0662 Hardware Specification Version 3.0

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Preface

This document details the Hardware Specifications for the models using SCSI interface of the ***0662*** product, a 1 GByte, 3.5-inch form factor, 1-inch high direct access storage device.

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1. Description

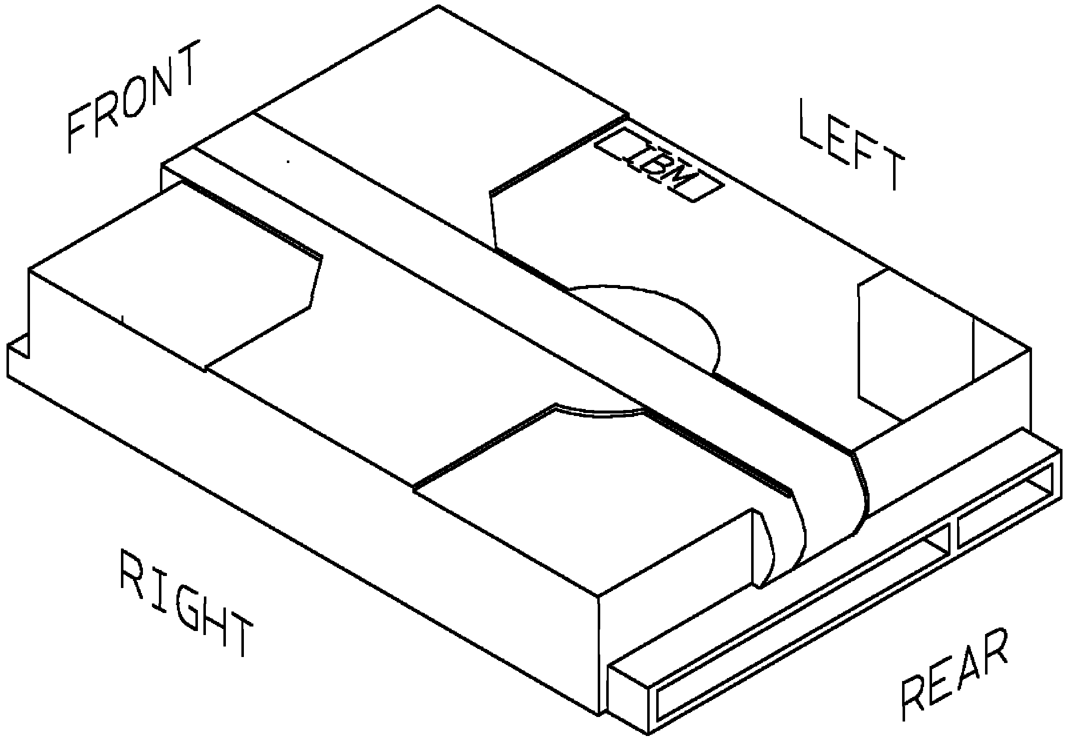


Figure 1. ***0662*** Drive Assembly Orientation

1.1 Features

General Features

- 1.05 gigabytes formatted capacity (512 bytes/sector)
- Industry-standard interface: ANSI SCSI-2 (*optional 68 pin from SCSI-3*)
- Rotary voice coil motor actuator
- Closed-loop digital actuator servo (dedicated disk servo surface plus data reference)
- Magnetoresistive (MR) heads
- (0,4/4) 8/9 rate encoding
- Partial Response Maximum Likelihood (PRML) data channel with digital filter
- All mounting orientations supported
- Jumperable auto spindle motor start
- Jumperable drive supplied terminator power
- Jumperable write protection
- Spindle synchronization
- LED Driver
- May be ordered with or without a bezel

Performance Summary

- Average read seek: 8.5 milliseconds
- Latency: 5.56 milliseconds
- Media data transfer rate: 6 and 5 MegaBytes/second (banded)
- SCSI data transfer rate: up to 20 MegaBytes/second (synchronous)
- SCSI Bus Overhead: < 40 microseconds

Interface Controller Features

- SCSI bus parity
- SCSI disconnect and reconnect capability
- Multiple initiator support
- Fast SCSI supported
- Wide SCSI models
- Variable logical block lengths (*180 - 5952 supported*)
- 512K byte, multi-segmented, dual port data buffer
- Read-ahead caching
- Write Cache supported (delayed write)
- Adaptive caching algorithm
- Tagged and untagged command queuing
- Command reordering
- Back-to-back writes (merged writes)
- Automatic retry and data correction on read errors
- Automatic sector reallocation
- In-line alternate sector assignment for high-performance
- Automatic power management
- Down-loadable SCSI firmware
- SCSI behavior customizing jumpers

  For example -
  - Disable Target Initiated Synchronous Negotiation
  - Disable Unit Attentions
  - Disable SCSI Parity
  - Auto Start Delay
  - etc.

Reliability Features

- Self-diagnostics on power up
- Dedicated head landing zone
- Automatic actuator latch
- Thermal compensation on each data surface for improving on-track positioning capability
- Buffer memory parity
- Longitudinal Redundancy Code (LRC)
- ECC on the fly
- Error logging and analysis
- Deep Data Recovery Procedures (DRP)
- Predictive Failure Analysis ® (PFA) ®
- No preventative maintenance required
- Two Field Replaceable Units (FRU's): electronics and HDA
- Probability of not recovering data: **10 in 10^{15}** bits read

1.2 Models

| The ***0662*** disk drive is available in several different models:

Model #	# of SCSI Connector Pins	SCSI Electrical Signal Type	# of data heads
S12	50	SE	5
SW1	68	SE	5
SWD	68	DF	5
Note: "SE" stands for Single Ended, while "DF" stands for Differential.			

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

The 68 pin SCSI connector models offer an 8/16 bit SCSI bus using the SCSI 'P' connector.

2. Specifications

| All specifications are nominal values unless otherwise noted, and are valid for drives with 1.x microcode
| Revision Levels 1.5 and beyond, and for drives with 2.x microcode Revision Levels 2.3 and beyond.

2.1 General

Note: The recording band located towards the outer diameter (OD) is referred to as 'Notch #1'. While the recording band located towards the inner diameter (ID) is called 'Notch #2'.

Data transfer rates

	Notch #1	Notch #2	
Buffer to/from media	6	5	MegaBytes/second (instantaneous)

Host to/from buffer up to 20.0 MegaBytes/second (synchronous)

| **Data Buffer Size (bytes)** 512 K (See 3, “Performance” on page 25 for user data capacity.)

Rotational speed (RPM) 5400
Average latency (milliseconds) 5.56

	Notch #1	Notch #2
Recording density (BPI)	78,202	86,880
Bit Rate Clock (brc) (MHz)	54	45

	Notch #1	Notch #2
Track density (TPI)	4077	4077

	Notch #1	Notch #2
Areal density (Megabits/square inch)	318.8	354.2

	Notch #1	Notch #2
Data band (mm)	17.95	6.89

Disks 3

Seek time

- **Single cylinder** 0.6 milliseconds (Read)
  2.5 milliseconds (Write)
- **Average (weighted)** 8.5 milliseconds (Read)
  10.0 milliseconds (Write)
  8.8 milliseconds (composite: 4 reads to 1 write)
- **Full stroke** 16.5 milliseconds (Read)
  18.0 milliseconds (Write)

Note: Times are typical for a file population under nominal voltages and casting temperature of 25 C. Weighted seeks are seeks to the cylinders of random logical block addresses.

	Notch #1	Notch #2
Total cylinders (total cyl)	3016	1120
User cylinders (user cyl)	3002	1117
Band 1 user cylinders (b1ucyl)	1998	747
Band 2 user cylinders (b2ucyl)	1004	370

Tracks/cylinder (trk/cyl)
Models S12,SW1,SWD 5

	Notch #1	Notch #2
Gross bytes/track (gb/trk)	66667	55556
Overhead bytes/sector (ob/sct)	104.4	101.5

User bytes/sector (ub/sct) 180 - 744 (even number of bytes only)

User bytes/logical block (ub/lba) 180 - 5952 (See rules for determining sct/lba below for determining supported ub/lba values.)

Sectors/logical block (sct/lba) 1-8

The lowest sct/lba that satisfies the following rules is used...

1. Block Length is evenly divisible by sct/lba (1-8).
2. Quotient of previous equation is evenly divisible by 2.
3. Quotient must be $\geq$ 180 and $\leq$ 744.

	Notch #1	Notch #2
Band 1 spares/cylinder (b1spr/cyl) **Models S12,SW1,SWD**	15	15
Band 2 spares/cylinder (b2spr/cyl) **Models S12,SW1,SWD**	20	20

Last cylinder extra spare sectors (lcspr)
Models S12,SW1,SWD 40

			Models S12,SW1,SWD	
bytes/ logical block	gross sectors/ track		formatted capacity (bytes)	logical blocks/ file
	Notch #1	Notch #2		
180	234	197	817,900,200	4,543,890
256	184	155	911,057,920	3,558,820
512	108	90	1,052,177,920	2,055,035
520	106	89	1,050,103,600	2,019,430
524	105	88	1,047,389,540	1,998,835
744	78	65	1,090,041,840	1,465,110

Table 1. User file capacity for several block sizes

2.1.1 Capacity Equations

2.1.1.1 For Each Notch

The next 7 equations should be calculated separately for each notch.

$$\text{user bytes/sector (ub/sct)} = \frac{\text{ub/lba}}{\text{sct/lba}}$$

gross bytes/sector (gb/sct) = ub/sct + ob/sct

$$\text{sectors/track (sct/trk)} = \text{INT}\left[\frac{111{,}055}{\text{INT}\left[\frac{(90)(\text{gb/sct}) + \text{brc} - 1}{\text{brc}}\right]}\right]$$

band 1 user sectors/cyl (b1us/cyl) = (sct/trk)(trk/cyl) - b1spr/cyl

band 2 user sectors/cyl (b2us/cyl) = (sct/trk)(trk/cyl) - b2spr/cyl

spares/notch (spr/nch) = (b1spr/cyl)(b1cyl) + (b2spr/cyl)(b2cyl)

Note: Add lcspr to the equation above for the notch closest to the inner diameter (#2).

user sectors/notch (us/nch) = (b1us/cyl)(b1ucyl) + (b2us/cyl)(b2ucyl)

Note: Subtract lcspr from the equation above for the notch closest to the inner diameter (#2).

2.1.1.2 For Entire Drive

spares/file (spr/file) = (spr/nch){Notch #1} + (spr/nch){Notch #2}

user sectors/file (us/file) = (us/nch){Notch #1} + (us/nch){Notch #2}

$$\text{logical blocks/file (lba/file)} = \text{INT}\left[\frac{\text{us/file}}{\text{sct/lba}}\right]$$

user capacity (fcap) = (lba/file)(ub/lba)

2.2 Power Requirements

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

2.2.1 12V SCSI and 5V Single Ended SCSI Power Requirements

Input Voltage

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

The following current values were measured on production level drives. Safety factors have not been applied.

Power Supply Current	Notes	Population Mean	Population Stand. Dev.
+5VDC (power-up)	Minimum voltage slew rate = 4.5 V/sec		
+5VDC (idle avg)		0.675 Amps[1]	.0080 Amps
+5VDC (R/W baseline)	Typical	0.988 Amps[2]	.0092 Amps
+5VDC (R/W pulse)	Base-to-peak	0.490 Amps[3]	.0215 Amps
+12VDC (power-up)	Minimum voltage slew rate = 7.4 V/sec		
+12VDC (idle avg)		.324 Amps	.0087 Amps
+12VDC (seek avg)	1 op/sec	.00517 Amps	.00017 Amps
+12VDC (seek peak)		1.600 Amps[4]	.0297 Amps
+12VDC (spin-up)	1.5 sec max	1.579 Amps[5]	.105 Amps

File power

Ave idle power		7.26 Watts	.14 Watts
Ave R/W power	30 ops/sec	10.69 Watts	.15 Watts

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

2 The baseline R/W current is the R/W current, with the pulses ignored, that the file requires for reading and writing. The average file R/W current may be above this value depending on the R/W operation.

3 The maximum R/W current is equal to the sum of the R/W baseline current and the R/W pulse current.

4 The idle average and seek peek should be added together to determine the total 12 volt peak current. See Figure 2 on page 21 for a typical buildup of these currents. Refer to examples on the following page to see how to combine these values.

5 The current at start is the total 12 volt current required (ie. the motor start current, module current and voice coil retract current). See Figure 3 on page 22 for the typical 12 volt current required during spindle motor start.

2.2.2 5V Differential SCSI Power Requirements

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

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

The following current values were measured on production level drives. Safety factors have not been applied.

Power Supply Current	Notes	Population Mean	Population Stand. Dev.
+5VDC (power-up)	Minimum voltage slew rate = 4.5 V/sec		
+5VDC (idle avg)		0.730 Amps[6]	.0034 Amps
+5VDC (R/W baseline)	Typical	1.040 Amps[7]	.0115 Amps
+5VDC (R/W pulse)	Base-to-peak	1.262 Amps[8]	.1018 Amps

As a reminder, when determining the current necessary to supply the differential cards, only one file per SCSI bus may be selected therefore only one file per SCSI bus may be sinking the maximum 5V current.

2.2.3 Power Calculation Examples

Example 1. Calculate the mean 12 volt average current.

If we assume a case of 30 operations/second then to compute the sum of the 12 volt mean currents the following is done.

	mean	
+12VDC (idle ave)	.324	amps
+12VDC (seek average) .00517 * 30 =	.155	amps
TOTAL	.479	amps

Example 2. Calculate the mean plus 3 sigma 12 volt average current.

To compute the sum of the 12 volt mean current's 1 sigma value assume all the distributions are normal. Therefore the square root of the sum of the squares calculation applies. Assume a case of 30 operations/second.

[6] 5 Volt Current is given with termination power provided by the using system.

[7] The baseline R/W current is the R/W current, with the pulses ignored, that the file requires for reading and writing. The average file R/W current may be above this value depending on the R/W operation.

[8] The maximum R/W current is equal to the sum of the R/W baseline current and the R/W pulse current.

		sigma
+12VDC (idle ave)		.0087 amps
+12VDC (seek average)	sqrt(30*((.00017)**2))=	.001 amps
TOTAL	sqrt((.0087)**2+(.001)**2))=	.0087 amps

So the mean plus 3 sigma mean current is .479 + 3*.0087 = .505 amps

Example 3. Power Calculation.

Nominal idle file power = (.675 Amps * 5 Volts) + (.324 Amps * 12 Volts) = 7.26 Watts

Nominal R/W file power for 30 random seek operations/second (1 block/second) = (0.988 Amps * 5 Volts) + (.479 Amps * 12 Volts) = 10.69 Watts

Mean plus 3 sigma file power for 30 random operations/second. Assume that the 5 volt and 12 volt distributions are independent therefore the square root of the sum of the squares applies.

+5VDC (1 sigma power)	.0092 * 5	= .046 watts
+12VDC (1 sigma power)	.0087 * 12	= .104 watts
Total (1 sigma power)	sqrt((.046)**2+(.104)**2)	= .114 watts
Total power	10.69 + 3 * .114	= 11.03 watts

Example 4. Calculate the 12 volt peak current.

To compute the sum of the 12 volt peak currents the following is done.

	mean	
+12VDC (idle ave)	.324	amps
| +12VDC (seek peak)	1.600	amps
| TOTAL	1.924	amps

Example 5. Calculate the mean plus 3 sigma 12 volt peak current.

To compute the sum of the 12 volt peak current's 1 sigma value assume all distributions are normal. Therefore the square root of the sum of the squares calculation applies.

	sigma	
+12VDC (idle ave)	.0087	amps
+12VDC (seek peak)	.0297	amps

TOTAL sqrt((.0087)**2+(.0297)**2)=.0309 amps

| So the mean plus 3 sigma peak current is 1.924 + 3*.0309 = 2.017 amps

The above formulas assume all system ops as a 1 block read or write transfer from a random LBA while at nominal voltage conditions.

Things to check when measuring 12 V supply current:

- Null the current probe frequently. Be sure to let it warm up.
- Adjust the power supply to 12.00 V *at the file terminals.*
- Use a proper window width, covering an integral number of spindle revolutions.
- Measure values at 25 degree C casting temperature.
- Get a reliable trigger for Seek Peak readings.

Externally Generated Ripple[9]
as seen at file power connector

	Maximum	Notes
+5VDC	150 mV peak-to-peak	0-20 MHz
+12VDC	150 mV peak-to-peak	0-20 MHz

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

| The file's mounting holes are electrically isolated from the file's disk enclosure. The disk enclosure is not at ground potential; therefore, any user mounting scheme must not result in the disk enclosure being shorted to ground at Direct Current, (DC).

| Since the disk enclosure is and can be electrically coupled to the user frame at frequencies above DC, the user frame must be within +/- 150 millivolts of the power supply ground. At no time should more than 35 milliamperes of current be injected into the file user frame. The frequency range which has been tested is from 0 to 100 MHz.

Hot plug/unplug support.

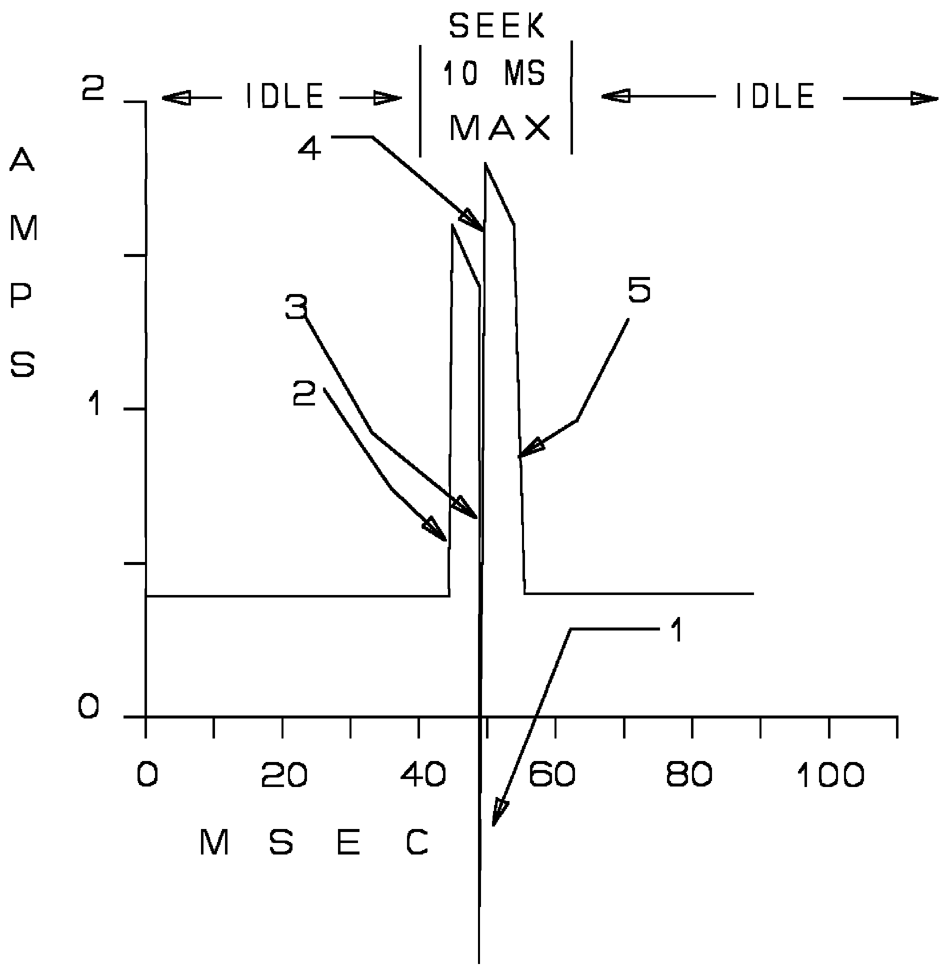
Power supply and SCSI bus hot plug and un-plug is allowed. There is no special sequence required for connecting 5 volt, 12 volt, or ground. During a hot plug-in event the file being plugged will draw a large amount of current at the instant of plug-in. This current spike is due to charging the bypass capacitors on the file. This current pulse may cause the power supply to go out of regulation. If this supply is shared by other files then a low voltage 'power on reset' may be initiated on those files. Therefore the recommendation for hot plugging is to have one supply for each file. 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 SCSI bus may cause glitches on the bus. To minimize the chance of glitching, it is recommended to plug in the SCSI bus before the power is applied.

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 file should be issued a SCSI Stop Unit command which is allowed to complete before un-plugging.

[9] This ripple must not cause the power supply to the file to go outside of the +/-5 % regulation tolerance.



Typical 12 volt current.

Figure 2.

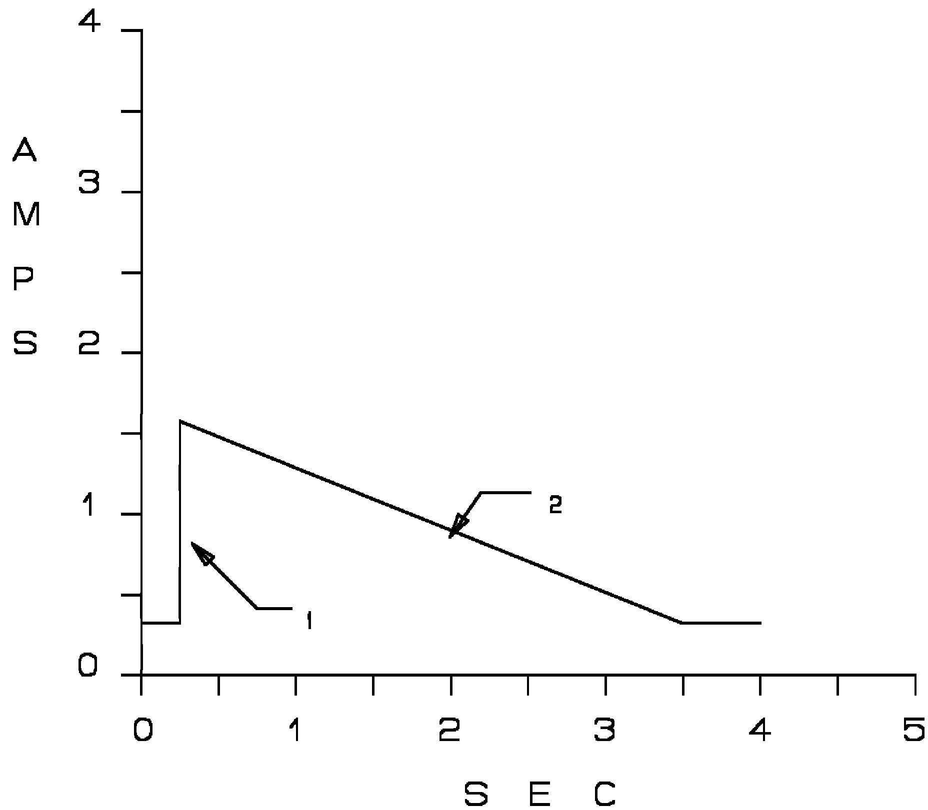
1. Instantaneous minimum current can be negative. The pulse may be as large as -1.1 amps and persist for up to 200 microseconds.

2. Maximum slew rate is 7 amps/millisecond.

3. Maximum slew rate is 100 amps/millisecond.

4. Maximum slew rate is 7 amps/millisecond.

5. Maximum slew rate is 3 amps/millisecond.



Typical 12 volt spin-up current.

Figure 3.

1. Maximum slew rate is 20 amps/millisecond.

2. Current drops off as motor comes up to speed.

If the spindle motor has difficulty starting, the start current will be pulsed (turned on and off several times). Two pulsing events will be attempted before a motor start failure will be reported.

2.2.4 Bring-up Sequence (and stop times)

	Nominal	Maximum	Notes
Power-up	2.0 sec	2.4 sec	*see Figure 4
Start-up	15 sec	1 min.	*see Figure 4
Spin-up	6.7 sec	15 sec	*see Figure 4
Stop Time	9.0 sec	12.5 sec	

Bring-up Sequence Times and Stop Time

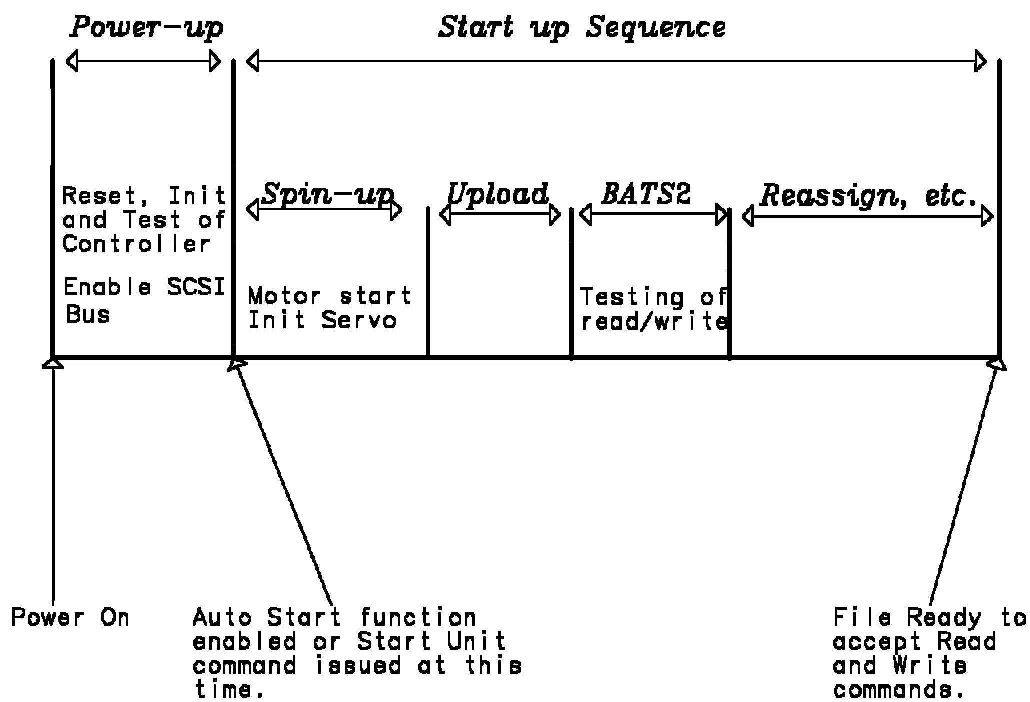


Figure 4. Start Time Diagram

Note: BATS is the abbreviation for Basic Assurance Tests. Start-up sequence spins up the spindle motor, uploads code, performs BATS2 (verifies read/write hardware), resumes "Reassign in Progress" operations, and more. For more information on the startup sequence, refer to the **0662 Interface Specification**.

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

Note: Reference 3.9.1.1.3, "Start/Stop Unit Time" on page 41 for additional details.

Note: See 5.4, "Spindle Synchronization" on page 63 for details about Start-up time increases when the device is requested via Mode Parameters to synchronize the spindle motor to another device.

3. Performance

3.1 Environment Definition

Drive performance criteria is based on the following operating environments. Average device performance is dependent on these environments. Deviations from these environments may cause deviations from this specification.

Items common to both specified environments are -

- Operations are either all Reads or all Writes. The specifications for Total Command Execution with Read Ahead describe exceptions to this restriction. For that scenario all commands are preceded by a Read command, except for sequential write commands.
- Data transfer size is set to 64 Blocks at 512 bytes per block.
- The number of data buffer segments is 8. The total data buffer length is 512k bytes. Each segment is of equal length. Therefore each data buffer segment is 64k bytes.

  | The number of blocks of customer data that can fit into one segment is reduced because 2 bytes of LRC information is also stored in the segment for each block of customer data stored in the segment. Therefore, use the following equation to determine how many blocks can fit into one segment.

$$\frac{\left(\frac{512KB}{\textbf{\# of segments}}\right)}{\textbf{ub/lba} + 2}$$

- 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.
- Ten byte SCSI Read and Write commands are used.
- SCSI environment consists of a single initiator and single target with no SCSI Bus contention.
- Buffer full/empty ratios are set to their optimum values such that a minimum number of intermediate disconnects occur during the SCSI data transfer and the overlap of the SCSI and Disk data transfer is maximized. This minimizes Total Command Execution times with no bus contention.
- Read Ahead Cache function is disabled. The specifications for Total Command Execution with Read Ahead describe exceptions to this restriction.
- Initiator delay while transferring SCSI command, status, message, and data bytes is assumed to be zero.
- The media is formatted with the skew definition that optimizes the disk data transfer rate for un-synchronized spindle operation.
- Tagged Command Queuing is not used, unless otherwise specified.
- All Current Mode Parameters are set to their Default values except where noted.
- SCSI data transfers are successfully negotiated to be 20 MB/sec.
- Averages are based on a sample size of 10,000 operations.

3.1.1 Sequential Environment

- No Seeks. The target LBA for all operations is the previous LBA + 64.

3.1.2 Random Environment

- All operations are to random LBAs. The average seek is an average weighted seek.

3.2 Command Execution Time

<table>
<tr><th></th><th colspan="5">Basic components of Total Command Execution</th><th colspan="3">Total Command Execution (See note 5)</th><th colspan="2">misc. values</th></tr>
<tr><th>Environment</th><th>Seek (See note 6)</th><th>Latency</th><th>Command Execution Overhead</th><th>Data Transfer to/from Disk (See notes 4 & 5)</th><th>Data Transfer to/from SCSI Bus</th><th>Normal</th><th>With Read Ahead and op delays of 50-150 msec</th><th>With Read Ahead and op delays of 0-10 msec</th><th>Post Command Processing</th><th>SCSI Bus Overhead (See Note 3)</th></tr>
<tr><td rowspan="2">Sequential Read cmds.</td><td rowspan="2">0.0</td><td rowspan="2">5.56</td><td rowspan="2">0.85</td><td>7.27</td><td rowspan="2">0.13</td><td>13.81</td><td>2.19</td><td rowspan="2">See Note 1</td><td rowspan="2">0.33</td><td rowspan="2">0.03</td></tr>
<tr><td>8.75</td><td>15.29</td><td>2.19</td></tr>
<tr><td rowspan="2">Sequential Write cmds.</td><td rowspan="2">0.0</td><td rowspan="2">5.56</td><td rowspan="2">0.88</td><td>7.27</td><td rowspan="2">0.08</td><td>13.79</td><td rowspan="2">See Note 2</td><td rowspan="2">See Note 2</td><td rowspan="2">0.33</td><td rowspan="2">0.04</td></tr>
<tr><td>8.75</td><td>15.27</td></tr>
<tr><td>Random Read cmds.</td><td>8.5</td><td>5.56</td><td>0.28</td><td>7.57</td><td>0.13</td><td>22.04</td><td>22.34</td><td>22.34</td><td>0.33</td><td>0.03</td></tr>
<tr><td>Random Write cmds.</td><td>10.0</td><td>5.56</td><td>0.38</td><td>7.57</td><td>0.00</td><td>23.51</td><td>23.81</td><td>23.81</td><td>0.33</td><td>0.04</td></tr>
<tr><td colspan="11">Note: 1) The Total Command Execution times of sequential reads with inter-op delays of 0-10 msec and Read Ahead enabled are 1 revolution less than similar operations with equal inter-op delays and Read Ahead disabled. They also have less Command Execution Overhead thus decreasing Total Command Execution time.</td></tr>
<tr><td colspan="11">Note: 2) Read Ahead does not affect Total Command Execution times of sequential writes with equivalent inter-op delays.</td></tr>
<tr><td colspan="11">Note: 3) The Disable Read Disconnect (DRD) and Disable Write Disconnect (DWD) Mode Parameters are off for values in this column. When they are on, SCSI Bus Overhead increases but Total Command Execution time may decrease.</td></tr>
<tr><td colspan="11">Note: 4) Times are calculated with Typical Data Sector Transfer Rates for models with 5 data heads.</td></tr>
<tr><td colspan="11">Note: 5) Times for random commands are averages over entire drive. For sequential commands the times are averages over a particular a Notch. The upper box is for Notch #1 and the lower box is for Notch #2.</td></tr>
<tr><td colspan="11">Note: 6) Seek time values are population averages, and vary as a function of operating conditions.</td></tr>
</table>

Table 2. Drive Specifications. All items listed are in msec.

Only the SCSI Bus Overhead and Total Command Execution times listed in Table 2 should be measured to ensure that they are within specification. All other times listed in this chapter are typical values provided for information only so that the performance for other environments can be approximated.

3.2.1 SCSI Data Transfer Rate

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

When the drive is configured for an 8 bit wide synchronous data transfer rate of 10.0 MB/sec (instantaneous), the average SCSI data transfer rate that is realized is at least 9.2 MB/sec. The 16 bit transfer rates are 20 MB/sec and 18.4 MB/sec respectively.

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

The SCSI data transfer rate specification only applies to the Data phase for logical block data for Read, Write, Write and Verify, etc... commands. The data rate for parameter/sense data for Request Sense, Mode Select, etc... commands is not specified.

3.2.2 Parameter Descriptions

Note: Reference Table 2 on page 26.

Seek

The average time from the initiation of the seek, to the acknowledgement that the seek has completed.

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.

Command Execution Overhead

The average time added to the operation response time due to the processing of the SCSI command.

(See 3.5, "Read Command Performance" on page 33 and 3.6, "Write Command Performance" on page 36 for a more detailed description of the components of Command Execution Overhead.)

The Command Execution Overhead specification is based on a normal operation with the Read Ahead function disabled. When Read Ahead is enabled, overhead for random commands immediately following a read command is increased by approximately .3 msec.

Overhead for sequential read commands immediately following a read command is decreased by approximately .44 msec.

Data Transfer to/from Disk

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

(Data Transferred)/(Media Transfer Rate).

There are four interpretations of Media Transfer Rate. How it is to be used helps decide which interpretation is appropriate to use.

1. Instantaneous Data Transfer Rate

   The same for the ID and OD bands of a given Notch formatted at any of the supported logical block lengths. It varies by Notch only and does not include any overhead. (See 2, "Specifications" on page 13 for values.)

2. Data Sector Transfer Rate

The same for the ID and OD bands of each Notch, but 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)

(See page 35 to calculate individual sector time.)

Note: These rates are used to help estimate optimum SCSI Buffer Full/Empty Ratios.

3. Theoretical Data Sector Transfer Rate

   Also includes time required for track and cylinder skew and overhead associated with each track. It also varies from band to band. (See 3.5.1.1, "Theoretical Data Sector Transfer Rate" on page 34 for a description on how to calculate it.) (Rates for drives formatted at 512 bytes/block are located in Table 3.)

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 **0662 Interface Specification** for a description of error recovery procedures.) (Rates for drives formatted at 512 bytes/block are located in Table 3.)

Model Number	Notch Number	Theoretical	Typical
S12,SW1,SWD	#1	4.556	4.507
	#2	3.778	3.744

Table 3. Data Sector Transfer Rates. (All rates are in MB/sec)

Note: The values for Typical Data Sector Transfer Rates in the above table assume a typically worst case value of 1 error in 10^8 bits read at nominal conditions for soft error rate.

Data Transfer to/from SCSI Bus

The time required to transfer data between the SCSI bus and the drive's internal data buffer, that is not overlapped with the time for the Seek, Latency, Command Execution Overhead, or Data Transfer to/from Disk. This time is based on a SCSI synchronous data transfer rate of 20.0 MB/sec.

Total Command Execution

The operation's response time, from initial selection to bus free following the Command Complete message. This time includes the time for the Seek, Latency, Command Execution Overhead, Data Transfer to/from Disk, and Data Transfer to/from SCSI Bus which are described above.

Normal

The Total Command Execution time when Read Ahead is not used.

With Read Ahead and op delays of 50-150 msec

The Total Command Execution time when the Read Ahead Cache function is enabled and the inter-op delay is a random value between 50 and 150 msec. 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. This parameter allows a comparison of identical command sequences with the Read Ahead Cache function enabled and disabled.

Note: This inter-op delay is such that the Read Ahead function has filled the drive's internal data buffer segment before the next Read or Write command is received.

Note: This value takes into account any change in Command Execution Overhead.

With Read Ahead and op delays of 0-10 msec

The Total Command Execution time when the Read Ahead Cache function is enabled and the inter-op delay is a random value between 0 and 10 msec. 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. This parameter allows a comparison of identical command sequences with the Read Ahead Cache function enabled and disabled.

Note: This inter-op delay is such that the Read Ahead function is still in the process of filling the drive's internal data buffer segment when the next Read or Write command is received.

Note: This value takes into account any change in Command Execution Overhead.

Post Command Processing

The average time required for process cleanup after the command has completed. This time indicates the minimum re-instruct time which the device supports. If a re-instruct rate, faster then this time is used, the difference is added to the Command Execution Overhead of the next operation.

SCSI Bus Overhead

The average time for transferring all SCSI Command, Status, and Message phase information bytes during the operation. This includes any processing delays between SCSI Bus phases while remaining connected to the SCSI Bus. Initiator delays while transferring information bytes are assumed to be zero. This time does not include the SCSI Data phase transfer. (See 3.5, “Read Command Performance” on page 33 and 3.6, “Write Command Performance” on page 36 for a more detailed description of the components of SCSI Bus Overhead.)

3.2.3 Comments

Overlap has been removed from the specification calculations. The components of the Total Command Execution times listed in Table 2 on page 26 are truly additive times to the entire operation. For example,

- The SCSI Bus Overhead data is not included in the calculation since some of it's components are also components of Command Execution Overhead and the remaining components overlap the Data Transfer to/from Disk. (See 3.5, “Read Command Performance” on page 33 and 3.6, “Write Command Performance” on page 36 for details.)
- The Post Command Processing times are not components of the Total Command Execution time therefore they are not included in the calculation.

The components of the Total Command Execution time are approximations of the time used by the various portions of the command. These components are provided for information only so that the performance for other environments can be approximated. Only the Total Command Execution time for each environment should be measured to ensure it is within specification.

The effects of idle time functions are not included in the above specifications. Section 3.1.1, “ Sequential Environment” on page 25 and 3.1.2, “ Random Environment” on page 26 both define environments where the effects due to increased command overhead of Idle Time Functions upon Total Command Execution time are less than 0.7 % during the 1st hour after power is applied and .2 % thereafter.

3.3 Disconnection During Read/Write Data Phase

If a nonzero Maximum Burst Size parameter is specified, the drive disconnects after transferring the number of blocks specified by the Maximum Burst Size parameter. This disconnection requires approximately 33 µsec and the subsequent reconnection requires approximately 20 µsec.

The drive also disconnects prior to completion of the Data phase if the drive's internal data buffer segment becomes empty during a Read command or full during a Write command. This disconnection occurs regardless of the Maximum Burst Size parameter. This intermediate disconnect causes a pause of approximately 0.24 msec during the Data phase. This disconnection requires approximately 33 µsec and the subsequent reconnection requires approximately 20 µsec.

3.4 Approximating Performance for Different Environments

3.4.1 For Different Transfer Sizes

The primary performance change due to a change of the Transfer Size, is the Data Transfer to/from Disk parameter. See 3.2.2, "Parameter Descriptions" on page 27, Data Transfer to/from Disk, for an explanation of the calculation of this parameter.

The values for several other parameters may also change if the transfer size is reduced to the point where certain internal control functions can no longer be overlapped with either the SCSI or disk data transfer. The parameters changed vary based on the type of environment (read, write, sequential, and random).

The following section, 3.4.1.1, "0.5KByte Sequential Read," gives an approximation of the performance changes for each of these environments, (read, write, sequential, and random), for a 0.5KByte transfer size.

3.4.1.1 0.5KByte Sequential Read

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

The magnitude of the performance advantage with the Read Ahead function enabled and op delays between 50 and 150 ms is reduced due to the smaller transfer size. The Total Command Execution time is reduced by approximately 5.7 msec.

Note: This time difference can be approximated for other transfer sizes by using the following equation:

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

The magnitude of the performance advantage of the Read Ahead with op delays of 0-10 msec varies with the size of the delay. Since the range of delays is less than the time for one revolution, the operation is "synchronized to the disk". The Read Ahead savings can be roughly approximated by:

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

Note: This time also varies with the size of the data transfer due to the difference between the SCSI data transfer rate and Disk data transfer rate. This time is insignificant for a 0.5KByte transfer size and has been ignored in the above equation.

3.4.1.2 0.5KByte Sequential Write

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

3.4.1.3 0.5KByte Random Read

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

3.4.1.4 0.5KByte Random Write

For this environment, only the Data Transfer to/from Disk changes as described in 3.4.1, “For Different Transfer Sizes” on page 30.

3.4.2 When Read Caching is Enabled

For read commands with Read Caching Enabled Total Command Execution time can be approximated by deleting Seek, Latency and Data Transfer to/from Disk times from those listed in the table if all of the requested data is available in a buffer segment (cache hit). When some, but not all, of the requested data is available in a buffer segment (partial cache hit) Data Transfer to/from Disk will be reduced but not eliminated. Seek and Latency may or may not be reduced depending upon the location of requested data not in the cache and location of the read/write heads at the time the command was received. The contribution of the Data Transfer to/from SCSI Bus to the Command Execution time may increase since a larger, or entire, portion of the transfer may no longer be overlapped with the parameters that were reduced.

3.4.3 When Write Caching is Enabled

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

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

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

Like Tagged Command Queuing, when the WCE bit is set Back-To-Back write commands are supported. See 3.4.4.2, “Back-To-Back Write Commands” on page 32 for more information.

3.4.4 For Queued Commands

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

3.4.4.1 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 Total Command Execution time is minimized. The amount of reduction is a function of the location of the 1st requested block per command and the rate at which the commands are sent to the drive.

3.4.4.2 Back-To-Back Write Commands

If all of the requirements are met as stated in the **0662 Interface Specification** section describing Back-To-Back write commands, contiguous data from 2 or more consecutive write commands can be written to the disk without requiring any disk Latency.

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

3.5 Read Command Performance

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

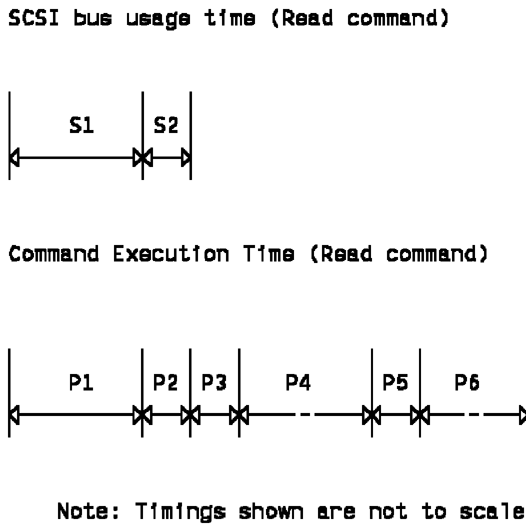


Figure 5. SCSI Read command performance measurements

SCSI bus usage time (Read command)

Note: All times listed in this section are provided for information only so that the performance for other environments can be approximated. These component times should not be measured against the specification.

S1 Selection, Identify Msg., Command Descriptor Block (CDB) 10 µsec
S2a Save Data Pointers (SDP) Msg. 1 µsec
S2b Disconnect Msg., Bus Free 1 µsec
S3 Arbitrate, Reselect, Identify Msg. 6 µsec
S4 Start SCSI transfer in 3 µsec
S5 SCSI bus data transfer in (Transfer size)/(SCSI Data Transfer Rate)
S6 SCSI read ending processing 2 µsec
S7 Status, Command Complete Msg., Bus Free 3 µsec

Note: The SCSI bus overhead for a Read Command is composed of S1,S2(a&b),S3,S4,S6,and S7. (0.03 msec total).

P1 Selection, Identify Msg., CDB	10 µsec
P2a SDP Msg.	1 µsec
P2b Disconnect Msg., Bus Free	1 µsec
P3 Start seek or head switch	258 µsec
P4 Seek or head switch (for example, average seek)	(Read Seek = 8.5 msec)
P5 Set up read disk transfer	0 µsec
P6 Latency (for example, half revolution)	(latency = 5.56 msec)
P7 Disk data transfer	(see Note 1 below)
P8 End read disk transfer	(Sector size)/(SCSI Data Transfer Rate)
P9 Transfer last few SCSI blocks in	(5)(Sector size)/(SCSI Data Transfer Rate)
P10 SCSI read ending processing	2 µsec
P11 Status, Command Complete Msg., Bus Free	3 µsec

Note: The Command execution overhead for a read command is composed of P1,P2(a&b),P3,P5,P10,and P11. (0.28 msec total).

Time to Read data = P1+P2+P3+P4+P5+P6+P7+P8+P9+P10+P11

Note: 1) Use the following formula to calculate P7.

P7 = (Data transferred)/(Data Sector Transfer Rate)

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

3.5.1.1 Theoretical Data Sector Transfer Rate

Theoretical Data Sector Transfer Rate does not account for time required for error recovery or defective sectors. (The Typical Data Sector Transfer Rate described in 3.2.2, “Parameter Descriptions” on page 27 does include those effects.) Each group of cylinders with a different number of gross sectors per track is called a Notch. Within each Notch, there are two 'Bands' that contain a different number of spare sectors per cylinder. The following shows values for the OD Band of Notch #1 for a 5 data head model. The "Notch Average" and "Drive Average" values used in tables Table 3 on page 28 and Table 2 on page 26 are sums of the individual Band values weighted by the number of LBAs in the associated Bands. For the other bands use values that correspond to those bands.

Data Sector Transfer Rate =

$$\frac{\text{MBytes/cylinder}}{\text{time for 1 cyl} + \text{4 track skews} + \text{1 cyl skew}}$$

MBytes/cylinder = {(tracks/cyl)(gross sectors/track) - spares/cyl}(user bytes/sector)
= {(5)(108) - 15}(512)
= 268.80 KBytes/cyl (OD band of Notch #1)

time for 1 cyl of data = {(tracks/cyl)(gross sectors/track) - spares/cyl}(sector time)
= {(5)(108) - 15}(.102881)
= 54.013 msec/cyl (OD Band of Notch #1)

time for 4 track skews = (tracks/cyl - 1)(track skew)(sector time)
= (5-1)(8)(.102881)
= 3.292 msec/cyl (Notch #1)

time for 1 cyl skew = (cylinder skew)(sector time)
= (16)(.102881)
= 1.646 msec/cyl (OD Band of Notch #1)

Data Sector Transfer Rate =

$$\frac{\text{268.80KBytes}}{\text{54.013 msec} + \text{3.292 msec} + \text{1.646 msec}}$$

= 4.560 MB/sec (OD Band of Notch #1)

Note: See 2, “Specifications” on page 13 for the descriptions of

- tracks/cyl (trk/cyl)
- gross sectors/track (gs/trk)
- spares/cyl (b1spr/cyl and b2spr/cyl)
- user bytes/sector (ub/sct)
- gross bytes/sector (gb/sct)

See 3.7, “Skew” on page 37 for the descriptions of

- track skew (tss)
- cylinder skew (css)

And average sector time can be calculated as follows:

- sector time (st) =

$$\left[\frac{100}{(9)(gs/trk)} \right] msec$$

And for transfers of few blocks (less than 1/2 of gs/trk) individual sector time can be calculated as follows:

- sector time (st) =

$$INT \left[\frac{(gb/sct)(90) + brc - 1}{brc} \right] \frac{1}{10000} \; msec$$

Note: The example Data Sector Transfer Rates use the average value for sector time since the number of sectors transferred in this example is greater than 1/2 gs/trk.

3.6 Write Command Performance

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

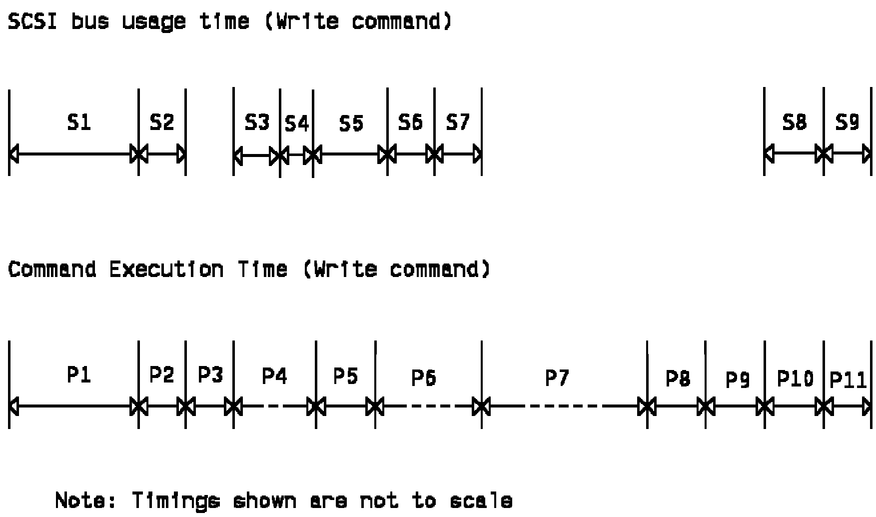


Figure 6. SCSI Write command performance measurements

SCSI bus usage time (Write command)

Note: All times listed in this section are provided for information only so that the performance for other environments can be approximated. These component times should not be measured against the specification.

S1 Selection, Identify Msg., CDB	10 µsec
S2a SDP Msg.	1 µsec
S2b Disconnect Msg., Bus Free	1 µsec
S3 Arbitrate, Reselect, Identify Msg.	6 µsec
S4 start SCSI transfer out	3 µsec
S5 SCSI bus data transfer out	(Transfer size)/(SCSI Data Transfer Rate)
S6 End SCSI transfer out	4 µsec
S7A SDP Msg.	1 µsec
S7B Disconnect Msg., Bus Free	1 µsec
S8 Arbitrate, Reselect, Identify Msg.	6 µsec
S9 Status, Command Complete Msg., Bus Free	3 µsec

Note: The SCSI bus overhead for a write command is composed of S1,S2(a&b),S3,S4,S6,S7,S8 and S9. (0.04 msec total).

P1 Selection, Identify Msg., CDB 10 µsec
P2a SDP Msg. 1 µsec
P2b Disconnect Msg., Bus Free 1 µsec
P3 Start seek 258 µsec
P4 Seek (for example, average seek) (Write Seek = 10.0 msec)
P5 Set up write disk transfer 0 µsec
P6 Latency (for example, half revolution) (Latency = 5.56 msec)
P7 Disk data transfer (see Note 1 below)
P8 End write disk transfer 75 µsec
P9 SCSI write ending processing 25 µsec
P10 Arbitrate, Reselect, Identify Msg. 6 µsec
P11 Status, Command Complete Msg., Bus Free 3 µsec

Note: The Command execution overhead for a write command is composed of P1, P2(a&b), P3, P5, P8, P9, P10 and P11. (0.38 msec total).

Time to Write data = P1+P2+P3+P4+P5+P6+P7+P8+P9+P10+P11

Note: 1) Use the following formula to calculate P7.

P7 = (Data transferred)/(Data Sector Transfer Rate)

Note: Use the 3.5.1.1, "Theoretical Data Sector Transfer Rate" on page 34 for an approximation of the Data Sector Transfer Rate.

3.7 Skew

3.7.1 Cylinder to Cylinder Skew

In order to increase the likelihood that equivalent LBA's on two or more devices are located at the same relative physical position when the devices are used in a synchronized spindle mode, cylinder skew is calculated differently than when a device is not formatted in that mode. The cylinder skew calculations do not take into account known defective sites. To prohibit revolutions from being missed on cylinder crossings by drives formatted while in a synchronized spindle mode, an extra allowance for several defects is added that is not added when optimally formatted in a non-synchronized mode.

Note: The value in the SCSI Mode Page 3 'Cylinder Skew Factor' is the non-synchronized spindle mode value for the OD band of Notch #1.

	Notch #1		Notch #2	
	OD Band	ID Band	OD Band	ID Band
cylinder skew bytes (csb)	7926		6605	
reassign allowance sectors (ras)	3	4	3	4
SAT allowance sectors (sas)	6	8	6	8

Table 4. Cylinder Skew Calculation Input Parameters

cylinder skew sectors (css)

$$= \frac{csb}{gb/sct} + ras$$

{rounded up to nearest integer}

{add ***sas*** if formatted in synchronized spindle mode}

Note: For example, in Notch #1, css = 16 sectors @OD and 17 sectors @ID (for 512 byte sectors).

3.7.2 Track to Track Skew

Note: The value in the SCSI Mode Page 3 'Track Skew Factor' is the value for Notch #1.

	Notch #1	Notch #2
track skew bytes (tsb)	4800	4000

track skew sectors (tss)

$$= \frac{tsb}{gb/sct}$$

{rounded up to nearest integer}

Note: For example, tss = 8 sectors in Notch #1 and 7 sectors in Notch #2 (for 512 byte sectors).

3.8 Idle Time Functions

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

1. Thermal Compensation Update
2. Disk Sweep
3. Save Counters & Pointers
4. Save Error Log
5. ***P***redictive ***F***ailure ***A***nalysis (***PFA***)

If a SCSI command is received by the drive while performing an idle time function the Arbitration, Selection, Message and Command phases, and disconnects controlled by the drive behave identical to the scenario where an idle time function is not currently in progress when a command is received. The only change with respect to performance and SCSI phase changes is that an initiator may detect is that the Total Command Execution time is increased by the amount of time it takes to complete the idle time function currently in progress.

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, except for ***PFA*** which when executed always follows a Thermal Compensation Update. Mechanisms to lessen, and in some cases virtually eliminate, performance impacts from an Initiator's point of view are also mentioned.

Following the descriptions is a summary of possible performance impacts.

3.8.1 Thermal Compensation Update

The drive periodically updates certain servo parameters to compensate for shifts caused by thermal changes. The drive is always compensating and the periodic updates are initiated automatically by the drive.

The update of one head is started every 36 sec during the first hour after power is applied, and every 3 minutes thereafter. Of that period, an average of 210 msec is spent updating a head.

Multiple SCSI commands are accepted and executed without delay during an update period if the commands are received less than 100 msec after the completion of the previous SCSI command.

There is an exception if a head due to be updated is not updated within the process period (due to the rapid arrival of SCSI commands and/or commands that take a large amount of time to execute relative to a process period). Then the drive delays SCSI non-Priority commands, except for Test Unit Ready, from executing until that one head is updated. (See the **0662 Interface Specification** for a description of Priority commands.)

This scheme insures that each head is updated at least every 3 minutes during the first hour after spin up, and every 15 minutes thereafter. The intent of the scheme is to minimize the negative effects of updates on drive performance.

The update effects upon performance can be reduced by setting the Page 0h Mode Parameter TCC (Thermal Compensation update Control) = 1. In read intensive workloads, updates can be effectively disabled for critical response time periods of operation by issuing Read (6) and/or Read (10) commands at least every 1 second when TCC = 1. This means that multiple SCSI Read commands are accepted and executed without delay if the commands are received by the drive within 1 second of the execution of a previous SCSI Read command. If a write command is issued and a process period for a head that is accessed by that command has elapsed such that an update is due, it will be updated. Heads that are not due to be updated, or are not accessed by a SCSI write command will not be updated during the execution of a command.

For all types of workloads, read and write, when TCC = 1 using systems can force updates to be executed by issuing the SCSI Rezero Unit command. This mechanism allows the updates to be executed at times known and controlled by the using system.

3.8.2 Disk Sweep

The disk sweep function is built into the drive microcode to prolong disk life. It is designed to move the heads over the disk surface during idle periods to prevent disk lubrication migration problems.

At the end of either a Thermal Compensation Update that was initiated after 100 msec of idle time or the end of a ***PFA*** test, the drive self-initiates an operation that moves the heads to a new cylinder within the highest fly height area of the disk.

The execution time that a SCSI command could be delayed is typically less than the time it takes to do one Full Stroke seek.

3.8.3 Save Counters & Pointers

The drive periodically writes a sector to the reserved area containing internally used counters and pointers. This occurs approximately every 26-35 minutes and is interleaved with SCSI commands. The operation takes approximately 50 msec to execute.

The effects upon performance can be reduced by setting the Page 0h Mode Parameter LITF (Limit Idle Time Functions) = 1. Execution can be effectively disabled for critical response time periods of operation by issuing SCSI commands at least every 1 second when LITF = 1. This means multiple commands are accepted and executed without delay if the commands are received by the drive within the "idle detection period" of 1 second of the execution of a previous SCSI command.

3.8.4 Save Error Log

If there have been entries added to the Error Log since it has been last written to the reserved area of the disk, the Error Log is written (or saved) to the reserved area of the disk. Execution of this operation, if required, occurs at the same time the Save Counters and Pointers function does and replaces the Save Counters and Pointers function for that cycle. The operation takes approximately 150 msec to execute.

Note: The Error Log is also written to the reserved area if the Log is full during the execution of commands that attempt error recovery.

3.8.5 Predictive Failure Analysis

PFA measures drive parameters and can predict if a drive failure is imminent.

After the drive has been spinning for between 10 to 15 minutes, a ***PFA*** algorithm will be performed which takes approximately 0.02 seconds to complete. After this initial ***PFA*** computation, approximately every 3 minutes thereafter, another ***PFA*** operation will be executed for the remaining untested data heads. 30 minutes after the previous test cycle was started, a test cycle which tests all heads 3 minutes apart starts again. Every 30 minutes thereafter, a new test cycle is started.

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. See the **0662 Interface Specification** for more details about ***PFA*** and how it's execution can be controlled by the using system via vendor unique SCSI Mode Parameters LITF and TCC.

Note: Setting LITF = 1 does not disable event driven ***PFA*** features. It only disables the time driven ***PFA*** features.

3.8.6 Summary

Idle Time Function Type	Period of Occurance (minutes)	Duration (ms)	Mechanism to Delay/Disable
Servo TCOMP (< 1st hour)	.6	210	Re-instruction Period & TCC
Servo TCOMP (> 1st hour)	3	210	Re-instruction Period & TCC
PFA (1)	3	80	TCC/LITF
Save Logs & Pointers	26	30	Re-instruction Period & LITF
Note: "TCOMP" is Thermal Compensation Update.			
Note: "Re-instruction Period" is the time between consecutive SCSI command requests.			
Note: (1) PFA durations are typically 20 ms. Once every 30 minutes duration may reach 80 ms. Even though the period is 3 minutes, PFA only executes 5 times every 30 minutes.			

Table 5. Summary of Idle Time Function Performance Impacts

3.9 Command Timeout Limits

The 'Command Timeout Limit' is defined as the time period from the SCSI Arbitration phase through the SCSI Command Complete message, associated with a particular command.

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

3.9.1.1.1 Reassignment Time: The drive should be allowed a minimum of 30 sec to complete a "Reassign Blocks" command.

3.9.1.1.2 Format Time: The drive should be allowed a minimum of 30 minutes to complete a "Format Unit" command.

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

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

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

3.9.1.1.4 Medium Access Command Time: The timeout limit for medium access commands that transfer user data and/or non-user data should be a minimum of 30 sec. These commands are:

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

Note: The 30 sec limit assumes the absence of bus contention and user data transfers of 64 blocks or less. This time should be adjusted for anticipated bus contention and if longer user data transfers are requested.

3.9.1.1.5 Timeout limits for other commands: The drive should be allowed a minimum of 5 sec to complete these commands:

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

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. Mechanical

4.1 Weight

Approximately 1.0 pounds (0.46 kilograms)

4.2 Dimensions for Single Ended SCSI Models

	U.S.	S.I. Metric
Height	1.00 inches	25.4 millimeters
Width	4.00 inches	101.6 millimeters
Depth	5.75 inches	146.0 millimeters

4.3 Dimensions for Differential SCSI Model

	U.S.	S.I. Metric
Height	1.00 inches	25.4 millimeters
Width	4.00 inches	101.6 millimeters
Depth	6.50 inches	165.2 millimeters

4.4 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 7 on page 44 shows the clearance requirements (Note 1). For proper cooling it is suggested that a clearance of 6 mm be provided under the file and on top of the file.

There should be 7 mm of clearance between the files that are mounted with their top sides (see Figure 23 on page 73 or Figure 25 on page 75 for top view of file) facing each other.

4.5 Mounting

The drive can be mounted with any surface facing down.

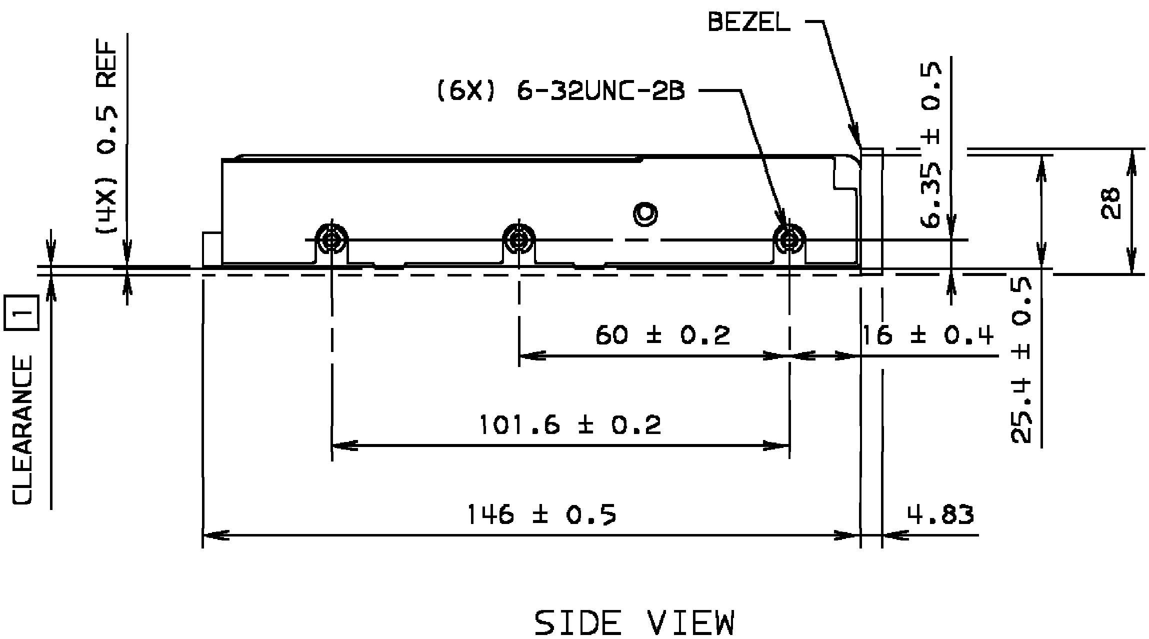
The drive is available with both side and bottom mounting holes. Refer to Figure 7 on page 44 to Figure 10 on page 47 for the location of these mounting holes for each configuration.

The maximum allowable penetration of the mounting screws is 3.8 mm.

The recommened torque applied to the mounting screws is 0.5 Newton-meters +/- 0.1 Newton-meters. Recommended torque driver speed not to exceed 300 RPM. IBM will provide technical assistance for users who wish to apply higher torques and/or higher speeds.

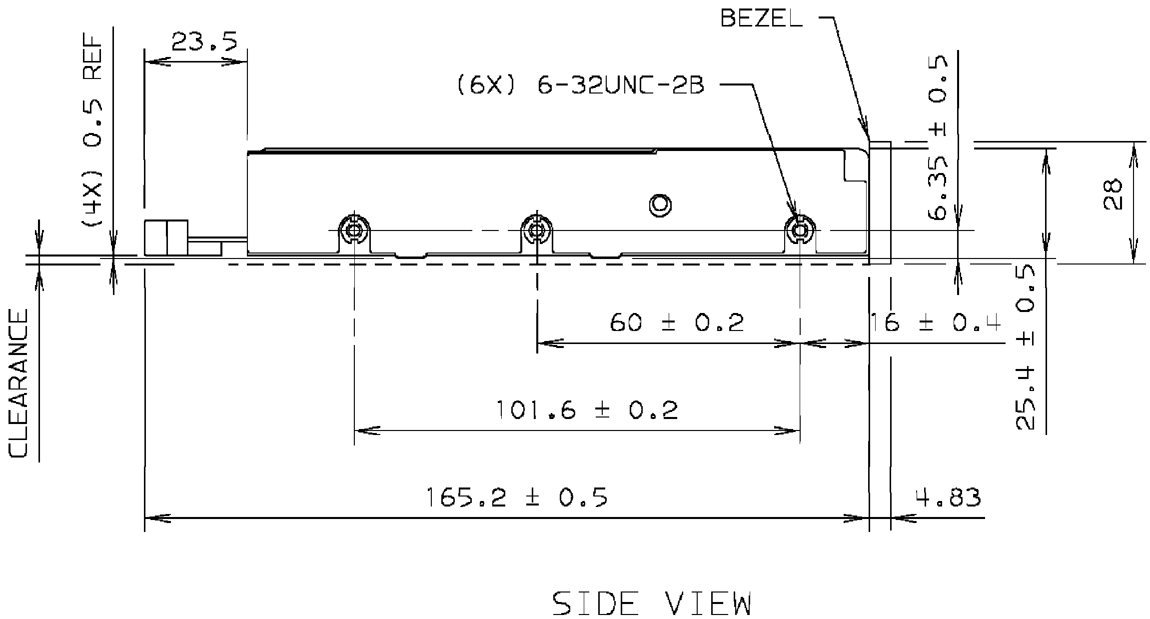
WARNING: Except for the isolated mounting holes, the body of the file is not at ground potential. Therefore any user mounting scheme must not result in the file being shorted to ground.

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



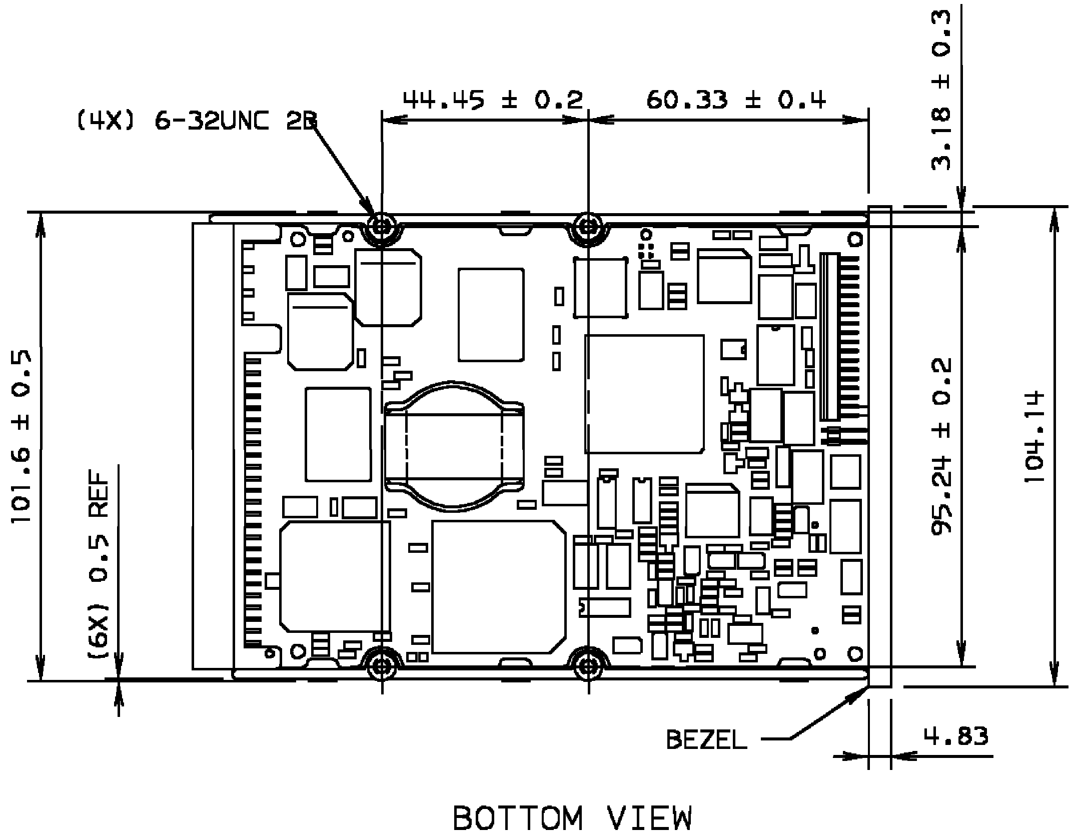
| **Note:** Dimensions are in millimeters.

| Figure 7. Location of Side Mounting Holes



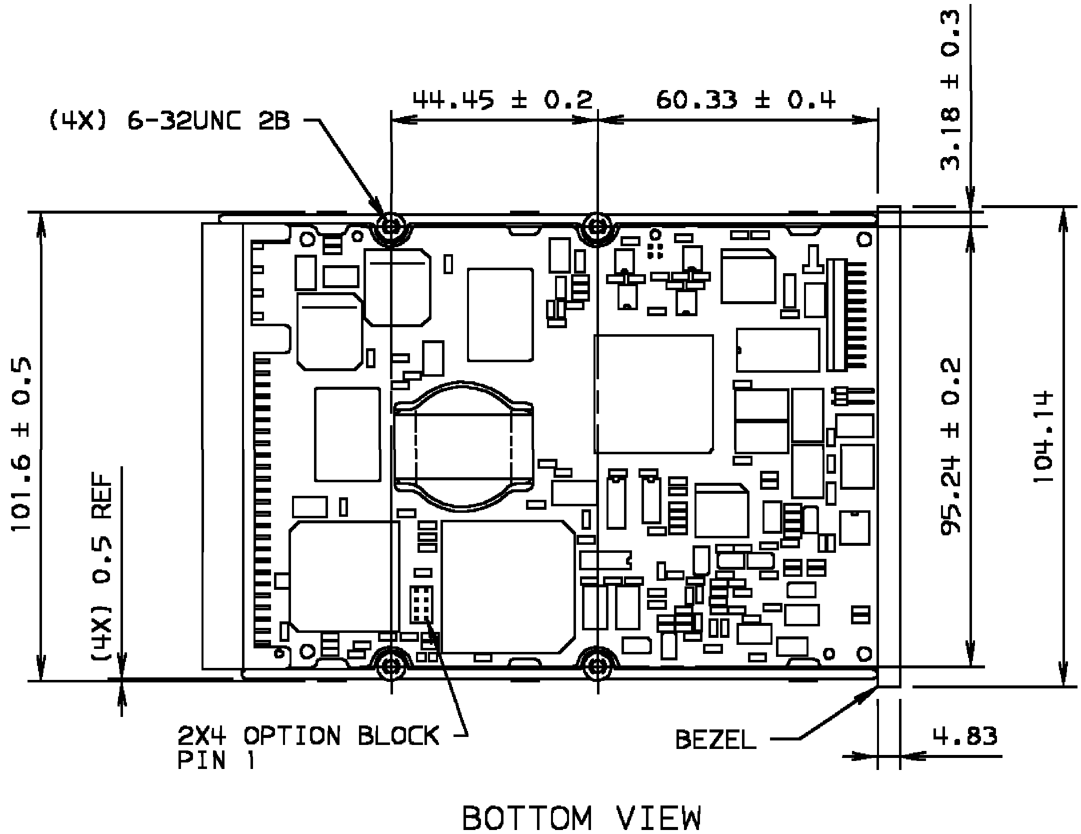
| **Note:** Dimensions are in millimeters.

| Figure 8. Location of Side Mounting Holes with Differential SCSI Cards



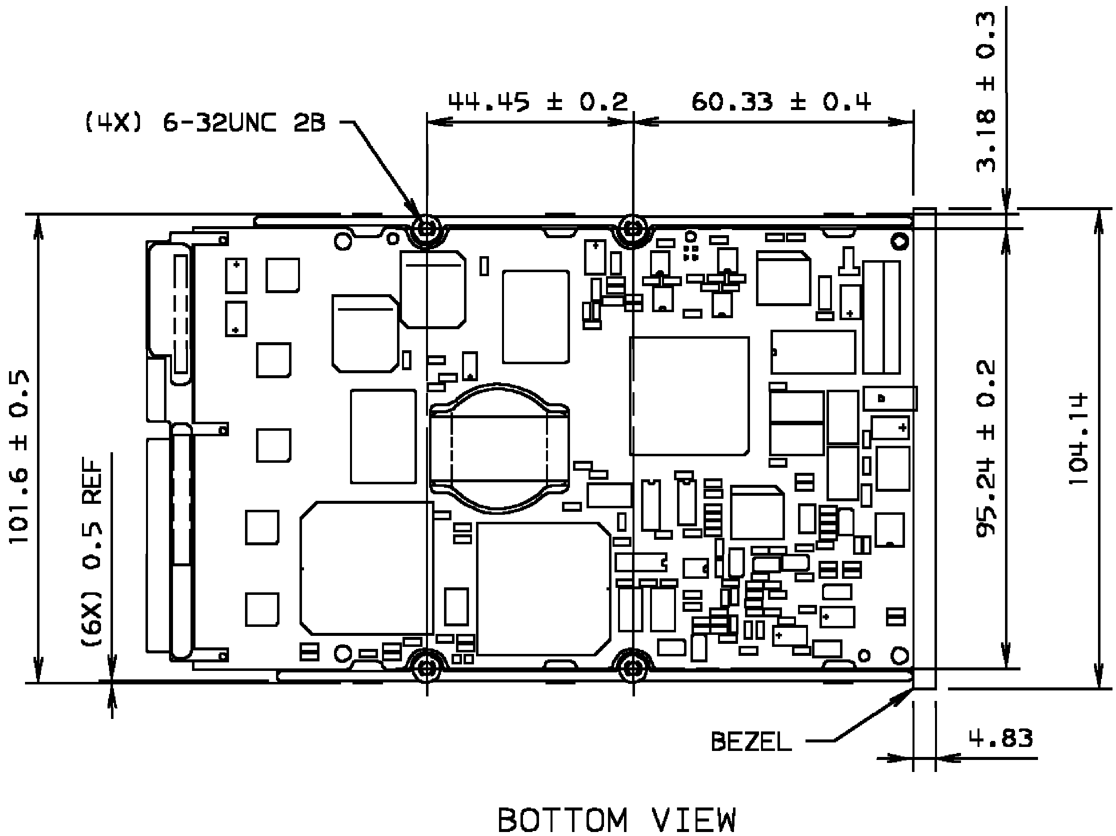
Note: Dimensions are in millimeters.

Figure 9. Location of Bottom Mounting Holes with SMD Card



Note: Dimensions are in millimeters.

Figure 10. Location of Bottom Mounting Holes with SMP Card

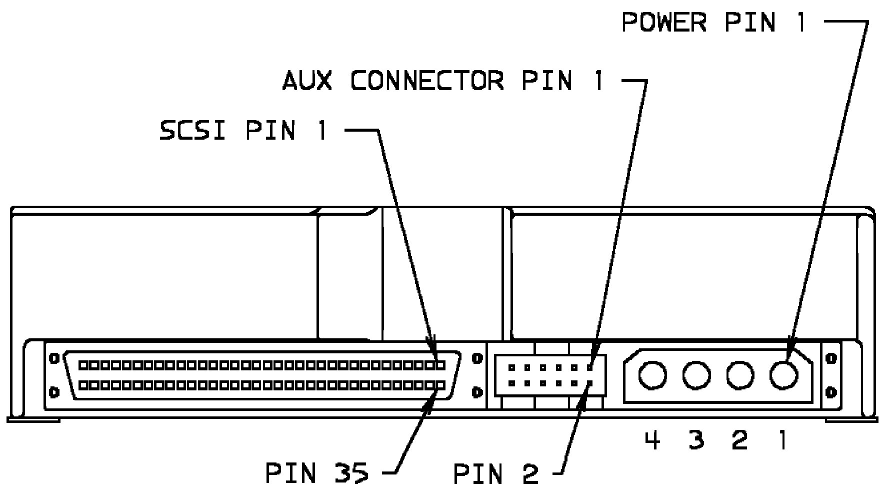


Note: Dimensions are in millimeters.

Figure 11. Location of Bottom Mounting Holes with Differential Cards

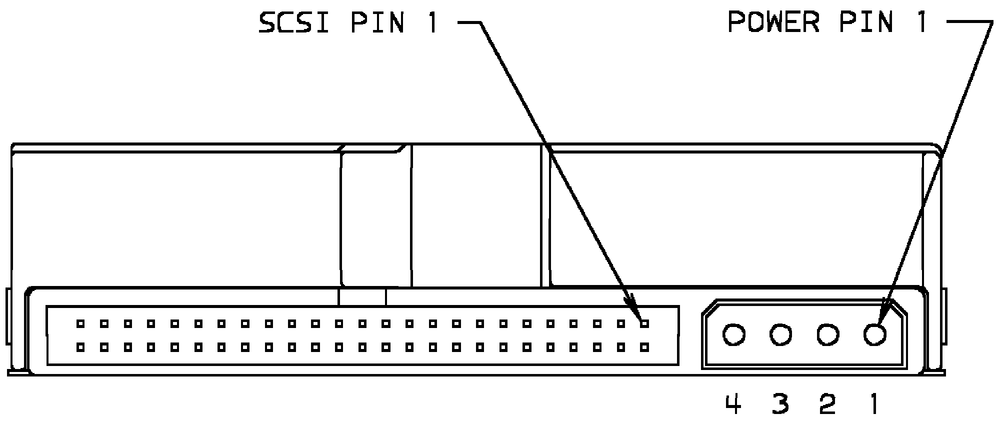
4.6 Electrical Connector Locations

The electrical connectors are located as shown in Figure 12 and Figure 13 on page 50. The front jumper pin locations are shown in Figure 14 on page 51 and Figure 15 on page 52.



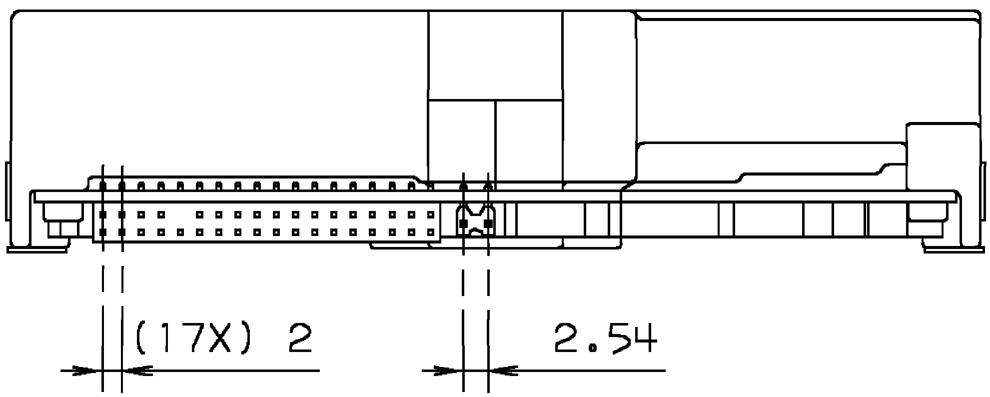
POWER PIN ASSIGNMENTS	
PIN	VOLTAGE
1	+ 12 V
2	GND
3	GND
4	+ 5 V

Figure 12. Electrical connectors (rear view) -- 68 pin SCSI.



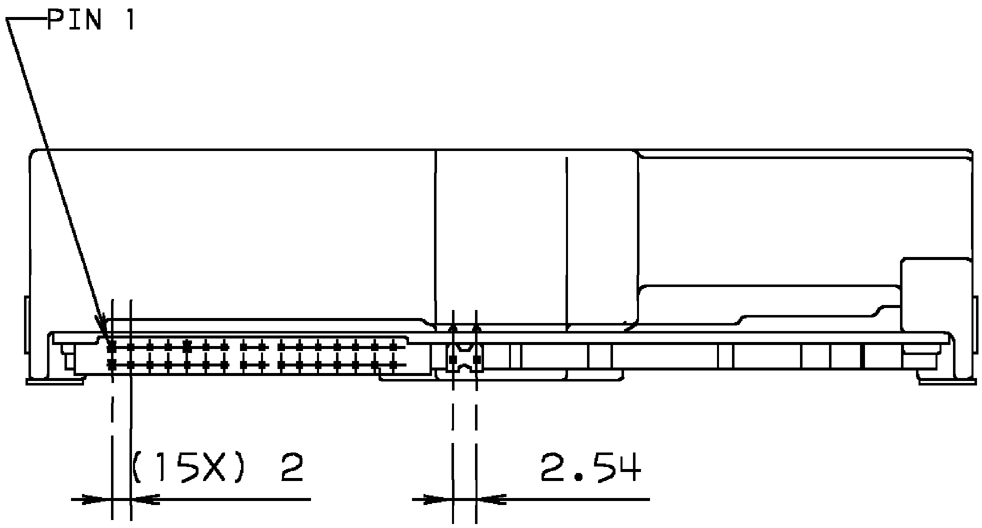
POWER PIN ASSIGNMENTS	
PIN	VOLTAGE
1	+ 12 V
2	GND
3	GND
4	+ 5 V

Figure 13. Electrical connectors (rear view) -- 50 pin SCSI



Note: Dimensions are in millimeters.

Figure 14. SMD Jumper pin locations (front view)



| **Note:** Dimensions are in millimeters.

| Figure 15. SMP Jumper pin locations (front view)

5. Electrical Interface

5.1 Power Connector

The DC power connector is designed to mate with a Molex 8981-4P4 crimp connector, or a Molex A-70156-2000 insulator displacement connector, or their equivalent. Pin assignments are shown in Table 6.

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

Table 6. Power connector pin assignments

Refer to the section entitled 2.2, “Power Requirements” on page 16 for details on power. Also see Figure 13 on page 50 and Figure 12 on page 49 for power connector pin locations.

5.2 SCSI Bus

This section describes the electrical specifications of the ***0662*** SCSI connector.

5.2.1 SCSI Bus Signal Connectors

| ***0662*** has different model types that support a 50 or 68 pin single-ended SCSI connector and a 68 pin SCSI
| differential driver/receiver alternative.

5.2.1.1 50 Pin Signal Connector

50 pin models use a Hirose MIF62B-54PB-2.54DS(02) connector on the "SMD" version of the electronics circuit board and a Hirose MIF62C-54PB-2.54DS on the "SMP" version of the electronics. They are both compatible with the ANSI SCSI-2 "A" connector specifications. It is limited to 8 bit data transfers only. Refer to Figure 13 on page 50 for a rear view of the 50 pin model connector.

The SCSI connector contact assignments for the 50 pin single-ended model is shown in Table 7.

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

Table 7. 50 Pin Single-Ended SCSI Connector Contact Assignments

5.2.1.2 68 Pin Signal Connector

68 pin models use an AMP 92-8012-16-1 connector that is compatible with the ANSI SCSI-3 "P" connector specifications. It can transfer data in both 8 bit (narrow) and 16 bit (wide) modes. Refer to Figure 12 on page 49 for a rear view of a 68 pin model.

Note that the "P" connector is not mechanically compatible with the 50-pin "A" connector as defined in the ANSI SCSI-2 standard. Therefore system cables used with 50 pin products cannot be plugged directly into 68 pin models. Despite the difference in connector, the differential 68 pin models are electrically compatible with differential 50 pin models and other 50 pin differential SCSI products and therefore can coexist on the same bus. In order to do so, the differences in connector types would need to be accounted for in the cable. The same can be said for connecting 68 and 50 pin single-ended models to the same bus. But differential and single-ended models do not work connected to the same bus.

SCSI connector contact assignments for 68 pin single-ended models are shown in Table 8 while 68 pin differential models are shown in Table 9 on page 56.

Signal Name	Connector Contact Number		Signal Name
GROUND	1	35	-DB(12)
GROUND	2	36	-DB(13)
GROUND	3	37	-DB(14)
GROUND	4	38	-DB(15)
GROUND	5	39	-DB(P1)
GROUND	6	40	-DB(0)
GROUND	7	41	-DB(1)
GROUND	8	42	-DB(2)
GROUND	9	43	-DB(3)
GROUND	10	44	-DB(4)
GROUND	11	45	-DB(5)
GROUND	12	46	-DB(6)
GROUND	13	47	-DB(7)
GROUND	14	48	-DB(P)
GROUND	15	49	GROUND
GROUND	16	50	GROUND
TERMPWR	17	51	TERMPWR
TERMPWR	18	52	TERMPWR
OPEN	19	53	OPEN
GROUND	20	54	GROUND
GROUND	21	55	-ATN
GROUND	22	56	GROUND
GROUND	23	57	-BSY
GROUND	24	58	-ACK
GROUND	25	59	-RST
GROUND	26	60	-MSG
GROUND	27	61	-SEL
GROUND	28	62	-C/D
GROUND	29	63	-REQ
GROUND	30	64	-I/O
GROUND	31	65	-DB(8)
GROUND	32	66	-DB(9)
GROUND	33	67	-DB(10)
GROUND	34	68	-DB(11)

Note: 8 bit devices which connect to the P-cable should tie the following signals inactive: -DB(8), -DB(9), -DB(10), -DB(11), -DB(12), -DB(13), -DB(14), -DB(15), -DB(P1). All other signals shall be connected as defined.

Table 8. 68 Pin Single-Ended SCSI Connector Contact Assignments

Signal Name	Connector Contact Number		Signal Name
+DB(12)	1	35	-DB(12)
+DB(13)	2	36	-DB(13)
+DB(14)	3	37	-DB(14)
+DB(15)	4	38	-DB(15)
+DB(P1)	5	39	-DB(P1)
GROUND	6	40	GROUND
+DB(0)	7	41	-DB(0)
+DB(1)	8	42	-DB(1)
+DB(2)	9	43	-DB(2)
+DB(3)	10	44	-DB(3)
+DB(4)	11	45	-DB(4)
+DB(5)	12	46	-DB(5)
+DB(6)	13	47	-DB(6)
+DB(7)	14	48	-DB(7)
+DB(P)	15	49	-DB(P)
DIFFSENS	16	50	GROUND
TERMPWR	17	51	TERMPWR
TERMPWR	18	52	TERMPWR
OPEN	19	53	OPEN
+ATN	20	54	-ATN
GROUND	21	55	GROUND
+BSY	22	56	-BSY
+ACK	23	57	-ACK
+RST	24	58	-RST
+MSG	25	59	-MSG
+SEL	26	60	-SEL
+C/D	27	61	-C/D
+REQ	28	62	-REQ
+I/O	29	63	-I/O
GROUND	30	64	GROUND
+DB(8)	31	65	-DB(8)
+DB(9)	32	66	-DB(9)
+DB(10)	33	67	-DB(10)
+DB(11)	34	68	-DB(11)
Note: 8 bit devices which connect to the P-cable should tie the following signals inactive: +/-DB(8), +/-DB(9), +/-DB(10), +/-DB(11), +/-DB(12), +/-DB(13), +/-DB(14), +/-DB(15), +/-DB(P1). All other signals shall be connected as defined.			

Table 9. 68 Pin Differential SCSI Connector Contact Assignments

5.2.2 SCSI Bus Cable

Single-ended models permit cable lengths of up to 6 meters (19.68 feet). It should be noted however that users who plan to use "Fast" data transfers with single-ended models should follow all of the SCSI-3 guidelines for single-ended "Fast" operations. This may include a cable length of less than 6 meters.

Differential models permit cable lengths of up to 25 meters (82.02 feet). Cables must meet the requirements for differential cables as set forth in the ANSI SCSI-2 standard under "Cable Requirements - Differential Cable".

The SCSI-2 standard states that any stub from main cable must not exceed 0.1 meters for single-ended cables and 0.2 meters for differential cables. ***0662*** has a maximum internal stub length of 0.053 meters on all SCSI signals. To remain compliant with the standard, the SCSI bus cable must not add more than 0.047 meters additional stub length to any of the single-ended SCSI signals or .147 meters to any differential SCSI signals.

5.2.3 SCSI Bus Terminators

| Only 50 pin single-ended models on request have optional internal SCSI bus active terminators that can be enabled by installing a jumper between pins 13 and 14 of the Front Options Jumper Block or pins 7 and 8 of the Rear Block on 68 pin SCSI models. (Refer to Figure 16 on page 59, Figure 17 on page 59 and Figure 19 on page 60). The using system is responsible for making sure that all required signals are terminated at both ends of the the cable. See 5.2.5, “SCSI Bus Electrical Characteristics” on page 58 for input capacitance values when terminators are disabled or not present.

Differential models do not have internal SCSI bus terminators. A terminator possibility is listed in Table 10.

For 68 Pin Models
Data Mate DM2050-01-68D

Table 10. Differential SCSI Terminator

5.2.4 SCSI Bus Termination Power

Termination power is optionally provided for systems that desire to use it. In order to use the termination power, the user needs to install a jumper between pins A01 and A02 of the TermPower Block. (Refer to Figure 16 on page 59 and Figure 17 on page 59.) The jumper should only be installed on one device, which should be the the last device on the SCSI bus (i.e. the drive that is physically closest to a terminator). 68 pin models can source up to 2.0 Amps of current at 5.0 Volts (+- 5%) for termination power. 50 pin models can source up to 1.5 Amps of current at 5.0 Volts (+- 5%) for termination power.

5.2.4.1 SCSI Bus Termination Power Short Circuit Protection

The ANSI SCSI-2 specification recommends for devices that optionally supply TERMPWR, to include current limiting protection for accidental short circuits. It also recommends that the maximum current available for TERMPWR should not exceed 5 Amps. UL has a different requirement that they call the 8 Amp rule. This rule states that when a power source leaves an enclosure (like SCSI TERMPWR in the SCSI cable), it must trip 8 Amps of current within 1 minute.

0662 uses a resettable "Positive Temperature Coefficient" (PTC) resistor for TERMPWR short circuit protection. These devices will trip when they are over-heated due to excess current flowing through them. When the over current condition (i.e. current surge due to a hot plug or intermittent short, or a solid short circuit) is removed, the device can automatically reset, allowing TERMPWR to again be sourced from this device.

0662 complies with the 8 Amp UL requirement. For systems that prefer to comply with the SCSI-2 5 Amp recommended TERMPWR limit, the 5 Volt power supplied to ***0662*** should be limited to prevent TERMPWR from exceeding 5 Amps. This would prevent a current surge in excess of 5 Amps that may occur in the event of a short circuit, before the PTC device can actually trip.

5.2.5 SCSI Bus Electrical Characteristics

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

- Ta = 0 to 70 deg. C

Symbol	SCSI I/O Parameters	min	max	Units	Notes
Vol	low level output voltage		0.4	V	Iout = 48.0 mA
Voh	high level output voltage	2.5		V	Iout = -400 uA
Vil	low level input voltage	0.0	0.8	V	
Vih	high level input voltage	2.0	5.5	V	
Iil	low level input current		10	uA	
Iih	high level input current		50	uA	
Vihys	input hysteresis	0.3		V	
Ci	input capacitance		25	pF	w/terminators disabled, Typ. = 19pF

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

5.2.6 Recommendations For SCSI Bus Noise Reduction

The SCSI committee has spent a large amount of resource looking into what needs to be done to assure SCSI devices will work as specified in the SCSI-2 standard. As a result of this, the committee is recommending the following approach:

- Use regulated 110 ohm terminator
- Use AWG 28 polyolefin shielded cables
- Make sure data and parity are on the outer ring of the cable and that REQ and ACK are in the core of the cable.

5.3 Options Jumper Block(s)

0662 contains a front jumper block with pins that can be used to access and enable certain features and select the SCSI address of the drive. Figure 16 shows the layout of those pins for the "SMD" version of the electronics circuit board. For the "SMP" version of the electronics circuit board, those functions are split into two groups of pins. The front block is shown in Figure 17. While the block located on the bottom is shown in Figure 18 on page 60.

68 pin models also contain a rear option jumper block that replicates some of the functions contained in the front block. The layout of those pins are shown in figure Figure 19 on page 60.

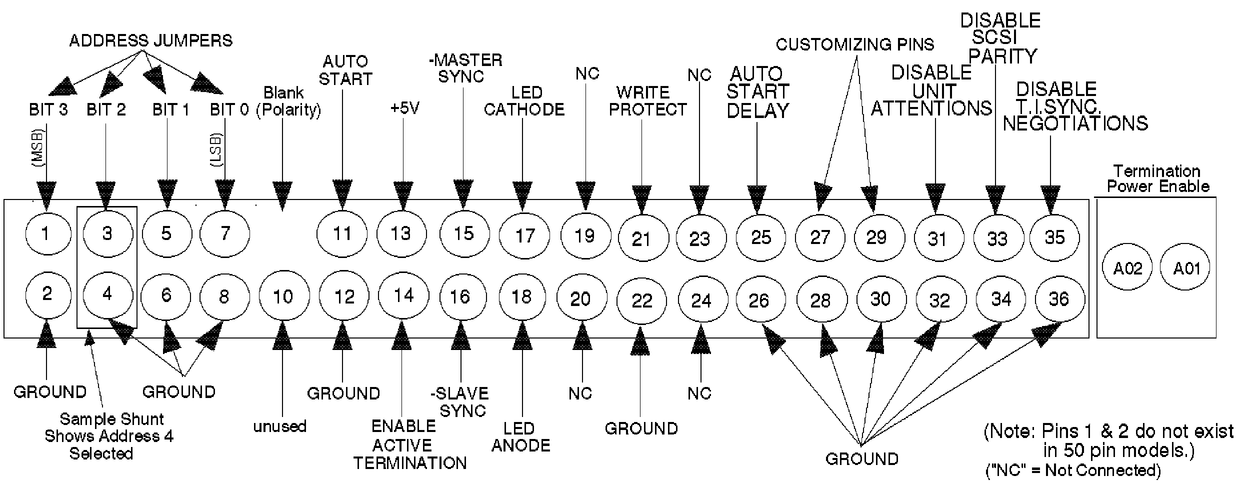


Figure 16. Front Options Jumper Block (& TermPower Block) for "SMD" Versions

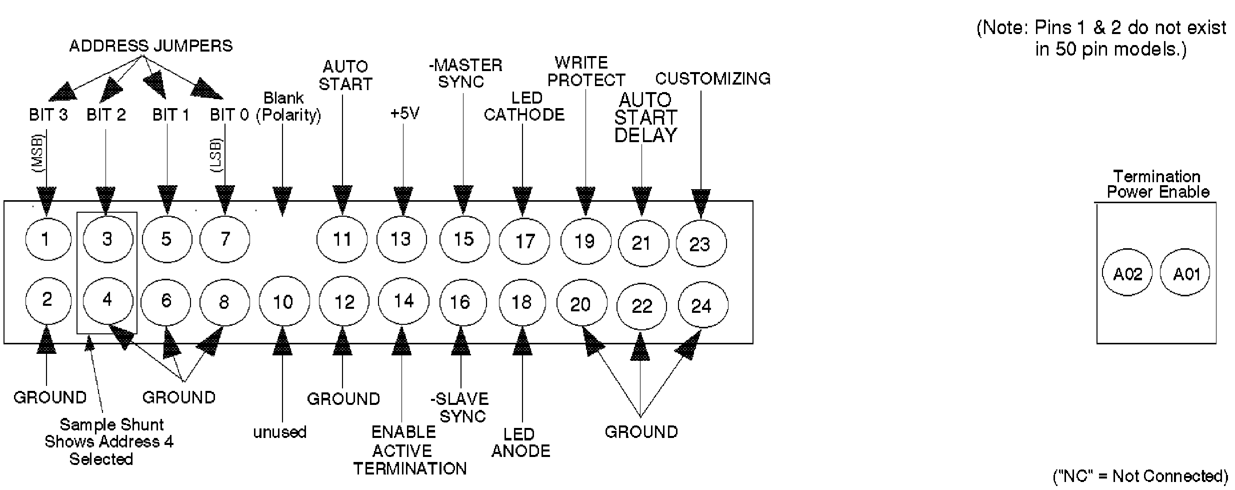


Figure 17. Front Options Jumper Block (& TermPower Block) for "SMP" Versions

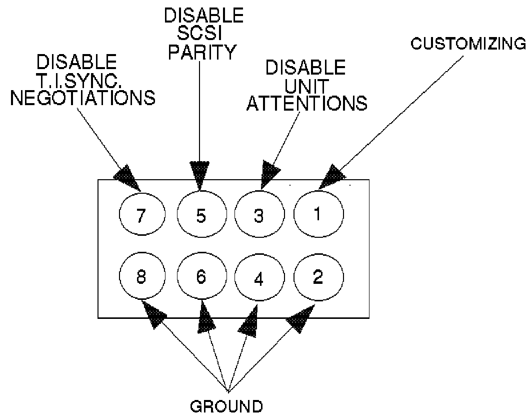


Figure 18. Bottom Options Jumper Block for "SMP" Versions

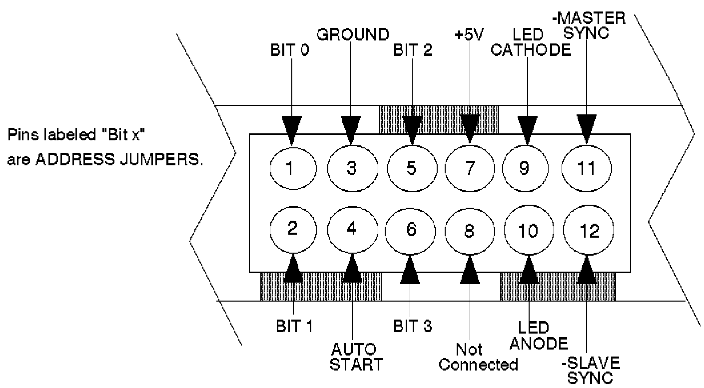


Figure 19. Rear Options Jumper Block for 68 pin models

5.3.1 SCSI Address Pins

Information on how to select a particular address for the SCSI device ID is given in Table 11 and Table 12.

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

BIT 3	BIT 2	BIT 1	BIT 0	ADDRESS
off	off	off	off	0
off	off	off	on	1
off	off	on	off	2
off	off	on	on	3
off	on	off	off	4
off	on	off	on	5
off	on	on	off	6
off	on	on	on	7
on	off	off	off	8
on	off	off	on	9
on	off	on	off	10
on	off	on	on	11
on	on	off	off	12
on	on	off	on	13
on	on	on	off	14
on	on	on	on	15

Table 11. Address Determination of 68 Pin SCSI Models

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

Table 12. Address Determination of 50 Pin SCSI Models

5.3.2 Auto Start (& Delay) Pins

The Auto Start and Auto Start Delay pins control when and how the drive can spin up and come ready. When configured for Auto-Startup, the motor spins up after power is applied without the need of a SCSI Start Unit command. For no Auto-Start, a SCSI Start Unit command is required to make the drive spin and be ready for media access operations. When in Auto-Start mode, the drive will delay it's start time by a period of time multiplied by it's own SCSI address. Table 13 on page 62 shows whether or not Auto-Start mode is active and the delay periods, where applicable, for all combinations of the pins.

AUTO START DELAY	AUTO START	Auto-Start Mode ?	Delay (sec)
off	off	NO	na
off	on	YES	0
on	off	YES	10
on	on	YES	4

Table 13. Auto Start Mode and Delay

5.3.3 LED Pins

The LED pins can be used to drive an external Light Emitting Diode. Please refer to the LED pin section of the **0662 Interface Specification** for a detailed functional description of when these pins are activated.

Up to 33 mA (+/- 5%) of TTL level LED drive capability is provided.

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

Note: 68 pin SCSI models have two sets of pins, a set on the front and a set on the back, that are connected to the same LED driver circuit. The combined drive capability is stated above.

5.3.4 Write Protect Pins

If the Write Protect pin is jumpered to ground the drive will inhibit SCSI commands that alter the customer data area portion of the media from being performed. See the **0662 Interface Specification** for functional details.

5.3.5 Disable T.I.Sync. Negotiation Pins

If a Disable Target Initiated Synchronous Negotiation pin is grounded then an Initiator is required to start a negotiation handshake if Synchronous SCSI transfers are desired. Please refer to the **0662 Interface Specification** for more details on this feature.

5.3.6 Disable SCSI Parity Pins

Grounding this pin will disable SCSI Parity checking.

5.3.7 Disable Unit Attention Pins

Grounding this pin will disable the drive from building Unit Attention Sense information for commands immediately following a Power On Reset (POR) or SCSI Bus Reset. Any pending Unit Attention conditions will also be cleared at POR or SCSI Reset times.

5.3.8 Customizing Pins

The customizing pins and their associated jumper pins are currently reserved for future use. They are for features specific to particular host systems that must be in affect immediately after power is applied to the drive. Please contact your IBM Customer Representative for functional details on other using system specific required features that these pins could possibly be used for.

5.4 Spindle Synchronization

5.4.1 Spindle Synchronization Overview

There are four modes of spindle synchronization. Reference Figure 20 for a list of how the -MASTER SYNC and -SLAVE SYNC pins on the Option Jumper Block are used for the different modes. The following paragraphs give a short description of each spindle synchronization mode:

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

Reference the 0662 SCSI Specification for further information on the different synchronization modes.

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

Figure 20. Spindle Synchronization Functional Modes

- File Synchronization with Offset.

  The file electronics receives the Master Index and creates the delayed Slave Index from the drive INDEX. The delay is determined by using the Mode select command, Rigid Disk Drive Geometry Parameters (page 4). A rotational offset of 0/256 of a revolution up to 255/256 of a revolution may be selected in increments of 1/256 of a revolution. Reference the 0662 SCSI Specification for further information on the rotational offset of synchronized spindles.

- Synchronization Time

  The SCSI MODE Select command is used to select the Spindle Sync. mode. It could take up to 1.75 seconds (1.25 sec. nominally) to sychronize the Slave drive to the Master drive. While the Slave drive is synchronizing to the Master, it will not be able to read and write data. Once synchronized, the drive will maintain +/- 20 usec synchronization tolerance.

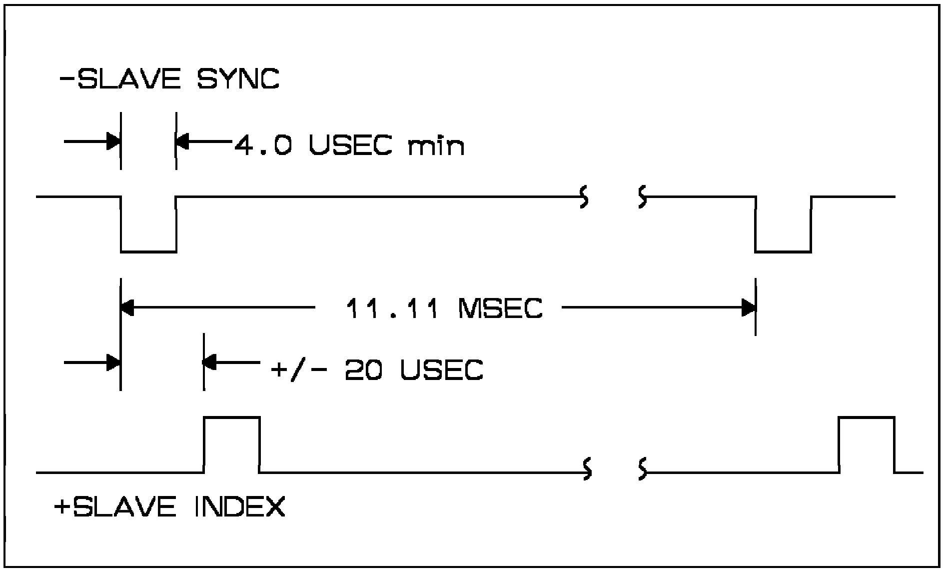


Figure 21. Slave-Sync to Slave-Index Timing

5.4.2 Spindle Synchronization Bus

The spindle synchronization Bus consists of the two signal lines, -MASTER SYNC and -SLAVE SYNC. Reference Figure 16 on page 59, Figure 17 on page 59 and Figure 19 on page 60 which show the location of these signal lines on the Option Jumper Block connector. One potential configuration of this bus for drives that are to be used in a synchronized mode is shown in the folowing figure. This example requires the -SLAVE SYNC lines to be daisy chained together.

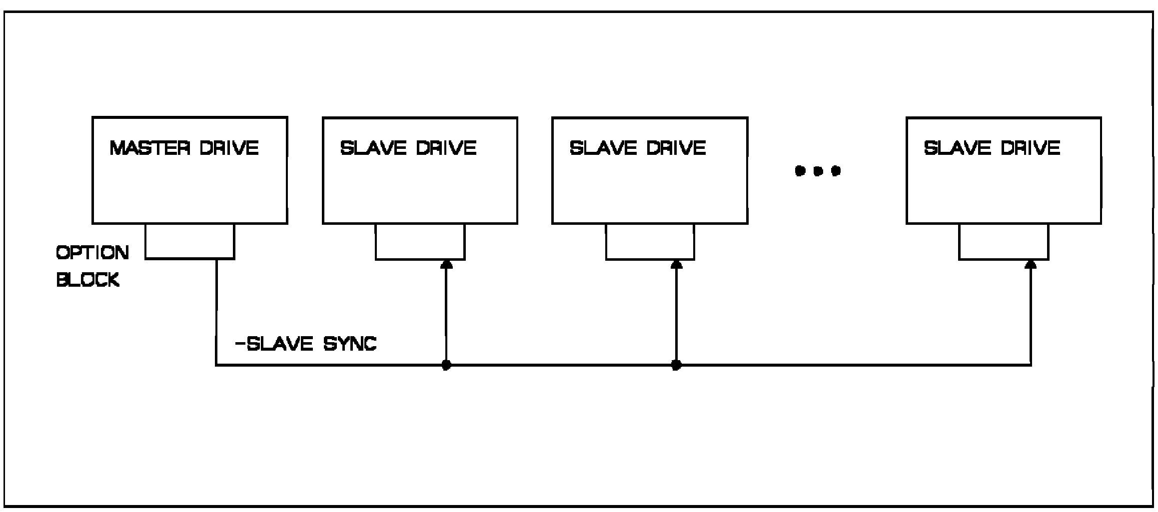


Figure 22. Daisy-Chain Connection of Synchronization Bus

- Termination

  Bus termination of the -MASTER SYNC and -SLAVE SYNC signals is internal to the file. These two signals each have a 2000 ohm pullup to the +5 volt supply. A maximum of 16 files can have their -MASTER SYNC or -SLAVE SYNC lines daisy chained together. Violating this could damage the Master file driver on the -MASTER SYNC and/or -SLAVE SYNC line.

  It is the using system's responsibility to provide the cable to connect the synchronized drives -SLAVE SYNC lines together.

- Bus Characteristics

  – maximum Bus length = 6 meters
  – 4 micro-second negative active pulse
  – 0.8 volts = valid low input
  – 2.0 volts = valid high input
  – 0.4 volts = low output
  – 64 milli-amps = maximum output low level sink current
  – high level output set by termination resistors

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

6. Reliability

Note: The reliability numbers are based on the conditions stated below. A separate evaluation should be made by the using system, using their operating conditions.

6.1 Error Detection

Error reporting ≥ 98%

All detected errors excluding interface and BATs #1 errors

Error detection ≥ 98%

FRU isolation = 100%

To the device when the "Recommended Initiator Error Recovery Procedures" in the 0662 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 (Population average)

Recoverable read errors 10 in 10^{11} bits read (Population average measured at nominal DC conditions and room environment.)

Probability of miscorrecting unrecoverable data

Note: Eighteen bytes of ECC and two bytes of LRC are provided for each data block. The codes have been configured to guarantee accurate detection and correction of errors that corrupt 6 or less consecutive bytes (per sector). Errors that corrupt 3 or less consecutive bytes are corrected automatically by the hardware (on the fly). Errors that corrupt between 7 and 12 consecutive bytes are guaranteed to be detected as uncorrectable errors. Errors that corrupt between 13 and 18 consecutive bytes are guaranteed to be detected, however, miscorrection may occur. The miscorrection probability of errors that corrupt 13 or more consecutive bytes is approximately 5.2 E-20. Errors that corrupt 19 or more consecutive bytes are subject to the same miscorrection probability, and also may not be detected by the codes. The misdetection probability for an error that corrupts 19 or more consecutive bytes is approximately 6.8 E-49. The following table summarizes this information.

Table 14. Data Reliability

Error length in bytes corrupted	Detection Guaranteed	Misdetection Probability	Correction Guaranteed	Miscorrection Probability
1 - 3	Yes	0	Yes - OTF*	0
4 - 6	Yes	0	Yes	0
7 - 12	Yes	0	No	0
13 - 18	Yes	0	No	5.2 E-20
19 - 764	No	6.8 E-49	No	5.2 E-20

Note: OTF* - corrected "on the fly"

6.3 Seek Error Rate

Maximum allowed seek errors 10 in 10^8 Seeks

6.4 Microcode Defect Rate

The interface microprocessor code target defect rate will be less than or equal to 0.150 total valid unique APARS per thousand lines of new/ changed source instructions (TVUA/KCSI) for the 60 month product life.

6.5 Power On Hours

Total Power on hours (with minimum power on/off cycles)

43,200 hours for life based on:

- 5 Power on/off cycles per month

- 720 power on hours per month

Total Power on hours (with maximum power on/off cycles)

10,140 hours for life based on:

- 90 Power on/off cycles per month

- 169 power on hours per month

6.6 Useful Life

Product Life 5 Years

Useful life is the length of time prior to the point at which product degradation begins to occur. The specification for the useful life calculation is the same as that for the *MTBF specification.

6.7 *Mean Time Between Failure (*MTBF)

The mean time to failure target is 800,000 device hours per fail (3.75% CDF) based on:

- 6000 power on hours per year (500 power on hours per month times 12 months)
- 300 average on/off cycles per year (25 power cycles per month times 12 months)
- Seeking/Reading/Writing is assumed to be 20% of power on hours (Approximately 10 read/write operations per second)
- | 15% uplift for system related causes
- Operating at normal environment (See Table 17 on page 71) and nominal voltages (See 2.2, "Power Requirements" on page 16)

Note: *MTBF - is a measure of the failure characteristics over **total product life**. *MTBF includes normal integration induced, installation, early life (latent), and intrinsic failures. *MTBF is predicated on supplier qualification, product design verification test, and field performance data.

6.8 Sample Failure Rate Projections

The following tables are for reference only. The tables contain failure rate projections for a given set of user conditions. Similar projections will be provided, upon request, for each user specific operating conditions.

Application	SCSI Electronics only - (RA/MM)				
	1st 30 days	1st 60 days	1st 90 days	30 day average over life	CDF
500POH/MM	0.001212	0.001849	0.002363	0.000390	2.34%
720POH/MM	0.001580	0.002436	0.003204	0.000562	3.37%

Table 15. Projected failure rate for the electronics only.

Application	SCSI Electronics and HDA - (RA/MM)				
	1st 30 days	1st 60 days	1st 90 days	30 day average over life	CDF
500POH/MM	0.001561	0.002465	0.003205	0.000625	3.75%
720POH/MM	0.002085	0.003314	0.004433	0.000900	5.40%

Table 16. Projected failure rate for the entire drive, (Electronics and HDA).

6.9 SPQL (Shipped product quality level)

	LA vintage	Ultimate (13th month)
Totals	.39%	.30%

6.10 Install Defect Free

Install Defect Free percentage 99.99 percent

6.11 Data lost due to DE replacement

Less than 5.4% of the total units in the field will fail due to the HDA (causing data loss) over 5 years (assuming 720 POH/MM usage). This assumes a 15% uplift for system related causes.

6.12 Periodic Maintenance

None required

6.13 ESD Protection

The **SPITFIRE** 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. 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 131˚F (5 to 55˚C)
Operating Casting Temperature 41 to 140˚F (5 to 60˚C)
Storage 34 to 149˚F (1.1 to 65˚C)
Shipping -40 to 149˚F (-40 to 65˚C)

Temperature Gradient
Operating 18˚F (10˚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)

7.1.1 Temperature Measurement Points

The following tables list measurement points and their temperatures (maximum and reliability) for the single-ended and differential SCSI models. Maximum temperatures must not be exceeded at the worst case file and system operating conditions with the file randomly seeking, reading and writing. Reliability temperatures must not be exceeded at the nominal file and system operating conditions with the file randomly seeking, reading, and writing.

Table 17. Operating Temperature Limits - Single-Ended SCSI

	Maximum	**Reliability**
Disk Enclosure Top	140˚F (60˚C)	113˚F (45˚C)
Disk Enclosure Bottom	140˚F (60˚C)	113˚F (45˚C)
PRDF Module	185˚F (85˚C)	158˚F (70˚C)
WD33C96 Module	167˚F (75˚C)	149˚F (65˚C)
ASERVO Module	167˚F (75˚C)	149˚F (65˚C)
GLUE Module	167˚F (75˚C)	149˚F (65˚C)

Note: Figure 23 on page 73 defines where measurements should be made to determine the top casting temperature during file operation and shows the location of the PRDF module for single-ended SCSI. Figure 24 on page 74 defines the modules that are located on the bottom side of the card and the measurement location on the bottom of the casting.

Table 18. Operating Temperature Limits - Differential SCSI

	Maximum	**Reliability**
Disk Enclosure Top	140˚F (60˚C)	113˚F (45˚C)
Disk Enclosure Bottom	140˚F (60˚C)	113˚F (45˚C)
PRDF Module	185˚F (85˚C)	158˚F (70˚C)
WD33C95 Module	158˚F (70˚C)	140˚F (60˚C)
ASERVO Module	167˚F (75˚C)	149˚F (65˚C)
GLUE Module	167˚F (75˚C)	149˚F (65˚C)
M23 Transceiver Module	140˚F (60˚C)	122˚F (50˚C)

Note: Figure 25 on page 75 defines where measurements should be made to determine the top casting temperature during file operation and shows the location of the PRDF module for differential SCSI. Figure 26 on page 76 defines the modules that are located on the bottom side of the card and the measurement location on the bottom of the casting.

There must be sufficient air flow through the drive so that the casting and module temperature limits defined in Table 17 on page 71 for single-ended SCSI or Table 18 for differential SCSI are not exceeded.

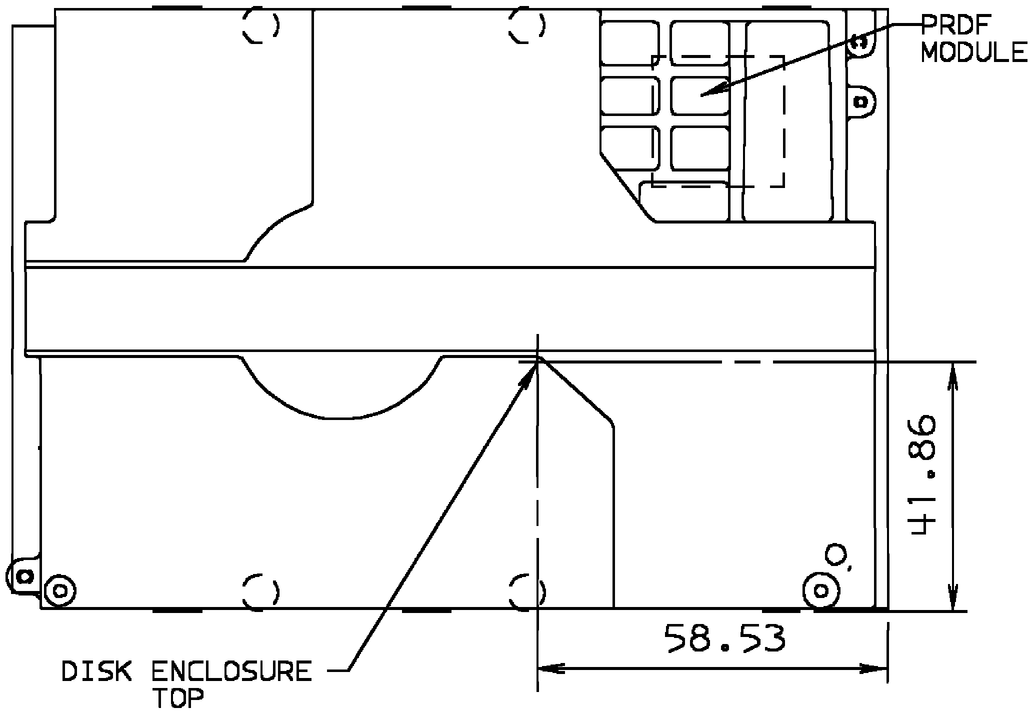


Figure 23. Temperature Measurement Points (top view)

Note: The PRDF module temperature should be measured with a thermocouple approximately centered on the top surface of the module.

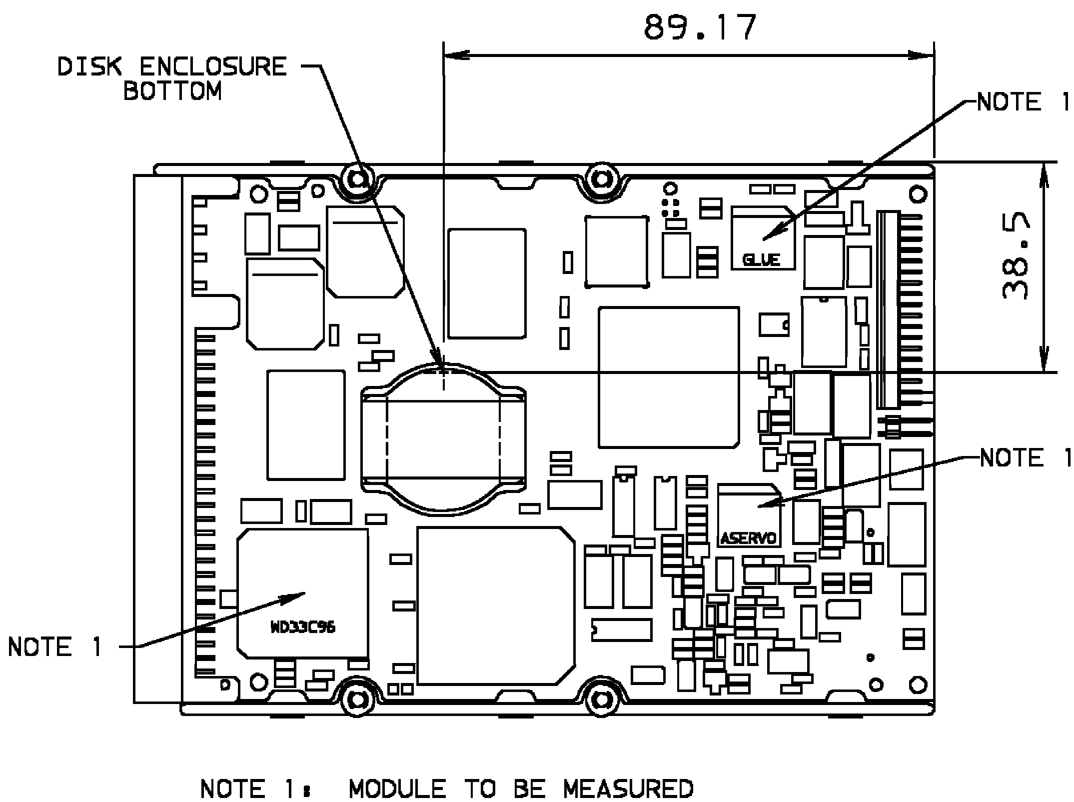


Figure 24. Temperature Measurement Points (bottom view). **See 7.1.1.1, "Module Temp. Measurement Notes" on page 76.**

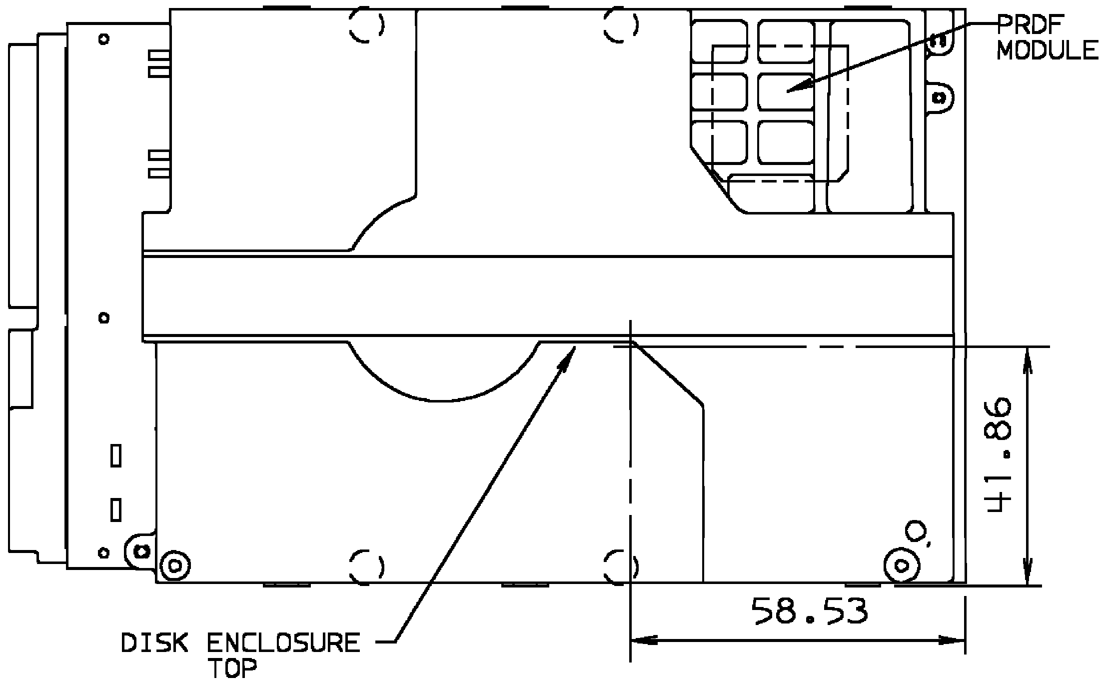


Figure 25. Temperature Measurement Points For Differential (top view)

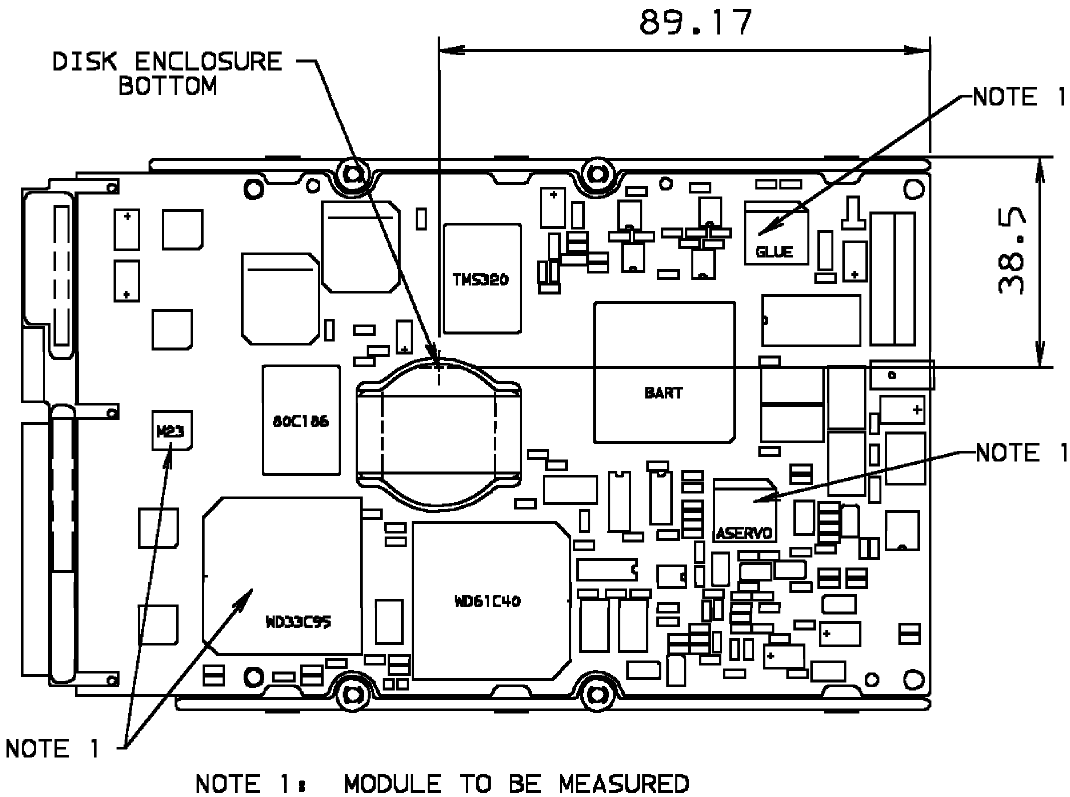


Figure 26. Temperature Measurement Points For Differential (bottom view). **See 7.1.1.1, "Module Temp. Measurement Notes" on page 76.**

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 file on 2 mm high by 10 mm diameter spacers as required by section 4.4, "Clearances" on page 43.
2. By mounting on any two opposing pairs of the 6-32 side mount holes.

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

7.2.1 Output Vibration Limits

spindle imbalance	2.0 gram-millimeters maximum

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 0662 files are sensitive to rotary vibration. Mounting within using systems should minimize the rotational input to the file mounting points during vibration.

The random and swept sine vibration levels below apply when any of the mounting holes on the file are used.

Random Vibration

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

For excitation in the z-direction, the file will meet the required throughput specifications when subjected to vibration levels not exceeding the V4S vibration level defined below.

Note: The RMS value in the table below is obtained by taking the square root of the area defined by the g^2/hz spectrum from 5 to 500 hz.

Table 19. Random Vibration Levels

Class	5 hz	17 hz	45 hz	48 hz	62 hz	65 hz	150 hz	200 hz	500 hz	RMS
V4	2.0E-5	1.1E-3	1.1E-3	8.0E-3	8.0E-3	1.0E-3	1.0E-3	8.0E-5	8.0E-5	0.56
V4S	2.0E-5	1.1E-3	1.1E-3	8.0E-3	8.0E-3	1.0E-3	1.0E-3	4.0E-5	4.0E-5	0.55
units	g^2/hz									g

Swept Sine Vibration

The file will operate without hard errors when subjected to the swept sine vibration of 1 G peak from 5 to 300 hz in the x- and y direction. For input in the z-direction, an input of 1 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.

7.2.2.1 Nonoperating Vibration

No damage will occur as long as vibration at the unpackaged drive in all three directions defined above does not exceed the levels defined in the table below. The test will consist of a sweep from 5 hz to 200 hz and back to 5 hz at a sweep rate of eight decades per hour.

Table 20. Non-operating Vibration Levels

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

7.2.3 Operating Shock

The drive will continue to operate, at the stated "Performance", when subjected to a 5 G half sine wave shock pulse of 11 milliseconds duration.

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

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

7.2.4 Nonoperating Shock

No damage will occur if the unpackaged drive is not subjected to a square wave shock greater than a "faired" value of 35 Gs applied to all three axis for a period of 20 milliseconds, one direction at a time.

Additionally, no damage will occur if the unpackaged drive is not subjected to an 11 millisecond half sine wave shock greater than 60 Gs 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)									
	Octave Band Center Frequency (Hz)							A-weighted	
	125	250	500	1K	2K	4K	8K	Maximum	Mean
Idle	4.5	3.5	3.3	3.5	4.3	4.3	4.0	4.75	4.4
Operating	4.5	4.0	3.6	4.1	4.3	4.6	4.3	5.00	4.7

Notes:

1. The above octave band and maximum sound power levels are statistical upper limits of the sound power levels. See C-B 1-1701-027 and C-S 1-1710-006 for further explanation.
2. The files are tested after a minimum of 20 minutes warm-up in idle mode.
3. The operating mode is simulated by seeking at a rate between 12 and 15 seeks per second.
4. The mean of a sample size of 10 or greater will be less than or equal to the stated mean with 95% confidence.

Additionally, the population average of the sound pressure measured one meter above the center of the drive in idle mode will not exceed 34 dB.

8. Standards

8.1 Safety

- UNDERWRITERS LABORATORY (U.L.) APPROVAL:

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

- CANADIAN STANDARDS AUTHORITY (C.S.A.) APPROVAL:

  The product is certified to CAN/CSA-C22.2 No. 950-M89 (without any D3 deviations). The CSA certification mark is located on the product.

- INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC) STANDARDS COMPLIANCE

  The product is certified to comply to EN60950 (IEC 950 with European additions) by TUV Rheinland. The Rheinland Bauart mark is located on the product.

- 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

  IBM has exercised care not to 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.

8.2 Electromagnetic Compatibility (EMC)

- FCC Requirements

  Pertaining to the ***0662*** 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 J Computing Devices "Class B Limits"**. Tests for conformance to this requirement are performed with the disk drive mounted in the using system.

- VDE Requirements

Pertaining to the ***0662*** disk drive, IBM will provide technical support to assist users in complying with the requirements of the **German Vereingung Deutcher Elektriker (VDE) 0871/6.78 Limit Class B**.

- CSPR Requirements

  Pertaining to the ***0662*** 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 B Limits"**.

8.3 Design Reference Documents

THE DOCUMENTS BELOW ARE NOT AT PRESENT MANDATORY BUT SHOULD ALL BE CONSIDERED FOR INCLUSION IN PRODUCT PLANS. IT IS PROBABLE THAT SOME MAY BECOME MANDATORY IN THE FUTURE.

2-0001-014	FAST TRANSIENT/BURST SUSCEPTIBILITY	N/A SEE NOTE 7
C-B 9005	POWER, SIGNAL AND CONTROL CABLES	

NOTES:

1. ELECTROMAGNETIC COMPATIBILITY: ADDITIONAL EMC DESIGN OBJECTIVES MUST BE PREPARED WITH THE COOPERATION AND APPROVAL OF THE LOCAL EMC COORDINATOR. WHERE THESE DESIGN OBJECTIVES ARE NOT MET, SOURCES OF EMANATIONS AND EFFECTS OF SUSCEPTIBILITY MUST BE IDENTIFIED. CONTROL TECHNIQUES ACCEPTABLE TO THE LOCAL EMC COORDINATOR MUST BE IDENTIFIED TO CONTROL POTENTIAL FIELD PROBLEMS.
2. STANDARD APPLIES TO SECOND ORDER AND MULTIPLE USAGE PRODUCTS.
3. THIS STANDARD WILL BE MEASURED, BUT ACTUAL CONFORMANCE WILL BE BY THE USING SYSTEM.
4. FILE USES DC POWER ONLY. ALL POWER AND CONTROL POWER IS PROVIDED BY THE USING SYSTEM.
5. ITEM NOT USED IN FILE.
6. NO EXTERNAL CABLES.
7. APPLIES TO USING SYSTEM.