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Product Manual

Cheetah 15K.5 SCSI

ST3300655LW
ST3146855LW
ST373455LW

ST3300655LC
ST3146855LC
ST373455LC

100384776
Rev. J
May 2010

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

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1.0 Seagate Technology support services

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

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

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

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

2.0 Scope

This manual describes Seagate® Technology LLC, Cheetah® 15K.5 SCSI disc drives.

Cheetah 15K.5 SCSI drives support the small computer system interface (SCSI) as described in the ANSI SCSI SPI-4 interface specifications to the extent described in this manual. The *SCSI Interface Manual* (part number 100293069) describes general SCSI interface characteristics of this and other families of Seagate drives.

From this point on in this product manual the reference to Cheetah 15K.5 SCSI models is referred to as “the drive” unless references to individual models are necessary.

3.0 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 9.4.

3.1 Standards

The Cheetah 15K.5 SCSI family complies with Seagate standards as noted in the appropriate sections of this Manual, the *Seagate Parallel SCSI Interface Manual*, part number 100293069, and the *SCSI Commands Reference Manual*, part number 100293068.

The Cheetah 15K.5 SCSI disc drive is a UL recognized component per UL1950, CSA certified to CSA C22.2 No. 950-95, and VDE or TUV certified to EN60950.

3.1.1 Electromagnetic compatibility

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

The design characteristics of the drive serve to minimize radiation when installed in an enclosure that provides reasonable shielding. 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.

3.1.2 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 Table 3, DC power requirements.

3.2 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.

This drive has been tested and complies with the Electromagnetic Interference/Electromagnetic Susceptibility (EMI/EMS) for Class B products.

Taiwanese BSMI

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

3.3 European Union Restriction of Hazardous Substances (RoHS)

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

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

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

3.4 Reference documents

Cheetah 15K.5 SCSI Installation Guide Seagate P/N 100384777

Safety and Regulatory Agency Specifications Seagate P/N 75789512

SCSI Commands Reference Manual Seagate P/N 100293068

Parallel SCSI Interface Product Manual Seagate P/N 100293069

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

T10/1143D	Enhanced SCSI Parallel Interface (EPI)
T10/1416D	Primary Commands-3 (SPC-3)
T10/1417D	SCSI Block Commands (SBC-2)
T10/1157D	SCSI Architectural Model-2 (SAM-2)
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.

4.0 General description

Cheetah 15K.5 SCSI drives combine Tunneling Magneto-resistive (TMR) heads 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/Ultra160/Ultra320 SCSI host adapters.

Table 1 lists the features that differentiate the Cheetah 15K.5 SCSI models.

Table 1: Drive model number vs. differentiating features

Model number	Number of active heads	I/O circuit type [1]	Number of I/O connector pins
ST3300655LW ST3146855LW ST373455LW	8 4 2	Single-ended (SE) and low voltage differential (LVD)	68
ST3300655LC ST3146855LC ST373455LC	8 4 2	Single-ended (SE) and low voltage differential (LVD)	80

[1] See Section 10.6 for details and definitions.

The drive records and recovers data on approximately 70 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 (volume 1), which defines the product performance characteristics of the Cheetah 15K.5 SCSI family of drives, the *Parallel SCSI Interface Manual*, part number 100293069, and the SCSI Commands Reference Manual, part number 100293068, which describe 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 logical block addressing.

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.

Cheetah 15K.5 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.

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

4.1 Standard features

The Cheetah 15K.5 SCSI family has the following standard features:

- Perpendicular recording technology.
- Integrated Ultra320 SCSI interface.
- 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 burst correction length of up to 400.
- Sealed head and disc assembly
- 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
- 16,384 kbytes data buffer
- Hot plug compatibility (Section 10.6.4.2 lists proper host connector needed) for LC model drives
- Drive Self Test (DST)
- Supports SCSI bus fairness

4.2 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.

4.3 Performance

- Supports industry standard Ultra320 SCSI interface
- Programmable multi-segmentable cache buffer (see Section 5.5)
- 15k RPM spindle. Average latency = 2.0 msec
- Command queuing of up to 64 commands
- Background processing of queue
- Supports start and stop commands (spindle stops spinning)

4.4 Reliability

- Annualized Failure Rate (AFR) of 0.62%
- Increased LSI circuitry integration
- Incorporates industry-standard Self-Monitoring, Analysis and Reporting Technology (S.M.A.R.T.)
- 5-year warranty

4.5 Formatted capacities

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

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

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

Sector Size	ST3300655LW ST3300655LC		ST3146855LW ST3146855LC		ST373455LW ST373455LC	
	Decimal	Hex	Decimal	Hex	Decimal	Hex
512	585,937,500	22ECB25C	286,749,488	11177330	143,374,744	88BB998
514	574,712,644	22416B44	282,050,768	10CFC0D0	141,025,384	867E068
520	573,653,847	22314357	280,790,184	10BC84A8	140,395,092	85E4254
522	570,053,000	21FA5188	279,041,740	10A1D6CC	139,463,602	8500BB2
524	566,007,800	21BC97F8	275,154,368	106685C0	137,577,184	83342E0
528	557,874,778	21407E5A	272,662,935	10408197h	136,331,467	82040CBh

2. Seagate drives also may be used at the maximum available capacity at a given sector size, but the excess capacity above the guaranteed level will vary between 10K and 15K families and from generation to generation, depending on how each sector size actually formats out for zone frequencies and splits over servo bursts. This added capacity potential may range from 0.1 to 1.3 percent above the guaranteed capacities listed above. Using the drives in this manner gives the absolute maximum capacity potential, but the user must determine if the extra capacity potential is useful, or whether their assurance of backward and forward compatibility takes precedence.

4.5.1 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 Interface Manual*. Refer to the Parameter list block descriptor number of blocks field. A value of zero in the number of blocks field indicates that the drive shall not change the capacity it is currently formatted to have. A number in the number of blocks field that is less than the maximum number of LBAs changes the total drive capacity to the value in the block descriptor number of blocks field. A value greater than the maximum number of LBAs is rounded down to the maximum capacity.

4.6 Factory installed accessories

OEM Standard drives are shipped with the *Cheetah 15K.5 Installation Guide*, part number 100384777, and the *Safety and Regulatory Agency Specifications*, part number 75789512 (unless otherwise specified). The factory also ships with the drive a small bag of jumper plugs used for the J5 and J6 option select jumper headers (on LW models only).

4.7 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 *Cheetah 15K.5 Installation Guide*, part number 100384777, usually ships with each standard OEM drive. Extra copies may be ordered.
- The *Safety and Regulatory Agency Specifications*, part number 75789512, usually ships with each standard OEM drive. Extra copies may be ordered.

4.8 Accessories

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

- Single unit shipping pack.

5.0 Performance characteristics

5.1 Internal drive characteristics (transparent to user)

	ST3300655LW ST3300655LC	ST3146855LW ST3146855LC	ST373455LW ST373455LC	
Drive capacity	300.0	146.8	73.4	GBytes (formatted)**
Read/write heads	8	4	2	
Tracks/surface (total)	74,340	74,340	74,340	Tracks (user accessible)
Tracks/inch	125,000	125,000	125,000	TPI
Peak bits/inch	890k	890k	890k	BPI
Areal Density	110	110	110	Gbits/inch ²
Internal data rate	960 to 1607	960 to 1607	960 to 1607	Mbits/sec (variable with zone)
Disc rotational speed	15k	15k	15k	rpm
Average rotational latency	2.0	2.0	2.0	msec

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

** Rounded off value.

5.2 SCSI performance characteristics (visible to user)

The values given in Section 5.2.1 apply to all models of the Cheetah 15K.5 SCSI family unless otherwise specified. Refer to the *Parallel SCSI Interface Manual* for additional timing details.

5.2.1 Seek time

		Not including controller overhead (msec) ^{1,2}	
		Read	Write
Average	Typical	3.5	4.0
Single Track	Typical	0.2	0.4
Full Stroke	Typical	6.8	7.5

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

5.2.2 Format command execution time (minutes) [1]

	ST3300655LW ST3300655LC	ST3146855LW ST3146855LC	ST373455LW ST373455LC
Maximum (with verify)	120	90	60
Maximum (no verify)	60	45	30

5.2.3 Generalized performance characteristics

Sustainable disc transfer rate:

Minimum [3]	73	Mbytes/sec
Maximum [3]	125	Mbytes/sec

SCSI interface data transfer rate (asynchronous):

Maximum instantaneous one byte wide	5.0	MBytes/sec [3]
Maximum instantaneous two bytes wide	10.0	MBytes/sec [3]

Synchronous transfer rate

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	2.00 msec

Notes for Section 5.2.

- [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] Assumes no errors and no sector has been relocated.
- [3] Assumes system ability to support the rates listed and no cable loss.

5.3 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 Interface Product 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 Commands Reference Manual*).

There is no power control switch on the drive.

5.4 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 Interface Product 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 5.5.1 and Section 5.5.2.

All default cache and prefetch Mode parameter values (Mode Page 08h) for standard OEM versions of this drive family are given in Table 10.

5.5 Cache operation

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

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

The drive keeps track of the logical block addresses of the data stored in each segment of the buffer. If the cache is enabled (see RCD bit in the *SCSI Interface Manual*), data requested by the host with a read command is retrieved from the buffer, if possible, before any disc access is initiated. If cache operation is not enabled, the buffer 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. All data transfers to the host are in accordance with buffer-full ratio rules. See the explanation provided with the information about Mode Page 02h (disconnect/reconnect control) in the *SCSI Interface Manual*.

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

Case A—read command is received and all of the requested logical blocks are already in the cache:

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

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

1. The drive fetches the requested logical blocks from the disc and transfers them into a segment, and then from there to the host in accordance with the Mode Select Disconnect/Reconnect parameters, page 02h.
2. If the prefetch feature is enabled, refer to section 5.5.2 for operation from this point.

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

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

5.5.1 Caching write data

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

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

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

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

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

Tables 10, 11 and 12 show the mode default settings for the drive.

5.5.2 Prefetch operation

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

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

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

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

6.0 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 9.4).

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^{16} bits transferred (OEM default settings)
Miscorrected Data	Less than 1 sector in 10^{21} bits transferred
Annualized Failure Rate (AFR)	0.62%
Preventive Maintenance	None required

Note.

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

6.1 Error rates

The error rates stated in this specification assume the following:

- The drive is operated per this specification using DC power as defined in this manual (see Section 7.2).
- Errors caused by host system failures are excluded from error rate computations.
- Assume random data.
- Default OEM error recovery settings are applied. This includes AWRE, ARRE, full read retries, full write retries and full retry time.

6.1.1 Recoverable Errors

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

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

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

6.1.2 Unrecoverable Error

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

6.1.3 Seek errors

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

6.2 Reliability and service

You can enhance the reliability of Cheetah 15K.5 SCSI disc drives by ensuring that the drive receives adequate cooling. Section 7.0 provides temperature measurements and other information that may be used to enhance the service life of the drive. Section 9.3 provides recommended air-flow information.

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

These drives shall achieve an AFR of 0.62% (MTBF of 1,400,000 hours) when operated in an environment that ensures the HDA case temperatures do not exceed the values specified in Section 7.4.1.

Operation at case temperatures outside the specifications in Section 7.4.1 may increase the AFR (decrease the MTBF). AFR and MTBF statistics are population statistics that are not relevant to individual units.

AFR and MTBF specifications are based on the following assumptions for Enterprise Storage System environments:

- 8,760 power-on hours per year
- 250 average on/off cycles per year
- Operating at nominal voltages
- System provides adequate cooling to ensure the case temperatures specified in Section 7.4.1 are not exceeded.

6.2.2 Preventive maintenance

No routine scheduled preventive maintenance shall be required.

6.2.3 Hot plugging Cheetah 15K.5 SCSI disc drives

The ANSI SPI-4 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 Cheetah 15K.5 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-4 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-4).

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 7.4.4, "Shock and vibration" in this manual.

6.2.4 S.M.A.R.T.

S.M.A.R.T. is an acronym for Self-Monitoring Analysis and Reporting Technology. This technology is intended to recognize conditions that indicate drive degradation 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 monitors a specific set of conditions in the operating performance of the drive, and the thresholds are optimized to minimize "false" 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 uninterruptible and the maximum delay is summarized below::

Maximum processing delay

	On-line only delay DEXCPT = 0, PERF = 1	Fully-enabled delay DEXCPT = 0, PERF = 0
S.M.A.R.T. delay times	42 milliseconds	163 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. This counter is referred to as the Failure History Counter. There is a separate Failure History Counter for each attribute. Should the counter continually be incremented such that it reaches the predictive threshold, a predictive failure is signaled.

6.2.5 Thermal monitor

Cheetah 15K.5 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 2) 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 2: 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.

6.2.6 Drive Self Test (DST)

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

There are two test coverage options implemented in DST:

1. Extended test
2. Short test

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

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

6.2.6.1 DST Failure Definition

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

The following conditions are considered DST failure conditions:

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

Recovered errors will not be reported as diagnostic failures.

6.2.6.2 Implementation

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

6.2.6.2.1 State of the drive prior to testing

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

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

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

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

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

6.2.6.2.2 Invoking DST

To invoke DST, submit the Send Diagnostic command with the appropriate Function Code (001b for the short test or 010b for the extended test) in bytes 1, bits 5, 6, and 7. Refer to the *SCSI Commands Reference Manual*, part number 100293068, for additional information about invoking DST.

6.2.6.2.3 Short and extended tests

DST has two testing options:

1. short
2. extended

These testing options are described in the following two subsections.

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

Short test (Function Code: 001b)

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

Extended test (Function Code: 010b)

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

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

6.2.6.2.4 Log page entries

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

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

After a self-test is complete or has been aborted, the drive updates the Self-Test Results Value field in its Self-Test Results Log page in non-volatile memory. The host may use Log Sense to read the results from up to the last 20 self-tests performed by the drive. The self-test results value is a 4-bit field that reports the results of the test. If the field is 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.

6.2.6.2.5 Abort

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

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

6.2.7 Product warranty

Beginning on the date of shipment to 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 or 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.

7.0 Physical/electrical specifications

This section provides information relating to the physical and electrical characteristics of the Cheetah 15K.5 SCSI drive.

7.1 AC power requirements

None.

7.2 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 tables show current values in Amperes.

Table 3: ST3300655LC DC power requirements

		Notes	LVD mode	
Voltage			+5 V	+12 V
Regulation		[5]	±5%	±5%[2]
Average idle current DC	X	[1][6]	0.70	0.80
Maximum starting current				
(peak DC) DC	3σ	[3]	0.76	1.94
(peak AC) AC	3σ	[3]	1.07	3.35
Delayed motor start (max) DC	3σ	[1][4]	0.57	0.03
Peak operating current				
DC	\bar{X}	[1]	0.69	1.18
Maximum DC	3σ	[1]	0.70	1.23
Maximum (peak) DC	3σ		1.38	2.90

Table 4: ST3146855LC DC power requirements

		Notes	LVD mode	
Voltage			+5 V	+12 V
Regulation		[5]	±5%	±5%[2]
Average idle current DC	X	[1][6]	0.71	0.57
Maximum starting current (peak DC) DC	3σ	[3]	0.74	1.94
(peak AC) AC	3σ	[3]	1.04	3.32
Delayed motor start (max) DC	3σ	[1][4]	0.56	0.03
Peak operating current DC	\bar{X}	[1]	0.67	0.88
Maximum DC	3σ	[1]	0.68	0.94
Maximum (peak) DC	3σ		1.42	2.50

Table 5: ST373455LC DC power requirements

		Notes	LVD mode	
Voltage			+5 V	+12 V
Regulation		[5]	±5%	±5%[2]
Average idle current DC	X	[1][6]	0.69	0.42
Maximum starting current (peak DC) DC	3σ	[3]	0.72	1.94
(peak AC) AC	3σ	[3]	1.00	3.32
Delayed motor start (max) DC	3σ	[1][4]	0.56	0.03
Peak operating current DC	\bar{X}	[1]	0.67	0.78
Maximum DC	3σ	[1]	0.68	0.82
Maximum (peak) DC	3σ		1.40	2.38

- [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 15,000 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 1.
- [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 7.2.1 "Conducted Noise Immunity." Specified voltage tolerance is inclusive of ripple, noise, and transient response.
- [6] 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 for Tables 3, 4, and 5:

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.

7.2.1 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 0 to 100 kHz 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.

7.2.2 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 supplied to 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 J6 connector on LW models or on the backplane for LC models. See Section 9.1 for pin selection information. To delay the motor until the drive receives a Start Unit command, enable the Enable Remote Motor Start option on the J6 connector on LW models or on the backplane for LC models.

7.2.3 Current profile

Figures 1 and 2 show +5V and +12V sample current profiles for the ST3300655LC model.

All times and currents are typical. See Table 3 for maximum current requirements.

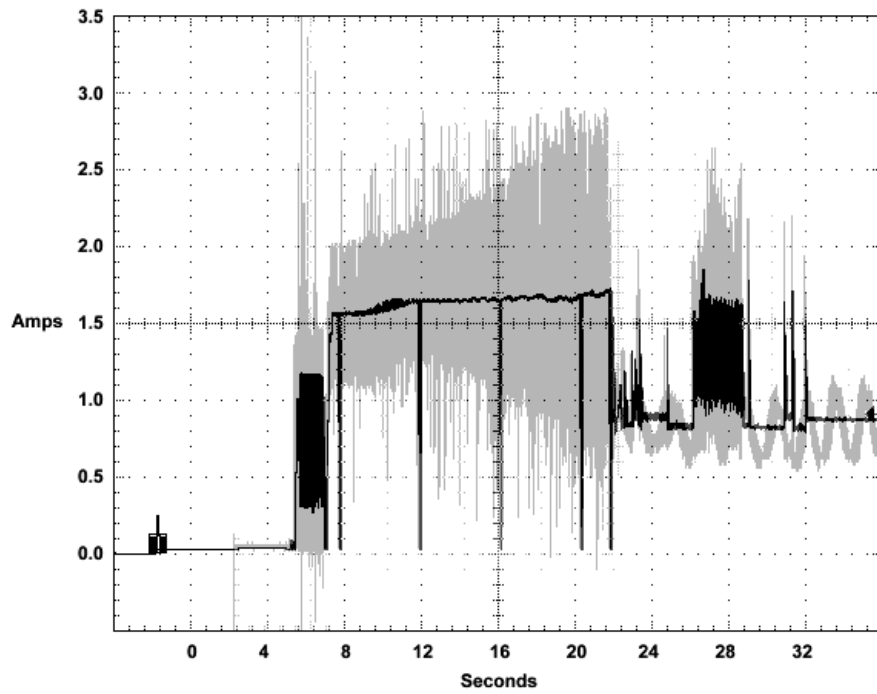


Figure 1. Typical ST3300655LW drive +12V LVD current profile

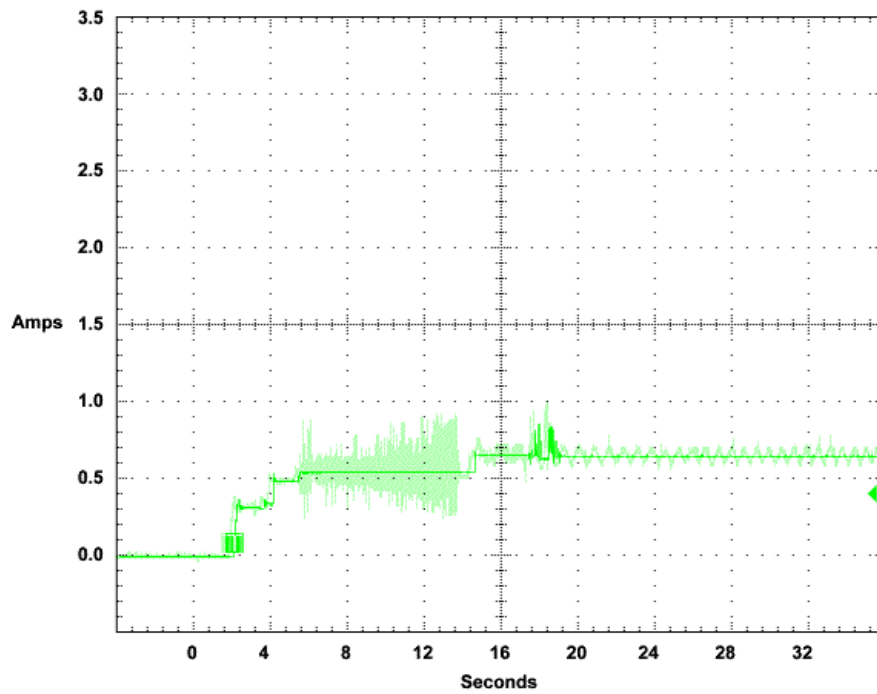


Figure 2. Typical ST3300655LW drive +5 V LVD current profile

7.3 Power dissipation

ST3300655LW/ST3300655LC

For drives using low voltage differential interface circuits, typical power dissipation under idle conditions is 13.1 watts (44.70 BTUs per hour).

To obtain operating power for typical random read operations, refer to the following I/O rate curve (see Figure 3). 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.)

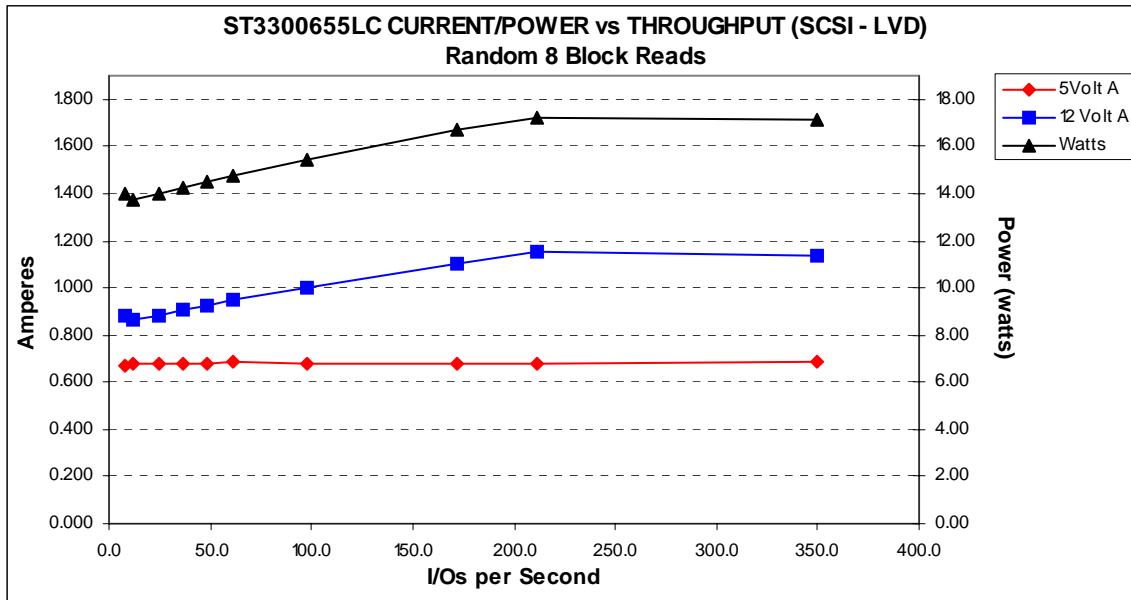


Figure 3. ST3300655LC DC current and power vs. IOPS (LVD)

ST3146855LW/ST3146855LC

For drives using low voltage differential interface circuits, typical power dissipation under idle conditions is 10.39 watts (35.45 BTUs per hour).

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

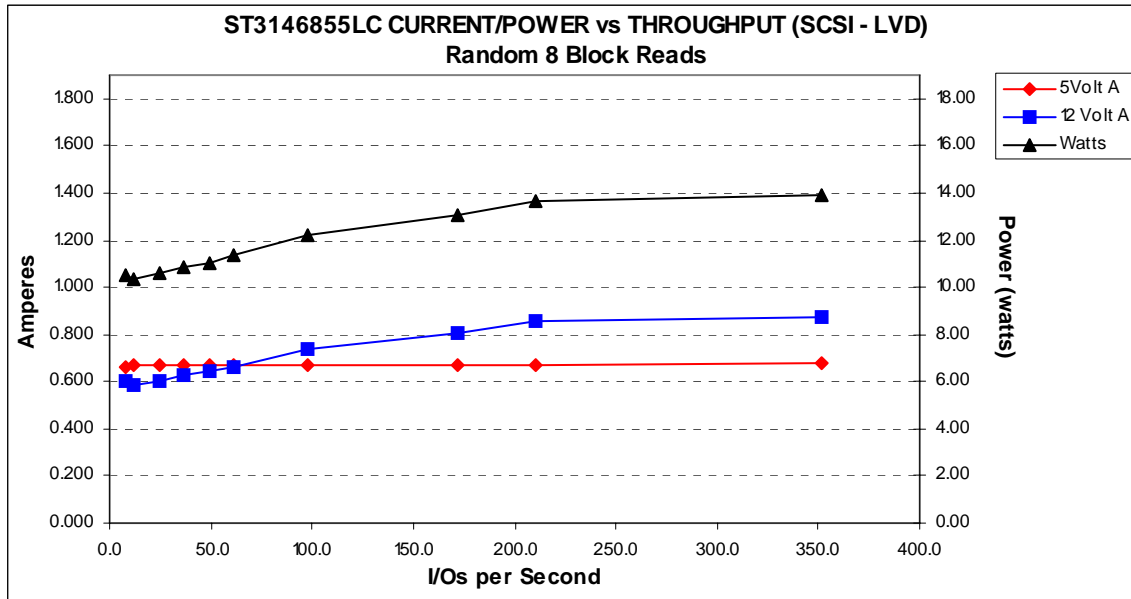


Figure 4. ST3146855LC DC current and power vs. IOPS (LVD)

ST373455LW/ST373455LC

For drives using low voltage differential interface circuits, typical power dissipation under idle conditions is 8.49 watts (28.97 BTUs per hour).

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

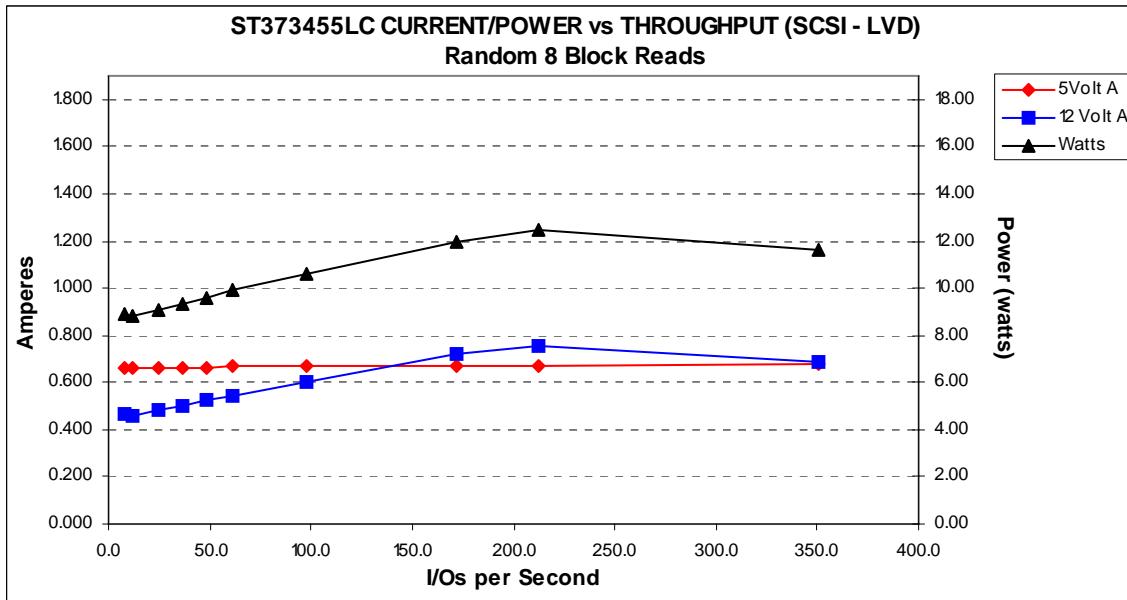


Figure 5. ST373455LC DC current and power vs. IOPS (LVD)

7.4 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).

7.4.1 Temperature

a. Operating

The maximum allowable continuous or sustained HDA case temperature for the rated Annualized Failure Rate (AFR) is 122°F (50°C). The maximum allowable HDA case temperature is 60°C. Occasional excursions of HDA case temperatures above 122°F (50°C) or below 41°F (5°C) may occur without impact to specified AFR. Continual or sustained operation at HDA case temperatures outside these limits may degrade AFR.

Provided the HDA case temperatures limits are met, 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. Air flow may be needed in the drive enclosure to keep within this range (see Section 8.3). Operation at HDA case temperatures outside this range may adversely affect the drives ability to meet specifications. To confirm that the required cooling for the electronics and HDA case is provided, place the drive in its final mechanical configuration, perform random write/read operations and measure the HDA case temperature after it has stabilized.

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.

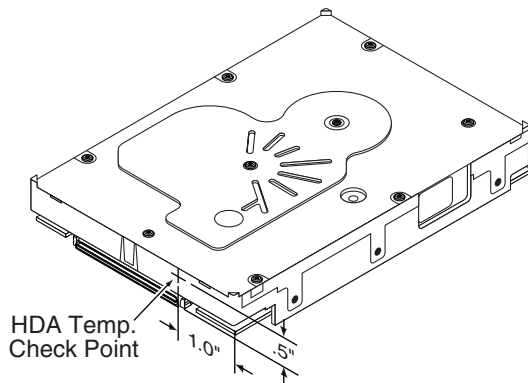


Figure 6. Locations of the HDA temperature check point

7.4.2 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 10% per hour.

b. Non-operating

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

7.4.3 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)

7.4.4 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 7, and in accordance with the restrictions of Section 9.4. Orientation of the side nearest the LED may be up or down.

7.4.4.1 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 60 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 250 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 120 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.

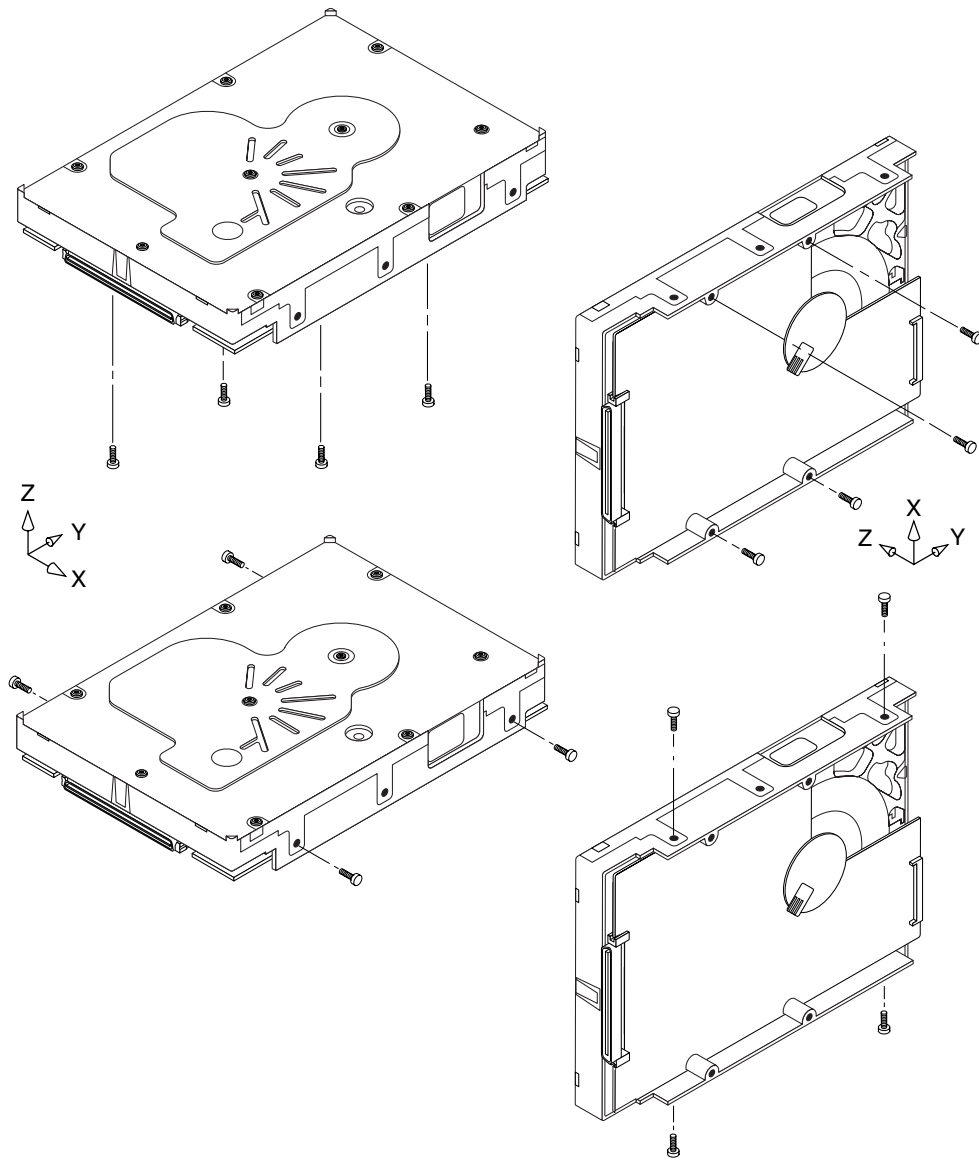


Figure 7. Recommended mounting

7.4.4.2 Vibration

a. Operating—normal

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

10–500 Hz @ 0.5 G (zero to peak)

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

Operating normal translational random flat profile:

10–500 Hz 0.4 gRMS

b. Operating—abnormal

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

15 minutes of duration at major resonant frequency

10–500 Hz @ 0.75 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.

Operating abnormal translational random flat profile

10 - 500 Hz 1.2 gRMS

c. Non-operating

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

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

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

22–500 Hz @ 2.00 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

7.4.5 Air cleanliness

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

7.4.6 Corrosive environment

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

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

7.4.7 Acoustics

Sound power during idle mode shall be 3.7 bels typical when measured to ISO 7779 specification. Sound power while operating shall be 4.3 bels typical when measured to ISO 7779 specification.

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

7.4.8 Electromagnetic susceptibility

See Section 3.1.2.

7.5 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 8 and 9 for detailed mounting configuration dimensions. See Section 9.4, "Drive mounting."

Height (max):	1.028 in.	26.11 mm
Width (max):	4.010 in.	101.85 mm
Depth (max):	5.787 in.	146.99 mm
Weight (max):	1.85 pounds	0.839 kilograms

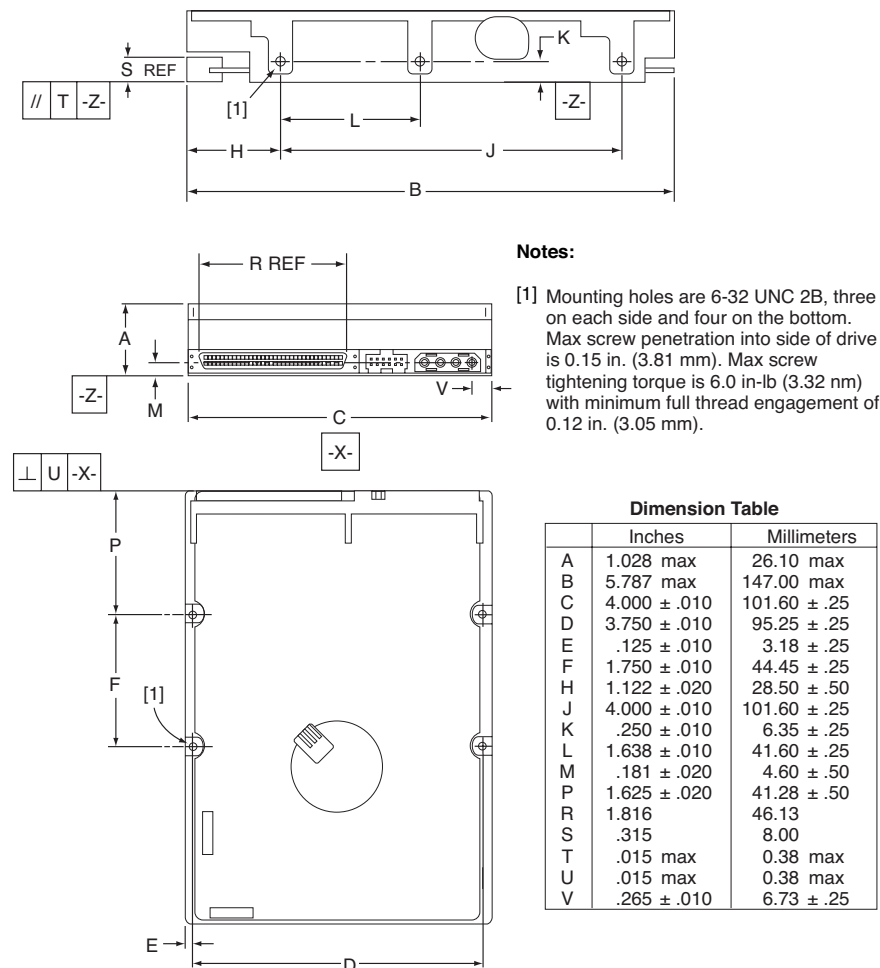


Figure 8. LW mounting configuration dimensions

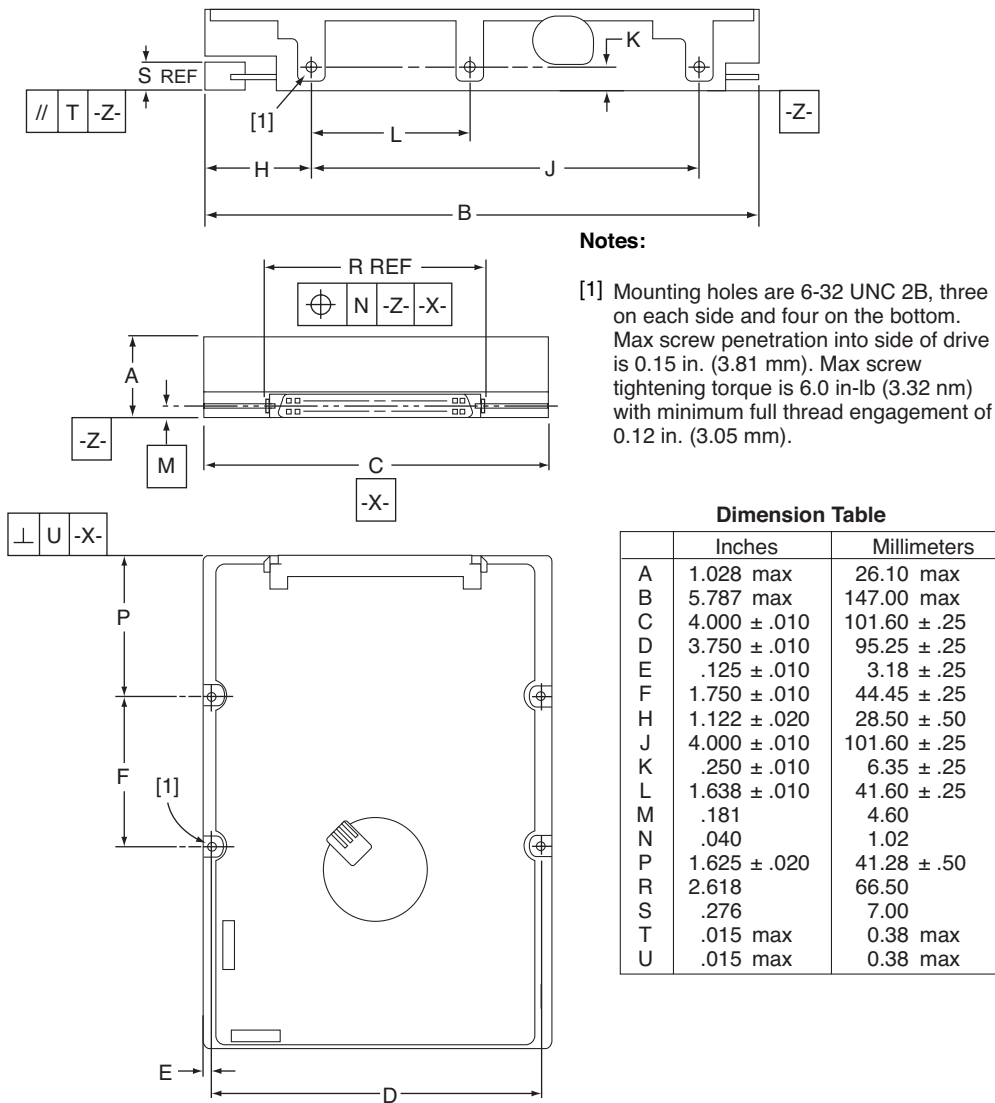


Figure 9. LC mounting configuration dimensions

8.0 Defect and error management

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

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

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

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

8.1 Drive internal defects

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 Commands Reference Manual*).

8.2 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 Interface Product 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 Commands 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 6 equates the Read and Write Retry Count with the maximum possible recovery time for read and write recovery of individual LBAs. The times given do not include time taken to perform reallocations, 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 6: Read and write retry count maximum recovery times [1]

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

[1] 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 253.11 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.

8.3 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 Interface Product 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 Commands Reference 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.

8.4 Background Media Scan

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

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

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

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

8.5 Media Pre-Scan

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

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

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

8.6 Deferred Auto-Reallocation

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

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

8.7 Idle Read After Write

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

9.0 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 usually done by installing small shorting jumpers on the J5 connector (see Figure 10), or via the drive to host I/O signals on the LC model. Some users connect cables to J5 and perform the set-up using remote switches.

Configure drive options

For option jumper locations and definitions refer to Figures 10 and 11. Drive default mode parameters are not normally needed for installation. Refer to Section 10.3.2 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 10.8 and 10.9.

- Set all appropriate option jumpers for desired operation prior to power on. If jumpers are changed after power has been applied, recycle the drive power to make the new settings effective.
- Installation instructions are provided by host system documentation or with any additionally purchased drive installation software. If necessary see Section 10 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

- Drives are shipped from the factory low level formatted with 512 byte sectors.

9.1 Drive ID/option select header

Figure 10 shows the drive ID select jumper connector. Figure 11 shows the option select jumper connector for all models. Figure 11 shows the drive's J6 jumper connector. The notes following the figures describe the functions of the various jumper positions on the connectors. Suggested part number for the jumpers used on J6 is Molex 52747-0211 (Seagate part number 77679052). A bag with the two jumper plug types is shipped with the standard OEM drives.

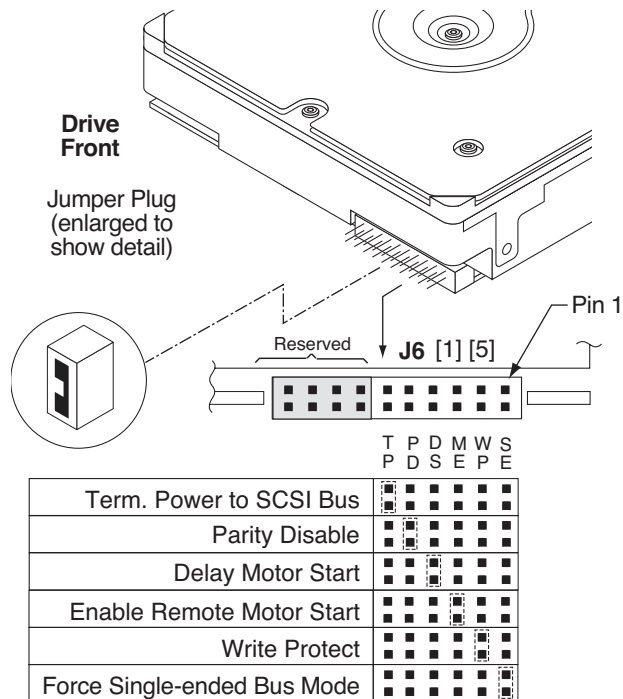


Figure 11. J6 option select header (on LW models only)

9.1.1 Notes for Figures 10 and 11.

[1] Notes explaining the functions of the various jumpers on J5 and J6 jumper header connectors are given here and in Section 9.1.2. The term “**default**” means as standard OEM units are configured with a jumper on those positions when shipped from factory. “Off” means no jumper is installed; “On” means a jumper is installed. OFF or ON underlined is factory **default** condition.

The PCBA on LC models does not have connector J5 or J6. The J5 connector signals conform to SFF-8009 Revision 2.0, Unitized Connector for Cabled Drives, signal assignments for auxiliary connectors.

[2] These signals are also on 80-pin J1 I/O connector. See tables 19 and 20, note 9.

[3] Voltage supplied by the drive.

[4] Dashed area is optional host circuitry (external to the drive) connected to host supplied optional usage plug.

[5] Do not connect anything to J5 pins 9, 11-12 or J6 pins 13-20.

[6] Connect an external Drive Activity LED to J5 pin 8 (see Figure 10) and the drive’s +5V power source, through an appropriately sized current limiting resistor.

9.1.2 Function description

J6 jumper installation

Jumper function description

SE

- On Forces drive to use single-ended I/O drivers/receivers only.
- Off Drive can operate on the interface in low voltage differential mode or single-ended, depending on the voltage state of the I/O "DIFFSNS" line. **Default** is SE jumper not installed.

DS ME

- Off Off Spindle starts immediately after power up - **Default** setting.
- Off On Drive spindle does not start until Start Unit command received from host.
- On Off Spindle Startup is delayed by SCSI ID times 12 seconds after power is applied, i.e., drive 0 spindle starts immediately when DC power connected, drive 1 starts after 12 second delay, drive 2 starts after 24 second delay, etc.
- On On Drive spindle starts when Start Unit command received from host. Delayed start feature is overridden and does not apply when **ME** jumper is installed.

WP

- On Entire drive is write protected.
- Off Drive is not write protected. **Default** is **WP** jumper not installed.

PD

- On Parity checking and parity error reporting by the drive is disabled.
- Off Drive checks for parity and reports result of parity checking to host.
Default is **PD** jumper not installed.

RES

- Off Reserved jumper position. **Default** is no **RES** jumper installed.

TP

- Off The drive does not supply terminator power to external terminators or to the SCSI bus I/O cable.
- On Drive supplies power to SCSI bus I/O cable. When drives have differential I/O circuits, a jumper on the **TP** position may be needed to power external terminators (see system documentation). These drives do not have terminator circuits on the drive.

Note. J6 does not exist on the LC model and is supported on the LW model only.

9.2 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.

9.3 Cooling

The host enclosure must provide heat removal from the drive. You should confirm that the host enclosure is designed to ensure that the drive operates within the temperature measurement guidelines described in Section 7.4.1. In some cases, forced airflow may be required to keep temperatures at or below the temperatures specified in Section 7.4.1.

If forced air is necessary, possible air-flow patterns are shown in Figure 12. The air-flow patterns are created by fans either forcing or drawing air as shown in the illustrations. Conduction, convection, or other forced air-flow patterns are acceptable as long as the temperature measurement guidelines of Section 7.4.1 are met.

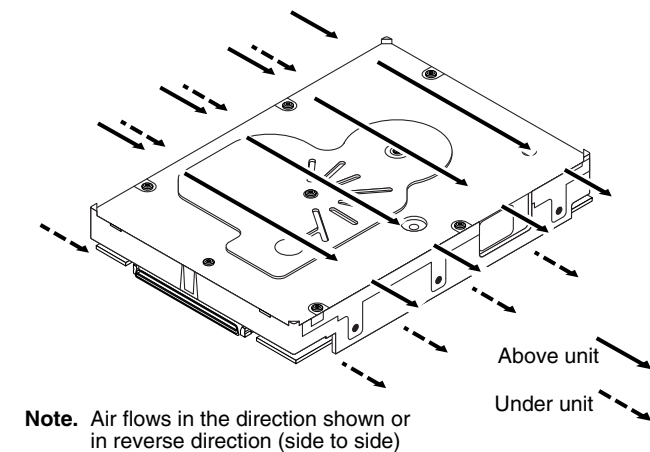
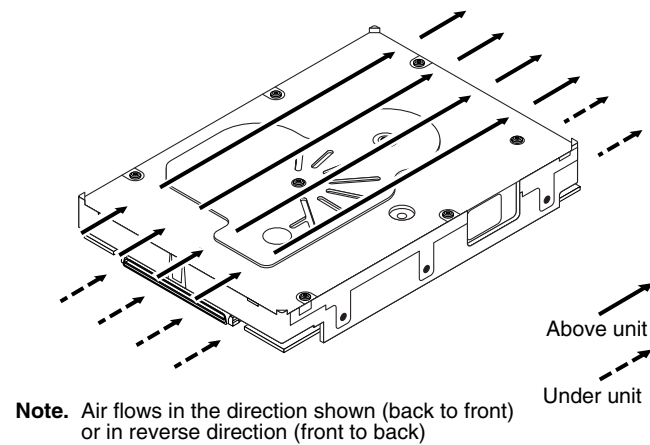


Figure 12. Air flow (suggested)

9.4 Drive mounting

When mounting the drive using the bottom holes (x-y plane in Figure 7) care must be taken to ensure that the drive is not physically distorted due to a stiff non-flat mounting surface. The allowable mounting surface stiffness is 80 lb/in (14.0 N/mm). The following equation and paragraph define the allowable mounting surface stiffness:

$$k * x = F \leq 15\text{lb} = 67\text{N}$$

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

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

9.5 Grounding

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

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

10.0 Interface requirements

This section partially describes the interface requirements as implemented on the drives.

10.1 General description

This section describes in essentially general terms the interface requirements supported by the Cheetah 15K.5 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 Parallel SCSI Interface Manual and the SCSI Commands Reference Manual*.

10.2 SCSI interface messages supported

Table 7 lists the messages supported by the Cheetah 15K.5 SCSI family drives.

Table 7: SCSI messages supported by Cheetah 15K.5 SCSI family drives

Message name	Message code	Supported (Y = yes) (N = no)
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	[1] [2]	Y
Queue tag messages (two bytes)		
ACA	24h	N
Head of queue tag	21h	Y

Table 7: SCSI messages supported by Cheetah 15K.5 SCSI family drives

Message name	Message code	Supported (Y = yes) (N = no)
Ordered queue tag	22h	Y
Simple queue tag	20h	Y
Quick Arbitration and Selection (QAS)	55h	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 Interface Product Manual*).

[2] Supports all options except qas_req and iu_req.

10.3 SCSI interface commands supported

Table 8 following lists the SCSI interface commands that are supported by the drive. OEM standard drives are shipped set to operate in Ultra320 mode.

Table 8: Commands supported by Cheetah 15K.5 SCSI family drive

Command name	Command code	Supported by SCSI-2/3
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

Table 8: Commands supported by Cheetah 15K.5 SCSI family drive (Continued)

Command name	Command code	Supported by SCSI-2/3
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
Background Medium Scan page (15h)		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
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
Background Scan mode subpage (01h)		Y
Notch and Partition Page (0Ch)		N
Port Control Page (19h)		Y
Power Condition page (1Ah)		Y

Table 8: Commands supported by Cheetah 15K.5 SCSI family drive (Continued)

Command name	Command code	Supported by SCSI-2/3
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
Supported Diagnostics pages (00h)		Y
Translate page (40h)		Y
Release	17h	Y
Release (10)	57h	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

Table 8: Commands supported by Cheetah 15K.5 SCSI family drive (Continued)

Command name	Command code	Supported by SCSI-2/3
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
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 10 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 9 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 100293069, Inquiry command section.

Table 9: Cheetah 15K.5 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	[33]	[33]	[30]	[30]	[36]	[35]	[35]	[4C]	[57] ³	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	[y]	COPYRIGHT
112-127	[y]	[y]	[y] 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 ST3300655LW. Refer to the values below for the values of bytes 18 through 26 of you particular model:

ST3300655LW	33	33	30	30	36	35	35	4C	57
ST3300655LC	33	33	30	30	36	35	35	4C	43
ST3146855LW	33	31	35	36	38	35	35	4C	57
ST3146855LC	33	31	35	36	38	35	35	4C	43
ST373455LW	33	37	33	34	35	35	4C	57	20
ST373455LC	33	37	33	34	35	35	4C	43	20

[]⁴ Copyright Year - the year the drive's firmware code was built.

10.3.1 Inquiry Vital Product data

Instead of the standard Inquiry data shown in Table 9, the initiator can request several Vital Product Data pages by setting the Inquiry command EVPD bit to one. The *SCSI Commands 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.

10.3.2 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 10 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 Commands Reference Manual*).

Definitions:

SAV = Current saved value.

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 10: ST3300655 Mode sense data

MODE SENSE HEADER DATA

ab 00 10 08 22 ec b2 5c 00 00 02 00

MODE SENSE PAGES DATA

SAV 81 0a c0 0b ff 00 00 00 05 00 ff ff

DEF 81 0a c0 0b ff 00 00 00 05 00 ff ff

CHG 81 0a ff ff 00 00 00 00 ff 00 ff ff

SAV 82 0e 80 80 00 0a 00 00 00 00 00 00 00 00 00 00

DEF 82 0e 80 80 00 0a 00 00 00 00 00 00 00 00 00 00

CHG 82 0e ff ff 00 00 00 00 00 00 ff ff 87 00 00 00

SAV 83 16 68 58 00 00 00 38 00 00 03 da 02 00 00 01 00 e6 00 aa 40 00 00 00

DEF 83 16 68 58 00 00 00 38 00 00 03 da 02 00 00 01 00 e6 00 aa 40 00 00 00

CHG 83 16 00

SAV 84 16 01 22 64 08 00 00 00 00 00 00 00 00 00 00 00 00 00 00 3a a7 00 00

DEF 84 16 01 22 64 08 00 00 00 00 00 00 00 00 00 00 00 00 00 00 3a a7 00 00

CHG 84 16 00

SAV 87 0a 00 0b ff 00 00 00 00 00 ff ff

DEF 87 0a 00 0b ff 00 00 00 00 00 ff ff

CHG 87 0a 0f ff 00 00 00 00 00 ff ff

SAV 88 12 14 00 ff ff 00 00 ff ff ff ff 80 20 00 00 00 00 00

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

CHG 88 12 a5 00 00 00 ff ff ff ff 00 00 20 00 00 00 00 00

SAV 8a 0a 02 00 00 00 00 00 00 0f 0c

DEF 8a 0a 02 00 00 00 00 00 00 0f 0c

CHG 8a 0a 03 f0 00 00 00 00 00 00 00

SAV 19 06 01 00 ff ff 00 00

DEF 19 06 01 00 ff ff 00 00

CHG 19 06 00 00 ff ff 00 00

SAV 9a 0a 00 02 00 00 00 0a 00 00 00 04

DEF 9a 0a 00 02 00 00 00 05 00 00 00 04

CHG 9a 0a 00 03 ff ff ff ff 00 00 00 00

SAV 9c 0a 10 00 00 00 00 00 00 00 00 01

DEF 9c 0a 10 00 00 00 00 00 00 00 00 01

CHG 9c 0a 9d 0f ff ff ff ff ff ff ff

SAV 80 06 00 00 0f 00 00 00

DEF 80 06 00 00 0f 00 00 00

CHG 80 06 f7 40 0f 00 00 00

READ CAPACITY DATA

22 ec b2 5b 00 00 02 00

Table 11: ST3146855 Mode sense data

MODE SENSE HEADER DATA

ab 00 10 08 11 17 73 30 00 00 02 00

MODE SENSE PAGES DATA

SAV 81 0a c0 0b ff 00 00 00 05 00 ff ff

DEF 81 0a c0 0b ff 00 00 00 05 00 ff ff

CHG 81 0a ff ff 00 00 00 00 ff 00 ff ff

SAV 82 0e 80 80 00 0a 00 00 00 00 00 00 00 00 00

DEF 82 0e 80 80 00 0a 00 00 00 00 00 00 00 00 00

CHG 82 0e ff ff 00 00 00 00 00 00 ff ff 87 00 00 00

SAV 83 16 34 2c 00 00 00 1c 00 00 03 da 02 00 00 01 00 e6 00 aa 40 00 00 00

DEF 83 16 34 2c 00 00 00 1c 00 00 03 da 02 00 00 01 00 e6 00 aa 40 00 00 00

CHG 83 16 00

SAV 84 16 01 22 64 04 00 00 00 00 00 00 00 00 00 00 00 00 00 00 3a a7 00 00

DEF 84 16 01 22 64 04 00 00 00 00 00 00 00 00 00 00 00 00 00 00 3a a7 00 00

CHG 84 16 00

SAV 87 0a 00 0b ff 00 00 00 00 00 ff ff

DEF 87 0a 00 0b ff 00 00 00 00 00 ff ff

CHG 87 0a 0f ff 00 00 00 00 00 ff ff

SAV 88 12 10 00 ff ff 00 00 ff ff ff ff 80 20 00 00 00 00 00

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

CHG 88 12 a5 00 00 00 ff ff ff ff 00 00 20 00 00 00 00 00 00

SAV 8a 0a 02 00 00 00 00 00 00 05 57

DEF 8a 0a 02 00 00 00 00 00 00 05 57

CHG 8a 0a 03 f0 00 00 00 00 00 00 00

SAV 19 06 01 00 ff ff 00 00

DEF 19 06 01 00 ff ff 00 00

CHG 19 06 00 00 ff ff 00 00

SAV 9a 0a 00 02 00 00 00 0a 00 00 00 04

DEF 9a 0a 00 02 00 00 00 05 00 00 00 04

CHG 9a 0a 00 03 ff ff ff ff 00 00 00 00

SAV 9c 0a 10 00 00 00 00 00 00 00 00 01

DEF 9c 0a 10 00 00 00 00 00 00 00 00 01

CHG 9c 0a 9d 0f ff ff ff ff ff ff ff

SAV 80 06 00 00 0f 00 00 00

DEF 80 06 00 00 0f 00 00 00

CHG 80 06 f7 40 0f 00 00 00

READ CAPACITY DATA

11 17 73 2f 00 00 02 00

Table 12: ST373455 Mode sense data

MODE SENSE HEADER DATA

ab 00 10 08 08 8b b9 98 00 00 02 00

MODE SENSE PAGES DATA

SAV 81 0a c0 0b ff 00 00 00 05 00 ff ff

DEF 81 0a c0 0b ff 00 00 00 05 00 ff ff

CHG 81 0a ff ff 00 00 00 00 ff 00 ff ff

SAV 82 0e 80 80 00 0a 00 00 00 00 00 00 00 00 00 00

DEF 82 0e 80 80 00 0a 00 00 00 00 00 00 00 00 00 00

CHG 82 0e ff ff 00 00 00 00 00 00 ff ff 87 00 00 00

SAV 83 16 1a 16 00 00 00 0e 00 00 03 da 02 00 00 01 00 e6 00 aa 40 00 00 00

DEF 83 16 1a 16 00 00 00 0e 00 00 03 da 02 00 00 01 00 e6 00 aa 40 00 00 00

CHG 83 16 00

SAV 84 16 01 22 64 02 00 00 00 00 00 00 00 00 00 00 00 00 00 00 3a a7 00 00

DEF 84 16 01 22 64 02 00 00 00 00 00 00 00 00 00 00 00 00 00 00 3a a7 00 00

CHG 84 16 00

SAV 87 0a 00 0b ff 00 00 00 00 00 ff ff

DEF 87 0a 00 0b ff 00 00 00 00 00 ff ff

CHG 87 0a 0f ff 00 00 00 00 00 ff ff

SAV 88 12 14 00 ff ff 00 00 ff ff ff ff 80 20 00 00 00 00 00

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

CHG 88 12 a5 00 00 00 ff ff ff ff 00 00 20 00 00 00 00 00

SAV 8a 0a 02 00 00 00 00 00 00 02 d1

DEF 8a 0a 02 00 00 00 00 00 00 02 d1

CHG 8a 0a 03 f0 00 00 00 00 00 00 00

SAV 19 06 01 00 ff ff 00 00

DEF 19 06 01 00 ff ff 00 00

CHG 19 06 00 00 ff ff 00 00

SAV 9a 0a 00 02 00 00 00 0a 00 00 00 04

DEF 9a 0a 00 02 00 00 00 05 00 00 00 04

CHG 9a 0a 00 03 ff ff ff ff 00 00 00 00

SAV 9c 0a 10 00 00 00 00 00 00 00 00 01

DEF 9c 0a 10 00 00 00 00 00 00 00 00 01

CHG 9c 0a 9d 0f ff ff ff ff ff ff ff

SAV 80 06 00 00 0f 00 00 00

DEF 80 06 00 00 0f 00 00 00

CHG 80 06 f7 40 0f 00 00 00

READ CAPACITY DATA

08 8b b9 97 00 00 02 00

10.4 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 *Parallel SCSI Interface Manual* and the *SCSI Commands Reference Manual* for details.

Table 13: SCSI bus conditions and other miscellaneous features

Condition/feature supported by:

Supported	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

Supported	Status
Y	Good
Y	Check Condition
Y	Condition Met/Good
Y	Busy
Y	Intermediate/Good
Y	Intermediate/Condition Met/Good
Y	Reservation Conflict
Y	Queue Full
N	ACA Active

10.5 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 *Parallel SCSI Interface Manual* and *SCSI Commands Reference Manual*.

10.5.1 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 14 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 14: 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 15 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 15: 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.

10.5.2 REQ/ACK offset

Cheetah 15K.5 SCSI family drives support REQ/ACK offset values from 7 to 63 (3Fh). Offsets of 1 through 6 are negotiated to 0 (asynchronous transfer).

10.6 Physical interface

This section describes the connectors, cables, signals, terminators and bus timing of the DC and SCSI I/O interface. See Section 10.8 and Section 10.9 for additional terminator information.

Figures 13 and 14 show the locations of the DC power connector, SCSI interface connector, drive select headers, and option select headers.

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 *Parallel SCSI Interface Manual*.

10.6.1 DC cable and connector

LW model drives receive DC power through a 4-pin connector (see Figure 15 for pin assignment) mounted at the rear of the main PCBA. Recommended part numbers of the mating connector are listed below, but equivalent parts may be used.

Type of cable	Connector	Contacts (20-14 AWG)
14 AWG	MP 1-480424-0	AMP 60619-4 (Loose Piece) AMP 61117-4 (Strip)

LC model drives receive power through the 80-pin I/O connector. See Tables 19 and 20.

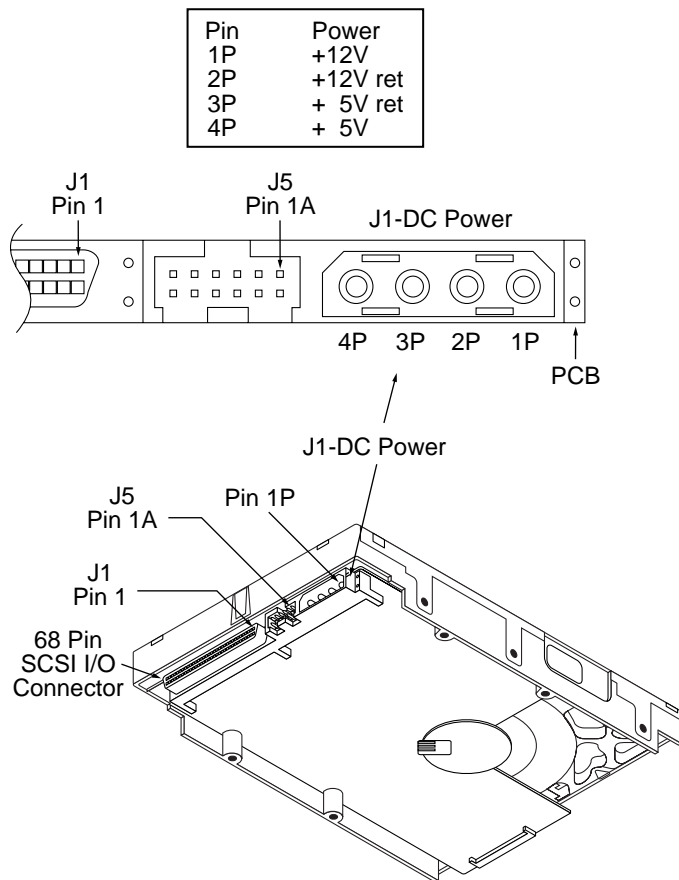


Figure 13. LW model drive physical interface (68-pin J1 SCSI I/O connector)

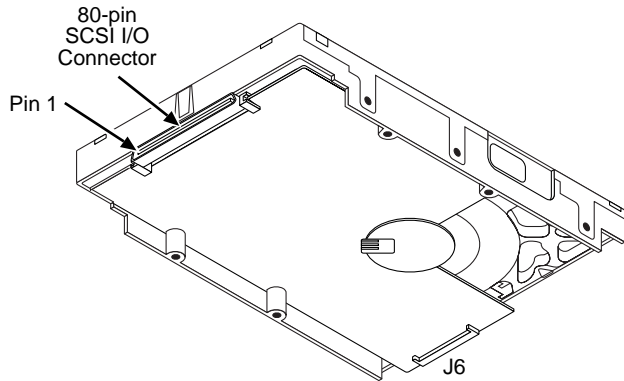


Figure 14. LC model drive physical interface (80-pin J1 SCSI I/O connector)

10.6.2 SCSI interface physical description

Cheetah 15K.5 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 preceding 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 bus with other SCSI devices. All devices on the bus must operate in the same mode, either SE or LVD, but not a mixture of these. All signals on the bus are common between all devices on the bus. This bus must be terminated at both ends with the proper impedance in order to operate correctly. Do not terminate intermediate SCSI devices. In some cases, the SCSI devices at each end have onboard termination circuits that can be enabled by installation of a jumper plug (**TE**) on the device. These termination circuits receive power from either a source internal to the device, or from a line in the interface cable specifically powered for that purpose. LC and LW 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 buses.

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

Table 16: 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	ST3300655LW/LC ST3146855LW/LC ST373455LW/LC	yes	yes	yes	yes	no	no	no
LVD	ST3300655LW/LC ST3146855LW/LC ST373455LW/LC	yes	yes	yes	yes	yes	yes	yes

10.6.3 SCSI interface cable requirements

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

10.6.3.1 Cable requirements

The characteristics of cables used to connect Ultra320 SCSI parallel interface devices are discussed in detail in Section 6 of ANSI Standard T10/1365D Rev. 3. The cable characteristics that must be considered when interconnecting the drives described in this manual in a Ultra320 SCSI parallel, daisy-chain interconnected system are:

- characteristic impedance (see T10/1365D Sections 6.3.3 and 6.3.4)
- propagation delay (see T10/1365D Sections 6.3.6 and 6.3.7)
- stub length (see T10/1365D Section 6.9)
- device spacing (see T10/1365D Section 6.9)

To minimize discontinuances and signal reflections, cables of different impedances should not be used in the same bus. Implementations may require trade-offs in shielding effectiveness, cable length, number of loads and spacing, transfer rates, and cost to achieve satisfactory system operation. If shielded and unshielded cables are mixed within the same SCSI bus, the effect of impedance mismatch must be carefully considered. Proper impedance matching is especially important in order to maintain adequate margin at FAST-20, FAST-40, FAST-80, and FAST-160 SCSI transfer rates.

Note. For LVD operation, twisted pair cables are recommended. For LVD Fast-40 operation, twisted pair cables are *strongly* recommended. For Fast-80 and Fast-160 operation, twisted pair cables are *required*.

LC Models

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 connectors on cables are not recommended.

10.6.4 Mating connectors

Part numbers for the different type connectors that mate with the various Cheetah 15K.5 SCSI I/O connectors are given in the sections following.

10.6.4.1 Mating connectors for LW model drives

The nonshielded cable connector shall be a 68 conductor connector consisting of two rows of 34 male contacts with adjacent contacts 0.050 inch (1.27 mm) apart.

Recommended mating flat cable connector part numbers are:

Amp Model 786096-7	Female, 68-pin, panel mount
Amp Model 786090-7	Female, 68-pin, cable mount
Amp Model 749925-5	(50 mil conductor centers, 28 or 30 AWG wire) Use two, 34 conductor, 50 mil center flat cable with this connector. This type connector can only be used on cable ends. [1]
Amp Model 88-5870-294-5	W/O Strain Relief (25 mil conductor centers, 30 AWG wire). Use either on cable ends or in cable middle section for daisy-chain installations [1].
Amp Model 1-480420-0	Power connector 4 circuit housing
Berg 69307-012	12-position, 2 x 6, 2 mm receptacle housing

[1] See Figure 15.

The drive device connector is a nonshielded 68 conductor connector consisting of two rows of 34 female pins with adjacent pins 50 mils apart. The connector is keyed by means of its shape (see Figure 16).

10.6.4.2 Mating connectors for LC model drives

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 17). 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. Multiconductor 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

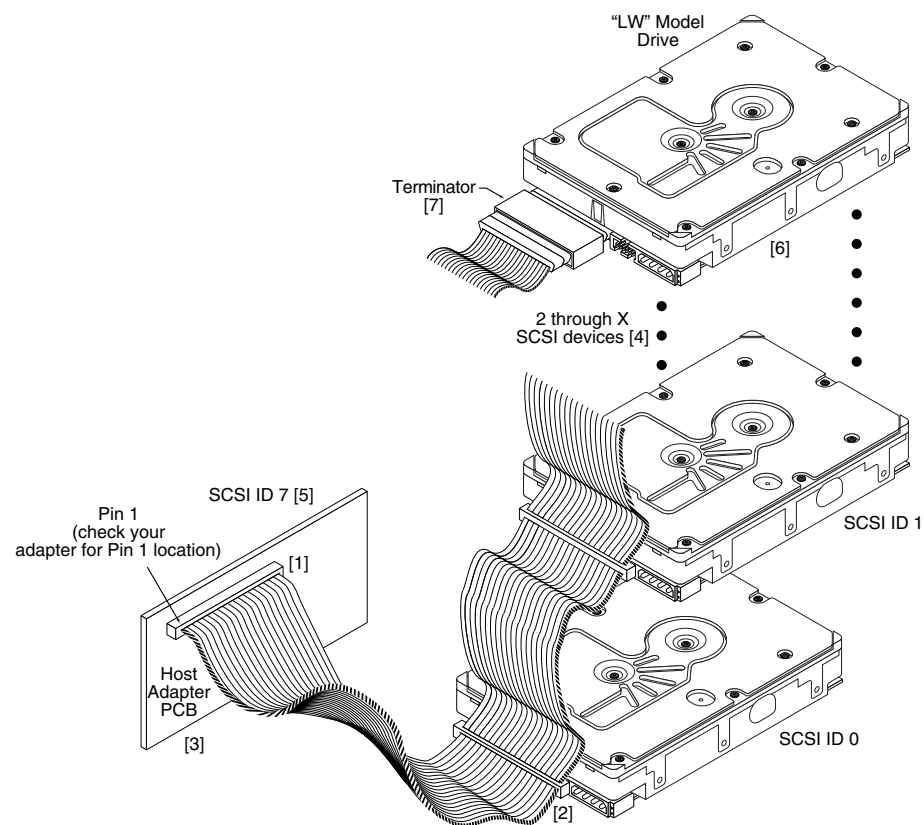
Recommended mating 80-position PCBA mount connectors:

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.



- [1] Closed end type 68-pin connector used. Terminators enabled.
- [2] Open end type (in-line application) connector used.
- [3] Host need not be on the end of the daisy-chain. Another device can be on the end with the terminator, the host having no terminator.
- [4] Total interface cable length must not exceed that specified in ANSI document T10/1365D (including host adapter/initiator). The cable length restriction limits the total number of devices allowed.
- [5] SCSI ID7 has highest arbitration priority, then ID15 to ID8 (ID 8 has the very lowest priority).
- [6] Last drive on the daisy chain.
- [7] Open-end type 68-pin connector used. If end device, use external terminator and closed-end type 68-pin connector.

Figure 15. SCSI daisy-chain interface cabling for LW drives

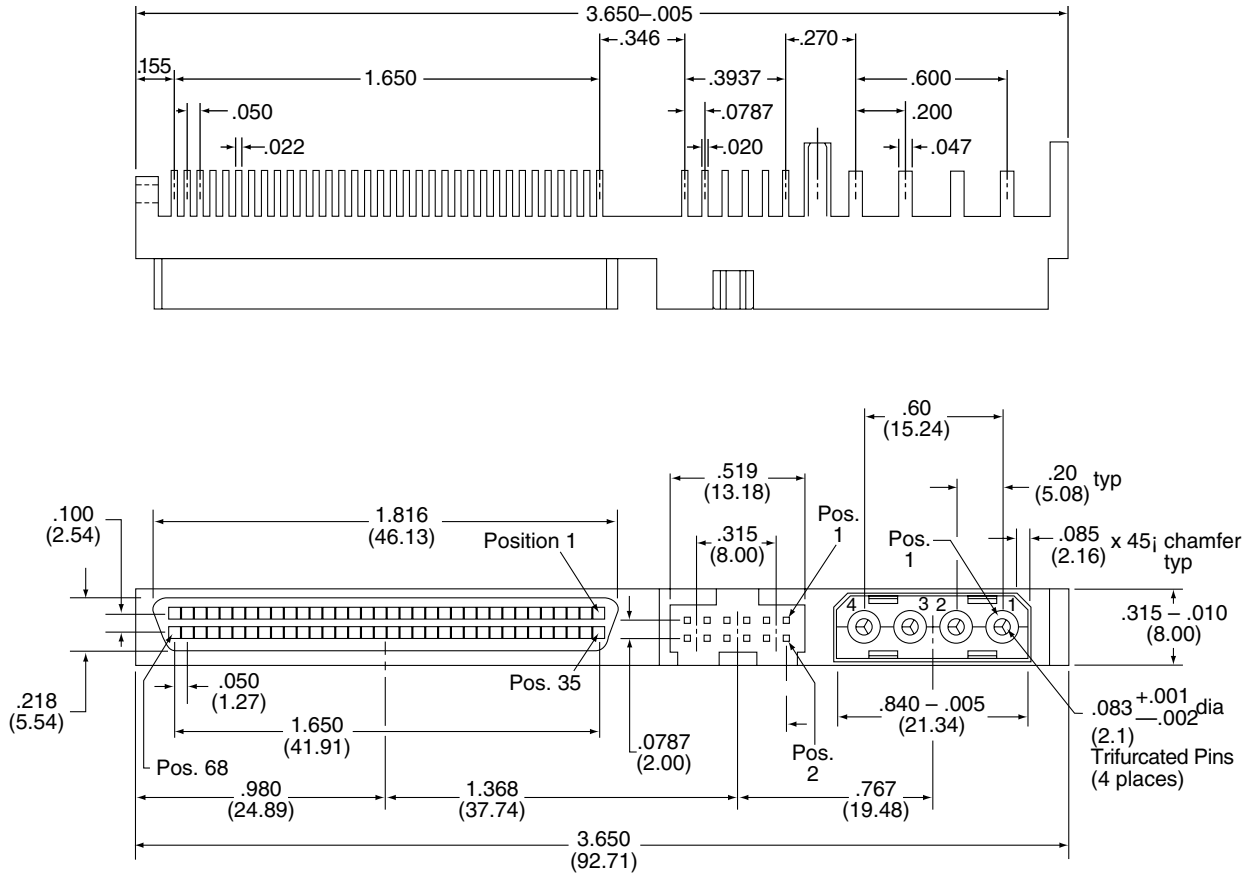


Figure 16. Nonshielded 68-pin SCSI device connector used on LW drives

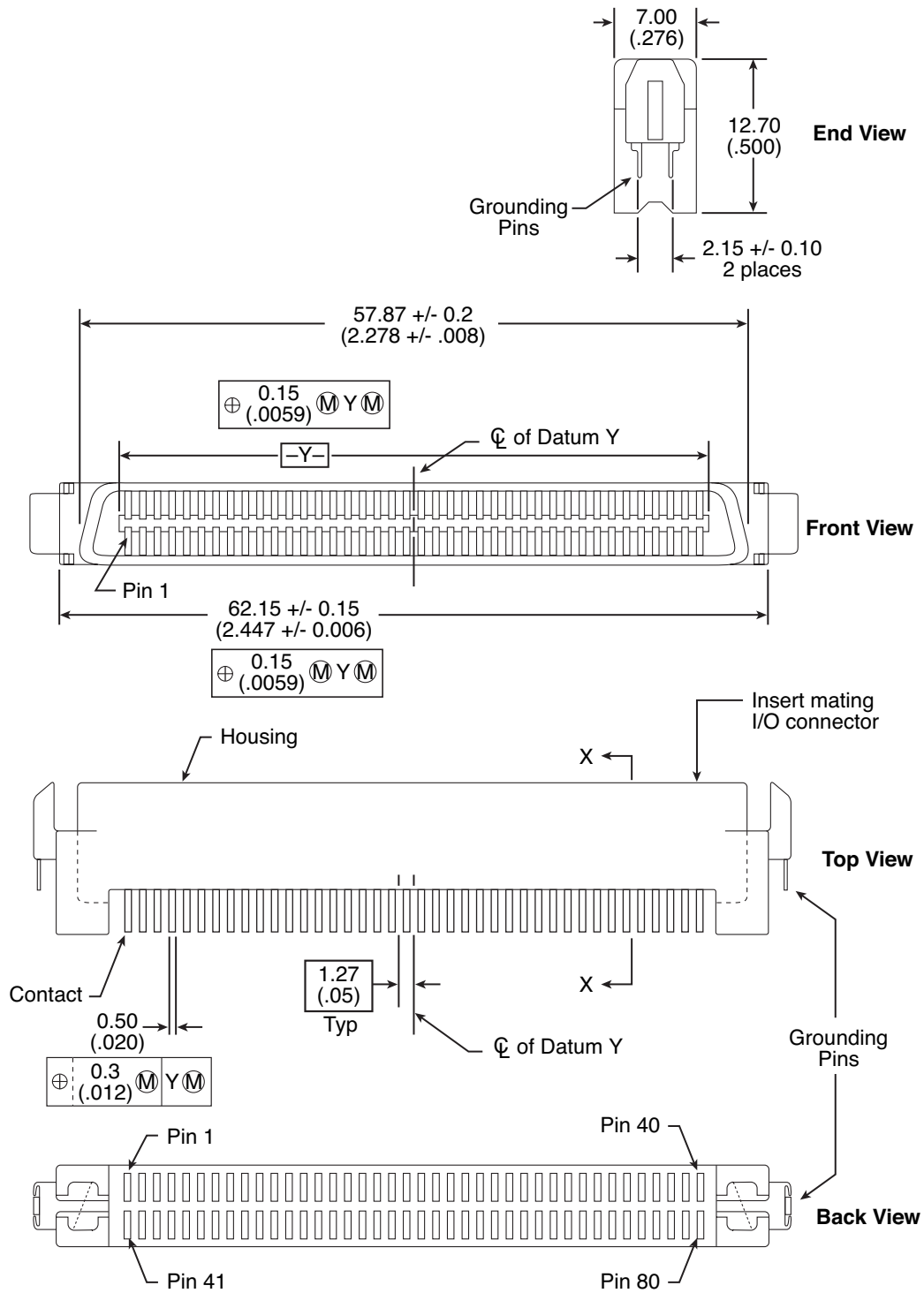


Figure 17. Nonshielded 80-pin SCSI SCA-2 connector used on LC drives

Table 17: LW 68-conductor single-ended (SE) P cable signal/pin assignments [11]**Note.** A minus sign preceding a signal name indicates that signal is active low.

Signal name [1]	Connector contact number [3]	Cable conductor number [2]		Connector contact number [3]	Signal name [1]
GND	1	1	2	35	-DB12
GND	2	3	4	36	-DB13
GND	3	5	6	37	-DB14
GND	4	7	8	38	-DB15
GND	5	9	10	39	-DBP1
GND	6	11	12	40	-DB0
GND	7	13	14	41	-DB1
GND	8	15	16	42	-DB2
GND	9	17	18	43	-DB3
GND	10	19	20	44	-DB4
GND	11	21	22	45	-DB5
GND	12	23	24	46	-DB6
GND	13	25	26	47	-DB7
GND	14	27	28	48	-DBP
GND	15	29	30	49	GND
GND	16	31	32	50	GND
TermPwr	17	33	34	51	TermPwr
TermPwr	18	35	36	52	TermPwr
Reserved	19	37	38	53	Reserved
GND	20	39	40	54	GND
GND	21	41	42	55	-ATN
GND	22	43	44	56	GND
GND	23	45	46	57	-BSY
GND	24	47	48	58	-ACK
GND	25	49	50	59	-RST
GND	26	51	52	60	-MSG
GND	27	53	54	61	-SEL
GND	28	55	56	62	-C/D
GND	29	57	58	63	-REQ
GND	30	59	60	64	-I/O
GND	31	61	62	65	-DB8
GND	32	63	64	66	-DB9
GND	33	65	66	67	-DB10
GND	34	67	68	68	-DB11

Notes []: See page following Table 20.

Table 18: LW 68-conductor LVD P cable signal/pin assignments [11]

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

Signal name [1]	Connector contact number [3]	Cable conductor number [2]		Connector contact number [3]	Signal name [1]
+DB12	1	1	2	35	-DB12
+DB13	2	3	4	36	-DB13
+DB14	3	5	6	37	-DB14
+DB15	4	7	8	38	-DB15
+DBP1	5	9	10	39	-DBP1
+DB0	6	11	12	40	-DB0
+DB1	7	13	14	41	-DB1
+DB2	8	15	16	42	-DB2
+DB3	9	17	18	43	-DB3
+DB4	10	19	20	44	-DB4
+DB5	11	21	22	45	-DB5
+DB6	12	23	24	46	-DB6
+DB7	13	25	26	47	-DB7
+DBP	14	27	28	48	-DBP
Ground	15	29	30	49	Ground
DIFFSNS [8]	16	31	32	50	Ground
TermPwr	17	33	34	51	TermPwr
TermPwr	18	35	36	52	TermPwr
Reserved	19	37	38	53	Reserved
Ground	20	39	40	54	Ground
+ATN	21	41	42	55	-ATN
Ground	22	43	44	56	Ground
+BSY	23	45	46	57	-BSY
+ACK	24	47	48	58	-ACK
+RST	25	49	50	59	-RST
+MSG	26	51	52	60	-MSG
+SEL	27	53	54	61	-SEL
+C/D	28	55	56	62	-C/D
+REQ	29	57	58	63	-REQ
+I/O	30	59	60	64	-I/O
+DB8	31	61	62	65	-DB8
+DB9	32	63	64	66	-DB9
+DB10	33	65	66	67	-DB10
+DB11	34	67	68	68	-DB11

Notes []: See page following Table 20.

Table 19: LC 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 20.

Table 20: LC 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 17 through 20.

- [1] See Section 10.6.4.1 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.

10.7 Electrical description

Cheetah 15K.5 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 T10/1320D for detailed electrical specifications.

10.7.1 Multimode—SE and LVD alternatives

When the interface "DIFFSENS" 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 "DIFFSENS" 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 or less (Fast-160 or Ultra320 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 and LW 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 = $0.32\text{ V} = < |V_s| = < 0.8\text{ V}$ (signal negation/logic 0)

Steady state High level output differential voltage = $0.32\text{ V} = < |V_s| = < 0.8\text{ V}$ (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 = $0.030\text{ V} = < V_{in} = < 3.6\text{ V}$ (signal negation/logic 0)

Steady state High level input differential voltage = $-3.6\text{ V} = < V_{in} = < -0.030\text{ V}$ (signal assertion/logic 1)

Differential voltage = $\pm 0.030\text{ V}$ minimum with common-mode voltage range $0.845\text{ V} = < V_{cm} = < 1.685\text{ V}$. (T10/1302D revision 20b, section A.3.1).

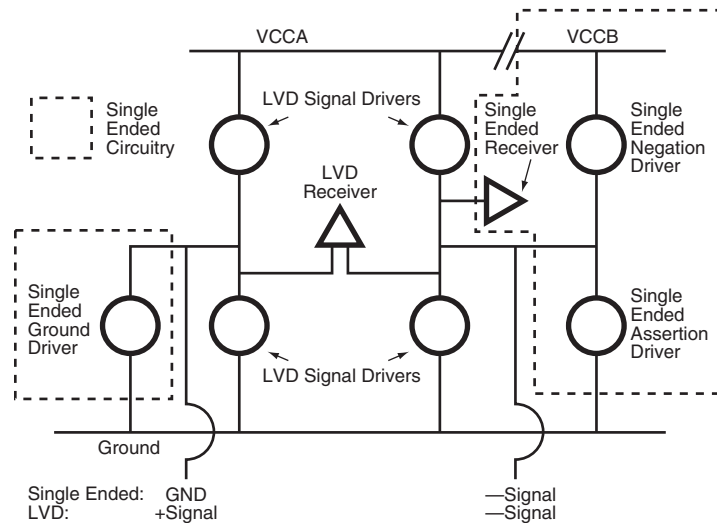


Figure 18. Typical SE-LVD alternative transmitter receiver circuits

10.7.1.1 General cable characteristics

To Minimize discontinuities and signal reflections, cables of different impedances should not be used in the same bus. Implementations may require trade-offs in shielding effectiveness, cable length, the number of loads, transfer rates, and cost to achieve satisfactory system operation. If shielded and unshielded cables are mixed within the same SCSI bus, the effect of impedance mismatch must be carefully considered. Proper impedance matching is especially important in order to maintain adequate margin at fast SCSI transfer rates.

10.7.1.2 Single-ended drivers/receivers

The maximum total cable length allowed with drives using single-ended I/O driver and receiver circuits depends on several factors. Table 21 lists the maximum lengths allowed for different configurations of drive usage. These values are from the SPI documents. All device I/O lines must have equal to or less than 25 pf capacitance to ground, measured at the beginning of the stub.

Table 21: Cable characteristics for single-ended circuits

I/O transfer rate	Maximum number of devices on the bus	Maximum length between SCSI S.E. terminators	Transmission line impedance	
			REQ/ACK	Other signals
$\leq 10\text{M}$ transfers/s (Fast 10)	16 (wide SCSI bus)	3 meters (9.8 ft)	$90 \pm 6\text{ Ohms}$	$90 \pm 10\text{ Ohms}$
$\leq 20\text{M}$ transfers/s (Fast 20)	4 (wide SCSI bus)	3 meters (9.8 ft)	$90 \pm 6\text{ Ohms}$	$90 \pm 10\text{ Ohms}$
$\leq 20\text{M}$ transfers/s (Fast 20)	8 (wide SCSI bus)	1.5 meters (4.9 ft)	$90 \pm 6\text{ Ohms}$	$90 \pm 10\text{ Ohms}$

A stub length of no more than 0.1 meter (0.33 ft) is allowed off the mainline interconnection with any connected equipment. The stub length is measured from the transceiver to the connection to the mainline SCSI bus.

Single-ended I/O cable pin assignments for LW drives are shown in Table 18.

Single-ended I/O pin assignments for LC models are shown in Table 19. The LC model does not require an I/O cable. It is designed to connect directly to a back panel connector.

10.7.1.3 Cables for low voltage differential drivers/receivers

The SPI-3 and SPI-4 specification for differential impedance for LVD cables is 122.5 ± 12.5 ohms.

The maximum SCSI bus length between the terminators for a SCSI LVD point-to-point system (one initiator and one target) is 25 meters (82 feet).

The maximum SCSI bus length between the terminators for a SCSI LVD multidrop system (up to 16 total SCSI devices) is 12 meters (39.37 feet). However, implementation of this 12-meter total length is dependent on the configuration of the system and the choice of cable. See Tables 22 and 23 for examples of recommended SCSI LVD cable types and lengths.

It should be noted from the data in Tables 22 and 23 that shielded round twisted-pair cables can be used to implement a 12-meter system, while Twist-n-flat cables cannot be used to implement a 12-meter system due to higher levels of attenuation and crosstalk. In addition, twist-n-flat cables with shorter sections of twist allow greater crosstalk and their lengths must be reduced as shown in Table 23.

Table 22: Shielded round twisted-pair cables—into a multi-drive backplane

Cable description	Differential impedance, nominal	Single-ended impedance, nominal	Single-ended capacitance, maximum	Time delay, nominal	Conductor DC resistance, nominal	Maximum shielded round twisted-pair cable length for U160/U320
30 AWG solid	130 ohms	90 ohms	17 pF/ft	1.36 ns/ft	0.113 ohms/ft	12 meters minus the SCSI trace length of the backplane
28 AWG stranded	123 ohms	80 ohms	19 pF/ft	1.54 ns/ft	0.067 ohms/ft	12 meters minus the SCSI trace length of the backplane
28 AWG stranded	132 ohms	85 ohms	20 pF/ft	1.50 ns/ft	0.065 ohms/ft	12 meters minus the SCSI trace length of the backplane

Table 23: Twist-n-flat cables—into a multi-drive backplane

Cable description	Differential impedance, nominal	Single-ended impedance, nominal	Single-ended capacitance, maximum	Time delay, nominal	Conductor DC resistance, nominal	Maximum Twist-n-flat cable length	
						U320	U160
TPE, 22.25" twist, 1.75" flat, (24" flat to flat), 30 AWG solid tinned copper	131 ohms	93 ohms	15.3 pF/ft	1.45 ns/ft	0.105 ohms/ft	3.05 meters (10.0 ft)	6.1 meters (20.0 ft)
TPE, 8.1" twist, 1.75" flat, (9.85" flat to flat), 30 AWG solid tinned copper	131 ohms	93 ohms	15.3 pF/ft	1.45 ns/ft	0.105 ohms/ft	2.45 meters (8.33 ft)	4.9 meters (16.66 ft)
TPE, 4.25" twist, 1.75" flat, (6" flat to flat), 30 AWG solid tinned copper	131 ohms	93 ohms	15.3 pF/ft	1.45 ns/ft	0.105 ohms/ft	1.52 meters (5.0 ft)	3.04 meters (10.0 ft)

10.8 Terminator requirements

Caution: 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. For LW drives, terminator modules can be purchased that plug between the SCSI I/O cable and the drive I/O connector or on the end of a short I/O cable stub extending past the last cable connector. LC drives are designed to be plugged into a backpanel connector without cabling.

10.9 Terminator power

LW drives

You can configure terminator power from the drive to the SCSI bus or have the host adaptor or other device supply terminator power to the external terminator. See Section 9.1 for illustrations that show how to place jumpers for this configuration.

LC drives

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

10.10 Disc drive SCSI timing

Table 24: Disc drive SCSI timing

These values are not current Cheetah 15K.5 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 μ s
Target Select Time (with Arbitration)	T01	4.5-1,2	1.93 μ s
Target Select to Command	T02	4.5-1	3.77 μ s
Target Select to MSG Out	T03	4.5-2	1.57 μ s
Identify MSG to Command	T04	4.5-3	3.36 μ s
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 μ s
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 μ s
Arbitration to Reselect	T13	4.5-7	1.60 μ s
Reselect to Identify MSG In	T14	4.5-7	1.39 μ s
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 μ s
Command Complete MSG to Bus Free	T19	4.5-5,8,15	0.51 μ s
Data to Save Data Pointer MSG	T20	4.5-14	4.00 μ s
Save Data Pointer MSG to Disconnect MSG	T21	4.5-14	0.79 μ s
Command Byte Transfer	T22	4.5-4	0.04 μ s
Next Command Byte Access:		4.5-4	
Next CDB Byte Access (Byte 2 of 6)	T23.6.2	4.5-4	0.58 μ s
Next CDB Byte Access (Byte 3 of 6)	T23.6.3	4.5-4	0.12 μ s
Next CDB Byte Access (Byte 4 of 6)	T23.6.4	4.5-4	0.12 μ s
Next CDB Byte Access (Byte 5 of 6)	T23.6.5	4.5-4	0.12 μ s
Next CDB Byte Access (Byte 6 of 6)	T23.6.6	4.5-4	0.12 μ s

Table 24: Disc drive SCSI timing (Continued)

These values are not current Cheetah 15K.5 SCSI values, but are listed for information only.

Description	Waveform symbol [1]	Waveform table [1]	Typical timing
Next CDB Byte Access (Byte 2 of 10)	T23.10.2	4.5-4	0.59 μ s
Next CDB Byte Access (Byte 3 of 10)	T23.10.3	4.5-4	0.11 μ s \pm 1 μ s
Next CDB Byte Access (Byte 4 of 10)	T23.10.4	4.5-4	0.12 μ s \pm 1 μ s
Next CDB Byte Access (Byte 5 of 10)	T23.10.5	4.5-4	0.11 μ s \pm 1 μ s
Next CDB Byte Access (Byte 6 of 10)	T23.10.6	4.5-4	0.11 μ s \pm 1 μ s
Next CDB Byte Access (Byte 7 of 10)	T23.10.7	4.5-4	0.13 μ s \pm 1 μ s
Next CDB Byte Access (Byte 8 of 10)	T23.10.8	4.5-4	0.12 μ s \pm 1 μ s
Next CDB Byte Access (Byte 9 of 10)	T23.10.9	4.5-4	0.12 μ s \pm 1 μ s
Next CDB Byte Access (Byte 10 of 10)	T23.10.10	4.5-4	0.12 μ s \pm 1 μ s
Data In Byte Transfer (parameter)	T24	4.5-12	0.04 μ s
Data Out Byte Transfer (parameter)	T25	4.5-13	0.04 μ s
Next Data In Byte Access (parameter)	T26	4.5-12	0.12 μ s
Next Data Out Byte Access (parameter)	T27	4.5-13	0.12 μ s
Data In Byte Transfer (media) [2]	T28	4.5-12	0.04 μ s
Data Out Byte Transfer (media) [2]	T29	4.5-13	0.04 μ s
Next Data In Byte access (media [2])	T30	4.5-12	0.12 μ s
Next Data Out Byte access (media [2])	T31	4.5-13	0.12 μ s
MSG IN Byte Transfer	T32	4.5-5,7,8,14,15	0.04 μ s
MSG OUT Byte Transfer	T33	4.5-2	0.04 μ s
STATUS Byte Transfer	T34	4.5-5,8,15	0.04 μ s
Synchronous Data Transfer Characteristics:			
Request Signal Transfer Period [3]	–	–	various (800 ns max)

Notes.

- [1] See the Timing examples section of the *Parallel SCSI Interface Manual*.
- [2] Maximum SCSI asynchronous interface transfer rate is given in Section 5.2.3 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 10.5. See also the Synchronous data transfer section and the Extended messages section of the *Parallel SCSI Interface Manual* for a description of synchronous data transfer operation.

10.11 Drive activity LED

The following table provides drive activity LED status.

Table 25: Drive activity LED status

Spindle status	Command status	LED status
Spinning up with DC power applied	N/A	On until spinup is complete
Spun down	Start Unit	On while processing the command
Powered down by removal of DC power	N/A	Off due to absence of power
Spun up	Stop Unit	On while processing the command
Spun down	No command activity	Off
Spun down	Write/Read Buffer	On while processing the command
Spun down	SCSI Bus Reset	On while processing the reset
Spun down	Test Unit Ready	On while processing the command
Spun up	No command activity	Off
Spun up	Write/Read	On while processing the command
Spun up	SCSI Bus Reset	On while processing the reset
Spun up	Test Unit Ready	On while processing the command
Spun up	Format with Immediate option on	On while the command is initially processed
Spun up	Format without Immediate	LED toggles on/off on each cylinder boundary
Spun up	Write Same Command in progress	Toggles on/off

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