Product Manual

Savvio® 10K.5 FC

ST9900805FC
ST9600205FC
ST9450405FC
ST9300605FC

100628563
Rev. F
April 2012

Revision history

Revision	Date	Sheets affected or comments
Rev. A	10/22/10	Initial release.
Rev. B	11/22/10	41.
Rev. C	02/14/11	41.
Rev. D	03/15/11	27 & 36.
Rev. E	08/10/11	4, 11, 14, 17, 27, 44, 60 & backcover.
Rev. F	04/20/12	14.

© 2012 Seagate Technology LLC. All rights reserved.

Publication number: 100628563, Rev. F, April 2012

Seagate, Seagate Technology and the Wave logo are registered trademarks of Seagate Technology LLC in the United States and/or other countries. Savvio 10K.5 and SeaTools are either trademarks or registered trademarks of Seagate Technology LLC or one ofand SeaTools 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.

No part of this publication may be reproduced in any form without written permission of Seagate Technology LLC. Call 877-PUB-TEK1(877-782-8351) to request permission.

When referring to drive capacity, one gigabyte, or GB, equals one billion bytes and one terabyte, or TB, equals one trillion bytes. Your computer's operating system may use a different standard of measurement and report a lower capacity. In addition, some of the listed capacity is used for formatting and other functions, and thus will not be available for data storage. Actual quantities will vary based on various factors, including file size, file format, features and application software. Actual data rates may vary depending on operating environment and other factors. The export or re-export of hardware or software containing encryption may be regulated by the U.S. Department of Commerce, Bureau of Industry and Security (for more information, visit www.bis.doc.gov), and controlled for import and use outside of the U.S. Seagate reserves the right to change, without notice, product offerings or specifications.

Contents

1.0 Seagate Technology support services . . . 1

2.0 Scope . . . 2

3.0 Applicable standards and reference documentation . . . 3

3.1 Standards . . . 3
3.1.1 Electromagnetic compatibility . . . 3
3.1.2 Electromagnetic compliance . . . 4
3.2 European Union Restriction of Hazardous Substances (RoHS) . . . 4
3.2.1 China Restriction of Hazardous Substances (RoHS) Directive . . . 5
3.3 Reference documents . . . 5

4.0 General description . . . 6

4.1 Standard features . . . 7
4.2 Media description . . . 7
4.3 Performance . . . 8
4.4 Reliability . . . 8
4.5 Formatted capacities . . . 8
4.6 Programmable drive capacity . . . 9
4.7 Factory-installed options . . . 9

5.0 Performance characteristics . . . 10

5.1 Internal drive characteristics . . . 10
5.2 Seek performance . . . 10
5.2.1 Access time . . . 10
5.2.2 Format command execution time for 512-byte sectors (minutes) . . . 11
5.2.3 General performance characteristics . . . 11
5.3 Start/stop time . . . 11
5.4 Prefetch/multi-segmented cache control . . . 11
5.5 Cache operation . . . 12
5.5.1 Caching write data . . . 13
5.5.2 Prefetch operation . . . 13

6.0 Reliability specifications . . . 14

6.1 Error rates . . . 14
6.1.1 Recoverable Errors . . . 14
6.1.2 Unrecoverable Errors . . . 14
6.1.3 Seek errors . . . 15
6.1.4 Interface errors . . . 15
6.2 Reliability and service . . . 15
6.2.1 Annualized Failure Rate (AFR) and Mean Time Between Failures (MTBF) . . . 15
6.2.2 Preventive maintenance . . . 15
6.2.3 Hot plugging the drive . . . 15
6.2.4 S.M.A.R.T. . . . 16
6.2.5 Thermal monitor . . . 17
6.2.6 Drive Self Test (DST) . . . 18
6.2.7 Product warranty . . . 20

7.0 Physical/electrical specifications . . . 21

7.1 PowerChoice™ power management . . . 21
7.1.1 PowerChoice reporting methods . . . 22
7.2 AC power requirements . . . 22
7.3 DC power requirements . . . 23
7.3.1 Conducted noise immunity . . . 27
7.3.2 Power sequencing . . . 27
7.3.3 Current profiles . . . 28

7.4 Power dissipation . . . 32
7.5 Environmental limits . . . 36
7.5.1 Temperature . . . 36
7.5.2 Relative humidity . . . 36
7.5.3 Effective altitude (sea level) . . . 37
7.5.4 Shock and vibration . . . 37
7.5.5 Acoustics . . . 39
7.5.6 Air cleanliness . . . 39
7.5.7 Corrosive environment . . . 40
7.5.8 Electromagnetic susceptibility . . . 40
7.6 Mechanical specifications . . . 41

8.0 Defect and error management . . . 42
8.1 Drive internal defects/errors . . . 42
8.2 Drive error recovery procedures . . . 42
8.3 FC-AL system errors . . . 43
8.4 Background Media Scan . . . 44
8.5 Media Pre-Scan . . . 44
8.6 Deferred Auto-Reallocation . . . 44
8.7 Idle Read After Write . . . 45
8.8 Protection Information (PI) . . . 45
8.8.1 Levels of PI . . . 45
8.8.2 Setting and determining the current Type Level . . . 45
8.8.3 Identifying a Protection Information drive . . . 46

9.0 Installation . . . 47
9.1 Drive ID/option selection . . . 47
9.2 Drive orientation . . . 47
9.3 Cooling . . . 47
9.4 Drive mounting . . . 48
9.5 Grounding . . . 49

10.0 Interface requirements . . . 50
10.1 FC-AL features . . . 50
10.1.1 Fibre Channel link service frames . . . 50
10.1.2 Fibre Channel task management functions . . . 51
10.1.3 Fibre Channel task management responses . . . 51
10.1.4 Fibre Channel port login . . . 52
10.1.5 Fibre Channel port login accept . . . 53
10.1.6 Fibre Channel Process Login . . . 53
10.1.7 Fibre Channel Process Login Accept . . . 54
10.1.8 Fibre Channel fabric login . . . 54
10.1.9 Fibre Channel fabric accept login . . . 55
10.1.10 Fibre Channel Arbitrated Loop options . . . 56
10.2 Dual port support . . . 56
10.3 SCSI commands supported . . . 57
10.3.1 Inquiry data . . . 61
10.3.2 Mode Sense data . . . 61
10.4 Miscellaneous operating features and conditions . . . 67
10.5 FC-AL physical interface . . . 68
10.5.1 Physical characteristics . . . 68
10.5.2 Connector requirements . . . 69
10.5.3 Electrical description . . . 69
10.5.4 Pin descriptions . . . 69
10.5.5 FC-AL transmitters and receivers . . . 70
10.5.6 Power . . . 71

10.5.7 Fault LED Out 71
10.5.8 Active LED Out. 72
10.5.9 Enable port bypass signals 72
10.5.10 Motor start controls 72
10.5.11 SEL_6 through SEL_0 ID lines 73
10.5.12 Device control codes 75
10.6 Signal characteristics. 75
10.6.1 TTL input characteristics 75
10.6.2 LED driver signals 76
10.6.3 FC Differential output 76
10.6.4 FC Differential input 76

1.0 Seagate Technology support services

SEAGATE ONLINE SUPPORT and SERVICES

For information regarding products and services, visit http://www.seagate.com/www/en-us/about/contact_us/

Available services include:

Presales & Technical support
Global Support Services telephone numbers & business hours
Authorized Service Centers

For information regarding Warranty Support, visit
http://www.seagate.com/www/en-us/support/warranty_&_returns_assistance

For information regarding Data Recovery Services, visit http://www.i365.com

For Seagate OEM & Distribution partner portal, visit https://direct.seagate.com/portal/system

For Seagate reseller portal, visit http://spp.seagate.com

2.0 Scope

This manual describes Seagate Technology® LLC, Savvio® 10K.5 FC (Fibre Channel) disk drives.

Savvio 10K.5 FC 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 100293070) describes the general Fibre Channel Arbitrated Loop characteristics of this and other Seagate Fibre Channel drives.

3.0 Applicable standards and reference documentation

The drives documented in this manual have been developed as system peripherals to the highest standards of design and construction. The drives depend on host equipment to provide adequate power and environment for 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 drives must be securely mounted to guarantee the specified performance characteristics. Mounting by bottom holes must meet the requirements of Section 9.4.

3.1 Standards

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

The drives are recognized in accordance with UL 60950 and CSA 60950 as tested by UL(CSA) and EN60950 as tested by TUV.

3.1.1 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. 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.

3.1.1.1 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 Tables 2 through 5, DC power requirements.

3.1.2 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 and comply with the Electromagnetic Interference/Electromagnetic Susceptibility (EMI/EMS) for Class B products. The selected system represents the most popular characteristics for test platforms. The system configurations include:

- Typical current use microprocessor
- Keyboard
- Monitor/display
- Printer
- 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 2004/108/EC as put into place on 20 July 2007.

Australian C-Tick

If this model has the C-Tick Marking it complies with the Australia/New Zealand Standard AS/NZ CISPR22 and meets the Electromagnetic Compatibility (EMC) Framework requirements of Australia's Spectrum Management Agency (SMA).

Korean KCC

If these drives have the Korean Communications Commission (KCC) logo, they comply with KN22, KN 24, and KN61000.

Taiwanese BSMI

If this model has the Taiwanese certification mark then it complies with Chinese National Standard, CNS13438.

3.2 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 disk 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.

3.2.1 China Restriction of Hazardous Substances (RoHS) Directive 中国限制危险物品的指令

This product has an Environmental Protection Use Period (EPUP) of 20 years. The following table contains information mandated by China's "Marking Requirements for Control of Pollution Caused by Electronic Information Products" Standard.

该产品具有20年的环境保护使用周期 （EPUP）。 下表包含了中国 “电子产品所导致的污染的控制的记号要求”所指定的信息。

Name of Parts 部件名称	Toxic or Hazardous Substances or Elements有毒有害物质或元素					
	Lead 铅 (Pb)	Mercury 汞 (Hg)	Cadmium 镉 (Cd)	Hexavalent Chromium 六价铬 (Cr6+)	Polybrominated Biphenyl 多溴联苯 (PBB)	Polybrominated Diphenyl Ether 多溴二苯醚 (PBDE)
PCBA	X	O	O	O	O	O
HDA	X	O	O	O	O	O

"O" indicates the hazardous and toxic substance content of the part (at the homogenous material level) is lower than the threshold defined by the China RoHS MCV Standard.

“O”表示该部件（于同类物品程度上）所含的危险和有毒物质低于中国RoHS MCV标准所定义的门槛值。

"X" indicates the hazardous and toxic substance content of the part (at the homogenous material level) is over the threshold defined by the China RoHS MCV Standard.

“X”表示该部件（于同类物品程度上）所含的危险和有毒物质超出中国RoHS MCV标准所定义的门槛值。

3.3 Reference documents

SCSI Commands Reference Manual	Seagate part number: 100293068
Fibre Channel Interface Manual	Seagate part number: 100293070
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-8222	Specification for 2.5” Form Factor Drives with SCA-2 Connectors
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	
X3.131-1994	(SCSI-2)
X3.270-1996	(SCSI-3) Architecture Model
NCITS 305-199X	(SCSI-3) Enclosure Services

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

4.0 General description

Savvio 10K.5 FC drives provide high performance, high capacity data storage for a variety of systems including engineering workstations, network servers, mainframes, and supercomputers. Savvio 10K.5 FC drives support 4-Gb Fibre Channel which can transfer data at up to 800MBs per second and 1600MBs per second in dual-loop configurations.

Savvio 10K.5 FC drives support the Fibre Channel Arbitrated Loop (FC-AL) and SCSI Fibre Channel Protocol as described in the ANSI specifications, this document, and the *Fibre Channel Interface Manual* which describes the general interface characteristics of this drive. Savvio 10K.5 FC 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 load/unload zone at the outermost 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 ramp load/unload when power is removed from the drive.

An automatic shipping lock prevents potential damage to the heads and disks 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.

4.1 Standard features

Savvio 10K.5 FC drives have the following standard features:

- Perpendicular recording technology
- 4-Gb Fibre Channel interface
- 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.
- Supports SCSI Enclosure Services through the interface connector
- 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” low profile form factor dimensions
- Programmable logical block reallocation scheme
- Flawed logical block reallocation at format time
- Programmable auto write and read reallocation
- Sealed head and disk assembly (HDA)
- No preventive maintenance or adjustments required
- Dedicated head load/upload zone and automatic shipping lock
- 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
- 64MB data buffer (see Section 5.5).
- Drive Self Test (DST)
- Background Media Scan (BMS)
- Idle Read After Write (IRAW)
- Power Choice
- Reallocation of defects on command (Post Format)

4.2 Media description

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

4.3 Performance

- Programmable multi-segmentable cache buffer
- 800MB/s maximum instantaneous data transfers per port
- 10K RPM spindle. Average latency = 2.98ms
- Command queuing of up to 128 commands
- Background processing of queue
- Supports start and stop commands (spindle stops spinning)
- Adaptive seek velocity; improved seek performance

4.4 Reliability

- Annualized Failure Rate (AFR) of 0.44%
- Mean Time Between Failures (MTBF) of 2,000,000 hours
- Self-Monitoring Analysis and Reporting Technology (S.M.A.R.T.)
- 5-year warranty

4.5 Formatted capacities

Standard OEM models are formatted to 512 bytes per block. The sector size is selectable at format time. 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	ST9900805FC		ST9600205FC		ST9450405FC		ST9300605FC	
	Decimal	Hex	Decimal	Hex	Decimal	Hex	Decimal	Hex
512	1,758,174,768	68CB9E30h	1,172,123,568	45DD2FB0h	879,097,968	3465F870h	585,937,500	22ECB25Ch
520	1,720,961,544	6693CA08h	1,147,307,696	446286B0h	860,480,776	3349E508h	573,653,848	22314358h
524	1,698,023,400	6535C7E8h	1,132,015,600	43792FF0h	849,011,704	329AE3F8h	566,007,800	21BC97F8h
528	1,673,624,336	63C17B10h	1,115,749,560	4280FCB8h	836,812,168	31E0BD88h	557,874,778	21407E5Ah

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 10K and 15K 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.

4.6 Programmable drive capacity

Using the Mode Select command, the drive can change its capacity to something less than maximum. See the Mode Select Parameter List table in the *SCSI Commands Reference Manual*. 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.

4.7 Factory-installed 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 *Safety and Regulatory Agency Specifications*, part number 75789512, is usually included with each standard OEM drive shipped, but extra copies may be ordered.

5.0 Performance characteristics

This section provides detailed information concerning performance-related characteristics and features of Savvio 10K.5 FC drives.

5.1 Internal drive characteristics

	ST9900805FC	ST9600205FC	ST9450405FC	ST9300605FC	
Drive capacity*	900	600	450	300	GBs (formatted, rounded off value)
Read/write data heads	6	4	3	2	
Tracks per inch	300,000	300,000	300,000	300,000	TPI
Peak bits per inch	1686	1686	1686	1686	kBPI
Areal density	506	506	506	506	Gb/in2
Internal data rate	1.00 to 1.91	1.00 to 1.91	1.00 to 1.91	1.00 to 1.91	Gb/s (ID to OD)
disk rotation speed	10K	10K	10K	10K	rpm
Avg rotational latency	3.0	3.0	3.0	3.0	ms

*One GB equals one billion bytes when referring to hard drive capacity. Accessible capacity may vary depending on operating environment and formatting.

5.2 Seek performance

See Section 10.5, "FC-AL physical interface" on page 68 and the *Fibre Channel Interface Manual* (part number 77767496) for additional timing details.

5.2.1 Access time

	Not including controller overhead[1,2](ms)			
	900GB models		600, 450 and 300GB models	
	Read	Write	Read	Write
Average	3.7	4.1	3.4	3.8
Single track	0.2	0.4	0.2	0.4
Full stroke	7.7	8.1	7.1	7.4

1. Typical access times are measured under nominal conditions of temperature, voltage, and horizontal orientation as measured on a representative sample of drives.
2. Access to data = access time + latency time.

5.2.2 Format command execution time for 512-byte sectors (minutes)

	900GB models	600GB models	450GB models	300GB models
Maximum (with verify)	234	156	117	78
Maximum (without verify)	116	75	58	36

Execution time measured from receipt of the last byte of the Command Descriptor Block (CDB) to the request for a Status Byte Transfer to the Initiator (excluding connect/disconnect).

Note. When changing sector sizes, the format times shown above may need to be increased by 30 minutes.

5.2.3 General performance characteristics

Sustainable disk transfer rate*:	
Data buffer to/from disk media (one 512-byte logical block)*	1.00 to 1.91 Gb/s
Sustained transfer rate	89 to 160 Mib/s ** 93 to 168 MB/s
Fibre Channel Interface maximum instantaneous transfer rate	800MB/s* per port (dual port = 1600MB/s*)
Logical block sizes Default is 512-byte data blocks Sector sizes variable to 512, 520, 524 and 528 bytes.	
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

*Assumes no errors and no relocated logical blocks. Rate measured from the start of the first logical block transfer to or from the host.
** MiB/s x 1.048 = MB/s

5.3 Start/stop time

If the Motor Start option is disabled, the drive becomes ready within 20 seconds after DC power is applied. If a recoverable error condition is detected during the start sequence, the drive executes a recovery procedure and the time to become ready may exceed 20 seconds. During spin up to ready time, the drive responds to some commands over the FC interface in less than 3 seconds after application of power. Stop time is 30 seconds (maximum) from removal of DC power.

If the Motor Start option is enabled, the internal controller accepts the commands listed in the *Fibre Channel Interface Manual* less than 3 seconds after DC power has been applied. After the Motor Start command has been received, the drive becomes ready for normal operations within 20 seconds (excluding the error recovery procedure). The Motor Start command can also be used to command the drive to stop the spindle.

There is no power control switch on the drive.

5.4 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 5.5.1 and 5.5.2.

All default cache and prefetch mode parameter values (Mode Page 08h) for standard OEM versions of this drive family are given in Section 10.3.2

5.5 Cache operation

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

Of the 64 Mbytes physical buffer space in the drive, approximately 30,000 kbytes are available as a data cache. The remaining buffer space is reserved for internal drive use.

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 *FC Interface Manual*), data requested by the host with a read command is retrieved from the buffer, if possible, before any disk access is initiated. If cache operation is not enabled, the buffer is still used, but only as circular buffer segments during disk 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. All data transfers to the host are in accordance with 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 all of the requested logical blocks are 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 disk 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 5.5.2 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.

5.5.1 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.

Tables 19 through 22 show the mode default settings for these drives.

5.5.2 Prefetch operation

If the Prefetch feature is enabled, data in contiguous logical blocks on the disk 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 disk 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.

6.0 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. See Section 10.6.4, "FC Differential input." on page 76
Mean Time Between Failures (MTBF)	2,000,000 hours
Annualized Failure Rate (AFR):	0.44%
Preventive maintenance:	None required

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

6.1 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 Section 7.3
- 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.

6.1.1 Recoverable Errors

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

Recoverable Data errors will use Error Correction when needed.

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.

6.1.2 Unrecoverable Errors

Unrecoverable Data Errors (Sense Key = 03h) are specified at less than 1 sector in error per 10^{16} bits transferred. Unrecoverable Data Errors resulting from the same cause are treated as 1 error for that block.

6.1.3 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.

6.1.4 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.

6.2 Reliability and service

You can enhance the reliability of disk drives by ensuring that the drive receives adequate cooling. Section 7.0 provides temperature measurements and other information that may be used to enhance the service life of the drive. Section 9.2 provides recommended air-flow information.

6.2.1 Annualized Failure Rate (AFR) and Mean Time Between Failures (MTBF)

These drives shall achieve an AFR of 0.44% (MTBF of 2,000,000 hours) when operated in an environment that ensures the HDA case temperatures do not exceed the values specified in Section 7.5.1.

Operation at case temperatures outside the specifications in Section 7.5.1 may increase the AFR (decrease the MTBF).

AFR and MTBF statistics are population statistics that are not relevant to individual units. AFR and MTBF specifications are based on the following assumptions for Enterprise Storage System environments:

- 8,760 power-on hours per year
- 250 average on/off cycles per year
- Operating at nominal voltages
- System provides adequate cooling to ensure the case temperatures specified in Section 7.5.1 are not exceeded.

6.2.2 Preventive maintenance

No routine scheduled preventive maintenance is required.

6.2.3 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 disk 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.

6.2.4 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 one hour.

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 disk so that the events that caused a predictive failure can be recreated. The drive measures and saves parameters once every hour subject to an idle period on the FC-AL bus. The process of measuring off-line attribute data and saving data to the disk is interruptable. The maximum on-line only processing delay is summarized below:

Maximum processing delay

	Fully-enabled delay DEXCPT = 0
S.M.A.R.T. delay times	75 ms

Reporting control

Reporting is controlled by the MRIE bits in the Informational Exceptions Control mode page (1Ch). Subject to the reporting method. For example, if the MRIE is set to one, the firmware will issue to the host an 01-5D00 sense code. The FRU field contains the type of predictive failure that occurred. 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.

6.2.5 Thermal monitor

Savvio 10K.5 FC 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. 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 68°C. If you specify a temperature greater than 68°C in this field, the temperature is rounded down to 68°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

6.2.6 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.

6.2.6.1 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.

6.2.6.2 Implementation

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

6.2.6.2.1 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 disk

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

6.2.6.2.2 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.

6.2.6.2.3 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.

6.2.6.2.4 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.

6.2.6.2.5 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).

6.2.7 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.

Storage

The maximum recommended storage period for the drive in a non-operational environment is 90 days. Drives should be stored in the original unopened Seagate shipping packaging when ever possible. Once the drive is removed from the Seagate original packaging the recommended maximum period between drive operation cycles is 30 days. During any storage period the drive non-operational temperature, humidity, wet bulb, atmospheric conditions, shock, vibration, magnetic and electrical field specifications should be followed.

7.0 Physical/electrical specifications

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

7.1 PowerChoice™ power management

Drives using the load/unload architecture provide programmable power management to tailor systems for performance and greater energy efficiency.

The table below lists the supported PowerChoice modes. The further you go down in the table, the more power savings you get. For example, Idle_B mode results in greater power savings than Idle_A mode. Standby modes results in the greatest power savings.

PowerChoice modes

Mode	Description
Idle_A	Reduced electronics
Idle_B	Heads unloaded. Disks spinning at full RPM
Idle_C	Heads unloaded. Disks spinning at reduced RPM
Standby_Y	Heads unloaded. Disks spinning at reduced RPM
Standby_Z	Heads unloaded. Motor stopped (disks not spinning)

PowerChoice can be invoked using one of these two methods:

- Power Condition mode page method—Enable and initialize the idle condition timers and/or the standby condition timers. The timer values are based on the values set in the Power Condition mode page.
- START STOP UNIT command method—Use the START STOP UNIT command (OPERATION CODE 1Bh). This allows the host to directly transition the drive to any supported PowerChoice mode.

If both the Power Condition mode page and START STOP UNIT command methods are used, the START STOP UNIT command request takes precedence over the Power Condition mode page power control and may disable the idle condition and standby condition timers. The REQUEST SENSE command reports the current PowerChoice state if active and also the method by which the drive entered the PowerChoice state.

When the drive receives a command, all power condition timers are suspended if they were enabled via the Power Condition mode page. Once all outstanding commands are processed, the power condition timers are reinitialized to the values defined in the Power Condition mode page.

7.1.1 PowerChoice reporting methods

PowerChoice™ provides these reporting methods for tracking purposes:

Request Sense command reports

- Current power condition
- Method of entry

Note. Processing the Request Sense command does not impact the drive's power save state.

Mode Sense command reports (mode page 0x1A)

- Idle conditions enabled / disabled
- Idle condition timer values (100ms increments) (default, saved, current, changeable)

Power Condition Vital Product Data (VPD) Page (VPD page 0x8A)

- Supported power conditions
- Typical recovery time from power conditions (1ms increments)

Start/Stop Cycle Counter Log Page reports (log page 0x0E)

- Specified and accumulated Start/Stops and Load/Unload cycles

Power Condition Transitions Log Page reports (log page 0x1A, subpage 0x00)

- Accumulated transitions to Active, Idle_A, Idle_B, Idle_C, Standby_Y, Standby_Z

7.2 AC power requirements

None.

7.3 DC power requirements

The voltage and current requirements for a single drive are shown below. Values indicated apply at the drive connector. Notes are shown following Table 5.

Table 2: DC power requirements for ST9900805FC model

			2Gb		4Gb	
		Notes	**(Amps)**	**(Amps)**	**(Amps)**	**(Amps)**
Voltage			+5V	+12V [2]	+5V	+12V [2]
Regulation		[6]	±5%	±5% [2]	±5%	±5% [2]
Avg idle current DC		[1] [8]	0.36	0.24	0.38	0.24
Advanced Idle Current						
Idle_A	3σ		0.37	0.24	0.39	0.25
Idle_B	3σ		0.25	0.21	0.27	0.22
Idle_C	3σ		0.25	0.10	0.27	0.11
Standby	3σ		0.25	0.06	0.27	0.07
Maximum starting current						
(peak DC) DC	3σ	[3]	0.64	1.02	0.64	1.03
(peak AC) AC	3σ	[3]	0.99	1.67	0.92	1.70
Delayed motor start (max) DC	3σ	[1] [5]	0.57	0.06	0.59	0.06
Peak operating current (random read):						
Typical DC		[1] [7]	0.45	0.44	0.46	0.44
Maximum DC	3σ	[1]	0.46	0.46	0.47	0.46
Maximum (peak) DC	3σ		2.00	2.68	1.26	1.60
Peak operating current (random write)						
Typical DC			0.51	0.45	0.52	0.45
Maximum DC	3σ		0.52	0.50	0.54	0.53
Maximum (peak) DC	3σ		1.15	1.63	1.15	1.60
Peak operating current (sequential read)						
Typical DC			0.83	0.23	0.85	0.23
Maximum DC	3σ		0.85	0.24	0.86	0.24
Maximum (peak) DC	3σ		1.12	0.42	1.17	0.44
Peak operating current (sequential write)						
Typical DC			0.90	0.23	0.92	0.23
Maximum DC	3σ		0.93	0.24	0.95	0.24
Maximum (peak) DC	3σ		1.17	0.40	1.24	0.42

Table 3: DC power requirements for ST9600205FC model

			2Gb		4Gb	
		Notes	**(Amps)**	**(Amps)**	**(Amps)**	**(Amps)**
Voltage			+5V	+12V [2]	+5V	+12V [2]
Regulation		[6]	±5%	±5% [2]	±5%	±5% [2]
Avg idle current DC		[1] [8]	0.37	0.18	0.39	0.18
Advanced Idle Current						
Idle_A	3σ		0.41	0.19	0.43	0.19
Idle_B	3σ		0.28	0.16	0.30	0.17
Idle_C	3σ		0.28	0.09	0.30	0.09
Standby	3σ		0.28	0.06	0.29	0.06
Maximum starting current						
(peak DC) DC	3σ	[3]	0.64	0.90	0.66	0.89
(peak AC) AC	3σ	[3]	0.97	1.58	1.02	1.58
Delayed motor start (max) DC	3σ	[1] [5]	0.61	0.06	0.63	0.06
Peak operating current (random read):						
Typical DC		[1] [7]	0.46	0.39	0.48	0.39
Maximum DC	3σ	[1]	0.50	0.40	0.52	0.41
Maximum (peak) DC	3σ		1.26	1.48	1.28	1.48
Peak operating current (random write)						
Typical DC			0.53	0.34	0.54	0.34
Maximum DC	3σ		0.56	0.39	0.58	0.41
Maximum (peak) DC	3σ		1.09	1.51	1.11	1.50
Peak operating current (sequential read)						
Typical DC			0.83	0.17	0.84	0.17
Maximum DC	3σ		0.90	0.17	0.92	0.17
Maximum (peak) DC	3σ		1.14	0.34	1.19	0.36
Peak operating current (sequential write)						
Typical DC			0.91	0.17	0.92	0.17
Maximum DC	3σ		0.96	0.17	0.98	0.17
Maximum (peak) DC	3σ		1.20	0.34	1.21	0.32

Table 4: DC power requirements for ST9450405FC model

			2Gb		4Gb	
		Notes	**(Amps)**	**(Amps)**	**(Amps)**	**(Amps)**
Voltage			+5V	+12V [2]	+5V	+12V [2]
Regulation		[6]	±5%	±5% [2]	±5%	±5% [2]
Avg idle current DC		[1] [8]	0.37	0.18	0.38	0.18
Advanced Idle Current						
Idle_A	3σ		0.37	0.19	0.40	0.19
Idle_B	3σ		0.26	0.17	0.28	0.17
Idle_C	3σ		0.26	0.09	0.28	0.09
Standby	3σ		0.26	0.06	0.28	0.06
Maximum starting current						
(peak DC) DC	3σ	[4]	0.64	0.89	0.65	0.89
(peak AC) AC	3σ	[4]	0.96	1.61	0.96	1.58
Delayed motor start (max) DC	3σ	[1] [5]	0.59	0.06	0.61	0.06
Peak operating current (random read):						
Typical DC		[1] [7]	0.45	0.40	0.46	0.40
Maximum DC	3σ	[1]	0.48	0.42	0.49	0.41
Maximum (peak) DC	3σ		1.23	1.52	1.26	1.50
Peak operating current (random write)						
Typical DC			0.51	0.36	0.52	0.36
Maximum DC	3σ		0.54	0.41	0.56	0.40
Maximum (peak) DC	3σ		1.14	1.56	1.06	1.52
Peak operating current (sequential read)						
Typical DC			0.83	0.17	0.84	0.17
Maximum DC	3σ		0.88	0.18	0.90	0.18
Maximum (peak) DC	3σ		1.13	0.30	1.21	0.31
Peak operating current (sequential write)						
Typical DC			0.90	0.17	0.92	0.17
Maximum DC	3σ		0.94	0.18	0.96	0.18
Maximum (peak) DC	3σ		1.14	0.39	1.20	0.30

Table 5: DC power requirements for ST9300605FC model

			2Gb		4Gb	
		Notes	**(Amps)**	**(Amps)**	**(Amps)**	**(Amps)**
Voltage			+5V	+12V [2]	+5V	+12V [2]
Regulation		[6]	±5%	±5% [2]	±5%	±5% [2]
Avg idle current DC		[1] [8]	0.36	0.15	0.38	0.15
Advanced Idle Current						
Idle_A	3σ		0.38	0.16	0.39	0.16
Idle_B	3σ		0.26	0.15	0.27	0.15
Idle_C	3σ		0.26	0.09	0.27	0.09
Standby	3σ		0.26	0.06	0.27	0.06
Maximum starting current						
(peak DC) DC	3σ	[4]	0.61	0.89	0.63	0.89
(peak AC) AC	3σ	[4]	0.95	1.54	0.99	1.52
Delayed motor start (max) DC	3σ	[1] [5]	0.57	0.06	0.58	0.06
Peak operating current (random read):						
Typical DC		[1] [7]	0.45	0.35	0.47	0.35
Maximum DC	3σ	[1]	0.47	0.37	0.49	0.37
Maximum (peak) DC	3σ		1.23	1.48	1.16	1.46
Peak operating current (random write)						
Typical DC			0.51	0.33	0.52	0.33
Maximum DC	3σ		0.53	0.36	0.54	0.36
Maximum (peak) DC	3σ		1.06	1.48	1.06	1.51
Peak operating current (sequential read)						
Typical DC			0.81	0.14	0.83	0.14
Maximum DC	3σ		0.86	0.15	0.87	0.14
Maximum (peak) DC	3σ		1.12	0.32	1.15	0.32
Peak operating current (sequential write)						
Typical DC			0.89	0.14	0.91	0.14
Maximum DC	3σ		0.94	0.15	0.95	0.14
Maximum (peak) DC	3σ		1.20	0.32	1.19	0.30

[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 9,936 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 5.

[4] See +12V current profile in Figure 6.

[5] This condition occurs when the Motor Start option is enabled and the drive has not yet received a Start Motor command.

[6] See paragraph 7.3.1, "Conducted noise immunity." Specified voltage tolerance includes ripple, noise, and transient response.

[7] Operating condition is defined as random 8 block reads.

[8] During idle, the drive heads are relocated every 30 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 1.2% 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 25-minute warm up.
5. No terminator power.

7.3.1 Conducted noise immunity

Noise is specified as a periodic and random distribution of frequencies covering a defined frequency range. Maximum allowed noise values given below are peak-to-peak measurements and apply at the drive power connector.

+5 V = 250 mV pp from 100 Hz to 20 MHz.
+12 V = 450 mV pp from 100 Hz to 100 KHz.
250 mV pp from 100 KHz to 20 MHz.
150 mV pp from 20 MHz to 100 MHz.

7.3.2 Power sequencing

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

7.3.3 Current profiles

The +12V and +5V current profiles for the all models are shown below.

Note: All times and currents are typical. See Tables 2 through 5 for maximum current requirements.

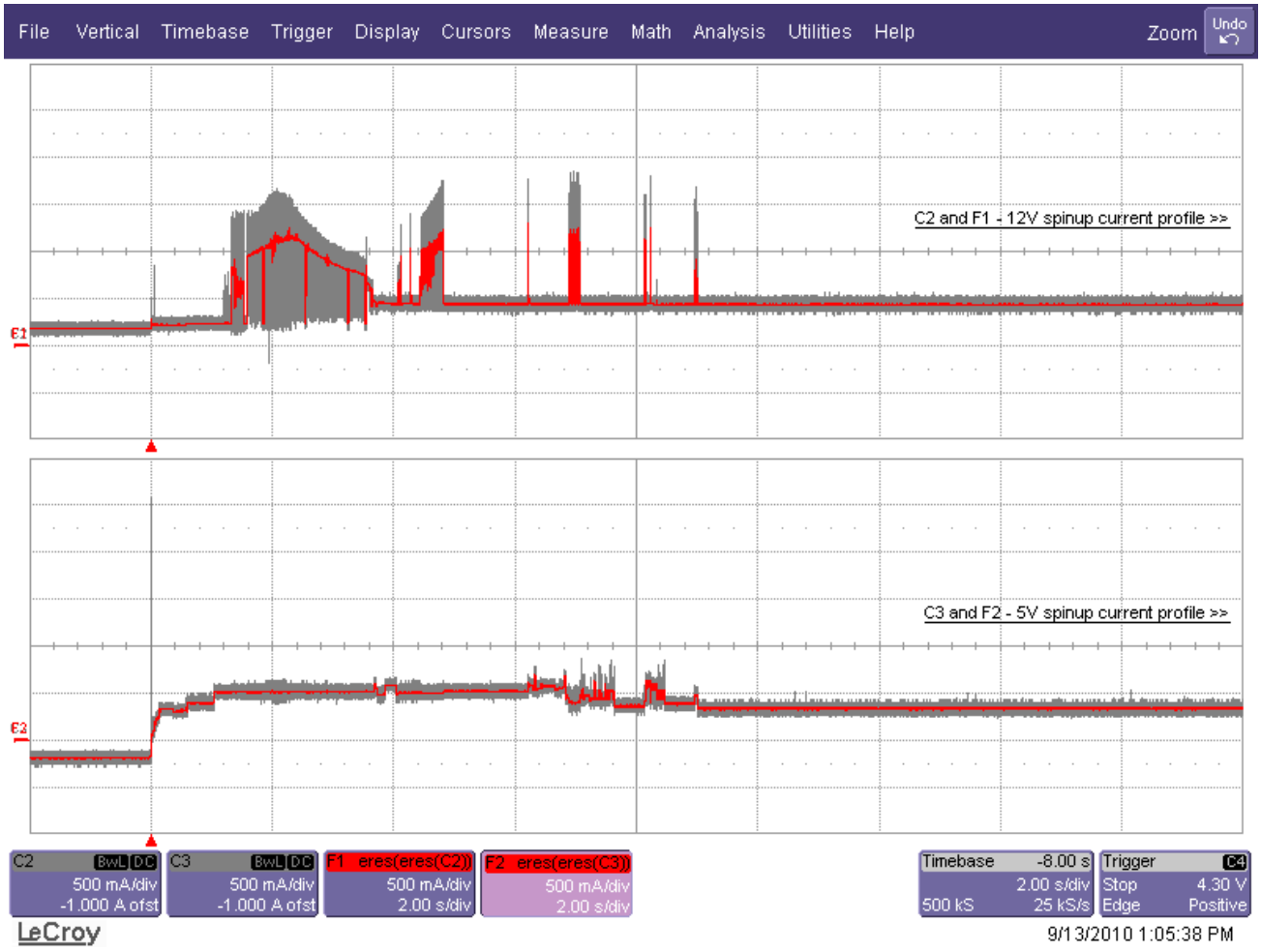


Figure 1. Typical ST9900805FC drive, 4Gb, +5V and +12V current profiles

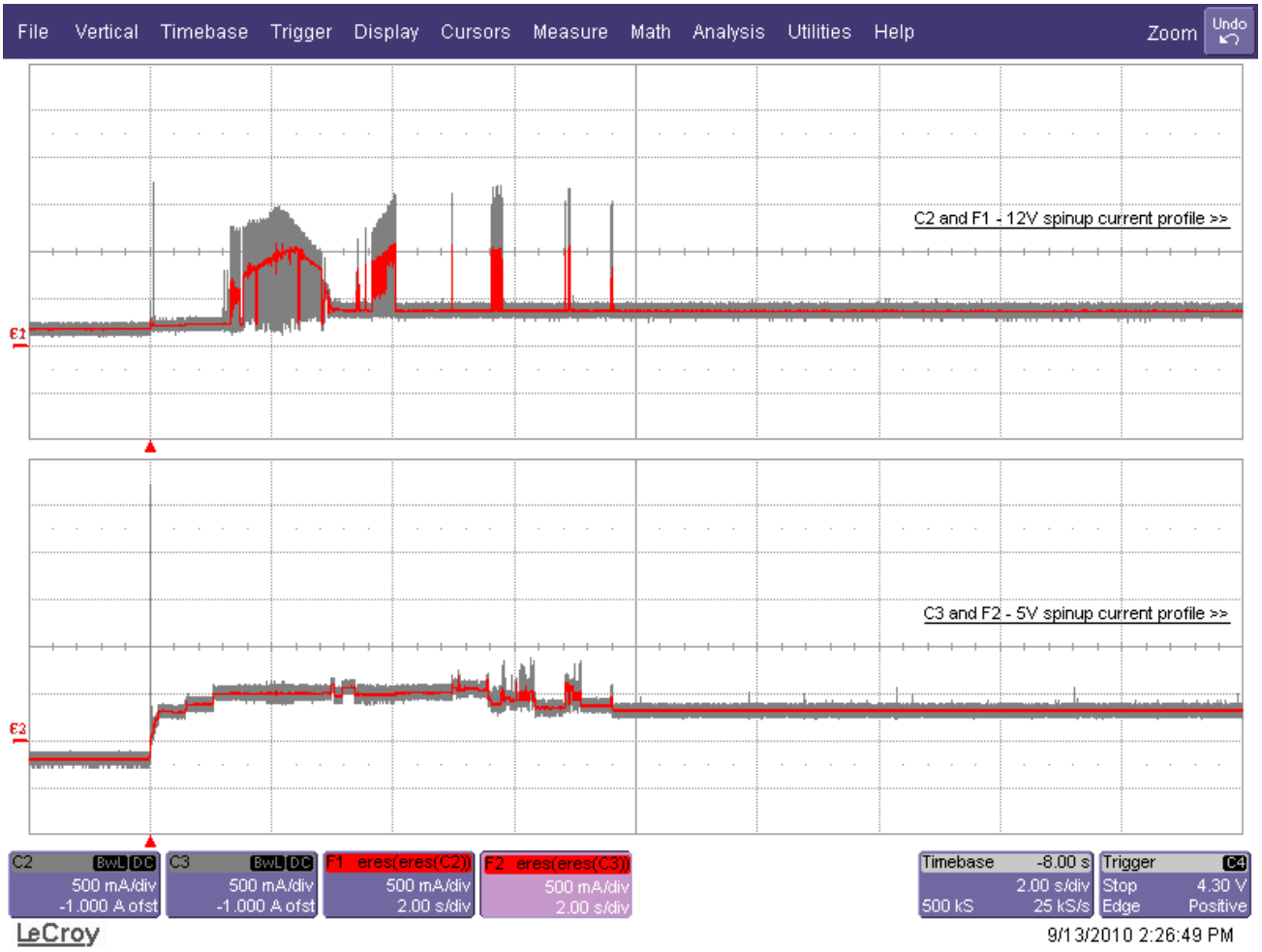


Figure 2. Typical ST9600205FC drive, 4Gb, +5V and +12V current profiles

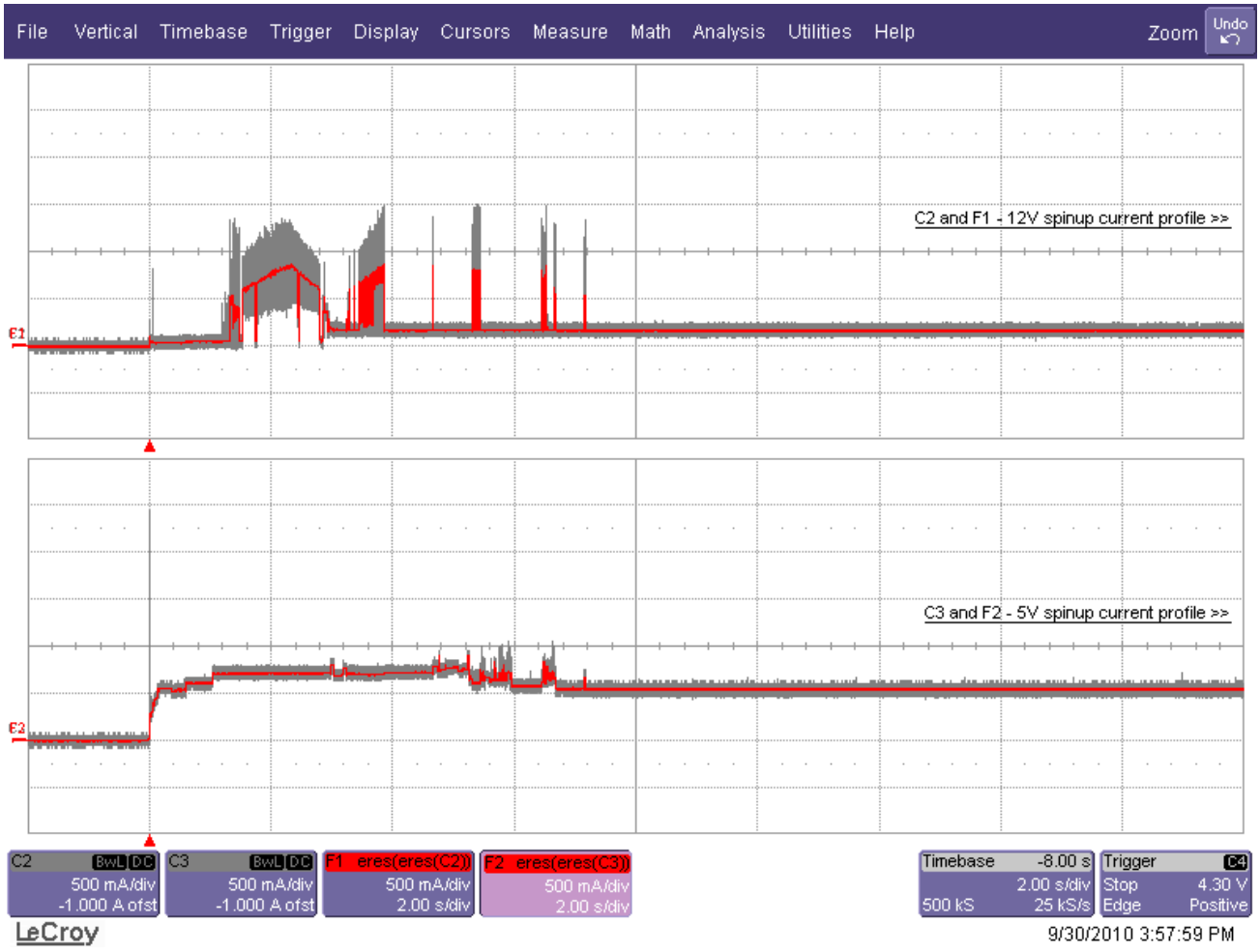


Figure 3. Typical ST9450405FC drive, 4Gb, +5V and +12V current profiles

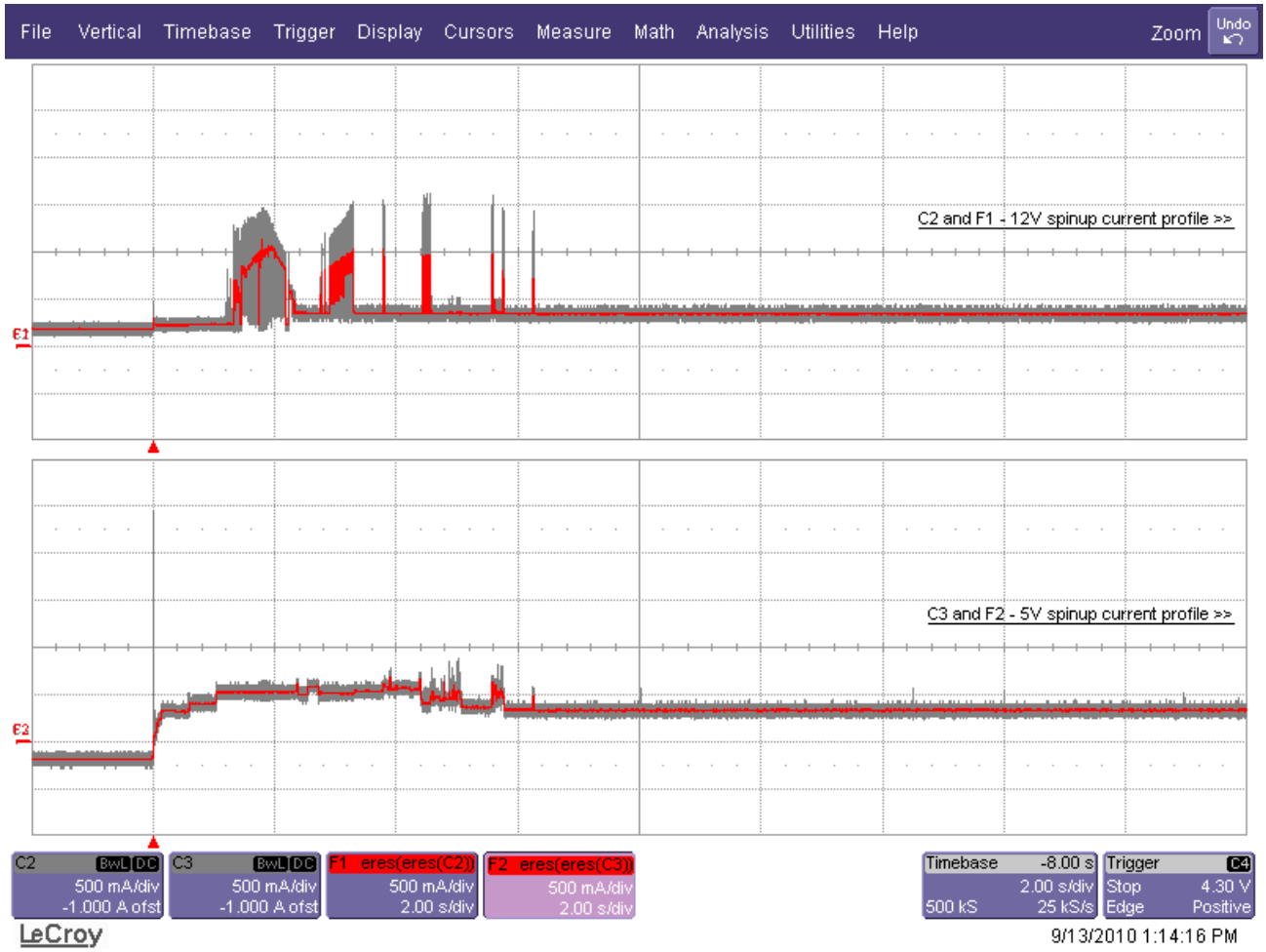


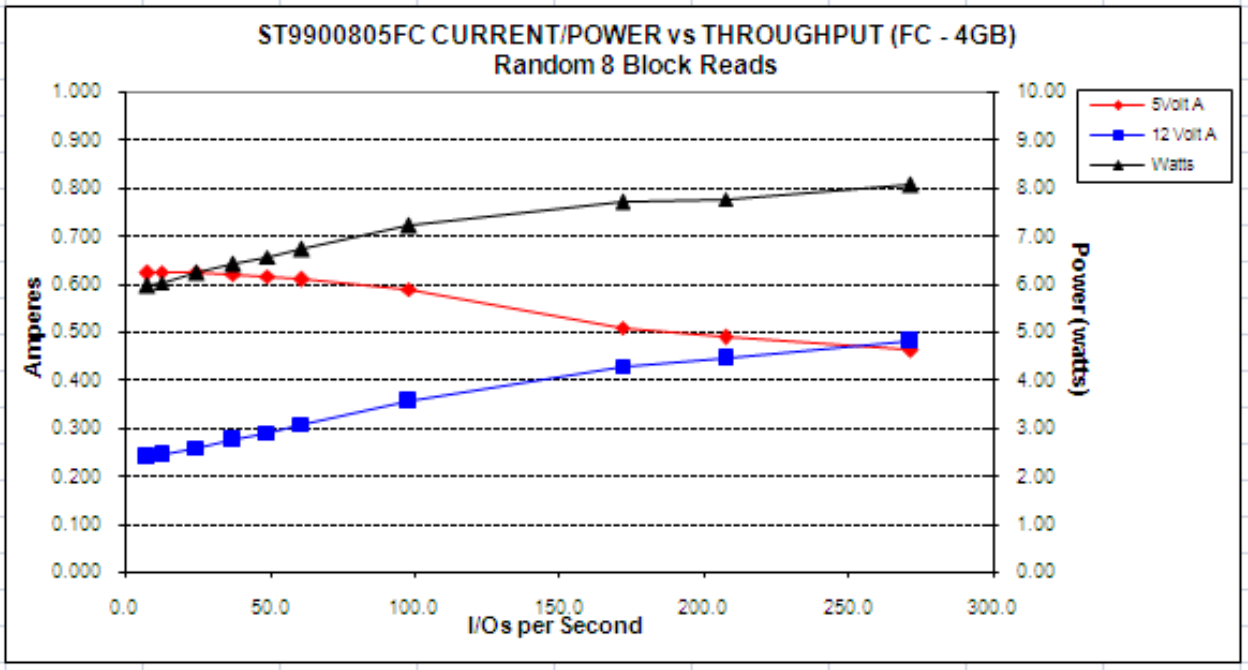
Figure 4. Typical ST9300605FC drive, 4Gb, +5V and +12V current profiles

7.4 Power dissipation

ST9900805FC

Typical power dissipation under idle conditions in 4Gb operation is 4.77 Watts (16.26 BTUs per hour).

To obtain operating power for typical random read operations, refer to the following I/O rate curve (see Figure 5). 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.



ST9900805FC DC current and power vs. input/output operations per second

ST9600205FC

Typical power dissipation under idle conditions in 4Gb operation is 4.13 watts (14.09 BTUs per hour).

To obtain operating power for typical random read operations, refer to the following I/O rate curve (see Figure 5). 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.

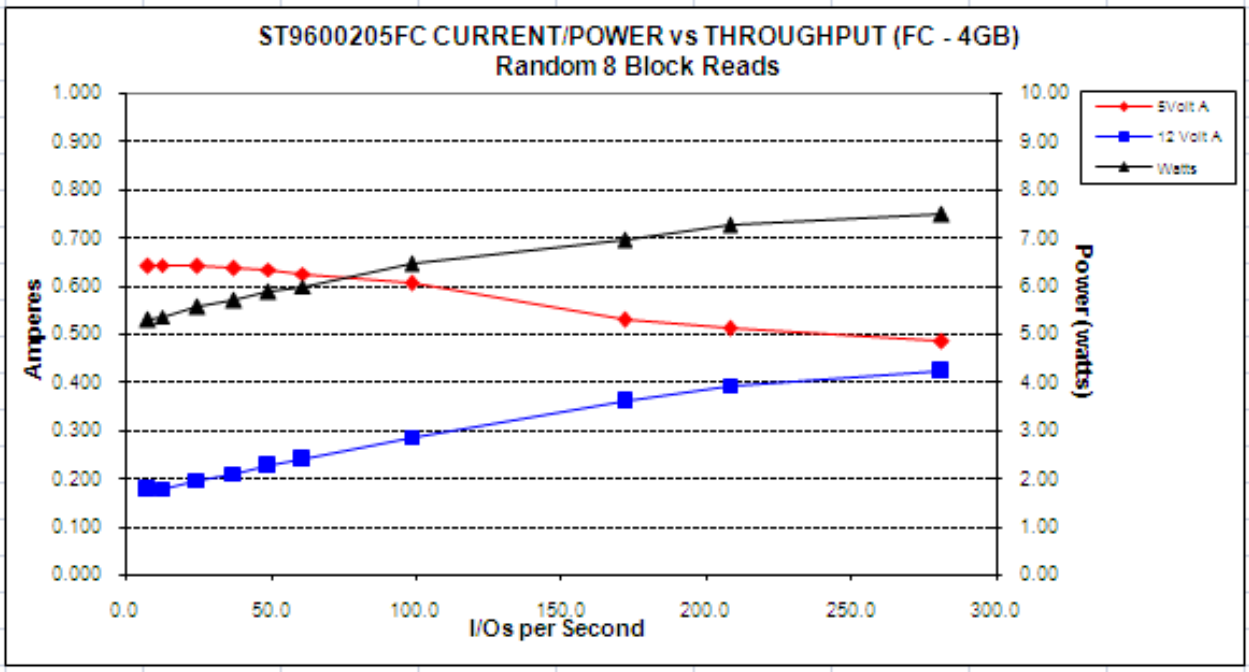


Figure 5. ST9600205FC DC current and power vs. input/output operations per second

ST9450405FC

Typical power dissipation under idle conditions in 4Gb operation is 4.07 watts (13.90 BTUs per hour).

To obtain operating power for typical random read operations, refer to the following I/O rate curve (see Figure 5). 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.

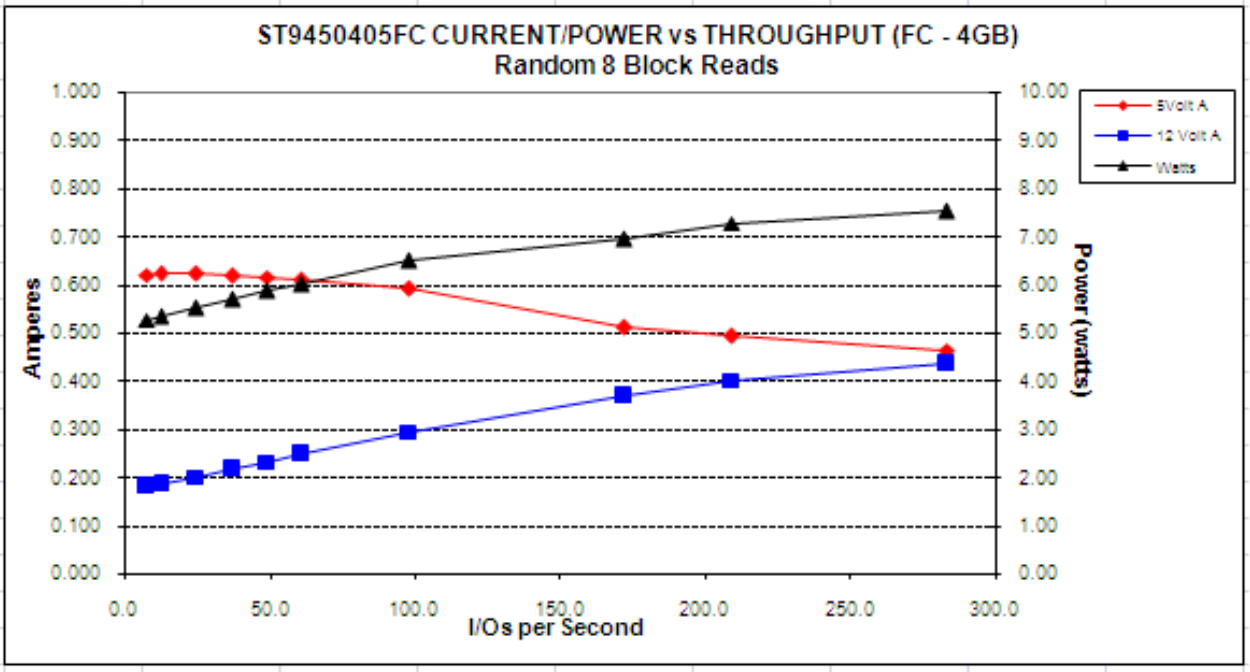


Figure 6. ST9450405FC DC current and power vs. input/output operations per second

ST9300605FC

Typical power dissipation under idle conditions in 4Gb operation is 3.73 watts (12.72 BTUs per hour).

To obtain operating power for typical random read operations, refer to the following I/O rate curve (see Figure 5). 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.

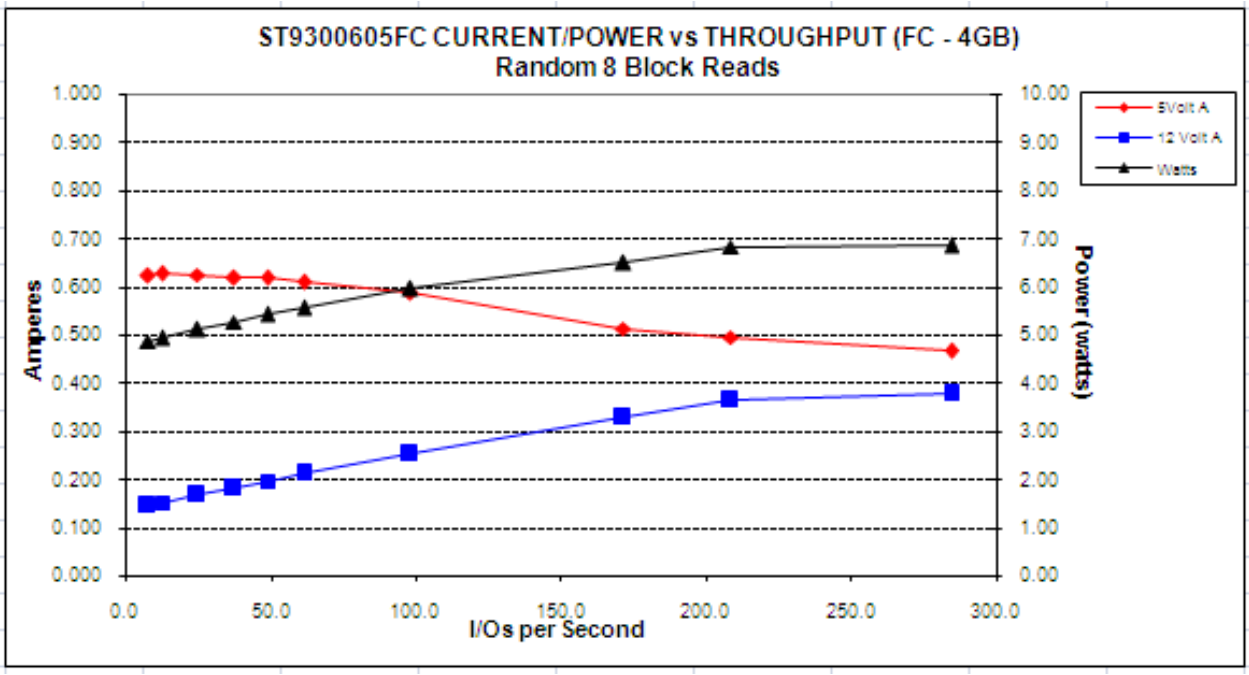


Figure 7. ST9300605FC DC current and power vs. input/output operations per second

7.5 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).

Note. To maintain optimal performance drives should be run at nominal case temperatures.

7.5.1 Temperature

a. Operating

The drive meets the operating specifications over a 41°F to 131°F (5°C to 55°C) drive case temperature range with a maximum temperature gradient of 36°F (20°C) per hour.

The maximum allowable drive case temperature is 60°C.

The MTBF specification for the drive assumes the operating environment is designed to maintain nominal case temperature. The rated MTBF is based upon a sustained case temperature of 122°F (50°C). Occasional excursions in operating temperature between the rated MTBF temperature and the maximum drive operating case temperature may occur without impact to the rated MTBF temperature. However continual or sustained operation at case temperatures beyond the rated MTBF temperature will degrade the drive MTBF and reduce product reliability.

Air flow may be required to achieve consistent nominal case temperature values (see Section 9.2). To confirm that the required cooling is provided for the electronics and HDA, place the drive in its final mechanical configuration, and perform random write/read operations. After the temperatures stabilize, measure the case temperature of the drive.

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.

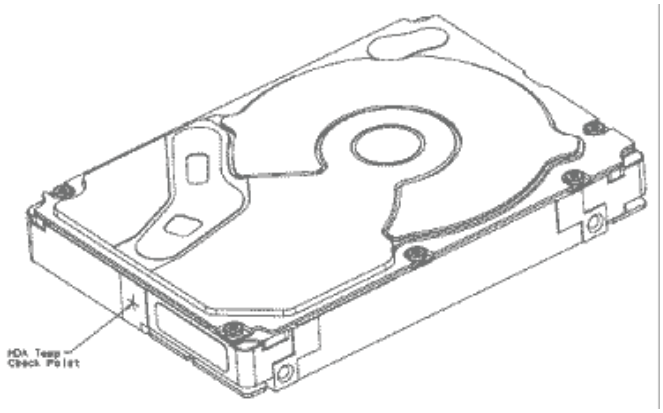


Figure 8. Locations of the HDA temperature check point

7.5.2 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.

7.5.3 Effective altitude (sea level)

a. Operating

–1,000 to +10,000 feet (–304.8 to +3,048 meters)

b. Non-operating

–1,000 to +40,000 feet (–304.8 to +12,192 meters)

7.5.4 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 9, and in accordance with the restrictions of Section 9.4.

7.5.4.1 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 duration of 11ms (half sinewave)
- 25 Gs at a duration of 2ms (half sinewave)
- 65 Gs at a duration of 2ms (half sinewave) when performing reads only

Shock may be applied in the X, Y, or Z axis. Shock is not to be repeated more than once every 2 seconds.

b. 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 the three values below, shall not exhibit device damage or performance degradation.

- 80 Gs at a duration of 11ms (half sinewave)
- 400 Gs at a duration of 2ms (half sinewave)
- 300 Gs at a duration of 0.5ms (half sinewave)

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

c. Packaged

Seagate finished drive bulk packs are designed and tested to meet or exceed applicable ISTA and ASTM standards. Volume finished drives will be shipped from Seagate factories on pallets to minimize freight costs and ease material handling. Seagate finished drive bulk packs may be shipped individually. For less than full shipments, instructions are printed on the bulk pack carton for minimum drive quantities and proper drive placement.

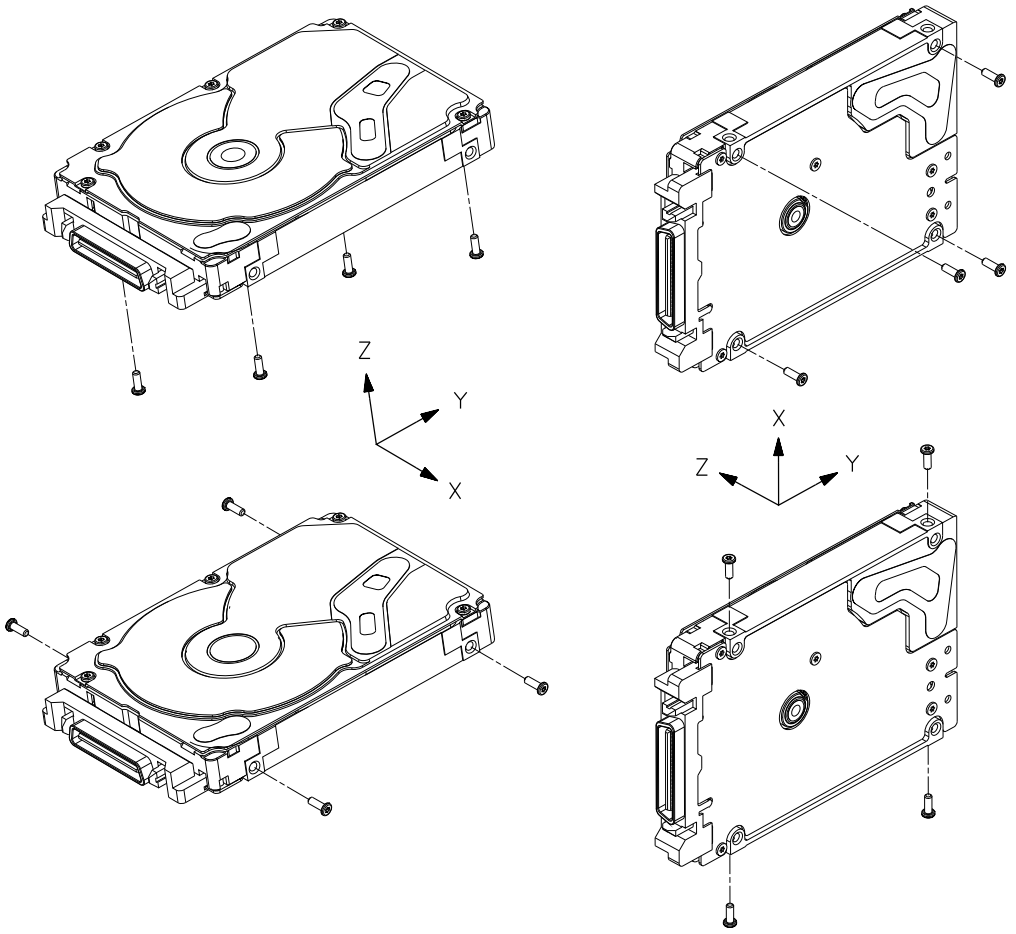


Figure 9. Recommended mounting

Note. Image of the HDA may not represent actual product, for reference only

7.5.4.2 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

5-500 Hz @ 0.5 G (zero to peak)

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

Operating normal translational random flat profile

10 - 500 Hz (transactional random flat profile) 0.5 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

5-500 Hz @ 0.75 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 (transactional random flat profile) 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

5-500 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 (transactional random flat profile) 2.4 GRMS

7.5.5 Acoustics

Sound power during idle mode shall be 3.0 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.

7.5.6 Air cleanliness

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

7.5.7 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.

7.5.8 Electromagnetic susceptibility

See Section 3.1.1.1.

7.6 Mechanical specifications

Refer to Figure 10 for detailed physical dimensions. See Section 9.4, “Drive mounting.”

Weight:	300GB models	.476 lb	.216 kg
	450GB models	.485 lb	.220 kg
	600GB models	.486 lb	.221 kg
	900GB models	.462 lb	.210 kg

Note. These dimensions conform to the Small Form Factor Standard documented in SFF-8201 and SFF-8222, found at www.sffcommittee.org.

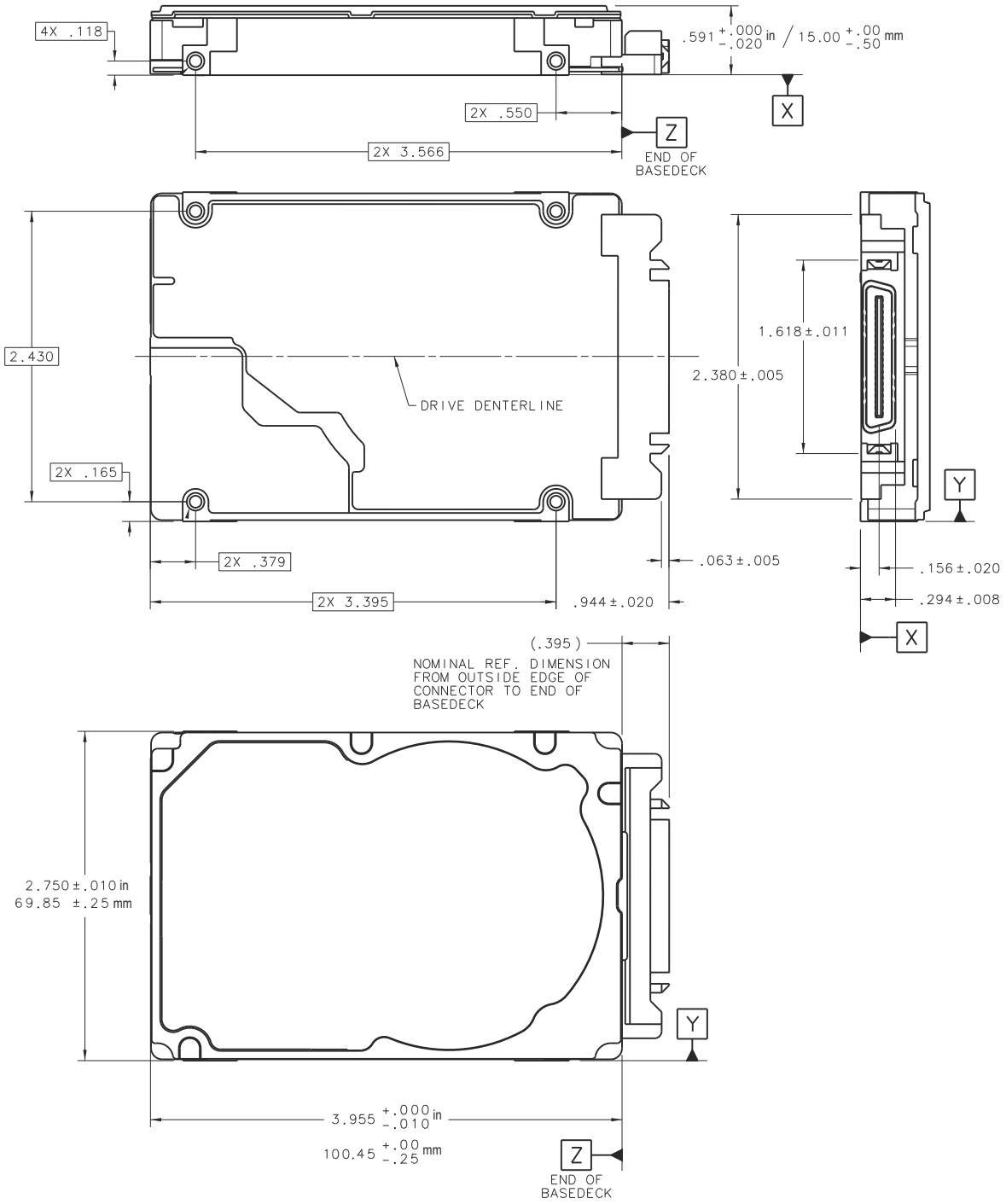


Figure 10. Mounting configuration dimensions

8.0 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 FC 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 8.4)
- Media Pre-Scan (see Section 8.5)
- Deferred Auto-Reallocation (see Section 8.6)
- Idle Read After Write (see Section 8.7)

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

8.1 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 *Fibre Channel Interface Manual*. Also, more information on the drive Error Recovery philosophy is presented in the *Fibre Channel Interface Manual*.

8.2 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 Interface 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 consist of 20 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 6 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 6: Read and write retry count maximum recovery times

Read retry count*	Maximum recovery time per LBA (cumulative, msec)
1	124.32
5	621.62
10	1243.23
15	1864.85
20 (default)	2486.47

Write retry count	Maximum recovery time per LBA (cumulative, msec)
0	35.94
1	53.91
2	79.89
3	97.86
4	175.85
5 (default)	421.79

* For read retry count, every tick ~ 5% of total error recovery. Valid range setting is 1-20.

e.g. 1 ~ 5%

5 ~ 25%

20 ~ 100%

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 and if the read retry count is set to 5, this means ~ 25% of error recovery will be executed which consumes 621.62 ms (please refer to the table above). If the limit is reached and a LBA has not yet been recovered (i.e. requires retries beyond 621.62 ms), the command will end with Check Condition status report and unrecoverable read error will be reported.

8.3 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.

8.4 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 limited time bursts then suspends activity 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 1ms.

8.5 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 disk.

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.

8.6 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.

8.7 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.

8.8 Protection Information (PI)

Protection Information is intended as a standardized approach to system level LRC traditionally provided by systems using 520 byte formatted LBAs. Drives formatted with PI information provide the same, common LBA count (i.e. same capacity point) as non-PI formatted drives. Sequential performance of a PI drive will be reduced by approximately 1.56% due to the extra overhead of PI being transferred from the media that is not calculated as part of the data transferred to the host. To determine the full transfer rate of a PI drive, transfers should be calculated by adding the 8 extra bytes of PI to the transferred LBA length, i.e. 512 + 8 = 520. PI formatted drives are physically formatted to 520 byte sectors that store 512 bytes of customer data with 8 bytes of Protection Information appended to it. The advantage of PI is that the Protection Information bits can be managed at the HBA and HBA driver level. Allowing a system that typically does not support 520 LBA formats to integrate this level of protection.

Protection Information is valid with any supported LBA size. 512 LBA size is used here as common example.

8.8.1 Levels of PI

There are 4 types of Protection Information.

Type 0 - Describes a drive that is not formatted with PI information bytes. This allows for legacy support in non-PI systems.

Type 1 - Provides support of PI protection using 10 and 16 byte commands. The RDPROTECT and WRTPROTECT bits allow for checking control through the CDB. Eight bytes of Protection Information are transmitted at LBA boundaries across the interface if RDPROTECT and WRTPROTECT bits are nonzero values. Type 1 does not allow the use of 32 byte commands.

Type 2 - Provides checking control and additional expected fields within the 32 byte CDBs. Eight bytes of Protection Information are transmitted at LBA boundaries across the interface if RDPROTECT and WRTPROTECT bits are nonzero values. Type 2 does allow the use of 10 and 16 byte commands with zero values in the RDPROTECT and WRTPROTECT fields. The drive will generate 8 bytes (e.g.0xFFFF) 8 bytes of Protection Information to be stored on the media, but the 8 bytes will not be transferred to the host during a read command.

Type 3 - Seagate products do not support Type 3.

8.8.2 Setting and determining the current Type Level

A drive is initialized to a type of PI by using the format command on a PI capable drive. Once a drive is formatted to a PI Type, it may be queried by a Read Capacity (16) command to report the PI type which it is currently formatted to. PI Types cannot coexist on a single drive. A drive can only be formatted to a single PI Type. It can be changed at anytime to a new Type but requires a low level format which destroys all existing data on the drive. No other vehicle for changing the PI type is provided by the T10 SBC3 specification.

Type 1 PI format CDB command: 04 90 00 00 00 00, Write Buffer: 00 A0 00 00

Type 2 PI format CDB command: 04 D0 00 00 00 00, Write Buffer: 00 A0 00 00

8.8.3 Identifying a Protection Information drive

The Standard Inquiry provides a bit to indicate if PI is support by the drive. Vital Product Descriptor (VPD) page 0x86 provides bits to indicate the PI Types supported and which PI fields the drive supports checking.

Note. For further details with respect to PI, please refer to SCSI Block Commands - 3 (SBC-3) Draft Standard documentation.

9.0 Installation

Savvio 10K.5 FC disk 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 10.5 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 28). 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.

9.1 Drive ID/option selection

All drive options are made through the interface connector (J1). Table 25 provides the pin descriptions for the 40-pin Fibre Channel single connector (J1).

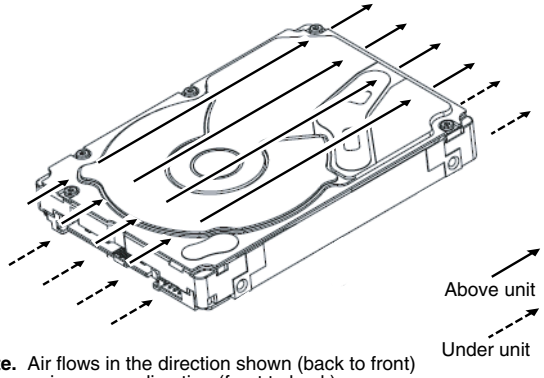
9.2 Drive orientation

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

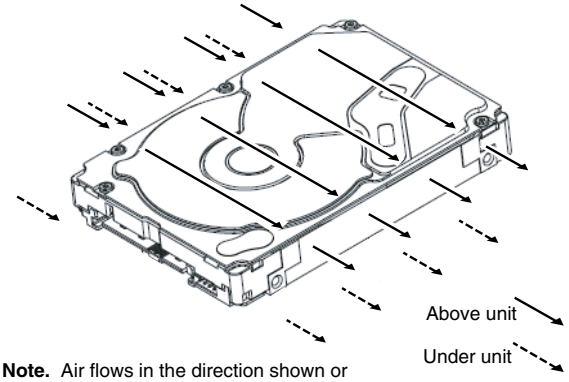
9.3 Cooling

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 7.5.1. In some cases, forced airflow may be required to keep temperatures at or below the temperatures specified in Section 7.5.1.

If forced air is necessary, possible air-flow patterns are shown in Figure 11. 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 7.5.1 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 11. Air flow

Note. Image of the HDA may not represent actual product, for reference only

9.4 Drive mounting

Mount the drive using the bottom or side mounting holes. If you mount the drive using the bottom holes, ensure that you do not physically distort the drive by attempting to mount it on a stiff, non-flat surface.

The allowable mounting surface stiffness is 80 lb/in (14.0 N/mm). The following equation and paragraph define the allowable mounting surface stiffness:

$$K \times X = F \leq 15lb = 67N$$

where K is the mounting surface stiffness (units in lb/in or N/mm) and X is the out-of-plane surface distortion (units in inches or millimeters). The out-of-plane distortion (X) is determined by defining a plane with three of the four mounting points fixed and evaluating the out-of-plane deflection of the fourth mounting point when a known force (F) is applied to the fourth point.

Note. Before mounting the drive in any kind of 3.5-inch to 5.25-inch adapter frame, verify with Seagate Technology that the drive can meet the shock and vibration specifications given herein while mounted in such an adapter frame. Adapter frames that are available may not have a mechanical structure capable of mounting the drive so that it can meet the shock and vibration specifications listed in this manual.

9.5 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.

10.0 Interface requirements

This section partially describes the interface requirements as implemented on Savvio 10K.5 FC drives. Additional information is provided in the *Fibre Channel Interface Manual* (part number 100293070).

10.1 FC-AL features

This section lists the Fibre Channel-specific features supported by Savvio 10K.5 FC drives.

10.1.1 Fibre Channel link service frames

Table 7 lists the link services supported by Savvio 10K.5 FC drives.

Table 7: 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 (PRLO) 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)

10.1.2 Fibre Channel task management functions

Table 8 lists the Fibre Channel SCSI Fibre Channel Protocol (FC SCSI FCP) task management functions supported.

Table 8: Fibre Channel SCSI FCP task management functions

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

10.1.3 Fibre Channel task management responses

Table 9 lists the FC SCSI FCP response codes returned for task management functions supported.

Table 9: FC SCSI FCP response codes

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

10.1.4 Fibre Channel port login

Table 10 identifies the required content of the N_Port Login (PLOGI) payload from an initiator.

Table 10: 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.

10.1.5 Fibre Channel port login accept

Table 11 identifies the N_Port Login access payload values.

Table 11: 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.	

10.1.6 Fibre Channel Process Login

Table 12 lists the process login payload data.

Table 12: Process Login (PLRI) payload

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

XX Indicates fields that are not used.

10.1.7 Fibre Channel Process Login Accept

Table 13 lists Savvio 10K.5 FC process login accept payload data.

Table 13: 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												

10.1.8 Fibre Channel fabric login

Table 14 lists the fabric login payload from the drive.

Table 14: 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.

10.1.9 Fibre Channel fabric accept login

Table 15 lists the required content of the Fabric Login Accept (ACC) payload from the fabric.

Table 15: 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

10.1.10 Fibre Channel Arbitrated Loop options

Table 16 lists the FC-AL options supported by Savvio 10K.5 FC drives.

Table 16: 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

10.2 Dual port support

Savvio 10K.5 FC 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 10K.5 FC 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.

10.3 SCSI commands supported

Table 17 lists the SCSI commands supported by Savvio 10K.5 FC drives.

Table 17: 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)
	Y	Disconnect/reconnect control (page 02h)
	Y	Format page (03h)
	Y	Rigid disk drive geometry page (04h)

Table 17: Supported commands *(continued)*

Command code	Supported [4]	Command name
	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)
	Y	Background Scan mode subpage (01h)
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
2Fh	Y	Verify
	Y	Disable page out
	Y	Byte check
	N	Relative address
30h	N	Search data high
31h	N	Search data equal

Table 17: Supported commands *(continued)*

Command code	Supported [4]	Command name
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
	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)

Table 17: Supported commands *(continued)*

Command code	Supported [4]	Command name
	Y	Temperature page (0Dh)
	Y	Application Client page (0Fh)
	Y	Self Test Results page (10h)
	Y	Background Medium Scan page (15h)
	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
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 10K.5 FC drives can format to 512, 520, 524 or 528 bytes per logical block.
[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.

10.3.1 Inquiry data

Table 18 lists the Inquiry command data that the drive should return to the initiator per the format given in the *Fibre Channel Interface Manual*.

Table 18: Savvio 10K.5 FC inquiry data

Bytes	Data (hex)																
0-15	00	00	xx**	12	8B	00	PP	02	53	45	41	47	41	54	45	20	Vendor ID
16-31	[53	54	39	39	30	30	38	30	35	46	43][1]	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*	39*	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).

** SCSI Revision support. Refer to the appropriate SPC release documentation for definitions.

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 16 through 26 reflect model of drive. The table above shows the hex values for model ST9900805FC.
Bytes 16 through 26 values for other models are shown below:

ST9600205FC	53	54	39	36	30	30	32	30	35	46	43
ST9450405FC	53	54	39	34	35	30	34	30	35	46	43
ST9300605FC	53	54	39	36	30	30	36	30	35	46	43

10.3.2 Mode Sense data

The Mode Sense command provides a way for the drive to report its operating parameters to the initiator. The drive maintains four sets of mode parameters:

1. Default values

   Default values are hard-coded in the drive firmware stored in flash E-PROM (nonvolatile memory) on the drive's PCB. These default values can be changed only by downloading a complete set of new firmware into the flash E-PROM. An initiator can request and receive from the drive a list of default values and use those in a Mode Select command to set up new current and saved values, where the values are changeable.

2. Saved values

   Saved values are stored on the drive's media using a Mode Select command. Only parameter values that are allowed to be changed can be changed by this method. Parameters in the saved values list that are not changeable by the Mode Select command get their values from default values storage.

   When power is applied to the drive, it takes saved values from the media and stores them as current values in volatile memory. It is not possible to change the current values (or the saved values) with a Mode Select command before the drive achieves operating speed and is "ready." An attempt to do so results in a "Check Condition" status.

On drives requiring unique saved values, the required unique saved values are stored into the saved values storage location on the media prior to shipping the drive. Some drives may have unique firmware with unique default values also.

On standard OEM drives, the saved values are taken from the default values list and stored into the saved values storage location on the media prior to shipping.

3. Current values

   Current values are volatile values being used by the drive to control its operation. A Mode Select command can be used to change the values identified as changeable values. Originally, current values are installed from saved or default values after a power on reset, hard reset, or Bus Device Reset message.

4. Changeable values

   Changeable values form a bit mask, stored in nonvolatile memory, that dictates which of the current values and saved values can be changed by a Mode Select command. A one (1) indicates the value can be changed. A zero (0) indicates the value is not changeable. For example, in Table 20, refer to Mode page 81, in the row entitled “CHG.” These are hex numbers representing the changeable values for Mode page 81. Note in columns 5 and 6 (bytes 04 and 05), there is 00h which indicates that in bytes 04 and 05 none of the bits are changeable. Note also that bytes 06, 07, 09, 10, and 11 are not changeable, because those fields are all zeros. In byte 02, hex value FF equates to the binary pattern 11111111. If there is a zero in any bit position in the field, it means that bit is not changeable. Since all of the bits in byte 02 are ones, all of these bits are changeable.

   The changeable values list can only be changed by downloading new firmware into the flash E-PROM.

Note. Because there are often several different versions of drive control firmware in the total population of drives in the field, the Mode Sense values given in the following tables may not exactly match those of some drives.

The following tables list the values of the data bytes returned by the drive in response to the Mode Sense command pages for SCSI implementation (see the *Fibre Channel Interface Manual*).

Definitions:

DEF = Default value. Standard OEM drives are shipped configured this way.
CHG = Changeable bits; indicates if default value is changeable.

Table 19: Mode Sense data saved, default and changeable values for ST9900805FC drives

```
MODE DATA HEADER:
00 e2 00 10 01 00 00 10

BLOCK DESCRIPTOR:
00 00 00 00 68 cb 9e 30 00 00 00 00 00 00 02 00

MODE PAGES:

DEF  81 0a c0 14 ff 00 00 00 05 00 ff ff
CHG  81 0a ff ff 00 00 00 00 ff 00 ff ff

DEF  82 0e 80 80 00 00 00 00 00 00 01 3a 00 00 00 00
CHG  82 0e ff ff 00 00 00 00 00 00 ff ff 00 00 00 00

DEF  83 16 bb d0 00 00 00 00 03 80 04 c4 02 00 00 01 00 a0 00 18 40 00 00 00
CHG  83 16 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

DEF  84 16 02 d3 c1 06 00 00 00 00 00 00 00 00 00 00 00 00 00 00 27 31 00 00
CHG  84 16 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

DEF  87 0a 00 14 ff 00 00 00 00 00 ff ff
CHG  87 0a 0f ff 00 00 00 00 00 00 ff ff

DEF  88 12 14 00 ff ff 00 00 ff ff ff ff 80 20 00 00 00 00 00 00
CHG  88 12 a5 00 00 00 ff ff ff ff 00 00 20 00 00 00 00 00 00 00

DEF  8a 0a 02 00 00 80 00 00 00 00 1d 88
CHG  8a 0a 07 f6 00 00 00 00 00 00 00 00

DEF  99 06 00 00 00 00 04 00
CHG  99 06 00 ff 00 00 00 ff

DEF  9a 26 00 06 00 00 00 0a 00 00 8c a0 00 00 17 70 00 00 46 50 00 00 46 50 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00
CHG  9a 26 01 0f ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00

DEF  9c 0a 10 00 00 00 00 00 00 00 00 01
CHG  9c 0a 9d 0f ff ff ff ff ff ff ff ff

DEF  80 06 00 80 0f 00 00 00
CHG  80 06 b7 c0 8f 00 00 00
```

Table 20: Mode Sense data saved, default and changeable values for ST9600205FC drives

```
MODE DATA HEADER:
00 e2 00 10 01 00 00 10

BLOCK DESCRIPTOR:
00 00 00 00 45 dd 2f b0 00 00 00 00 00 00 02 00

MODE PAGES:

DEF  81 0a c0 14 ff 00 00 00 05 00 ff ff
CHG  81 0a ff ff 00 00 00 00 ff 00 ff ff

DEF  82 0e 80 80 00 00 00 00 00 00 01 3a 00 00 00 00
CHG  82 0e ff ff 00 00 00 00 00 00 ff ff 00 00 00 00

DEF  83 16 bb d0 00 00 00 00 03 80 04 c4 02 00 00 01 00 9a 00 18 40 00 00 00
CHG  83 16 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

DEF  84 16 02 d3 c1 04 00 00 00 00 00 00 00 00 00 00 00 00 00 00 27 31 00 00
CHG  84 16 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

DEF  87 0a 00 14 ff 00 00 00 00 00 ff ff
CHG  87 0a 0f ff 00 00 00 00 00 00 ff ff

DEF  88 12 14 00 ff ff 00 00 ff ff ff ff 80 20 00 00 00 00 00 00
CHG  88 12 a5 00 00 00 ff ff ff ff 00 00 20 00 00 00 00 00 00 00

DEF  8a 0a 02 00 00 80 00 00 00 00 13 b0
CHG  8a 0a 07 f6 00 00 00 00 00 00 00 00

DEF  99 06 00 00 00 00 04 00
CHG  99 06 00 ff 00 00 00 ff

DEF  9a 26 00 06 00 00 00 0a 00 00 8c a0 00 00 17 70 00 00 46 50 00 00 46 50 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00
CHG  9a 26 01 0f ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00

DEF  9c 0a 10 00 00 00 00 00 00 00 01
CHG  9c 0a 9d 0f ff ff ff ff ff ff ff ff

DEF  80 06 00 80 0f 00 00 00
CHG  80 06 b7 c0 8f 00 00 00
```

Table 21: Mode Sense data default and changeable values for ST9450405FC drives

```
MODE DATA HEADER:
00 e2 00 10 01 00 00 10

BLOCK DESCRIPTOR:
00 00 00 00 34 65 f8 70 00 00 00 00 00 00 02 00

MODE PAGES:

DEF  81 0a c0 14 ff 00 00 00 05 00 ff ff
CHG  81 0a ff ff 00 00 00 00 ff 00 ff ff

DEF  82 0e 80 80 00 00 00 00 00 00 01 3a 00 00 00 00
CHG  82 0e ff ff 00 00 00 00 00 00 ff ff 00 00 00 00

DEF  83 16 bb d0 00 00 00 00 03 80 04 c4 02 00 00 01 00 9a 00 18 40 00 00 00
CHG  83 16 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

DEF  84 16 02 d3 c1 03 00 00 00 00 00 00 00 00 00 00 00 00 00 00 27 31 00 00
CHG  84 16 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

DEF  87 0a 00 14 ff 00 00 00 00 00 ff ff
CHG  87 0a 0f ff 00 00 00 00 00 00 ff ff

DEF  88 12 14 00 ff ff 00 00 ff ff ff ff 80 20 00 00 00 00 00 00
CHG  88 12 a5 00 00 00 ff ff ff ff 00 00 20 00 00 00 00 00 00 00

DEF  8a 0a 02 00 00 80 00 00 00 00 0e c4
CHG  8a 0a 07 f6 00 00 00 00 00 00 00 00

DEF  99 06 00 00 00 00 04 00
CHG  99 06 00 ff 00 00 00 ff

DEF  9a 26 00 06 00 00 00 0a 00 00 8c a0 00 00 17 70 00 00 46 50 00 00 46 50 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00
CHG  9a 26 01 0f ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00

DEF  9c 0a 10 00 00 00 00 00 00 00 00 01
CHG  9c 0a 9d 0f ff ff ff ff ff ff ff ff

DEF  80 06 00 80 0f 00 00 00
CHG  80 06 b7 c0 8f 00 00 00
```

Table 22: Mode Sense data default and changeable values for ST9300605FC drives

```
MODE DATA HEADER:
  00 e2 00 10 01 00 00 10

BLOCK DESCRIPTOR:
  00 00 00 00 22 ec b2 5c 00 00 00 00 00 00 02 00

MODE PAGES:

DEF  81 0a c0 14 ff 00 00 00 05 00 ff ff
CHG  81 0a ff ff 00 00 00 00 ff 00 ff ff

DEF  82 0e 80 80 00 00 00 00 00 00 01 3a 00 00 00 00
CHG  82 0e ff ff 00 00 00 00 00 00 ff ff 00 00 00 00

DEF  83 16 bb d0 00 00 00 00 03 80 04 c4 02 00 00 01 00 9a 00 18 40 00 00 00
CHG  83 16 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

DEF  84 16 02 d3 c1 02 00 00 00 00 00 00 00 00 00 00 00 00 00 00 27 31 00 00
CHG  84 16 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

DEF  87 0a 00 14 ff 00 00 00 00 00 ff ff
CHG  87 0a 0f ff 00 00 00 00 00 00 ff ff

DEF  88 12 14 00 ff ff 00 00 ff ff ff ff 80 20 00 00 00 00 00 00
CHG  88 12 a5 00 00 00 ff ff ff ff 00 00 20 00 00 00 00 00 00 00

DEF  8a 0a 02 00 00 80 00 00 00 00 09 d8
CHG  8a 0a 07 f6 00 00 00 00 00 00 00 00

DEF  99 06 00 00 00 00 04 00
CHG  99 06 00 ff 00 00 00 ff

DEF  9a 26 00 06 00 00 00 0a 00 00 8c a0 00 00 17 70 00 00 46 50 00 00 46 50 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00
CHG  9a 26 01 0f ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00

DEF  9c 0a 10 00 00 00 00 00 00 00 00 01
CHG  9c 0a 9d 0f ff ff ff ff ff ff ff ff

DEF  80 06 00 80 0f 00 00 00
CHG  80 06 b7 c0 8f 00 00 00
```

10.4 Miscellaneous operating features and conditions

Table 23 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 23: Miscellaneous features

Supported	Feature or condition
Y	FC-AL selective reset (LIP 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 24: 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

10.5 FC-AL physical interface

Figure 12 shows the location of the J1 Fibre Channel single connection attachment (FC-SCA). Figure 14 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*.

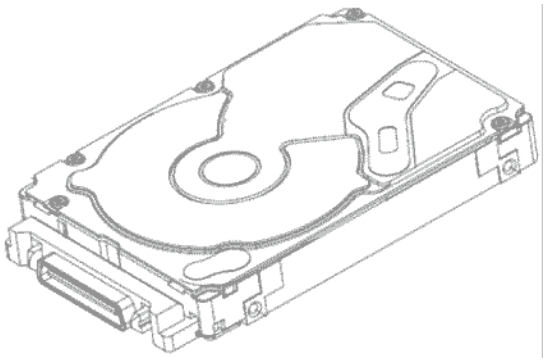


Figure 12. Physical interface

Note. Image of the HDA may not represent actual product, for reference only.

10.5.1 Physical characteristics

This section defines physical interface connector.

10.5.1.1 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 13 shows the relationship between the PBC and FC-AL device.

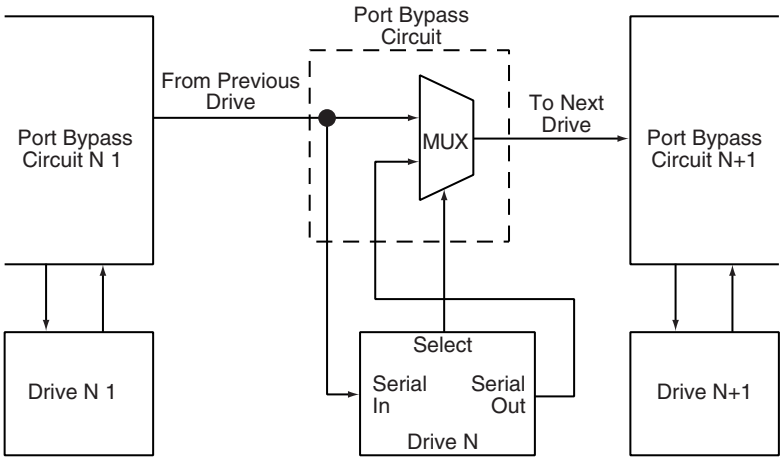


Figure 13. Port bypass circuit physical interconnect

10.5.2 Connector requirements

The FC-AL SCA device connector is illustrated in Figure 14.

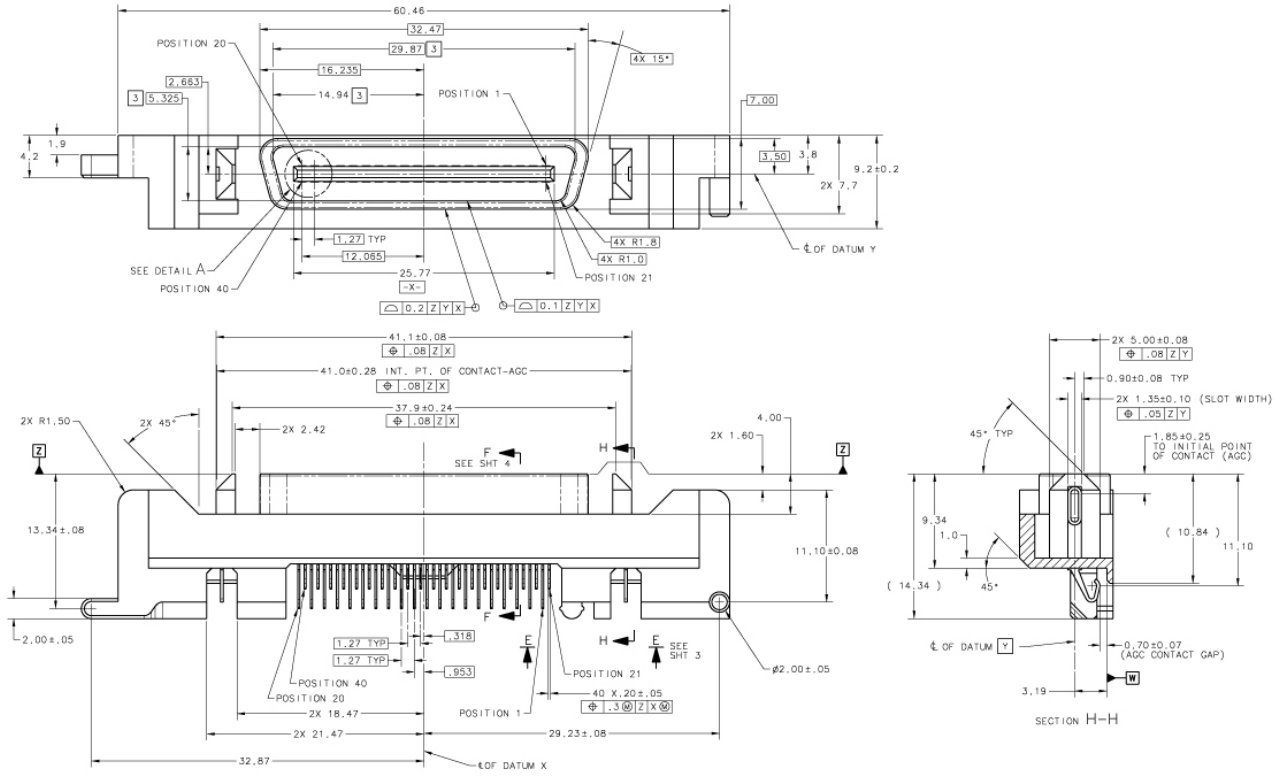


Figure 14. FC-AL SCA device connector dimensions

10.5.3 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.

10.5.4 Pin descriptions

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

Table 25: FC-SCA pin descriptions

Pin	Signal name	Signal type
1*	-EN bypass port A	Low Voltage TTL output
2*	12 Volts	
3*	12 Volts	
4*	12 Volts	
5*	-Parallel ESI	
6*	Ground[1]	
7*	Active LED out	Open collector out
8*	Reserved	
9*	Start_1[2]	TTL input
10*	Start_2[2]	TTL input
11*	-EN bypass port B	Low Voltage TTL output
12*	SEL_6	TTL input/output
13*	SEL_5	TTL input/output
14*	SEL_4	TTL input
15*	SEL_3	TTL input/output
16*	Fault LED out	Open collector out
17*	DEV_CTRL_CODE_2[2]	TTL input
18*	DEV_CTRL_CODE_1[2]	TTL input
19*	5 Volts	
20*	5 Volts	

Pin	Signal name	Signal type
21	12 Volts charge	
22	Ground	
23	Ground	
24*	+Port A_in	FC Diff. input pair
25*	-Port A_in	
26	Ground	
27*	+Port B_in	FC Diff. input pair
28*	-Port B_in	
29	Ground	
30*	+Port A_out	FC Diff. output pair
31*	-Port A_out	
32	Ground	
33*	+Port B_out	FC Diff. output pair
34*	-Port B_out	
35	Ground	
36	SEL_2	TTL input/output
37	SEL_1	TTL input/output
38	SEL_0	TTL input/output
39	DEV_CTRL_CODE_0[2	TTL input
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.

10.5.5 FC-AL transmitters and receivers

A typical FC-AL differential copper transmitter and receiver pair is shown in Figure 15. The receiver is required to provide the AC coupling to eliminate ground shift noise.

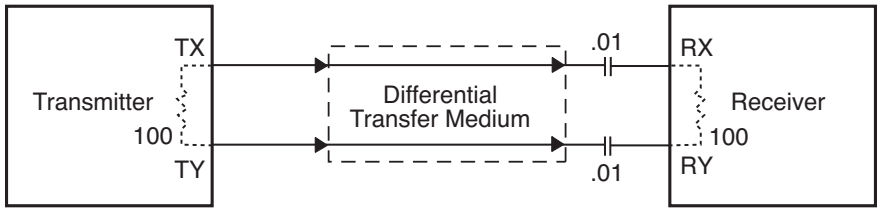


Figure 15. FC-AL transmitters and receivers

10.5.6 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.

10.5.7 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.

10.5.8 Active LED Out

The Active LED Out signal is driven by the drive as indicated in Table 26.

Table 26: 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	Toggles on/off
Write Same command in progress	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.

10.5.9 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 disk 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 disk drive. A pull down resistor, 1K, located with the PBC should be used to insure the bypass is enabled if the disk drive is not installed.

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

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

10.5.10 Motor start controls

The drive's motor is started according to the Start_1 and Start_2 signals described in Table 27. The state of these signals can be wired into the backplane socket or driven by logic on the backplane.

Table 27: 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.
4	High	High	The drive will not spin up.

10.5.11 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 28 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 30 on page 75.

Note. Table 28 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.

10.5.11.1 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 28: 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
B1	21	33
AE	22	34
AD	23	35
AC	24	36
AB	25	37
AA	26	38
A9	27	39
A7	28	40
A6	29	41
A5	2A	42
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
5C	4C	76
5A	4D	77
59	4E	78
56	4F	79
55	50	80
54	51	81
53	52	82
52	53	83
51	54	84
4E	55	85
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
17	77	119
10	78	120
0F	79	121
08	7A	122
04	7B	123
02	7C	124
01	7D	125

10.5.12 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 29: 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	4.250 GHz operation on both ports.
1	1	0	2.125 GHz operation on both ports.
1	1	1	1.0625 GHz operation on both ports.

10.6 Signal characteristics

This section describes the electrical signal characteristics of the drive's input and output signals. See Table 25 on page 70 for signal type and signal name information.

10.6.1 TTL input characteristics

Table 30 provides the TTL characteristics.

Table 30: TTL characteristics

State	**Voltage**	**Current**
Input high	$1.9 < V_{IH} < 5.5V$	I_{IH} = ±500nA max.
Input low	$-0.5V < V_{IL} < 0.9V$	I_{OL} = ±500nA 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)	$0 < V_{OL} < .45V$	$I_{OL} < 1.6mA$

10.6.2 LED driver signals

Fault and Active LED signals are located in the FC-SCA connector (J1). See Table 31 for the output characteristics of the LED drive signals.

Table 31: LED drive signal

State	Current drive available	Output voltage
LED off, high	$0 < I_{OH} < 100\mu A$	
LED on, low	$I_{OL} < -30$ mA	$0 < V_{OL} < 0.8V$

10.6.3 FC Differential output

The serial output signal voltage characteristics are provided in Table 32. 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 32: FC Differential output characteristics

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

Figure 16 provides the data output valid eye diagram relative to the bit cell time.

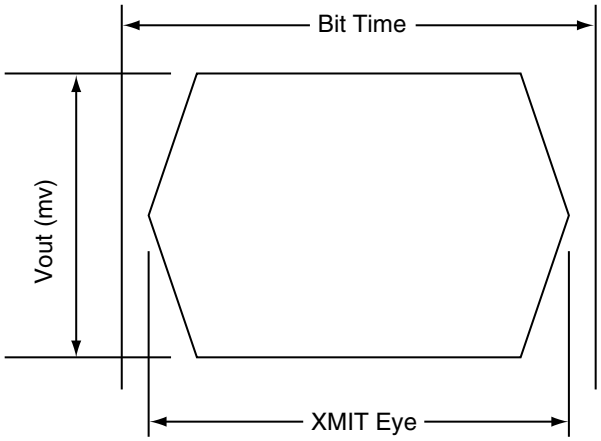


Figure 16. Transmit eye diagram

10.6.4 FC Differential input

The serial input signal voltage characteristics are provided in Table 33.

Table 33: FC Differential input characteristics

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

Figure 17 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.

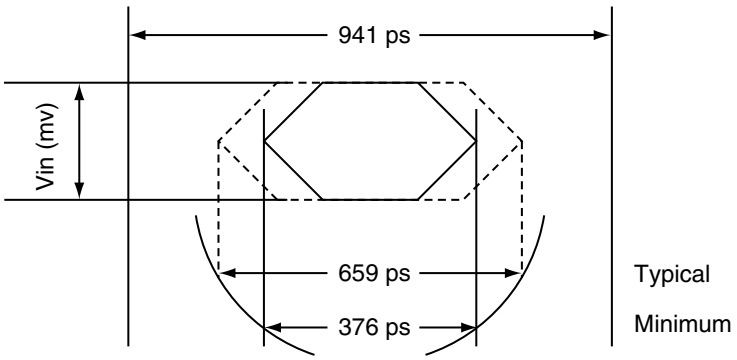


Figure 17. Receive eye diagram

Table 34: Eye diagram data values

		Link rate		
		1 GHz	**2 GHz**	**4 GHz**
Bit time		941 ps	470 ps	235 ps
XMIT eye		725 ps min.	315 ps min.	158[1]/113[2]
RCV eye	Typical	659 ps	305 ps	145 ps
	Minimum	395 ps	226 ps	113 ps

1. Short Ideal load.
2. End of compliance channel.

Index

Numerics

12 volt
    pins 71
3rd party reserve command 60
5 volt pins 71

A

Abort Sequence (ABTS) 50
abort task set function 51
AC coupling 70
AC power requirements 22
ACA active status 67
ACA active, faulted initiator status 67
Accept (ACC) 50
acoustics 39
active LED Out signal 72
Actual retry count bytes command 57
actuator
    assembly design 6
adaptive caching 67
Address Discovery (ADISC) 50
addresses 68
AFR 14
air cleanliness 39
air flow 48
    illustrated 48
Alternate credit model 52, 55
altitude 37
ambient 36
Annualized Failure Rates (AFR) 15
ANSI documents
    fibre channel 5
    SCSI 5
arbitrated loop physical address (AL_PA) 47
arbitration 47
asynchronous event notification 67
audible noise 3
Australian C-Tick 4
auto negotiation of link rate 75
auto write and read reallocation
    programmable 7
automatic contingent allegiance 67
average idle current 23, 24, 25, 26
average rotational latency 10

B

Background Media Scan 44
backpanel 69
backplane 72
basic link service frames 50
Basic_Accept (BA_ACC) 50
Basic_Reject (BA_RJT) 50
BB 52, 55
BB-Credit 52, 55
BMS 44
buffer
    data 7
busy status 67
bypass circuit 15
Byte check command 58

C

cache operation 12
cache segments 12
Caching parameters page (08h) command 58
caching write data 13
Canadian Department of Communications 3
capacity
    unformatted 10
capacity, drive, programmable 9
CC 53, 54
CF 52, 55
Change definition command 59
character sync 15
charge pins 71
check condition status 67
China RoHS directive 5
Class 3 parameters 52, 55
class B limit 3
Class valid 52, 55
clear ACA function 51
clear task set function 51
commands supported 57
Common features 52, 55
Company ID 53, 54
Compare command 59
Concurrent sequences 52
condensation 36
condition met/good status 67
connector
    illustrated 69
    requirements 69
continuous vibration 39
Continuously increasing offset 52, 55
control code values 75
Control mode page (0Ah) command 58
cooling 47
Copy and verify command 59
Copy command 57
CRC 15
    error 15
CS 52
Current profiles 28
customer service 20

D

DAR 44
data block size
  modifing the 8
data buffer to/from disk media 11
data heads
  read/write 10
data rate
  internal 10
data transfer rate 11
data valid eye 77
Date code page command 57
DC power 69
  requirements 23
defect and error management 42
defects 42
Deferred Auto-Reallocation 44
deferred error handling 67
description 6
DEV_CTRL_CODE 75
Device Behavior page command 57
device control code values 75
Device Identification page command 57
device selection IDs 47
devices 47
dimensions 41
Disable page out command 58
Disconnect/reconnect control (page 02h) command 57
disk rotation speed 10
Download microcode and save modes (5) 59
Download microcode mode (4) 59
Download microcode with offsets and save mode (7) 59
Download microcode with offsets mode (6) 59
drive 39
drive capacity
  programmable 9
drive characteristics 10
drive ID 47
drive ID/option select headers 47
drive mounting 41, 48
drive orientation 47
drive select 69
driver signals 76
drivers and receivers 7
dual port support 56

E

electrical
  description of connector 69
  signal characteristics 75
  specifications 21
electromagnetic compatibility 3
Electromagnetic compliance for the European Union 4
electromagnetic susceptibility 40
EMI requirements 3
enable bypass
  port A 72
  port B 72
  state 15
Enclosure Services interface 69
Enclosure services page command 58
environmental
  limits 36
  requirements 14
environmental control 39
error
  detection mechanisms, FC 15
  rates 14
error management 42
Error recovery page (01h) command 57
errors 42
extended link service
  frames 50
  reply frames 50
Extended sense command 57
Extent reservation command 60

F

fabric 55
Fabric Address Notification (FAN) 50
Fabric Login (FLOGI) 50
FAN 55
fault LED out signal 71
FC differential input 76
FC Interface Manual 3
FC-AL
  document 5
  interface 47, 69
  options supported 56
  physical interface 68
  SCA device connector, illustrated 69
  selective reset 67
FCC rules and regulations 3
FCP
  for SCSI, document 5
  response codes 51
  task management functions 51
FC-PH document 5
features 7
  interface 50
Fibre Channel documents 5
Fibre Channel Interface Control page (19h) 58
Fibre Channel Interface Manual 2
Fibre Channel Services 50
Field pointer bytes command 57
firmware 7

corruption 60
Firmware download option command 59
Firmware numbers page command 57
flawed sector reallocation 7
FLOGI
received on Port A 54
received on Port B 54
Force unit access command 58
form factor 7
format 47
Format command execution time 11
Format page (03h) command 57
Format unit command 57
FS 52, 53, 55
function
complete, code 00 51
not supported, code 05 51
reject, code 04 51

G

Good status 67
gradient 36
ground shift noise 70
grounding 49

H

hard assigned arbitrated loop physical address (AL_PA) 47
HDA 49
heads
read/write data 10
heat removal 47
host equipment 49
hot plugging the drive 15
humidity 36
humidity limits 36

I

IC 52
ID and configuration options 7
Identifying a PI drive 46
Idle Read After Write 45
Idle1 21
Idle2 21
Idle3 21
Implemented operating def. page command 57
Information exceptions control page (1Ch) command 58
Initiator control 52
Inquiry command 57
inquiry data 61
installation 47
guide 5
interface 47
commands supported 57
description 68
error rate 14
errors 15
illustrated 68
physical 68
requirements 50
intermediate/condition met/good status 67
intermediate/good status 67
Intermix 52, 55
internal data rate 10
internal defects/errors 42
internal drive characteristics 10
IRAW 45

J

J1 connector 47
Jumper settings page command 57
jumpers 47

K

Korean KCC 4

L

latency
average rotational 10
LBdata 59
LED driver signals 76
Link Service Reject (LS_RJT) 50
link services supported 50
Lock-unlock-cache command 59
Log select command 59
Log sense command 59
logic power 71
logical block address 12
logical block reallocation scheme 7
logical block size 7, 11
Logout (LOGO) 50
loop 68, 72
disruption 15
initialization 47
loop position
FC-AL options 56
loop position report
FC-AL options 56
LS_RJT 52, 55

M

maintenance 14
maximum delayed motor start 23, 24, 25, 26
maximum start current 23, 24, 25, 26
mean time between failure (MTBF) 15
media description 7

Media Pre-Scan 44
miscellaneous feature support
Adaptive caching 67
Asynchronous event notification 67
Automatic contingent allegiance 67
Deferred error handling 67
FC-AL selective reset 67
Parameter rounding 67
Queue tagging 67
Reporting actual retry count 67
Segmented caching 67
SMP = 1 in Mode Select command 67
Synchronized (locked) spindle operation 67
Zero latency read 67
miscellaneous status support
ACA active 67
ACA active, faulted initiator 67
Busy 67
Check condition 67
Condition met/good 67
Good 67
Intermediate/condition met/good 67
Intermediate/good 67
Reservation conflict 67
Task set full 67
miscorrected media data 14
Mode select
(10) command 60
command 57
Mode sense
(10) command 60
command 57
data, table 61, 63, 64
monitoring state 15
motor start
controls 72
option 11
mounting 48
holes 48
orientations 47
Mounting configuration dimensions 41
MTBF 15

N

N_Port Login (PLOGI) 50
payload 52
payload values 53
NN 52, 55
Node Name 55
Node name 52
noise
audible 3
noise immunity 27
non-operating 36, 37, 39
temperature 36
non-operating vibration 39

O

office environment 39
old port state
FC-AL options 56
OPEN Full Duplex
FC-AL options 56
OPEN half duplex
FC-AL options 56
Open sequences per exchange 52
operating 36, 37, 39
option configurations 47
option selection 69
options 9, 56
orientation 37
OS 52
out-of-plane distortion 48

P

P_LOGI
received on Port A 53
received on Port B 53
packaged 37
parameter rounding 67
pass-through state 15
PBC 68, 72
PBdata 59
PCBA 49
peak bits per inch 10
peak operating current 23, 24, 25, 26
peak-to-peak measurements 27
performance characteristics
detailed 10
general 11
performance degradation 37
performance highlights 8
physical damage 39
physical interface 68
description 68
physical specifications 21
PI 53, 54
PI level - Type 0 45
PI level - Type I 45
PI level - Type II 45
PI level - Type III 45
PI Levels 45
pin descriptions 69
PN 52, 55
port bypass circuit 15, 16, 68, 72
Port DISCovery 52
Port Discovery (PDISC) 50
port identifier field 53, 54
port login 52

accept 53
Port Name 55
Port name (initiator's) 52
power 71
dissipation 32
requirements, AC 22
requirements, DC 23
sequencing 27
Power Condition mode page 21
Power control page (1Ah) command 58
power distribution 3
power failure warning 75
power management 21
PowerChoice 21
PowerChoice reports 22
Prefetch command 59
prefetch/multi-segmented cache control 11
preventive maintenance 14
private loop
FC-AL options 56
Proc Assc 52
Process Accept (ACC) 54
Process Login (PRLI) 50, 53
Process Login Accept (ACC) payload 54
process login payload data 53
Process Logout (PRLO) 50
programmable drive capacity 9
protection information 45
public loop
FC-AL options 56
pull down resistor 72

Q

queue tagging 67

R

radio interference regulations 3
Random relative offset 52, 55
RCD bit 12
Read buffer command 59
Read capacity command 58
Read combined header and data mode (0) 59
Read command 57
Read data mode (2) 59
Read defect data command 59
Read descriptor mode (3) 59
read error rates 14, 42
Read extended command 58
Read Link Status (RLS) 50
Read long command 59
read/write data heads 10
Reassign blocks command 57
Receive buffer field size 52, 55
receive buffer field size 53
Receive diagnostic results command 58
receive eye
diagram 77
receivers 70
recommended mounting 38
Recoverable Errors 14
recovered media data 14
reference
documents 5
Regenerate command 60
Register FC-4 Types (RFT_ID) 50
Relative address command 58
relative humidity 36
Release command 57
Released (10) command 60
reliability 8
specifications 14
reliability and service 15
repair and return information 20
reporting actual retry count 67
Request sense command 57
reservation conflict status 67
Reserve command 57
Reserved (10) command 60
resonance 37
return information 20
Rezero unit command 57
Rigid disk drive geometry page
command 57
RoHS 4, 5
rotation speed 10
running disparity 15

S

safety 3
SCSI interface
commands supported 57
Search data
equal command 58
high command 58
low command 59
Seek command 57
seek error
defined 15
rate 14
Seek extended command 58
seek performance characteristics 10
seek time
average typical 10
full stroke typical 10
single track typical 10
segmented caching 67
SEL ID 47
lines 73
standard feature 7

Self-Monitoring Analysis and Reporting Technology 8, 16
Send diagnostics page command 58
Sequential delivery 52, 55
Service Options 55
Service options 52
Set limits command 59
shielding 3
shipping 20
shipping container 36
shock 37
  and vibration 37
shock mount 49
signal
  characteristics 75
  LED driver 76
single-unit shipping pack kit 9
SMART 8, 16
SMP = 1 in Mode Select command 67
SO 52, 55
spindle brake 7
Stacked connection req. 52, 55
standards 3
Standby1 21
Standby2 21
START STOP UNIT command 21
Start unit/stop unit command 58
start/stop time 11
support services 1
Supported diagnostics pages command 58
surface stiffness
  allowable for non-flat surface 48
switches 47
Synchronize cache command 59
synchronized spindle
  operation 67
system chassis 49

T

Taiwanese BSMI 4
target reset function 51
task management functions 51
  Abort task set 51
  Clear ACA 51
  Clear task set 51
  Target reset 51
  terminate task 51
task management response codes 51
  Function complete 00 51
  Function not supported 05 51
  Function reject 04 51
task set full status 67
technical support services 1
temperature 36, 47
  limits 36
  non-operating 36
  regulation 3
  See also cooling
terminate task function 51
terminators 47
Test unit ready command 57
Third-party Process Logout (TRPLO) 50
tracks per inch 10
Translate page command 58
transmit eye diagram 76
transmitters 70
transporting the drive 20
TTL input characteristics 75
Type 1 PI format 45
Type 2 PI format 45

U

UI 53, 54
unformatted 8
unique identifier 53, 54
Unit attention page (00h) command 57
Unit serial number page command 57
Unrecoverable Errors 14
unrecovered media data 14

V

Valid version level 52, 55
Verify command 58
Verify error recovery page (07h) command 58
vibration 37, 39
Vital product data page command 57

W

warranty 20
word sync 15
Write and verify command 58
Write buffer command 59
Write combined header and data mode (0) 59
Write command 57
Write data mode (2) 59
Write extended command 58
Write long command 59
Write same command 59

X

XD read 60
XD write 60
XD write extended command 60
XID reassign 52
XP write 60

Z

zero latency read 67

zone bit recording (ZBR) 7

Seagate Technology LLC
AMERICAS Seagate Technology LLC 10200 South De Anza Boulevard, Cupertino, California 95014, United States, 408-658-1000
ASIA/PACIFIC Seagate Singapore International Headquarters Pte. Ltd. 7000 Ang Mo Kio Avenue 5, Singapore 569877, 65-6485-3888
EUROPE, MIDDLE EAST AND AFRICA Seagate Technology SAS 16-18 rue du Dôme, 92100 Boulogne-Billancourt, France, 33 1-4186 10 00

Publication Number: 100628563, Rev. F
April 2012