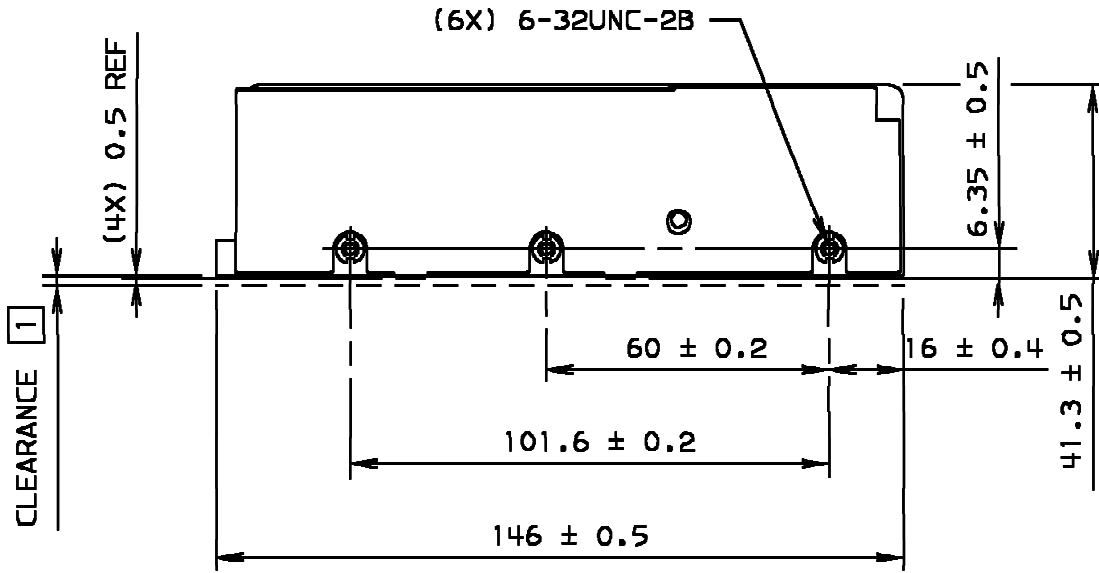
For more information on mounting guidelines see section 7.5, "Drive Mounting Guidelines" on page 55

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 9. Location of Side Mounting Holes of 4.55GB Model

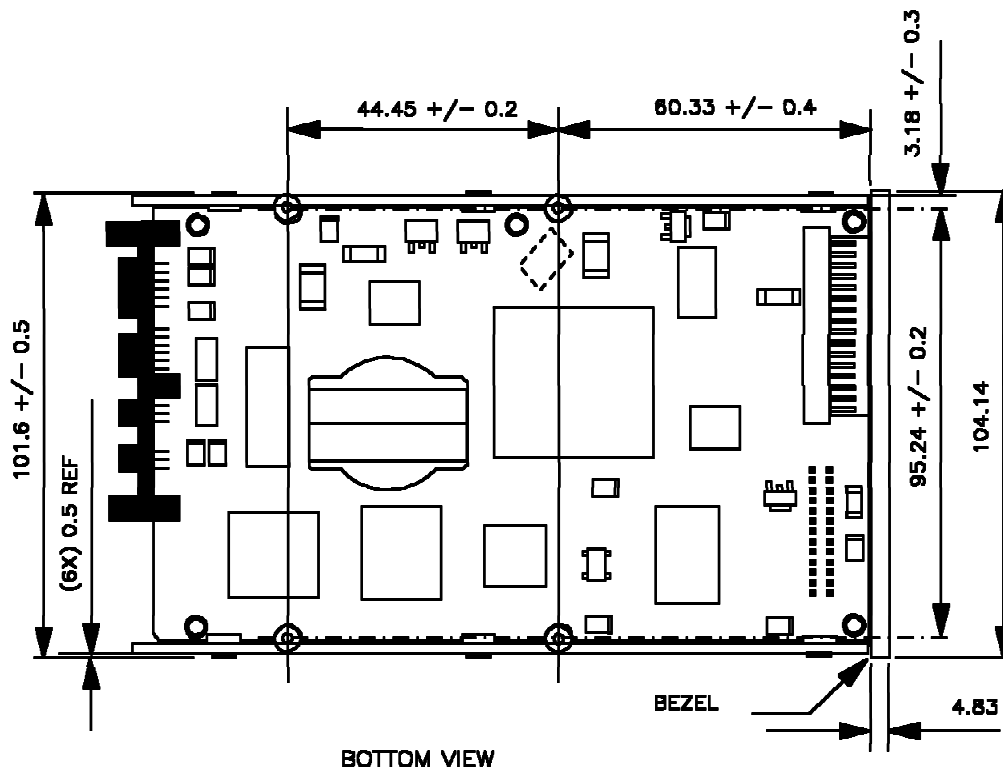


SIDE VIEW

Note: Dimensions are in millimeters.

Note: Clearance = 7 mm

Figure 10. Location of Side Mounting Holes of 9.11GB Model



Note: Dimensions are in millimeters.

Figure 11. Location of Bottom Mounting Holes

4.4 Electrical Connector Locations

The electrical connectors are located as shown in

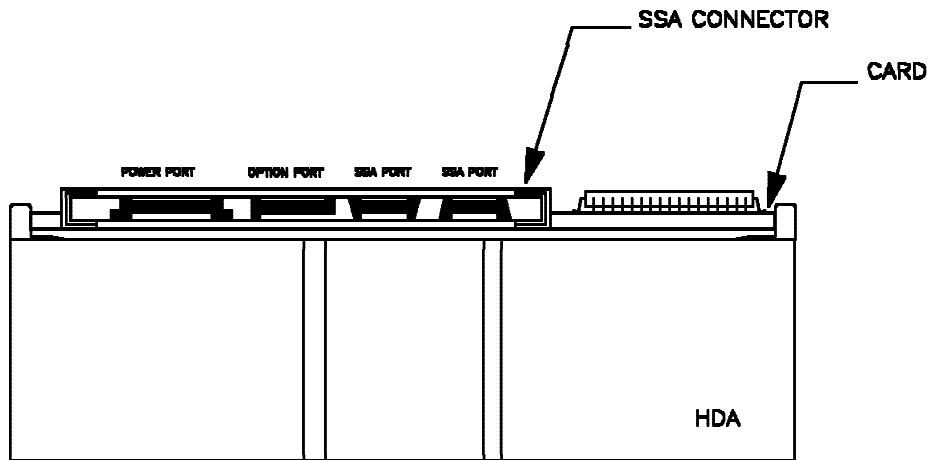


Figure 12. SSA Electrical connector (rear View)

5.0 Electrical Interface

5.1 SSA Unitized Connector

Electrical connections are provided by a single connector mounted on the rear of the drive. Connections are provided for two SSA ports, fault sensors and indicators, option customization, and power. Refer to Figure 13 and Table 11 on page 41 for contact assignments.

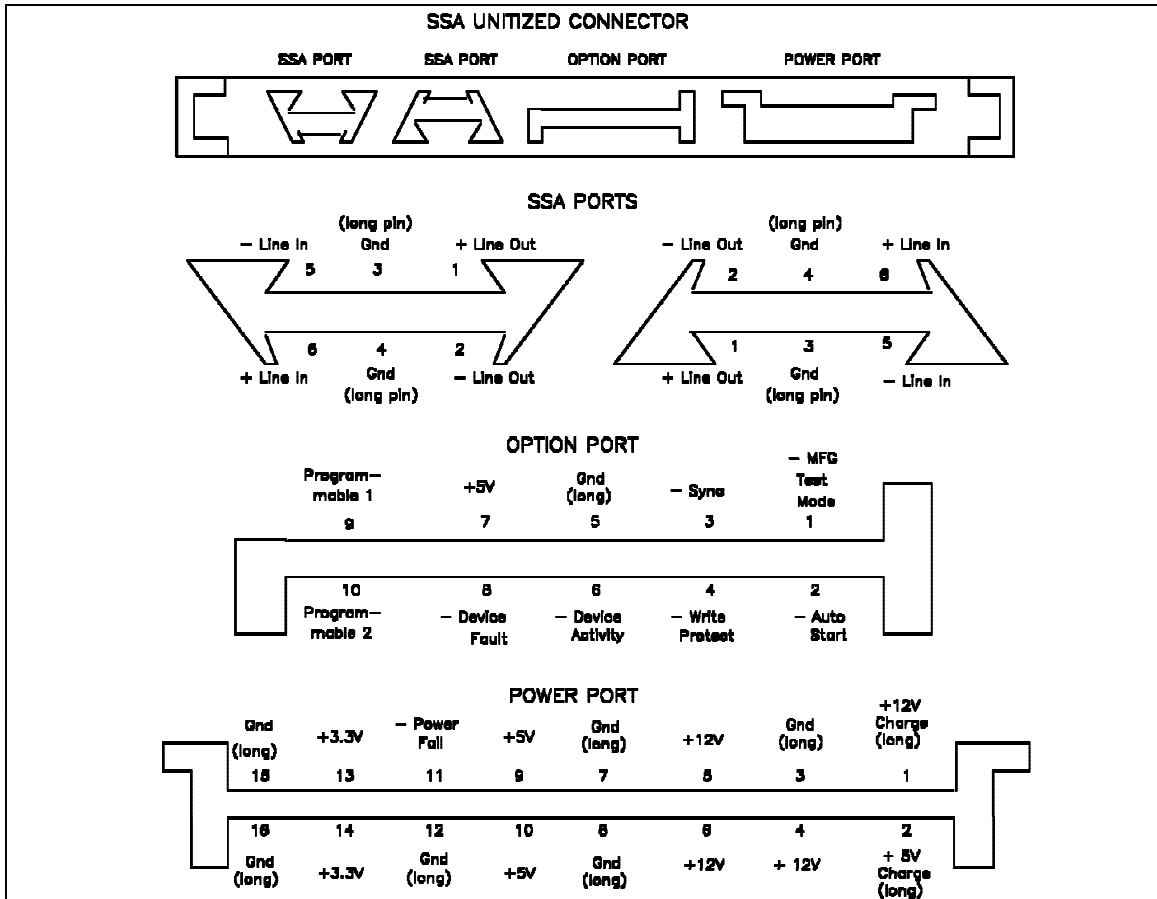


Figure 13. Unitized Connector (looking in the file at the connector end)

Pin	SSA PORT	SSA PORT	OPTION PORT	POWER PORT
1	+ Line Out	+ Line Out	- MTM	+ 12V Charge (long)
2	- Line Out	- Line Out	- Auto Start	+ 5V Charge (long)
3	Gnd (long)	Gnd (long)	- Sync	Gnd (long)
4	Gnd (long)	Gnd (long)	- Write Protect	+ 12V
5	- Line In	- Line In	Gnd (long)	+ 12V
6	+ Line In	+ Line In	- Device Activity	+ 12V
7	N/A	N/A	+ 5V	Gnd (long)
8	N/A	N/A	- Device Fault	Gnd (long)
9	N/A	N/A	Programmable 1	+ 5V
10	N/A	N/A	Programmable 2	+ 5V
11	N/A	N/A	N/A	- Power Fail
12	N/A	N/A	N/A	GND (long)
13	N/A	N/A	N/A	+ 3.3V
14	N/A	N/A	N/A	+ 3.3V
15	N/A	N/A	N/A	Gnd (long)
16	N/A	N/A	N/A	Gnd (long)

Table 11. Electrical Connector Contact Assignments —

5.2 SSA Link Cable

The SSA link cable must meet the specifications described in the Electrical Specifications section of *Serial Storage Architecture 1995 Physical (SSA-IA/9sPH) rev 0*.

5.3 SSA Link Electrical Characteristics

The drive SSA link line driver, line receiver, and line receiver termination are fully compliant with the specifications described in the Electrical Specifications section of *Serial Storage Architecture 1995 Physical (SSA-IA/9sPH) rev 0*.

5.4 Option Pins and Indicators

Ultrastar 2XP drives contain option pins and/or indicators used to sense and report fault conditions, and to enable certain features of the drive. The electrical characteristics and requirements of these pins are fully compliant with the specifications described in the Electrical Specification section of *Serial Storage Architecture 1995 Physical (SSA-IA/9sPH) rev 0*. The existence and definition of these pins are model dependent.

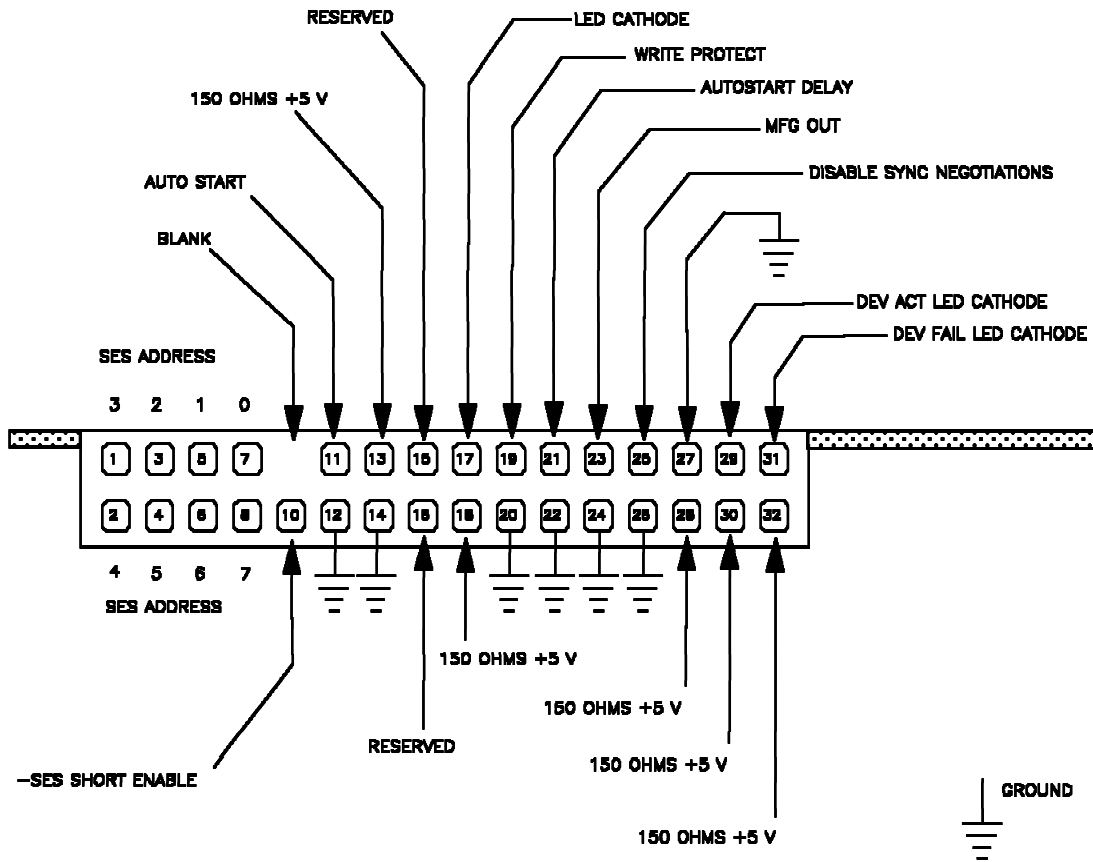


Figure 14. Option Block Definitions

5.4.1 Manufacturing Test Mode (Option Port Pin 1)

A low active input pin, that when active (pulled below .8V) makes pins 2, 3, 4, 6, 8, 9 and 10 available to be redefined. Pins 5 and 7 must remain Ground and +5 V respectively. One possible purpose for this pin is to allow a manufacturing tester to redefine the option pins to whatever functions it desires, while allowing the shipped product to return to the standard definitions in the customers environment. All models reserve this pin but it is not connected to any internal logic.

5.4.2 Auto Start Pin (Option Port Pin 2)

A low active input pin, that when active (pulled below 0.8 V) the drive motor to spin up and become ready for media access operations after power is applied without the need to receive a Start/Stop Unit command. When inactive (pulled above 2.0 V), the drive motor shall not spin up until after the receipt of a Start/Stop Unit command. The signal is to be sampled by the device at power on, or hard reset or soft reset conditions. Refer to the "Option Pins" section of the for a detailed functional description of operations associated with this pin.

5.4.3 Sync Pin (Option Port Pin 3)

The *Sync* input/output pin can be used for synchronizing among devices. The synchronization is achieved by having one device uses this pin as output to transmit one sync character once per spindle revolution. The other nodes may use this pin as an input and synchronize their spindle revolution position to match the Sync signal. The SSA network provide Sync character over SSA link, but this option pin allows synchronization across multiple SSA networks, or allow tighter latency of the Sync pulse. Refer to Figure 15 on page 46 for examples of Synchronization connection.

The width, period, and tolerance of the negative active Sync pulse is manufacturer dependent, and thus synchronization across different manufacturers or even different product lines of the same manufacturer is not guaranteed. The Sync pin usage is controlled by mode pages within the mode select command.

5.4.4 Write Protect (Option Port Pin 4)

a low active input pin, that when active (pulled below 0.8 V), the drive will prohibit commands that alter the customer data area portion of the the media from being performed. The state of this pin is monitored on a per command basis. Refer to "Option pins" section of the for a detailed functional description of this pin.

5.4.5 Ground long (Option Port Pin 5)

The *Ground* long output pin shall be capable of sinking 1.0 Amp of current. This pin is longer than any others in the option block to allow for the ground to mate first or last in a hot-plug or hot-unplug situation.

5.4.6 Device Activity Pin/Indicator (Option Port Pin 6)

A low active LED output pin can be used to drive an external Light Emitting Diode. for a detailed functional description of this pin/LED.

All models provide up to 24 mA of TTL level LED sink current capability. Current limiting for the LED is provided on the electronics card. The anode may be tied to the +5V power source (provided on the the unitized connector). The LED Cathode is then connected to the *Device Activity* pin to complete the circuit. A 150 OHM resistor is in series with the LED as a current limiter.

5.4.7 + 5V (Option Port Pin 7)

The + 5V output pin shall supply up to 1.0 Amp of current limited +5 V (+/- 10%), as long as power is supplied to the device.

5.4.8 Device Fault Pin/Indicator (Option Port Pin 8)

The *Device Fault* pin can be used to drive an external Light Emitting Diode. for a detailed functional description of this pin/LED.

All models provide up to 24 mA of TTL level LED sink current capability. Current limiting for the LED is provided on the electronics card. The anode may be tied to the +5V power source (provided on the the unitized connector). The LED Cathode is then connected to the *Device Fault* pin to complete the circuit. A 150 OHM resistor is in series with the LED as a current limiter.

5.4.9 Programmable pin 1 (Option Port Pin 9)

This pin can be used by a manufacturer for what ever purposes it desires within the specified definition, electrical characteristic and the availability of microcode. This pin is completely controlled by microcode. Refer to the "Option Pins" section of the for a detailed functional description of this pin.

5.4.10 Programmable pin 2 (Option Port Pin 10)

This pin is reserved and it is not connected to any internal logic.

5.4.11 Early Power Off Warning or Power Fail (Power Port Pin 11)

The *Early Power Off Warning* input pin can be used to indicate to the drive that a power loss will occur by pulling this signal to ground. The input must provide a minimum of 6 milliseconds warning before power falls below operating specifications in order for the drive to stop its activities and handle the fault. Refer to the "Option Pins" section of the for a detailed functional description of the fault handling associated with this pin..

5.4.12 12V Charge and 5V Charge (Power Port pin 1 and 2)

These pins are longer than the others. They help to reduce current spikes during hot plug. Each pin require a resistor (not in the drive) in series between the power source and the drive connector. This allows for more controlled current draw as prior to other voltage pins. It is up to the subsystem to determine the proper resistance to add to these pins to meet the +/- 10% voltage drop limitations and the current draw limitation of the connector.

5.5 Front Jumper Connector

There is no front jumper block.

5.6 Spindle Synchronization

5.6.1 Synchronization overview

Spindle synchronization of drives is achieved by one node transmitting a special Sync character or a Sync pulse once per every revolution of its drive. The transmitting is done either on SSA Link (sending Sync character) or on a hard-wire (Sending Sync pulse) that connects all the drives via the SSA Option Port 'Sync' pin. The synchronization mode is controlled by the RPL field of the Mode Select Page 04h parameter (see *Ultrastar 2XP (DCHC) SSA Models Interface Specification* for more details). The drive can operate in one of three modes:

Note: Sync characters and sync pulses cannot be mixed.

5.6.2 Synchronization Mode

Mode	Operation
No Sync	Spindle synchronization is disabled.
Slave Sync	Spindle synchronization is attempted by synchronizing the spindle motor to the Sync special character on SSA link (or the Sync pulse on Sync hard-wire) that is driven by another node.
Master Sync	Spindle synchronization is not attempted by this device. It generates a Sync special character via SSA link (or a Sync pulse via a hard-wire) once per its spindle revolution.

Master Sync Control Master Sync Control is not supported.

5.6.3 Synchronization time

It will take 6 seconds to synchronize the Slave drive to the Master drive. While the Slave drive is synchronizing to these characters, it is not able to read or write data. Once synchronized the drive will maintain ± 20 microseconds synchronization tolerance.

When operating in Slave Sync mode, the drive must receive the Spindle Sync special characters at a period of 8.333 milliseconds with a tolerance of $\pm .025\%$ (2.08 microseconds).

5.6.4 Synchronization with Offset

The **Rotational Offset** value is the amount of rotational skew that the Target uses when synchronized. The rotational skew is applied in the retarded direction (lagging the synchronized spindle master control). The value in the field is the numerator of a fractional multiplier that has 256 as its denominator (e.g., a value of 128 indicates a one-half revolution skew). A value of 00h indicates that rotational offset is not used. The rotational offset is only used when the Drive is running in the Slave Sync RPL mode.

5.6.5 Synchronization Route

5.6.5.1 Over SSA Link

Spindle Sync special characters are forwarded from one SSA link to the other with a delay of 350 nanoseconds with a tolerance of ± 50 nanoseconds. This delay can be increased by 50 nanoseconds when the drive is sending the second of a double character sequence (RR or ACK) and by 50 nanoseconds when sending a SAT or SAT' character.

The spindle synchronization timing requirements are met in a string composed of *Ultrastar 2XP* drives when there are no more than seventeen drives between the one operating in Master Sync mode and the furthest drive operating in Slave Sync mode.

5.6.5.2 Over Sync Hard-wire

There will be a single wire that connects all the drives together through the SSA Option Port pin 3 (- Sync pin). One of these drives will be a Master drive. Two potential configurations of this hard-wire connection are shown in the following figures:

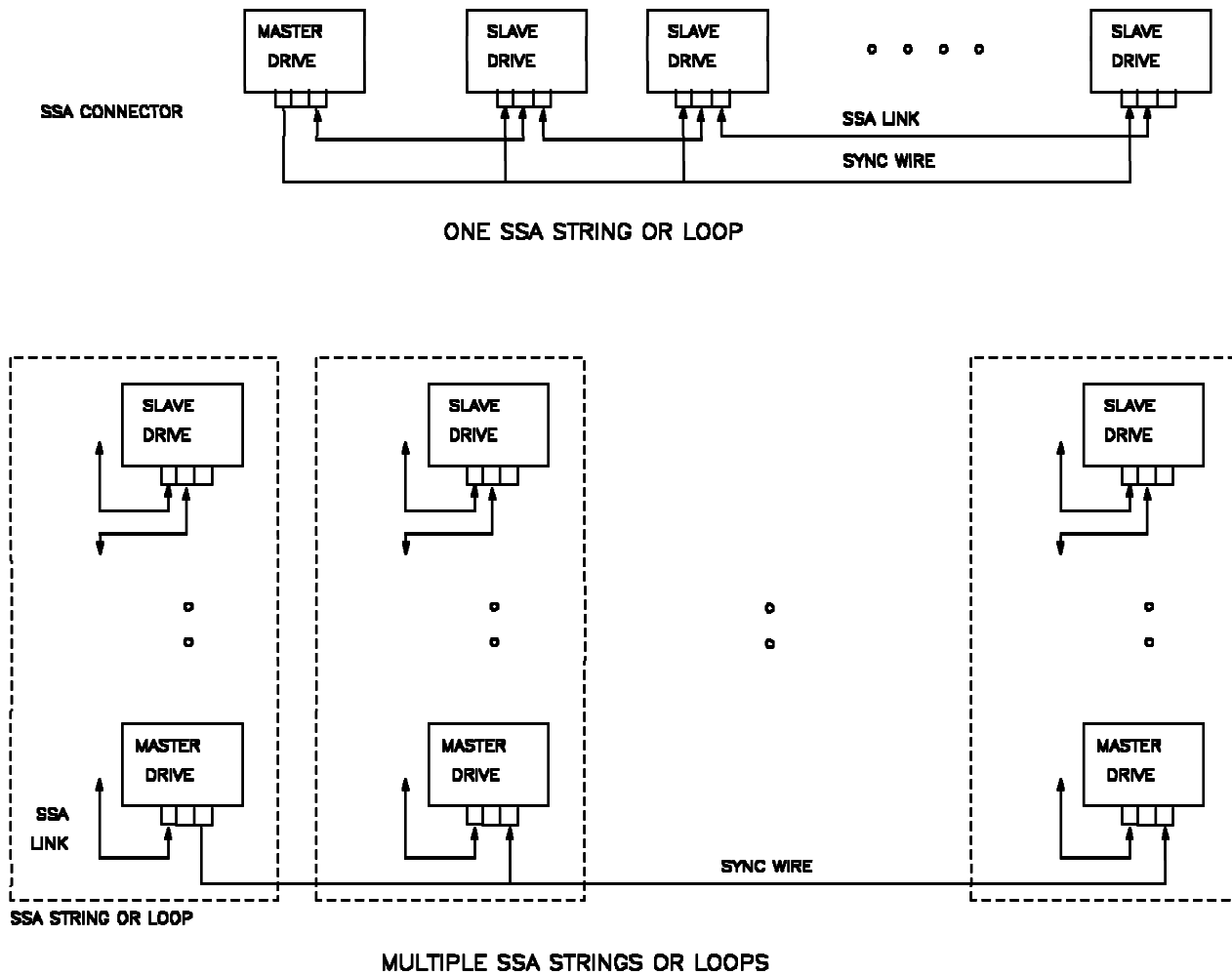


Figure 15. Two examples of Daisy-Chain Connection of Synchronization

- Termination

Bus termination of the - SYNC signals is internal to the drive. This signal has a 5.1K ohm pulled-up to the +5 volt supply. A maximum of 30 drives can have their - SYNC line daisy chained together. Violating this could damage the Master drive line driver on the - SYNC line

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

- Bus Characteristics

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

The driver used for these two signal lines is a Open Drain buffer.

6.0 Reliability

6.1 Error Detection

Error reporting \geq 99%

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

Error detection \geq 99%

FRU isolation = 100%

To the device when the "Recommended Initiator Error Recovery Procedure 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 17.²

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.

² * 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 17 on page 52 defines where measurements should be made to determine the top disk enclosure temperature during drive operation. Figure 16 on page 51 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 12 on page 51 are not exceeded.

Table 12. 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 ³	194°F (90°C)	176°F (80°C)
SSA Module	203°F (95°C)	176°F (80°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.

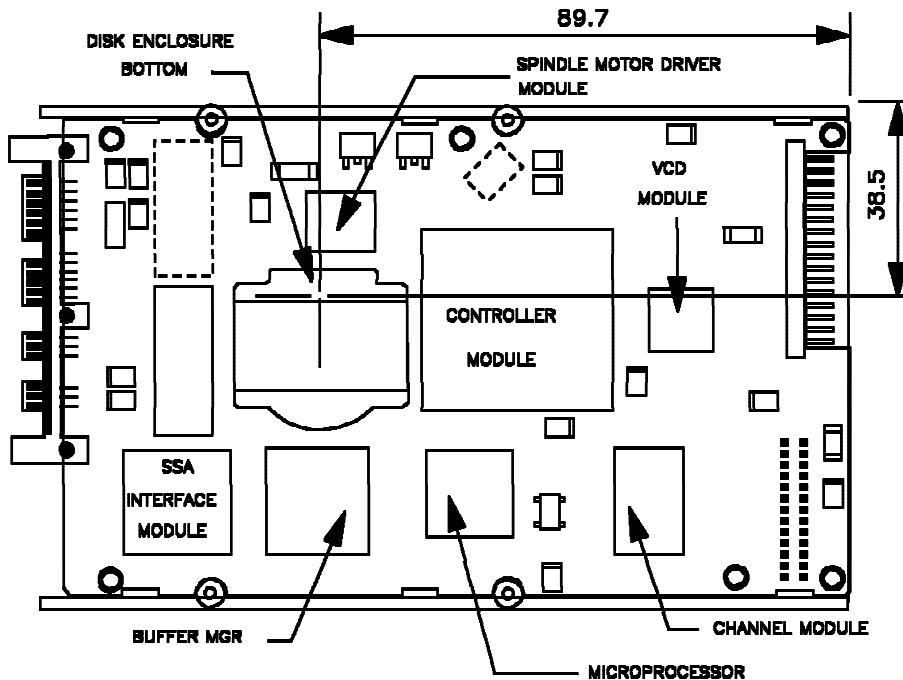


Figure 16. Temperature Measurement Points (bottom view)

³ For continuous read applications the channel module will run at higher temperatures and will require additional cooling.

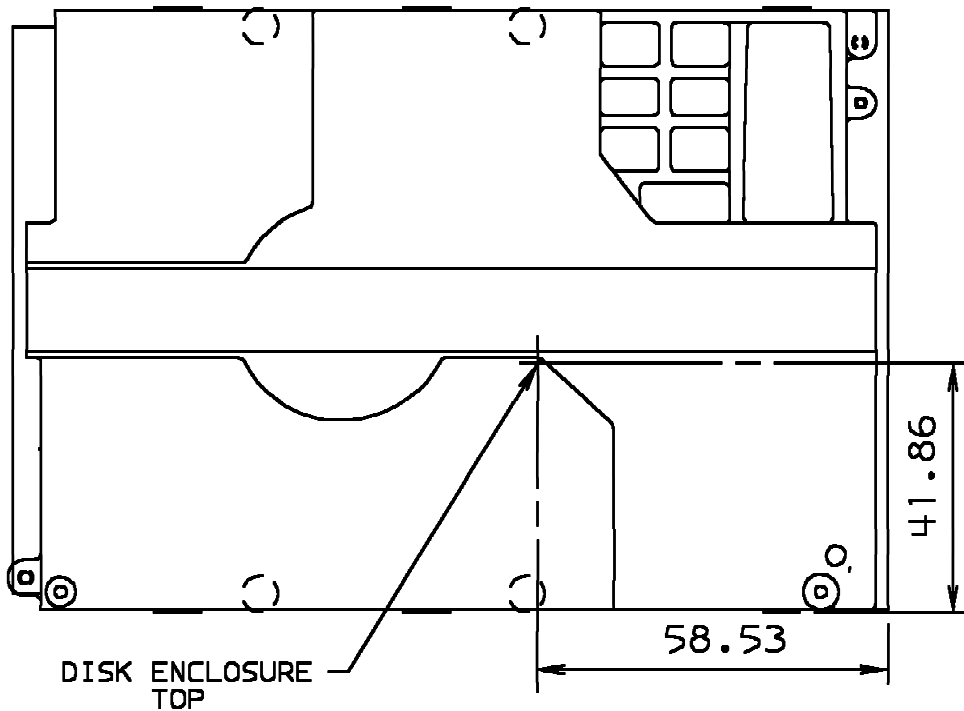


Figure 17. Temperature Measurement Points (top view)

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 35
2. By mounting on any two opposing pairs of the 6-32 side mount holes.

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

7.2.1 Output Vibration Limits

spindle 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.

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.

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 than creating a weak carrier that flexes to fit the drive, hold the mounting gap to tighter tolerances. A flexible carrier may contain resonances that cause operational vibration and/or shock problems.
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. 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 casing and module temperature listed in Table 12 on page 51. Operating Limits in accordance with the Temperature measurement points shown Figure 17 on page 52. 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 54 and 7.2.5, "Non-Operating Shock" on page 54. Both operating and non-operating shock should be measured in all 3 planes and found to be within the limits set in this specification.

Vibration (Operating and Non-Operating)

The system must maintain an environment that is compatible with the operating vibration specification found in section 7.2.2, "Operating Vibration" on page 53 . Random vibration must be measured in all three planes and found to be compatible with the vibration level in Table 13 on page 53. Swept Sine Vibration must also be measured and be compatible with 7.2.2, "Operating Vibration" on page 53.

To achieve system compatibility for vibration, it is recommended that the system conform to section 7.5, "Drive Mounting Guidelines" on page 55 .

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

Electromagnetic Compatibility(EMC)

The system must be designed to insure that stray fields are not placed close to the device. Minimum clearances must be maintained. Clearance guidelines are found in section 4.2, "Clearances" on page 35.

Electrostatic Discharge(ESD)

The drive contains electrical components sensitive to ESD. System design and assembly process, must protect the drive and must be verified to conform the the protection, care and handling guidelines found in section 7.10, "ESD Protection" on page 59.

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 40.

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

Final verification of drive/system compatibility must be determined through functional testing. Adequate system testing must be performed to demonstrate conformance to the Data Reliability requirements, reference 6.2, "Data Reliability" on page 48.

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.

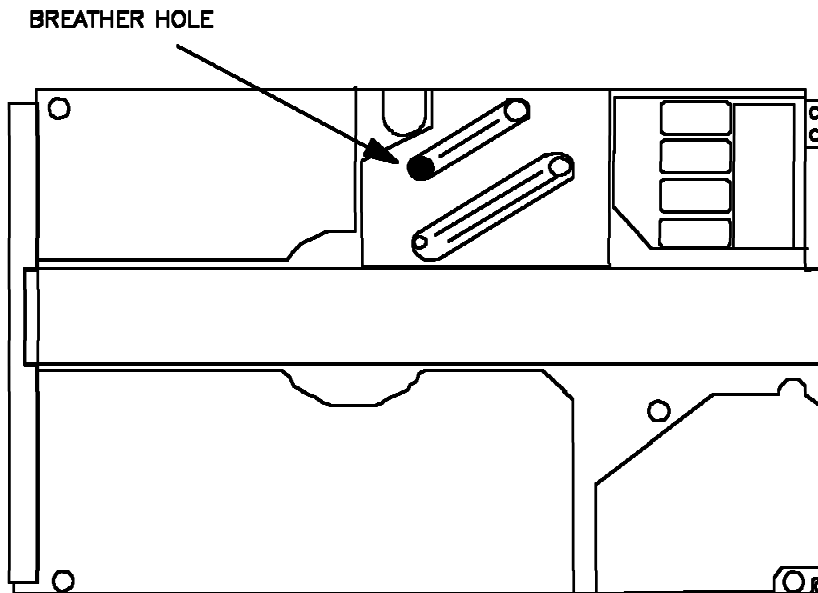


Figure 18. Breather Hole for Filter

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.

- 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. Over-current 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.