IBM

OEM

ULTRASTAR 18XP/9LP

Hardware/Functional Specification
4.5/9.1/18.2 GB Models, 7200 RPM
SSA Disk Drive Type DGHC
Models C18/C09/C04, G18/G09/G04
Version 2.5

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Preface

This document contains the Hardware/Functional Specifications for the ***ULTRASTAR 18XP/9LP SSA*** High Performance Family of 3.5-inch Disk Drives.

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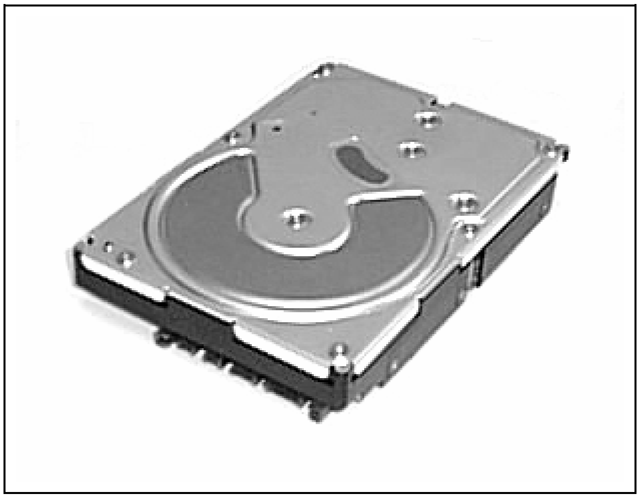

Fig. 1. *SSA-ULTRASTAR 9LP* Disk Drive Assembly

1.1 Features

General Features

- 18.2GB/9.1GB/4.5GB (512 bytes/sector)
- SSA-IA/95PH and SSA-IA/95PH+ Compliant:
  - UIG-95 SSA Compliant
  - Serial Storage Architecture (SSA-40) attachment (dual port)
  - Supports up to 40MB/s interface speed
  - Industry standard SSA Unitized Connector
  - Enclosure Service Support (SES compliant)
- Rotary voice coil motor actuator
- Closed-loop digital actuator servo
- Embedded sector servo
- Magnetoresistive (MR) heads
- 16/17 rate encoding
- Partial Response Maximum Likelihood (PRML) data channel with analog filter
- NoID® sector format
- All mounting orientations supported
- 1MB segmented cache buffer
- Two open-collector LED drivers
- Bezel (optional on some models)

Performance Summary

- Average read seek time, 4.5GB : 6.5 mS.

- Average read seek time, 9.1GB : 6.5 mS.
- Average read seek time 18.2GB : 7.5 milliseconds
- Average Latency: 4.2 mS.
- Media data transfer rate: 11.52 to 22.40 MB/S (16 bands)

Interface Controller Features

- Multiple initiator support
- Variable logical block lengths (512 - 732 supported on word boundaries)
- Read-ahead caching
- Adaptive caching algorithms
- Write Caching
- Back-to-back writes (merged writes)
- Automatic retry and data correction on read errors
- Automatic sector reallocation
- In-line alternate sector assignment
- Downloadable firmware

Reliability, Availability and Serviceability Features

- Self-diagnostics on power up
- Dedicated head landing zone
- Magnetic actuator latch
- Entire Read/Write customer data path protected by 32 Bit CRC
- 18 Byte Error Correcting Code (ECC)
- 9 Byte ECC on the fly
- Predictive Failure Analysis ® (PFA)
- Error Recovery Procedures (ERP)
- Data Recovery Procedures (DRP)
- Probability of not recovering data: 10 in 10E15 bits read
- No preventative maintenance required
- Event logging and analysis
- High-temperature monitoring and logging

1.2 Models

The *SSA-ULTRASTAR 18XP/9LP* disk drive is available in capacities of 4.5, 9.1, or 18.2 GB (refer to Table 5 for exact capacities based on user block size).

The following Model Numbers that correspond to the above capacities are listed in the following table.

4.5 GB Models	**HDA Type**	**Capacity, GB**	**Connector Type**	**Interface Speed**
DGHC C04	1”	4.5	38-Pin Unitized	20 MB/S
DGHC G04	1”	4.5	38-Pin Unitized	20 or 40 MB/S

9.1GB Models	**HDA Type**	**Capacity, GB**	**Connector Type**	**Interface Speed**
DGHC C09	1"	9.1	38-Pin Unitized	20 MB/S
DGHC G09	1"	9.1	38-Pin Unitized	20 or 40 MB/S

18.2 GB Models	**HDA Type**	**Capacity, GB**	**Connector Type**	**Interface Speed**
DGHC C18	1.6"	18.2	38-Pin Unitized	20 MB/S
DGHC G18	1.6"	18.2	38-Pin Unitized	20 or 40 MB/S

Table 1. Models and Capacities

The models listed in the above table have an optional bezel which is not identified via the model number.

2 Specifications

All specification numbers are mean population values unless otherwise noted.

2.1 General

Note: The recording band located nearest the disk outer diameter (OD) is referred to as 'Notch #1', the recording band located nearest the inner diameter (ID) is called 'Notch #16'. 'Average' values are weighted by the number of LBAs per notch when the drive is formatted with 512 byte blocks. Throughout this document 1 MB refers to 1,000,000 bytes and 1 GB refers to 1,000,000,000 bytes.

Data transfer rates

	Notch #1	Notch #16	Average	
Buffer to/from media	22.4	11.5230.15	18.27	MB/s instantaneous
	15.47	7.75	12.66	MB/s sustained

Host to/from buffer Up to 40 MB/s (G04, G09, & G18 models)
Up to 20 MB/s (C04, C09, & C18 models)

Buffer Size 1024 KB

Rotational speed 7200 RPM

Average Latency 4.17 mS

Track density 8356 TPI

	Minimum	Maximum
Recording density	132.67 kbpi	150 kbpi
Areal density	1109 Mb/sq inch	1253.4 Mb/sq inch

Models	4.5 GB/9.1 GB	18.2 GB
Disks	3/5	10
Heads	5/10	20

Seek timing Measured at nominal voltage and temperature

	4.5 GB/9.1 GB	18.2 GB
Single cylinder	0.7 ms (Read)	0.7 ms (Read)
	2.0 ms (Write)	2.0 ms (Write)
Average weighted	6.5 ms (Read)	7.5 ms (Read)
	8.0/7.5 ms (Write)	8.5 ms (Write)
Full stroke	14.0 ms (Read)	17.0 ms (Read)
	16.0 ms (Write)	19.0 ms (Write)

2.2 Notch Details (512-byte block length example)

User bytes/Sector 512

Sectors/logical block 1

User bytes/logical block 512

Number of cylinders 8162

Notch	Start Cylinder	User Data cylinders	Media Data Rate	Sectors Per Track
1	19/10/8 (4/9/18)	576/585/587 (4/9/18)	22.400	280
2	595	1471	21.145	270
3	2066	677	20.413	255
4	2743	483	19.784	247
5	3226	438	19.156	240
6	3664	420	18.528	230
7	4084	373	17.900	225
8	4457	306	17.377	216
9	4763	324	16.801	210
10	5087	433	16.016	198
11	5520	428	15.231	188
12	5948	612	14.132	180
13	6560	427	13.399	165
14	6987	386	12.771	157
15	7373	400	12.143	150
16	7773	389	11.520	140

Table 2. Cylinder notch table for 512 Byte Format

Notch	Last Cylinder	User Data cylinders	Media Data Rate	Sectors Per Track
16	8161	389	11.520	140

Table 3. Maximum LBAs and Cylinders

2.3 Capacities by Format Length

	User logical blocks/drive		
User bytes / logical block	**4.5 GB**	**9.1 GB**	**18.2 GB**
512	8,935,353	17,916,240	35,843,670
514	8,867,028	17,779,500	35,570,150
520	8,692,248	17,429,580	34,870,150
522	8,644,733	17,334,100	34,678,990
524	8,609,693	17,264,020	34,538,830
528	8,581,583	17,207,800	34,426,390
536	8,483,688	17,012,010	34,034,810
688	6,795,163	13,630,100	27,268,830
732	6,410,563	12,859,820	25,727,790

Note: Max Addressable LBA = (number of logical blocks) - 1

Table 4. User LBA capacity

		User bytes/drive	
User bytes / logical block	**4.5 GB**	**9.1 GB**	**18.2 GB**
512	4,574,900,736	9,173,114,880	18,351,959,040
514	4,557,652,392	9,138,663,000	18,283,057,100
520	4,519,968,960	9,063,381,600	18,132,478,000
522	4,512,550,626	9,048,400,200	18,102,432,780
524	4,511,479,132	9,046,346,480	18,098,346,920
528	4,531,075,824	9,085,718,400	18,177,133,920
536	4,547,256,768	9,118,437,360	18,242,658,160
688	4,675,072,144	9,377,508,800	18,760,955,040
732	4,692,532,116	9,413,388,240	18,832,742,280

Table 5. User Byte Capacity

2.4 Power Requirements

2.4.1 Specifications

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

Input Voltage

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

Power Supply On/Off Requirements

+5V	4.5 V/sec Minimum Slew.
+12V	7.4 V/sec Minimum Slew.

There are no power-off slew-rate requirements.

Power Supply Current - 4.5/9.1 GB Models

	Mean	**Range**
+5V (power save mode)	0.82 A	± 10%
+5V (idle avg.)	0.87 A	± 10%
+5V (R/W pulse)	1.16 A	± 10%
+12V (idle)	0.44 A	± 10%
+12V (seek peak)	2.07 A	Maximum
+12V (start max.)	1.6 A	± 0.3 A

Power Supply Current - 18.2 GB Model

	Mean	**Range**
+5V (power save mode)	0.82 A	± 10%
+5V (idle avg.)	0.87 A	± 10%
+5V (R/W pulse)	1.16 A	± 10%
+12V (idle)	0.8 A	± 10%
+12V (seek peak)	2.43 A	Maximum
+12V (start max.)	2.7 A	± 0.3 A

Energy Consumption

4.5 GB	2.2 mW/MB
9.1 GB	1.1 mW/MB
18.2 GB	0.78 mW/MB

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

2.4.2 RMS Power Measurements

Mode	4.5/9.1 GB (Watts)	18.2 GB (Watts)
Power-Save	8.9	13.5
Idle	10.0	14.2
15 ops/second	10.5	14.9
30 ops/second	11.4	16.0
60 ops/second	12.7	17.4
90 ops/second	13.5	18.2

Table 6. RMS Power Measurements

Notes:

1. Idle and Power-Save measurements are done after a 30 minute warm-up time with the drive track-following on cylinder 0.
2. For the non-idle measurements an op is defined as a read transfer of 4K bytes over a random distribution of LBAs across the drive.
3. All power measurements were made using a Clarke Hess Model 259 Digital Wattmeter.

2.4.3 Power Supply Current Profiles

The following Current Profiles are approximate representations of drive power supply currents based on lab measurements with nominal power supplies. The measurements exclude inductive spikes caused by leads, power supplies and components that will vary with different setup configurations.

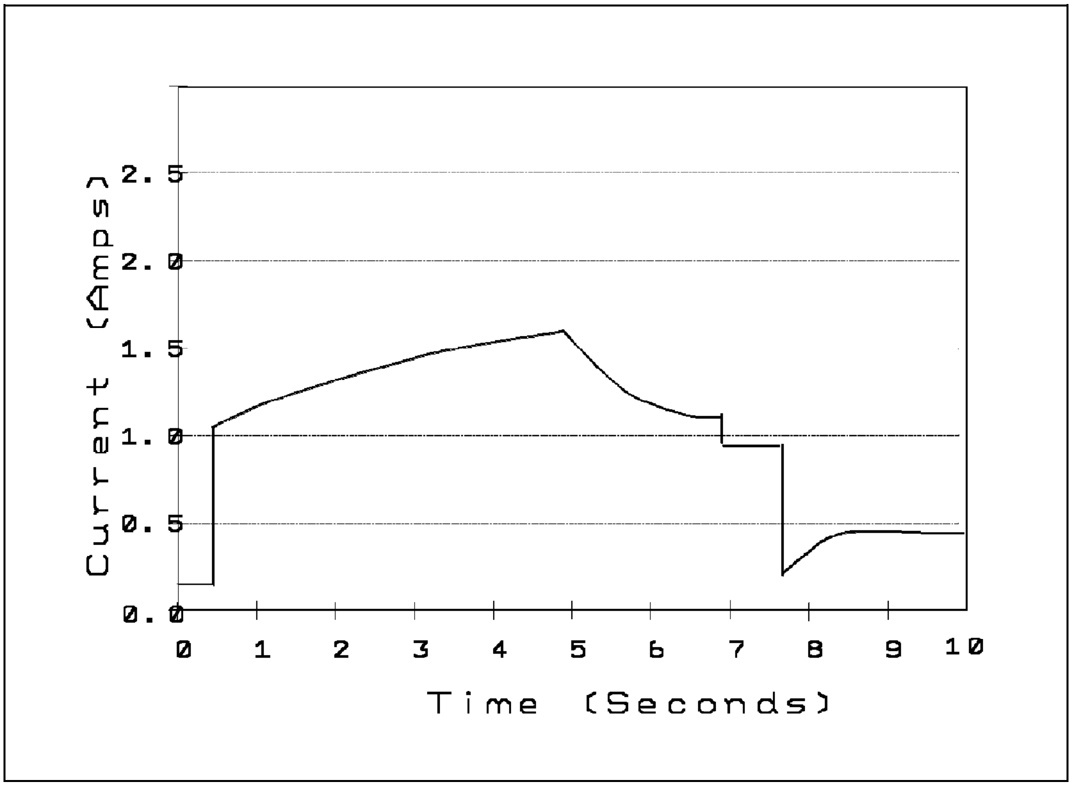

Fig. 2. 12V Start Current, 4.5/9.1 GB Models

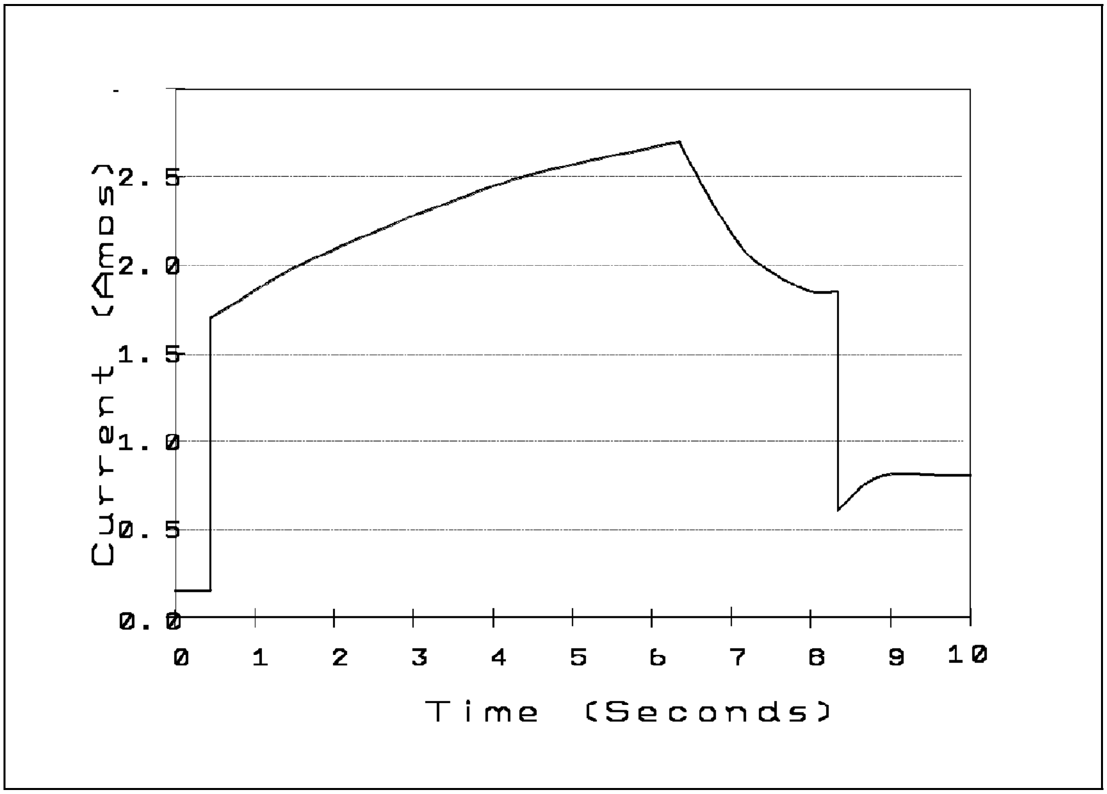

Fig. 3. 12V Start Current, 18.2 GB Model

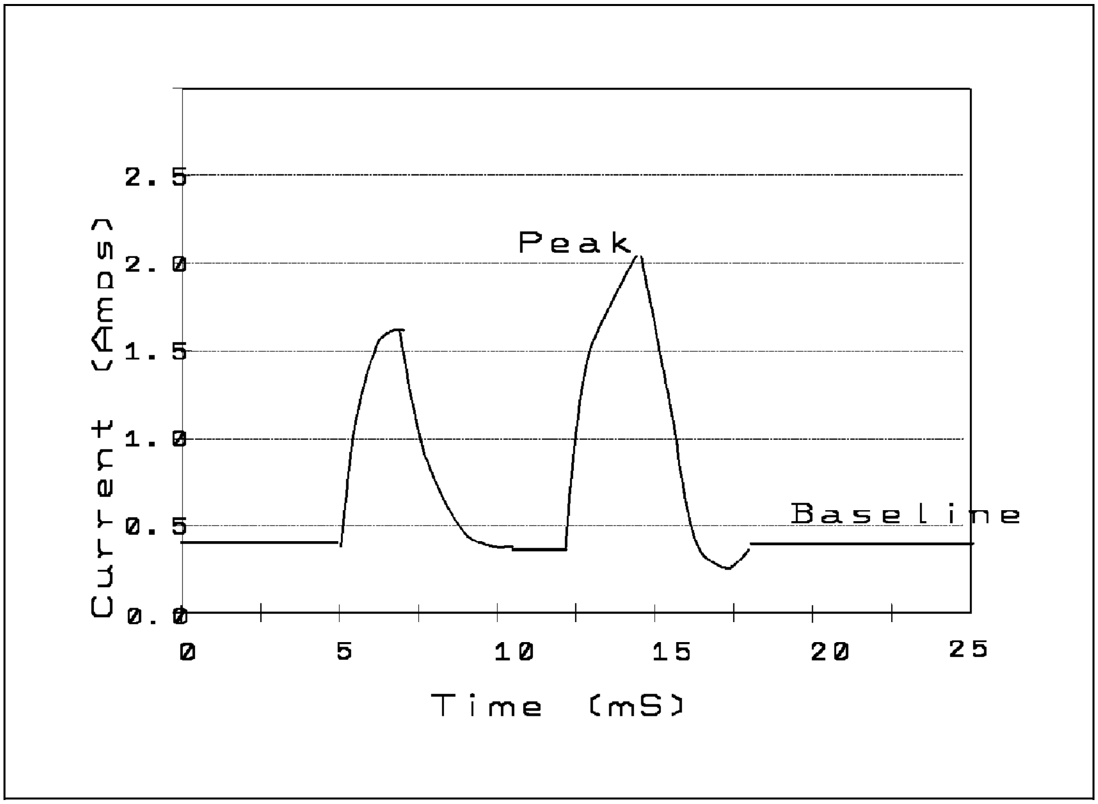

Fig. 4. Typical Seek-with-Read 12V Current, 4.5/9.1 GB Models

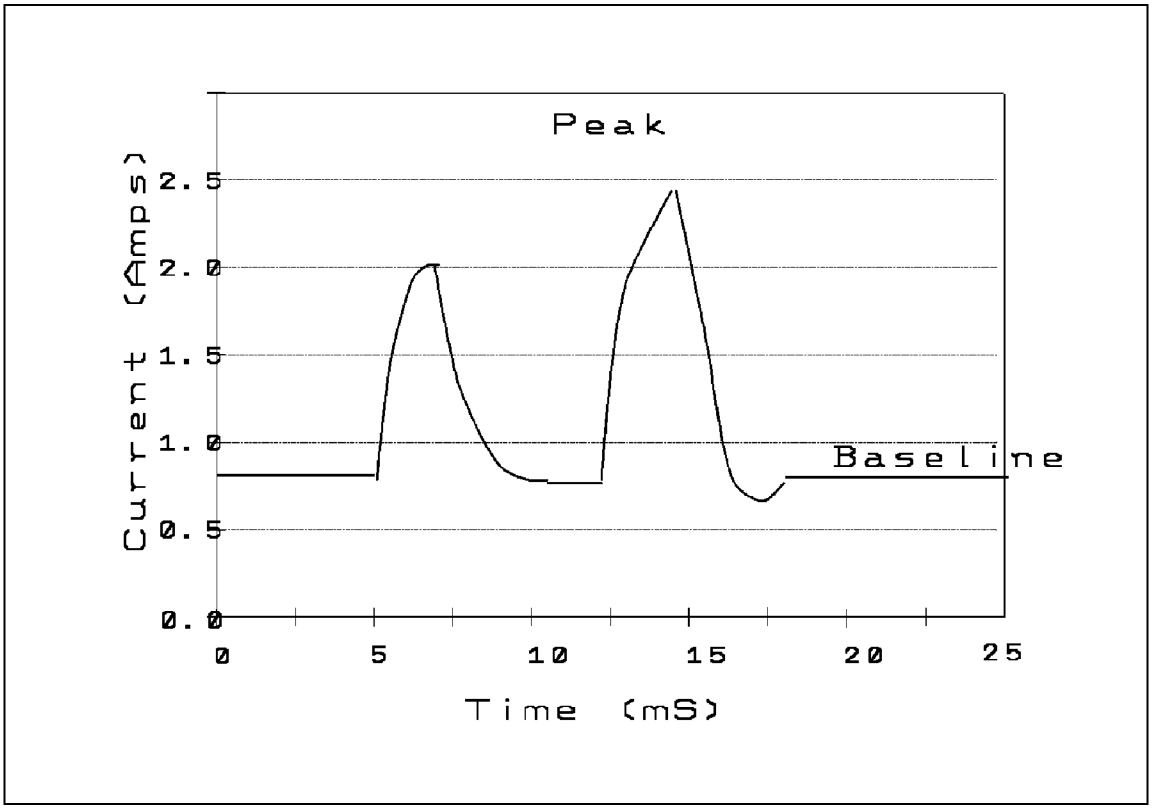

Fig. 5. Typical Seek-with-Read 12V Current, 18.2 GB Model

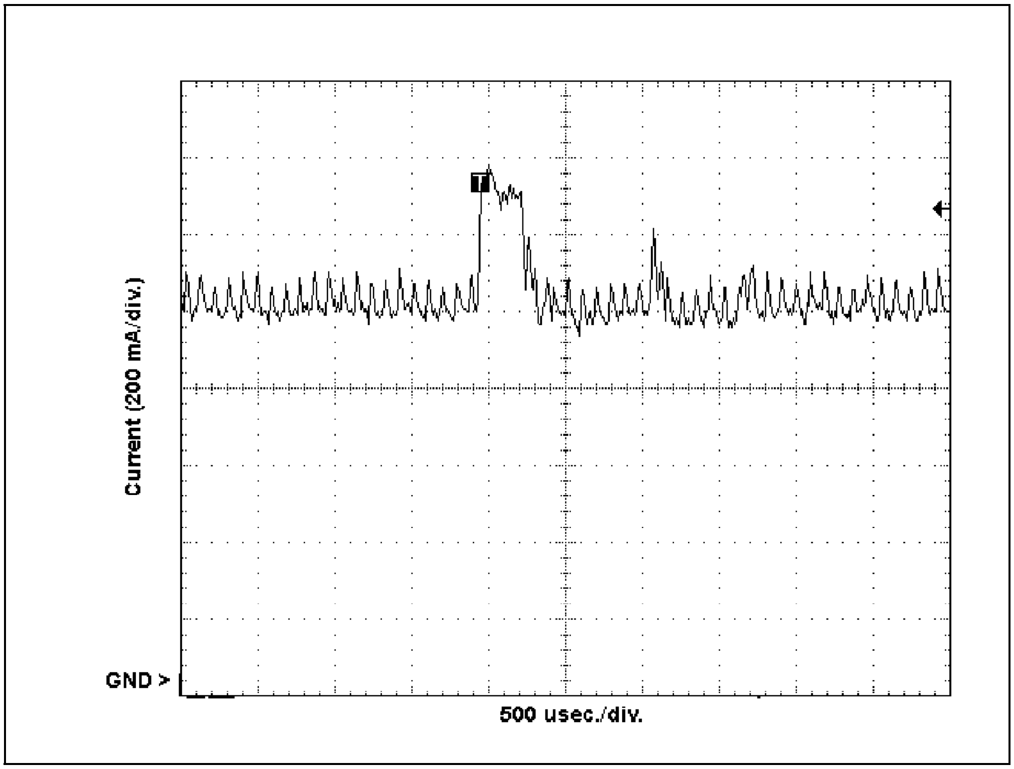

Fig. 6. Typical Random-Read 5-Volt Current, All Models

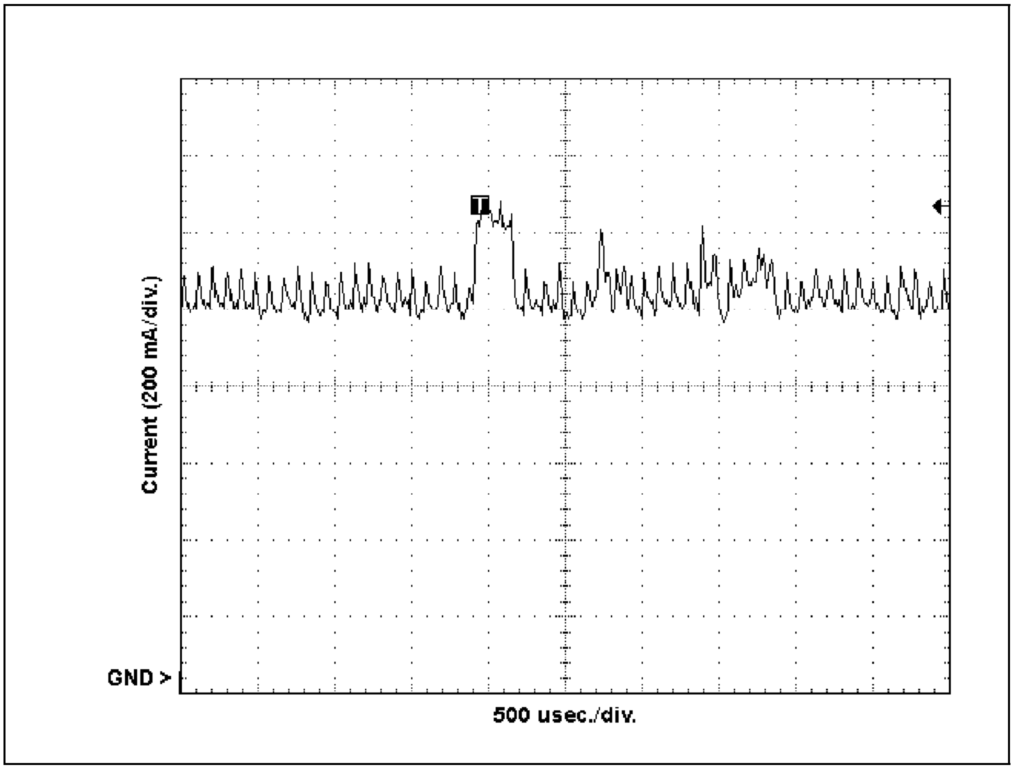

Fig. 7. Typical Random-Write 5V Current, All Models

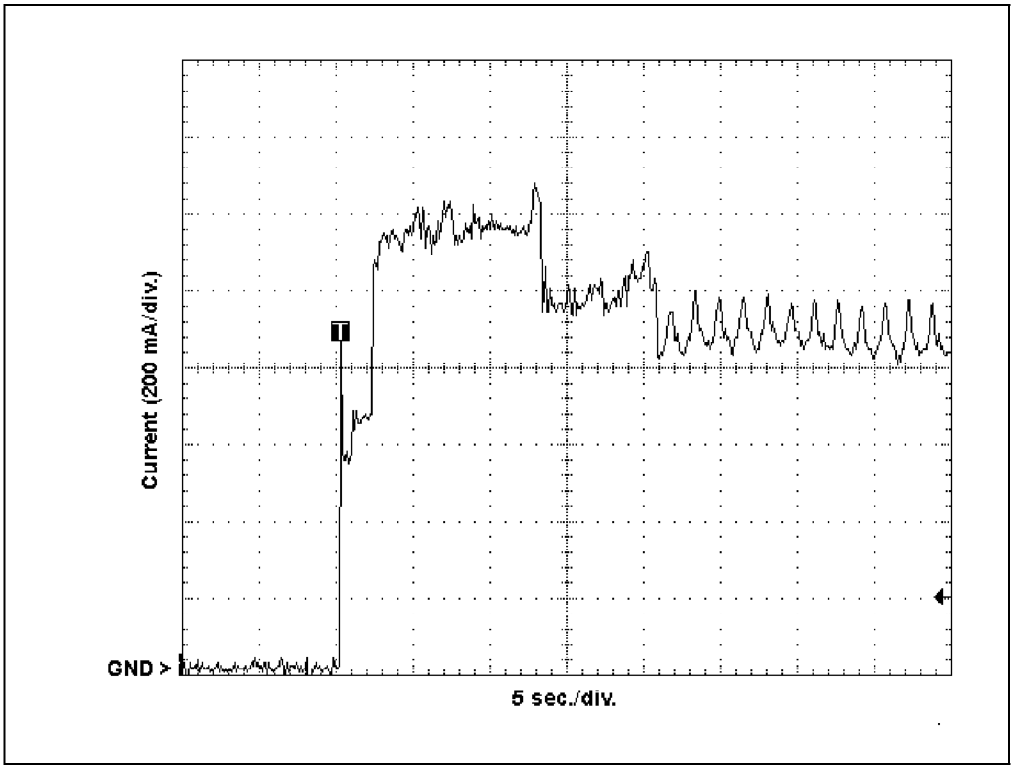

Fig. 8. 5V Start-Up Current Profile, All Models

2.4.4 Power Supply Ripple

Externally-generated ripple as seen at the drive power connector:

+5V: 200mV P-P (0-20 MHz)
+12V: 200mV P-P (0-20 MHz)

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

2.4.5 Input Capacitance

Internal bulk capacitance as seen at the drive power connector:

+5V: 72 µF ± 20%
+12V: 510 µF ± 20%

2.4.6 Grounding Requirements of the Disk Enclosure

The disk enclosure is at power supply ground potential.

For the best Electromagnetic Compatibility (EMC) performance a common ground connection should be provided between the disk enclosure and the system's mounting frame. The disk enclosure not become an excessive return current path from the system frame to power supply. The system 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

Hot plug and unplug is allowed for all SSA models.

There is no special sequence required for connecting 5 volt, 12 volt, or ground. During a hot plug 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 unplugging.

2.5 Bring-Up Sequence

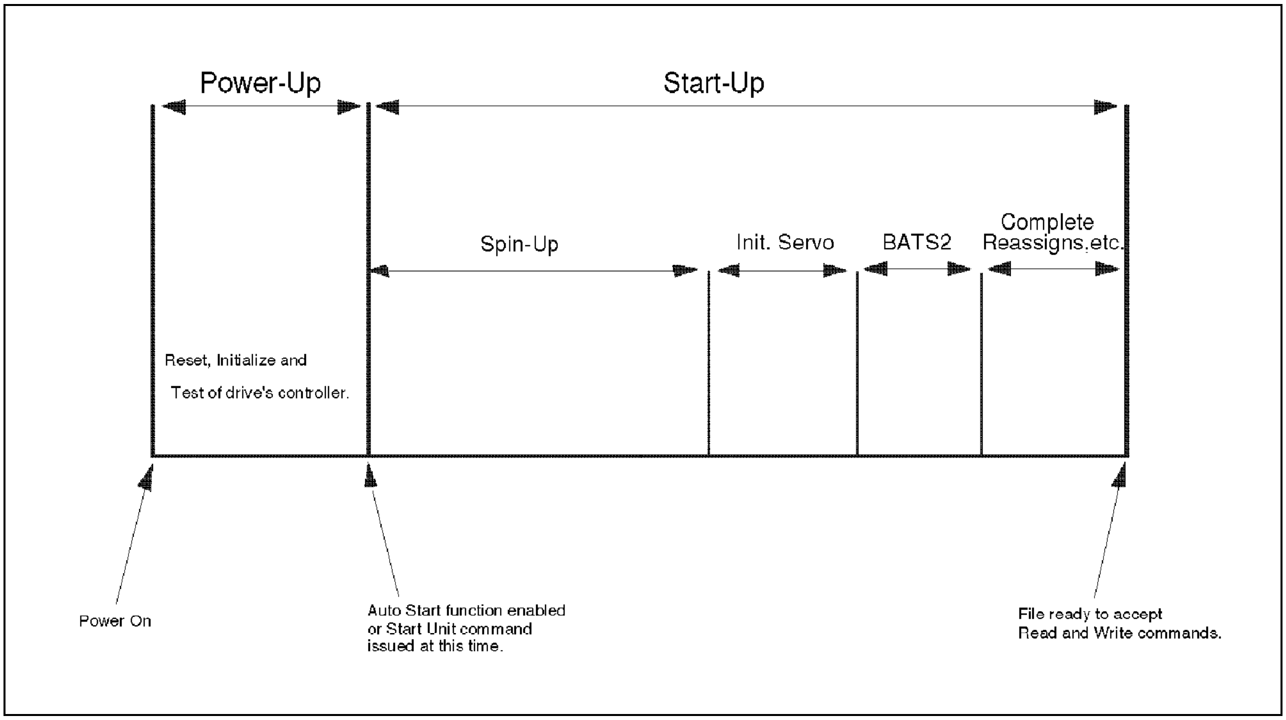

Fig. 9. Start-Time Diagram

A full Bring-Up Sequence consists of a Power-up Sequence and Start-Up Sequence.

"Power On" is defined as when the power at the drive meets all of the power specifications as defined in this document. The Start-Up sequence spins up the spindle motor, initializes the servo subsystem, performs Basic-Assurance-Tests-2 (BATs2) (verifies read/write hardware), resumes "Reassign in Progress" operations and more. See the *Ultrastar 18XP/9LP SSA Interface Specification* for additional details on the Start-Up sequence.

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

A startup sequence initiated by SCSI "Start/Stop Unit" command that follows a spindle stop initiated by a SCSI "Start/Stop Unit" command by less than 10 seconds, may result in the Startup sequence increasing by as much as 10 seconds. For example, if a delay of only 3 seconds exists between the 2 commands, the 2nd command can take 7 seconds longer than if 10 seconds or more had been allowed between the "Start/Stop Unit" commands.

Model	**18.2 GB**		**9.1 GB**		**4.5 GB**	
Event	**Nominal**	**Maximum**	**Nominal**	**Maximum**	**Nominal**	**Maximum**
Power-up	2.5 sec	3.0 sec	2.5 sec	3.0 sec	2.5 sec	3.0 sec
Start-up	16.5 sec	45 sec	17 sec	45 sec	17 sec	45 sec
Spin-up	10.5 sec	30 sec	11 sec	30 sec	11 sec	30 sec
Spindle Stop	15 sec	15 sec	15 sec	15 sec	15 sec	15 sec

Table 7. Bring-up Sequence and Stop Times

2.5.1 Spin-Down Times

After power is removed the drive should be allowed 15 seconds to park the heads and spin down before any attempt is made to handle the drive. It is recommended that after power is removed, a period of 2 seconds should be allowed before power is reapplied to the drive.

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

3 Performance

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

3.1 Environment Definition

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

- Nominal physical environment (voltage, temperature, vibration, etc.) as defined elsewhere in this specification.
- Block lengths are formatted at 512 bytes per block.
- The number of data buffer segments is 4. The total data buffer length is 671KB. The size of each equally-sized segment, in either bytes or blocks, is determined via the SCSI Mode Page 8h parameter called "Cache Segment Size". The number of blocks of customer data that can fit into one segment is reduced because 2 bytes of buffer CRC information is stored in the segment for each block of customer data.
- Ten byte SCSI Read and Write commands are used.
- The SSA environment consists of a single initiator and single target.
- All performance enhancing functions are disabled, except where noted. More specifically,
  - Commands are not queued unless otherwise specified
  - Read Caching and Read Ahead functions are enabled and Write Caching is disabled, except where noted.
  - Data Ready/Reply messages are exchanged for Read (DDRM=0)
- The initiator delay while transferring commands, status, message, and data bytes is assumed to be zero.
- All Current Mode Parameters are set to their Default values except where noted.
- 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 the minimum that the test system will support. This is to ensure that the maximum stress is placed on the drive to validate its maximum performance.

3.2.1 Sequential

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

3.2.2 Random

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

3.3 Command Execution Time

Command Execution, or Service, Times are 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 SSA Link

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

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

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

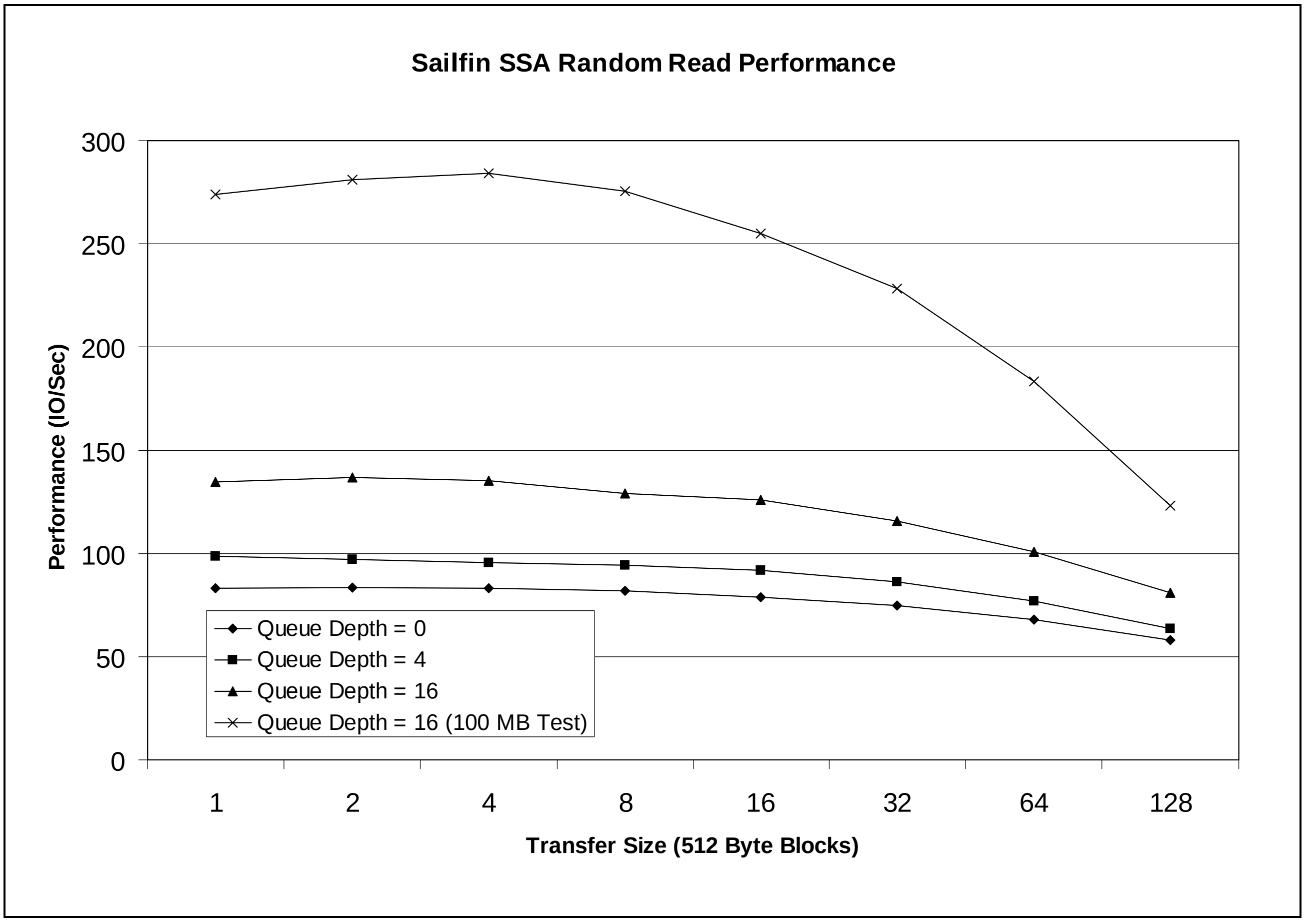

Fig. 10. Random Read Performance, 20 MB/S

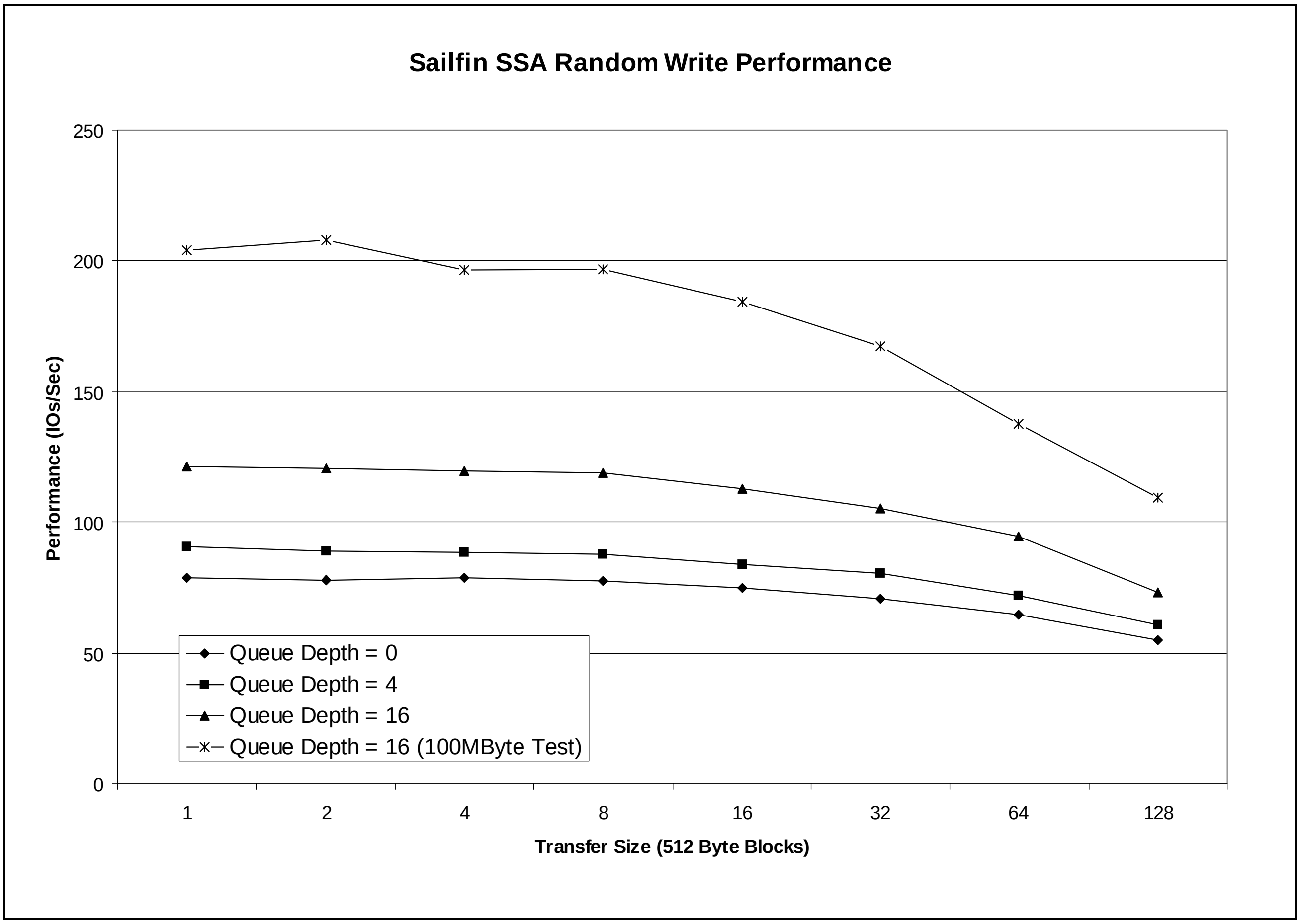

Fig. 11. Random Write Performance, 20 MB/S

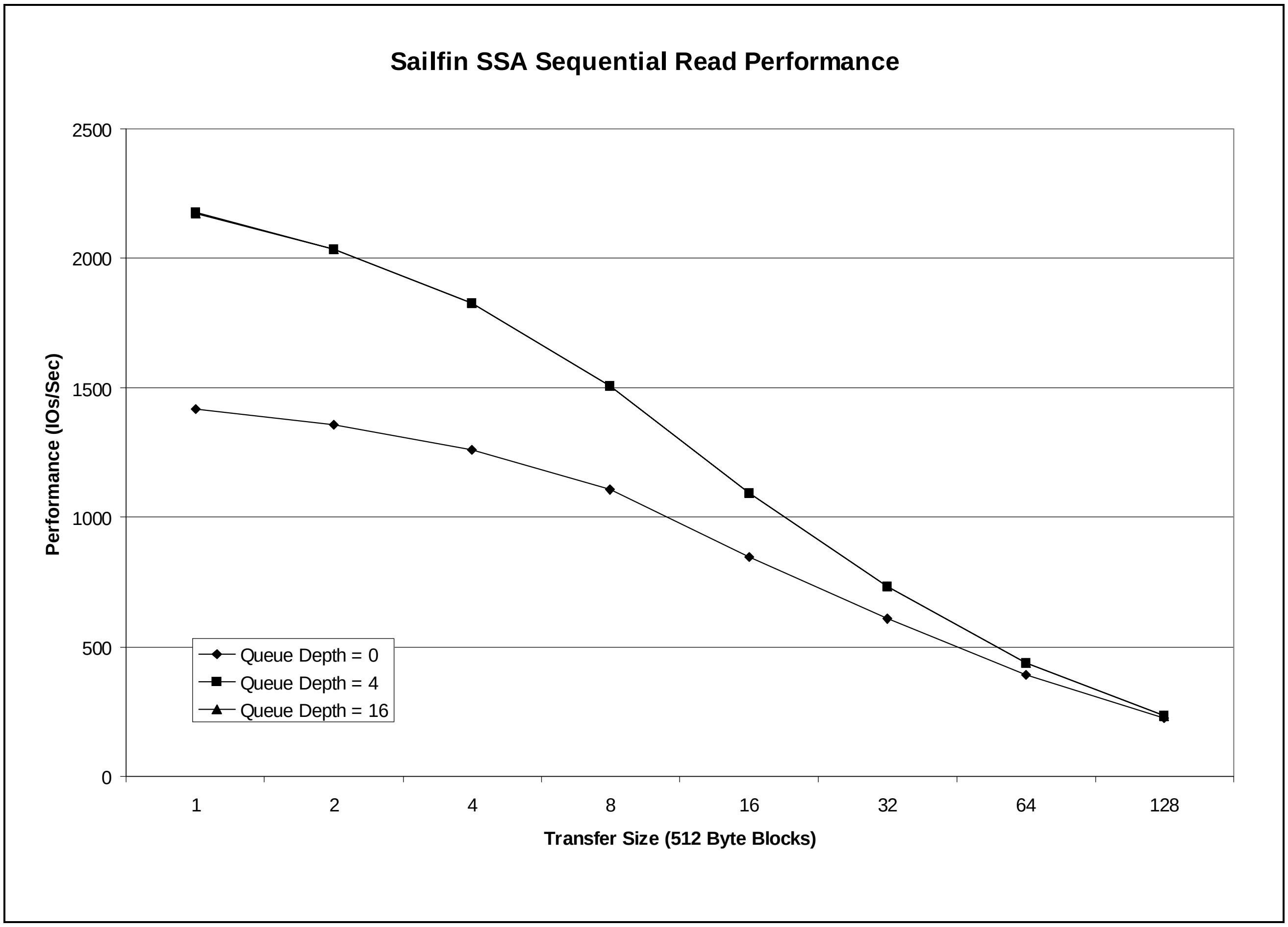

Fig. 12. Sequential Read Performance, 20 MB/S

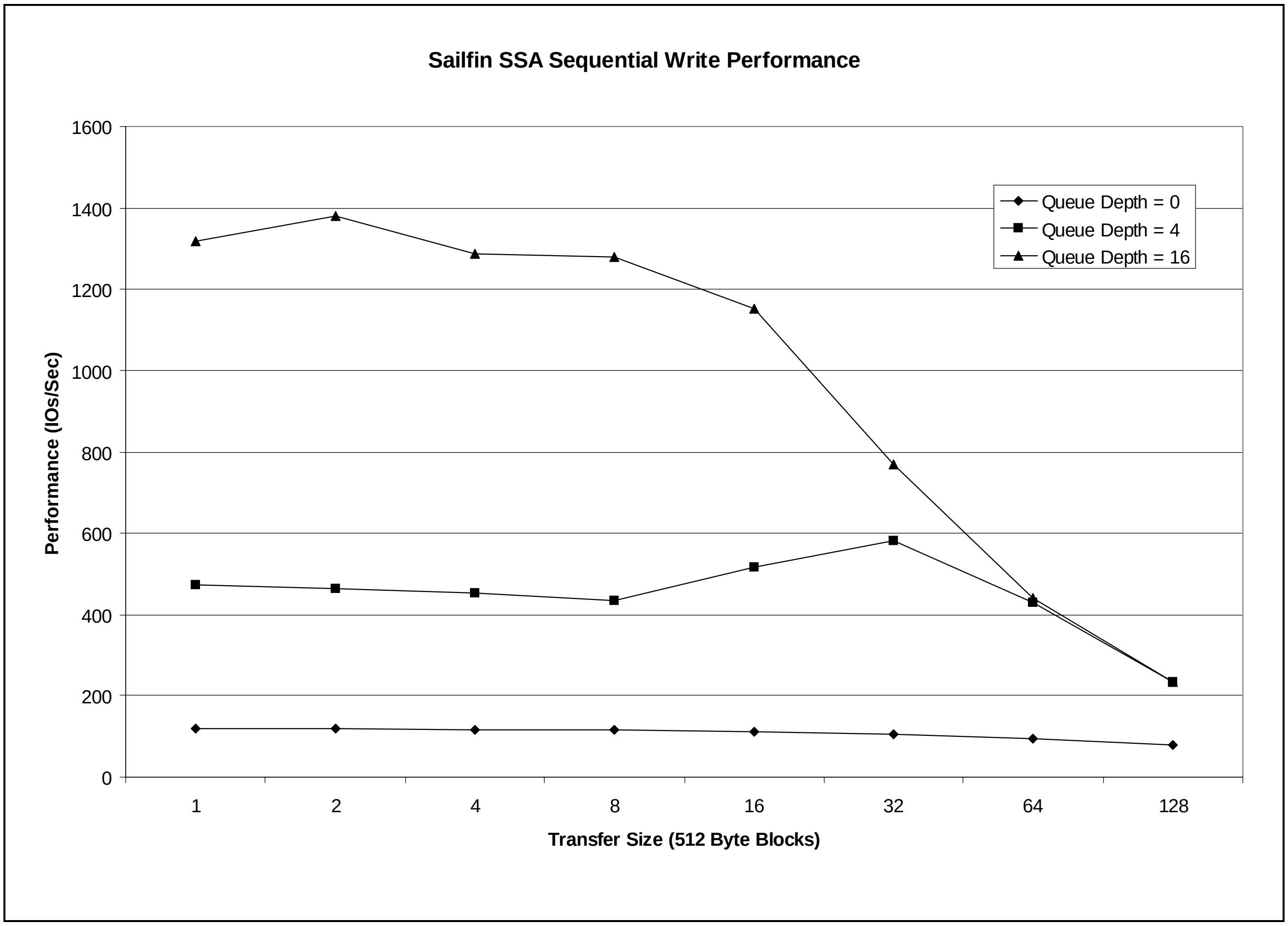

Fig. 13. Sequential Write Performance, 20 MB/S

3.3.1 Basic Component Descriptions

- Seek
  The average time from the initiation of the seek, to the acknowledgment that the R/W head is on the track that contains the first requested LBA. Values are population averages, and vary as a function of operating conditions.

  The values used in the graphs showing Command Execution Times for sequential commands is 0 ms and the values for random commands are shown in section 2.1 , "General".

- 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 ms.

- 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 processing a command while not doing a disk operation or SSA Link data transfer. The value of this parameter varies greatly depending upon workloads and environments.

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

Workload	Command Execution (mS)
Sequential Read (RA & Data Reply)	0.37
Sequential Write (WCE=0)	0.62
Random Read (no RA/RA)	0.21 / 0.38
Random Write	0.21

Table 8. Overhead Values

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

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

- 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 :

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

   1/(individual byte time)

2. Track Data Sector Transfer Rate
   Varies depending upon the formatted logical block length and varies from notch to notch. It includes the overhead associated with each individual sector. This is calculated from:

   (user bytes/sector)/(individual sector time)

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

3. Theoretical Data Sector Transfer Rate
   Also includes time required for track and cylinder skew and overhead associated with each track. Use the following to calculate it.

   Data Sector Transfer Rate = (Bytes/cylinder) / (time for 1 cyl)+ (track skews + 1 cyl skew)

4. Typical Data Sector Transfer Rates
   Also includes the effects of defective sectors and skipped revolutions due to error recovery. (See Appendix B. of the *Ultrastar 18XP/9LP SSA Interface Specification* for a description of error recovery procedures.)

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

Model	**All**		**18.2 GB**		**9.1 GB**		**4.5 GB**	
Notch	**Inst.**	**Track**	**Theor.**	**Typical**	**Theor.**	**Typical**	**Theor.**	**Typical**
Avg.	18.27	14.08	12.72	12.20	12.63	12.11	12.45	11.95
1	22	17.20	15.53	15.51	15.42	15.41	15.21	15.19
2	21.145	16.59	14.98	14.96	14.87	14.86	14.67	14.65
3	20.413	15.67	14.14	14.14	14.04	14.03	13.84	13.84
4	19.784	15.18	13.70	13.69	13.60	13.60	13.42	13.40
5	19.156	14.75	13.31	13.30	13.22	13.21	13.04	13.02
6	18.528	14.13	12.76	12.74	12.67	12.66	12.49	12.48
7	17.900	13.83	12.48	12.47	12.39	12.38	12.22	12.21
8	17.377	13.27	11.98	11.97	11.89	11.88	11.73	11.72
9	16.801	12.9	11.65	11.64	11.57	11.55	11.41	11.40
10	16.016	12.17	10.98	10.97	10.91	10.89	10.75	10.74
11	15.231	11.55	10.43	10.42	10.35	10.34	10.21	10.20
12	14.132	11.06	9.83	9.97	9.91	9.90	9.878	9.77
13	13.399	10.14	9.15	9.14	9.08	9.08	8.96	8.95
14	12.771	9.65	8.71	8.70	8.65	8.64	8.53	8.52
15	12.143	9.22	8.32	8.31	8.26	8.25	8.15	8.14
16	11	8.6	7.76	7.76	7.71	7.70	7.60	7.60

Table 9. Data Sector Transfer Rates (MB/s)

Notes:

- The values for Typical Data Sector Transfer Rates assume a typically worst case value of 3 errors in 10E9 bits read at nominal conditions for soft error rate.
- Contact an IBM Customer Representative for values when formatted at other block lengths.
- Each group of cylinders with a different number of gross sectors per track is called a notch. "Average" values used in this specification are sums of the individual notch values weighted by the number of LBAs in the associated notches.

- 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 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 20/40 MB/s, that is 10/5 microseconds per block (18.5/37 MB/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.

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

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

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

3.4 Approximating Performance for Different Environments

The values for several Basic Components may change based on the type of environment and workload. For example, Command Overhead may change because certain internal control functions may no longer be overlapped with either the SSA or disk data transfers, etc. The following paragraphs describe which parameters are affected by which features.

3.4.1 When Read Caching is Enabled

For read commands with Read Caching Enabled Command Execution time can be approximated by deleting Seek, Latency and Data Transfer to/from Disk times from those shown on the graphs if all of the requested data is available in a cache segment (cache hit). When some, but not all, of the requested data is available in a cache segment (partial cache hit), 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.

3.4.2 When Read Ahead is Enabled

The reduction in sequential (contiguous and non-contiguous) read workload with long inter-op delays Command execution times can be approximated by using the following equation:

-(Latency + (Xfer Size)/(Disk Data Rate) - (Xfer Size)/(SSA Data Rate)) = Read Ahead savings

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

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

This time also varies with the size of the data transfer due to the difference between the SSA 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.

3.4.3 When Write Caching is Enabled

For write commands with the Write Caching Enabled (WCE) Mode parameter bit set, Command Execution time can be approximated by deleting Seek, Latency and Data Transfer to/from Disk times from those shown in the graphs. The contribution of the Data Transfer to/from SSA Link 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 are added to the Post Command Processing Time.

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

When the WCE bit is set, Back-To-Back write commands are supported. See 3.4.5.2, “Back-To-Back Write Commands” for more information.

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

3.4.4 When Adaptive Caching is Enabled

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

3.4.5 For Queued Commands

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

3.4.5.1 Reordered Commands

If the Queue Algorithm Modifier Mode Parameter field is set to allow it, commands in the device command queue may be executed in a different order than they were received. Commands are reordered so that the Seek 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.

3.4.5.2 Back-To-Back Write Commands

If all of the requirements are met as stated in the *Ultrastar 18XP/9LP SSA Interface Specification* section describing Back-To-Back write commands, contiguous data from two or more consecutive write commands can be written to the disk without requiring any disk Latency.

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

3.4.6 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 nonexistent (eg. a cache hit), up to .70 µs can be saved by setting

DDRM=1. This minimizes the time between receiving the first block of data into the buffer and starting to transfer it on the SSA Link. 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).

3.5 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 minimum amount of time and therefore the number of sectors varies depending on which notch is being accessed and the block length. The minimum amount of time required for a cylinder switch is 2.13 ms.

3.5.2 Track-to-Track Skew

Track Skew is the time required to perform a switch between heads on the same cylinder; it is 0.83 mS.

3.6 Idle-Time Function Considerations

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

1. Predictive Failure Analysis (PFA)
2. Save Logs and Pointers
3. Disk Sweep

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

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

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

1. Normal recommended operation
   Idle-Time Functions are only started if the drive has not received a SCSI command for at least 5 seconds. This means that multiple SCSI commands are accepted and executed without delay if the commands are received by the drive within 5 seconds after the completion of a previous SCSI command. This mechanism has the benefit of not requiring special system software (such as issuing SCSI Rezero Unit commands at known & fixed time intervals) in order to control if and when this function executes.
2. Synchronized operation
   Applications which can not accommodate interruptions at all may consider synchronizing idle activities to the system needs through use of the TCC bit in Mode Page 0h and the Rezero Unit command.

   An example of this limiting mechanism's use would be if a system is known to issue SCSI commands for an application greater than 5 seconds apart and an Idle -Time Function delay could not be tolerated by the system on any of those commands. This would eliminate drive initiated Idle-Time Function from even starting while the system/application is in a critical response time period of operation.
3. No PFA operation

Idle-Time initiated PFA can be disabled by setting the "Perf" bit in Mode Page 1Ch. See the *Ultrastar 18XP/9LP SSA Interface Specification* for details.

3.6.1 Predictive Failure Analysis (PFA)

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

There are also "measurement driven" PFA processes which occur during Idle Time. Seven different PFA measurements are taken for each head. The measurements for all heads are taken over a period of 4 hours, therefore the frequency of PFA is dependent on the number of heads a particular model has. The drive attempts to spread the measurements out evenly in time and each measurement takes about 80 milliseconds. For example, a model with 20 heads (18.2 GB) will perform one PfA measurement every 1.7 minutes (240 / 7*20). Models with 10 heads (9.1/4.5 GB) perform a PFA measurement every 3.4 minutes. For the last head tested for a particular measurement type (once every 34 minutes), the data is analyzed and stored. The extra execution time for those occurrences is approximately 40 milliseconds.

This measurement/analysis feature can be disabled for critical response time periods of operation by setting the Page 1Ch Mode Parameter PERF = 1. The using system also has the option of forcing execution at known times by issuing the SCSI Rezero Unit command if the Page 0h Mode Parameter TCC = 1. All tests for all heads occur at those times. See the *Ultrastar 18XP/9LP SSA Interface Specification* for more details about PFA, PERF and TCC.

3.6.2 Data Logs

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 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 it is less than 30 mS.

3.6.3 Disk Sweep

The heads are moved to another area of the disk if the drive has not received a SCSI command for at least 40 seconds. After flying in the same spot for 9 minutes without having received another SCSI command, the heads are moved to another position. If no other SCSI command is received, the heads are moved every 9 minutes thereafter. As soon as a SCSI command is received, the period for the first occurrence is reduced back down to 40 seconds. The period is increased back to 9 minutes for subsequent occurrences should no more SCSI commands be received during that time. Execution time is less than one full-stroke seek time

3.6.4 Summary

Idle Time Function Type	Period of Occurrence (minutes)	Duration (ms)	Mechanism to Delay	Mechanism to Disable
PFA	34/(trk/cyl)	80	Re-instruction Period, TCC	PERF
Save Logs & Pointers	26	30	Re-instruction Period, TCC	N/A
Disk Sweep	2/3 - since last command	17	Re-instruction Period	N/A
	9 - since last occurrence			

Table 10. Summary of Idle-Time Function Performance Impacts

3.6.5 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.

3.6.5.1 Reassignment Time

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

3.6.5.2 Format Time

18.2 GB models should be allowed 110 minutes to complete a "Format Unit" command. If the Vendor Unique Mode Page 00h bit named "FFMT" is set equal to ’1’b, then they should be allowed 60 seconds to complete.

9.1 GB models should be allowed 55 minutes to complete a "Format Unit" command. If the Vendor Unique Mode Page 00h bit named "FFMT" is set equal to ’1’b, then they should be allowed 30 seconds to complete.

4.5 GB models should be allowed 28 minutes to complete a "Format Unit" command. If the Vendor Unique Mode Page 00h bit named "FFMT" is set equal to ’1’b, then they should be allowed 15 seconds to complete.

3.6.5.3 Start/Stop Unit Time

The drive should be allowed a minimum of 30 s 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.

3.6.5.4 Medium Access Command Time

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

- Log Sense
- Mode Select (6)
- Mode Select (10)
- Mode Sense (6)

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

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

3.6.5.5 Timeout limits for other commands

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

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

The command timeout 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 previously.

4 Mechanical

4.1 Weights and Dimensions

	U.S. 1.0" Models	**S.I. Metric 1.0" Models**	**U.S. 1.6" Models**	**S.I. Metric 1.6" Models**
Weight	1.41 pounds	0.64 Kilograms	2.38 pounds	1.08 Kilograms
Height	1.02 inches	25.97 millimeters	1.61 inches	41.0 millimeters
Width	4.00 inches	101.85 millimeters	4.00 inches	101.85 millimeters
Depth	5.79 inches	147.0 millimeters	5.79 inches	147.0 millimeters
Note: These are nominal weights and dimensions provided for reference only. The dimensional tolerances are shown in the next four figures. The weight tolerance is +/- 10%. Card interface types and disk quantity (on 1.0" models) determine the weight variability.				

Table 11. Weights and Dimensions

4.2 Clearances

A minimum of 2 mm clearance should be given to the bottom surface except for a 10 mm maximum diameter area around the bottom mounting holes. A minimum of 1 mm clearance should be given to the cover flanges around the top edge of the drive. There should be 7 mm of clearance between ***SSA-ULTRASTAR 18XP/9LP*** drives that are mounted with their top sides facing each other. Drives from other manufactures may require additional spacing due to stray magnetic fields.
For proper cooling it is suggested that a minimum clearance of 7 mm be provided under the drive and on top of the drive.

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 the following figures for the location of these mounting holes for each configuration.

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

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

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

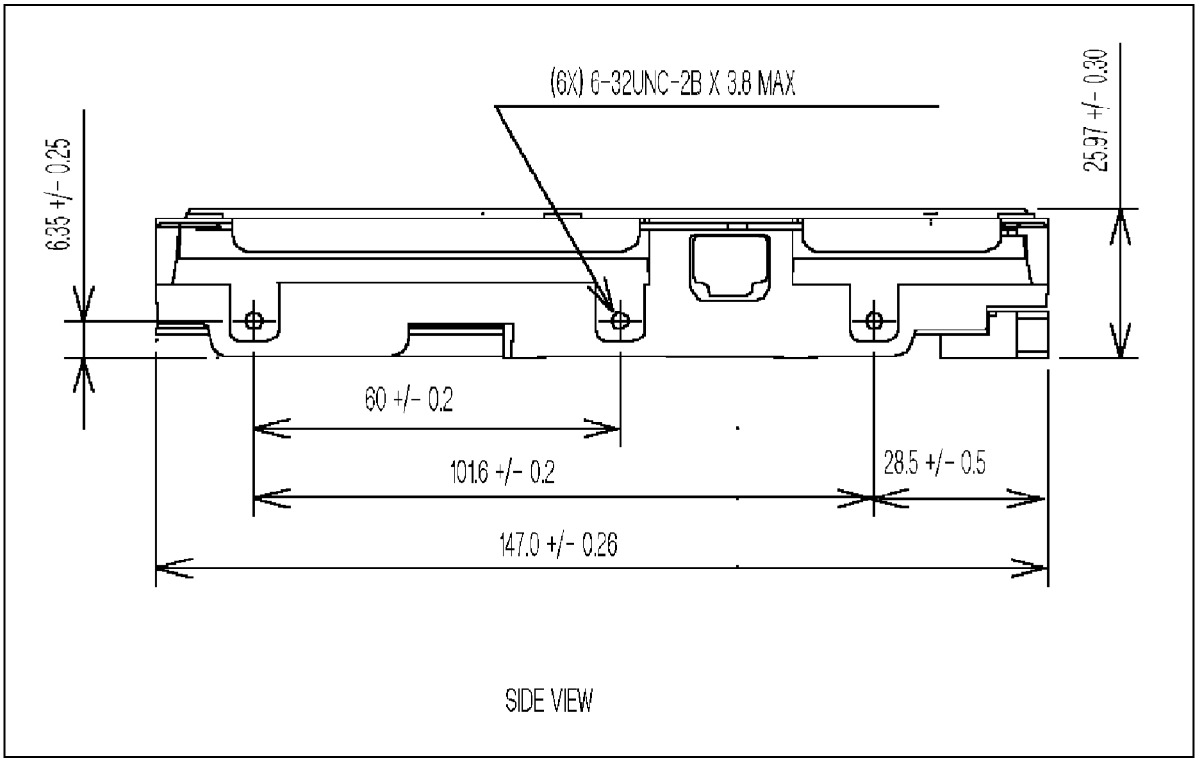

Fig. 14. Location of Side Mounting Holes of 4.5/9.1 GB Models

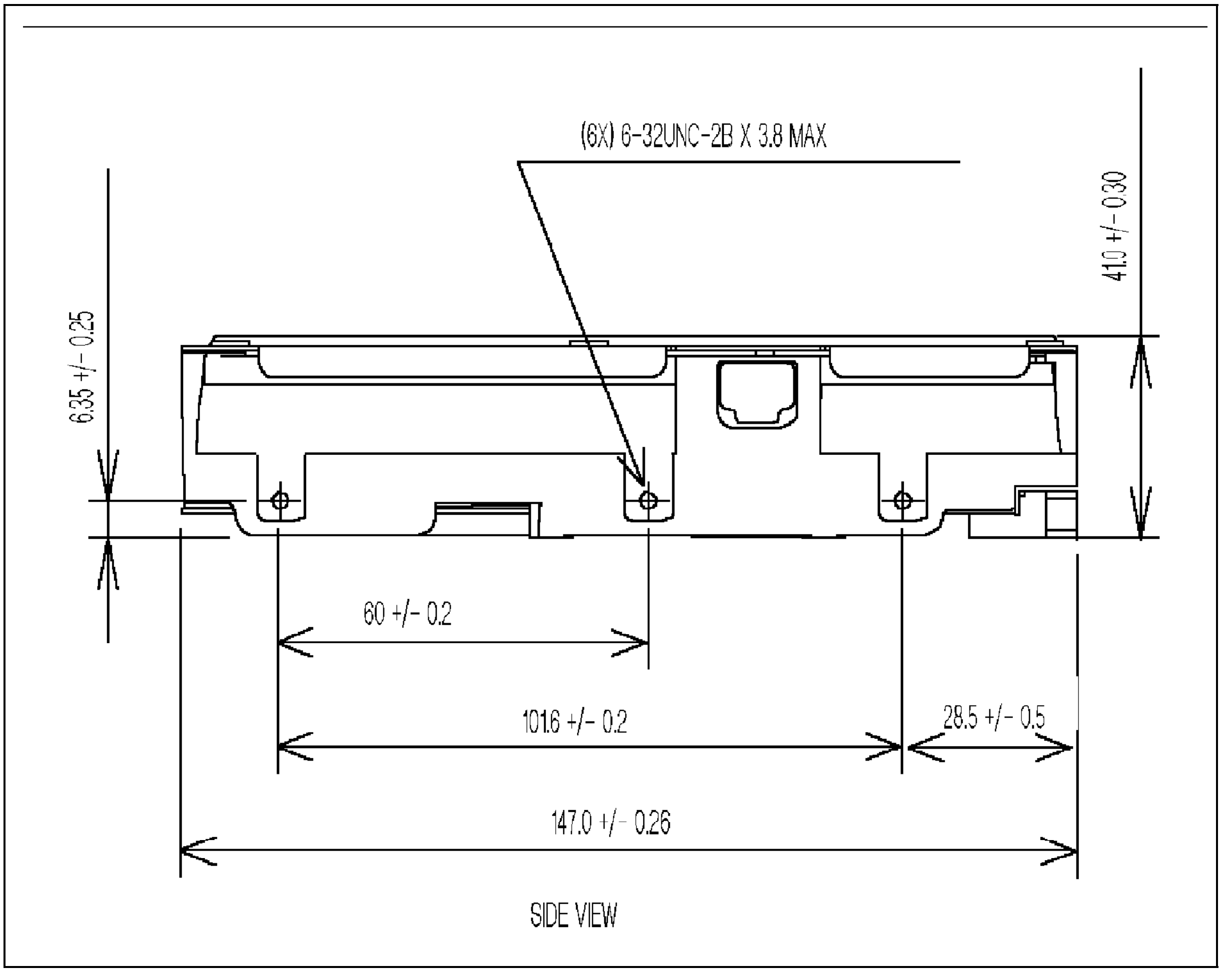

Fig. 15. Location of Side Mounting Holes of 18.2 GB Model

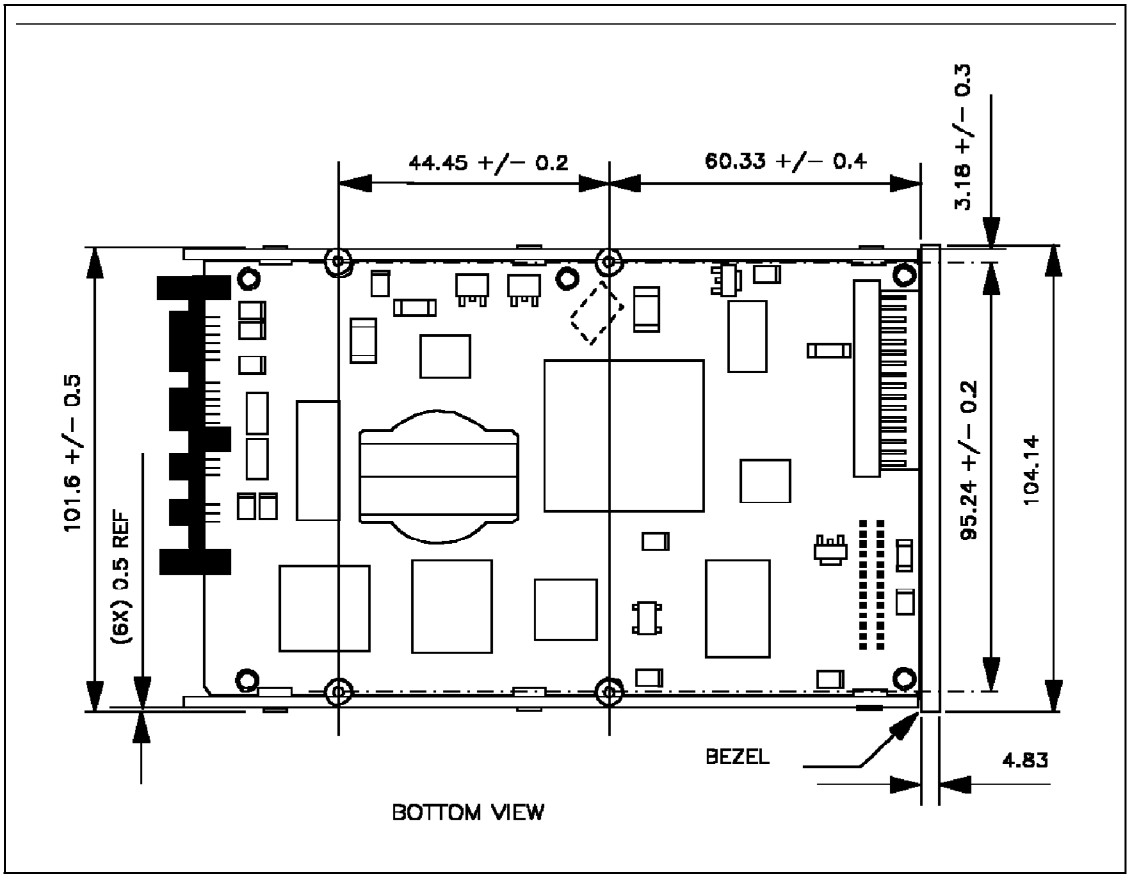

Fig. 16. Locations of Bottom Mounting Holes

4.4 Electrical Connector Locations

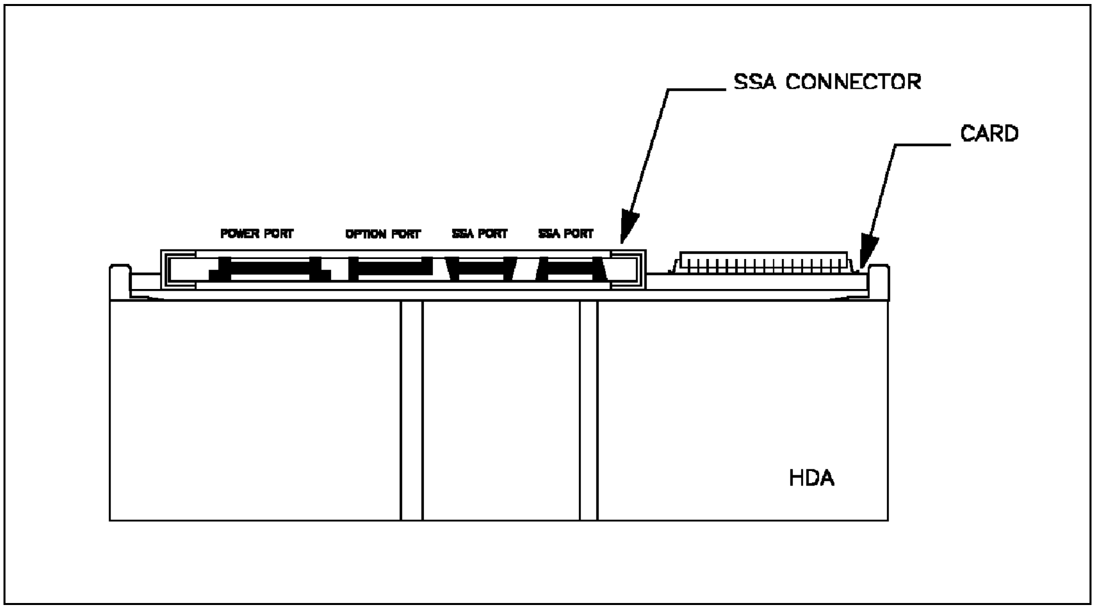

Fig. 17. SSA Electrical Connector (Rear View)

5 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 Fig. 18 and Table 12 for contact assignments.

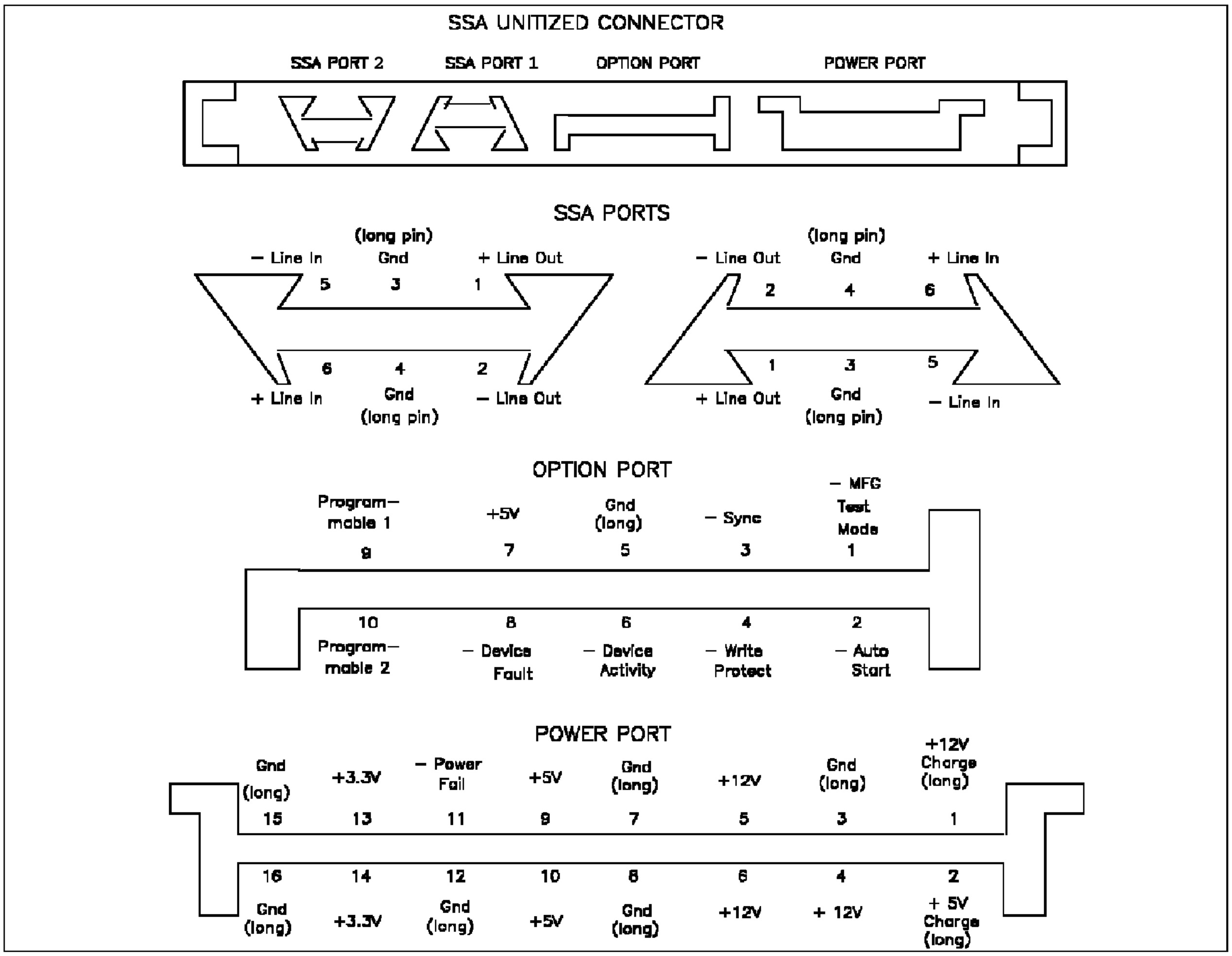

Fig. 18. Unitized Connector

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 12. SSA Connector Pin 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/95PH) rev 2*.

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/95PH) rev 2*.

5.4 Option Pins and Headers

SSA-ULTRASTAR 18XP/9LP 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/95PH) rev 2*. The existence and definition of these pins are model-dependent.

For detailed descriptions of the following pin functions see the *Marlin/Sailfin SSA Interface Specification*.

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 +5V 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) causes 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. The default state is inactive.

5.4.3 Sync Pin (Option Port Pin 3)

The ***Sync*** input/output pin is not supported.

5.4.4 Write Protect (Option Port Pin 4)

An active-low input pin that when active (pulled below 0.8 V), will prohibit commands that alter the customer data area portion of the the media from being performed. The state of this pin is checked at the start of each command. The default state is no write protection.

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 during hot-plug or hot-unplug.

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

An active-low LED output pin can be used to drive an external Light Emitting Diode.

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.

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 TTL compatible pin has 4mA of current sink capability. It can dynamically serve as either an input or as an output, completely under firmware control. It has two uses on ***SSA-ULTRASTAR 18XP/9LP***: first, by default, it serves as a "Loss of Redundant Power" status indicator from the enclosure to the drive. The drive will sam ple this pin approximately every 50msec. When active, the drive will initiate an Async Alert Message over the SSA Interface as a warning to the system. Second, this pin serves as DSI_A when the drive determines that the enclosure supports SES Long mode. Refer to 5.6 , "SES (SCSI Enclosure Services) Mode Support" for a description of the various SES modes supported by the drive.
This pin is completely controlled by microcode.

5.4.10 Programmable Pin 2 (Option Port Pin 10)

This TTL compatible pin has 4mA of current sink capability. It can dynamically serve as either an input or as an output, completely under firmware control. On ***SSA-ULTRASTAR 18XP/9LP*** it's defined function is to serve as DSI_B, when the drive determines that the enclosure supports SES Long mode. Refer to 5.6 , "SES (SCSI Enclosure Services) Mode Support" for a description of the various SES modes supported by the drive.

This pin is completely controlled by microcode.

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.

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

These pins are longer than the other pins and help to reduce current spikes during hot plug. Each pin require a resistor (not included on the drive) in series between the power source and the drive connector to provide current limiting. 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 Option Block Connector (Jumper Block)

SSA-ULTRASTAR 18XP/9LP models contain a jumper block that can be used to enable optional features. This jumper block is refered to as the 'Front' Option Jumper Block because of its location on the drive (opposite the SSA Unitized connector). It provides some useful features not available with the unitized options.

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

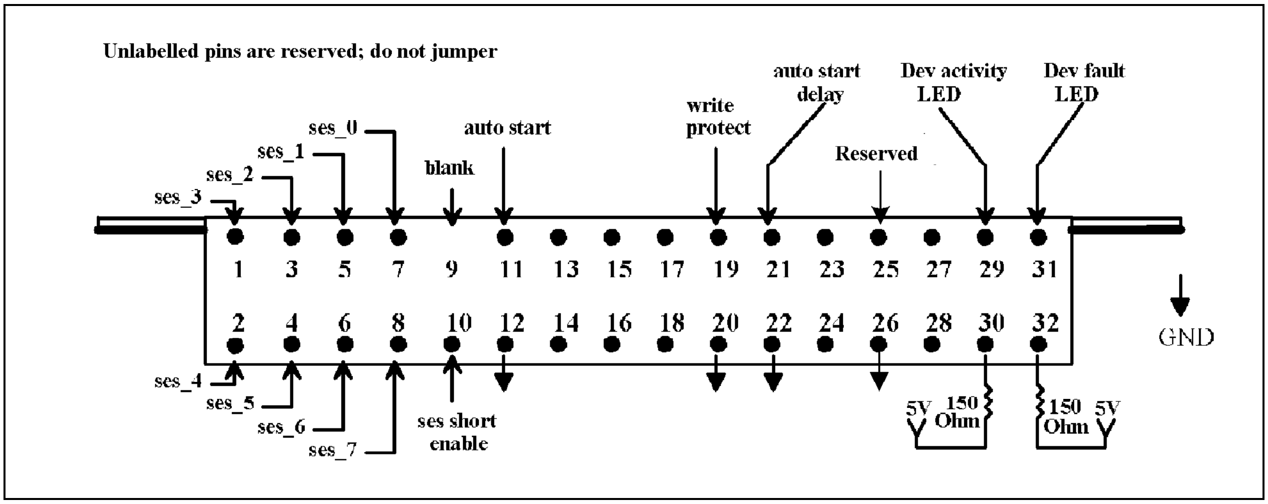

Fig. 19. Front Option Jumper Block

The option block pins are described in the following subsections.

5.5.1 SES_0 - SES_7 (Option Pins 1-8)

The SES_x option pins are TTL compatible inputs to the drive. They are used to define 8 bits of enclosure status to the drive when it has been established that the enclosure supports SES_Short mode. SES_Short mode is determined by the drive at power up, based on the state of the SES_Short Enable option pin. The drive does not try to interpret these pins, but simply samples them and sends them to the host when requested. Please refer to 5.6 , "SES (SCSI Enclosure Services) Mode Support" for a description of the various SES modes supported by the drive.

5.5.2 SES_Short Enable (Option Pin 10)

The SES Short Enable pin is a TTL compatible input to the drive. It is sampled by the drive at power up to determine if the enclosure supports SES_Short mode. This pin is active low and should be grounded when SES_Short mode is desired. This pin has a 5K Ohm pull-up resistor connected to it which defaults SES_Short mode to off (i.e. SES_OFF mode).

5.5.3 Auto-Start (Option Pin 11)

This is physically the same pin as the SSA Unitized Option pin 2 (see 5.4.2 , "Auto Start Pin (Option Port Pin 2)"). It is provided here as an alternate means of access. If this option is used, it should be applied either on the SSA Unitized Option block or on the front option block, but not on both locations.

5.5.4 Write Protect (Option Pin 19)

This is physically the same pin as the SSA Unitized Option pin 4 (see 5.4.4 , "Write Protect (Option Port Pin 4)"). It is provided here as an alternate means of access. If this option is used, it should be applied either on the SSA Unitized Option block or on the front option block, but not on both locations.

5.5.5 Auto-Start Delay (Option Pin 21)

This is a TTL compatible input to the drive. When this pin is pulled to a TTL low state (below 0.8V), and when the Auto Start option is utilized (see 5.5.3 , "Start (Option Pin 11)"), a delay will be applied before starting the motor. The default is no Auto Start Delay.

5.5.6 Device Activity LED (Option Pin 29)

This is physically the same pin as the SSA Unitized Option pin 6 (see 5.4.6 , "Device Activity Pin/Indicator (Option Port Pin 6)") with the exception that it does not have the 150 Ohm series current limiting resistor. It is provided here as an alternate means of access. If this option is used, it should be applied either on the SSA Unitized Option block or on the front option block, but not on both locations. If this LED function is used here, it is expected that the LED cathode will be connected to pin 29 and that the LED anode will be connected to pin 30. Pin 30 provides the 150 Ohms of current limiting required. The LED anode may be connected elsewhere provided that current limiting is also provided to insure that the current draw does not exceed 24mA.

5.5.7 Device Fault LED (Option Pin 31)

This is physically the same pin as the SSA Unitized Option pin 8 (see 5.4.8 , "Device Fault Pin/Indicator (Option Port Pin 8)") with the exception that it does not have the 150 Ohm series current-limiting resistor. It is provided here as an alternate means of access. If this option is used, it should be applied either on the SSA Unitized Option block or on the front option block, but not on both locations. If this LED function is used here, it is expected that the LED cathode will be connected to pin 31 and that the LED anode will be connected to pin 32. Pin 32 provides the 150 Ohms of current limiting required. The LED anode may be connected elsewhere provided that current limiting is also provided to insure that the current draw does not exceed 24mA.

5.6 SES (SCSI Enclosure Services) Mode Support

SSA-ULTRASTAR 18XP/9LP supports 3 different SES modes, refered to as:

- SES_Off (default)
- SES_Short (established by 5.5.2 , "SES_Short Enable (Option Pin 10)")
- SES_Long (established by 5.4.9 , "Programmable pin 1 (Option Port Pin 9)" and 5.4.10 , "Programmable pin 2 (Option Port Pin 10)")

The drive powers-up in the SES_Off mode. In SES_Off mode, enclosure services are unsupported. This will be indicated in the drives Inquiry data.

During power-on initialization, the drive samples the **SES_Short Enable** option pin. If this pin has a TTL logic low state applied to it, the drive will enter into **SES_Short** mode. In SES_Short mode the drive does provide limited enclosure service support and will indicate so in it’s Inquiry data. It will respond to the appropriate Receive Diagnostics SCSI-3 command with the value sampled from SES_0-SES_7 at power-on, and send that information in the command response. The drive does not try to interpret the information on the SES_0-SES_7 pins.

In **SES_Long** mode the drive uses the Device Service Interface (i.e. DSI) to communicate with the enclosure. Please refer to “Device Services Interface (DSI)” by Ian Judd (SSD Havant) for a detailed description of DSI. Every 50msec, the drive will sample the DSI_A and DSI_B pins when in SES_off mode (see 5.4.9 , "Programmable pin 1 (Option Port Pin 9)" and 5.4.10 , "Programmable pin 2 (Option Port Pin 10)"). If a DSI Idle is detected (DSI_A=0, DSI_B=1), the drive will enter the SES_Long mode. This transition into SES_Long can occur from either SES_Off or SES_Short (SES_short mode is enabled by option pin 10). Once the drive enters SES_Long, it will stay there until the next power on initialization. In this mode, the drive will indicate support for SES in its Inquiry data. It will respond to the Send/Receive Diagnostic SCSI-3 commands by passing information back and forth between the SCSI Initiator and the enclosure via the DSI interface.

Please refer to the "Enclosure Services" section of the *Ultrastar 18XP/9LP SSA Interface Specification* and *SCSI Enclosure Services (SES) for SSA Disk Drives* by Richard Rolls for a more detailed functional description of SES support.

6 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 Procedures" in the *Ultrastar 18XP/9LPSSA Interface Specification* are followed.

No isolation to subassemblies within the device are specified.

6.2 Data Reliability:

Probability of not recovering data	10 in 10E15 bits read
Recoverable read errors (Mean of the Population)	10 in 10E13 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 18. (3)

6.3 SPQL (Shipped Product Quality Level)

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

6.4 Failure Rate

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

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

6.5 Shelf Life

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

6.6 Start/Stop Cycles

The maximum number of start/stop cycles supported is 1800.

7 Operating Limits

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

7.1 Environmental

- Temperature

Operating Ambient	5 to 50C (41 to 122F)
Operating Disk Enclosure	5 to 65C (41 to 149F)
Storage	1 to 65C (34 to 149 F); see note below.
Shipping	-40 to 65C (-40 to 149F)

- Temperature Gradient

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

- Humidity

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

- Wet Bulb Temperature

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

- Elevation

Operating and Storage	-304.8 to 2134 meters (-1000 to 7,000 feet)
Shipping	-304.8 to 12,192 meters (-1000 to 40,000 feet)

Note: Guidelines for storage below 1C 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.

Fig. 20 defines where measurements should be made to determine the top disk enclosure temperature during drive operation. Fig. 21 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 13 are not exceeded.

Location	Maximum (1)	Maximum Recommended(2)
Disk Enclosure Top	65C (149F)	50C (122F)
Disk Enclosure Bottom	65C (149F)	50C (122F)
Channel Module **(3)**	95C (203F)	75C (167F)
Microprocessor Module	80C (176F)	60C (140F)
DSP Module	95C (203F)	75C (167F)
Spindle Motor Driver Module	90C (194F)	70C (158F)
SSA Controller Module	95C (203F)	75C (167F)

(1) Operating the drive above the Maximum temperatures may cause permanent damage.
(2) Maximum Recommended temperatures are for nominal ambient temperature.
(3) For continuous read applications the channel module will run at higher temperatures and will require additional cooling.

Table 13. Maximum and Maximum Recommended Case Temperature Limits

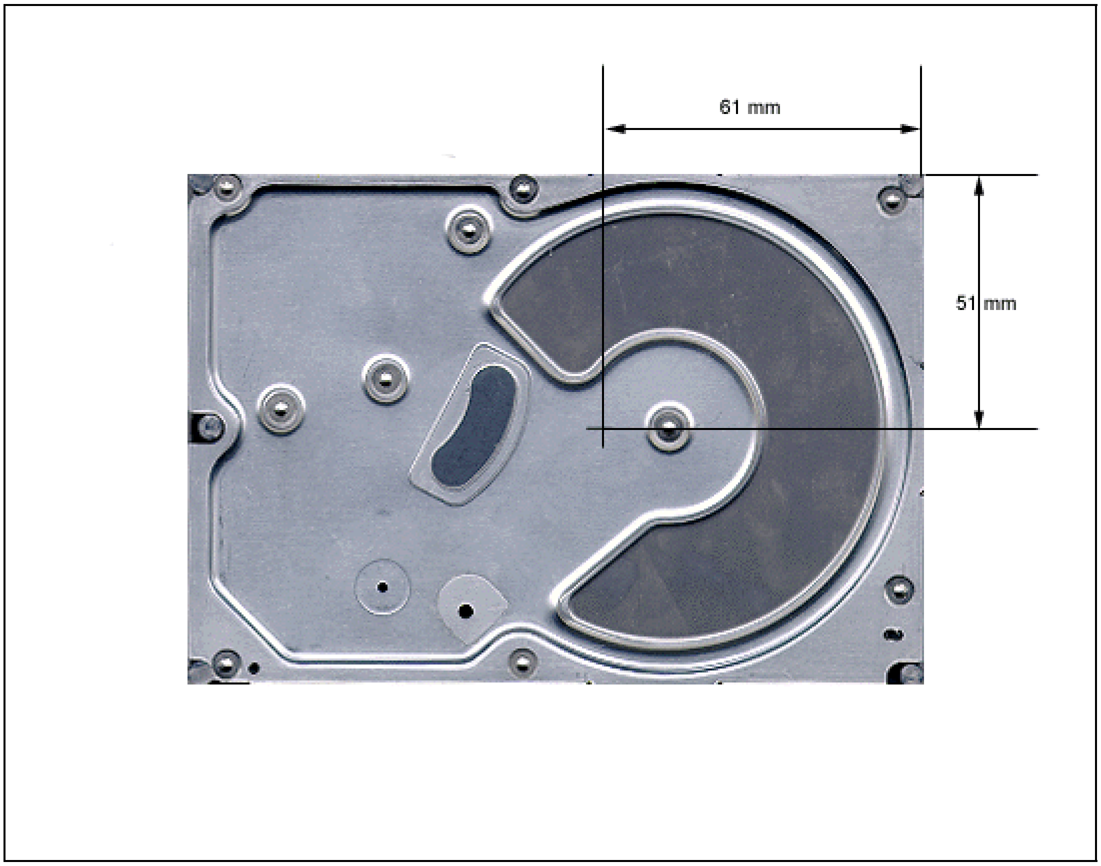

Fig. 20. Temperature Measurement Points (top view)

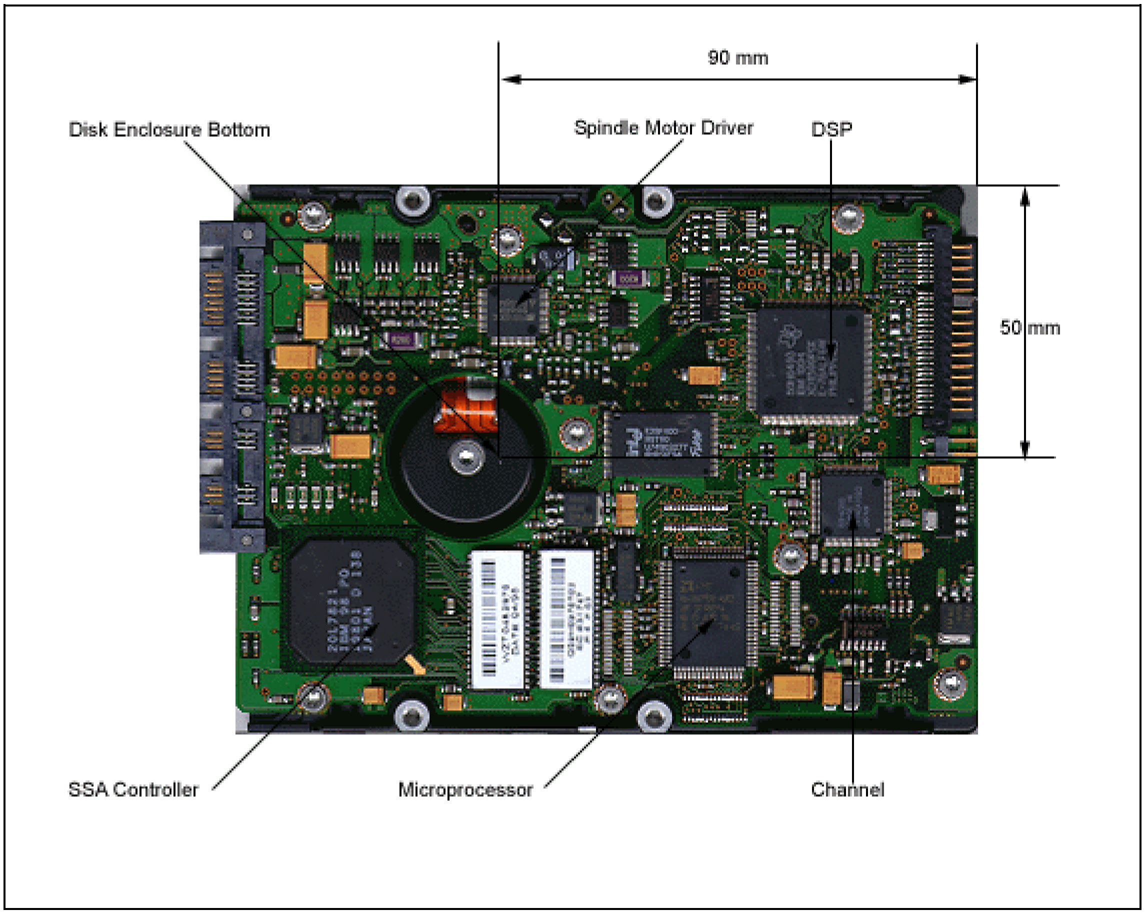

Fig. 21. Temperature Measurement Points (bottom view)

Module Temperature 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 Shock and Vibration

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

1. By mounting with the 6-32 bottom holes with the drive on 2 mm high by 10 mm diameter spacers as required by section 4.2 , "Clearances"
2. By mounting on any two opposing pairs of the 6-32 side mount holes.

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

7.2.1 Output Vibration Limits

Spindle residual imbalance will not exceed 0.5 gram-millimeters for either 1.0 inch or 1.6 inch models.

7.2.2 Operating Vibration

The operating vibration limits are defined with the vibration applied in each of the three mutually perpendicular axes, one axes at a time. Referring to Figure 1, 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: All drives are sensitive to rotary vibration. Mounting within using systems should minimize the rotational input to the drive mounting points due to external vibration. IBM will provide technical support to assist users to overcome problems due to vibration.

7.2.1.1 Random Vibration

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

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

Note: The RMS value in the table below is obtained by taking the square root of the area defined by the g2/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

Table 14. Random Vibration Levels

7.2.1.2 Swept-Sine Vibration

The drive will operate without hard errors when subjected to the swept sine vibration of 1.0 G peak from 5 to 300 hz in the x, y, and z directions.

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

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

7.2.1 Non-Operating Vibration

No physical damage or degraded throughput will occur as long as vibration at the unpackaged drive in all three directions defined above does not exceed the levels defined in the table below. This measurement is performed by sweeping from 5hz to 300 hz and back to 5 hz at a sweep rate of eight decades per hour.

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

Table 15. Non-operating vibration limits

7.2.2 Operating Shock

No permanent damage will occur to the drive when subjected to a 10 G half sine wave shock pulse of 2 mS duration.
The shock pulses are applied in each of three mutually perpendicular axes, one axis at a time.

7.2.3 Non-Operating Shock

7.2.3.1 Translational

For both the 1.0" and the 1.6" models, no hard errors will occur if the unpackaged drive is subjected to a 20 mS square pulse shock of 35 Gs or less applied to all three axes, one direction at a time.

For the 1.0" models, no hard errors will occur if the unpackaged drive is subjected to a 2-mS half-sine pulse shock of 150 Gs or less applied to all three axes, one direction at a time.

For the 1.6" models, no hard errors will occur if the unpackaged drive is subjected to a 2mS half-sine pulse shock of 140 Gs or less applied to all three axes, one direction at a time.

7.2.3.2 Rotational

The actuator will remain latched in the disk landing zone if the unpackaged drive is subjected to a 2 milliseconds half-sine pulse shock of 15,000 radians per second squared or less applied to all three axes, 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 1.0 inch Models									
	Octave Band Center Frequency (Hz)								A-weighted
	125	250	500	1K	2K	4K	8K	16K	Bel
Idle	4.4	3.2	3.2	3.4	4.0	4.1	3.8	3.8	4.4
Operating	4.4	3.2	3.2	3.9	4.2	5.2	4.5	4.2	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 1.6 inch Models									
	Octave Band Center Frequency (Hz)								A-weighted
	125	250	500	1K	2K	4K	8K	16K	Bel
Idle	4.5	2.6	3.2	3.5	4.4	4.5	4.8	3.9	5.0
Operating	4.5	3.3	3.3	4.1	5.1	5.3	4.8	4.0	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 of 32 seeks per second.
4. The values for a sample size of 5 or greater will be less than or equal to the stated upper limits with 90% confidence.

7.4.1 Acoustic Degradation Resulting from Nonoperating Shock

For the 1.0" models, no degradation in A-weighted idle sound power will occur if the unpackaged drive is limited to a 2 mS half sine pulse shock of 150 Gs or less applied in the axial direction (z axis), or 300 Gs or less applied in radial direction (x-y plane).

For the 1.6" models, no degradation in A-weighted idle sound power will occur if the unpackaged drive is limited to a 2 mS half sine pulse shock of 70 Gs or less applied in the axial direction (z axis), or 150 Gs or less applied in the radial direction (x-y plane). The average A-weighted idle sound power will increase by 0.3 Bels if the unpackaged drive is subjected to a 2-mS sine pulse shock of 110 Gs applied in the axial direction (z axis), or 210 Gs applied in the radial direction (x-y plane).

7.5 Drive Mounting Guidelines

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 (multiples of 120 Hz).
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 18XP/9LP SSA 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 2.6 , "Power Requirements" In addition to voltage, current and capacitance, the system must be capable of remaining within regulation when the maximum number of drives are installed in the system.
  Special consideration must be given to hot plugging. Refer to 2.6.7 , "'Hot Plug/Unplug' support"of this specification for requirements and guidelines.

- Thermal

  The system must supply adequate cooling and air flow to maintain the maximum casting and module temperatures listed in Table 13, "Maximum and Maximum Recommended Case Temperature Limits". Operating Limits must be in accordance with the tmperature measurement points shown in Fig. 24 and Fig. 25. 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" and 7.2.5 , "Non-Operating Shock". 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". This must include random vibration (measured in all three planes) and swept sine vibration.

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

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

- Electromagnetic Compatibility (EMC)

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

- Electrostatic Discharge (ESD)

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

- 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".

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".

7.7 Recommendations for Handling 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 Opening

Under no circumstances should the Filter Breather Opening be obstructed.

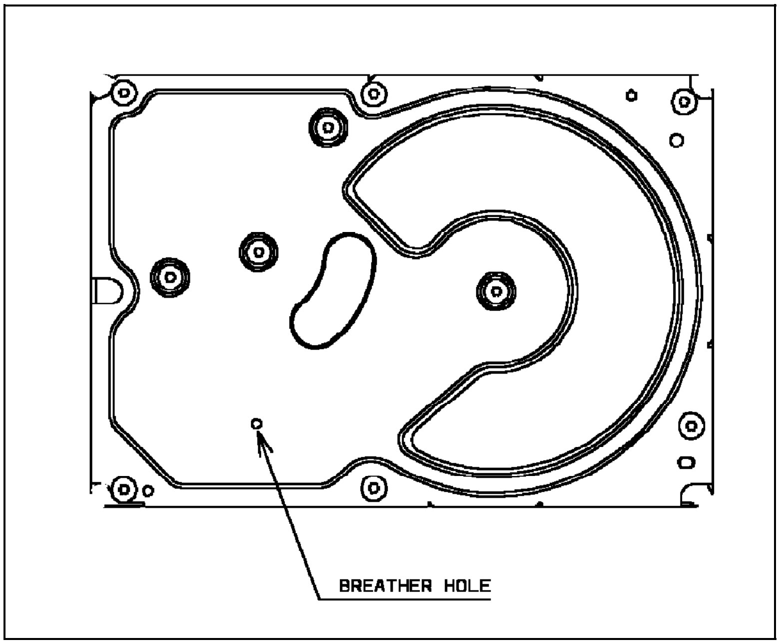

Fig. 22. Breather Filter Opening

7.9 Periodic Maintenance

No periodic maintenance is required.

7.10 ESD Protection

The ***SSA-ULTRASTAR 18XP/9LP*** 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. Stray field magnetic susceptibility is as follows. Field strength must be equal to or below the values shown in the following table where the drive is mounted.

Frequency	DC (Static Field)	47 Hz to 400 Hz	400 Hz to 5 kHz	5 kHz to 50 kHz	50 kHz to 200 kHz

Magnitude (Gauss)	5	5	2	0.5	0.1

Table 16. Stray Magnetic Field Strength

8 Standards

8.1 Safety

- UNDERWRITERS LABORATORY (UL) APPROVAL:

The product is approved as a Recognized Component for use in Information Technology Equipment according to UL 1950 Standard, third edition (without any D3 deviations). The UL Recognized Component marking is located on the product (UL E133560 Vol 19 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).

- 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 drive of 10 amps or less should provide sufficient protection.

8.2 Electromagnetic Compatibility

- FCC Requirements

IBM will provide technical support to assist users of the ***SSA-ULTRASTAR 18XP/9LP*** disk drive in complying with the **United States Federal Communications Commission (FCC) Rules and Regulations, Part15, Subpart B Digital Devices "Class A Limits"**. Tests for conformance to this requirement are performed with the disk drive mounted in the using system.

- CISPR 22 Requirements

IBM will provide technical support to assist users of the ***SSA-ULTRASTAR 18XP/9LP*** disk drive in complying with the **Comite International Special des Perturbations Radio Electriques (International Special Committee on Radio Interference) CISPR 22 "Class A Limits"** .

- European Declaration of Conformity.

IBM will provide technical support to assist users of the ***SSA-ULTRASTAR 18XP/9LP*** disk drive in complying with the **European Council Directive 89/336/EEC** so the final product can thereby bear the "CE" Mark of Conformity.