Product Manual

Savvio SCSI

ST973401LC

ST936701LC

Seagate

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1.0 Scope

This manual describes Seagate® Savvio™ disc drives.

Savvio SCSI drives support the small computer system interface (SCSI) as described in the ANSI SCSI SPI-3 interface specifications to the extent described in this manual. The *SCSI Interface Product Manual* (part number 75789509) describes general SCSI interface characteristics of this and other families of Seagate drives.

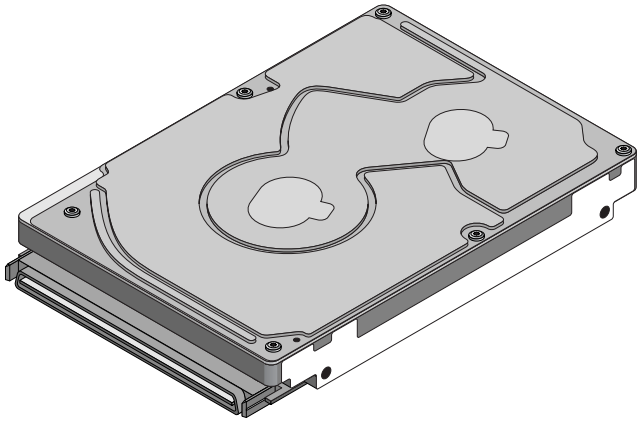


Figure 1. Savvio SCSI family drive

2.0 Applicable standards and reference documentation

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

2.1 Standards

The Savvio SCSI family complies with Seagate standards as noted in the appropriate sections of this Manual and the Seagate *SCSI Interface Product Manual*, part number 75789509.

The Savvio SCSI disc drive is a UL recognized component per UL1950, CSA certified to CSA C22.2 No. 950-95, and VDE certified to VDE 0805 and EN60950.

2.1.1 Electromagnetic compatibility

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

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

2.1.2 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 Section 5.1.1 and Table 2, DC power requirements.

2.2 Electromagnetic compliance

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

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

Although the test system with this Seagate model complies to the directives/standard(s), we cannot guarantee that all systems will comply. The computer manufacturer or system integrator shall confirm EMC compliance and provide CE Marking and C-Tick Marking for their product.

Electromagnetic compliance for the European Union

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

Australian C-Tick

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

Korean MIC

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

Taiwanese BSMI

If this model has two Chinese words meaning "EMC certification" followed by an eight digit identification number, as a Marking, it complies with Chinese National Standard (CNS) 13438 and meets the Electromagnetic Compatibility (EMC) Framework requirements of the Taiwanese Bureau of Standards, Metrology, and Inspection (BSMI).

2.3 Reference documents

Savvio SCSI Installation Guide	Seagate P/N 100293076
Safety and Regulatory Agency Specifications	Seagate P/N 75789512
SCSI Interface Product Manual	Seagate P/N 75789509

Applicable ANSI small computer system interface (SCSI) document numbers:

T10/1143D	Enhanced SCSI Parallel Interface (EPI)
T10/1416D	Primary Commands-2 (SPC-3)
T10/1417D	SCSI Block Commands (SBC-2)
T10/1157D	SCSI Architectural Model-2 (SAM-2)
T10/1302D	SPI-3 (SCSI Parallel Interface version 3)
T10/1365D	SPI-4 (SCSI Parallel Interface version 4)
SFF-8451	Specification for SCA-2 Unshielded Connections
Package Test Specification	Seagate P/N 30190-001 (under 100 lb.)
Package Test Specification	Seagate P/N 30191-001 (over 100 lb.)
Specification, Acoustic Test Requirements, and Procedures	Seagate P/N 30553-001

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

3.0 General description

Savvio SCSI drives combine giant magnetoresistive (GMR) heads, partial response/maximum likelihood (PRML) read channel electronics, embedded servo technology, and a wide Ultra320 SCSI interface to provide high performance, high capacity data storage for a variety of systems including engineering workstations, network servers, mainframes, and supercomputers.

Ultra320 SCSI uses negotiated transfer rates. These transfer rates will occur only if your host adapter supports these data transfer rates and is compatible with the required hardware requirements of the I/O circuit type. This drive also operates at SCSI-1 and SCSI-2 data transfer rates for backward compatibility with non-Ultra/Ultra2/Ultra320 SCSI host adapters.

Table 1 lists the features that differentiate the Savvio SCSI models.

Table 1: Drive model number vs. differentiating features

Model number	Number of heads	Formatted Capacity
ST973401LC ST936701LC	4 2	73.4 Gbytes 36.7 Gbytes

[1] See Section 9.6 for details and definitions.

The drive records and recovers data on approximately 2.5-inch (65 mm) non-removable discs.

The drive supports the Small Computer System Interface (SCSI) as described in the ANSI SCSI interface specifications to the extent described in this manual, which defines the product performance characteristics of the Savvio SCSI family of drives, and the *SCSI Interface Product Manual*, part number 75789509, which describes the general interface characteristics of this and other families of Seagate SCSI drives.

The drive's interface supports multiple initiators, disconnect/reconnect, self-configuring host software, and automatic features that relieve the host from the necessity of knowing the physical characteristics of the targets (logical block addressing is used).

The head and disc assembly (HDA) is sealed at the factory. Air circulates within the HDA through a non-replaceable filter to maintain a contamination-free HDA environment.

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 contains no replaceable parts. Opening the HDA voids your warranty.

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

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

Savvio SCSI drives decode track 0 location data from the servo data embedded on each surface to eliminate mechanical transducer adjustments and related reliability concerns.

A high-performance actuator assembly with a low-inertia, balanced, patented, straight-arm design provides excellent performance with minimal power dissipation.

3.1 Standard features

The Savvio SCSI family has the following standard features:

- Integrated Ultra320 SCSI controller
- Multimode SCSI drivers and receivers—single-ended (SE) and low voltage differential (LVD)
- 16 bit I/O data bus
- Asynchronous and synchronous data transfer protocol
- Firmware downloadable via SCSI interface
- Selectable even byte sector sizes from 512 to 528 bytes/sector
- Programmable sector reallocation scheme
- Flawed sector reallocation at format time
- Programmable auto write and read reallocation
- Reallocation of defects on command (post format)
- ECC maximum burst correction length of 320 bits
- No preventative maintenance or adjustment required
- Dedicated head landing zone
- Embedded servo design
- Self diagnostics performed when power is applied to the drive
- Zoned bit recording (ZBR)
- Vertical, horizontal, or top down mounting
- Dynamic spindle brake
- 8,192 kbytes data buffer
- Hot plug compatibility (Section 9.6.4.1 lists proper host connector needed)
- Drive Self Test (DST)
- BackGround Media Scan (BGMS)
- Data Integrity Check
- Power Save
- Supports SCSI bus fairness

3.2 Media characteristics

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

3.3 Performance

- Supports industry standard Ultra320 SCSI interface
- Programmable multi-segmentable cache buffer (see Section 4.5)
- 10,000 RPM spindle. Average latency = 3.00 ms
- Command queuing of up to 64 commands
- Background processing of queue
- Supports start and stop commands (spindle stops spinning)

3.4 Reliability

- Mean time Between Failure (MTBF) of 1,400,000 hours
- LSI circuitry
- Balanced low mass rotary voice coil actuator
- Incorporates industry-standard Self-Monitoring, Analysis and Reporting Technology (S.M.A.R.T.)
- 5-year warranty

3.5 Formatted capacities

Standard OEM models are formatted to 512 bytes per block. The 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:

	ST936701		ST973401	
Sector Size	**Decimal**	**Hex**	**Decimal**	**Hex**
512	71,687,372	445DCCC	143,374,744	88BB998
514	70,512,692	433F034	141,025,384	867E068
520	70,197,546	42F212A	140,395,092	85E4254
522	68,914,176	41B8C00	137,828,352	8371800
524	68,766,592	4194B80	137,577,184	83342E0

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

3.5.1 Programmable drive capacity

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

3.6 Factory installed accessories

OEM Standard drives are shipped with the *Savvio SCSI Installation Guide*, part number 100293076, and the *Safety and Regulatory Agency Specifications*, part number 75789512 (unless otherwise specified).

3.7 Options (factory installed)

All customer requested options are incorporated during production or packaged at the manufacturing facility before shipping. Some of the options available are (not an exhaustive list of possible options):

- Other capacities can be ordered depending on sparing scheme and sector size requested.
- Single unit shipping pack. The drive is normally shipped in bulk packaging to provide maximum protection against transit damage. Units shipped individually require additional protection as provided by the single unit shipping pack. Users planning single unit distribution should specify this option.
- The *Savvio SCSI Installation Guide*, part number 100293076, is usually included with each standard OEM drive shipped, but extra copies may be ordered.
- The *Safety and Regulatory Agency Specifications*, part number 75789512, is usually included with each standard OEM drive shipped, but extra copies may be ordered.

3.8 Accessories (user installed)

The following accessories are available. All accessories may be installed in the field.

- Single unit shipping pack.

4.0 Performance characteristic

4.1 Internal drive characteristics (transparent to user)

	ST973401	ST936701	
Drive capacity	73.4	36.7	GBytes (formatted, rounded off values)
Read/write heads	4	2	
Bytes/track	360,000	360,000	Kbytes (average, rounded off values)
Bytes/surface	18,387	18,387	Mbytes (formatted, rounded off values)
Tracks/surface (total)	51,052	51,052	Tracks (user accessible)
Tracks/inch	105	105	KTPI
Peak bits/inch	660	660	KBPI
Internal data rate	506-753	506-753	Mbits/sec (variable with zone)
Disc rotational speed	10,009	10,009	revolutions/min (RPM)
Average rotational latency	3.00	3.00	msec

4.2 SCSI performance characteristics (visible to user)

The values given in Section 4.2.1 apply to all models of the Savvio SCSI family unless otherwise specified. Refer to Section 9.9 and to the *SCSI Interface Product Manual* for additional timing details.

4.2.1 Access time [5]

	Including controller overhead (without disconnect) [1] [3]		Not including controller overhead (without disconnect) [1] [3]	
	Drive level		Drive level	
	Read	Write	Read	Write
	msec		msec	
Average—Typical [2]	4.70	5.10	4.50	4.90
Single Track—Typical [2]	0.65	0.95	0.45	0.75
Full Stroke—Typical [2]	8.70	9.10	8.50	8.90

4.2.2 Format command execution time (minutes) [1]

	ST973401	ST936701
Maximum (with verify)	52	26
Maximum (no verify)	26	13

4.2.3 Generalized performance characteristics

Minimum sector interleave 1 to 1

Data buffer transfer rate to/from disc media (one 512-byte sector):

Minimum **[3]***	63	Mbytes/sec
Maximum **[3]**	94	Mbytes/sec

SCSI interface data transfer rate (asynchronous):

Maximum instantaneous one byte wide	5.0 Mbytes/sec [4]
Maximum instantaneous two bytes wide	10.0 Mbytes/sec [4]

Synchronous transfer rate	**Ultra320 SCSI**
In low voltage differential (LVD) interface mode	5.0 to 320 Mbytes/sec

Sector Sizes:

Default	512 byte user data blocks
Variable	512 to 528 bytes per sector in even number of bytes per sector. If n (number of bytes per sector) is odd, then n-1 will be used.

Read/write consecutive sectors on a track	Yes
Flaw reallocation performance impact (for flaws reallocated at format time using the spare sectors per sparing zone reallocation scheme.)	Negligible
Average rotational latency	3.00 msec

Notes for Section 4.2.

[1] 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).
[2] Typical access times are measured under nominal conditions of temperature, voltage, and horizontal orientation as measured on a representative sample of drives.
[3] Assumes no errors and no sector has been relocated.
[4] Assumes system ability to support the rates listed and no cable loss.
[5] Access time = controller overhead + average seek time and applies to all data transfer commands.
Access to data = access time + latency time.

4.3 Start/stop time

After DC power at nominal voltage has been applied, the drive becomes ready within 20 seconds if the Motor Start Option is disabled (i.e. the motor starts as soon as the power has been applied). If a recoverable error condition is detected during the start sequence, the drive executes a recovery procedure which may cause the time to become ready to exceed 20 seconds. During spin up to ready time the drive responds to some commands over the SCSI interface in less than 3 seconds after application of power. Stop time is 30 seconds from removal of DC power.

If the Motor Start Option is enabled, the internal controller accepts the commands listed in the SCSI Command Reference 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 typically (excluding an error recovery procedure). The Motor Start Command can also be used to command the drive to stop the spindle (see the *SCSI Command Reference Manual*).

There is no power control switch on the drive.

4.4 Prefetch/multi-segmented cache control

The drive provides prefetch (read look-ahead) and multi-segmented cache control algorithms that in many cases can enhance system performance. “Cache” as used herein refers to the drive buffer storage space when it is used in cache operations. To select prefetch and cache features the host sends the Mode Select command with the proper values in the applicable bytes in Mode Page 08h (see the *SCSI Command Reference Manual*). Prefetch and cache operation are independent features from the standpoint that each is enabled and disabled independently via the Mode Select command. However, in actual operation the prefetch feature overlaps cache operation somewhat as is noted in Section 4.5.1 and 4.5.2.

All default cache and prefetch Mode parameter values (Mode Page 08h) for standard OEM versions of this drive family are given in Tables 15.

4.5 Cache operation

In general, 7,100 kbytes of the physical buffer space in the drive can be used as storage space for cache operations. The buffer can be divided into logical segments (Mode Select Page 08h, byte 13) from which data is read and to which data is written. The drive supports a maximum of 64 cache segments. The drive maintains a table of logical block disc medium addresses of the data stored in each segment of the buffer. If cache operation is enabled (RCD bit = 0 in Mode Page 08h, byte 2, bit 0. See *SCSI Command Reference Manual*), data requested by the host with a Read command is retrieved from the buffer (if it is there), before any disc access is initiated. If cache operation is not enabled, the buffer (still segmented with required number of segments) is still used, but only as circular buffer segments during disc medium read operations (disregarding Prefetch operation for the moment). That is, the drive does not check in the buffer segments for the requested read data, but goes directly to the medium to retrieve it. The retrieved data merely passes through some buffer segment on the way to the host. On a cache miss, all data transfers to the host are in accordance with buffer-full ratio rules. On a cache hit the drive ignores the buffer-full ratio rules. See explanations associated with Mode page 02h (disconnect/reconnect control) in the *SCSI Command Reference Manual*.

The following is a simplified description of a read operation with cache operation enabled:

Case A - A Read command is received and the first logical block (LB) is already in cache:

1. Drive transfers to the initiator the first LB requested plus all subsequent contiguous LBs that are already in the cache. This data may be in multiple segments.
2. When the requested LB is reached that is not in any cache segment, the drive fetches it and any remaining requested LBs from the disc and puts them in a segment of the cache. The drive transfers the remaining requested LBs from the cache to the host in accordance with the disconnect/reconnect specification mentioned above.
3. If the prefetch feature is enabled, refer to Section 4.5.2 for operation from this point.

Case B - A Read command requests data, the first LB of which is not in any segment of the cache:

1. The drive fetches the requested LBs from the disc and transfers them into a segment, and from there to the host in accordance with the disconnect/reconnect specification referred to in case A.
2. If the prefetch feature is enabled, refer to Section 4.5.2 for operation from this point.

Each buffer segment is actually a self-contained circular storage (wrap-around occurs), the length of which is an integer number of disc medium sectors. The wrap-around capability of the individual segments greatly enhances the buffer’s overall performance as a cache storage, allowing a wide range of user selectable configurations, which includes their use in the prefetch operation (if enabled), even when cache operation is disabled (see Section 4.5.2). The number of segments is set dynamically by the drive and cannot be set by the host. The size in Kbytes of each segment is not reported by the Mode Sense command page 08h, bytes 14 and 15. The value 0XFFFF is always reported. If a size specification is sent by the host in a Mode Select command (bytes 14 and 15) no new segment size is set up by the drive, and 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 unchangeable parameters (see *SCSI Command Reference Manual*).

4.5.1 Caching write data

Write caching is a write operation by the drive that makes use of a drive buffer storage area where the data to be written to the medium is stored in one or more segments 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 exceeds 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 15 show Mode default settings for the drives.

4.5.2 Prefetch operation

If the Prefetch feature is enabled, data in contiguous logical blocks on the disc immediately beyond that which was requested by a Read command can be 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. Prefetch is enabled using Mode Select page 08h, byte 12, bit 5 (Disable Read Ahead - DRA bit). DRA bit = 0 enables prefetch. Since data that is prefetched replaces data already in some buffer segment(s), the host can limit the amount of prefetch data to optimize system performance. The max prefetch field (bytes 8 and 9) limits the amount of prefetch. The drive does not use the Prefetch Ceiling field (bytes 10 and 11).

During a prefetch operation, the drive crosses a cylinder boundary to fetch more data only if the Discontinuity (DISC) bit is set to one in bit 4 of byte 2 of Mode parameters page 08h.

Whenever prefetch (read look-ahead) is enabled (enabled by DRA = 0), it operates under the control of ARLA (Adaptive Read Look-Ahead). If the host uses software interleave, ARLA enables prefetch of contiguous blocks from the disc when it senses that a prefetch hit will likely occur, even if two consecutive read operations were not for physically contiguous blocks of data (e.g., “software interleave”). ARLA disables prefetch when it decides that a prefetch hit will not likely occur. If the host is not using software interleave, and if two sequential read operations are not for contiguous blocks of data, ARLA disables prefetch, but as long as sequential read operations request contiguous blocks of data, ARLA keeps prefetch enabled.

4.5.3 Optimizing cache performance for desktop and server applications

Desktop and server applications require different drive caching operations for optimal performance. This means it is difficult to provide a single configuration that meets both of these needs. In a desktop environment, you want to configure the cache to respond quickly to repetitive accesses of multiple small segments of data without taking the time to “look ahead” to the next contiguous segments of data. In a server environment, you

want to configure the cache to provide large volumes of sequential data in a non-repetitive manner. In this case, the ability of the cache to “look ahead” to the next contiguous segments of sequential data is a good thing.

The Performance Mode (PM) bit controls the way the drive switches the cache buffer into different modes of segmentation. In “server mode” (PM bit = 0), the drive can dynamically change the number of cache buffer segments as needed to optimize the performance, based on the command stream from the host. In “desktop mode” (PM bit = 1), the number of segments is maintained at the value defined in Mode Page 8, Byte 13, at all times (unless changed by using a Mode Select command). For additional information about the PM bit, refer to the Unit Attention Parameters page (00h) of the Mode Sense command (1Ah) in the *SCSI Interface Product Manual*, part number 75789509.

5.0 Reliability specifications

The following reliability specifications assume correct host/drive operational interface, including all interface timings, power supply voltages, environmental requirements and drive mounting constraints (see Section 8.3).

Seek Errors	Less than 10 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^{15} bits transferred (OEM default settings)
Miscorrected Data	Less than 1 sector in 10^{21} bits transferred
MTBF	1,400,000 hours
Service Life	5 years
Preventive Maintenance	None required

Note.

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

5.1 Error rates

The error rates stated in this specification assume the following:

- The drive is operated per this specification using DC power as defined in this manual (see Section 6.2).
- The drive has been formatted with the SCSI FORMAT command.
- Errors caused by media defects or host system failures are excluded from error rate computations. Refer to Section 3.2, “Media Characteristics.”
- Assume random data.

5.1.1 Environmental interference

When evaluating systems operation under conditions of Electromagnetic Interference (EMI), the performance of the drive within the system shall be considered acceptable if the drive does not generate an unrecoverable condition.

An unrecoverable error, or unrecoverable condition, is defined as one that:

- Is not detected and corrected by the drive itself;
- Is not capable of being detected from the error or fault status provided through the drive or SCSI interface; or
- Is not capable of being recovered by normal drive or system recovery procedures without operator intervention.

5.1.2 Read errors

Before determination or measurement of read error rates:

- The data that is to be used for measurement of read error rates must be verified as being written correctly on the media.
- All media defect induced errors must be excluded from error rate calculations.

5.1.3 Write errors

Write errors can occur as a result of media defects, environmental interference, or equipment malfunction. Therefore, write errors are not predictable as a function of the number of bits passed.

If an unrecoverable write error occurs because of an equipment malfunction in the drive, the error is classified as a failure affecting MTBF. Unrecoverable write errors are those which cannot be corrected within two attempts at writing the record with a read verify after each attempt (excluding media defects).

5.1.4 Seek errors

A seek error is defined as a failure of the drive to position the heads to the addressed track. There shall be no more than ten recoverable seek errors in 10^8 physical seek operations. After detecting an initial seek error, the drive automatically performs an error recovery process. If the error recovery process fails, a seek positioning error (15h) is reported with a Hardware error (4h) reported in the Sense Key. This is an unrecoverable seek error. Unrecoverable seek errors are classified as failures for MTBF calculations. Refer to the *SCSI Interface Product Manual,* part number 75789509, for Request Sense information.

5.2 Reliability and service

You can enhance the reliability of Savvio SCSI disc drives by ensuring that the drive receives adequate cooling. Section 6 provides temperature measurements and other information that may be used to enhance the service life of the drive. Section 8.2 provides recommended air-flow information.

5.2.1 Mean time between failure

The production disc drive shall achieve an MTBF of 1,400,000 hours when operated in an environment that ensures the HDA case temperatures specified in Section 6.4 are not exceeded. Short-term excursions up to the specification limits of the operating environment will not affect MTBF performance. Continual or sustained operation at case temperatures above the values shown in Section 6.4.1 may degrade product reliability.

The MTBF target is specified as device power-on hours (POH) for all drives in service per failure.

$$\text{Estimated power-on operating hours in the period} = \frac{\text{MTBF per measurement period}}{\text{Number of drive failures in the period}}$$

Estimated power-on operation hours means power-up hours per disc drive times the total number of disc drives in service. Each disc drive shall have accumulated at least nine months of operation. Data shall be calculated on a rolling average base for a minimum period of six months.

MTBF is based on the following assumptions:

- 8,760 power-on hours per year.
- 250 average on/off cycles per year.
- Operations at nominal voltages.
- Systems will provide adequate cooling to ensure the case temperatures specified in Section 6.4.1 are not exceeded.

Drive failure means any stoppage or substandard performance caused by drive malfunction.

A S.M.A.R.T. predictive failure indicates that the drive is deteriorating to an imminent failure and is considered an MTBF hit.

5.2.2 Preventive maintenance

No routine scheduled preventive maintenance shall be required.

5.2.3 Service life

The drive shall have a useful service life of five years. Depot repair or replacement of major parts is permitted during the lifetime (see Section 5.2.4).

5.2.4 Service philosophy

Special equipment is required to repair the drive HDA. In order to achieve the above service life, repairs must be performed only at a properly equipped and staffed service and repair facility. Troubleshooting and repair of PCBs in the field is not recommended, because of the extensive diagnostic equipment required for effective servicing. Also, there are no spare parts available for this drive. Drive warranty is voided if the HDA is opened.

5.2.5 Service tools

No special tools are required for site installation or recommended for site maintenance. Refer to Section 5.2.4. The depot repair philosophy of the drive precludes the necessity for special tools. Field repair of the drive is not practical since there are no user purchasable parts in the drive.

5.2.6 Hot plugging Savvio SCSI disc drives

The ANSI SPI-3 (T10/1302D) document defines the physical requirements for removal and insertion of SCSI devices on the SCSI bus. Four cases are addressed. The cases are differentiated by the state of the SCSI bus when the removal or insertion occurs.

Case 1 - All bus devices powered off during removal or insertion

Case 2 - RST signal asserted continuously during removal or insertion

Case 3 - Current I/O processes not allowed during insertion or removal

Case 4 - Current I/O process allowed during insertion or removal, except on the device being changed

Seagate Savvio SCSI disc drives support all four hot plugging cases. Provision shall be made by the system such that a device being inserted makes power and ground connections prior to the connection of any device signal contact to the bus. A device being removed shall maintain power and ground connections after the disconnection of any device signal contact from the bus (see SFF-8451 Specification for SCA-2 Unshielded Connections).

It is the responsibility of the systems integrator to assure that no hazards from temperature, energy, voltage, or ESD potential are presented during the hot connect/disconnect operation.

All I/O processes for the SCSI device being inserted or removed shall be quiescent. All SCSI devices on the bus shall have receivers that conform to the SPI-3 standard.

If the device being hot plugged uses single-ended (SE) drivers and the bus is currently operating in low voltage differential (LVD) mode, then all I/O processes for all devices on the bus must be completed, and the bus quiesced, before attempting to hot plug. Following the insertion of the newly installed device, the SCSI host adapter must issue a Bus Reset, followed by a synchronous transfer negotiation. Failure to perform the SCSI Bus Reset could result in erroneous bus operations.

The SCSI bus termination and termination power source shall be external to the device being inserted or removed.

End users should not mix devices with high voltage differential (HVD) drivers and receivers and devices with SE, LVD, or multimode drivers and receivers on the same SCSI bus since the common mode voltages in the HVD environment may not be controlled to safe levels for SE and LVD devices (see ANSI SPI-3).

The disc drive spindle must come to a complete stop prior to completely removing the drive from the cabinet chassis. Use of the Stop Spindle command or partial withdrawal of the drive, enough to be disconnected from the power source, prior to removal are methods for insuring that this requirement is met. During drive insertion, care should be taken to avoid exceeding the limits stated in Section 6.4.4, "Shock and vibration" in this manual.

5.2.7 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 a drive failure and is designed to provide sufficient warning of a failure to allow data back-up before an actual failure occurs.

Note. The firmware will monitor specific attributes for degradation over time but cannot predict instantaneous drive failures.

Each 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 bit and the PERF bit of the “Informational Exceptions Control Mode Page” (1Ch). The DEXCPT bit is used to enable or disable the S.M.A.R.T. process. Setting the DEXCPT bit will disable all S.M.A.R.T. functions. When enabled, S.M.A.R.T. will collect on-line data as the drive performs normal read/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.

The process of measuring off-line attributes and saving data can be forced by the Rezero Unit command. Forcing S.M.A.R.T. will reset the timer so that the next scheduled interrupt will be two hours.

The drive can be interrogated by the host to determine the time remaining before the next scheduled measurement and data logging process will occur. This is accomplished by a log sense command to log page 0x3E. The purpose is to allow the customer to control when S.M.A.R.T. interruptions occur. As described above, forcing S.M.A.R.T by the Rezero Unit command will reset the timer.

Performance impact

S.M.A.R.T. attribute data will be saved to the disc for the purpose of recreating the events that caused a predictive failure. The drive will measure and save parameters once every two hours subject to an idle period on the SCSI bus. The process of measuring off-line attribute data and saving data to the disc is uninterruptable and the maximum delay is summarized below:

Maximum processing delay

	On-line only delay	**Fully enabled delay**
	DEXCPT = 0, PERF = 1	**DEXCPT = 0, PERF = 0**
S.M.A.R.T. delay times	60 milliseconds	370 milliseconds

Reporting control

Reporting is controlled in the Informational Exceptions Control Page (1Ch). Subject to the reporting method, the firmware will issue a 01-5D00 sense code to the host. 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 error rate 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 rate, hence for each attribute the occurrence of an error is 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 simply 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 the interval. If the number of errors exceeds the threshold before the interval expires, then the error rate is considered to be unacceptable. If the number of errors does not exceed the threshold before the interval expires, then 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 whenever the error rate is unacceptable and decremented (not to exceed zero) whenever the error rate is acceptable. Should the counter continually be incremented such that it reaches the predictive threshold, a predictive failure is signaled. This counter is referred to as the Failure History Counter. There is a separate Failure History Counter for each attribute.

5.2.8 Thermal monitor

Savvio SCSI 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 exceed the threatening temperature value.

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

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

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

The current algorithm implements two temperature trip points. The first trip point is set at 68°C which is the maximum temperature limit according to the drive specification. The second trip point is user-selectable using the Log Select command. The reference temperature parameter in the temperature log page (see Table 11)

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 11: Temperature Log page (0Dh)

Parameter Code	Description
0000h	Primary Temperature
0001h	Reference Temperature

When the first temperature trip point is exceeded, S.M.A.R.T. data is collected and a frame is saved to the disc.

5.2.9 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 text

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

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

5.2.9.1 DST Failure Definition

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

The following conditions are considered DST failure conditions:

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

Recovered errors will not be reported as diagnostic failures.

5.2.9.2 Implementation

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

5.2.9.2.1 State of the drive prior to testing

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

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

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

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

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

5.2.9.2.2 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. Refer to the Seagate *SCSI Interface Product Manual*, part number 75789509, for additional information about invoking DST.

5.2.9.2.3 Short and extended tests

DST has two testing options:

1. short
2. extended

These testing options are described in the following two subsections.

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

Short test (Function Code: 001b)

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

Extended test (Function Code: 010b)

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

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

5.2.9.2.4 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 zero, the drive passed with no errors detected by the DST. If the field is not zero, the test failed for the reason reported in the field.

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

5.2.9.2.5 Abort

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

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

5.2.10 Product warranty

Beginning on the date of shipment to customer and continuing for a period of five years, Seagate warrants that each product (including components and subassemblies) or spare part that fails to function properly under normal use due to defect in materials on workmanship or due to nonconformance to the applicable specifications will be repaired or replaced, at Seagate's option and at no charge to 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 customer. For more detailed warranty information refer to the Standard terms and conditions of Purchase for Seagate products.

Shipping

When transporting or shipping a drive, a Seagate approved container must be used. Keep your original box. They are easily identified by the Seagate-approved package label. Shipping a drive in a non-approved container voids the drive warranty.

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

Product repair and return information

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

6.0 Physical/electrical specifications

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

6.1 AC power requirements

None.

6.2 DC power requirements

The voltage and current requirements for a single drive are shown in the following table. Values indicated apply at the drive power connector. The table shows current values in Amperes.

Table 2: DC power requirements

		Notes	ST973401				ST936701			
			SE mode		LVD mode		SE mode		LVD mode	
Voltage			+5 V	+12 V	+5 V	+12 V	+5 V	+12 V	+5 V	+12 V
Regulation		[5]	+10%/ -7.5%	+10%/ -7.5%[2]	+10%/ -7.5%	+10%/ -7.5%[2]	+10%/ -7.5%	+10%/ -7.5%[2]	+10%/ -7.5%	+10%/ -7.5%[2]
Average idle current DC	$\overline{X}$	[1][7]	0.51	0.21	0.50	0.21	0.51	0.19	0.50	0.19
Maximum starting current		[3]								
(peak DC) DC	3σ	[3]	0.68	1.68	0.72	1.68	0.70	1.58	0.65	1.58
(peak AC) AC	3σ		1.01	2.70	1.14	2.65	1.00	2.68	1.03	2.66
Delayed motor start (max) DC	3σ	[1][4]	0.49	0.05	0.48	0.05	0.49	0.05	0.49	0.05
Peak operating current		[1][6]								
DC	$\overline{X}$	[1]	0.73	0.40	0.74	0.43	0.74	0.46	0.69	0.47
Maximum DC	3σ		0.75	0.46	0.75	0.49	0.76	0.49	0.74	0.49
Maximum (peak) DC	3σ		1.12	1.50	1.32	1.54	1.14	1.48	1.30	1.48

[1] Measured with average reading DC ammeter or equivalent sampling scope. Instantaneous current peaks will exceed these values. Power supply at nominal voltage. Number of drives tested = 6, 35 Degrees C ambient.

[2] For +12 V, a –10% tolerance is permissible during initial start of spindle, and must return to ±5% before 10,000 rpm is reached. 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 +12 V current profile in Figure 2.

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

[5] See Section 6.2.1 “Conducted Noise Immunity.” Specified voltage tolerance is inclusive of ripple, noise, and transient response.

[6] Operating condition is defined as random 8 block reads at:
259 I/Os per second (ST973401LC)
259 I/Os per second (ST936701LC)

[7] During idle, the drive heads are relocated every 60 seconds to a random location within the band from three-quarters to maximum track.

General Notes from Table 2:

1. Minimum current loading for each supply voltage is not less than 1.2% of the maximum operating current shown.
2. The +5 and +12 volt supplies shall employ separate ground returns.
3. Where power is provided to multiple drives from a common supply, careful consideration for individual drive power requirements should be noted. Where multiple units are powered on simultaneously, the peak starting current must be available to each device.
4. Parameters, other than spindle start, are measured after a 10-minute warm up.
5. No terminator power.

6.2.1 Conducted noise immunity

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

+5 V = 250 mV pp from 100 hz to 20 Mhz.
+12 V = 800 mV pp from 100 hz to 8 Khz;
450 mV pp from 8 Khz to 20 Khz;
250 mV pp from 20 Khz to 5 Mhz.

6.2.2 Power sequencing

The drive does not require power sequencing. The drive protects against inadvertent writing during power-up and down. Daisy-chain operation requires that power be maintained on the SCSI bus terminator to ensure proper termination of the peripheral I/O cables. To automatically delay motor start based on the target ID (SCSI ID) enable the Delay Motor Start option and disable the Enable Motor Start option on the backplane. To delay the motor until the drive receives a Start Unit command, enable the Enable Remote Motor Start option on the backplane.

6.2.3 12 V - Current profile

Figure 2 and 4 identify the drive +12 V current profiles and figures 3 and 5 identify the drive +5 V current profiles. The current during the various times is as shown:

T0 - Power is applied to the drive.
T1 - Controller self tests are performed.
T2 - Spindle begins to accelerate under current limiting after performing drive internal diagnostics. See Note 1 of Table 2.
T3 - The spindle is up to speed and the head-arm restraint is unlocked.
T4 - The adaptive servo calibration sequence is performed.
T5 - Calibration is complete and drive is ready for reading and writing.

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

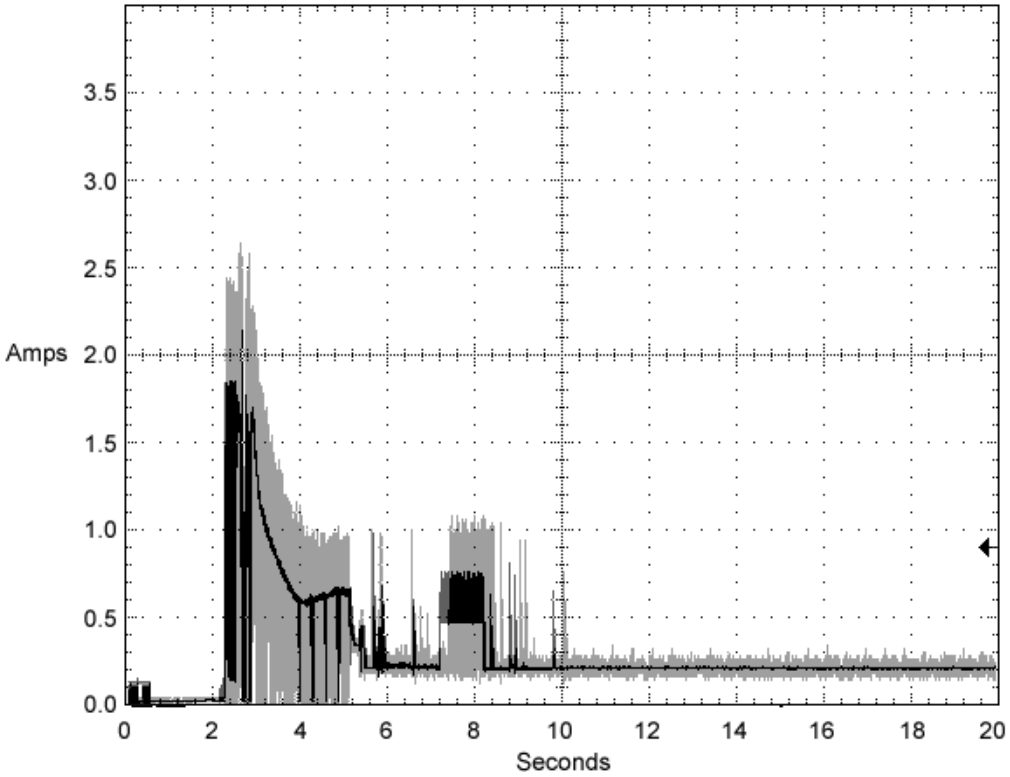


Figure 2. Typical ST973401 drive +12 V current profile

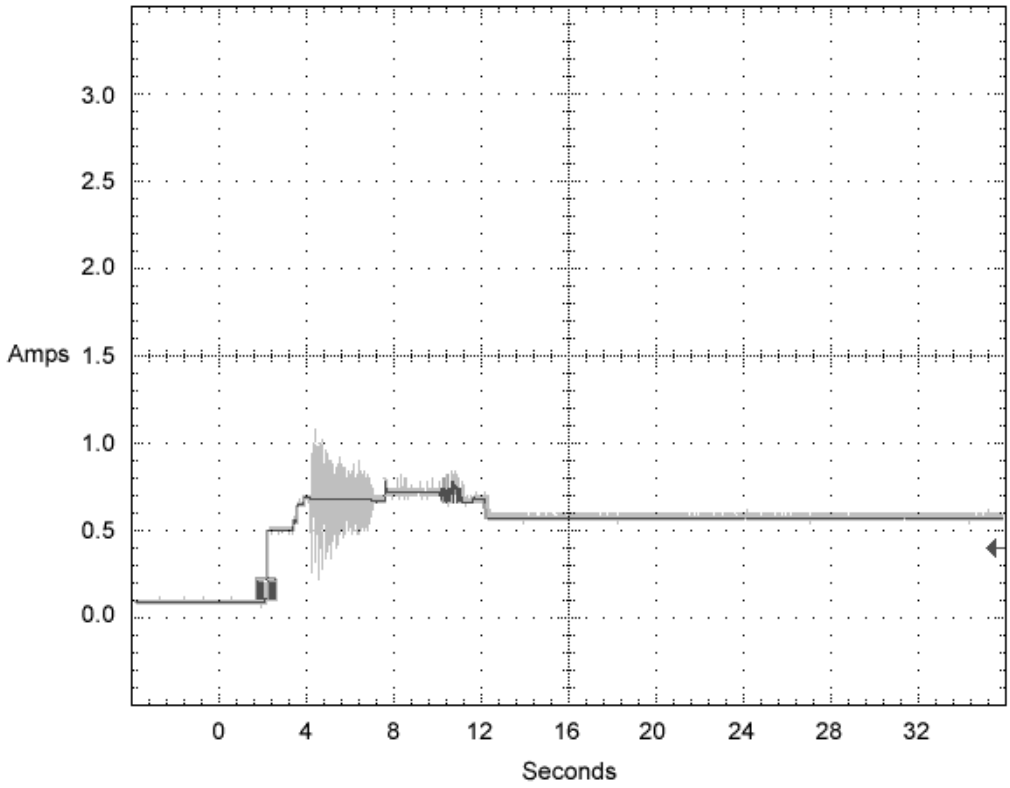


Figure 3. Typical ST973401 drive +5 V current profile

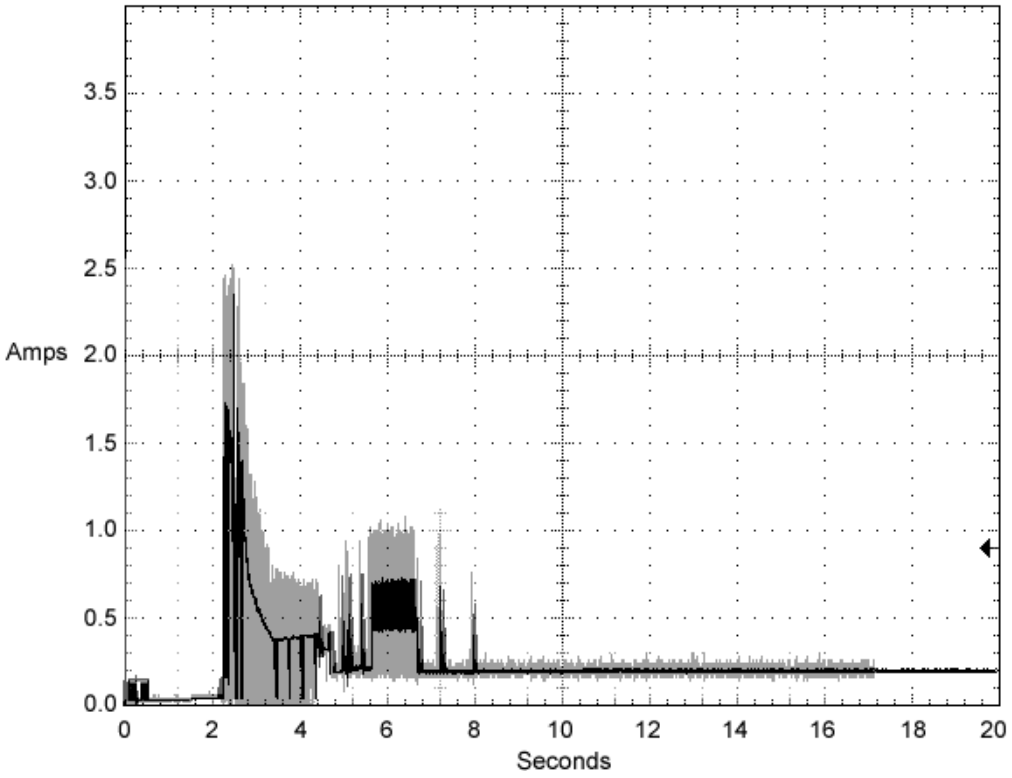


Figure 4. Typical ST936701 drive +12 V current profile

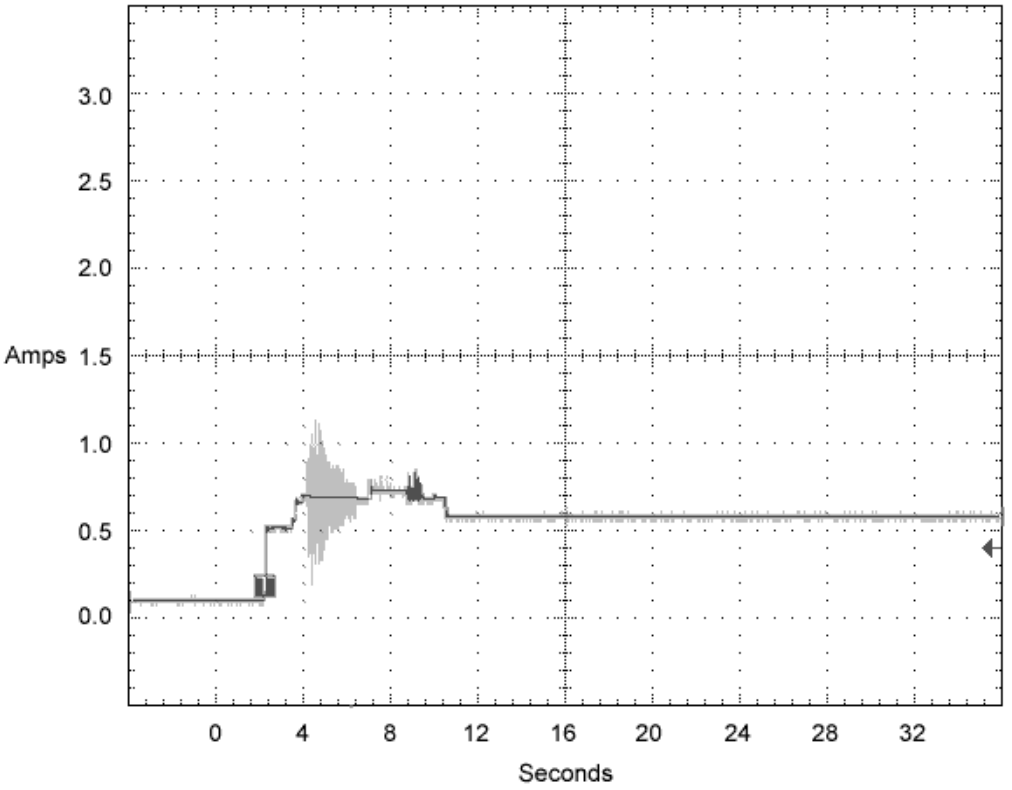


Figure 5. Typical ST936701 drive +5 V current profile

6.3 Power dissipation

ST973401

For drives using single-ended interface circuits, typical power dissipation under idle conditions is 5.07 watts (17.3 BTUs per hour).

For drives using low voltage differential interface circuits, typical power dissipation under idle conditions is 5.02 watts (17.1 BTUs per hour).

To obtain operating power for typical random read operations, refer to the following two I/O rate curves (see Figures 6 and 7). 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.

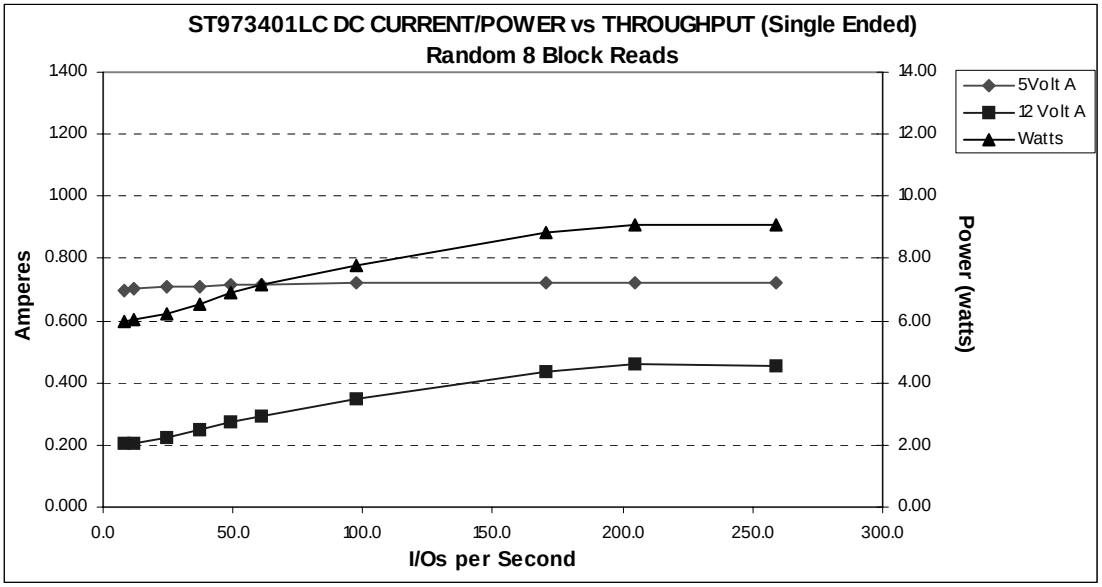


Figure 6. ST973401 DC current and power vs. input/output operations per second (SE)

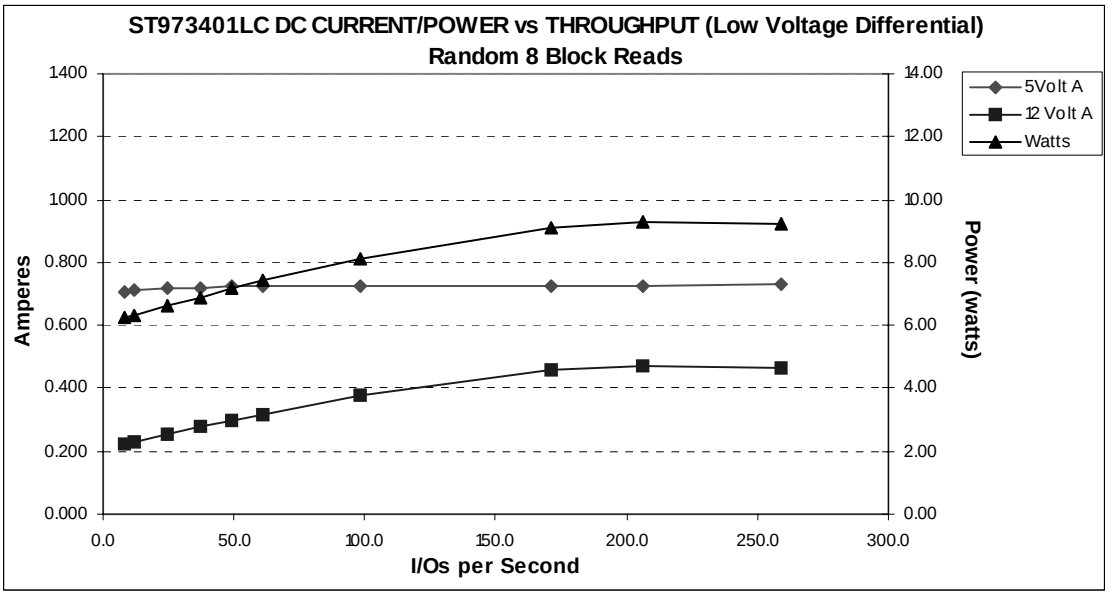


Figure 7. ST973401 DC current and power vs. input/output operations per second (LVD)

For drives using single-ended interface circuits, typical power dissipation under idle conditions is 4.83 watts (16.5 BTUs per hour).

For drives using low voltage differential interface circuits, typical power dissipation under idle conditions is 4.83 watts (16.5 BTUs per hour).

To obtain operating power for typical random read operations, refer to the following two I/O rate curves (see Figures 6 and 7). 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.

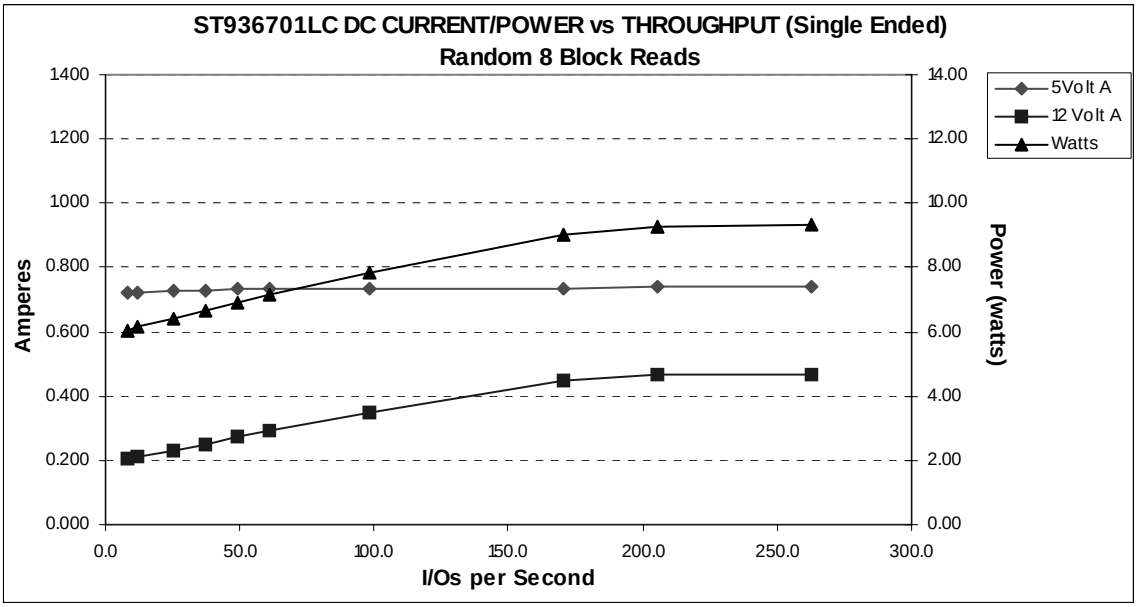


Figure 8. ST936701 DC current and power vs. input/output operations per second (SE)

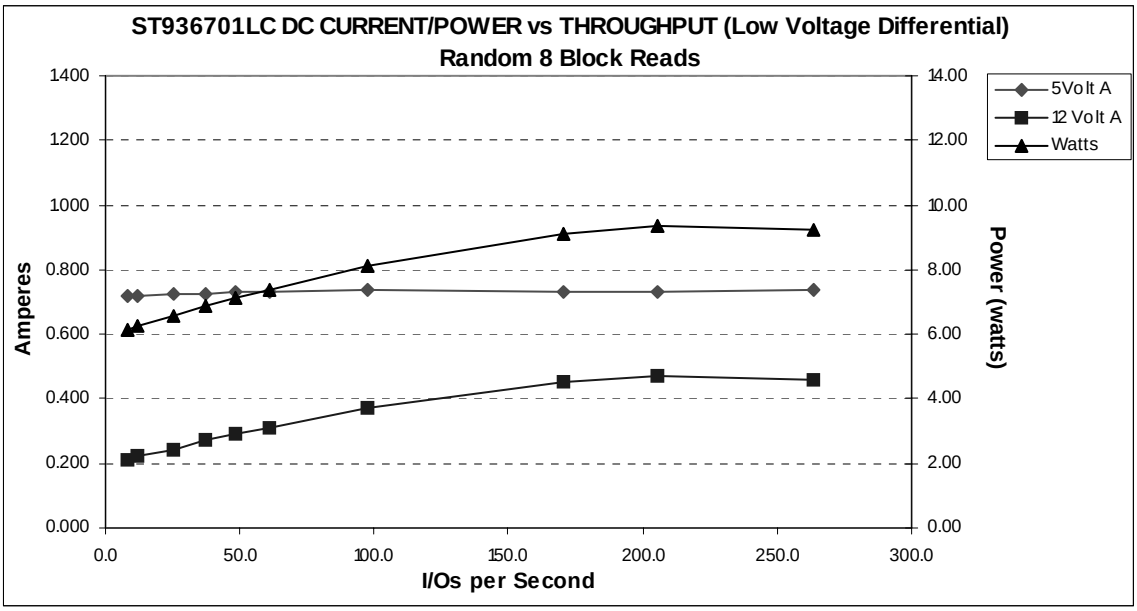


Figure 9. ST936701 DC current and power vs. input/output operations per second (LVD)

6.4 Environmental limits

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

6.4.1 Temperature

a. Operating

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

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

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

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

b. Non-operating

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

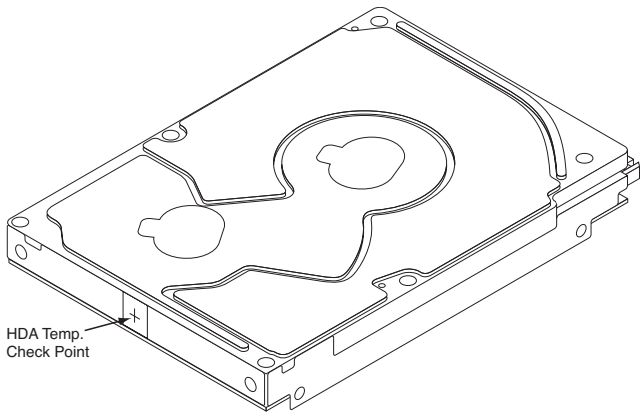


Figure 10. Location of the HDA temperature check point

6.4.2 Relative humidity

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

a. Operating

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

b. Non-operating

   5% to 95% non-condensing relative humidity.

6.4.3 Effective altitude (sea level)

a. Operating

   –1,000 to +10,000 feet (–305 to +3,048 meters)

b. Non-operating

   –1,000 to +40,000 feet (–305 to +12,210 meters)

6.4.4 Shock and vibration

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

The limits of shock and vibration defined within this document are specified with the drive mounted by any of the four methods shown in Figure 11, and in accordance with the restrictions of Section 8.3. Orientation of the side opposite the I/O connector may be up or down.

6.4.4.1 Shock

a. Operating—normal

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

b. Operating—abnormal

   Equipment, as installed for normal operation, does not incur physical damage while subjected to intermittent shock not exceeding 40 Gs at a maximum duration of 11 msec (half sinewave). Shock occurring at abnormal levels may promote degraded operational performance during the abnormal shock period. Specified operational performance will continue when normal operating shock levels resume. Shock may be applied in the X, Y, or Z axis. Shock is not to be repeated more than two times per second.

c. Non-operating

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

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

   The drive subjected to nonrepetitive shock not exceeding 275 Gs at a maximum duration of 2 msec (half sinewave) does not exhibit device damage or performance degradation. Shock may be applied in the X, Y, or Z axis.

   The drive subjected to nonrepetitive shock not exceeding 150 Gs at a maximum duration of 0.5 msec (half sinewave) does not exhibit device damage or performance degradation. Shock may be applied in the X, Y, or Z axis.

d. Packaged

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

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

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

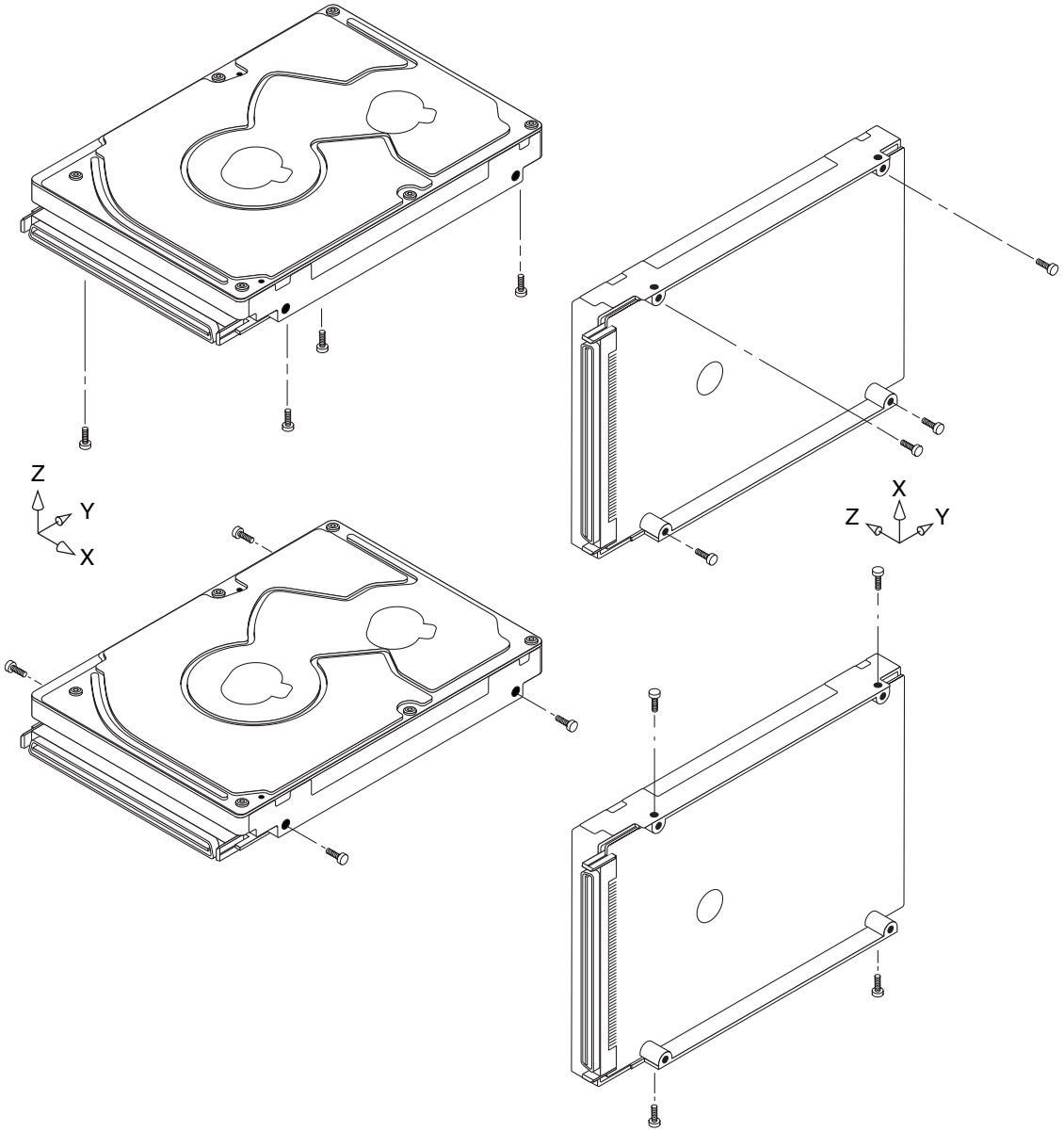


Figure 11. Recommended mounting

6.4.4.2 Vibration

a. Operating - normal

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

5-500 Hz @ 1.0 G (zero to peak)

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

Operating normal translational random flat profile

10 - 500 Hz	0.5 gRMS (grams Root Mean Square)

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 @ 1.5 G (X, Y, or Z axis, zero to peak)

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

Operating abnormal translational random flat profile

10 - 500 Hz	1.2 gRMS (grams Root Mean Square)

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 @ 3.00 G (zero to peak)

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

Non-operating translational random flat profile

10 - 500 Hz	1.2 gRMS (grams Root Mean Square)

6.4.5 Air cleanliness

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

6.4.6 Corrosive environment

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

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

6.4.7 Acoustics

Sound power during idle mode shall be 3.5 bels typical when measured to ISO 7779 specification.

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

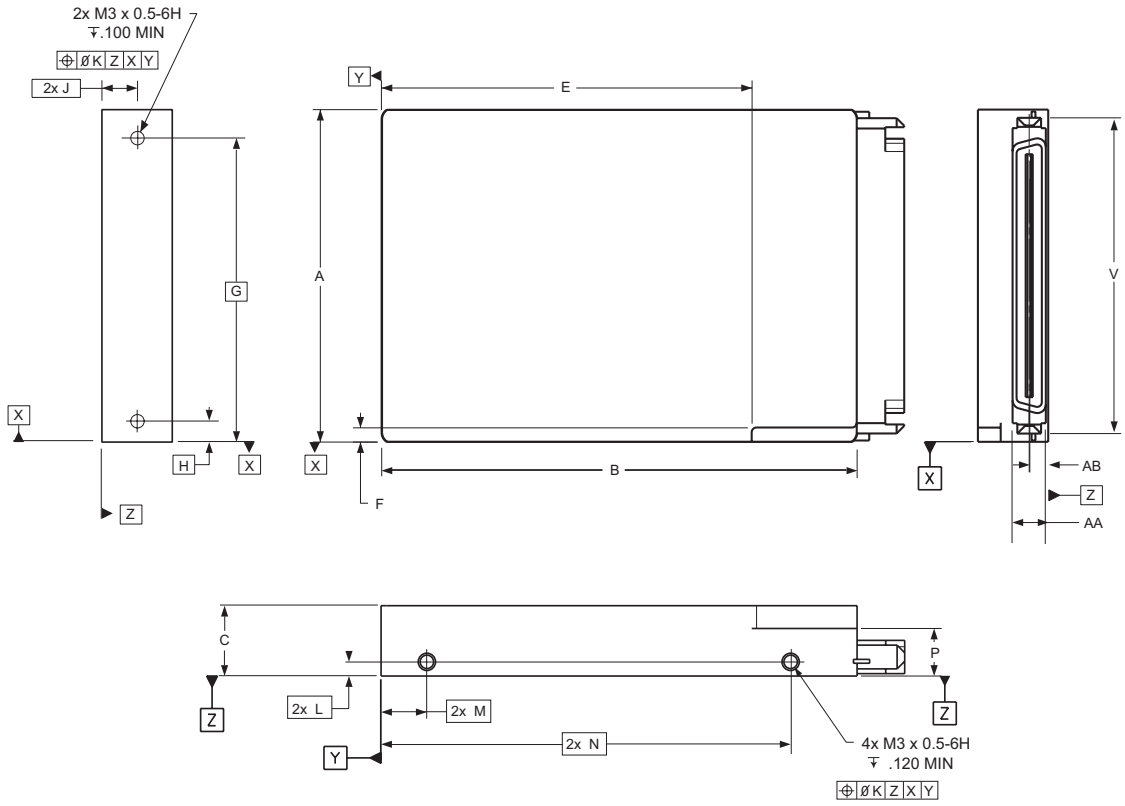
6.4.8 Electromagnetic susceptibility

See Section 2.1.2.

6.5 Mechanical specifications

The following nominal dimensions are exclusive of the decorative front panel accessory. However, dimensions of the front panel are shown in figure below. Refer to Figures 12 for detailed mounting configuration dimensions. See Section 8.3, “Drive mounting.”

Height:	0.583 in	15 mm
Width:	2.76 in	70.1 mm
Depth:	4.40 in	111.7 mm
Weight:	0.49 pounds	0.22 kilograms



Dimension Table

	Inches	Millimeters
A	2.755 +/- 0.005	69.98 +/- 0.13
B	3.945 +/- 0.005	100.20 +/- 0.13
C	0.583 +/- 0.008	14.81 +/- 0.20
E	3.072 +/- 0.005	78.03 +/- 0.13
F	0.118 +/- 0.005	3.00 +/- 0.13
G	2.520	64.01
H	0.177	4.50
J	0.295	7.49
K	0.014	0.36
L	0.118	3.00
M	0.379	9.63
N	3.395	86.23
P	0.394 +/- 0.005	10.01 +/- 0.13
Q	3.395	86.23
R	0.379	9.63
S	0.160	4.06
T	2.590	65.79
U	0.945 +/- 0.020	24.00 +/- 0.51
V	2.618 +/- 0.011	66.50 +/- 0.28
AA	0.276 +/- 0.008	7.00 +/- 0.20
AB	0.157 +/- 0.020	3.99 +/- 0.51

Figure 12. Mounting configuration dimensions

7.0 Defect and error management

The drive, as delivered, complies with this specification. The read error rate and specified storage capacity are not dependent upon use of defect management routines by the host (initiator).

Defect and error management in the SCSI system involves the drive internal defect/error management and SCSI systems error considerations (errors in communications between Initiator and the drive). Tools for use in designing a defect/error management plan are briefly outlined in this section, with references to other sections where further details are given.

7.1 Drive internal defects

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 (see the *SCSI Command Reference Manual*).

7.2 Drive error recovery procedures

Whenever 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 up in the error recovery parameters mode page. Error recovery and defect management may involve the use of several SCSI commands, the details of which are described in the *SCSI Command Reference Manual.* The drive implements selectable error recovery time limits such as are required in video applications. For additional information on this, refer to the Error Recovery Page table in the *SCSI Command Reference Manual*, which describes the Mode Select/Mode Sense Error Recovery parameters.

The error recovery scheme supported by the drive provides a means 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 via 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 via the Read Retry Count or Write Retry Count bytes in the Error Recovery Mode Page.

The drive firmware error recovery algorithms consist of 11 levels for read recoveries and 5 levels for writes.

Table 3 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, if reallocations are performed. 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.

The Read Continuous (RC) bit, when set to one, requests the disc drive to transfer the requested data length without adding delays (for retries or ECC correction) that may be required to insure data integrity. The disc drive may send erroneous data in order to maintain the continuous flow of data. The RC bit should only be

used when data integrity is not a concern and speed is of utmost importance. If the Recovery Time Limit or retry count is reached during error recovery, the state of the RC bit is examined. If the RC bit is set, the drive will transfer the unrecovered data with no error indication and continue to execute the remaining command. If the RC bit is not set, the drive will stop data transfer with the last good LBA, and report a “Check Condition, Unrecovered Read Error.”

Table 3: Read and write retry count maximum recovery times [1]

Read retry count [1]	Maximum recovery time per LBA (cumulative, msec)
0	77.7
1	89.7
2	305
3	353
4	401
5	419
6	466
7	586
8	676
9	724
10	777
11 (default)	1,591

Write retry count	Maximum recovery time per LBA (cumulative, msec)
0	35.9
1	53.8
2	83.7
3	101.7
4	179.4
5 (default)	221.3

[1] These values are subject to change.

Setting these retry counts to a value below the default setting could result in an increased unrecovered error rate which may exceed the value given in this product manual. A setting of zero (0) will result in the drive not performing error recovery.

For example, suppose the Read/Write Recovery page has the RC bit set to 0, read retry count set to 4, and the recovery time limit field (Mode Sense page 01, bytes 10 and 11) set to FF FF hex (maximum). A four LBA Read command is allowed to take up to 401 msec recovery time for each of the four LBAs in the command. If the recovery time limit is set to 00 C8 hex (200 msec decimal) a four LBA read command is allowed to take up to 200 msec for all error recovery within that command. The use of the Recovery Time Limit field allows finer granularity on control of the time spent in error recovery. The recovery time limit only starts counting when the drive is executing error recovery and it restarts on each command. Therefore, each command’s total recovery time is subject to the recovery time limit. Note: A recovery time limit of 0 will use the drive’s default value of FF FF. Minimum recovery time limit is achieved by setting the Recovery Time Limit field to 00 01.

7.3 SCSI systems errors

Information on the reporting of operational errors or faults across the interface is given in the *SCSI Interface Product Manual*. Message Protocol System is described in the *SCSI Command Reference Manual*. Several of the messages are used in the SCSI systems error management system. The Request Sense command 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 *SCSI Interface Product Manual*. Status reporting plays a role in the SCSI systems error management and its use in that respect is described in sections where the various commands are discussed.

8.0 Installation

Note. These drives are designed to be used only on single-ended (SE) or low voltage differential (LVD) busses. Do not install these drives on a high voltage differential (HVD) bus.

The first thing to do when installing a drive is to set the drive SCSI ID and set up certain operating options. This is done via the drive to host I/O signals.

Configure drive options

Drive default mode parameters are not normally needed for installation. Refer to Section 9.3.2 for default mode parameters if they are needed.

- Ensure that the SCSI ID of the drive is not the same as the host adapter. Most host adapters use SCSI ID 7 because ID 7 is the highest priority on both 8 and 16 bit data buses.
- If multiple devices are on the bus set the drive SCSI ID to one that is not presently used by other devices on the bus.
- If the drive is the only device on the bus, attach it to the end of the SCSI bus cable. The user, system integrator, or host equipment manufacturer must provide external terminators.

Note. For additional information about terminator requirements, refer to Sections 9.8 and 9.8.1.

- Installation instructions are provided by host system documentation or with any additionally purchased drive installation software. If necessary see Section 10.0 for Seagate support services telephone numbers.
- Do not remove the manufacturer's installed labels from the drive and do not cover with additional labels, as the manufacturer labels contain information required when servicing the product.

Formatting

- It is not necessary to low level format this drive. The drive is shipped from the factory low level formatted in 512 byte sectors.
- Reformat the drive if a different spare sector allocation scheme is selected.
- High level formatting the drive involves assigning one or more partitions or logical drives to the drive volume. Follow the instructions in the system manuals for the system into which the drive is to be installed.

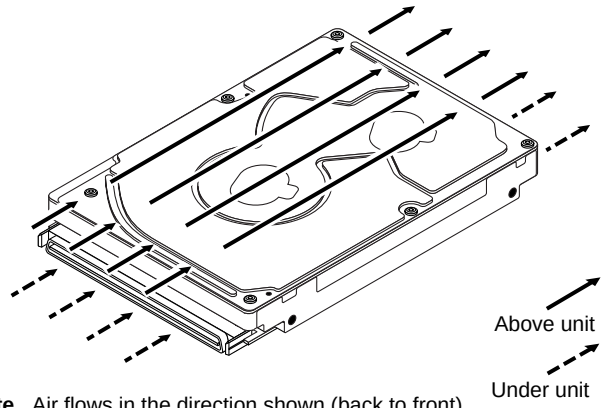
8.1 Drive orientation

The balanced rotary arm actuator design of the drive allows it to be mounted in any orientation. All drive performance characterization, however, has been done with the drive in horizontal (discs level) and vertical (drive on its side) orientations, and these are the two preferred mounting orientations.

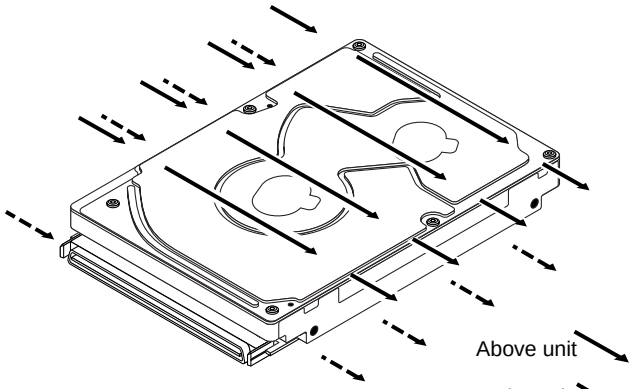
8.2 Cooling

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

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



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



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

Figure 13. Air flow (suggested)

8.3 Drive mounting

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

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

8.4 Grounding

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

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

9.0 Interface requirements

This section describes the drive-specific interface requirements as implemented on the drive.

9.1 General description

This section describes in essentially general terms the interface requirements supported by the Savvio SCSI. No attempt is made to describe all of the minute details of conditions and constraints that must be considered by designers when designing a system in which this family of drives can properly operate. Seagate declares that the drives operate in accordance with the appropriate ANSI Standards referenced in various places herein, with exceptions as noted herein or in the Seagate *SCSI Interface Product Manual*.

9.2 SCSI interface messages supported

Table 12 lists the messages supported by the SCSI-2 and SCSI-3 modes of the Savvio SCSI family drives.

Table 12: SCSI messages supported by Savvio SCSI family drives

Message name	Message code	Supported
Abort	06h	Y
Abort-tag	0Dh	Y
Bus device reset	0Ch	Y
Clear ACA	16h	N
Clear queue	0Eh	Y
Command complete	00h	Y
Continue I/O process	12h	N
Disconnect	04h	Y
Extended messages	01h[1]	Y
Identify	80h-FFh	Y
Ignore wide residue (two bytes)	23h	Y
Initiate recovery	0Fh	N
Initiator detected error	05h	Y
Linked command complete	0Ah	Y
Linked command complete with flag	0Bh	Y
Message parity error	09h	Y
Message reject	07h	Y
Modify data pointer	[1]	N
No operation	08h	Y
Parallel Protocol Request		Y
Queue tag messages (two bytes)		
ACA	24h	N
Head of queue tag	21h	Y
Ordered queue tag	22h	Y
Simple queue tag	20h	Y
Release recovery	10h	N
Restore pointers	03h	Y
Save data pointer	02h	Y
Synchronous data transfer req.	[1]	Y
Target transfer disable	13h	N
Terminate I/O process	11h	N
Wide data transfer request	[1]	Y

Notes.

[1] Extended messages (see the *SCSI Command Reference Manual*).
[2] Supports all options except qas_req and iu_req.

9.3 SCSI interface commands supported

Table 13 following lists the SCSI interface commands that are supported by the drive. OEM standard drives are shipped set to operate in Ultra320 mode.

Table 13: Commands supported by Savvio SCSI family drive

Command name	Command code	Supported
Change Definition	40h	N
Compare	39h	N
Copy	18h	N
Copy and Verify	3Ah	N
Format Unit [1]	04h	Y
DPRY bit supported		N
DCRT bit supported		Y
STPF bit supported		Y
IP bit supported		Y
DSP bit supported		Y
IMMED bit supported		Y
VS (vendor specific)		N
Inquiry	12h	Y
Date Code page (C1h)		Y
Device Behavior page (C3h)		Y
Firmware Numbers page (C0h)		Y
Implemented Operating Def page (81h)		Y
Jumper Settings page (C2h)		Y
Supported Vital Product Data page (00h)		Y
Unit Serial Number page (80h)		Y
Lock-unlock cache	36h	N
Log Select	4Ch	Y
PCR bit		Y
DU bit		N
DS bit		Y
TSD bit		Y
ETC bit		N
TMC bit		N
LP bit		N
Log Sense	4Dh	Y
Application Client Log page (0Fh)		Y
Buffer Over-run/Under-run page (01h)		N
Cache Statistics page (37h)		Y
Factory Log page (3Eh)		Y
Last n Deferred Errors or Asynchronous Events page (0Bh)		N

Table 13: Commands supported by Savvio SCSI family drive (Continued)

Command name	Command code	Supported
Last n Error Events page (07h)		N
Non-medium Error page (06h)		Y
Pages Supported list (00h)		Y
Read Error Counter page (03h)		Y
Read Reverse Error Counter page (04h)		N
Self-test Results page (10h)		Y
Start-stop Cycle Counter page (0Eh)		Y
Temperature page (0Dh)		Y
Verify Error Counter page (05h)		Y
Write error counter page (02h)		Y
Mode Select (same pages as Mode Sense 1Ah)	15h	Y [2]
Mode Select (10) (same pages as Mode Sense 1Ah)	55h	Y
Mode Sense	1Ah	Y [2]
Caching Parameters page (08h)		Y
Control Mode page (0Ah)		Y
Disconnect/Reconnect (02h)		Y
Error Recovery page (01h)		Y
Format page (03h)		Y
Information Exceptions Control page (1Ch)		Y
Notch and Partition Page (0Ch)		N
Port Control Page (19h)		Y
Power Condition page (1Ah)		Y
Rigid Disc Drive Geometry page (04h)		Y
Unit Attention page (00h)		Y
Verify Error Recovery page (07h)		Y
Xor Control page (10h)		N
Mode Sense (10) (same pages as Mode Sense 1Ah)	5Ah	Y
Prefetch	34h	N
Read	08h	Y
Read Buffer (modes 0, 2, 3, Ah and Bh supported)	3Ch	Y
Read Capacity	25h	Y
Read Defect Data (10)	37h	Y
Read Defect Data (12)	B7h	Y
Read Extended	28h	Y
DPO bit supported		Y
FUA bit supported		Y
Read Long	3Eh	Y
Reassign Blocks	07h	Y
Receive Diagnostic Results	1Ch	Y

Table 13: Commands supported by Savvio SCSI family drive (Continued)

Command name	Command code	Supported
Supported Diagnostics pages (00h)		Y
Translate page (40h)		Y
Release	17h	Y
Release (10)	57h	Y
Report LUNS	A0h	Y
Request Sense	03h	Y
Actual Retry Count bytes		Y
Extended Sense		Y
Field Pointer bytes		Y
Reserve	16h	Y
3rd Party Reserve		Y
Extent Reservation		N
Reserve (10)	56h	Y
3rd Party Reserve		Y
Extent Reservation		N
Rezero Unit	01h	Y
Search Data Equal	31h	N
Search Data High	30h	N
Search Data Low	32h	N
Seek	0Bh	Y
Seek Extended	2Bh	Y
Send Diagnostics	1Dh	Y
Supported Diagnostics pages (00h)		Y
Translate page (40h)		Y
Set Limits	33h	N
Start Unit/Stop Unit (spindle ceases rotating)	1Bh	Y
Synchronize Cache	35h	Y
Test Unit Ready	00h	Y
Verify	2Fh	Y
BYTCHK bit		Y
Write	0Ah	Y
Write and Verify	2Eh	Y
DPO bit		Y
Write Buffer (modes 0, 2, supported)	3Bh	Y
Firmware Download option (modes 5, 7, Ah and Bh supported) [3]		Y
Write Extended	2Ah	Y
DPO bit		Y
FUA bit		Y

Table 13: Commands supported by Savvio SCSI family drive (Continued)

Command name	Command code	Supported
Write Long	3Fh	Y
Write Same	41h	Y
PBdata		N
LBdata		N
XDRead	52h	N
XDWrite	50h	N
XPWrite	51h	N

[1] The drive can format to any even number of bytes per sector from 512 to 528.
[2] Tables 15 show how individual bits are set and which are changeable by the host.
[3] **WARNING:** A power loss during flash programming can result in firmware corruption. This usually makes the drive inoperable.

Table 14 lists the Standard Inquiry command data that the drive should return to the initiator per the format given in the *SCSI Interface Product Manual,* part number 75789509, Inquiry command section.

Table 14: Savvio SCSI family drive Standard Inquiry data

Bytes	Data (HEX)																
0-15	00	00	[03][1]	[12][2]	8B	00	01	3E	53	45	41	47	41	54	45	20	VENDOR ID
16-31	53	54	[39]	[37]	[33]	[34]	[30]	[31]	[4C]	[43][3]	[20]	20	20	20	20	20	PRODUCT ID
32-47	R#	R#	R#	R#	S#	S#	S#	S#	S#	S#	S#	S#	00	00	00	00	
48-63	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
64-79	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
80-95	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
96-111	00	43	6F	70	79	72	69	67	68	74	20	28	63	29	20	[32]	COPYRIGHT
112-127	[30]	[30]	[34][4]	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	

[ ][1] 03 means SCSI-3 (Ultra160) implemented.

Note. Seagate has chosen to set this bit to 03, SCSI-3 (Ultra160) implemented, rather than 04, SCSI-4 (Ultra320) implemented, due to compatibility issues with some host bus adapters. This setting will not affect the Ultra320 functionality of the drive.

[ ][2] The drive can be changed between these two configurations:
02 means response data in SCSI-2/SCSI-3 format.
12 means the drive uses the hierarchical addressing mode to assign LUNs to logical units (default is 12).

R# Four ASCII digits representing the last four digits of the product Firmware Release number. This information is also given in the Vital Product Data page C0h, together with servo RAM and ROM release numbers.

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

[ ][3] Bytes 18 through 26 reflect model of drive. The table above shows the hex values for Model ST973401LC.
Refer to the values below for the values of bytes 18 through 26 of you particular model:

ST973401LC	39	37	33	34	30	31	4C	43	20
ST936701LC	39	33	36	37	30	31	4C	43	20

[ ][4] Copyright Year - changes with actual year.

9.3.1 Inquiry Vital Product data

Instead of the standard Inquiry data shown in Table 14, the initiator can request several Vital Product Data pages by setting the Inquiry command EVPD bit to one. The *SCSI Command Reference Manual* lists the Vital Product Data pages and describes their formats. A separate Inquiry command must be sent to the drive for each Vital Product Data page the initiator wants the drive to send back.

9.3.2 Mode Sense data

The Mode Sense command provides a means for the drive to report its operating parameters to the initiator. The drive maintains four sets of Mode parameters, Default values, Saved values, Current values and Changeable values.

Default values are hard coded in the drive firmware that is stored in flash EPROM nonvolatile memory on the drive PCBA. Default values can be changed only by downloading a complete set of new firmware into the flash EPROM. 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.

Saved values are stored on the disc media using a Mode Select command. Only parameter values that are allowed to be changed can be changed by this method. See “Changeable values” defined below. Parameters in the saved values list that are not changeable by the Mode Select command get their values from the default values storage.

Current values are volatile values currently being used by the drive to control its operation. A Mode Select command can be used to change these values (only those that are changeable). Originally, they are installed from saved or default values after a power on reset, hard reset, or Bus Device Reset message.

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” allows a change to a corresponding bit; a “zero” allows no change. For example, in Table 15 refer to Mode page 01, in the row entitled “CHG”. These are hex numbers representing the changeable values for mode page 01. Note that bytes 04, 05, 06, and 07 are not changeable, because those fields are all zeros. If some changeable code had a hex value EF, that equates to the binary pattern 1110 1111. If there is a zero in any bit position in the field, it means that bit is not changeable. Bits 7, 6, 5, 3, 2, 1, and 0 are changeable, because those bits are all ones. Bit 4 is not changeable.

Though the drive always reports non-zero values in bytes 00 and 01, those particular bytes are never changeable.

The Changeable values list can only be changed by downloading new firmware into the flash EPROM.

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.

When a drive is powered up, it takes saved values from the media and stores them to the current values storage in volatile memory. It is not possible to change the current values (or the saved values) with a Mode Select command before the drive is up to speed and is “ready.” An attempt to do so results in a “Check Condition status being returned.

Note. Because there may be 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 Ultra160 implementation (see the *SCSI Command Reference Manual*).

Definitions:

DEF = Default value. Standard drives are shipped configured this way.
CHG= Changeable bits; indicates if current and saved values are changeable.

Note. Saved values for OEM drives are normally the same as the default values.

Table 15: ST973401 Mode sense data

Bytes	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mode Sense Data	00	ae	00	10	00	00	00	08	08	8b	b9	98	00	00	02	00								
Mode Page	<----------Mode Page Headers and Parameter Data Bytes---------->																							
01 DEF	81	0a	c0	0b	f f	00	00	00	05	00	f f	f f												
01 CHG	81	0a	f f	f f	00	00	00	00	f f	00	f f	f f												
02 DEF	82	0e	80	80	00	0a	00	00	00	00	00	00	00	00	00	00								
02 CHG	82	0e	f f	f f	00	00	00	00	00	00	00	00	87	00	00	00								
03 DEF	83	16	28	ec	00	00	00	14	00	00	02	be	02	00	00	01	00	b4	00	6c	40	00	00	00
03 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
04 DEF	84	16	00	c7	bc	04	00	00	00	00	00	00	00	00	00	00	00	00	00	00	27	31	00	00
04 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
07 DEF	87	0a	00	0b	f f	00	00	00	00	00	f f	f f												
07 CHG	87	0a	0f	f f	00	00	00	00	00	00	f f	f f												
08 DEF	88	12	14	00	f f	f f	00	00	f f	f f	f f	f f	00	20	00	00	00	00	00	00				
08 CHG	88	12	b5	00	00	00	f f	f f	f f	f f	00	00	a0	f f	00	00	00	00	00	00				
0A DEF	8a	0a	02	00	00	00	00	00	00	00	06	18												
0A CHG	8a	0a	03	f1	00	00	00	00	00	00	00	00												
19 DEF	19	06	01	00	f f	f f	00	00																
19 CHG	19	06	00	00	f f	f f	00	00																
1A DEF	9a	0a	00	02	00	00	00	05	00	00	00	04												
1A CHG	9a	0a	00	03	f f	f f	f f	f f	00	00	00	00												
1C DEF	9c	0a	10	00	00	00	00	00	00	00	00	01												
1C CHG	9c	0a	9d	0f	f f	f f	f f	f f	f f	f f	f f	f f												
00 DEF	80	06	00	00	0f	00	00	00																
00 CHG	80	06	f7	40	0f	00	00	00																
Read capacity data																								
	08	8b	b9	97	00	00	02	00																

Table 16: ST936701 Mode sense data

Bytes	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mode Sense Data	00	ae	00	10	00	00	00	08	04	45	dc	cc	00	00	02	00								
Mode Page	<----------Mode Page Headers and Parameter Data Bytes---------->																							
01 DEF	81	0a	c0	0b	f f	00	00	00	05	00	f f	f f												
01 CHG	81	0a	f f	f f	00	00	00	00	f f	00	f f	f f												
02 DEF	82	0e	80	80	00	0a	00	00	00	00	00	00	00	00	00	00								
02 CHG	82	0e	f f	f f	00	00	00	00	00	00	00	00	87	00	00	00								
03 DEF	83	16	14	76	00	00	00	0a	00	00	02	be	02	00	00	01	00	87	00	6c	40	00	00	00
03 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
04 DEF	84	16	00	c7	bc	02	00	00	00	00	00	00	00	00	00	00	00	00	00	00	27	31	00	00
04 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
07 DEF	87	0a	00	0b	f f	00	00	00	00	00	f f	f f												
07 CHG	87	0a	0f	f f	00	00	00	00	00	00	f f	f f												
08 DEF	88	12	14	00	f f	f f	00	00	f f	f f	f f	f f	00	20	00	00	00	00	00	00				
08 CHG	88	12	b5	00	00	00	f f	f f	f f	f f	00	00	a0	f f	00	00	00	00	00	00				
0A DEF	8a	0a	02	00	00	00	00	00	00	00	03	19												
0A CHG	8a	0a	03	f1	00	00	00	00	00	00	00	00												
19 DEF	19	06	01	00	f f	f f	00	00																
19 CHG	19	06	00	00	f f	f f	00	00																
1A DEF	9a	0a	00	02	00	00	00	05	00	00	00	04												
1A CHG	9a	0a	00	03	f f	f f	f f	f f	00	00	00	00												
1C DEF	9c	0a	10	00	00	00	00	00	00	00	00	01												
1C CHG	9c	0a	9d	0f	f f	f f	f f	f f	f f	f f	f f	f f												
00 DEF	80	06	00	00	0f	00	00	00																
00 CHG	80	06	f7	40	0f	00	00	00																
Read capacity data																								
	04	45	dc	cb	00	00	02	00																

9.4 SCSI bus conditions and miscellaneous features supported

Asynchronous SCSI bus conditions supported by the drive are listed below. These conditions cause the SCSI device to perform certain actions and can alter the SCSI bus phase sequence. Other miscellaneous operating features supported are also listed here. Refer to the *SCSI Interface Product Manual* for details.

Table 4: SCSI bus conditions and other miscellaneous features

SCSI-2/SCSI-3	Conditions or feature
Y	Adaptive Caching
Y	Arbitrating System
Y	Asynchronous Data Transfer
N	Asynchronous Event Notification
Y	Attention Condition
N	Auto Contingent Allegiance Condition
Y	Contingent Allegiance Condition
Y	Deferred Error Handling
Y	Disconnect/Reconnect
N	High voltage differential (HVD) interface available
Y	Low voltage differential (LVD) interface available
Y	Parameter Rounding (controlled by the Round bit in Mode Select page 0)
Y	Queue tagging (up to 64 Queue tags supported)
Y	Reporting actual retry count in Extended Sense bytes 15, 16 and 17.
Y	Reset Condition
Y	Segmented Caching
Y	Synchronous Data Transfer
N	Zero Latency Read

SCSI-2/SCSI-3	Status supported
Y	Good
Y	Check Condition
Y	Condition Met/Good
Y	Busy
Y	Intermediate/Good
Y	Intermediate/Condition Met/Good
Y	Reservation Conflict
Y	Queue Full
N	ACA Active

9.5 Synchronous data transfer

The data transfer period to be used by the drive and the initiator is established by an exchange of messages during the Message Phase of operation. See the section on message protocol in the *SCSI Interface Product Manual,* part number 75789509.

9.5.1 Synchronous data transfer periods supported

In the following tables, M is the synchronous period value (in the transfer rate negotiation message) that represents the associated transfer period and transfer rate values.

Table 17 lists the synchronous data transfer periods supported by the drive in DT DATA phase. DT DATA phase is only allowed when using the LVD interface.

Table 17: Synchronous DT DATA transfer periods

M (decimal)	Transfer period (nanoseconds)	Transfer rate (megatransfers/second)	Transfer rate (Mbytes/second) on wide bus
8	6.25	160.0	320.0
9	12.5	80.0	160.0
10	25	40.0	80.0
12	50	20.0	40.0
25	100	10.0	20.0

Table 18 lists the synchronous data transfer periods supported by the drive in ST DATA phase. ST DATA phase is allowed with either LVD or SE interface except as noted.

Table 18: Synchronous ST DATA transfer periods

M (decimal)	Transfer period (nanoseconds)	Transfer rate (megatransfers/second)
10	25	40.0[1]
12	50	20.0
25	100	10.0
50	200	5.0

1. This transfer rate is only allowed when using the LVD interface.

9.5.2 REQ/ACK offset

Savvio SCSI family drives support REQ/ACK offset values from 7 to 63 (3Fh). Offsets of 1 through 6 are negotiated to 0 (asynchronous transfer).

9.6 Physical interface

This section describes the connectors, cables, signals, terminators and bus timing of the DC and SCSI I/O interface. See Section 9.8 and Section 9.8.1 for additional terminator information.

Figure 14 shows the location of the SCSI interface connector.

Details of the physical, electrical and logical characteristics are given in sections following, while the SCSI operational aspects of Seagate drive interfaces are given in the *SCSI Interface Product Manual*.

9.6.1 DC cable and connector

SFF.1 LC model drives receive power through the 80-pin I/O connector. See Tables 20 and 21.

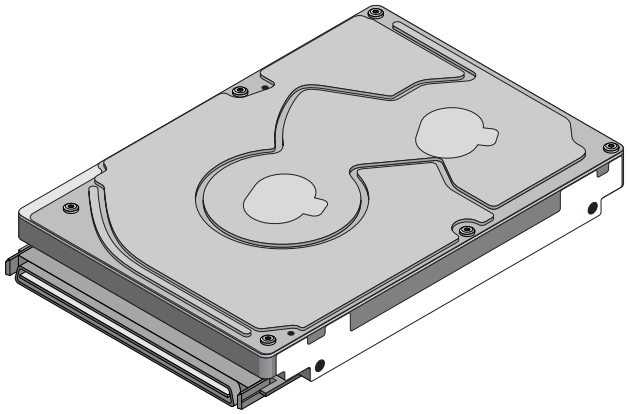


Figure 14. Physical interface (80-pin SCSI I/O connector)

9.6.2 SCSI interface physical description

Savvio SCSI drives support the physical interface requirements of the Ultra320 SCSI Parallel Interface-4 (SPI-4), and operate compatibly at the interface with devices that support earlier SCSI-2 and SCSI-3 standards. It should be noted that this is only true if the systems engineering has been correctly done, and if earlier SCSI-2 and SCSI-3 devices respond in an acceptable manner (per applicable SCSI Standards) to reject newer Ultra320 protocol extensions that they don't support.

The drives documented in this manual support single-ended and low voltage differential physical interconnects (hereafter referred to as SE and LVD, respectively) as described in the corresponding ANSI SPI document referenced in the preceeding paragraph. These drives implement driver and receiver circuits that can operate either SE or LVD. However, they cannot switch dynamically between SE and LVD operation.

The drives typically operate on a daisy-chain interface in which other SCSI devices are also operating. Devices on the daisy chain must all operate in the same mode, either SE or LVD, but not a mixture of these. On the interface daisy chain, all signals are common between all devices on the chain, or bus, as it is also called. This daisy chain of SCSI devices must be terminated at both ends with the proper impedance in order to operate correctly. Do not terminate intermediate SCSI devices. LC model drives do not have onboard termination circuits. Some type of external termination circuits must be provided for these drives by the end user or designers of the equipment into which the drives will be integrated. See the ANSI T10 Standard referenced above for the maximum number of devices that can successfully operate at various interface transfer rates on SE and LVD daisy chains.

LC model drives plug into PCBA or bulkhead connectors in the host. They may be connected in a daisy chain by the host backplane wiring or PCBA circuit runs that have adequate DC current carrying capacity to support the number of drives plugged into the PCBA or bulkhead connectors. A single 80-pin I/O connector cable cannot support the DC current needs of several drives, so no daisy chain cables beyond the bulkhead connectors should be used. A single drive connected via a cable to a host 80-pin I/O connector is not recommended.

Table 19 shows the interface transfer rates supported by the various drive models defined in this manual.

Table 19: Interface transfer rates supported

Interface type/ drive models		Maximum transfer rate						
		Asynchronous	**Fast-5**	**Fast-10**	**Fast-20 (Ultra)**	**Fast-40 (Ultra2)**	**Fast-80 (Ultra160)**	**Fast-160 (Ultra320)**
SE	ST973401LC ST936701LC	yes	yes	yes	yes	no	no	no
LVD	ST973401LC ST936701LC	yes	yes	yes	yes	yes	yes	yes

9.6.3 SCSI interface cable requirements

The characteristics of cables used to connect parallel interface drives are discussed in the ANSI standards referenced in this section.

9.6.3.1 Cable requirements

The 80-pin connector option provided on LC models is intended for use on drives that plug directly into backplane connector in the host equipment. In such installations, all backplane wiring segments are subject to the electromagnetic concepts presented in Standard T10/1365D, Rev. 3, Section 6. Installations with connectors on cables are not recommended.

9.6.4 Mating connectors

Part numbers for the different type connectors that mate with the various Savvio SCSI I/O connectors are given in the sections following.

9.6.4.1 Mating connectors

The nonshielded connector shall be an 80-conductor connector consisting of two rows of 40 contacts with adjacent contacts 50 (1.27 mm) mils apart (see Figure 15). I/O connection using a cable is not recommended. The length and size of the host equipment DC power carrying conductors from the DC power source to the host equipment 80-pin disc drive interface connector(s) should be strictly designed according to proper power transmission design concepts. No possibility for the equipment user to attach an 80-pin cable/connector should be allowed, since the length of the DC power carrying conductors could not be controlled and therefore could become too long for safe power transmission to the drive. Daisy-chain 80-conductor cables should especially not be allowed, since the power-carrying conductors on the 80-conductor interface were not intended to support a series of drives.

To insure that both drive connector and host equipment mating connector mate properly, both drive connector and host equipment mating connector must meet the provisions of “SFF-8451 Specification for SCA-2 Unshielded Connections.” To obtain this specification, visit the following web site: www.sffcommittee.org

Recommended mating 80-position PCBA mount connectors:

Straight-in connector		**Hot plug version (with ground guide-pin)**	
Seagate P/N:	77678703		
Amp US P/N:	2-557103-1	787311-1	with polarization
or	94-0680-02-1		
Amp US P/N:	2-557103-2	787311-2	without polarization
or	94-0680-02-2		
Amp Japan P/N:	5-175475-9		

Right-angle to PCBA connectors

Seagate P/N:	77678559
Amp US P/N:	2-557101-1
Amp Japan P/N:	5-175474-9

For additional information call Amp FAX service at 1-800-522-6752.

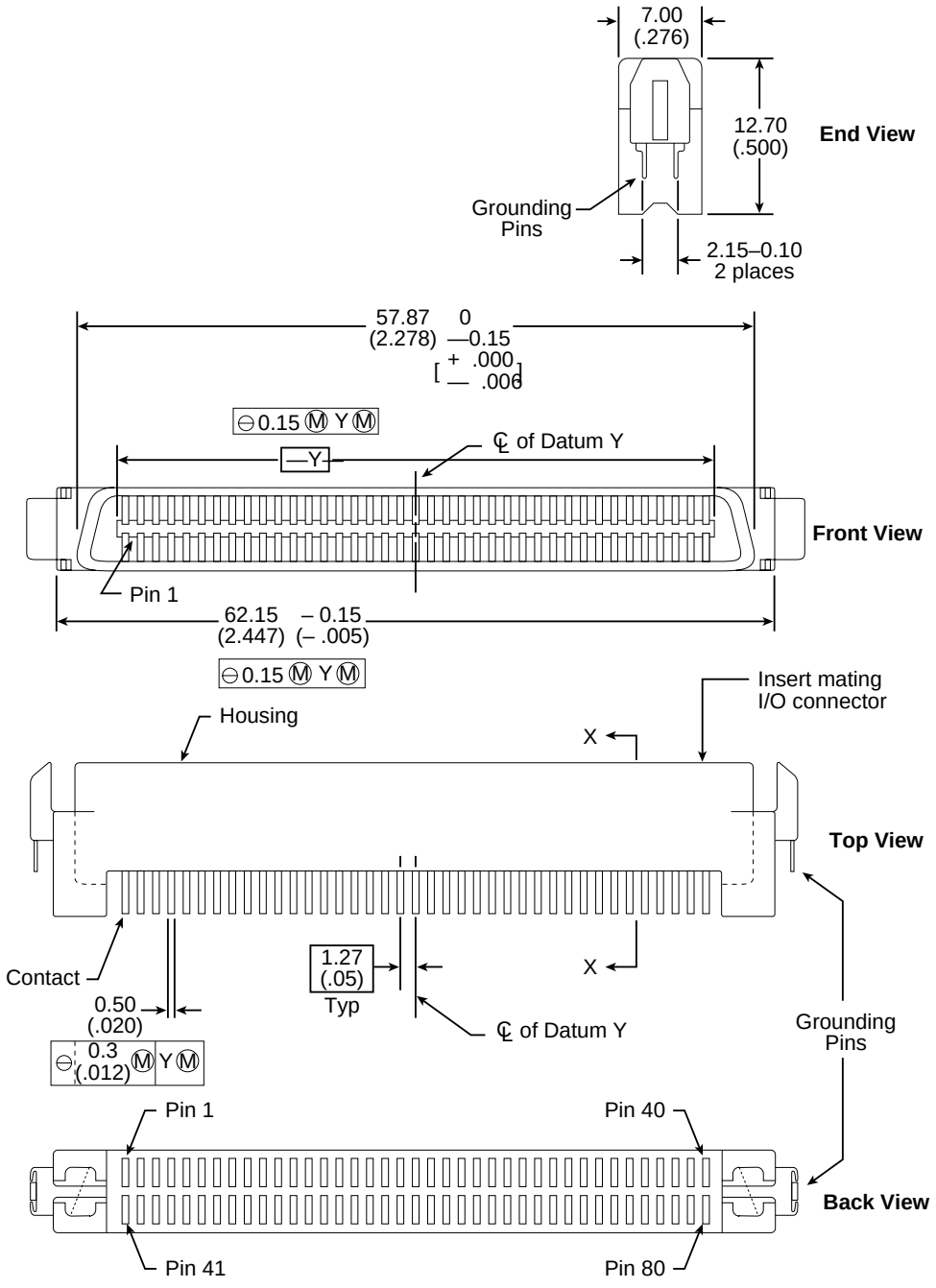


Figure 15. Nonshielded 80-pin SCSI “SCA-2” connector

Table 20: 80-pin single-ended (SE) I/O connector pin assignments [11]

Note. A minus sign preceding a signal name indicates that signal is active low.

Signal name [1]	Connector contact number [3]	Signal number [3]	Contact name[1]
12 V CHARGE	1	41	12 V GND
12 V	2	42	12 V GND
12 V	3	43	12 V GND
12 V	4	44	MATED 1 [12]
NC [10]	5	45	NC [10]
NC [10]	6	46	DIFFSNS [8]
–DB11	7	47	GND
–DB10	8	48	GND
–DB9	9	49	GND
–DB8	10	50	GND
–I/O	11	51	GND
–REQ	12	52	GND
–C/D	13	53	GND
–SEL	14	54	GND
–MSG	15	55	GND
–RST	16	56	GND
–ACK	17	57	GND
–BSY	18	58	GND
–ATN	19	59	GND
–DBP	20	60	GND
–DB7	21	61	GND
–DB6	22	62	GND
–DB5	23	63	GND
–DB4	24	64	GND
–DB3	25	65	GND
–DB2	26	66	GND
–DB1	27	67	GND
–DB0	28	68	GND
–DP1	29	69	GND
–DB15	30	70	GND
–DB14	31	71	GND
–DB13	32	72	GND
–DB12	33	73	GND
+5 V	34	74	MATED 2
+5 V	35	75	5 V GND
+5 V	36	76	5 V GND
NC [10]	37	77	ACTIVE LED OUT [4] [9]
RMT-START [5] [9] [12]	38	78	DLYD-START [6] [9] [12]
SCSI ID (0) [7] [9] [12]	39	79	SCSI ID (1) [7] [9] [12]
SCSI ID (2) [7] [9] [12]	40	80	SCSI ID (3) [7] [9] [12]

Notes [ ]: See page following Table 21.

Table 21: 80-pin single-ended (LVD) I/O connector pin assignments [11]

Note. A minus sign preceding a signal name indicates that signal is active low.

Signal name [1]	Connector contact number [3]	Signal number [3]	Contact name[1]
12 V CHARGE	1	41	12 V GND
12 V	2	42	12 V GND
12 V	3	43	12 V GND
12 V	4	44	MATED 1 [12]
NC [10]	5	45	NC [10]
NC [10]	6	46	DIFFSNS [8]
–DB11	7	47	+DB11
–DB10	8	48	+DB10
–DB9	9	49	+DB9
–DB8	10	50	+DB8
–I/O	11	51	+I/O
–REQ	12	52	+REQ
–C/D	13	53	+C/D
–SEL	14	54	+SEL
–MSG	15	55	+MSG
–RST	16	56	+RST
–ACK	17	57	+ACK
–BSY	18	58	+BSY
–ATN	19	59	+ATN
–DBP	20	60	+DBP0
–DB7	21	61	+DB7
–DB6	22	62	+DB6
–DB5	23	63	+DB5
–DB4	24	64	+DB4
–DB3	25	65	+DB3
–DB2	26	66	+DB2
–DB1	27	67	+DB1
–DB0	28	68	+DB0
–DBP1	29	69	+DP1
–DB15	30	70	+DB15
–DB14	31	71	+DB14
–DB13	32	72	+DB13
–DB12	33	73	+DB12
+5 V	34	74	MATED 2
+5 V	35	75	5 V GND
+5 V CHARGE	36	76	5 V GND
NC [10]	37	77	ACTIVE LED OUT [4] [9]
RMT_START [5] [9] [12]	38	78	DLYD_START [6] [9] [12]
SCSI ID (0) [7] [9] [12]	39	79	SCSI ID (1) [7] [9] [12]
SCSI ID (2) [7] [9] [12]	40	80	SCSI ID (3) [7] [9] [12]

Notes [ ]: See page following this table.

Notes [ ] for Tables 20 and 21.

[1] See Section 9.6.4.1 for detailed electrical characteristics of these signals.
[2] The conductor number refers to the conductor position when using 0.025-inch (0.635 mm) centerline flat ribbon cable. Other cables types may be used to implement equivalent contact assignments.
[3] Connector contacts are on 0.050 inch (1.27 mm) centers.
[4] Front panel LED signal; indicates drive activity for host front panel hard drive activity indicator.
[5] Asserted by host to enable Motor Start option (enables starting motor via SCSI bus command).
[6] Asserted by host to enable Delayed Motor Start option (motor starts at power on or after a delay of 12 seconds times drive ID). This and [3] above are mutually exclusive options.
[7] Binary code on A3, A2, A1 and A0 asserted by host to set up SCSI bus ID in drive.
[8] GND provides a means for differential devices to detect the presence of a single ended device on the bus. Drive will not operate I/O bus at Ultra2 or faster SCSI data rates if this is grounded.
[9] Signals [4] through [7] are used in place of installing jumpers and cables on option select connector J6. See Section 8.1.1 notes.
[10] “NC” means no connection.
[11] 8 bit devices which are connected to the 16 data bit LVD I/O shall leave the following signals open: –DB8, –DB9, –DB10, –DB11, –DB12, –DB13, –DB14, –DB15, and –DBP1.
8 bit devices which are connected to the 16 data bit single-ended (SE) I/O shall have the following signals open: DB8, –DB9, –DB10, –DB11, –DB12, –DB13, –DB14, –DB15, and –DBP1.
All other signals should be connected as shown.
[12] Pins 38, 39, 40, 44, 78, 79, and 80 are option select pins and are tied high by the drive circuitry. The preferred electrical connection at the backplane is either open or grounded (open for the ‘1’ setting, grounded for the ‘0’ setting). Alternatively, these pins may be driven by a 3.3V logic device, pulled up to 3.3V through a pull-up resistor (recommended size of 10K ohm), or grounded through some other means.

9.7 Electrical description

Savvio SCSI drives are multimode devices. That is, their I/O circuits can operate as either single-ended or low voltage differential drivers/receivers (selectable using the I/O “DIFFSENS” line).

See ANSI Standard T10/1302D for detailed electrical specifications.

9.7.1 Multimode—SE and LVD alternatives

When the interface “DIFFSNS” line is between -0.35 V and +0.5 V, the drive interface circuits operate single-ended and up to and including 20 M transfers/s (Fast-20 or Ultra SCSI). When “DIFFSNS” is between +0.7 V and +1.9 V, the drive interface circuits operate low voltage differential and up to and including 160 M transfers/s (Fast-160 or U320 SCSI).

This multimode design does not allow dynamically changing transmission modes. Drives must operate only in the mode for which the installation and interface cabling is designed. Multimode I/O circuits used by these drives do not operate at high voltage differential levels and should never be exposed to high voltage differential environments unless the common mode voltages in the environment are controlled to safe levels for single-ended and low voltage differential devices (see ANSI SPI-4 specification T10/1365D).

LC model drives do not have onboard terminators. Termination of the I/O lines must be provided for by the Host equipment designers or end users.

LVD output characteristics

Each differential signal driven by LVD interface drivers shall have the following output characteristics when measured at the disc drive connector:

Steady state Low level output differential voltage = 0.320 V = < $|V_S|$ = < 0.800 V (signal negation/logic 0)
Steady state High level output differential voltage = 0.320 V = < $|V_S|$ = < 0.800 V (signal assertion/logic 1)

LVD input characteristics

Each differential signal received by LVD interface receiver circuits shall have the following input characteristics when measured at the disc drive connector:

Steady state Low level input differential voltage = 0.030 V = < V_{in} = < 3.6 V (signal negation/logic 0)
Steady state High level input differential voltage = –3.6 V = < V_{in} = < –0.030 V (signal assertion/logic 1)
Differential voltage = $\pm$0.030 V minimum with common-mode voltage range 0.845 V = < V_{cm} = < 1.655 V. (T10/1302D revision 14, section A.3.2).

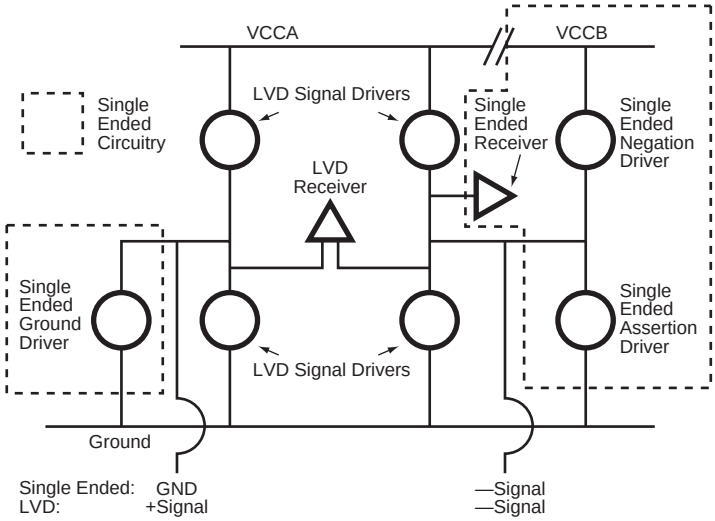


Figure 16. Typical SE-LVD alternative transmitter receiver circuits

9.7.1.1 General cable characteristics

The 80-pin connector option provided on LC models is intended for use on drives that plug directly into backplane connector in the host equipment. In such installations, all backplane wiring segments are subject to the electromagnetic concepts presented in Standard T10/1365D, Rev. 3, Section 6. For LC model drives, installations with cables are not recommended.

9.7.1.2 Single-ended drivers/receivers

Single-ended I/O pin assignments are shown in Table 20. The LC model drives do not require an I/O cable. These models are designed to connect directly to a back panel connector.

9.8 Terminator requirements

These drives do not have onboard internal terminators. The user, systems integrator or host equipment manufacturer must provide a terminator arrangement external to the drive when termination is required. LC model drives are designed to be plugged into a backpanel connector without cabling.

9.8.1 Terminator power

These drives cannot furnish terminator power because no conductors in the 80-pin I/O connector are devoted to terminator power.

9.9 Disc drive SCSI timing

Table 22: Disc drive SCSI timing

These values are not current Savvio SCSI values, but are listed for information only.

Description	Waveform symbol [1]	Waveform table [1]	Typical timing
Target Select Time (no Arbitration)	T00	N/A	<1 µs
Target Select Time (with Arbitration)	T01	4.5-1,2	1.93 µs
Target Select to Command	T02	4.5-1	3.77 µs
Target Select to MSG Out	T03	4.5-2	1.57 µs
Identify MSG to Command	T04	4.5-3	3.36 µs
Command to Status	T05	4.5-5	Command Dependent
Command to Data (para. In)	T06	4.5-9	Command Dependent
Command to Data (para. Out)	T07	4.5-10	Command Dependent
Command to Data (Write to Data Buffer)	T08	4.5-10	Command Dependent
Command to Disconnect MSG	T09	4.5-6	Command Dependent
Disconnect MSG to Bus Free	T10	4.5-6,14	0.52 µs
Disconnect to Arbitration (for Reselect) This measures disconnected CMD overhead	T11	4.5-6	Command Dependent
Target win Arbitration (for Reselect)	T12	4.5-7	3.00 µs
Arbitration to Reselect	T13	4.5-7	1.60 µs
Reselect to Identify MSG In	T14	4.5-7	1.39 µs
Reselect Identify MSG to Status	T15	4.5-8	Command Dependent
Reselect Identify MSG to Data (media)	T16	4.5-11	Command Dependent
Data to Status	T17	4.5-15	Command Dependent
Status to Command Complete MSG	T18	4.5-5,8,15	0.98 µs
Command Complete MSG to Bus Free	T19	4.5-5,8,15	0.51 µs
Data to Save Data Pointer MSG	T20	4.5-14	4.00 µs
Save Data Pointer MSG to Disconnect MSG	T21	4.5-14	0.79 µs
Command Byte Transfer	T22	4.5-4	0.04 µs
Next Command Byte Access:		4.5-4	
Next CDB Byte Access (Byte 2 of 6)	T23.6.2	4.5-4	0.58 µs
Next CDB Byte Access (Byte 3 of 6)	T23.6.3	4.5-4	0.12 µs
Next CDB Byte Access (Byte 4 of 6)	T23.6.4	4.5-4	0.12 µs
Next CDB Byte Access (Byte 5 of 6)	T23.6.5	4.5-4	0.12 µs
Next CDB Byte Access (Byte 6 of 6)	T23.6.6	4.5-4	0.12 µs
Next CDB Byte Access (Byte 2 of 10)	T23.10.2	4.5-4	0.59 µs
Next CDB Byte Access (Byte 3 of 10)	T23.10.3	4.5-4	0.11 µs ±1 µs
Next CDB Byte Access (Byte 4 of 10)	T23.10.4	4.5-4	0.12 µs ±1 µs
Next CDB Byte Access (Byte 5 of 10)	T23.10.5	4.5-4	0.11 µs ±1 µs
Next CDB Byte Access (Byte 6 of 10)	T23.10.6	4.5-4	0.11 µs ±1 µs
Next CDB Byte Access (Byte 7 of 10)	T23.10.7	4.5-4	0.13 µs ±1 µs

Table 22: Disc drive SCSI timing (Continued)

These values are not current Savvio SCSI values, but are listed for information only.

Description	Waveform symbol [1]	Waveform table [1]	Typical timing
Next CDB Byte Access (Byte 8 of 10)	T23.10.8	4.5-4	0.12 µs ±1 µs
Next CDB Byte Access (Byte 9 of 10)	T23.10.9	4.5-4	0.12 µs ±1 µs
Next CDB Byte Access (Byte 10 of 10)	T23.10.10	4.5-4	0.12 µs ±1 µs
Data In Byte Transfer (parameter)	T24	4.5-12	0.04 µs
Data Out Byte Transfer (parameter)	T25	4.5-13	0.04 µs
Next Data In Byte Access (parameter)	T26	4.5-12	0.12 µs
Next Data Out Byte Access (parameter)	T27	4.5-13	0.12 µs
Data In Byte Transfer (media) [2]	T28	4.5-12	0.04 µs
Data Out Byte Transfer (media) [2]	T29	4.5-13	0.04 µs
Next Data In Byte access (media [2]	T30	4.5-12	0.12 µs
Next Data Out Byte access (media [2]	T31	4.5-13	0.12 µs
MSG IN Byte Transfer	T32	4.5-5,7,8,14,15	0.04 µs
MSG OUT Byte Transfer	T33	4.5-2	0.04 µs
STATUS Byte Transfer	T34	4.5-5,8,15	0.04 µs
Synchronous Data Transfer Characteristics:			
Request Signal Transfer Period [3]	–	–	various (800 ns max)

Notes.

[1] See the Timing examples section of the *SCSI Interface Product Manual*.
[2] Maximum SCSI asynchronous interface transfer rate is given in Section 4.2.3 of this manual.
[3] Synchronous Transfer Period is determined by negotiations between an Initiator and a Drive. The Drive is capable of setting periods as given in Section 9.5. See also the Synchronous data transfer section and the Extended messages section of the *SCSI Command Reference Manual* for a description of synchronous data transfer operation.

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India[2, 4]	1-600-180-1104	—	—
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