

A decorative graphic on the left side of the page, featuring a large dashed circle, a solid blue circle, and several overlapping curved lines in blue and grey.

Product Manual

Savvio® 15K.1 FC

ST973451FC
ST936751FC

100384763
Rev. B
August 2007

©2007, Seagate Technology LLC All rights reserved.

Publication number: 100384763, Rev. B

August 2007

Seagate, Seagate Technology and the Wave logo are registered trademarks of Seagate Technology LLC in the United States and/or other countries. LD25 Series, SeaTools and SeaTDD are either trademarks or registered trademarks of Seagate Technology LLC or one of its affiliated companies in the United States and/or other countries. All other trademarks or registered trademarks are the property of their respective owners.

One gigabyte, or GB, equals one billion bytes when referring to hard drive capacity. Accessible capacity may vary depending on operating environment and formatting. Quantitative usage examples for various applications are for illustrative purposes. Actual quantities will vary based on various factors, including file size, file format, features and application software. Seagate reserves the right to change, without notice, product offerings or specifications.

Contents

1.0	Scope	1
2.0	Applicable standards and reference documentation	3
2.1	Standards	3
2.1.1	Electromagnetic compatibility	3
2.1.2	Electromagnetic compliance	4
2.2	European Union Restriction of Hazardous Substances (RoHS)	4
2.3	Reference documents	5
3.0	General description	7
3.1	Standard features	8
3.2	Media description	9
3.3	Performance	9
3.4	Reliability	9
3.5	Formatted capacities	9
3.5.1	Programmable drive capacity	10
3.6	Factory-installed accessories	10
3.7	Options	10
4.0	Performance characteristics	11
4.1	Internal drive characteristics	11
4.2	Seek performance characteristics	11
4.2.1	Access time	11
4.2.2	Format command execution time	12
4.2.3	General performance characteristics	12
4.3	Start/stop time	12
4.4	Prefetch/multi-segmented cache control	13
4.5	Cache operation	13
4.5.1	Caching write data	13
4.5.2	Prefetch operation	14
5.0	Reliability specifications	15
5.1	Error rates	15
5.1.1	Recoverable Errors	15
5.1.2	Unrecoverable Errors	16
5.1.3	Seek errors	16
5.1.4	Interface errors	16
5.2	Reliability and service	16
5.2.1	Annualized Failure Rate (AFR) and Mean Time Between Failure (MTBF)	16
5.2.2	Preventive maintenance	16
5.2.3	Hot plugging the drive	17
5.2.4	S.M.A.R.T.	17
5.2.5	Thermal monitor	18
5.2.6	Drive Self Test (DST)	19
5.2.7	Product warranty	21

6.0	Physical/electrical specifications	23
6.1	AC power requirements	23
6.2	DC power requirements	23
	6.2.1 Conducted noise immunity	25
	6.2.2 Power sequencing	25
	6.2.3 Current profiles	25
6.3	Power dissipation	27
6.4	Environmental limits	30
	6.4.1 Temperature	30
	6.4.2 Relative humidity	31
	6.4.3 Effective altitude (sea level)	31
	6.4.4 Shock and vibration	31
	6.4.5 Air cleanliness	34
	6.4.6 Corrosive environment	34
	6.4.7 Acoustics	35
	6.4.8 Electromagnetic susceptibility	35
6.5	Mechanical specifications	36
7.0	Defect and error management	37
7.1	Drive internal defects/errors	37
7.2	Drive error recovery procedures	37
7.3	FC-AL system errors	38
7.4	Background Media Scan	39
7.5	Media Pre-Scan	39
7.6	Deferred Auto-Reallocation	39
7.7	Idle Read After Write	40
8.0	Installation	41
8.1	Drive orientation	41
8.2	Cooling	41
8.3	Drive mounting	42
8.4	Grounding	42
9.0	Interface requirements	43
9.1	FC-AL features	43
	9.1.1 Fibre Channel link service frames	43
	9.1.2 Fibre Channel task management functions	44
	9.1.3 Fibre Channel task management responses	44
	9.1.4 Fibre Channel port login	45
	9.1.5 Fibre Channel port login accept	46
	9.1.6 Fibre Channel Process Login	46
	9.1.7 Fibre Channel Process Login Accept	47
	9.1.8 Fibre Channel fabric login	47
	9.1.9 Fibre Channel fabric accept login	48
	9.1.10 Fibre Channel Arbitrated Loop options	49
9.2	Dual port support	49
9.3	SCSI commands supported	50
	9.3.1 Inquiry data	55
9.4	Miscellaneous operating features and conditions	56

9.5	FC-AL physical interface	57
9.5.1	Physical characteristics	57
9.5.2	Connector requirements	58
9.5.3	Electrical description	58
9.5.4	Pin descriptions	59
9.5.5	FC-AL transmitters and receivers	60
9.5.6	Power	60
9.5.7	Fault LED Out	60
9.5.8	Active LED Out.	61
9.5.9	Enable port bypass signals	61
9.5.10	Motor start controls	61
9.5.11	SEL_6 through SEL_0 ID lines	62
9.5.12	Device control codes	64
9.6	Signal characteristics.	64
9.6.1	TTL input characteristics	64
9.6.2	Differential PECL output.	65
9.6.3	Differential PECL input.	65
10.0	Seagate Technology support services.	67

List of Figures

Figure 1.	Savvio 15K.1 family disc drive	1
Figure 2.	Typical ST973451FC drive +12V and +5V current profiles	25
Figure 3.	Typical ST936751FC drive +12V and +5V current profiles	26
Figure 4.	ST973451FC DC current and power vs. input/output operations per second at 1 Gbit	27
Figure 5.	ST973451FC DC current and power vs. input/output operations per second at 2 Gbit	27
Figure 6.	ST973451FC DC current and power vs. input/output operations per second at 4 Gbit	28
Figure 7.	ST936751FC DC current and power vs. input/output operations per second at 1 Gbit	29
Figure 8.	ST936751FC DC current and power vs. input/output operations per second at 2 Gbit	29
Figure 9.	ST936751FC DC current and power vs. input/output operations per second at 4 Gbit	30
Figure 10.	Locations of the HDA temperature check point	31
Figure 11.	Recommended mounting	33
Figure 12.	Drive dimensions (inches)	36
Figure 13.	Air flow	42
Figure 14.	Physical interface	57
Figure 15.	Port bypass circuit physical interconnect	57
Figure 16.	FC-AL SCA device connector dimensions	58
Figure 17.	FC-AL transmitters and receivers	60
Figure 18.	Transmit eye diagram	65
Figure 19.	Receive eye diagram	65

1.0 Scope

This manual describes Seagate Technology® LLC, Savvio® 15K.1 FC (Fibre Channel) disc drives.

Savvio drives support the Fibre Channel Arbitrated Loop and SCSI Fibre Channel Protocol specifications to the extent described in this manual. The *Fibre Channel Interface Manual* (part number 77767496) describes the general Fibre Channel Arbitrated Loop characteristics of this and other Seagate Fibre Channel drives.

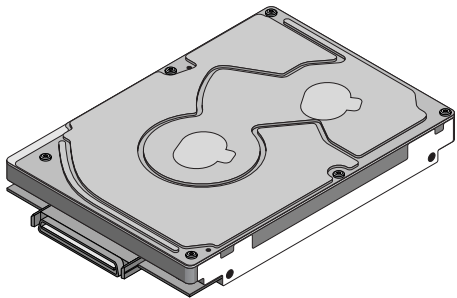


Figure 1. Savvio 15K.1 family disc drive

2.0 Applicable standards and reference documentation

The drive has been developed as a system peripheral to the highest standards of design and construction. The drive depends upon its host equipment to provide adequate power and environment in order to achieve optimum performance and compliance with applicable industry and governmental regulations. Special attention must be given in the areas of safety, power distribution, shielding, audible noise control, and temperature regulation. In particular, the drive must be securely mounted in order to guarantee the specified performance characteristics. Mounting by bottom holes must meet the requirements of Section 8.3.

2.1 Standards

The Savvio family complies with Seagate standards as noted in the appropriate sections of this manual and the Seagate *Fibre Channel Interface Manual*, part number 100293070.

The Savvio disc drive is a UL recognized component per UL1950, CSA certified to CAN/CSA C22.2 No. 950-95, and VDE or TUV certified to EN60950.

2.1.1 Electromagnetic compatibility

The drive, as delivered, is designed for system integration and installation into a suitable enclosure prior to use. As such the drive is supplied as a subassembly and is not subject to Subpart B of Part 15 of the FCC Rules and Regulations nor the Radio Interference Regulations of the Canadian Department of Communications.

The design characteristics of the drive serve to minimize radiation when installed in an enclosure that provides reasonable shielding. As such, the drive is capable of meeting the Class B limits of the FCC Rules and Regulations of the Canadian Department of Communications when properly packaged. However, it is the user's responsibility to assure that the drive meets the appropriate EMI requirements in their system. Shielded I/O cables may be required if the enclosure does not provide adequate shielding. If the I/O cables are external to the enclosure, shielded cables should be used, with the shields grounded to the enclosure and to the host controller.

2.1.1.1 Electromagnetic susceptibility

As a component assembly, the drive is not required to meet any susceptibility performance requirements. It is the responsibility of those integrating the drive within their systems to perform those tests required and design their system to ensure that equipment operating in the same system as the drive or external to the system does not adversely affect the performance of the drive. See Table 2, DC power requirements.

2.1.2 Electromagnetic compliance

Seagate uses an independent laboratory to confirm compliance with the directives/standards for CE Marking and C-Tick Marking. The drive was tested in a representative system for typical applications. The selected system represents the most popular characteristics for test platforms. The system configurations include:

- Typical current use microprocessor
- 3.5-inch floppy disc drive
- Keyboard
- Monitor/display
- Printer
- External modem
- Mouse

Although the test system with this Seagate model complies with the directives/standards, we cannot guarantee that all systems will comply. The computer manufacturer or system integrator shall confirm EMC compliance and provide the appropriate marking for their product.

Electromagnetic compliance for the European Union

If this model has the CE Marking it complies with the European Union requirements of the Electromagnetic Compatibility Directive 89/336/EEC of 03 May 1989 as amended by Directive 92/31/EEC of 28 April 1992 and Directive 93/68/EEC of 22 July 1993.

Australian C-Tick

If this model has the C-Tick Marking it complies with the Australia/New Zealand Standard AS/NZS3548 1995 and meets the Electromagnetic Compatibility (EMC) Framework requirements of Australia's Spectrum Management Agency (SMA).

Korean MIC

If this model has the Korean Ministry of Information and Communication (MIC) logo, it complies with paragraph 1 of Article 11 of the Electromagnetic Compatibility (EMC) Control Regulation and meets the Electromagnetic Compatibility Framework requirements of the Radio Research Laboratory (RRL) Ministry of Information and Communication Republic of Korea.

Taiwanese BSMI

If this model has the Chinese National Standard (CNS) 13438 marking, it complies with Chinese National Standard (CNS) 13438 and meets the Electromagnetic Compatibility (EMC) Framework requirements of the Taiwanese Bureau of Standards, Metrology, and Inspection (BSMI).

2.2 European Union Restriction of Hazardous Substances (RoHS)

The European Union Restriction of Hazardous Substances (RoHS) Directive restricts the presence of chemical substances, including Lead (Pb), in electronic products effective July 2006.

A number of parts and materials in Seagate products are procured from external suppliers. We rely on the representations of our suppliers regarding the presence of RoHS substances in these parts and materials. Our supplier contracts require compliance with our chemical substance restrictions, and our suppliers document their compliance with our requirements by providing material content declarations for all parts and materials for the disc drives documented in this publication. Current supplier declarations include disclosure of the inclusion of any RoHS-regulated substance in such parts or materials.

Seagate also has internal systems in place to ensure ongoing compliance with the RoHS Directive and all laws and regulations which restrict chemical content in electronic products. These systems include standard operating procedures that ensure that restricted substances are not utilized in our manufacturing operations, laboratory analytical validation testing, and an internal auditing process to ensure that all standard operating procedures are complied with.

2.3 Reference documents

<i>Savvio 15K.1 FC Installation Guide</i>	Seagate part number: 100384764
<i>Fibre Channel Interface Manual</i>	Seagate part number: 100293070
<i>SCSI Commands Reference Manual</i>	Seagate part number: 100293068
ANSI Fibre Channel Documents	
X3.230-1994	FC Physical and Signaling Interface (FC-PH)
X3.297.1997	FC-PH-2 Fibre Channel Physical and Signaling Interface-2
X3.303.1998	FC-PH-3 Fibre Channel Physical and Signaling Interface-3
X3.272-1996	FC Arbitrated Loop (FC-AL)
X3.269-1996	Fibre Channel Protocol for SCSI (FCP)
NCITS TR-19	Private Loop SCSI Direct Attach (PLDA)
NCITS TR-20	Fabric Loop Attachment (FC-FLA)
SFF-8045	Specification for 40-pin SCA-2 Connector with Parallel Selection
SFF-8067	Specification for 40-pin SCA-2 Connector with Bidirectional Enclosure Services Interface
ANSI Small Computer System Interface (SCSI) Documents	
X3.270-1996	(SCSI-3) Architecture Model
NCITS 305-199X	(SCSI-3) Enclosure Services
<i>Specification for Acoustic Test Requirement and Procedures</i>	
	Seagate part number: 30553-001
Package Test Specification	Seagate P/N 30190-001 (under 100 lb.)
Package Test Specification	Seagate P/N 30191-001 (over 100 lb.)

In case of conflict between this document and any referenced document, this document takes precedence.

3.0 General description

Savvio drives combine Tunneling Magnetoresistive (TMR) heads and a Fibre Channel interface to provide high performance, high capacity data storage for a variety of systems including engineering workstations, network servers, mainframes, and supercomputers. Savvio drives also support 4-Gbit Fibre Channel which can transfer data at up to 400 Mbytes per second and 800 Mbytes per second in dual-loop configurations.

Savvio drives support the Fibre Channel Arbitrated Loop (FC-AL) and SCSI Fibre Channel Protocol as described in the ANSI specifications, this document, the *SCSI Commands Reference Manual* (part number 100293068), and the *Fibre Channel Interface Manual* (part number 100293070) which describes the general interface characteristics of this drive. Savvio drives are classified as intelligent peripherals and provide level 2 conformance (highest level) with the ANSI SCSI-1 standard.

Note. Never disassemble the HDA and do not attempt to service items in the sealed enclosure (heads, media, actuator, etc.) as this requires special facilities. The drive does not contain user-replaceable parts. Opening the HDA for any reason voids your warranty.

Savvio drives use a dedicated landing zone at the innermost radius of the media to eliminate the possibility of destroying or degrading data by landing in the data zone. The heads automatically go to the landing zone when power is removed from the drive.

An automatic shipping lock prevents potential damage to the heads and discs that results from movement during shipping and handling. The shipping lock disengages and the head load process begins when power is applied to the drive.

The drives also use a high-performance actuator assembly with a low-inertia, balanced, patented, straight arm design that provides excellent performance with minimal power dissipation.

3.1 Standard features

Savvio drives have the following standard features:

- Perpendicular recording technology
- 4-Gbit Fibre Channel interface. For 4 gigabit operation, the block size must be divisible by 8
- Integrated dual port FC-AL controller
- Concurrent dual port transfers
- Support for FC arbitrated loop, private and public attachment
- Differential copper FC drivers and receivers
- Downloadable firmware using the FC-AL interface
- Supports SCSI enclosure services via interface connector
- 128-deep task set (queue)
- Supports up to 32 initiators
- Drive selection ID and configuration options are set on the FC-AL backpanel or through interface commands. Jumpers are not used on the drive.
- Fibre Channel worldwide name uniquely identifies the drive and each port
- User-selectable logical block size (512, 520, 524, or 528 bytes per logical block)
- Selectable frame sizes from 256 to 2,112 bytes
- Industry standard SFF 2.5-inch dimensions
- Programmable logical block reallocation scheme
- Flawed logical block reallocation at format time
- Programmable auto write and read reallocation
- No preventive maintenance or adjustments required
- Dedicated head landing zone
- Embedded servo design
- Automatic shipping lock
- Self-diagnostics performed when power is applied to the drive
- Zone bit recording (ZBR)
- Vertical, horizontal, or top down mounting
- Dynamic spindle brake
- 16 Mbyte data buffer (see Section 4.5).
- Drive Self Test (DST)
- BackGround Media Scan (BGMS)
- Idle Read After Write (IRAW)
- Power Save

3.2 Media description

The media used on the drive has an aluminum substrate coated with a thin film magnetic material, overcoated with a proprietary protective layer for improved durability and environmental protection.

3.3 Performance

- Firmware-controlled multisegmented cache designed to dynamically adjust segments for enhanced system performance.
- 400 Mbytes/sec maximum instantaneous data transfers per port
- 15k RPM spindle; average latency = 2.0 msec
- Background processing of queue
- Supports start and stop commands (spindle stops spinning)
- Adaptive seek velocity; improved seek performance

3.4 Reliability

- Annualized Failure Rate (AFR) of 0.55%
- Mean Time Between Failures (MTBF) of 1,600,000 hours
- Incorporates industry-standard Self-Monitoring Analysis and Reporting Technology (S.M.A.R.T.)
- 5-year warranty

3.5 Formatted capacities

Standard OEM models are formatted to 512 bytes per block. The block size is selectable at format time and must be a multiple of 4 bytes. Users having the necessary equipment may modify the data block size before issuing a format command and obtain different formatted capacities than those listed.

To provide a stable target capacity environment and at the same time provide users with flexibility if they choose, Seagate recommends product planning in one of two modes:

1. Seagate designs specify capacity points at certain sector sizes that Seagate guarantees current and future products will meet. We recommend customers use this capacity in their project planning, as it ensures a stable operating point with backward and forward compatibility from generation to generation. The current guaranteed operating points for this product are:

Sector Size	ST973451FC		ST936751FC	
	Decimal	Hex	Decimal	Hex
512	143,374,744	88BB998h	71,687,372	445DCCCh
520	140,395,093	85E4255h	70,197,547	42F212Bh
524	137,577,184	83342E0h	68,766,592	4194B80h
528	136,331,467	82040CBh	68,165,733	4102065h

2. Seagate drives also may be used at the maximum available capacity at a given sector size, but the excess capacity above the guaranteed level will vary between other drive families and from generation to generation, depending on how each sector size actually formats out for zone frequencies and splits over servo bursts. This added capacity potential may range from 0.1 to 1.3 percent above the guaranteed capacities listed above. Using the drives in this manner gives the absolute maximum capacity potential, but the user must determine if the extra capacity potential is useful, or whether their assurance of backward and forward compatibility takes precedence.

3.5.1 Programmable drive capacity

Using the Mode Select command, the drive can change its capacity to something less than maximum. See the Mode Select (6) parameter list table in the *Fibre Channel Interface Manual*, part number 100293070. Refer to the Parameter list block descriptor number of blocks field. A value of zero in the number of blocks field indicates that the drive shall not change the capacity it is currently formatted to have. A number in the number of blocks field that is less than the maximum number of LBAs changes the total drive capacity to the value in the block descriptor number of blocks field. A value greater than the maximum number of LBAs is rounded down to the maximum capacity.

3.6 Factory-installed accessories

OEM standard drives are shipped with the *Savvio 15K.1 FC Installation Guide* (part number 100384764) and the *Safety and Regulatory Agency Specifications*, part number 75789512 (unless otherwise specified).

3.7 Options

You may order the following items which are incorporated at the manufacturing facility during production or packaged before shipping. Some of the options available are (not an exhaustive list of possible options):

- Other capacities can be ordered depending on sparing scheme and sector size requested.
- Single-unit shipping pack. The drive is normally shipped in bulk packaging to provide maximum protection against transit damage. Units shipped individually require additional protection as provided by the single unit shipping pack. Users planning single unit distribution should specify this option.
- The *Savvio 15K.1 FC Installation Guide*, part number 100384764, is usually included with each standard OEM drive shipped, but extra copies may be ordered.
- The *Safety and Regulatory Agency Specifications*, part number 75789512, is usually included with each standard OEM drive shipped, but extra copies may be ordered.

4.0 Performance characteristics

This section provides detailed information concerning performance-related characteristics and features of Savvio drives.

4.1 Internal drive characteristics

	ST973451FC	ST936751FC	
Drive capacity	73.4	36.2	Gbytes (formatted, rounded off value)
Read/write data heads	4	2	
Tracks per surface (total)	42,554	42,554	Tracks (user accessible)
Tracks per inch	150	150	kTPI (average)
Peak bits per inch	861.81	861.81	kBPI
Areal Density	130.58	130.58	Gbit/in ²
Internal data rate	957.51 to 1,282.08	957.51 to 1,282.08	Mbits/sec (variable with zone)
Sustained data transfer rate	57-89	57-89	Mbytes/sec (variable with zone)
Disc rotation speed	15k	15k	revolutions/min (RPM)
Avg rotational latency	2.0	2.0	msec

4.2 Seek performance characteristics

See Section 9.5, "FC-AL physical interface" on page 57 and the *Fibre Channel Interface Manual* (part number 100293070) for additional timing details.

4.2.1 Access time

		Not Including controller overhead ^{1,2} (msec)	
		Read	Write
Average	Typical ^{3,4}	2.6	3.1
Single track	Typical ^{3,4}	0.2	0.4
Full stroke	Typical ^{3,4}	4.9	5.5

1. Execution time measured from receipt of the FCP Command to the FCP Response.
2. Assumes no errors and no sector has been relocated.
3. Typical access times are measured under nominal conditions of temperature, voltage, and horizontal orientation as measured on a representative sample of drives.
4. Access to data = access time + latency time.

4.2.2 Format command execution time

	ST973451FC	ST936751FC
Maximum (with verify)	52 minutes	26 minutes
Maximum (without verify)	35 minutes	18 minutes

4.2.3 General performance characteristics

Sustained transfer rate	79 to 112 Mbytes/sec
Fibre Channel Interface maximum instantaneous transfer rate	400 Mbytes/sec* per port (dual port = 800 Mbytes/sec*)
Logical block sizes	
- 512 (default)	
- 520	
- 524	
- 528	
Read/write consecutive sectors on a track	Yes
Flaw reallocation performance impact (for flaws reallocated at format time using the spare sectors per sparing zone reallocation scheme.)	Negligible
Average rotational latency	2.0 msec

*Assumes no errors and no relocated logical blocks. Rate measured from the start of the first logical block transfer to or from the host.

4.3 Start/stop time

The drive accepts the commands listed in the SAS Interface Manual less than 3 seconds after DC power has been applied.

If the drive receives a NOTIFY (ENABLE SPINUP) primitive through either port and has not received a START STOP UNIT command with the START bit equal to 0, the drive becomes ready for normal operations within 20 seconds (excluding the error recovery procedure).

If the drive receives a START STOP UNIT command with the START bit equal to 0 before receiving a NOTIFY (ENABLE SPINUP) primitive, the drive waits for a START STOP UNIT command with the START bit equal to 1. After receiving a START STOP UNIT command with the START bit equal to 1, the drive waits for a NOTIFY (ENABLE SPINUP) primitive. After receiving a NOTIFY (ENABLE SPINUP) primitive through either port, the drive becomes ready for normal operations within 20 seconds (excluding the error recovery procedure).

If the drive receives a START STOP UNIT command with the START bit and IMMED bit equal to 1 and does not receive a NOTIFY (ENABLE SPINUP) primitive within 5 seconds, the drive fails the START STOP UNIT command.

The START STOP UNIT command may be used to command the drive to stop the spindle. Stop time is 30 seconds (maximum) from removal of DC power. There is no power control switch on the drive.

4.4 Prefetch/multi-segmented cache control

The drive provides a prefetch (read look-ahead) and multi-segmented cache control algorithms that in many cases can enhance system performance. Cache refers to the drive buffer storage space when it is used in cache operations. To select this feature, the host sends the Mode Select command with the proper values in the applicable bytes in page 08h. Prefetch and cache operations are independent features from the standpoint that each is enabled and disabled independently using the Mode Select command; however, in actual operation, the prefetch feature overlaps cache operation somewhat as described in sections 4.5.1 and 4.5.2.

4.5 Cache operation

Note. Refer to the *Fibre Channel Interface Manual* for more detail concerning the cache bits.

Of the 16 Mbytes physical buffer space in the drive, approximately 13,000 Kbytes can be used as a cache. The buffer can be divided into logical segments from which data is read and to which data is written.

The drive keeps track of the logical block addresses of the data stored in each segment of the buffer. If the cache is enabled (see RCD bit in the *Fibre Channel Interface Manual*), data requested by the host with a read command is retrieved from the buffer, if possible, before any disc access is initiated. If cache operation is not enabled, the buffer (still segmented with the required number of segments) is still used, but only as circular buffer segments during disc medium read operations (disregarding Prefetch operation for the moment). That is, the drive does not check in the buffer segments for the requested read data, but goes directly to the medium to retrieve it. The retrieved data merely passes through some buffer segment on the way to the host. On a cache miss, all data transfers to the host are in accordance with buffer-full ratio rules. On a cache hit, the drive ignores the buffer-full ratio rules. See the explanation provided with the information about Mode Page 02h (disconnect/reconnect control) in the *Fibre Channel Interface Manual*.

The following is a simplified description of the prefetch/cache operation:

Case A—read command is received and the first logical block is already in the cache:

1. Drive transfers the requested logical blocks to the initiator.

Case B—A Read command requests data, and at least one requested logical block is not in any segment of the cache:

1. The drive fetches the requested logical blocks from the disc and transfers them into a segment, and then from there to the host in accordance with the Mode Select Disconnect/Reconnect parameters, page 02h.
2. If the prefetch feature is enabled, refer to section 4.5.2 for operation from this point.

Each cache segment is actually a self-contained circular buffer whose length is an integer number of logical blocks. The drive dynamically creates and removes segments based on the workload. The wrap-around capability of the individual segments greatly enhances the cache's overall performance.

Note. The size of each segment is not reported by Mode Sense command page 08h, bytes 14 and 15. The value 0XFFFF is always reported regardless of the actual size of the segment. Sending a size specification using the Mode Select command (bytes 14 and 15) does not set up a new segment size. If the STRICT bit in Mode page 00h (byte 2, bit 1) is set to one, the drive responds as it does for any attempt to change an unchangeable parameter.

4.5.1 Caching write data

Write caching is a write operation by the drive that makes use of a drive buffer storage area where the data to be written to the medium is stored while the drive performs the Write command.

If read caching is enabled (RCD=0), then data written to the medium is retained in the cache to be made available for future read cache hits. The same buffer space and segmentation is used as set up for read functions. The buffer segmentation scheme is set up or changed independently, having nothing to do with the state of RCD. When a write command is issued, if RCD=0, the cache is first checked to see if any logical blocks that are to be written are already stored in the cache from a previous read or write command. If there are, the respective cache segments are cleared. The new data is cached for subsequent Read commands.

If the number of write data logical blocks exceed the size of the segment being written into, when the end of the segment is reached, the data is written into the beginning of the same cache segment, overwriting the data that was written there at the beginning of the operation; however, the drive does not overwrite data that has not yet been written to the medium.

If write caching is enabled (WCE=1), then the drive may return Good status on a write command after the data has been transferred into the cache, but before the data has been written to the medium. If an error occurs while writing the data to the medium, and Good status has already been returned, a deferred error will be generated.

The Synchronize Cache command may be used to force the drive to write all cached write data to the medium. Upon completion of a Synchronize Cache command, all data received from previous write commands will have been written to the medium.

Table 19 shows the mode default settings for the drive.

4.5.2 Prefetch operation

If the Prefetch feature is enabled, data in contiguous logical blocks on the disc immediately beyond that which was requested by a Read command are retrieved and stored in the buffer for immediate transfer from the buffer to the host on subsequent Read commands that request those logical blocks (this is true even if cache operation is disabled). Though the prefetch operation uses the buffer as a cache, finding the requested data in the buffer is a prefetch hit, not a cache operation hit.

To enable Prefetch, use Mode Select page 08h, byte 12, bit 5 (Disable Read Ahead - DRA bit). DRA bit = 0 enables prefetch.

The drive does not use the Max Prefetch field (bytes 8 and 9) or the Prefetch Ceiling field (bytes 10 and 11).

When prefetch (read look-ahead) is enabled (enabled by DRA = 0), the drive enables prefetch of contiguous blocks from the disc when it senses that a prefetch hit will likely occur. The drive disables prefetch when it decides that a prefetch hit is not likely to occur.

5.0 Reliability specifications

The following reliability specifications assume correct host and drive operational interface, including all interface timings, power supply voltages, environmental requirements and drive mounting constraints.

Seek error rate	Less than 10 errors in 10^8 seeks
Read Error Rates ¹	
Recovered Data	Less than 10 errors in 10^{12} bits transferred (OEM default settings)
Unrecovered Data	Less than 1 sector in 10^{16} bits transferred
Miscorrected Data	Less than 1 sector in 10^{21} bits transferred
Interface error rate	Less than 1 error in 10^{12} bits transferred with minimum receive eye. Less than 1 error in 10^{14} bits transferred with typical receive eye. See Section 9.6.3, "Differential PECL input." on page 65
MTBF	1,600,000 hours
Annualized Failure Rate (AFR)	0.55%
Preventive maintenance	None required

1. Error rate specified with automatic retries and data correction with ECC enabled and all flaws reallocated.

5.1 Error rates

The error rates stated in this manual assume the following:

- The drive is operated in accordance with this manual using DC power as defined in paragraph 6.2, "DC power requirements."
- Errors caused by host system failures are excluded from error rate computations.
- Assume random data.
- Default OEM error recovery settings are applied. This includes AWRE, ARRE, full read retries, full write retries and full retry time.

5.1.1 Recoverable Errors

Recoverable errors are those detected and corrected by the drive, and do not require user intervention.

Recoverable Data errors will use correction, although ECC on-the-fly is not considered for purposes of recovered error specifications.

Recovered Data error rate is determined using read bits transferred for recoverable errors occurring during a read, and using write bits transferred for recoverable errors occurring during a write.

5.1.2 Unrecoverable Errors

An unrecoverable data error is defined as a failure of the drive to recover data from the media. These errors occur due to head/media or write problems. Unrecoverable data errors are only detected during read operations, but not caused by the read. If an unrecoverable data error is detected, a MEDIUM ERROR (03h) in the Sense Key will be reported. Multiple unrecoverable data errors resulting from the same cause are treated as 1 error.

5.1.3 Seek errors

A seek error is defined as a failure of the drive to position the heads to the addressed track. After detecting an initial seek error, the drive automatically performs an error recovery process. If the error recovery process fails, a seek positioning error (Error code = 15h or 02h) will be reported with a Hardware error (04h) in the Sense Key. Recoverable seek errors are specified at Less than 10 errors in 10^8 seeks. Unrecoverable seek errors (Sense Key = 04h) are classified as drive failures.

5.1.4 Interface errors

An interface error is defined as a failure of the receiver on a port to recover the data as transmitted by the device port connected to the receiver. The error may be detected as a running disparity error, illegal code, loss of word sync, or CRC error. The total error rate for a loop of devices is the sum of the individual device error rates.

5.2 Reliability and service

You can enhance the reliability of Savvio disc drives by ensuring that the drive receives adequate cooling. Section 6.0 provides temperature measurements and other information that may be used to enhance the service life of the drive. Section 8.1 provides recommended air-flow information.

5.2.1 Annualized Failure Rate (AFR) and Mean Time Between Failure (MTBF)

The production disc drive achieves an AFR of 0.55% (MTBF of 1,600,000 hours) when operated in an environment that ensures the case temperatures do not exceed the values specified in Section 6.4.1. Operation at case temperatures outside the specifications in Section 6.4, "Environmental limits", may increase the product AFR (decrease the MTBF). The AFR is a population statistic not relevant to individual units.

The AFR specification is based on the following assumptions for Business Critical Storage System environments:

- 8,760 power-on hours per year
- 250 average on/off cycles per year
- Operating at nominal voltages
- System will provide adequate cooling to ensure the case temperatures specified in Section 6.4 are not exceeded. Temperatures outside the specifications in Section 6.4 may increase the product AFR and decrease the MTBF.

5.2.2 Preventive maintenance

No routine scheduled preventive maintenance is required.

5.2.3 Hot plugging the drive

Inserting and removing the drive on the FC-AL will interrupt loop operation. The interruption occurs when the receiver of the next device in the loop must synchronize to a different input signal. FC error detection mechanisms, character sync, running disparity, word sync, and CRC are able to detect any error. Recovery is initiated based on the type of error.

The disc drive defaults to the FC-AL Monitoring state, Pass-through state, when it is powered-on by switching the power or hot plugged. The control line to an optional port bypass circuit (external to the drive), defaults to the Enable Bypass state. If the bypass circuit is present, the next device in the loop will continue to receive the output of the previous device to the newly inserted device. If the bypass circuit is not present, loop operation is temporarily disrupted until the next device starts receiving the output from the newly inserted device and regains synchronization to the new input.

The Pass-through state is disabled while the drive performs self test of the FC interface. The control line for an external port bypass circuit remains in the Enable Bypass state while self test is running. If the bypass circuit is present, loop operation may continue. If the bypass circuit is not present, loop operation will be halted while the self test of the FC interface runs.

When the self test completes successfully, the control line to the bypass circuit is disabled and the drive enters the FC-AL Initializing state. The receiver on the next device in the loop must synchronize to output of the newly inserted drive.

If the self-test fails, the control line to the bypass circuit remains in the Enable Bypass state.

Note. It is the responsibility of the systems integrator to assure that no temperature, energy, voltage hazard, or ESD potential hazard is presented during the hot connect/disconnect operation. Discharge the static electricity from the drive carrier prior to inserting it into the system.

Caution. The drive motor must come to a complete stop prior to changing the plane of operation. This time is required to insure data integrity.

5.2.4 S.M.A.R.T.

S.M.A.R.T. is an acronym for Self-Monitoring Analysis and Reporting Technology. This technology is intended to recognize conditions that indicate imminent drive failure and is designed to provide sufficient warning of a failure to allow you to back up the data before an actual failure occurs.

Note. The drive's firmware monitors specific attributes for degradation over time but can't predict instantaneous drive failures.

Each monitored attribute has been selected to monitor a specific set of failure conditions in the operating performance of the drive and the thresholds are optimized to minimize "false" and "failed" predictions.

Controlling S.M.A.R.T.

The operating mode of S.M.A.R.T. is controlled by the DEXCPT and PERF bits on the Informational Exceptions Control mode page (1Ch). Use the DEXCPT bit to enable or disable the S.M.A.R.T. feature. Setting the DEXCPT bit disables all S.M.A.R.T. functions. When enabled, S.M.A.R.T. collects on-line data as the drive performs normal read and write operations. When the PERF bit is set, the drive is considered to be in "On-line Mode Only" and will not perform off-line functions.

You can measure off-line attributes and force the drive to save the data by using the Rezero Unit command. Forcing S.M.A.R.T. resets the timer so that the next scheduled interrupt is in two hours.

You can interrogate the drive through the host to determine the time remaining before the next scheduled measurement and data logging process occurs. To accomplish this, issue a Log Sense command to log page 0x3E. This allows you to control when S.M.A.R.T. interruptions occur. Forcing S.M.A.R.T. with the RTZ command resets the timer.

Performance impact

S.M.A.R.T. attribute data is saved to the disc so that the events that caused a predictive failure can be recreated. The drive measures and saves parameters once every two hours subject to an idle period on the FC-AL bus. The process of measuring off-line attribute data and saving data to the disc is uninterruptable. The maximum on-line only processing delay is summarized below:

Maximum processing delay

	On-line only delay DEXCPT = 0, PERF = 1	Fully-enabled delay DEXCPT = 0, PERF = 0
S.M.A.R.T. delay times	50 milliseconds	300 milliseconds

Reporting control

Reporting is controlled by the MRIE bits in the Informational Exceptions Control mode page (1Ch). Subject to the reporting method, the firmware will issue to the host an 01-5Dxx sense code. The error code is preserved through bus resets and power cycles.

Determining rate

S.M.A.R.T. monitors the rate at which errors occur and signals a predictive failure if the rate of degraded errors increases to an unacceptable level. To determine rate, error events are logged and compared to the number of total operations for a given attribute. The interval defines the number of operations over which to measure the rate. The counter that keeps track of the current number of operations is referred to as the Interval Counter.

S.M.A.R.T. measures error rates. All errors for each monitored attribute are recorded. A counter keeps track of the number of errors for the current interval. This counter is referred to as the Failure Counter.

Error rate is the number of errors per operation. The algorithm that S.M.A.R.T. uses to record rates of error is to set thresholds for the number of errors and their interval. If the number of errors exceeds the threshold before the interval expires, the error rate is considered to be unacceptable. If the number of errors does not exceed the threshold before the interval expires, the error rate is considered to be acceptable. In either case, the interval and failure counters are reset and the process starts over.

Predictive failures

S.M.A.R.T. signals predictive failures when the drive is performing unacceptably for a period of time. The firmware keeps a running count of the number of times the error rate for each attribute is unacceptable. To accomplish this, a counter is incremented each time the error rate is unacceptable and decremented (not to exceed zero) whenever the error rate is acceptable. If the counter continually increments such that it reaches the predictive threshold, a predictive failure is signaled. This counter is referred to as the Failure History Counter. There is a separate Failure History Counter for each attribute.

5.2.5 Thermal monitor

Savvio drives implement a temperature warning system which:

1. Signals the host if the temperature exceeds a value which would threaten the drive.
2. Signals the host if the temperature exceeds a user-specified value.
3. Saves a S.M.A.R.T. data frame on the drive which exceeds the threatening temperature value.

A temperature sensor monitors the drive temperature and issues a warning over the interface when the temperature exceeds a set threshold. The temperature is measured at power-up and then at ten-minute intervals after power-up.

The thermal monitor system generates a warning code of 01-0B01 when the temperature exceeds the specified limit in compliance with the SCSI standard. The drive temperature is reported in the FRU code field of mode sense data. You can use this information to determine if the warning is due to the temperature exceeding the drive threatening temperature or the user-specified temperature.

This feature is controlled by the Enable Warning (EWasc) bit, and the reporting mechanism is controlled by the Method of Reporting Informational Exceptions field (MRIE) on the Informational Exceptions Control (IEC) mode page (1Ch).

The current algorithm implements two temperature trip points. The first trip point is set at 68°C which is the maximum temperature limit according to the drive specification. The second trip point is user-selectable using the Log Select command. The reference temperature parameter in the temperature log page (see Table 1) can be used to set this trip point. The default value for this drive is 68°C, however, you can set it to any value in the range of 0 to 65°C. If you specify a temperature greater than 68°C in this field, the temperature is rounded down to 65°C. A sense code is sent to the host to indicate the rounding of the parameter field.

Table 1: Temperature Log Page (0Dh)

Parameter Code	Description
0000h	Primary Temperature
0001h	Reference Temperature

5.2.6 Drive Self Test (DST)

Drive Self Test (DST) is a technology designed to recognize drive fault conditions that qualify the drive as a failed unit. DST validates the functionality of the drive at a system level.

There are two test coverage options implemented in DST:

1. Extended test
2. Short test

The most thorough option is the extended test that performs various tests on the drive and scans every logical block address (LBA) of the drive. The short test is time-restricted and limited in length—it does not scan the entire media surface, but does some fundamental tests and scans portions of the media.

If DST encounters an error during either of these tests, it reports a fault condition. If the drive fails the test, remove it from service and return it to Seagate for service.

5.2.6.1 DST failure definition

The drive will present a “diagnostic failed” condition through the self-tests results value of the diagnostic log page if a functional failure is encountered during DST. The channel and servo parameters are not modified to test the drive more stringently, and the number of retries are not reduced. All retries and recovery processes are enabled during the test. If data is recoverable, no failure condition will be reported regardless of the number of retries required to recover the data.

The following conditions are considered DST failure conditions:

- Seek error after retries are exhausted
- Track-follow error after retries are exhausted
- Read error after retries are exhausted
- Write error after retries are exhausted

Recovered errors will not be reported as diagnostic failures.

5.2.6.2 Implementation

This section provides all of the information necessary to implement the DST function on this drive.

5.2.6.2.1 State of the drive prior to testing

The drive must be in a ready state before issuing the Send Diagnostic command. There are multiple reasons why a drive may not be ready, some of which are valid conditions, and not errors. For example, a drive may be in process of doing a format, or another DST. It is the responsibility of the host application to determine the “not ready” cause.

While not technically part of DST, a Not Ready condition also qualifies the drive to be returned to Seagate as a failed drive.

A Drive Not Ready condition is reported by the drive under the following conditions:

- Motor will not spin
- Motor will not lock to speed
- Servo will not lock on track
- Drive cannot read configuration tables from the disc

In these conditions, the drive responds to a Test Unit Ready command with an 02/04/00 or 02/04/03 code.

5.2.6.2.2 Invoking DST

To invoke DST, submit the Send Diagnostic command with the appropriate Function Code (001b for the short test or 010b for the extended test) in bytes 1, bits 5, 6, and 7.

5.2.6.2.3 Short and extended tests

DST has two testing options:

1. short
2. extended

These testing options are described in the following two subsections.

Each test consists of three segments: an electrical test segment, a servo test segment, and a read/verify scan segment.

Short test (Function Code: 001b)

The purpose of the short test is to provide a time-limited test that tests as much of the drive as possible within 120 seconds. The short test does not scan the entire media surface, but does some fundamental tests and scans portions of the media. A complete read/verify scan is not performed and only factual failures will report a fault condition. This option provides a quick confidence test of the drive.

Extended test (Function Code: 010b)

The objective of the extended test option is to empirically test critical drive components. For example, the seek tests and on-track operations test the positioning mechanism. The read operation tests the read head element and the media surface. The write element is tested through read/write/read operations. The integrity of the media is checked through a read/verify scan of the media. Motor functionality is tested by default as a part of these tests.

The anticipated length of the Extended test is reported through the Control Mode page.

5.2.6.2.4 Log page entries

When the drive begins DST, it creates a new entry in the Self-test Results Log page. The new entry is created by inserting a new self-test parameter block at the beginning of the self-test results log parameter section of the log page. Existing data will be moved to make room for the new parameter block. The drive reports 20 parameter blocks in the log page. If there are more than 20 parameter blocks, the least recent parameter block will be deleted. The new parameter block will be initialized as follows:

1. The Function Code field is set to the same value as sent in the DST command
2. The Self-Test Results Value field is set to Fh
3. The drive will store the log page to non-volatile memory

After a self-test is complete or has been aborted, the drive updates the Self-Test Results Value field in its Self-Test Results Log page in non-volatile memory. The host may use Log Sense to read the results from up to the last 20 self-tests performed by the drive. The self-test results value is a 4-bit field that reports the results of the test. If the field is set to zero, the drive passed with no errors detected by the DST. If the field is not set to zero, the test failed for the reason reported in the field.

The drive will report the failure condition and LBA (if applicable) in the Self-test Results Log parameter. The Sense key, ASC, ASCQ, and FRU are used to report the failure condition.

5.2.6.2.5 Abort

There are several ways to abort a diagnostic. You can use a SCSI Bus Reset or a Bus Device Reset message to abort the diagnostic.

You can abort a DST executing in background mode by using the abort code in the DST Function Code field. This will cause a 01 (self-test aborted by the application client) code to appear in the self-test results values log. All other abort mechanisms will be reported as a 02 (self-test routine was interrupted by a reset condition).

5.2.7 Product warranty

Beginning on the date of shipment to the customer and continuing for the period specified in your purchase contract, Seagate warrants that each product (including components and subassemblies) that fails to function properly under normal use due to defect in materials or workmanship or due to nonconformance to the applicable specifications will be repaired or replaced, at Seagate's option and at no charge to the customer, if returned by customer at customer's expense to Seagate's designated facility in accordance with Seagate's warranty procedure. Seagate will pay for transporting the repair or replacement item to the customer. For more detailed warranty information, refer to the standard terms and conditions of purchase for Seagate products on your purchase documentation.

The remaining warranty for a particular drive can be determined by calling Seagate Customer Service at 1-800-468-3472. You can also determine remaining warranty using the Seagate web site (www.seagate.com). The drive serial number is required to determine remaining warranty information.

Shipping

When transporting or shipping a drive, use only a Seagate-approved container. Keep your original box. Seagate approved containers are easily identified by the Seagate Approved Package label. Shipping a drive in a non-approved container voids the drive warranty.

Seagate repair centers may refuse receipt of components improperly packaged or obviously damaged in transit. Contact your authorized Seagate distributor to purchase additional boxes. Seagate recommends shipping by an air-ride carrier experienced in handling computer equipment.

Product repair and return information

Seagate customer service centers are the only facilities authorized to service Seagate drives. Seagate does not sanction any third-party repair facilities. Any unauthorized repair or tampering with the factory seal voids the warranty.

6.0 Physical/electrical specifications

This section provides information relating to the physical and electrical characteristics of the drive.

6.1 AC power requirements

None.

6.2 DC power requirements

The voltage and current requirements for a single drive are shown below. Values indicated apply at the drive connector.

Table 2: DC power requirements for ST973451FC

	Notes	ST973451FC (1 Gbit)		ST973451FC (2 Gbit)		ST973451FC (4 Gbit)	
		(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)
Voltage		+5V	+12V [2]	+5V	+12V [2]	+5V	+12V [2]
Regulation	[5]	±5%	±5% [2]	±5%	±5% [2]	±5%	±5% [2]
Avg idle current $DC\bar{X}$	[1] [7]	0.64	0.19	0.65	0.19	0.72	0.19
Maximum starting current							
(peak DC) DC	3 σ [3]	0.72	1.19	0.74	1.19	0.80	1.19
(peak AC) AC	3 σ [3]	1.00	1.75	0.99	1.71	1.07	1.73
Delayed motor start (max) DC	3 σ [1] [4]	0.51	0.02	0.53	0.02	0.59	0.02
Peak operating current:							
Typical $DC\bar{X}$	[1] [6]	0.65	0.37	0.67	0.37	0.73	0.36
Maximum DC	3 σ [1]	0.65	0.39	0.67	0.39	0.74	0.37
Maximum (peak) DC	3 σ	1.28	1.16	1.34	1.16	1.38	1.16

Table 3: DC power requirements for ST936751FC

	Notes	ST936751FC (1 Gbit)		ST936751FC (2 Gbit)		ST936751FC (4 Gbit)	
		(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)
Voltage		+5V	+12V [2]	+5V	+12V [2]	+5V	+12V [2]
Regulation	[5]	±5%	±5% [2]	±5%	±5% [2]	±5%	±5% [2]
Avg idle current DC \bar{X}	[1] [7]	0.71	0.15	0.72	0.15	0.79	0.15
Maximum starting current							
(peak DC) DC	3 σ [3]	0.74	1.08	0.76	1.07	0.84	1.07
(peak AC) AC	3 σ [3]	1.23	1.49	1.32	1.49	1.06	1.46
Delayed motor start (max) DC	3 σ [1] [4]	0.42	0.01	0.44	0.01	0.51	0.02
Peak operating current:							
Typical DC \bar{X}	[1] [6]	0.67	0.34	0.69	0.34	0.73	0.34
Maximum DC	3 σ [1]	0.67	0.37	0.71	0.36	0.77	0.36
Maximum (peak) DC	3 σ	1.36	1.12	1.40	1.10	1.48	1.10

- [1] Measured with average reading DC ammeter. Instantaneous +12V current peaks will exceed these values. Power supply at nominal voltage. N (number of drives tested) = 6, 35 Degrees C ambient.
- [2] For +12 V, a –10% tolerance is allowed during initial spindle start but must return to ±5% before reaching 15,000 RPM. The ±5% must be maintained after the drive signifies that its power-up sequence has been completed and that the drive is able to accept selection by the host initiator.
- [3] See +12V current profile in Figure 2.
- [4] This condition occurs when the Motor Start option is enabled and the drive has not yet received a Start Motor command.
- [5] See paragraph 6.2.1, "Conducted noise immunity." Specified voltage tolerance includes ripple, noise, and transient response.
- [6] Operating condition is defined as random 8 block reads
- [7] During idle, the drive heads are relocated every 60 seconds to a random location within the band from three-quarters to maximum track.

General DC power requirement notes.

1. Minimum current loading for each supply voltage is not less than 1.7% of the maximum operating current shown.
2. The +5V and +12V supplies should employ separate ground returns.
3. Where power is provided to multiple drives from a common supply, careful consideration for individual drive power requirements should be noted. Where multiple units are powered on simultaneously, the peak starting current must be available to each device.
4. Parameters, other than spindle start, are measured after a 10-minute warm up.
5. No terminator power.

6.2.1 Conducted noise immunity

Noise is specified as a periodic and random distribution of frequencies covering a band from DC to 10 MHz. Maximum allowed noise values given below are peak-to-peak measurements and apply at the drive power connector.

	+5V	+12V
0 to 100 kHz	150mV	150mV
100 kHz to 10 MHz	100mV	100mV

6.2.2 Power sequencing

The drive does not require power sequencing. The drive protects against inadvertent writing during power-up and down.

6.2.3 Current profiles

The +12V and +5V current profiles are shown below.

Note: All times and currents are typical. See Table 2 for maximum current requirements.

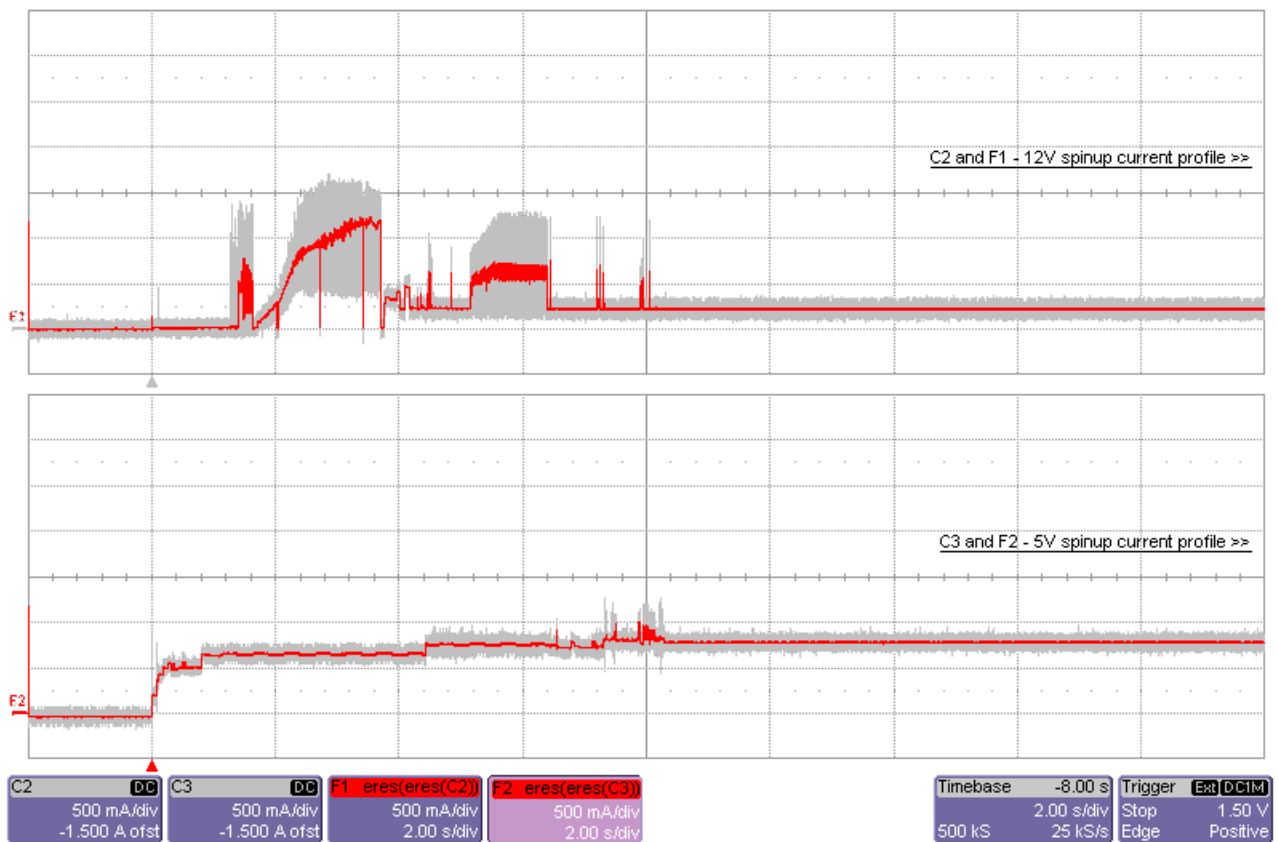


Figure 2. Typical ST973451FC drive +12V and +5V current profiles

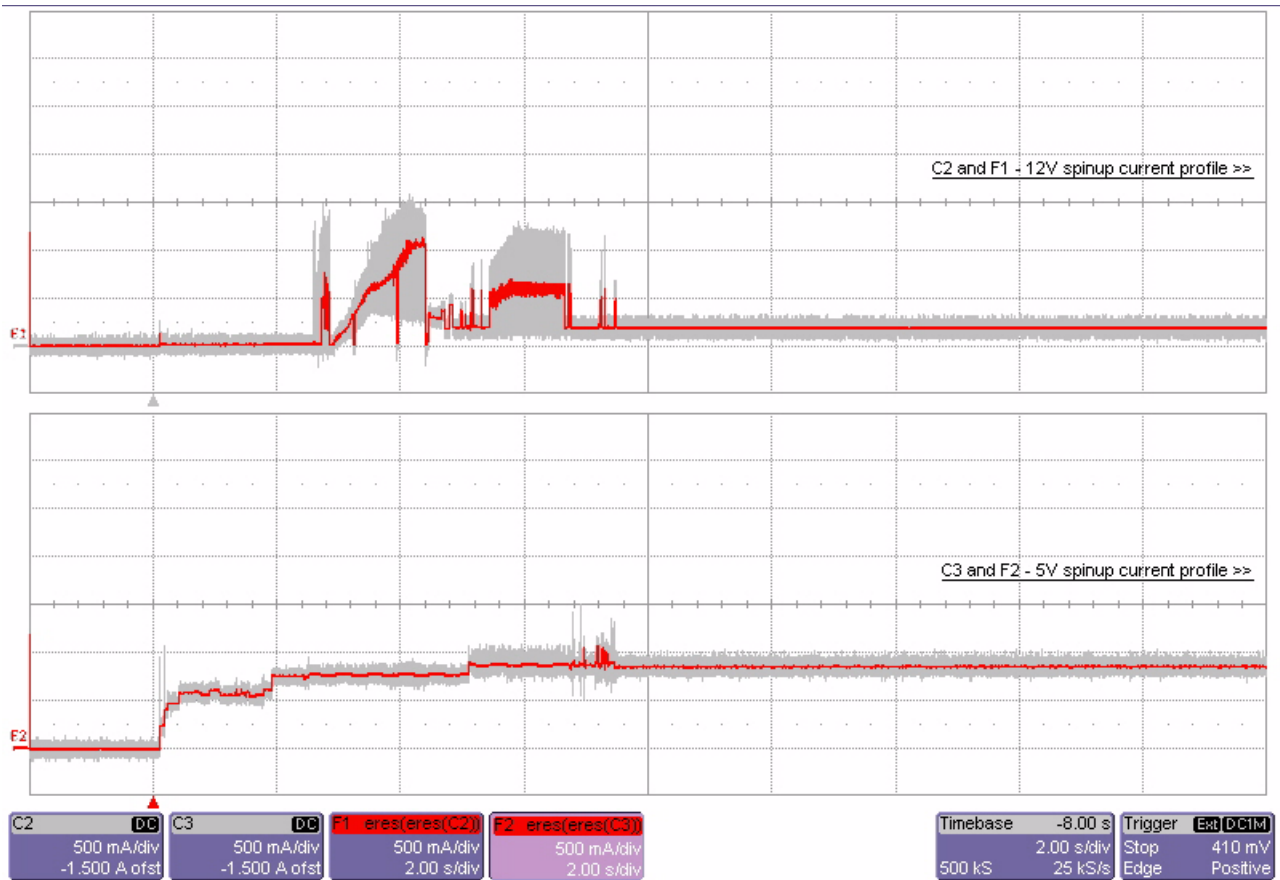


Figure 3. Typical ST936751FC drive +12V and +5V current profiles

6.3 Power dissipation

ST973451FC

Typical power dissipation under idle conditions in 1Gb operation is 5.58 watts (19.04 BTUs per hour).
 Typical power dissipation under idle conditions in 2Gb operation is 5.58 watts (19.04 BTUs per hour).
 Typical power dissipation under idle conditions in 4Gb operation is 5.88 watts (20.06 BTUs per hour).

To obtain operating power for typical random read operations, refer to the following I/O rate curve (see Figure 4). Locate the typical I/O rate for a drive in your system on the horizontal axis and read the corresponding +5 volt current, +12 volt current, and total watts on the vertical axis. To calculate BTUs per hour, multiply watts by 3.4123.

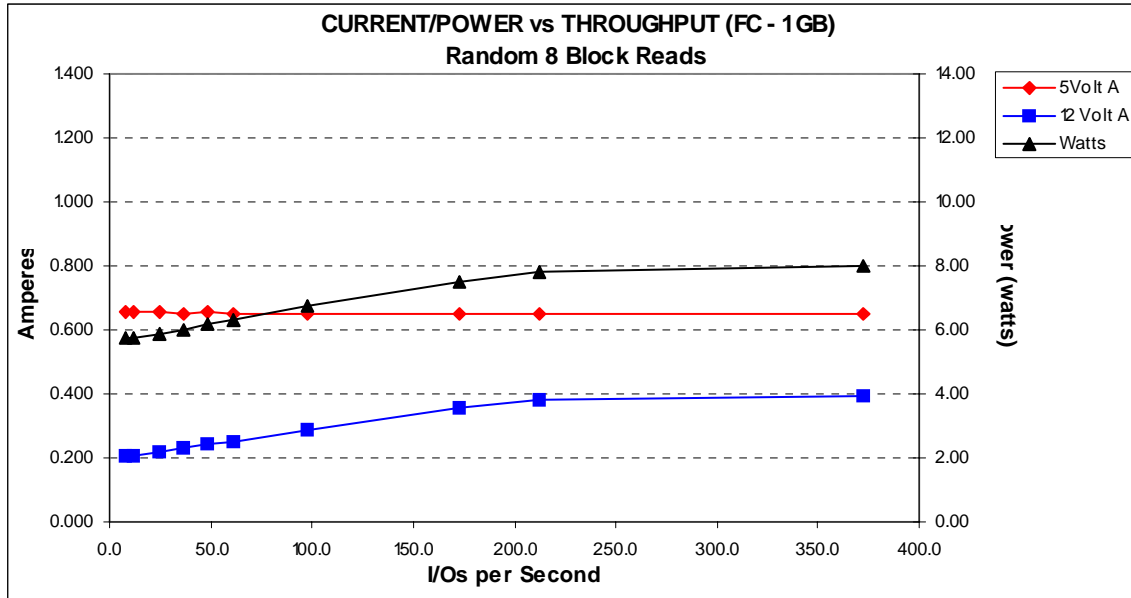


Figure 4. ST973451FC DC current and power vs. input/output operations per second at 1 Gbit

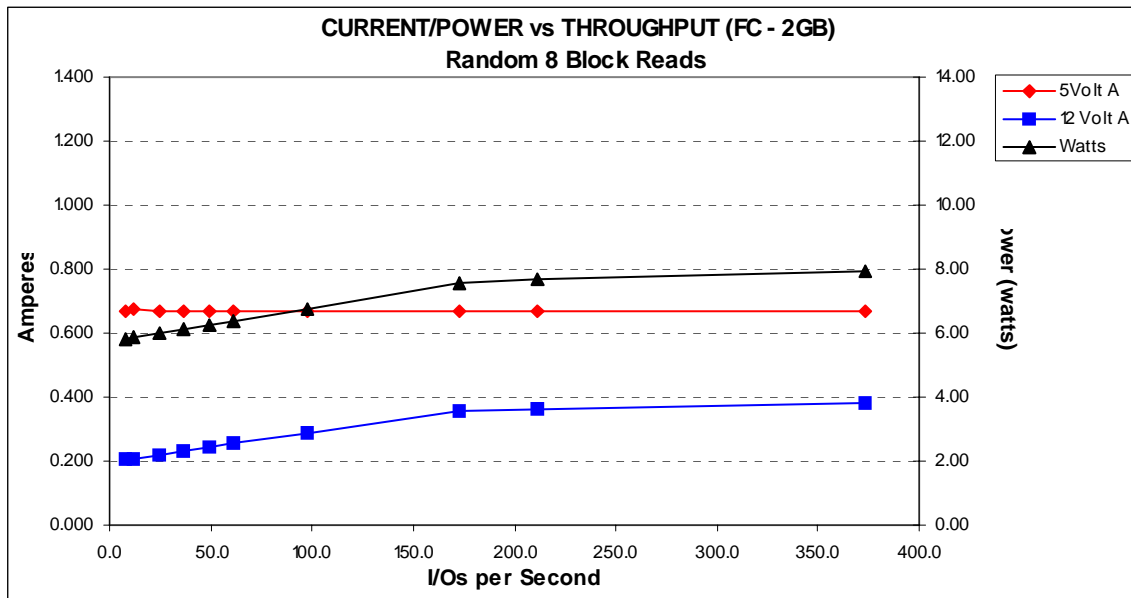


Figure 5. ST973451FC DC current and power vs. input/output operations per second at 2 Gbit

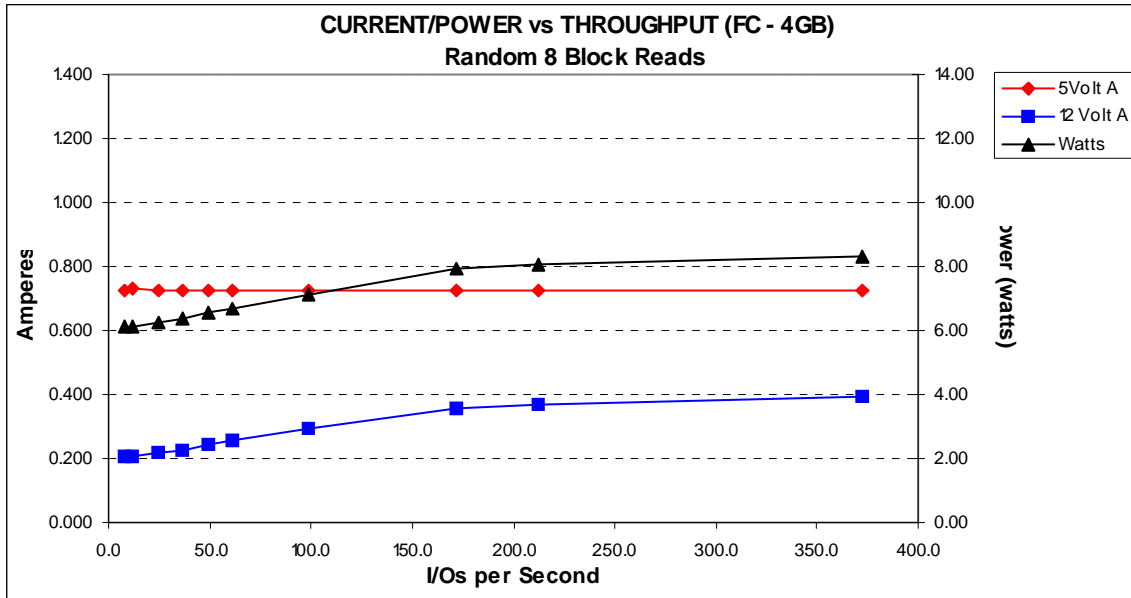


Figure 6. ST973451FC DC current and power vs. input/output operations per second at 4 Gbit

ST936751FC

Typical power dissipation under idle conditions in 1Gb operation is 5.35 watts (18.26 BTUs per hour).
 Typical power dissipation under idle conditions in 2Gb operation is 5.4 watts (18.43 BTUs per hour).
 Typical power dissipation under idle conditions in 4Gb operation is 5.75 watts (19.62 BTUs per hour).

To obtain operating power for typical random read operations, refer to the following I/O rate curve (see Figure 4). Locate the typical I/O rate for a drive in your system on the horizontal axis and read the corresponding +5 volt current, +12 volt current, and total watts on the vertical axis. To calculate BTUs per hour, multiply watts by 3.4123.

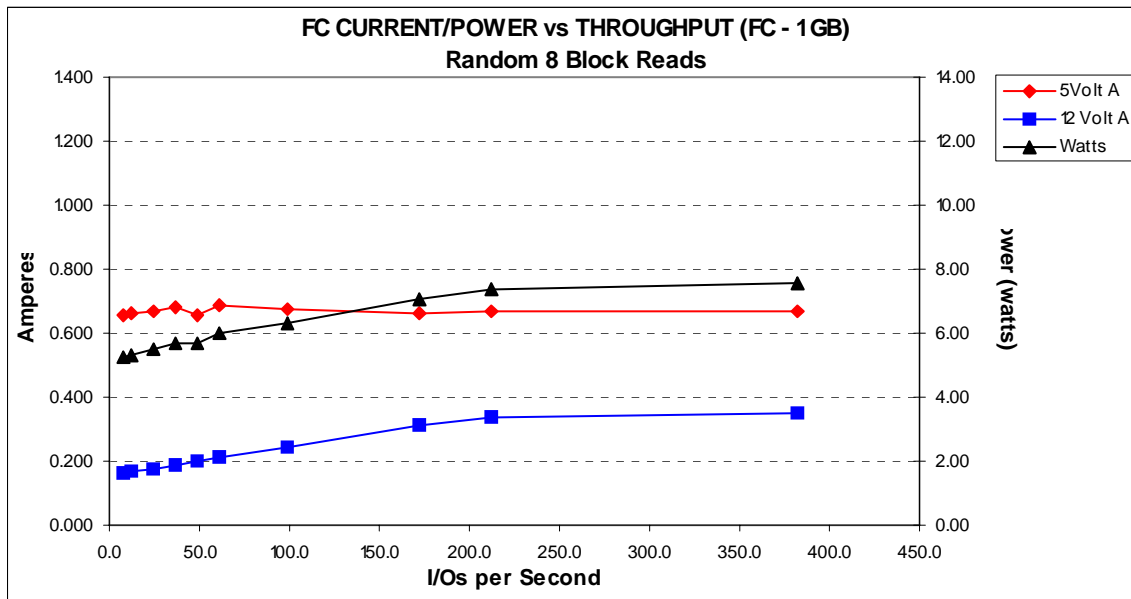


Figure 7. ST936751FC DC current and power vs. input/output operations per second at 1 Gbit

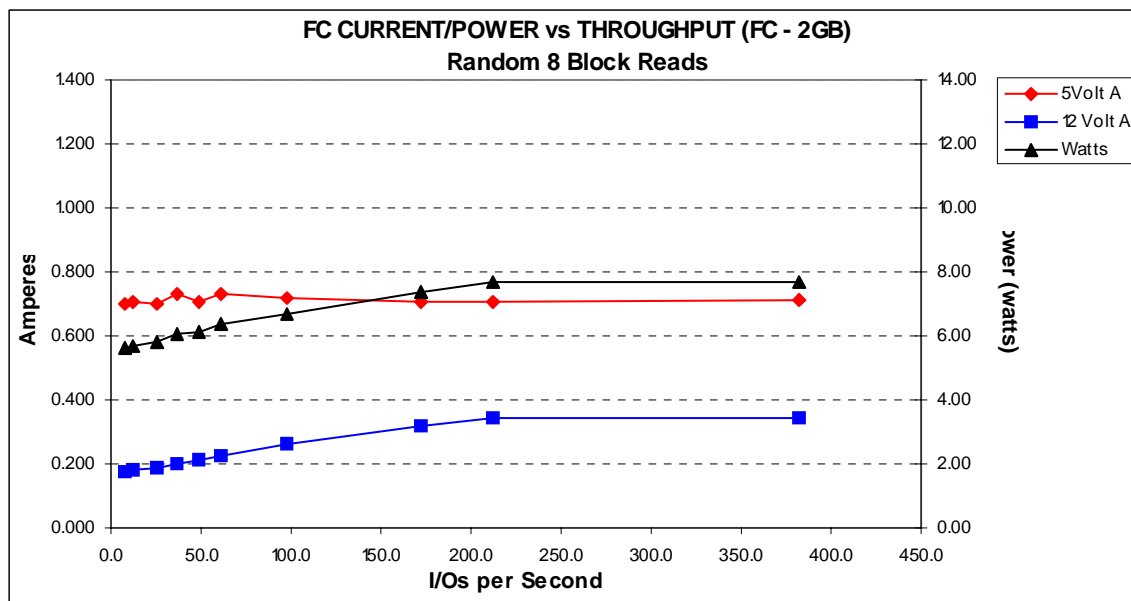


Figure 8. ST936751FC DC current and power vs. input/output operations per second at 2 Gbit

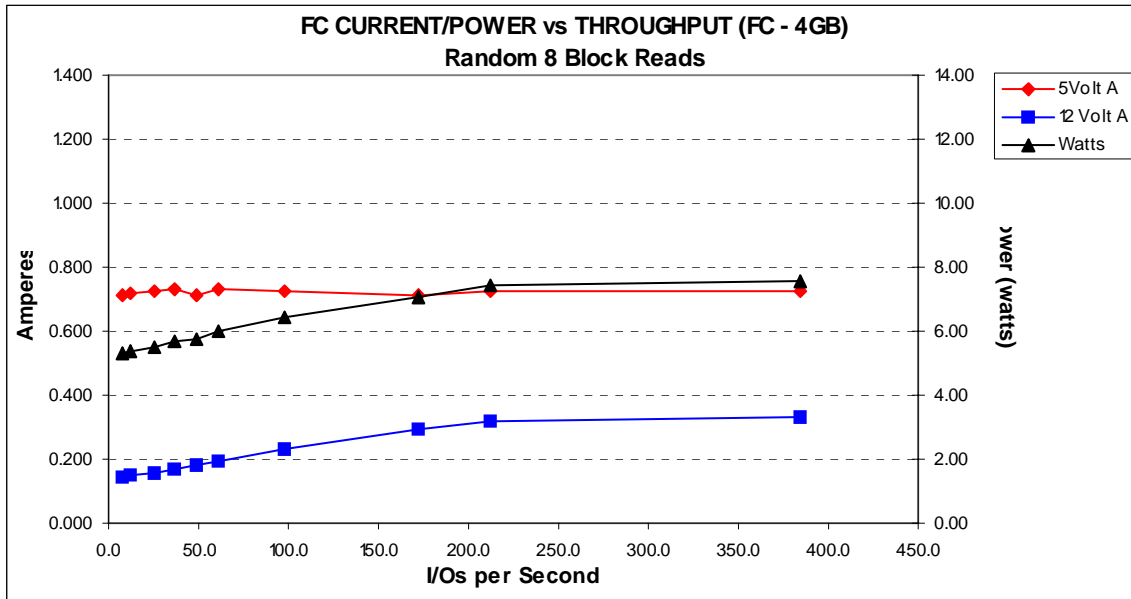


Figure 9. ST936751FC DC current and power vs. input/output operations per second at 4 Gbit

6.4 Environmental limits

Temperature and humidity values experienced by the drive must be such that condensation does not occur on any drive part. Altitude and atmospheric pressure specifications are referenced to a standard day at 58.7°F (14.8°C). Maximum wet bulb temperature is 82°F (28°C).

6.4.1 Temperature

a. Operating

With cooling designed to maintain the case temperatures, the drive meets all specifications over a 41°F to 131°F (5°C to 55°C) drive ambient temperature range with a maximum temperature gradient of 36°F (20°C) per hour. The enclosure for the drive should be designed such that these temperatures not exceeded. Air flow may be needed to achieve these temperature values (see Section 8.2). Operation at case temperatures above these values may adversely affect the drives ability to meet specifications.

The MTBF specification for the drive is based on operating in an environment that ensures that the case temperatures are not exceeded. Occasional excursions to drive ambient temperatures of 131°F (55°C) or 41°F (5°C) may occur without impact to specified MTBF. Air flow may be needed to achieve these temperatures. Continual or sustained operation at case temperatures above these values may degrade MTBF. The maximum allowable continuous or sustained HDA case temperature for the rated MTBF is 122°F (50°C).

To confirm that the required cooling for the electronics and HDA is provided, place the drive in its final mechanical configuration, perform random write/read operations. After the temperatures stabilize, measure the case temperature of the drive.

The maximum allowable HDA case temperature is 60°C. Operation of the drive at the maximum case temperature is intended for short time periods only. Continuous operation at the elevated temperatures will reduce product reliability.

b. Non-operating

–40° to 158°F (–40° to 70°C) package ambient with a maximum gradient of 36°F (20°C) per hour. This specification assumes that the drive is packaged in the shipping container designed by Seagate for use with drive.

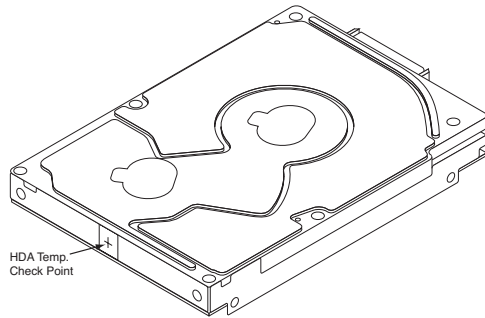


Figure 10. Locations of the HDA temperature check point

6.4.2 Relative humidity

The values below assume that no condensation on the drive occurs.

a. Operating

5% to 95% non-condensing relative humidity with a maximum gradient of 20% per hour.

b. Non-operating

5% to 95% non-condensing relative humidity.

6.4.3 Effective altitude (sea level)

a. Operating

–200 to +10,000 feet (–60.96 to +3,048 meters)

b. Non-operating

–200 to +40,000 feet (–60.96 to +12,210 meters)

6.4.4 Shock and vibration

Shock and vibration limits specified in this document are measured directly on the drive chassis. If the drive is installed in an enclosure to which the stated shock and/or vibration criteria is applied, resonances may occur internally to the enclosure resulting in drive movement in excess of the stated limits. If this situation is apparent, it may be necessary to modify the enclosure to minimize drive movement.

The limits of shock and vibration defined within this document are specified with the drive mounted by any of the four methods shown in Figure 11, and in accordance with the restrictions of Section 8.3.

6.4.4.1 Shock

a. Operating—normal

The drive, as installed for normal operation, shall operate error free while subjected to intermittent shock not exceeding 15 Gs at a maximum duration of 11 msec (half sinewave). The drive, as installed for normal operation, shall operate error free while subjected to intermittent shock not exceeding 20 Gs at a maximum duration of 2 msec (half sinewave). Shock may be applied in the X, Y, or Z axis.

b. Operating—abnormal

Equipment, as installed for normal operation, does not incur physical damage while subjected to intermittent shock not exceeding 40 Gs at a maximum duration of 11 msec (half sinewave). Shock occurring at

abnormal levels may promote degraded operational performance during the abnormal shock period. Specified operational performance will continue when normal operating shock levels resume. Shock may be applied in the X, Y, or Z axis. Shock is not to be repeated more than two times per second.

c. Non-operating

The limits of non-operating shock shall apply to all conditions of handling and transportation. This includes both isolated drives and integrated drives.

The drive subjected to nonrepetitive shock not exceeding 75 Gs at a maximum duration of 11 msec (half sinewave) shall not exhibit device damage or performance degradation. Shock may be applied in the X, Y, or Z axis.

The drive subjected to nonrepetitive shock not exceeding 300 Gs at a maximum duration of 2 msec (half sinewave) does not exhibit device damage or performance degradation. Shock may be applied in the X, Y, or Z axis.

The drive subjected to nonrepetitive shock not exceeding 200 Gs at a maximum duration of 0.5 msec (half sinewave) does not exhibit device damage or performance degradation. Shock may be applied in the X, Y, or Z axis.

d. Packaged

Disc drives shipped as loose load (not palletized) general freight will be packaged to withstand drops from heights as defined in the table below. For additional details refer to Seagate specifications 30190-001 (under 100 lbs/45 kg) or 30191-001 (over 100 lbs/45 Kg).

Package size	Packaged/product weight	Drop height
<600 cu in (<9,800 cu cm)	Any	60 in (1524 mm)
600-1800 cu in (9,800-19,700 cu cm)	0-20 lb (0 to 9.1 kg)	48 in (1219 mm)
>1800 cu in (>19,700 cu cm)	0-20 lb (0 to 9.1 kg)	42 in (1067 mm)
>600 cu in (>9,800 cu cm)	20-40 lb (9.1 to 18.1 kg)	36 in (914 mm)

Drives packaged in single or multipacks with a gross weight of 20 pounds (8.95 kg) or less by Seagate for general freight shipment shall withstand a drop test from 48 inches (1,070 mm) against a concrete floor or equivalent.

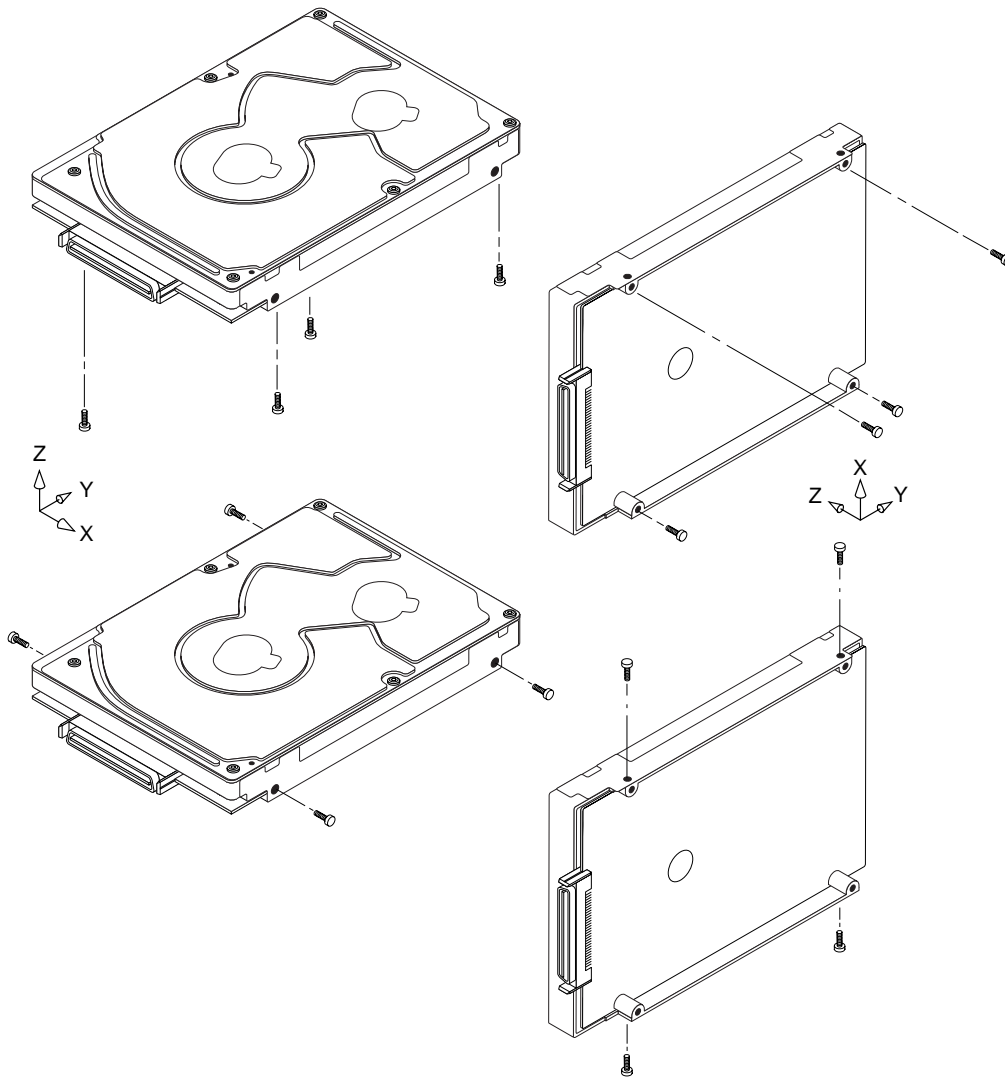


Figure 11. Recommended mounting

6.4.4.2 Vibration

a. Operating—normal

The drive as installed for normal operation, shall comply with the complete specified performance while subjected to continuous vibration not exceeding

10-500 Hz @ 1.0 G (zero to peak)

Vibration may be applied in the X, Y, or Z axis.

Operating normal translational random flat profile

10 - 400 Hz 0.4 GRMS

b. Operating—abnormal

Equipment as installed for normal operation shall not incur physical damage while subjected to periodic vibration not exceeding:

15 minutes of duration at major resonant frequency

10-500 Hz @ 1.5 G (X, Y, or Z axis)

Vibration occurring at these levels may degrade operational performance during the abnormal vibration period. Specified operational performance will continue when normal operating vibration levels are resumed. This assumes system recovery routines are available.

Operating abnormal translational random flat profile

10 - 500 Hz 1.2 GRMS

c. Non-operating

The limits of non-operating vibration shall apply to all conditions of handling and transportation. This includes both isolated drives and integrated drives.

The drive shall not incur physical damage or degraded performance as a result of continuous vibration not exceeding

5-22 Hz @ 0.040 inches (1.02 mm) displacement (zero to peak)

20-500 Hz @ 3.0 G (zero to peak)

Vibration may be applied in the X, Y, or Z axis.

Non-operating translational random flat profile

10 - 500 Hz 1.2 GRMS

6.4.5 Air cleanliness

The drive is designed to operate in a typical office environment with minimal environmental control.

6.4.6 Corrosive environment

Seagate electronic drive components pass accelerated corrosion testing equivalent to 10 years exposure to light industrial environments containing sulfurous gases, chlorine and nitric oxide, classes G and H per ASTM B845. However, this accelerated testing cannot duplicate every potential application environment.

Users should use caution exposing any electronic components to uncontrolled chemical pollutants and corrosive chemicals as electronic drive component reliability can be affected by the installation environment. The silver, copper, nickel and gold films used in Seagate products are especially sensitive to the presence of sulfide, chloride, and nitrate contaminants. Sulfur is found to be the most damaging. In addition, electronic components should never be exposed to condensing water on the surface of the printed circuit board assembly (PCBA) or exposed to an ambient relative humidity greater than 95%. Materials used in cabinet fabrication, such as vulcanized rubber, that can outgas corrosive compounds should be minimized or eliminated. The useful life of any electronic equipment may be extended by replacing materials near circuitry with sulfide-free alternatives.

6.4.7 Acoustics

Sound power during idle mode shall be 3.1 bels typical when measured to ISO 7779 specification.

There will not be any discrete tones more than 10 dB above the masking noise on typical drives when measured according to Seagate specification 30553-001. There will not be any tones more than 24 dB above the masking noise on any drive.

6.4.8 Electromagnetic susceptibility

See Section 2.1.1.1.

6.5 Mechanical specifications

Height:	0.583 in	14.8 mm
Width:	2.755 in	69.98 mm
Depth:	3.945 in	100.2 mm
Weight:	0.50 pounds	0.227 kilograms

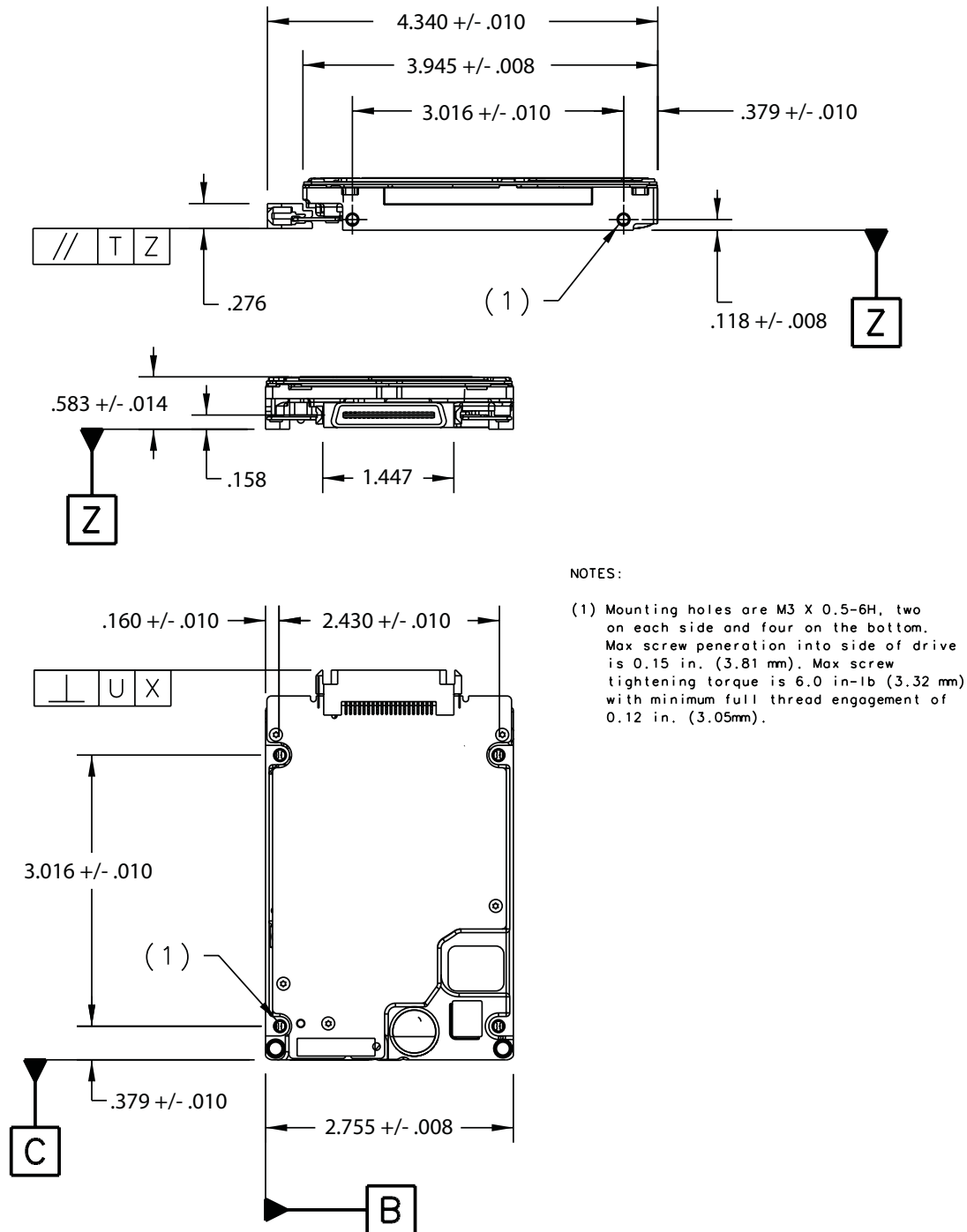


Figure 12. Drive dimensions (inches)

7.0 Defect and error management

Seagate continues to use innovative technologies to manage defects and errors. These technologies are designed to increase data integrity, perform drive self-maintenance, and validate proper drive operation.

SCSI defect and error management involves drive internal defect/error management and SAS system error considerations (errors in communications between the initiator and the drive). In addition, Seagate provides the following technologies used to increase data integrity and drive reliability:

- Background Media Scan (see Section 7.4)
- Media Pre-Scan (see Section 7.5)
- Deferred Auto-Reallocation (see Section 7.6)
- Idle Read After Write (see Section 7.7)

Note. The read error rates and specified storage capacities are not dependent on host (initiator) defect management routines.

7.1 Drive internal defects/errors

During the initial drive format operation at the factory, media defects are identified, tagged as being unusable, and their locations recorded on the drive primary defects list (referred to as the “P” list and also as the ETF defect list). At factory format time, these known defects are also reallocated, that is, reassigned to a new place on the medium and the location listed in the defects reallocation table. The “P” list is not altered after factory formatting. Locations of defects found and reallocated during error recovery procedures after drive shipment are listed in the “G” list (defects growth list). The “P” and “G” lists may be referenced by the initiator using the Read Defect Data command.

Details of the SCSI commands supported by the drive are described in the *SCSI Commands Reference Manual*. Also, more information on the drive Error Recovery philosophy is presented in the *Fibre Channel Interface Manual*.

7.2 Drive error recovery procedures

When an error occurs during drive operation, the drive, if programmed to do so, performs error recovery procedures to attempt to recover the data. The error recovery procedures used depend on the options previously set in the Error Recovery Parameters mode page. Error recovery and defect management may involve using several SCSI commands described in the *SCSI Commands Reference Manual*. The drive implements selectable error recovery time limits required in video applications.

The error recovery scheme supported by the drive provides a way to control the total error recovery time for the entire command in addition to controlling the recovery level for a single LBA. The total amount of time spent in error recovery for a command can be limited using the Recovery Time Limit bytes in the Error Recovery mode page. The total amount of time spent in error recovery for a single LBA can be limited using the Read Retry Count or Write Retry Count bytes in the Error Recovery mode page.

The drive firmware error recovery algorithms consists of 11 levels for read recoveries and five levels for write. Each level may consist of multiple steps, where a step is defined as a recovery function involving a single re-read or re-write attempt. The maximum level used by the drive in LBA recovery is determined by the read and write retry counts.

Table 4 equates the read and write retry count with the maximum possible recovery time for read and write recovery of individual LBAs. The times given do not include time taken to perform reallocations. Reallocations are performed when the ARRE bit (for reads) or AWRE bit (for writes) is one, the RC bit is zero, and the recovery time limit for the command has not yet been met. Time needed to perform reallocation is not counted against the recovery time limit.

When the RC bit is one, reallocations are disabled even if the ARRE or AWRE bits are one. The drive will still perform data recovery actions within the limits defined by the Read Retry Count, Write Retry Count, and Recovery Time Limit parameters. However, the drive does not report any unrecovered errors.

Table 4: Read and write retry count maximum recovery times

Read retry count ¹	Maximum recovery time per LBA (cumulative, msec)	Write retry count ¹	Maximum recovery time per LBA (cumulative, msec)
0	51.87	0	23.94
1	59.85	1	35.91
2	203.49	2	55.86
3	219.45	3	67.83
4	253.11	4	119.79
5	279.35	5 (default)	147.72
6	311.27		
7	395.12		
8	463.12		
9	495.04		
10	530.95		
11 (default)	1,282.97		

[1] Setting these retry counts to a value below the default setting could result in degradation of the unrecovered error rate. For example, suppose the read/write recovery page has the RC bit = 0, the read retry count set to 4, and the recovery time limit set to 450. A 4-block read command can take up to 401 msec recovery time for each block and a maximum of 450 msec recovery for all four blocks. If either of these limits is reached and a block has not yet been recovered, the command will end with Check Condition status and an unrecoverable read error will be reported.

7.3 FC-AL system errors

Information on the reporting of operational errors or faults across the interface is given in the *Fibre Channel Interface Manual*. The FCP Response returns information to the host about numerous kinds of errors or faults. The Receive Diagnostic Results reports the results of diagnostic operations performed by the drive.

Status returned by the drive to the initiator is described in the *Fibre Channel Interface Manual*. Status reporting plays a role in systems error management and its use in that respect is described in sections where the various commands are discussed.

7.4 Background Media Scan

Background Media Scan (BMS) is a self-initiated media scan. BMS is defined in the T10 document SPC-4 available from the T10 committee. BMS performs sequential reads across the entire pack of the media while the drive is idle. In RAID arrays, BMS allows hot spare drives to be scanned for defects prior to being put into service by the host system. On regular duty drives, if the host system makes use of the BMS Log Page, it can avoid placing data in suspect locations on the media. Unreadable and recovered error sites will be logged or reallocated per ARRE/AWRE settings.

With BMS, the host system can consume less power and system overhead by only checking BMS status and results rather than tying up the bus and consuming power in the process of host-initiated media scanning activity.

Since the background scan functions are only done during idle periods, BMS causes a negligible impact to system performance. The first BMS scan for a newly manufactured drive is performed as quickly as possible to verify the media and protect data by setting the “Start time after idle” to 5ms, all subsequent scans begin after 500ms of idle time. Other features that normally use idle time to function will function normally because BMS functions for bursts of 800ms and then suspends activity for 100ms to allow other background functions to operate.

BMS interrupts immediately to service host commands from the interface bus while performing reads. BMS will complete any BMS-initiated error recovery prior to returning to service host-initiated commands. Overhead associated with a return to host-servicing activity from BMS only impacts the first command that interrupted BMS, this results in a typical delay of about 1 ms.

7.5 Media Pre-Scan

Media Pre-Scan is a feature that allows the drive to repair media errors that would otherwise have been found by the host system during critical data accesses early in the drive’s life. The default setting for Media Pre-Scan is enabled on standard products. Media Pre-Scan checks each write command to determine if the destination LBAs have been scanned by BMS. If the LBAs have been verified, the drive proceeds with the normal write command. If the LBAs have not been verified by BMS, Pre-Scan will convert the write to a write verify to certify that the data was properly written to the disc.

Note. During Pre-Scan write verify commands, write performance may decrease by 50% until Pre-Scan completes. Write performance testing should be performed after Pre-Scan is complete. This may be checked by reading the BMS status.

To expedite the scan of the full pack and subsequently exit from the Pre-Scan period, BMS will begin scanning immediately when the drive goes to idle during the Pre-Scan period. In the event that the drive is in a high transaction traffic environment and is unable to complete a BMS scan within 24 power on hours BMS will disable Pre-Scan to restore full performance to the system.

7.6 Deferred Auto-Reallocation

Deferred Auto-Reallocation (DAR) simplifies reallocation algorithms at the system level by allowing the drive to reallocate unreadable locations on a subsequent write command. Sites are marked for DAR during read operations performed by the drive. When a write command is received for an LBA marked for DAR, the auto-reallocation process is invoked and attempts to rewrite the data to the original location. If a verification of this rewrite fails, the sector is re-mapped to a spare location.

This is in contrast to the system having to use the Reassign Command to reassign a location that was unreadable and then generate a write command to rewrite the data. DAR is most effective when AWRE and ARRE are enabled—this is the default setting from the Seagate factory. With AWRE and ARRE disabled DAR is unable to reallocate the failing location and will report an error sense code indicating that a write command is being attempted to a previously failing location.

7.7 Idle Read After Write

Idle Read After Write (IRAW) utilizes idle time to verify the integrity of recently written data. During idle periods, no active system requests, the drive reads recently written data from the media and compares it to valid write command data resident in the drives data buffer. Any sectors that fail the comparison result in the invocation of a rewrite and auto-reallocation process. The process attempts to rewrite the data to the original location. If a verification of this rewrite fails, the sector is re-mapped to a spare location.

8.0 Installation

Savvio disc drive installation is a plug-and-play process. There are no jumpers, switches, or terminators on the drive. Simply plug the drive into the host's 40-pin Fibre Channel backpanel connector (FC-SCA)—no cables are required. See Section 9.5 for additional information about this connector.

Use the FC-AL interface to select drive ID and all option configurations for devices on the loop.

If multiple devices are on the same FC-AL and physical addresses are used, set the device selection IDs (SEL IDs) on the backpanel so that no two devices have the same selection ID. This is called the hard assigned arbitrated loop physical address (AL_PA). There are 125 AL_PAs available (see Table 23). If you set the AL_PA on the backpanel to any value other than 0, the device plugged into the backpanel's SCA connector inherits this AL_PA. In the event you don't successfully assign unique hard addresses (and therefore have duplicate selection IDs assigned to two or more devices), the FC-AL generates a message indicating this condition. If you set the AL_PA on the backpanel to a value of 0, the system issues a unique soft-assigned physical address automatically.

Loop initialization is the process used to verify or obtain an address. The loop initialization process is performed when power is applied to the drive, when a device is added or removed from the Fibre Channel loop, or when a device times out attempting to win arbitration.

- Set all option selections in the connector prior to applying power to the drive. If you change options after applying power to the drive, recycle the drive power to activate the new settings.
- It is not necessary to low-level format this drive. The drive is shipped from the factory low-level formatted in 512-byte logical blocks. You need to reformat the drive only if you want to select a different logical block size.

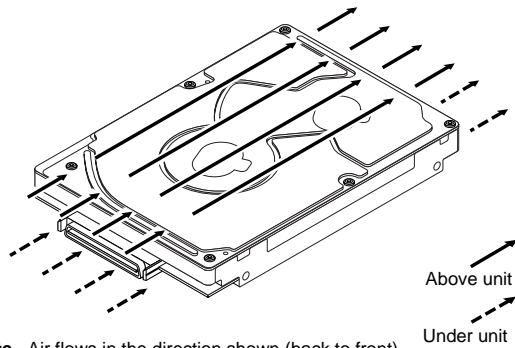
8.1 Drive orientation

The drive may be mounted in any orientation. All drive performance characterizations, however, have been done with the drive in horizontal (discs level) and vertical (drive on its side) orientations, which are the two preferred mounting orientations.

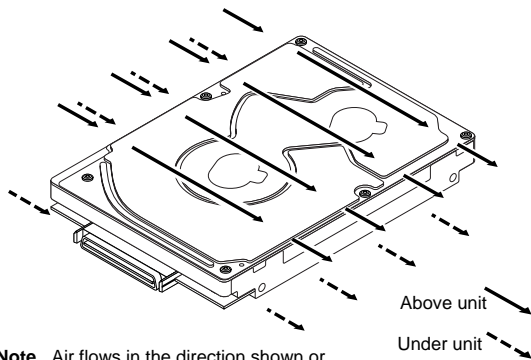
8.2 Cooling

The host enclosure must dissipate heat from the drive. You should confirm that the host enclosure is designed to ensure that the drive operates within the temperature measurement guidelines described in Section 6.4.1. In some cases, forced airflow may be required to keep temperatures at or below the temperatures specified in Section 6.4.1.

If forced air is necessary, possible air-flow patterns are shown in Figure 13. The air-flow patterns are created by fans either forcing or drawing air as shown in the illustrations. Conduction, convection, or other forced air-flow patterns are acceptable as long as the temperature measurement guidelines of Section 6.4.1 are met.



Note. Air flows in the direction shown (back to front) or in reverse direction (front to back)



Note. Air flows in the direction shown or in reverse direction (side to side)

Figure 13. Air flow

8.3 Drive mounting

Use M3 x .5 metric screws to mount the drive using either side, bottom, or end mounting holes. Select a screw length that results in a minimum thread engagement of 0.12 inches when using the side-mounting holes or a minimum thread engagement of 0.10 inches when using the bottom or end mounting holes. Use a maximum torque of 4.5 +/- .45 in lbs. If the screws are torques above the specified values, threads could be stripped.

Note. Before mounting the drive in any kind of adapter frame, verify that the drive can meet the shock and vibration specifications while mounted in such an adapter frame.

8.4 Grounding

Signal ground (PCBA) and HDA ground are connected together in the drive and cannot be separated by the user. The equipment in which the drive is mounted is connected directly to the HDA and PCBA with no electrically isolating shock mounts. If it is desired for the system chassis to not be connected to the HDA/PCBA ground, the systems integrator or user must provide a nonconductive (electrically isolating) method of mounting the drive in the host equipment.

Increased radiated emissions may result if you do not provide the maximum surface area ground connection between system ground and drive ground. This is the system designer's and integrator's responsibility.

9.0 Interface requirements

This section partially describes the interface requirements as implemented on Savvio drives. Additional information is provided in the *Fibre Channel Interface Manual* (part number 100293070).

9.1 FC-AL features

This section lists the Fibre Channel-specific features supported by Savvio drives.

9.1.1 Fibre Channel link service frames

Table 5 lists the link services supported by Savvio drives.

Table 5: Link services supported

Type of frame	Link service
Basic link service frames	Abort Sequence (ABTS)
Basic link service reply frames	Basic_Accept (BA_ACC) Basic_Reject (BA_RJT)
Extended link service frames	N_Port Login (PLOGI) Fabric Login (FLOGI) Logout (LOGO) Process Login (PRLI) Process Logout (PRL0) Read Link Status (RLS) Fabric Address Notification (FAN) Port Discovery (PDISC) Address Discovery (ADISC) Third-party Process Logout (TRPLO)
Extended link service reply frames	Accept (ACC) Link Service Reject (LS_RJT)
Fibre Channel Services	Register FC-4 Types (RFT_ID)

9.1.2 Fibre Channel task management functions

Table 6 lists the Fibre Channel SCSI Fibre Channel Protocol (FC SCSI FCP) task management functions supported.

Table 6: Fibre Channel SCSI FCP task management functions

Task name	Supported
Terminate task	No
Clear ACA	No
Target reset	Yes
Clear task set	Yes
Abort task set	Yes

9.1.3 Fibre Channel task management responses

Table 7 lists the FC SCSI FCP response codes returned for task management functions supported.

Table 7: FC SCSI FCP response codes

Function name	Response code
Function complete	00
Function not supported	04
Function reject	05

9.1.4 Fibre Channel port login

Table 8 identifies the required content of the N_Port Login (PLOGI) payload from an initiator.

Table 8: N_Port login (PLOGI) payload

Bytes																	
0-15	03	00	00	00	09	09	BB	BB	CF	XX	FS	FS	XX	XX	XX	XX	Common
16-31	XX	XX	XX	XX	PN	PN	PN	PN	PN	PN	PN	PN	NN	NN	NN	NN	
32-35	NN	NN	NN	NN													
36-47					XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	Class 1
48-51	XX	XX	XX	XX													
52-63					XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	Class 2
64-67	XX	XX	XX	XX													
68-79					SO	SO	IC	IC	XX	XX	FS	FS	XX	CS	XX	XX	Class 3
80-83	OS	OS	XX	XX													
84-95					XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	Reserved
96-99	XX	XX	XX	XX													
100-111					XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	Vendor
112-115	XX	XX	XX	XX													Version

X Indicates a four-bit (hex) field is not checked.

x Indicates a single bit is not checked.

BB BB-Credit. This field is not checked. The FC-AL drive uses BB-Credit of zero (0).

CF Common features. This binary field selects the common features requested by the initiator login.

MSB	Continuously increasing offset	Must = 1
	Random relative offset	Not checked. Port Login Accept will return a 0—not supported.
	Valid version level	x
	N_Port/F_Port	Must = 0, N_Port
	Alternate credit model	Must = 1
	Other bits reserved	xxx XX

FS Receive buffer field size. The FS field in the common and Class 3 parameters is checked for the range $128 < FS < 2,112$ and a multiple of four bytes. For multiple frame sequences, all frames but the last frame of the sequence must be this size. Only the receive buffer field size in the Class 3 parameters is used.

PN Port name (initiator's)—saved with the login parameters. If a change of the port name/AL_PA address association is detected during a Port DISCOVERY, and implicit logout occurs and the initiator returns a LS_RJT.

NN Node name. The node name is not checked or saved by the drive.

SO Service options Class 3 only.

MSB	Class valid	Must = 1
	Intermix	x
	Stacked connection req.	xx
	Sequential delivery	x
	Other bits reserved	xxx XX

IC Initiator control

MSB	XID reassign	xx
	Proc Assc	10 or 11 causes the login to be rejected. Other values are accepted.
	Other bits	XXX

CS Concurrent sequences Must be a value greater than 0.

OS Open sequences per exchange Must be a value greater than 0.

9.1.5 Fibre Channel port login accept

Table 9 identifies the N_Port Login access payload values.

Table 9: N_Port Login Accept (ACC) payload

Bytes																	
0-15	02	00	00	00	09	09	00	00	88	00	FS	FS	00	FF	00	01	Common
16-31	00	00	01	F4	2P	00	CC	CC	CC	UI	UI	UI	20	00	CC	CC	
32-35	CC	UI	UI	UI													
36-47					00	00	00	00	00	00	00	00	00	00	00	00	Class 1
48-51	00	00	00	00													
52-63					00	00	00	00	00	00	00	00	00	00	00	00	Class 2
64-67	00	00	00	00													
68-79					80	00	00	00	00	00	FS	FS	00	FF	00	00	Class 3
80-83	00	01	00	00													
84-95					00	00	00	00	00	00	00	00	00	00	00	00	Reserved
96-99	00	00	00	00													
100-111					00	00	00	00	00	00	00	00	00	00	00	00	Vendor -
112-115	00	00	00	00													Version

CC	Bytes (22, 23 and 24) and (30, 31 and 32) are currently factory set to 00 04 CF respectively (subject to change).															
FS	Receive buffer field size. The drive returns and uses the receive buffer size from the N_Port Login Class 3 receive buffer.															
UI	Unique identifier. This 24-bit field is uniquely assigned to the drive. This same UI appears in the Port Name and Node Name fields.															
P	Byte port identifier field.															
	0	P_LOGI received on Node.														
	1	P_LOGI received on Port A.														
	2	P_LOGI received on Port B.														

9.1.6 Fibre Channel Process Login

Table 10 lists the process login payload data.

Table 10: Process Login (PLRI) payload

Bytes																	
0-15	20	10	00	14	08	00	20	00	XX	XX	XX	XX	XX	XX	XX	XX	XX
16-19	00	00	00	22													

XX Indicates fields that are not used.

9.1.7 Fibre Channel Process Login Accept

Table 11 lists Savvio process login accept payload data.

Table 11: Process Login Accept (ACC) payload

Bytes																
0-15	02	10	00	14	08	00	21	00	00	00	00	00	00	00	00	00
16-31	00	00	00	12												

9.1.8 Fibre Channel fabric login

Table 12 lists the fabric login payload from the drive.

Table 12: Fabric Login (FLOGI) payload

Bytes																	
0-15	04	00	00	00	09	09	00	00	08	00	08	40	00	00	00	00	Common
16-31	00	00	02	F4	2P	00	CC	CC	CC	UI	UI	UI	02	00	CC	CC	
32-35	CC	UI	UI	UI													
36-47					00	00	00	00	00	00	00	00	00	00	00	00	Class 1
48-51	00	00	00	00													
52-63					00	00	00	00	00	00	00	00	00	00	00	00	Class 2
64-67	00	00	00	00													
68-79					80	00	00	00	00	00	08	40	00	00	00	00	Class 3
80-83	00	00	00	00													
84-95					00	00	00	00	00	00	00	00	00	00	00	00	Reserved
96-99	00	00	00	00													
100-111					00	00	00	00	00	00	00	00	00	00	00	00	Vendor -
112-115	00	00	00	00													Version

CC Bytes (22, 23 and 24) and (30, 31 and 32) are currently factory set to 00 04 CF respectively (subject to change).

UI Unique identifier. This 24-bit field is uniquely assigned to the drive. This same UI appears in the Port Name and Node Name fields.

P Port identifier field.

1 FLOGI originated on Port A.

2 FLOGI originated on Port B.

9.1.9 Fibre Channel fabric accept login

Table 13 lists the required content of the Fabric Login Accept (ACC) payload from the fabric.

Table 13: Fabric Login Accept (ACC) payload

Bytes																	
0-15	02	00	00	00	09	09	BB	BB	CF	XX	FS	FS	R_	A_	T0	V_	Common
16-31	E_	D_	T0	V_	PN	PN	PN	PN	PN	PN	PN	PN	NN	NN	NN	NN	
32-35	NN	NN	NN	NN													
36-47					XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	Class 1
48-51	XX	XX	XX	XX													
52-63					XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	Class 2
64-67	XX	XX	XX	XX													
68-79					SO	SO	xx	xx	XX	XX	FS	FS	XX	xx	XX	XX	Class 3
80-83	OS	OS	XX	XX													
84-95					XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	Reserved
96-99	XX	XX	XX	XX													
100-111					XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	Vendor -
112-115	XX	XX	XX	XX													Version

X Indicates a four-bit (hex) field is not checked.

x Indicates a single bit is not checked.

BB BB-Credit. This field is not checked. The FC-AL drive uses BB-Credit of zero (0).

CF Common features. This binary field selects the common features requested by the fabric login.

MSB	Continuously increasing offset	x
	Random relative offset	x
	Valid version level	x
	N_Port/F_Port	Must = 1, F_Port
	Alternate credit model	Must = 1
	Other bits reserved	xxx XX

FS Receive buffer field size. The FS field in the common and Class 3 parameters is checked for the range $128 < FS < 2,112$ and a multiple of four bytes. The receive buffer field size in the Class 3 parameters is used. The drive uses the lower FS of Fabric Login Accept or N_Port Login when sending frames to an initiator.

PN Port Name. The fabric port name is saved with the login parameters. If a change of the port name is detected during a FAN, an implicit logout occurs and a LS_RJT is returned to the fabric.

NN Node Name. The drive does not check or save the node name.

SO Service Options—Class 3 only.

MSB	Class valid	Must = 1
	Intermix	x
	Stacked connection req.	xx
	Sequential delivery	Must = 1
	Other bits reserved	xxx XX

9.1.10 Fibre Channel Arbitrated Loop options

Table 14 lists the FC-AL options supported by Savvio drives.

Table 14: FC-AL options supported

Option	Supported
OPEN Half Duplex	Accepted from another device.
OPEN Full Duplex	Sent to open another device. Accepted from another device.
Private Loop	Yes
Public Loop	Yes
Old Port State	No
Loop Position	Yes
Loop Position Report	Yes

9.2 Dual port support

Savvio drives have two independent FC-AL ports. These ports may be connected on independent loops or on the same loop. Port A and Port B may be connected in any order or combination.

- If both ports are connected on independent loops and hard addressing is used, the drive interface address is selected through the interface connector, both ports will seek the same loop address. If no conflict, both ports will have the same loop address.
- If both ports are connected in the same loop and hard addressing is used, at least one port will attempt taking a soft address to prevent an address conflict.

Subject to buffer availability, the Savvio drives support:

- Concurrent port transfers—The drive supports receiving transfers on both ports at the same time when the ports are on independent loops.
- Full duplex—The drive supports sending FCP_Data, FCP_RSP, FCP_XFR_RDY and ELS transfers while receiving frames on both ports.

9.3 SCSI commands supported

Table 15 lists the SCSI commands supported by Savvio drives.

Table 15: Supported commands

Command code	Supported [4]	Command name
00h	Y	Test unit ready
01h	Y	Rezero unit
03h	Y	Request sense
	Y	Extended sense
	Y	Field pointer bytes
	Y	Actual retry count bytes
04h	Y	Format unit [1]
07h	Y	Reassign blocks
08h	Y	Read
0Ah	Y	Write
0Bh	Y	Seek
12h	Y	Inquiry
	Y	Vital product data page (00h)
	Y	Unit serial number page (80h)
	Y	Implemented operating def. page (81h)
	Y	Device Identification page (83h)
	Y	Firmware numbers page (C0h)
	Y	Date code page (C1h)
	Y	Jumper settings page (C2h)
	Y	Device Behavior page (C3h)
15h	Y	Mode select (same pages as Mode Sense command shown below) [3]
16h	Y	Reserve
	N	3rd party reserved
	N	Extent reservation
17h	Y	Release
18h	N	Copy
1Ah	Y	Mode sense
	Y	Unit attention page (00h)
	Y	Error recovery page (01h)

Table 15: Supported commands (continued)

Command code	Supported [4]	Command name
	Y	Disconnect/reconnect control (page 02h)
	Y	Format page (03h)
	Y	Rigid disc drive geometry page (04h)
	Y	Verify error recovery page (07h)
	Y	Caching parameters page (08h)
	Y	Control mode page (0Ah)
	Y	Fibre Channel Interface Control page (19h)
	Y	Power control page (1Ah)
	Y	Information exceptions control page (1Ch)
1Bh	Y	Start unit/stop unit
1Ch	Y	Receive diagnostic results
	Y	Supported diagnostics pages
	Y	Translate page
	Y	Enclosure services page
1Dh	Y	Send diagnostics page
	Y	Supported diagnostics pages
	Y	Translate page
25h	Y	Read capacity
28h	Y	Read extended
	Y	Disable page out
	Y	Force unit access
	N	Relative address
2Ah	Y	Write extended
	Y	Disable page out
	Y	Force unit access
	N	Relative address
2Bh	Y	Seek extended
2Eh	Y	Write and verify
	Y	Disable page out
	Y	Byte check
	N	Relative address

Table 15: Supported commands (continued)

Command code	Supported [4]	Command name
2Fh	Y	Verify
	Y	Disable page out
	Y	Byte check
	N	Relative address
30h	N	Search data high
31h	N	Search data equal
32h	N	Search data low
33h	N	Set limits
34h	N	Prefetch
35h	Y	Synchronize cache
36h	N	Lock-unlock-cache
37h	Y	Read defect data
39h	N	Compare
3Ah	N	Copy and verify
3Bh	Y	Write buffer
	Y	Write combined header and data mode (0)
	Y	Write data mode (2)
	N	Download microcode mode (4)
	Y	Download microcode and save modes (5)
	N	Download microcode with offsets mode (6)
	Y	Download microcode with offsets and save mode (7)
	Y	Firmware download option [2]
3Ch	Y	Read buffer
	Y	Read combined header and data mode (0)
	Y	Read data mode (2)
	Y	Read descriptor mode (3)
3Eh	Y	Read long
3Fh	Y	Write long
40h	N	Change definition
41h	Y	Write same
	N	PBdata

Table 15: Supported commands (continued)

Command code	Supported [4]	Command name
	N	LBdata
42-4Bh	N	Not used
4Ch	Y	Log Select
4Dh	Y	Log Sense
	Y	Support Log page (00h)
	Y	Write Error Counter page (02h)
	Y	Read Error Counter page (03h)
	N	Read Reverse Error Counter page (04h)
	Y	Verify Error Counter page (05h)
	Y	Non-medium Error Counter page (06h)
	Y	Temperature page (0Dh)
	N	Application Client page (0Fh)
	Y	Self Test Results page (10h)
	Y	Cache Statistics Counter page (37h)
	Y	Factory Log page (3Eh)
4E-4Fh	N	Not used
50h	N	XD write
51h	N	XP write
52h	N	XD read
53-54h	N	Not used
55h	Y	Mode Select (10) [3]
56h	Y	Reserved (10)
	Y	3rd party reserve
	N	Extent reservation
57h	Y	Released (10)
58-59h	N	Not used
5Ah	Y	Mode Sense (10) [3]
5B-5Dh	N	Not used
5E	A	Persistent reserve in
5F	A	Persistent reserve out
60-7Fh	N	Not used

Table 15: Supported commands (continued)

Command code	Supported [4]	Command name
80h	N	XD write extended
81h	N	Rebuild
82h	N	Regenerate
83-8Fh	N	Not used
A0h	Y	Report LUNS
C0-DFh	N	Not used
EO-FFh	N	Not used

- [1] Savvio drives can format to any multiple of four bytes per logical block in the range 512 to 528 bytes.
- [2] **Warning.** Power loss during flash programming can result in firmware corruption. This usually makes the drive inoperable.
- [3] Reference Mode Sense command 1Ah for mode pages supported.
- [4] Y = Yes. Command is supported.
N = No. Command is not supported.
A = Support is available on special request.

9.3.1 Inquiry data

Table 16 lists the Inquiry command data that the drive should return to the initiator per the format given in the *Fibre Channel Interface Manual*.

Table 16: Savvio inquiry data

Bytes	Data (hex)																
0-15	00	00	03**	12	8B	00	PP	0A	53	45	41	47	41	54	45	20	Vendor ID
16-31	[53	54	39	37	33	34	35	31	46	43	20]	20	20	20	20	20	Product ID
32-47	R#	R#	R#	R#	S#	S#	S#	S#	S#	S#	S#	S#	00	00	00	00	
48-63	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
64-79	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
80-95	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
96-111	00	43	6F	70	79	72	69	67	68	74	20	28	63	29	20	32*	*Copyright
112-127	30*	30*	37*	20	53	65	61	67	61	74	65	20	41	6C	6C	20	notice
128-143	72	69	67	68	74	73	20	72	65	73	65	72	76	65	64	20	

* Copyright year (changes with actual year).

** 02 = SCSI-2 implemented with some SCSI-3 features (default).

03 = SCSI-3 implemented.

PP 50 = Inquiry data for an Inquiry command received on Port A.

70 = Inquiry data for an Inquiry command received on Port B.

R# Four ASCII digits representing the last four digits of the product firmware release number.

S# Eight ASCII digits representing the eight digits of the product serial number.

[] Bytes 18 through 26 reflect model of drive. The table above shows the hex values for Model ST973451FC.

Refer to the values below for the values of bytes 18 through 26 of you particular model:

ST973451FC 53 54 39 37 33 34 35 31 46 43 20

ST936751FC 53 54 39 33 36 37 35 31 46 43 20

9.4 Miscellaneous operating features and conditions

Table 17 lists various features and conditions. A “Y” in the support column indicates the feature or condition is supported. An “N” in the support column indicates the feature or condition is not supported.

Table 17: Miscellaneous features

Supported	Feature or condition
Y	FC-AL selective reset
N	Automatic contingent allegiance
N	Asynchronous event notification
N	Synchronized (locked) spindle operation
Y	Segmented caching
N	Zero latency read
Y	Queue tagging (up to 128 queue tags supported)
Y	Deferred error handling
Y	Parameter rounding (controlled by Round bit in Mode Select page 0)
Y	Reporting actual retry count in Extended Sense bytes 15, 16, and 17
N	Adaptive caching
Y	SMP = 1 in Mode Select command needed to save RPL and rotational offset bytes

Table 18: Miscellaneous status

Supported	Status
Y	Good
Y	Check condition
Y	Condition met/good
Y	Busy
Y	Intermediate/good
Y	Intermediate/condition met/good
Y	Reservation conflict
Y	Task set full
N	ACA active
N	ACA active, faulted initiator

9.5 FC-AL physical interface

Figure 14 shows the location of the J1 Fibre Channel single connection attachment (FC-SCA). Figure 16 provides the dimensions of the FC-SCA connector.

Details of the physical, electrical, and logical characteristics are provided within this section. The operational aspects of Seagate's Fibre Channel drives are provided in the *Fibre Channel Interface Manual*.

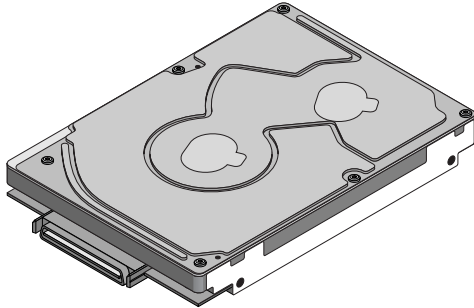


Figure 14. Physical interface

9.5.1 Physical characteristics

This section defines physical interface connector.

9.5.1.1 Physical description

Fibre Channel drives may be connected in a loop together or with other compatible FC-AL devices. A maximum of 127 devices may have addresses; however, one of the addresses is reserved for a fabric port switch device. This means 126 addresses are available for FC-AL devices. More FC-AL compatible devices may physically reside on the loop, but they will not be functional because they would not be able to obtain valid addresses.

Port bypass circuits (PBCs) allow devices to be inserted into unpopulated locations or removed from the loop with loop operation recovery after a brief interruption. These PBCs are located external to the FC-AL device. Figure 15 shows the relationship between the PBC and FC-AL device.

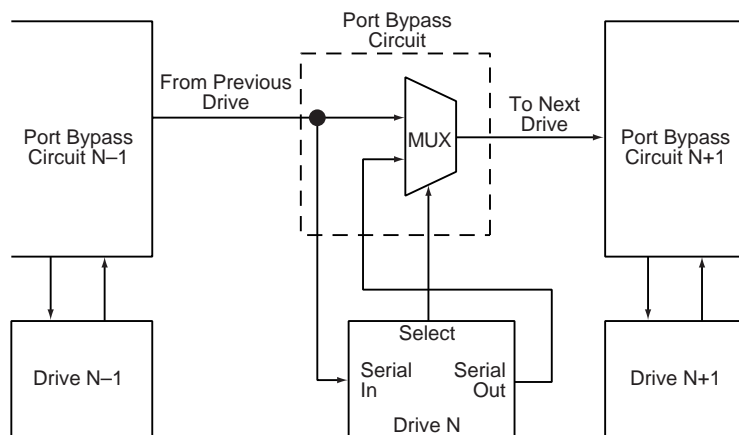


Figure 15. Port bypass circuit physical interconnect

9.5.2 Connector requirements

Table 19: Recommended mating SCA part numbers

Part description	Positions	Part number	Features
AMP Vertical (SCA sequence)	40	787317-1	With polarization
Berg	40	71781	With polarization
Methode	40	512-220-91-101N	With polarization
Molex	40	717431040	With polarization

The FC-AL SCA device connector is illustrated in Figure 16.

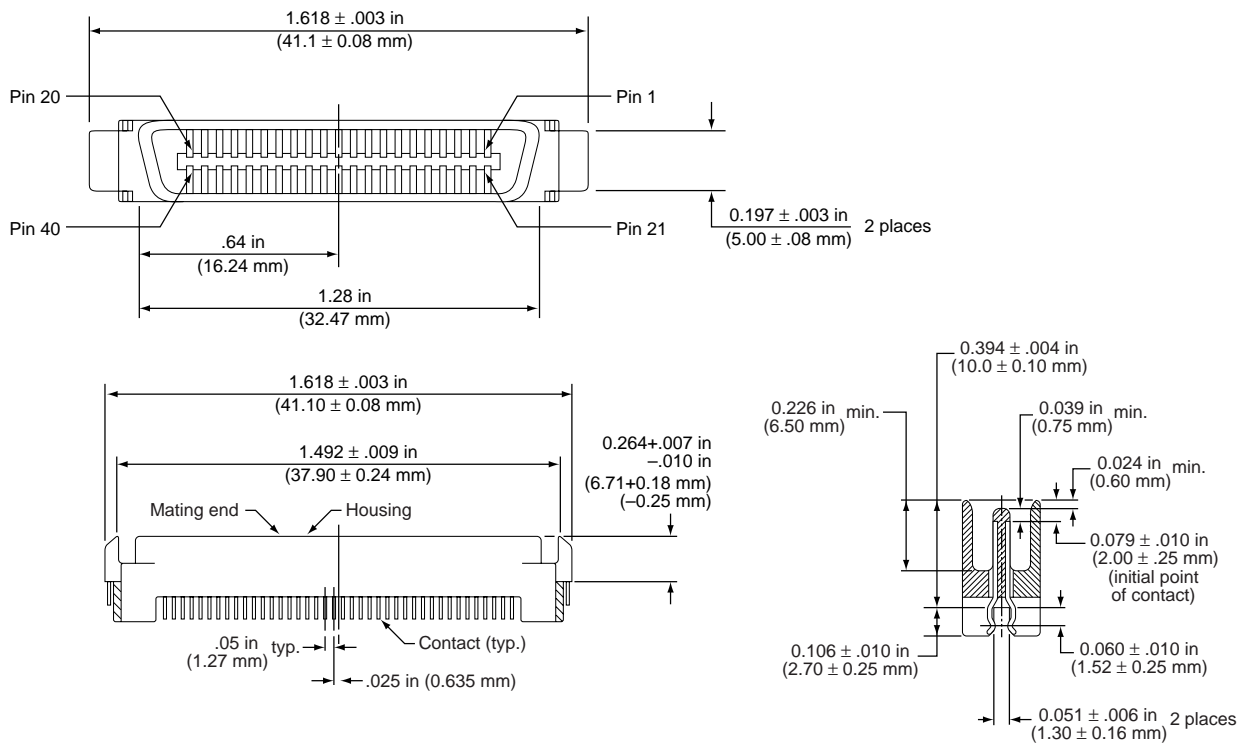


Figure 16. FC-AL SCA device connector dimensions

9.5.3 Electrical description

Fibre Channel drives use the FC-SCA connector for:

- DC power
- FC-AL interface
- Drive select (device identification)
- Option selection
- Enclosure Services interface

This 40-pin connector is designed to plug directly into a backpanel. External cables are not required.

9.5.4 Pin descriptions

This section provides a pin-out of the FC-SCA and a description of the functions provided by the pins.

Table 20: FC-SCA pin descriptions

Pin	Signal name	Signal type	Pin	Signal name	Signal type
1*	-EN bypass port A	Low Voltage TTL output	21	12 Volts charge	
2*	12 Volts		22	Ground	
3*	12 Volts		23	Ground	
4*	12 Volts		24*	+Port A_in	Diff. PECL input pair
5*	-Parallel ESI		25*	-Port A_in	
6*	Ground ^[1]		26	Ground	
7*	Active LED out	Open collector out	27*	+Port B_in	Diff. PECL input pair
8*	Reserved		28*	-Port B_in	
9*	Start_1 ^[2]	TTL input	29	Ground	
10*	Start_2 ^[2]	TTL input	30*	+Port A_out	Diff PECL output pair
11*	-EN bypass port B	Low Voltage TTL output	31*	-Port A_out	
12*	SEL_6	TTL input/output	32	Ground	
13*	SEL_5	TTL input/output	33*	+Port B_out	Diff PECL output pair
14*	SEL_4	TTL input	34*	-Port B_out	
15*	SEL_3	TTL input/output	35	Ground	
16*	Fault LED out	Open collector out	36	SEL_2	TTL input/output
17*	DEV_CTRL_CODE_2 ^[2]	TTL input	37	SEL_1	TTL input/output
18*	DEV_CTRL_CODE_1 ^[2]	TTL input	38	SEL_0	TTL input/output
19*	5 Volts		39	DEV_CTRL_CODE_0 ^[2]	TTL input
20*	5 Volts		40	5 Volts charge	

*Short pins in mating backpanel connector.

- [1] This pin may be connected to external logic to detect the presence of the drive. The drive connects this pin to the common ground.
- [2] Pins 9, 10, 17, 18, and 39 are option select pins and are tied high by the drive circuitry. The preferred electrical connection at the backplane is either open or grounded (open for the '1' setting, grounded for the '0' setting). Alternatively, these pins may be driven by a 3.3V logic device, pulled up to 3.3V through a pull-up resistor (recommended size of 10k ohm), or grounded through some other means.

9.5.5 FC-AL transmitters and receivers

A typical FC-AL differential copper transmitter and receiver pair is shown in Figure 17. The receiver is required to provide the AC coupling to eliminate ground shift noise.

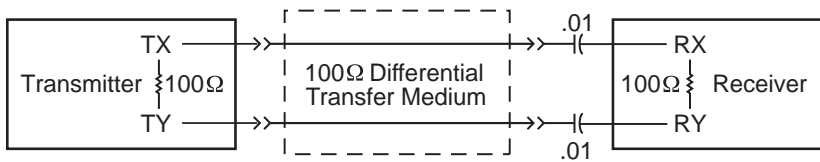


Figure 17. FC-AL transmitters and receivers

Savvio drives use 100 ohm termination which makes it compatible with backplanes designed for 1, 2, or 4 Gbit Fibre Channel transfer rates. Previous generations of Seagate FC products used 150 ohm impedance for operation in host systems designed to operate in 1 or 2 Gbit transfer rate environments.

9.5.6 Power

Power is supplied through the FC-SCA with support for +5 volts and +12 volts. All of the voltage pins in the drive connector are the same length.

Four 12 volt pins provide +12 volt power to the drive. The current return for the +12 volt power supply is through the common ground pins. The supply current and return current must be distributed as evenly as possible among the pins. The maximum current typically occurs while the drive motor is starting.

Three 5 volt pins provide logic power to the drive. The current return for the +5 volt power supply is through the common ground pins. Distribute supply and return current as evenly as possible among the voltage and ground pins.

The mating connector pins use shorter contacts to achieve power surge reductions and to aid in “hot plugging” the drives. There are longer voltage contacts in the connector to enable the drive filter capacitors to charge. Current to the drive through the long charge pins is limited by the system in which the drive operates. Three of the +12 volt pins are shorter to allow capacitive pre-charging through the longer +12 volt charge pin. Two of the +5 volt pins are shorter to allow capacitive precharging through the longer +5 volt charge pin.

9.5.7 Fault LED Out

The Fault LED Out signal is driven by the drive when:

- the drive detects failure of both ports
- the drive detects an internal failure
- the drive receives the appropriate fault LED command from the host

The Fault LED Out signal is designed to pull down the cathode of an LED. The anode is attached to the proper +5 volt supply through an appropriate current-limiting resistor. The LED and the current-limiting resistor are external to the drive.

9.5.8 Active LED Out

The Active LED Out signal is driven by the drive as indicated in Table 21.

Table 21: Active LED Out conditions

Normal command activity	LED status
Spun down and no activity	Slow blink (20% on and 80% off a 2 sec cycle)
Spun down and activity (command executing)	On
Spun up and no activity	On
Spun up and activity (command executing)	Off
Spinning up or down	Blinks steadily (50% on and 50% off)
Format in progress, each cylinder change	Toggles on/off

The Active LED Out signal is designed to pull down the cathode of an LED. The anode is attached to the proper +5 volt supply through an appropriate current limiting resistor. The LED and the current limiting resistor are external to the drive.

9.5.9 Enable port bypass signals

The – Enable Bypass Port A (– EN BYP Port A) and – Enable Bypass Port B (– EN BYP Port B) signals control the port bypass circuits (PBC) located external to the disc drive. The PBC allows a loop to remain functional in the event of a drive failure or removal. When these signals are active, low, the PBC bypasses the drive on the associated port. When an Enable Bypass signal is active, the corresponding Port Bypass LED signal in connector J1 is driven low by the disc drive. A pull down resistor, 1K, located with the PBC should be used to insure the bypass is enabled if the disc drive is not installed.

The Enable Bypass signal is active under failing conditions within the drive, on detection of the Loop Port Bypass primitive sequence, or on removal of the drive. In the bypass state the drive continues to receive on the inbound fibre. Enable Bypass may be deactivated by detection of a Loop Port Enable primitive sequence if the drive has completed self-test and a hardware failure is not present.

Failure modes detected by the disc drive that will enable bypass include:

- Transmitter/receiver wrap test failure
- Loss of receive clock
- Loss of transmission clock
- Drive interface hardware error

9.5.10 Motor start controls

The drive's motor is started according to the Start_1 and Start_2 signals described in Table 22. The state of these signals can be wired into the backplane socket or driven by logic on the backplane.

Table 22: Motor start control signals

Case	Start_2	Start_1	Motor spin function
1	Low	Low	Motor spins up at DC power on.
2	High	Low	Motor spins up only when SCSI Start command is received.
3	Low	High	Motor spins up after a delay of 12 seconds times the modulo 8 value of the numeric SEL ID of the drive from DC power on.

Table 22: Motor start control signals

Case	Start_2	Start_1	Motor spin function
4	High	High	The drive will not spin up.

9.5.11 SEL_6 through SEL_0 ID lines

The SEL_6 through SEL_0 ID lines determine drive address, and, optionally, for an Enclosure Services Interface. When the Parallel ESI line is high, the enclosure backpanel must provide address information on the SEL line. Refer to table 23 for a mapping of SEL to FC-AL physical addresses (AL_PA). You can think of the SEL lines as the equivalent of a backpanel logic plug. The drives does not provide pull up resistors on these lines. The backpanel is required to provide high and low inputs to the SEL_ID lines per the specifications in table 25 on page 64.

Note. Table 23 gives AL_PA values for each SEL value. The first entry in the table is SEL_ID 00. The last entry is SEL_ID 7D. SEL_ID 7E is AL_PA 00 which is not valid for an NL_Port, so is not included in the table. Also, SEL_ID 7Fh does map to a valid AL_PA; however, this value signals the drive that physical addresses are not being assigned using the SEL lines and that a “soft” address will be determined by FC-AL loop initialization.

When the Parallel ESI line is low, the enclosure backpanel logic switches to ESI mode if supported. There are two modes of ESI, seven bits of enclosure status and a bidirectional mode. ESI support and the mode are determined by the drive using a discovery process. Refer to the *Fibre Channel Interface Manual* for a description of ESI operation.

9.5.11.1 Parallel Enclosure Services Interface (ESI)

The parallel ESI line is an output from the drive. This line provides the enclosure with an indication of the present function of the SEL lines. A high level, the default state, indicates the drive requires address information on the SEL lines. A low level indicates the drive is attempting an ESI transfer. The enclosure may not support ESI on any or all drive locations. It may only support the address function. Support of ESI is discovered by the drive. Refer to the *Fibre Channel Interface Manual* for a description of ESI operations.

Table 23: Arbitrated loop physical address (AL_PA) values

AL_PA (hex)	SEL ID (hex)	Setting (dec)
EF	00	00
E8	01	01
E4	02	02
E2	03	03
E1	04	04
E0	05	05
DC	06	06
DA	07	07
D9	08	08
D6	09	09
D5	0A	10
D4	0B	11
D3	0C	12
D2	0D	13
D1	0E	14
CE	0F	15
CD	10	16
CC	11	17
CB	12	18
CA	13	19
C9	14	20
C7	15	21
C6	16	22
C5	17	23
C3	18	24
BC	19	25
BA	1A	26
B9	1B	27
B6	1C	28
B5	1D	29
B4	1E	30
B3	1F	31
B2	20	32

AL_PA (hex)	SEL ID (hex)	Setting (dec)
A3	2B	43
9F	2C	44
9E	2D	45
9D	2E	46
9B	2F	47
98	30	48
97	31	49
90	32	50
8F	33	51
88	34	52
84	35	53
82	36	54
81	37	55
80	38	56
7C	39	57
7A	3A	58
79	3B	59
76	3C	60
75	3D	61
74	3E	62
73	3F	63
72	40	64
71	41	65
6E	42	66
6D	43	67
6C	44	68
6B	45	69
6A	46	70
69	47	71
67	48	72
66	49	73
65	4A	74
63	4B	75

AL_PA (hex)	SEL ID (hex)	Setting (dec)
4D	56	86
4C	57	87
4B	58	88
4A	59	89
49	5A	90
47	5B	91
46	5C	92
45	5D	93
43	5E	94
3c	5F	95
3A	60	96
39	61	97
36	62	98
35	63	99
34	64	100
33	65	101
32	66	102
31	67	103
2E	68	104
2D	69	105
2C	6A	106
2B	6B	107
2A	6C	108
29	6D	109
27	6E	110
26	6F	111
25	70	112
23	71	113
1F	72	114
1E	73	115
1D	74	116
1B	75	117
18	76	118

9.5.12 Device control codes

The drive inputs a Device Control Code on the DEV_CTRL_CODE lines at power up to determine the link rate on the Fibre Channel ports. Both ports run at the same rate. If the backpanel does not connect to these lines, the drive has 10K ohm pull up resistors that default the device control code to 7 (1.0625 GHz). Table lists the supported codes.

Table 24: Device control code values

2 (pin 17)	1 (pin 18)	0 (pin 39)	Definition
0	0	0	Reserved for power failure warning.
0	0	1	Reserved for auto negotiation of link rate.
0	1	0	Reserved.
0	1	1	Reserved.
1	0	0	Reserved.
1	0	1	Reserved.
1	1	0	2.125 GHz operation on both ports.
1	1	1	1.0625 GHz operation on both ports.

9.6 Signal characteristics

This section describes the electrical signal characteristics of the drive's input and output signals. See Table 20 on page 59 for signal type and signal name information.

9.6.1 TTL input characteristics

Table 25 provides the TTL characteristics.

Table 25: TTL characteristics

State	Voltage	Current
Input high	$1.9 < V_{IH} < 5.5V$	$I_{IH} = \pm 500nA \text{ max.}$
Input low	$-0.5V < V_{IL} < 0.9V$	$I_{OL} = \pm 500nA \text{ max.}$
Output high (-EN Bypass A, B)	$2.4 < V_{OH} < 5.25V$	$I_{OH} < -3mA$
Output low (-EN Bypass A, B)	$V_{OL} < 0.5V$	$I_{OL} < 3mA$
Output high (-Parallel ESI)	$2.4 < V_{OH} < 0.9 V_{CC}$ $V_{OH} > 0.9V_{CC}$	$I_{OH} < -2.4mA$ $I_{OH} < -500\mu A$
Output low (-Parallel ESI)	$0 < V_{OL} < .45V$	$I_{OL} < 2.4mA$
Output high (all other outputs)	$2.4 < V_{OH} < 0.9 V_{CC}$ $V_{OH} > 0.9V_{CC}$	$I_{OH} < -1.6mA$ $I_{OH} < -500\mu A$
Output low (all other outputs)	$0 < V_{OL} < .45V$	$I_{OL} < 1.6mA$

9.6.2 Differential PECL output

The serial PECL output signal voltage characteristics are provided in Table 26. The outputs are not AC coupled in order to deliver maximum signal without rise and fall time degradation. You must AC couple the receiver to isolate potentially different DC characteristics of the outputs and the receiver.

Table 26: Differential PECL output characteristics

Description	Parameter	Notes
Serial output voltage swing	$600 < V_{out} < 1300$ mV	Centered at 1.32V

Figure 18 provides the data output valid eye diagram relative to the bit cell time.

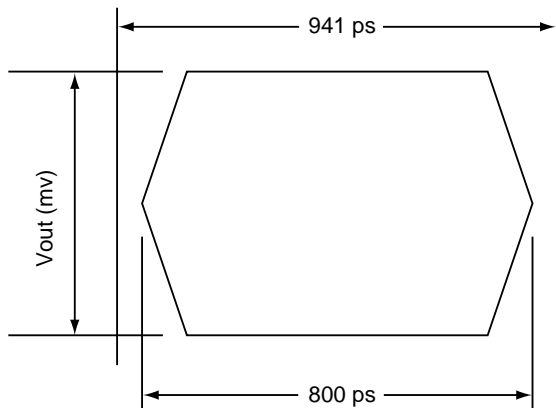


Figure 18. Transmit eye diagram

9.6.3 Differential PECL input

The serial PECL input signal voltage characteristics are provided in Table 27.

Table 27: Differential PECL input characteristics

Description	Parameter	Notes
Serial input voltage swing	$200 < V_{in} < 1.300$ mV	AC coupled

Figure 19 provides the data valid eye diagram for typical and minimum requirements to recover data at the specified interface error rate. The inputs are AC coupled on the drive.

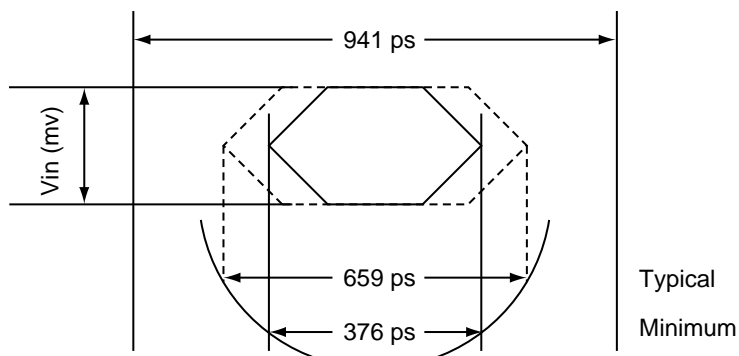


Figure 19. Receive eye diagram

10.0 Seagate Technology support services

Internet

For information regarding Seagate products and services, visit www.seagate.com. Worldwide support is available 24 hours daily by email for your questions.

Presales Support:

Presales@Seagate.com

Technical Support:

DiscSupport@Seagate.com

Warranty Support:

<http://www.seagate.com/support/service/index.html>

mySeagate

my.seagate.com is the industry's first Web portal designed specifically for OEMs and distributors. It provides self-service access to critical applications, personalized content and the tools that allow our partners to manage their Seagate account functions. Submit pricing requests, orders and returns through a single, password-protected Web interface-anytime, anywhere in the world.

spp.seagate.com

spp.seagate.com supports Seagate resellers with product information, program benefits and sales tools. You may register for customized communications that are not available on the web. These communications contain product launch, EOL, pricing, promotions and other channel-related information. To learn more about the benefits or to register, go to spp.seagate.com, any time, from anywhere in the world.

Seagate Service Centers

Presales Support

Our Presales Support staff can help you determine which Seagate products are best suited for your specific application or computer system, as well as product availability and compatibility.

Technical Support

Seagate technical support is available to assist you online at support.seagate.com or through one of our call centers. Have your system configuration information and your "ST" model number available.

SeaTDD™ (+1-405-324-3655) is a telecommunications device for the deaf (TDD). You can send questions or comments 24 hours daily and exchange messages with a technical support specialist during normal business hours for the call center in your region.

Customer Service Operations

Warranty Service

Seagate offers worldwide customer support for Seagate products. Seagate distributors, OEMs and other direct customers should contact their Seagate Customer Service Operations (CSO) representative for warranty-related issues. Resellers or end users of drive products should contact their place of purchase or Seagate warranty service for assistance. Have your serial number and model or part number available.

Data Recovery Services

Seagate offers data recovery services for all formats and all brands of storage media. Our data recovery services labs are currently located throughout the world. . Additional information, including an online request form and data loss prevention resources, is available at <http://services.seagate.com/index.aspx>

Authorized Service Centers

Seagate Service Centers are available on a global basis for the return of defective products. Contact your customer support representative for the location nearest you.

USA/Canada/Latin America support services

For an extensive list of telephone numbers to technical support, presales and warranty service in USA/Canada/Latin America, including business hours, go to the "Contact Us" page on www.seagate.com.

Global Customer Support

Presales, Technical, and Warranty Support

Call Center	Toll-free	Direct dial
USA, Canada, and Mexico	1-800-SEAGATE	+1-405-324-4700

Data Recovery Services

Call Center	Toll-free	Direct dial	FAX
USA, Canada, and Mexico	1-800-475-01435	+1-905-474-2162	1-800-475-0158 +1-905-474-2459

Europe, the Middle East and Africa Support Services

For an extensive list of telephone numbers to technical support, presales and warranty service in Europe, the Middle East and Africa, go to the "Contact Us" page on www.seagate.com.

Asia/Pacific Support Services

For an extensive list of telephone numbers to technical support, presales and warranty service in Asia/Pacific, go to the "Contact Us" page on www.seagate.com.

Index

Numerics

1 Gbit 60
12 volt
 pins 60
2 Gbit 60
3rd party reserve command 53
4 Gbit 60
5 volt pins 60

A

Abort Sequence (ABTS) 43
abort task set function 44
AC coupling 60
AC power requirements 23
ACA active status 56
ACA active, faulted initiator status 56
Accept (ACC) 43
acoustics 35
active LED Out signal 61
Actual retry count bytes command 50
actuator
 assembly design 7
adaptive caching 56
Address Discovery (ADISC) 43
addresses 57
air cleanliness 34
air flow
 illustrated 42
Alternate credit model 45, 48
altitude 31
ambient 31
ANSI documents
 fibre channel 5
 SCSI 5
arbitrated loop physical address (AL_PA) 41
arbitration 41
asynchronous event notification 56
audible noise 3
auto negotiation of link rate 64
auto write and read reallocation
 programmable 8
automatic contingent allegiance 56
average idle current 23, 24
average rotational latency 11

B

backpanel 58
backplane 61
basic link service frames 43
Basic_Accept (BA_ACC) 43
Basic_Reject (BA_RJT) 43

BB 45, 48
BB-Credit 45, 48
buffer
 data 8
 space 13
busy status 56
bypass circuit 17
Byte check command 51, 52

C

cache operation 13
Caching parameters page (08h) command 51
caching write data 13
Canadian Department of Communications 3
capacity
 unformatted 11
CC 46, 47
CF 45, 48
Change definition command 52
character sync 17
charge pins 60
check condition status 56
Class 3 parameters 45, 48
class B limit 3
Class valid 45, 48
clear ACA function 44
clear task set function 44
commands supported 50
Common features 45, 48
Company ID 46, 47
Compare command 52
Concurrent sequences 45
condensation 31
condition met/good status 56
connector
 illustrated 58
 requirements 58
continuous vibration 34
Continuously increasing offset 45, 48
control code values 64
Control mode page (0Ah) command 51
cooling 41
Copy and verify command 52
Copy command 50
CRC 17
 error 16
CS 45
Current profiles 25
customer service 22

D

data heads
 read/write 11
data rate

- internal 11
- data transfer rate 12
- data valid eye 65
- Date code page command 50
- DC power 58
 - requirements 23
- defect and error management 37
- deferred error handling 56
- description 7
- DEV_CTRL_CODE 64
- Device Behavior page command 50
- device control code values 64
- Device Identification page command 50
- device selection IDs 41
- devices 41
- differential PECL input 65
- Disable page out command 51, 52
- disc rotation speed 11
- Disconnect/reconnect control (page 02h) command 51
- Download microcode and save modes (5) 52
- Download microcode mode (4) 52
- Download microcode with offsets and save mode (7) 52
- Download microcode with offsets mode (6) 52
- drive 34
- drive characteristics 11
- drive ID 41
- drive mounting 42
- drive orientation 41
- drive select 58
- drivers and receivers 8
- dual port support 49

E

- electrical
 - description of connector 58
 - signal characteristics 64
 - specifications 23
- electromagnetic compatibility 3
- electromagnetic susceptibility 35
- EMI requirements 3
- enable bypass
 - port A 61
 - port B 61
 - signal 61
 - state 17
- Enclosure Services interface 58
- Enclosure services page command 51
- environmental
 - limits 30
 - requirements 15
- environmental control 34
- error
 - detection mechanisms, FC 17

- rates 15
- Error recovery page (01h) command 50
- extended link service
 - frames 43
 - reply frames 43
- Extended sense command 50
- Extent reservation command 53
- external data rate 11

F

- fabric 48
- Fabric Address Notification (FAN) 43
- Fabric Login (FLOGI) 43
- FAN 48
- fault LED out signal 60
- FC-AL
 - document 5
 - interface 41, 58
 - options supported 49
 - physical interface 57
 - SCA device connector, illustrated 58
 - selective reset 56
- FCC rules and regulations 3
- FCP
 - for SCSI, document 5
 - response codes 44
 - task management functions 44
- FC-PH document 5
- features 8
 - interface 43
- Fibre Channel documents 5
- Fibre Channel Interface Control page (19h) 51
- Fibre Channel Interface Manual 1, 3, 5
- Fibre Channel Services 43
- Field pointer bytes command 50
- firmware 8
 - corruption 54
- Firmware download option command 52
- Firmware numbers page command 50
- flawed sector reallocation 8
- FLOGI
 - received on Port A 47
 - received on Port B 47
- Force unit access command 51
- format 41
- Format command execution time 12
- Format page (03h) command 51
- Format unit command 50
- FS 45, 46, 48
- function
 - complete, code 00 44
 - not supported, code 05 44
 - reject, code 04 44

G

Good status 56
gradient 31
ground shift noise 60
grounding 42

H

hard assigned arbitrated loop physical address
(AL_PA) 41
HDA 42
heads
 read/write data 11
host equipment 42
hot plugging the drive 17
humidity 31
humidity limits 30

I

IC 45
ID and configuration options 8
Implemented operating def. page command 50
Information exceptions control page (1Ch) command
 51
Initiator control 45
Inquiry command 50
inquiry data 55
installation 41
 guide 5
interface 41
 commands supported 50
 description 57
 error rate 15
 errors 16
 illustrated 57
 physical 57
 requirements 43
intermediate/condition met/good status 56
intermediate/good status 56
Intermix 45, 48
internal data rate 11
internal defects/errors 37
internal drive characteristics 11

J

Jumper settings page command 50
jumpers 41

L

latency
 average rotational 11, 12
LBdata 53
Link Service Reject (LS_RJT) 43
link services supported 43

Lock-unlock-cache command 52
Log select command 53
Log sense command 53
logic power 60
logical block address 13
logical block reallocation scheme 8
logical block size 8, 12
logical segments 13
Logout (LOGO) 43
loop 57, 61
 disruption 17
 initialization 41
loop position
 FC-AL options 49
loop position report
 FC-AL options 49
LS_RJT 45, 48

M

maintenance 15
maximum delayed motor start 23, 24
maximum start current 23, 24
Mean time between failures 16
media description 9
minimum sector interleave 12
miscellaneous feature support
 Adaptive caching 56
 Asynchronous event notification 56
 Automatic contingent allegiance 56
 Deferred error handling 56
 FC-AL selective reset 56
 Parameter rounding 56
 Queue tagging 56
 Reporting actual retry count 56
 Segmented caching 56
 SMP = 1 in Mode Select command 56
 Synchronized (locked) spindle operation 56
 Zero latency read 56
miscellaneous status support
 ACA active 56
 ACA active, faulted initiator 56
 Busy 56
 Check condition 56
 Condition met/good 56
 Good 56
 Intermediate/condition met/good 56
 Intermediate/good 56
 Reservation conflict 56
 Task set full 56
miscorrected media data 15
Mode select
 (10) command 53
 command 50
Mode sense
 (10) command 53

- command 50
- monitoring state 17
- motor start
 - controls 61
- mounting 42
 - orientations 41
- mounting configuration dimensions 37
- MTBF 9, 15, 16

N

- N_Port Login (PLOGI) 43
 - payload 45
 - payload values 46
- NN 45, 48
- Node Name 48
- Node name 45
- noise
 - audible 3
- noise immunity 25
- non-operating 31, 32, 34
 - temperature 31
- non-operating vibration 34

O

- office environment 34
- ohm 60
- old port state
 - FC-AL options 49
- OPEN Full Duplex
 - FC-AL options 49
- OPEN half duplex
 - FC-AL options 49
- Open sequences per exchange 45
- operating 31, 34
- option configurations 41
- option selection 58
- options 10, 49
- OS 45

P

- P_LOGI
 - received on Port A 46
 - received on Port B 46
- package size 32
- package test specification 5
- packaged 32
- parameter rounding 56
- pass-through state 17
- PBC 57, 61
- PBdata 52
- PCBA 42
- peak bits per inch 11
- peak operating current 23, 24
- peak-to-peak measurements 25

- PECL input 65
- performance characteristics
 - detailed 11
 - general 12
- performance degradation 32
- performance highlights 9
- physical damage 34
- physical interface 57
 - description 57
- physical specifications 23
- PI 46, 47
- pin descriptions 59
- PN 45, 48
- port bypass circuit 17, 57, 61
- Port DISCOVERY 45
- Port Discovery (PDISC) 43
- port identifier field 46, 47
- port login 45
 - accept 46
- Port Name 48
- Port name (initiator's) 45
- power 60
 - dissipation 27
 - requirements, AC 23
 - requirements, DC 23
 - sequencing 25
- Power control page (1Ah) command 51
- power distribution 3
- power failure warning 64
- Prefetch command 52
- prefetch/multi-segmented cache control 13
- preventive maintenance 15
- private loop
 - FC-AL options 49
- Proc Assc 45
- Process Accept (ACC) 47
- Process Login (PRLI) 43, 46
- Process Login Accept (ACC) payload 47
- process login payload data 46
- Process Logout (PRLO) 43
- public loop
 - FC-AL options 49
- pull down resistor 61

Q

- queue tagging 56

R

- radio interference regulations 3
- Random relative offset 45, 48
- RCD bit 13
- Read buffer command 52
- Read capacity command 51
- Read combined header and data mode (0) 52

- Read command 50
- Read data mode (2) 52
- Read defect data command 52
- Read descriptor mode (3) 52
- read error rates 15
- Read extended command 51
- Read Link Status (RLS) 43
- Read long command 52
- read/write data heads 11
- Reassign blocks command 50
- Receive buffer field size 45, 48
- receive buffer field size 46
- Receive diagnostic results command 51
- receive eye
 - diagram 65
- receivers 60
- recommended mounting 33
- Recoverable Errors 15
- recovered media data 15
- reference
 - documents 5
- Regenerate command 54
- Register FC-4 Types (RFT_ID) 43
- Relative address command 51, 52
- relative humidity 31
- Release command 50
- Released (10) command 53
- reliability 9
 - specifications 15
- reliability and service 16
- repair and return information 22
- reporting actual retry count 56
- Request sense command 50
- reservation conflict status 56
- Reserve command 50
- Reserved (10) command 53
- resonance 31
- return information 22
- Rezero unit command 50
- Rigid disc drive geometry page
 - command 51
- rotation speed 11
- running disparity 17

S

- safety 3
- SCA part numbers 58
- SCSI Commands Reference Manual 5
- SCSI interface
 - commands supported 50
- Search data
 - equal command 52
 - high command 52
 - low command 52
- Seek command 50

- seek error
 - defined 16
 - rate 15
- Seek extended command 51
- seek performance characteristics 11
- seek time
 - average typical 11
 - full stroke typical 11
 - single track typical 11
- segmented caching 56
- SEL ID 41
 - lines 62
 - standard feature 8
- Self-Monitoring Analysis and Reporting Technology
 - 9, 17
- Send diagnostics page command 51
- Sequential delivery 45, 48
- Service Options 48
- Service options 45
- Set limits command 52
- shielding 3
- shipping 21
- shipping container 31
- shock 31, 32
 - and vibration 31
- shock mount 42
- signal
 - characteristics 64
- single-unit shipping pack kit 10
- SMART 9, 17
- SMP = 1 in Mode Select command 56
- SO 45, 48
- spindle brake 8
- Stacked connection req. 45, 48
- standards 3
- Start unit/stop unit command 51
- start/stop time 12
- support services 67
- Supported diagnostics pages command 51
- switches 41
- Synchronize cache command 52
- synchronized spindle
 - operation 56
- system chassis 42

T

- target reset function 44
- task management functions 44
 - Abort task set 44
 - Clear ACA 44
 - Clear task set 44
 - Target reset 44
 - terminate task 44
- task management response codes 44
 - Function complete 00 44

- Function not supported 05 44
- Function reject 04 44
- task set full status 56
- technical support services 67
- temperature 30
 - limits 30
 - non-operating 31
 - regulation 3
 - See also* cooling
- terminate task function 44
- termination 60
- terminators 41
- Test unit ready command 50
- Third-party Process Logout (TRPLO) 43
- tracks per inch 11
- tracks per surface 11
- Translate page command 51
- transmit eye diagram 65
- transmitters 60
- transporting the drive 21
- TTL input characteristics 64

U

- UI 46, 47
- unformatted 9
- unique identifier 46, 47
- Unit attention page (00h) command 50
- Unit serial number page command 50
- Unrecoverable Errors 16
- unrecovered media data 15

V

- Valid version level 45, 48
- Verify command 52
- Verify error recovery page (07h) command 51
- vibration 31, 34
- Vital product data page command 50

W

- warranty 21
- word sync 17
- Write and verify command 51
- Write buffer command 52
- Write combined header and data mode (0) 52
- Write command 50
- Write data mode (2) 52
- Write extended command 51
- Write long command 52
- Write same command 52

X

- XD read 53
- XD write 53

- XD write extended command 54
- XID reassign 45
- XP write 53

Z

- zero latency read 56
- zone bit recording (ZBR) 8



Seagate Technology LLC
920 Disc Drive, Scotts Valley, California 95066-4544, USA
Publication Number: 100384763, Rev. B, Printed in USA