STEC

Zeus Fibre Channel
3.5-Inch Solid State Drive
Product Datasheet

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DATASHEET CONVENTIONS

The following icons are used throughout this document to identify additional information of which the reader should be aware.

SHOCK HAZARD: This icon indicates the danger of harmful or fatal shock to the user.

ELECTROSTATIC DISCHARGE: This icon indicates the possible presence of Electrostatic Discharge (ESD or "static electricity) that may harm the internal electronic components. The user is advised to handle the device only after discharging any possible electrostatic buildup that may be present.

CAUTION: This icon indicates the existence of a hazard that could result in equipment or property damage or equipment failure if the safety instruction is not observed.

NOTE: This icon identifies information that relates to the safe operation of the equipment or related items.

TIP: This icon identifies helpful hints and tips.

REVISION HISTORY

Revision Status Summary Sheet

Revision	Date	Sheet(s) Affected
1.0	01/02/2007	All. Datasheet re-written and re-organized.
1.1	06/28/2007	Page 6 - Removed "Firmware Upgrades" topic and bullet point. Page 70 - Removed "Firmware Upgrades" topic.
1.2	07/09/2007	All - Removed all references to "2,000,000 write/erase cycles". Minor spelling and grammatical corrections.

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Figure 1. *The Zeus 3.5-Inch Fibre Channel Solid State Drive*

OVERVIEW

This product datasheet describes the applications, specifications, and installation of the 3.5-inch Zeus Fibre Channel Solid State Drive (SSD). The contents of this datasheet can be quickly ascertained by reviewing the abstracts in this section.

AUDIENCE

This document is intended for system engineers or system designers employed by an Original Equipment Manufacturer (OEM). It was therefore written specifically for a technically advanced audience; it is not intended for end-users that will eventually purchase the commercially available product. The *user*, as referenced throughout the document, is primarily concerned with industrial, commercial or military applications.

Standards and Reference Documents

This section discusses the formal standards that may apply to the Zeus 3.5-inch Fibre Channel SSD, including electrical product standards and military information systems security standards. In addition, this section lists reference documents relevant to the FC-AL and FCP-SCSI protocols used for the Zeus 3.5-inch Fibre Channel SSD.

Standard Features and Optional Features

These two sections list the standard and optional features of the Zeus 3.5-inch Fibre Channel SSD.

Product Description

This section provides a general description of the Zeus 3.5-inch Fibre Channel SSD, and includes media, performance, reliability and capacity information.

Performance Characteristics

This section describes the internal and seek characteristics of the Zeus SSD and includes information on the access execution times.

Electrical Specifications

This section describes the power requirements and power consumption parameters of the Zeus 3.5-inch SSD and includes explanations of power saving commands supported by the drive.

Interface Specifications

This section provides a table of the connector pinout and tables of the electrical characteristics for the pin signals. In addition, this section describes how the drive uses the pin signals when interacting with the host system.

FC-AL Features

This section discusses issues related to the FC-AL ports and loop addressing of the Zeus 3.5-inch Fibre Channel SSD. The section also provides an overview of the SCSI commands implemented on the Zeus 3.5-Inch Fibre Channel SSD.

Fibre Channel Standard

This section discusses the implementation of the Fibre Channel Arbitrated Loop specific to the Zeus 3.5-inch Fibre Channel SSD.

Physical Characteristics

This section describes the overall physical dimensions of the SSD, the materials used in its construction, and the average weight of the assembly.

Environmental Characteristics

The general operating and non-operating conditions for the Zeus SSD are detailed in this section. This section includes operating temperatures, relative humidity, altitude, and shock, drop and vibration testing results.

Installation

This section discusses issues relating to the installation of the Zeus 3.5-inch Fibre Channel SSD in a PC or other enclosure, including cooling and grounding.

Regulatory Compliance

This section provides an overview of the marking, approval, documentation and reporting conventions for the Zeus 3.5-inch Fibre Channel SSD.

Contact and Ordering Information

Please consult this section if you need to contact the Solid State Drive Team. The Ordering Information table allows you to decode the part number found on your model of Zeus drive.

Standards and Reference Documents

This section discusses various standards for electronic products and military use, and how those standards apply to the Zeus 3.5-inch Fibre Channel SSD.

Electromagnetic Susceptibility

The Zeus 3.5-inch Fibre Channel SSD is intended for installation by the user in an appropriate enclosure, i.e., a PC or alternate enclosure. The enclosure must be designed so that the use of the Zeus drive does not impair nearby electronic equipment within the same enclosure and external to the enclosure. Typically, the user is a system integrator or a designer employed by an Original Equipment Manufacturer (OEM).

The user is responsible for choosing, designing and testing the enclosure so that it is appropriate as previously defined, and complies to related regulations, such as Subpart B of Part 15 of FCC Rules and Regulations, and the Radio Interference Regulations of the Canadian Department of Communications.

Electromagnetic Compatibility

Independent laboratories have confirmed that the Zeus 3.5-inch Fibre Channel SSD meets the requirements for CE Marking. While the drive may have CE Marking, the OEM user must confirm CE Marking for the product in which the drive has been integrated. Test systems confirming the CE Marking may include the following:

- A current microprocessor
- 3.5-inch floppy drive
- Keyboard
- Monitor
- Printer
- External modem
- Mouse

Military Information Systems Security Standards

The optional Milpurge™ feature of the Zeus 3.5-inch Fibre Channel SSD adheres to the following military purge standards:

- DoD 5220.22-M
- NSA 130-2
- AFSSI 5220
- AR380-19
- Navso 5239

Reference Documents

The following list of ANSI Fibre Channel documents relate to the Zeus 3.5-inch Fibre Channel SSD:

- X3.230-1994 FC Physical and Signaling Interface (FC-PH)
- X3.297.1997 FC-PH-2 Fibre Channel Physical and Signaling Interface-2
- X3.303.1998 FC-PH-3 Fibre Channel Physical and Signaling Interface-3
- X3.272-1996 FC Arbitrated Loop (FC-AL)
- X3.269-1996 Fibre Channel Protocol for SCSI (FCP)
- NCITS TR-19 Private Loop SCSI Direct Attach (PLDA)
- NCITS TR-20 Fabric Loop Attachment (FC-FLA)
- SFF-8045 Specification for 40-pin SCA-2 Connector with Parallel Selection
- SFF-8067 Specification for 40-pin SCA-2 Connector with Bidirectional Enclosure Services Interface

The following list of ANSI SCSI documents relate to the Zeus 3.5-inch Fibre Channel SSD:

- X3.131-1994 SCSI-2
- X3.270-1996(SCSI-3) Architecture Model
- NCITS 305-199X (SCSI-3) Enclosure Services

Standard Features

Interface Standard

- 40-pin SCA-2 connector (Level 4 Hot Swap) for copper cable
- Dual FC-AL ports for connection to a Fibre Channel Arbitrated Loop
- 126 AL-PAs supported
- Unique worldwide name for connection to a fabric
- Service Class TBD
- FCP-SCSI protocol
- Hot plug support

Performance

- Latency of 0.3 msec
- Sustained Read of 56 Mbytes/sec
- Sustained Write of 72 Mbytes/sec
- Duplex Burst Read/Write of 400 Mbytes/sec
- Cache of 64MBytes
- Command queuing of up to 128 commands
- Background processing of queue
- Supports reserve and release commands

Physical Characteristics

- 3.5-inch standard form factor
- 5.787 x 4.004 x 0.374 inch (147.0 x101.7 x 9.5 mm)
- Light-weight aluminum alloy case, less than 0.7 lb (0.3 kg)

Media Characteristics

- Single Level Cell (SLC) flash memory
- Patented wear-leveling algorithm
- EDC/CRC algorithms

Unformatted Capacities

- 10, 40, and 80 Gigabytes

Reliability

- Non-Recoverable Read Errors per Bits Read of 1 sector per 10^{20}

- Data Retention of 10 years

- Bad Block mapping

- Patented wear-leveling algorithm

- Diagnostic Self Test (DST) command implemented

- Power On Self Test (POST) implemented

- EDC/ECC algorithms

- Solid-state design (no electromechanical failures)

- Rugged aluminum alloy case

- 5 year warranty

Environmental Characteristics

- Two operating temperature ranges available:

    - Commercial range of 0°C to 70°C

    - Industrial range of -40°C to 85°C

- Storage Temperature of -55°C to 95°C

- Humidity of 5% to 95% relative, non-condensing

- Operating Altitude of 80,000 feet

- Operating Shock of 1,500G, MIL-STD-810F
  (0.3 to 0.75ms duration, half sine, 3 cycles per axis)

- Operating Vibration of 16.3G RMS, MIL-STD-810F
  (random, 20Hz to 2000Hz; 1 hour duration, 3 axes)

- 0dB Noise Amplitude

Power

- Input Voltage: 5 V DC ± 5%

- Typical consumption:

    - Idle/Standby of 6.0W

    - Sustained Read/Write of 9.0W

Optional Features

Optional Purge Features

- BasicPurge™: Erases solid state drive

- RapidPurge™: Erases solid state drive in seconds

- MilPurge™: Erases solid state drive in compliance with security guidance (DoD 5220.22-M, NSA 130-2, AFSSI 5220, AR380-19, Navso 5239

- Intelligent Destructive Purge™: physically damages the flash media to make it totally unusable as media

- Hardware Purge

Optional Environmental Features

- Conformal coating

Manufacturing

- Santa Ana, California
  United States of America

- ISO 9001 Certified

PRODUCT DESCRIPTION

General Description

The Zeus 3.5-inch Fibre Channel Solid State Drive (SSD) is a non-volatile mass storage device. The SSD is designed as a replacement for a standard SCSI-compliant hard disk drive (HDD). The SSD conforms to the same mechanical and mounting requirements as a standard rotating disk drive.No additional device drivers are required, and the drive can be configured as a boot or data storage device.

Fibre Channel Interface

The Zeus Fibre Channel SSD can be installed in any operating system environment that supports FCP-4 devices and is fully SCSI compliant. The Fibre Channel Protocol (FCP) is a method for transmitting SCSI commands and data over FC-FS-2 Exchanges and Information Units. It is a high-speed serial architecture that allows for connections over optical or electrical cable. It also supports point-to-point, fabric-switched and arbitrated-loop network topologies.

Drive Capacities

Zeus 3.5-inch SSDs are available with unformatted memory capacities of 10, 40, and 80 gigabytes. The memory subsystem is comprised of Single-Level Cell (SLC) NAND flash components. In addition, the drives are configured with a cache buffer of 64 megabytes.

Performance

Zeus Fibre Channel SSDs can operate at sustained data transfer rates of up to 56 megabytes per second for Read operations, and 72 megabytes per second for Write operations. Power consumption is kept to a minimum; Zeus SSDs can be powered from a single 5-volt source. The solid state design eliminates electromechanical noise and delay inherent in traditional magnetic rotating media. The wear-leveling and bad-block mapping algorithms ensure consistency, accuracy, and integrity of user data. Superior data reliability is achieved through embedded Error Detection Code and Cyclic Redundancy Checking (EDC/CRC). The non-recoverable error rate of Zeus Fibre Channel SSDs is less than 1 error per 10^{20} bits read.

Data Security

Zeus SSDs offer data sanitization (purge) features that can be customized by the user. Supporting both sanitized erase/fill and non-recoverable sanitization options, Zeus SSDs can be configured to remove data from the drive, freeing storage space for later reuse, or to remove data and destroy the storage media, making the SSD unusable and data retrieval impossible. The data security features comply with Department of Defense (DoD) and U.S. military data security standards, including AFSSI 5020, AR 380-19, NAVSO P-5239-26, NISPOM DoD 5220.22-M and NSA 130-2.

PERFORMANCE CHARACTERISTICS

Endurance

The useful life of the flash media is limited by the number of write/erase operations that can be performed on the media. To extend the useful life of Zeus SSDs, special wear-leveling and bad-block mapping algorithms are integrated into the firmware.

Wear-Leveling

The dynamic wear-leveling algorithm guarantees that erase/write cycles are evenly distributed across all of the flash memory block locations. Wear-leveling eliminates repeated writes to the same physical flash memory location, thereby preventing blocks from premature wear.

Bad-Block Mapping

The bad-block mapping algorithm replaces bad blocks with new ones from available spares. Two percent (2%) of the flash memory is held in reserve (spare block) for bad block substitution. Bad blocks in the media are flagged when detected. The next time an attempt is made to access a flagged block, it is immediately replaced by a spare block. The bad block mapping function enables data to be automatically transferred from a bad sector to an available spare block.

Data Retention

Data stored on Zeus SSDs remains valid for ten (10) years without requiring power support. The unit can be stored under certain environmental conditions for extended periods without any occurrence of data degradation.

Error Detection and Correction

The Error Detection Code and Error Correcting Code (EDC/ECC) algorithm helps maintain data integrity by allowing single or multiple bit corrections to the data stored in the flash array. If the data in the flash array is corrupted due to aging or during the programming process, EDC/ECC will compensate for the errors to ensure the delivery of accurate data to the host computer. The EDC/ECC engine on the drive is capable of correcting up to 4 bits in error and detecting up to 5 bits in error per block (512 bytes). An extensive retry algorithm is also implemented on the drive, so that single event disturbances such as ESD or EMF occurring during a read operation can be readily overcome.

Reliability

- DC power is maintained as specified in the product datasheet.

- Errors caused by host are excluded from rates.

- Errors from the same causes are counted as 1 block.

- Data stream is assumed random.

Error Rates

Table 1 lists the error limit specifications. When all data correction mechanisms are enabled, the error rate will be sustained through all operating temperature ranges as specified in the upcoming sections.

Table 1.   Error Limit Specifications

Error Type	Maximum Number of Errors
Recoverable Data Error	1 bit in 10^{20}
Unrecoverable Data Error	Less than 1 bit in 10^{20}

Diagnostic Self Test (DST)

The Zeus 3.5-inch Fibre Channel SSD implements the Diagnostic Self Test (DST) command. The DST is invoked with the Send Diagnostics page (1Dh). When issued, Byte 1, bits 5, 6, and 7 (the Function Control byte) select between the short test (001b) and the extended test (010b).

The short test performs functional checks, while the extended test also performs a thorough media integrity test. The results are reported on the Self Test Results Log page (10h). If the results are zero, the drive passed the DST. A nonzero value indicates the type of failure found. The anticipated duration of the DST command can be read on the Control Mode page (0Ah).

When a DST command is in progress, it can be aborted through the following:

- Performing a diagnostic SCSI bus reset

- Performing a bus device reset

- Invoking a DST with the abort code in the function code field

Mount Time

The amount of time required to initialize and mount a Zeus SSD varies according to the operating system (Windows®, Linux®, etc.) in which the SSD is running and the storage capacity of the drive.

Access Time

Unlike a magnetic rotating disk, the Zeus SSD has no moving read/write head or platter. The average access time is approximately 0.3 milliseconds. The actual access time may be affected by the operating system and the storage capacity of the drive.

Data Transfer Rates

The data transfer rate of the Zeus SSD depends on the flash controller/flash memory configuration of the drive. The scalable architecture of the drive is capable of accommodating sustained and burst data transfer rates as outlined in *Table 2.*

Notes:

1   Access times are measured under nominal temperature and voltages from a representative sample of the drive.

2   Access times are measured from receipt of last byte of the Command Descriptor Block (CDB) to the request for a Status Byte Transfer to the Initiator, excluding Connect/Disconnect.

3   Data transfer rates to and from the media assumes system ability to support rates and no cable loss.

Table 2.   Data Transfer Rates

Parameter	Value	Units
Average Access	0.3	m/sec
Average Latency	0.3	m/sec
Sustained Read	56	Megabytes/sec
Sustained Write	72	Megabytes/sec
Duplex Burst Read	400	Megabytes/sec
Duplex Burst Write	400	Megabytes/sec
Minimum Sector Interleave	1:1	

Purge Times

The time required to purge a Zeus SSD depends on the actual purge option invoked by the user and the flash controller/flash memory configuration of the drive.

Table 3.   Purge Times

Purge Option	Value	Units
BasicPurge	360	sec for 40GB
RapidPurge	Fixed	sec for 40GB
MilPurge	Varies	sec for 40GB
Intelligent Destructive Purge	2	sec for 40GB

Cache Operations

The Zeus 3.5-inch Fibre Channel SSD is configured with 64 MB of usable cache. The drive will track the location of the data and the type of data stored in the cache, and will use the cache data instead of re-transferring the data from the host or the media, if the cache contains the data needed for the read or write.

The cache operation is circular and when the end of the segment is addressed, it will wrap around to the beginning location of the segment. The Write Buffer command (3Bh) can be used force the data in the cache to be written to the media.

The host can use the Force Unit Access bit (Extended Read command, 28h, Byte 1, bit 3) to force the read data to be transferred from the cache (FUA=0), or from the media (FUA=1).

The host can use the Disable Page Out bit (Extended Read command, 28h, Byte 1, bit 4) to flag the logical blocks accessed as likely to be accessed again and cached (DPO=0), or to set the caching priority of the logical blocks to lowest (DPO=1).

By using the Read Cache Disable bit (Mode Select command, 15h or 55h, Caching Parameters Page, 08h), the read cache can allow reads from cache or media (RCD=0), or media only (RCD=1).

Hot Plugging

The Zeus 3.5-inch Fibre Channel SSD can be inserted or removed from a loop during operation. This capability is known as "hot plugging". Fibre Channel error recovery procedures will recover from any errors introduced by hot plugging. Whenever a drive is hot plugged, sync is detected lost due to the removal or insertion of the drive into the loop.

The loop will recover as follows:

1   If a bypass circuit is used, the loop will re-synchronize and is operational while the user waits for the drive to power up and become ready. If a bypass circuit is not used, the loop loses synchronization and is not operational during this time.

2   When the drive becomes ready, and the bypass circuit (if used) is disabled, the drive will re synchronize with the next drive in the loop, and test the loop.

3   After the loop initializes, the loop is in monitoring state and arbitration of ownership can occur.

Repairs

A defective SSD should be replaced. There are no parts, assemblies or subassemblies that can be repaired individually by the user. Please see the section titled *Certification and Warranty* on the inside of the back cover page. Unauthorized repairs to the SSD will void the warranty.

Preventative Maintenance

No preventative maintenance is required. The SSD unit is sealed at the factory, and there are no parts, assemblies or subassemblies that require preventative maintenance on behalf of the user. Please see the section titled *Certification and Warranty* on the inside of the back cover page. Unauthorized maintenance to the SSD will void the warranty.

ELECTRICAL SPECIFICATIONS

Power Supply

The Zeus 3.5-inch Fibre Channel SSD does not use the 12 volt supply available on a typical 40-Pin SCA-2 connector. Three 5-volt pins provide power to the drive. The return current is through the common ground pins. Supply and return current are to be distributed as evenly as possible among the voltage and ground pins. To provide capacitive pre-charging when the drive is hot plugged, the 5V charge pin is designed longer than the other two 5V pins.

Power Requirements

The Zeus 3.5-inch Fibre Channel SSD requires a 5V +/-5% DC power source. If a power failure occurs, the drive design ensures that the data contained in the storage memory is preserved. Data loss or corruption does not occur. 12V and AC Power are not required for the operation of the drive and no external power sequencing is needed.

Table 4.   Zeus 3.5-Inch SSD Power Requirements

Item	
Input Voltage	5V +/-5%
Minimum Voltage	4.75V
Maximum Voltage	5.25
Regulation	5%
Supply Rise Time	TBD
Supply Fall Time	TBD

Power Consumption

Table 5.   Zeus Fibre Channel SSD Typical Power Consumption

Item	Value	Unit
Noise[3]	50	mV
Average Idle DC Current	600	mA
Start Current (Max DC RMS)	1,100	mA
Peak Operating Current		
DC Typical	1000	mA
DC Maximum	1,200	mA
DC Maximum Peak	2,000	mA

Notes:

1   Regulation voltage tolerance includes ripple, noise and transient response.

2   Typical operating current is specified with 8 block reads at 1,500 I/Os per second. Current and power is specified at nominal voltage.

3   Noise is defined as the maximum allowed value peak-to-peak, mV, from 100Hz to 20MHz at the drive power connector.

Grounding

Signal and chassis ground are not connected together in the drive. To ensure minimal EM emissions, the user should provide maximum surface contact area when connecting the drive to chassis ground.

Hardware Purge (Optional)

Pins 2, 3 and 4 will invoke a hardware purge. The user can employ a software utility to preset whether BasicPurge™, RapidPurge™, MilPurge™, or Intelligent Destructive Purge™ is used when a voltage is applied to any of the pins. The pins are 28-volt tolerant.

Fault LED Out Signal

The Fault LED Out signal will pull down the cathode of an LED, when the anode of a LED is attached to a +5V supply through a current-limiting resistor. The Fault LED Out signal is driven by the drive when the following events occur:

• The drive detects failure of both ports

• The drive detects an internal failure

• The drive receives the appropriate fault LED command from the host

Active LED Out Signal

The Active LED Out signal will pull down the cathode of an LED, when the anode of a LED is attached to a +5V supply through a current-limiting resistor. The Active LED Out signal is driven by the drive when the following events occur:

- The drive is accessed

- The drive is being initialized

- The drive is performing background tests

Refer to *Table 6* for the LED Output Characteristics.

Table 6.   LED Output Characteristics

State	Current Drive Available	Output Voltage
LED Off, High	0 < Ioh < 100 μA	
LED On, Low	Iol < -30mA	0 < Vol < 0.8V

TTL Characteristics

The TTL signal characteristics are specified in *Table 7.*

Table 7.   TTL Characteristics

State	Voltage	Current
Input High	1.9 < Vih < 5.5V	Iih = ±500nA max.
Input Low	-0.5 < Vil <0.9V	Iol = ±500nA max.
Output High (-EN Bypass, A, B)	2.4 < Voh < 5.25V	Ioh < -3mA
Output Low (-EN Bypass, A, B)	Vol < 0.5V	Iol < 3mA
Output High (-Parallel ESI)	2.4 < Voh < 0.9 VCC	Ioh < -2.4mA
	Voh > 0.9 VCC	Ioh <-500μA
Output Low (-Parallel ESI)	0 < Vol < 0.45V	Iol < 2.4mA
Output High (all other inputs)	2.4 < Voh < 0.9 VCC	Ioh < -1.6mA
	Voh > 0.9 VCC	Ioh <-500μA
Output Low (all other outputs)	0 < Vol < 0.45V	Iol < 1.6mA

Differential PECL Characteristics

The differential PECL characteristics are described in *Table 8* and *Figures 2and 3.*

Table 8.   Differential PECL Characteristics

Parameter	1GHz Link Rate	2GHz Link Rate
Bit Time	941ps	270ps
XMIT Eye	725 ps min	315 ps min
RCV Eye	659 ps typ	305 ps typ
	395 ps min.	226 ps min
Parameter	Value	Notes
Serial Input Voltage Swing	400 < Vin < 2.000mV	AC coupled
Serial Output Voltage Swing	600 < Vout < 1300mV	Not AC coupled
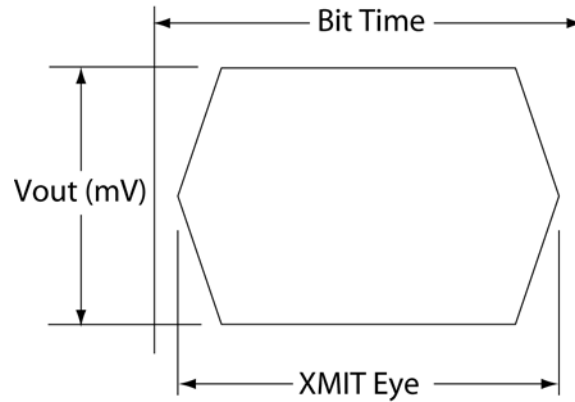
Figure 2.   Transmit Eye
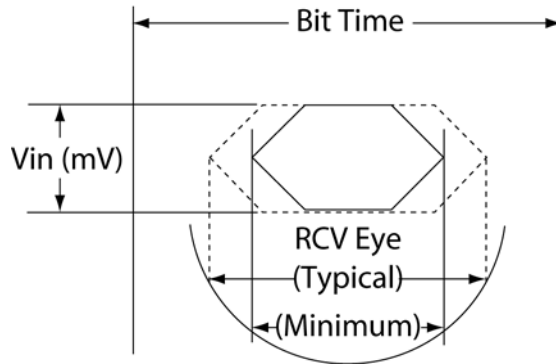
Figure 3. *Receive Eye*

FC-AL Transmitters and Receivers AC Coupling

The user must AC-couple the receiver to isolate potentially different DC characteristics of the outputs and the receiver to eliminate ground shift noise. A typical FC-AL differential copper transmitter and receiver pair are shown in *Figure 4.*
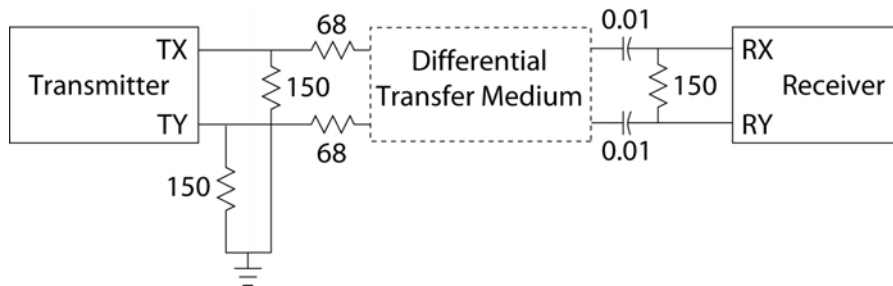
Figure 4. *AC Coupling*

Enable Port Bypass Signals

The enable port bypass signals (active low) inform the backplane when to bypass the drive on the loop, allowing the loop to remain operational when the drive is not ready. A pull down resistor of 1K ohms should be used on the backplane bypass circuit to ensure that the bypass is enabled when the drive is not installed.

The enable port bypass signal goes active on one of the following conditions:

- The drive detects a Loop Port Bypass primitive sequence
- The drive is removed
- The drive transmitter or receiver fails the wrap test
- The drive receive clock is loss
- The drive transmit clock is loss
- The drive has a hardware error

The enable bypass signal goes inactive if all of the following conditions are met:

- The drive detects a Loop Port Enable primitive sequence
- The drive has completed POST
- The drive has no hardware failures

Select and Parallel ESI Signals

If the -Parallel ESI line is high (inactive), then the SEL_6 to SEL_0 signals are the AL-PA (physical address on the loop) that the drive inherits from the backplane.

If the -Parallel EST line is low (active), then the SEL_6 to SEL_0 signals become the "Enclosure Services Interface (ESI)," that is, a bus that signals the enclosure how it can service the drive.

There are two possible ESI buses defined by the Fibre Channel standard that the enclosure may be implementing. Whether the enclosure is implementing ESI, and if so, which of the ESI buses it is implementing, is determined by the drive thorough a discovery process.

Further details on ESI can be found by consulting the ANSI Fibre Channel Documents SFF-8045 and SFF-8067.

When the SEL_6 to SEL_0 signals are used to select the AL-PA, the mapping of SEL_ID=7E (AL_PA=00) is reserved for the loop fabric port and is not a valid AL_PA for the drive. Also, the mapping of SEL_ID=7F does not become the hard address for the drive, but rather indicates that the loop is providing a soft address for the drive.

Refer to *Table 9* for the SEL_6 to SEL_0 signal mapping to the AL-PAs.

Table 9.   AL-PA Mapping

AL PA (Hex)	SELID (Hex)	Setting (Dec)	AL PA (Hex)	SELID (Hex)	Setting (Dec)	AL PA (Hex)	SELID (Hex)	Setting (Dec)
EF	00	00	A3	2B	43	4D	56	86
E8	01	01	9F	2C	44	4C	57	87
E4	02	02	9E	2D	45	4B	58	88
E2	03	03	9D	2E	46	4A	59	89
E1	04	04	9B	2F	47	49	5A	90
EO	05	05	98	30	48	47	5B	91
DC	06	06	97	31	49	46	5C	92
DA	07	07	90	32	50	45	5D	93
D9	08	08	8F	33	51	43	5E	94
D6	09	09	88	34	52	3C	5F	95
D5	0A	10	84	35	53	3A	60	96
D4	0B	11	82	36	54	39	61	97
D3	0C	12	81	37	55	36	62	98
D2	0D	13	80	38	56	35	63	99
D1	0E	14	7C	39	57	34	64	100

Table 9.   AL-PA Mapping

CE	0F	15	7A	3A	58	33	65	101
CD	10	16	79	3B	59	32	66	102
CC	11	17	76	3C	60	31	67	103
CB	12	18	75	3D	61	2E	68	104
CA	13	19	74	3E	62	2D	69	105
C9	14	20	73	3F	63	2C	6A	106
C7	15	21	72	40	64	2B	6B	107
C6	16	22	71	41	65	2A	6C	108
C5	17	23	6E	42	66	29	6D	109
C3	18	24	6D	43	67	27	6E	110
BC	19	25	6C	44	68	26	6F	111
BA	1A	26	6B	45	69	25	70	112
B9	1B	27	6A	46	70	23	71	113
B6	1C	28	69	47	71	1F	72	114
B5	1D	29	67	48	72	1E	73	115
B4	1E	30	66	49	73	1D	74	116
B3	1F	31	65	4A	74	1B	75	117
B2	20	32	63	4B	75	18	76	118
B1	21	33	5C	4C	76	17	77	119
AE	22	34	5A	4D	77	10	78	120
AD	23	35	59	4E	78	0F	79	121
AC	24	36	56	4F	79	08	7A	122

Device Control Codes

The drive reads the Device Control Code (DCC) signals at power up to determine the link rate for the Fibre Channel ports. In case the Device Control Code signals are not connected on the backplane, the signals are pulled up by the drive through 10K ohm resistors. This defaults the link rate to 1.0625 GHz. Ports A and B run at the same rate. Refer to *Table 10* for how the Device Control Code signals map to the link rates.

Table 10.   Device Control Code (DCC) Mapping

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

Start_1 and Start_2 Signals

These signals are used to control the motor spin on rotating media drives. Because the Zeus 3.5-inch Fibre Channel SSD is solid-state and has no motor, these signals are ignored by the drive.

INTERFACE SPECIFICATIONS

SSD Operation

The Zeus Fibre Channel SSD is comprised of three primary functional blocks: the SCA-2 interface connector, the Zeus controller and NAND flash memory. A description of each drive component is provided under *Functional Blocks* on page 24.

Read/write data transfer requests are initiated by the host via the SCSI bus interface. Once received, the Zeus controller, under the direction of the microcontroller, processes the request.

> It is the microcontroller that will initiate and monitor all activity within the Zeus controller, including the execution of the bad-block mapping and wear-leveling algorithms.

> The Zeus controller will decode an incoming host command, and will configure the appropriate interrupts and status for the local microprocessor to handle various ATA commands. For read and write transfer commands, the hardware can handle the initial handshake with the host automatically. If firmware enables full auto mode, read and write transfers can be fully handled by hardware with minimum firmware support.

Commands that do not require data to be read from or written to the flash memory controller are typically handled by the Zeus controller. Some commands may require the Zeus controller to use external circuitry (for example, Intelligent Destructive Purge™), that do not involve the flash memory controller.

When a write operation is requested and data is received, the controller uses integrated DMA controllers to transfer the data from the host memory to the flash memory controller. Through a standard ATA/IDE interface, the flash memory controller transfers the data from the Zeus controller to available locations in the local flash memory of the SSD. The Zeus controller notifies the host after the write operation is completed.

If the unit receives a read request, the Zeus controller retrieves the data from the local flash memory via the flash memory controller. If the Zeus controller is responding to a PIO read operation, it presents the data to the ATA bus. If it is responding to a UDMA read request, the Zeus controller writes the data directly to the system memory on the host. Regardless of the type of operation (PIO or UDMA), the Zeus controller notifies the host when the data is ready for transmission.

Functional Blocks

Zeus Fibre Channel SSDs are comprised of the following primary functional component blocks:

- SCSI Interface Block (SCA-2 or greater)
- SSD Control Block
- NAND Flash Memory

SCSI Interface Block

This section provides information on the SCA-2 connector of the Zeus Fibre Channel SSD.

SCA-2 Interface Connector

The 3.5-inch Zeus SSD is equipped with a 40-pin SCA-2 bus connector. The connector is located on the underside of the drive. DC power and bus traffic is supplied through a non-shielded 40-conductor I/O cable. *Figure 5* shows the location of Pins 1, 20, 21 and 40 relative to the connector housing. *See Connector Pinout* on page 25.
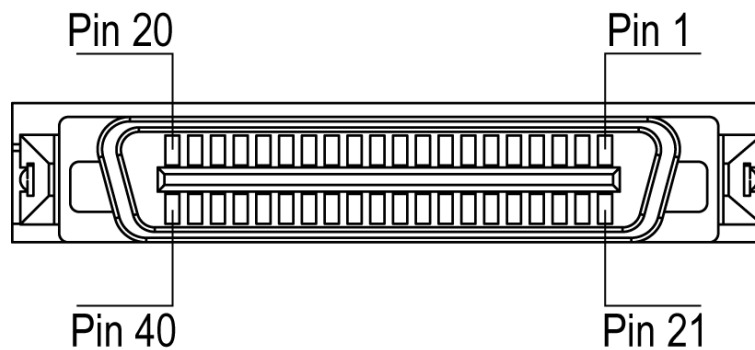
Figure 5.   Pin Locations on SCA-2 Connector

Connector Pinout

This section provides the pinout of the 40-pin SCA-2 connector, the pinout signal characteristics, and the use of the pinout signals with respect to the Zeus 3.5-inch Fibre Channel SSD. Refer to *Table 11* for the 40-pin SCA-2 connector pin-out.

Table 11.   40-Pin SCA-2 Connector Pinout

Pin	Signal Name	Signal Type	Pin	Signal Name	Signal Type
1	-EN Bypass Port A	Low Voltage TTL Output	21	12 Volts Charge	(Not Used)
2	12 Volts (Not Used)	Hardware Purge	22	Ground	GND
3	12 Volts (Not Used)	Hardware Purge	23	Ground	GND
4	12 Volts (Not Used)	Hardware Purge	24	+Port A_In	Differential PECL Input Pair
5	-Parallel ESI		25	-Port A_In	
6	Ground	GND	26	Ground	GND
7	Active LED Out	Open Collector Out	27	+Port B_In	Differential PECL Input Pair
8	Reserved		28	-Port B_In	
9	Start_1	TTL Input	29	Ground	GND
10	Start_2	TTL Input	30	+Port A_Out	Differential PECL Output Pair
11	-EN Bypass Port B	Low Voltage TTL Output	31	-Port A_Out	
12	SEL_6	TTL Input/Output	32	Ground	GND
13	SEL_5	TTL Input/Output	33	+Port B_Out	Differential PECL Output Pair
14	SEL_4	TTL Input	34	-Port B_Out	
15	SEL_3	TTL Input/Output	35	Ground	GND
16	Fault LED Out	Open Collector Out	36	SEL_2	TTL Input/Output
17	DEV_CTRL_CODE_2	TTL Input	37	SEL_1	TTL Input/Output
18	DEV_CTRL_CODE_1	TTL Input	38	SEL_0	TTL Input/Output
19	5 Volts		39	DEV_CTRL_CODE_0	TTL Input
20	5 Volts		40	5 Volts Charge	

SSD Control Block

The control block of the Zeus SSD is comprised of three integrated components:

- Zeus FPGA Controller
- RISC Microcontroller
- NAND SLC Flash Memory

FPGA Controller

The Field Programmable Gate Array (FPGA) Controller provides the interface between the SSD and the host, and the IDE interface to the local flash memory installed in the drive. The integrated DMA controller interfaces with the system memory to facilitate data transfer between the host and local flash memory of the SSD.

RISC Microcontroller

An integrated microcontroller initiates and monitors all activity within the Zeus controller. The microcontroller features 1 Mbit of on-chip SRAM and a wide range of peripheral functions, with 8 Mbits of flash memory into a single 120-BGA package. The embedded microcontroller is a high-performance processor with a high-density instruction set with very low power consumption. In addition, a large number of internally banked registers provide very fast exception handling, making it ideal for the real-time application control requirements of the SSD. The 8-level priority-vectored interrupt controller, together with the Peripheral Data Controller, significantly enhance the real-time performance of the SSD.

The flash memory controller architecture requires only minimal external component support. The flash controller is compatible with flash memory devices from Samsung® and Toshiba®, as well as a number of compatible flash memory devices from other manufacturers.

Features of the flash memory controller include:

- Integrated 3.3V voltage regulator for flash memory supply
- Data transfer rates up to 60 MB/sec (controller to flash memory)
- True-IDE mode support
- Embedded ECC unit
- Wear-leveling and bad-block mapping software

NAND SLC Flash Memory

The local subsystem uses Single-Level Cell (SLC) NAND, non-volatile flash memory that has only two states and one bit of stored data. The SLC NAND flash control logic on the SSD is able to conserve energy when managing the electrical charge during operation.

FC-AL FEATURES

Loop Connections

The Zeus 3.5-inch Fibre Channel SSD features two independent FC-AL ports. These ports may be connected in different loops or the same loop.

If the ports are 1) connected in different loops, 2) hard addressing is used, and 3) the drive interface address is selected through the interface connector, then both ports will seek the same loop address. If there are no duplicate addresses on the different loops, both ports will use the same address.

If the ports are 1) connected in the same loop and 2) hard addressing is used, then one of the two ports will attempt taking a soft address to prevent address conflict.

If the drive has 1) its ports connected to different loops, and 2) buffer availability, then the drive is able to receive transfers on both ports at the same time. This capability is called "concurrent port transfers".

In addition, the drive can send transfers while receiving frames on both ports. This capability is called "full duplex".

Table 12 summarizes the FC-AL options supported by the drive.

Table 12.   FC-AL Supported Options

Option	Support
OPEN Half Duplex	Accepted from another device
OPEN Full Duplex	Sent to open another device; accepted from another device
Private Loop	Supported
Public Loop	Supported
Old Port State	Not supported
Loop Position	Supported
Loop Position Report	Supported

FCP-SCSI Commands

The following table summarizes the SCSI commands supported by the Zeus Fibre Channel SSD. For more information, please consult the SCSI Specification, Fibre Channel Protocol - 3 (FCP-3), Project T10/1560D, ANSI INCITS 416-2006.

Table 13.   Supported SCSI Commands

Command Code	Command Name
00h	Test Unit Ready
01h	Rezero Unit
03h	Request Sense
04h	Format Unit
08h	Read (6)
0Ah	Write (6)
12h	Inquiry
	Vital Product Data Page (00h)
	Unit Serial Number Page (80h)
	Device Identification Page (83h)
15h	Mode Select (6)
	Error Recovery Page (01h)
	Disconnect/Reconnect Control Page (02h)
	Verify Error Recovery Page (07h)
	Caching Parameters Page (08h)
	Fibre Channel Interface Control Page (19h)
	Control Mode Page (0Ah)
	Power Control Page (1Ah)
	Information Exceptions Control Page (1Ch)
16h	Reserve (6)
17h	Release (6)
1Ah	Mode Sense (6)
1Bh	Start Unit/Stop Unit
1Ch	Receive Diagnostic Results
	Enclosure Services Page
1Dh	Send Diagnostics Page
25h	Read Capacity
28h	Read Extended (10)
2Ah	Write Extended (10)
55h	Mode Select (10)
56h	Reserve (10)
57h	Release (10)
5Ah	Mode Sense (10)
2Ch	Erase

Test Unit Ready Command (00h)

The TEST UNIT READY command provides a method to check if the logical unit is ready. This is not a request for a self-test. If the logical unit would accept an appropriate medium-access command without returning CHECK CONDITION status, this command shall return a GOOD status. If the logical unit cannot become operational or is in a state such that an initiator action is required to make the unit ready, the target shall return CHECK CONDITION status with a sense key of NOT READY. *See Table 14.*

Table 14.   Test Unit Ready CDB

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (00h)							
1	Reserved				Reserved			
2	Reserved							
3	Reserved							
4	Reserved							
5	Control							

Rezero Unit Command (01h)

The REZERO UNIT command requests that the target set the logical unit to a specific state. This is implemented on the drive as a NOP command and has no effect other than to verify the CDB. *See Table 15.*

Table 15.   Rezero Unit CDB

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (01h)							
1	Logical Unit Number (RSVD)			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Control							

Request Sense Command (03h)

The REQUEST SENSE command requests that the drive transfer sense data to the initiator. If the drive has no sense data available to return, it will return a sense key of NO SENSE and an additional sense code of NO ADDITIONAL SENSE INFORMATION. The sense data shall be preserved by the target for the initiator until retrieved by a REQUEST SENSE command or until the receipt of any other I/O process for the same I_T_x nexus. Sense data shall be cleared upon receipt of any subsequent I/O process (including REQUEST SENSE) to the same I_T_x nexus. *See Tables 16 and 17.*

Table 16.   Request Sense CDB

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (03h)							
1	Reserved			Reserved				
2	Reserved							
3	Reserved							
4	Allocation Length							
5	Control							

The target shall return CHECK CONDITION status for a REQUEST SENSE command only to report exception conditions specific to the command itself. For example:

- A non-zero reserved bit is detected in the command descriptor block;
- An unrecovered parity error is detected on the data bus;
- A target malfunction prevents return of the sense data.

If a recovered error occurs during the execution of the REQUEST SENSE command, the target shall return the sense data with GOOD status. If a target returns CHECK CONDITION status for a REQUEST SENSE command, the sense data may be invalid.

The drive is capable of returning eighteen bytes of data in response to a REQUEST SENSE command. If the allocation length is eighteen or greater, and the drive returns less than eighteen bytes of data, the initiator should assume that the bytes not transferred would have been zeros had the target returned those bytes. Initiators can determine how much sense data was returned by examining the allocation length parameter in the command descriptor block and the additional sense length in the sense data.

The sense data format for error codes 70h (current errors) and 71 h (deferred errors) are defined below. For further details on the Request Sense command, please refer to the SCSI specification.

Table 17.   Sense Data Format

Bit Byte	7	6	5	4	3	2	1	0
0	Valid	Error Code (70h or 71h)						
1	Segment Number							
2	Filemar	EOM	ILI	Reserve	Sense Key			
3	(MSB)	Information						
6								(LSB)
7	Additional Sense Length (n-7)							
S	(MSB)	Command-specific Information						
11								(LSB)
12	Additional Sense Code							
13	Additional Sense Code Qualifier							
14	Field Replaceable Unit Code							
15	SKSV	Sense-Key Specific						
17								
18	Additional Sense Bytes							
n								

Format Unit Command (04h)

The FORMAT UNIT command formats the medium into initiator addressable logical blocks per the initiator-defined options. In addition, the medium may be certified and control structures may be created for the management of the medium and defects. *See Table 18.*

Table 18.   Format Unit CDB

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (04h)							
1	Logical Unit Number (RSVD)			FmtData	CmpLst	Defect List Format		
2	Vendor-Specific							
3	(MSB)		Interleave					
4								(LSB)
5	Control							

Only the simplest and mandatory forms of the FORMAT UNIT command (with no formal data) are implemented on the drive. This routine accomplishes medium formatting with little initiator control over defect management.

The FORMAT UNIT command shall be rejected with RESERVATION CONFLICT status if the logical unit is reserved, or any extent reservation, from any initiator, is active in the specified logical unit. During the execution of the FORMAT UNIT command, the drive may perform a medium defect management algorithm.

A *FmtData* bit of zero indicates that a DATA OUT phase shall not occur. The source of defect information is not specified. This is the only form of the command the drive supports.

A *CmpLst* (complete list) bit of one indicates that the defect list sent by the initiator is a complete list of defects. The existing defect list is discarded by the drive and a new primary defect list is constructed. A CmpLst bit of zero indicates that the current defect list should be maintained. As a result, a new primary is constructed that contains the existing list and any new defects the drive may add during the format operation.

Read (6) Command (08h)

The READ (6) command requests that the drive transfer data to the initiator. The most recent data value written in the addressed logical block shall be returned. *See Table 19.*

Table 19.   Read (6) CDB

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (08h)							
I	Logical Unit Number (RSVD)			(MSB)				
2	Logical Block Address							
3								(LSB)
4	Transfer Length							
5	Control							

The logical block address field specifies the logical block at which the read operation shall begin. The transfer length field specifies the number of contiguous logical blocks of data to be transferred. A transfer length of zero indicates that 256 logical blocks shall be transferred. Any other value indicates the number of logical blocks that shall be transferred.

Write (6) Command (0Ah)

The WRITE (6) command requests that the target write the data transferred by the initiator to the medium. *See Table 20.*

Table 20.   Write (6) CDB

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (0Ah)							
1	Logical Unit Number (RSVD)			(MSB)				
2	Logical Block Address							
3								(LSB)
4	Transfer Length							
5	Control							

The logical block address field specifies the logical block at which the write operation shall begin. The transfer length field specifies the number of contiguous logical blocks of data to transfer. A transfer length of zero indicates that 256 logical blocks shall be transferred. Any other value indicates the number of logical blocks that shall be transferred.

Inquiry Command (12h)

The INQUIRY command requests that information regarding parameters of the drive be sent to the initiator. *See Tables 21 and 22.*

Table 21.   Inquiry CDB

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (12h)							
1	Logical Unit Number (RSVD)			Reserved				EVPD
2	Page Code							
3	Reserved							
4	Allocation Length							
5	Control							

An Enable Vital Product Data (EVPD) bit of one specifies that the drive return the optional vital product data specified by the page code field. If any optional fields in the CDB are set that the drive does not support, it will return a CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and an additional sense code of INVALID FIELD IN CDB.

An EVPD bit of zero specifies that the drive return the standard INQUIRY data. If the page code field is not zero, the target shall return CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and an additional sense code of INVALID FIELD IN CDB. The page code field specifies which page of vital product data information the drive returns.

The INQUIRY command shall return CHECK CONDITION status only when the target cannot return the requested INQUIRY data. The INQUIRY data should be returned even though the peripheral device may not be ready for other commands. If an INQUIRY command is received from an initiator with a pending unit attention condition, the drive will perform the INQUIRY command and not clear the unit attention condition.

Note: Please refer to the SCSI specification for further details on the vital product data pages and formats.

Table 22.   Standard Inquiry Data Format

Bit Byte	7	6	5	4	3	2	1	0
0	Peripheral Qualifier			Peripheral Device Type				
1	RME	Device-Type Modifier						
2	ISO Version		ECMA Version			ANSI-approved Version		
3	AEHC	TrmIOP	Reserved		Response Data Format			
4	Additional Length (n-4)							
5	Reserved							
6	Reserved							
7	RelAdr	Wbus32	Wb16	Sync	Linked	Reserve	CmdQu	SftRe
8	(MSB)	Vendor Identification						
15								(LSB)
16	(MSB)	Product Identification						
31								(LSB)
32	(MSB)	Product Revision Level						
35								(LSB)
36	Vendor-Specific							
55								
56	Reserved							
95								
	Vendor-Specific Parameters							
96	Vendor-Specific							
n								

Mode Select (6) Command (15h)

The MODE SELECT (6) command allows the initiator to specify a medium, logical unit, or peripheral device parameters to the disk drive. The drive also implements the MODE SENSE (6) command. *See Mode Sense (6) Command (1Ah).* Initiators should issue Mode Sense prior to Mode Select to determine the supported pages, page lengths, and remaining parameters.

Table 23.   Mode Select (6) Command (15h)

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (15h)							
1	0 Reserved	0	0	PF	0	0	0	SP
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	Parameter List Length							
5	Control							

The drive maintains a common set of mode parameters shared by all initiators. If an initiator sends a Mode Select command that changes any of the parameters, the drive will generate a UNIT ATTENTION condition for all initiators except for the initiator that issued the Mode Select command. The drive will set the additional sense code to MODE PARAMETERS CHANGED.

Reserve (6) Command (16h)

The RESERVE (6) (16h) command provides the basic mechanism for contention resolution in multiple-initiator systems. The command consists of 6 bytes. The command will reserve a logical unit, or if the extent reservation option is used, extents within a logical unit. The third-party reservation allows logical units or extents to be reserved for another specified SCSI device. *See Release (6) Command (17h), Reserve (10) Command (56h)* and *Release (10) Command (57h)*.

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (16h)							
1	0	0	0	3rd Party	Third Party Device ID			Extent
	Reserved							
2	Reservation Identification							
3	(MSB)							
4	Extent List Length							
								(LSB)
5	Control							

Release (6) Command (17h)

The RELEASE (6) Command (17h) provides the basic mechanism for contention resolution in multiple-initiator systems. The command consists of 6 bytes. The command is used to release a previously reserved logical unit, or if the extent release option is implemented, to release previously reserved extents within a logical unit. An error does not occur when an initiator attempts to release an invalid reservation. In this scenario, the drive will return a GOOD status without altering any other reservation. The command is implemented by the drive for an Entire Unit Release with Third Party Release supported and with the drive-specific parameters as outlined in *Table 24*. *See Reserve (6) Command (17h)*, *Reserve (10) Command (56h)* and *Release (10) Command (57h)*.

Table 24.   Release (6) Command (17h)

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (17h)							
1	0	0	0	3rd Party	Third Party Device ID			Extent
	Reserved							
2	Reservation Identification							
3	Reserved							
4	Reserved							
5	Control							

Mode Sense (6) Command (1Ah)

The MODE SENSE (6) command provides a means for a target to report parameters to the initiator. It is a complementary to the MODE SELECT (6) command. *See Tables 25 and 26.*

Table 25.   Mode Sense CDB

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (1Ah)							
1	Logical Unit Number (RSVD)			Reserve	DED	Reserved		
2	PC		Page Code					
3	Reserved							
4	Allocation Length							
5	Control							

A Disable Block Descriptors (DBD) bit of zero indicates that the target may return zero or more block descriptors in the returned MODE SENSE data, at the target's discretion. A DBD bit of one specifies that the target shall not return any block descriptors in the returned MODE SENSE data. The page control (PC) field defines the type of mode parameter values to be returned in the mode pages. The page code specifies which mode page to return.

Table 26.   Page Code Field Descriptions

Page Code	Description	Subclause
00h	Vendor-specific (does not require page format)	
01h - 1Fh	See specific device-types	
20h - 3Eh	Vendor-specific (page format required)	
3Fh	Return all mode pages	

Start Unit/Stop Unit (1Bh)

The START UNIT/STOP UNIT (1Bh) command requests that the target enable the logical unit for further operations (START) or stop spindle rotation (STOP). The drive is able to execute the following commands when the spindle is not rotating, or in a simulated stopped condition. *See Table 27.*

Test Unit Ready	Reserve	Receive Diagnostic Results
Request Sense	Release	Write Data Buffer
Inquiry	Motor Start'	Read Data Buffer

The remaining commands cannot be executed until after the drive has spindled up. If the drive receives one of these commands before it can be executed, a CHECK CONDITION status is returned with a sense key of NOT READY. The initiator will close the loop after a Start Unit is executed. The drive arbitrates for the loop when the unit is up to speed and READY or when operation is initiated if the Immed bit is 1.

Table 27.   Start Unit/Stop Unit (1Bh) Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (1Bh)							
1	0	0	0	0	0	0	0	Immed
	Reserved							
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	Start
5	Control							

Receive Diagnostic Results (1Ch) Command

The RECEIVE DIAGNOSTIC RESULTS (1Ch) command will request analysis data after completion of a SEND DIAGNOSTIC command or SCSI-3 Enclosure Services (SES) pages be sent to the initiator. The drive supports the optional Page format, wherein the initiator sends additional pages after a Send Diagnostic command. These additional pages have a page code that specifies the data format to the drive that is to be returned after it receives a Receive Diagnostic Results command.

Table 28. Receive Diagnostic Results (1Ch) Command

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (1Ch)							
1	0	0	0	0	0	0	0	PCV
	Reserved							
2	Page Code							
3	Allocation Length in bytes (MSB)							
4	Allocation Length in bytes (LSB)							
5	Control							

Send Diagnostic Page(1Dh)

The SEND DIAGNOSTIC command requests that the drive perform diagnostic operations on itself. The only mandatory implementation of this command is the self-test feature with the parameter list length of zero. *See Table 29.*

Table 29.   Send Diagnostics CDB

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (1Dh)							
1	Logical Unit Number (RSVD)			PF	Reserve	SelfTest	DevOfL	UnitOfL
2	Reserved							
3	(MSB)							
4	Parameter List Length							
5								(LSB)
6	Control							

Read Capacity (25h)

The READ CAPACITY command provides a means for the initiator to request information regarding the capacity of the logical unit. *See Table 30.*

Table 30.   Read Capacity CDB

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (25h)							
1	Logical Unit Number (RSVD)			Reserved				RelAdr
2	(MSB)							
3	Logical Block Address							
4								
5								(LSB)
6	Reserved							
7	Reserved							
8	Reserved							PMI
9	Control							

Read Extended (10) (28h)

The READ (10) EXTENDED (28h) command requests that the target transfer data to the initiator. The most recent data value written in the addressed logical block is returned. *See Table 31.*

Table 31.   Read Extended (10) CDB

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (28h)							
1	Logical Unit number (RSVD)			DPO	FUA	Reserved		RelAdr
2	(MSB)							
3	Logical Block Address							
4								
5								(LSB)
6	Reserved							
7	(MSB)							
8	Transfer Length							(LSB)
9	Control							

Write Extended (10) (2Ah)

The WRITE (10) EXTENDED (2Ah) command requests that the drive write the data transferred by the initiator to the medium. *See Table 32.*

Table 32.   Write (10) CDB

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (2Ah)							
1	Logical Unit Number (RSVD)			DPO	FUA	Reserve	Reserve	RelAdr
2	(MSB)							
3	Logical Block Address							
4								
5								(LSB)
6	Reserved							
7	(MSB)							
8	Transfer Length							(LSB)
9	Control							

Mode Select (10) Command (55h)

The MODE SELECT (10) command allows the initiator to specify a medium, logical unit, or peripheral device parameters to the drive. The drive will also implement the MODE SENSE (10) command. If implemented, the drive will use the 10-bit command set by default. *See Mode Select (6) Command (1Ah) and Mode Sense (6) Command (15h)*.

Table 33.   Mode Select (10) Command (55h)

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (55h)							
1	0	0	0	PF	0	0	0	SP
	Reserved							
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB)							
	Parameter List Length							
8								(LSB)
9	Control							

The drive maintains a common set of mode parameters shared by all initiators. If an initiator sends a Mode Select command that changes any of the parameters, the drive will generate a UNIT ATTENTION condition for all initiators except for the initiator that issued the Mode Select command. The drive will set the additional sense code to MODE PARAMETERS CHANGED.

Reserve (10) Command (56h)

The RESERVE (10) (56h) command provides the basic mechanism for contention resolution in multiple-initiator systems. The command consists of 10 bytes. The command will reserve a logical unit, or if the extent reservation option is used, extents within a logical unit. The third-party reservation allows logical units or extents to be reserved for another specified SCSI device. *See Reserve (6) Command (17h), Release (6) Command (17h)* and *Release (10) Command (57h).*

Table 34.   Reserve (10) Command (56h)

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (56h)							
1	0 Reserved	0	0	3rdPty	0 Reserved	0	Long ID	Extent
2	Reservation Identification							
3	Third-Party Device ID							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB)							
8	Parameter List Length							(LSB)
9	Control							

Release (10) Command (57h)

The RELEASE (10) (57h) command provides the basic mechanism for contention resolution in multiple-initiator systems. The command consists of 10 bytes. The command is used to release a previously reserved logical unit, or if the extent release option is implemented, to release previously reserved extents within a logical unit. An error does not occur when an initiator attempts to release an invalid reservation. In this scenario, the drive will return a GOOD status without altering any other reservation. The command is implemented by the drive for an Entire Unit Release with Third Party Release supported and with the drive-specific parameters as outlined in *Table 32. See Reserve (6) Command (17h)*, *Release (6) Command (17h)* and *Reserve (10) Command (56h)*.

Table 35.   Release (10) Command (57h)

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (57h)							
1	0	0	0	3rdPty	0	0	Long ID	0
	Reserved				Reserved			Extent
2	Reservation Identification							
3	Third-Party Device ID							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB)			Parameter List Length				
8								(LSB)
9	Control							

Mode Sense (10) Command (5Ah)

The MODE SENSE (10) command provides a means for a target to report parameters to the initiator. It is complementary to the MODE SELECT (10) command. *See Table 36.*

Table 36.   Mode Sense (10) Command (5Ah)

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (5Ah)							
1	0	0	0	Reserved	DBD	Reserved		
	Reserved							
2	PCF			Page Code				
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB)			Allocation Length				
8								(LSB)
9	Control							

A Disable Block Descriptors (DBD) bit of zero indicates that the target may return zero or more block descriptors in the returned MODE SENSE data, at the target's discretion. A DBD bit of one specifies that the target shall not return any block descriptors in the returned MODE SENSE data. The page control (PC) field defines the type of mode parameter values to be returned in the mode pages. The page code specifies which mode page to return.

Table 37.   Page Code Field Descriptions for Mode Sense (10)

Page Code	Description	Subclause
00h	Vendor-specific (does not require page format)	
01h - 1Fh	See specific device types	
20h - 3Eh	Vendor-specific (page format required)	
3Fh	Return all mode pages	

Erase Command (2Ch)

The ERASE (10) command requests that the target erase the specified number of blocks starting at the specified logical block address on the medium. As used here, erase means the previous data recorded on the medium shall not be recoverable. The media defect and control management tables are retained, thus allowing write and read access to the memory. *See Table 38.*

Table 38.   Erase CDB

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (2Ch)							
1	Logical Unit Number (RSVD)			Reserved		ERA	Reserve	RelAdr
2	(MSB)							
3	Logical Block Address							
4								
5								(LSB)
6	Reserved							
7	(MSB) Transfer Length							
8								(LSB)
9	Control							

The Erase All (ERA) bit set to one indicates that all blocks on the medium shall be erased. If the ERA bit is set to one and if the number of blocks is not zero, the drive will return CHECK CONDITION, and the sense key shall be set to ILLEGAL REQUEST, with an additional sense code of INVALID FIELD IN CDB. If the ERA bit is zero a transfer length of zero indicates that no blocks shall be erased. This condition is not considered an error and no data is erased. Any other value indicates the number of logical blocks that shall be erased.

The ERASE command has been implemented as a security erase mechanism on the drive. The command was originally used by tape backup devices. When executed with ERA set, a 1 Gbyte drive can be wiped clean in about 10 seconds. All storage locations on the drive are erased, including both user and system (protected) data areas. At the conclusion of the erase command, the existing media defect and control management tables are restored to memory.

FIBRE CHANNEL STANDARD

The Fibre Channel standard has coined various terms that are important to know when using the Zeus 3.5-inch Fibre Channel SSD. This section will present the basic terms in context to help provide an intuitive understanding of the Fibre Channel interface.

Fibre Channel Arbitrated Loop

"Fibre" or "link" is the copper or optical cable that connects two Fibre Channel devices via their ports. A device, known as a "node", can have more than one port. For example, the Zeus 3.5-inch Fibre Channel SSD is a node with two ports that is linked with a copper cable, or fibre.

Nodes are connected in a "topology". The Zeus 3.5-inch Fibre Channel SSD may be connected to an "Arbitrated Loop" (AL), where the nodes of the loop are connected in a circle. *See Figure 6.*
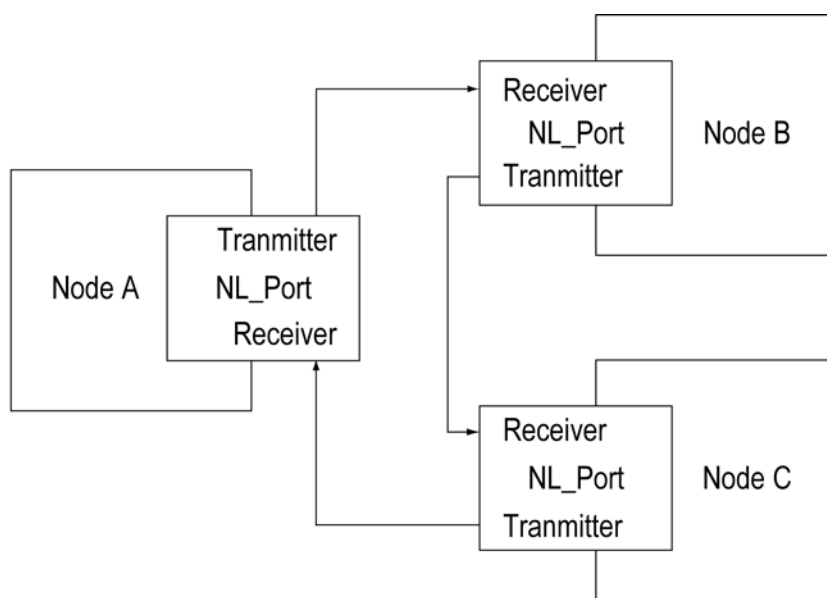
Figure 6.   Arbitrated Loop Topology Connection

An Arbitrated Loop has certain rules.

1   Each port on the loop has an Arbitrated Loop Physical Address (AL-PA) that is set on the "backplane" or the board to where the device is connected. Once set, the port attached to the backplane inherits the AL-PA.

2   The AL-PA must have "neutral disparity", i.e., the number of binary 0s and 1s in the AL-PA are equal. Out of the 127 addresses, one is reserved on the loop for the fabric switch, leaving 126 possible AL-PAs.

3   There may be more than 126 ports physically attached on a loop, but only 126 will be functional, with the rest unable to obtain valid addresses.

4   If the AL-PA of a device is not unique on the loop, the loop will inform the user and the user must choose another "hard address", i.e., an AL-PA. If a unique hard address cannot be set, the user can set the backplane to an AL-PA so that the loop will assign a "soft address" to the device.

5   The lower the AL-PA, the higher priority the device has on the loop while keeping "fairness". Fairness means that every device on the loop has a chance to own the loop once before another device owns it twice.

Fabric Node Connection

The Zeus can also be connected to a "fabric" where any node on the fabric can connect to any other node in the fabric.

F_Port = Fabric Port
N_Port = Node Port
FL_Port = Fabric Arbitrated Loop Port
NL_Port = Node Arbitrated Loop Port
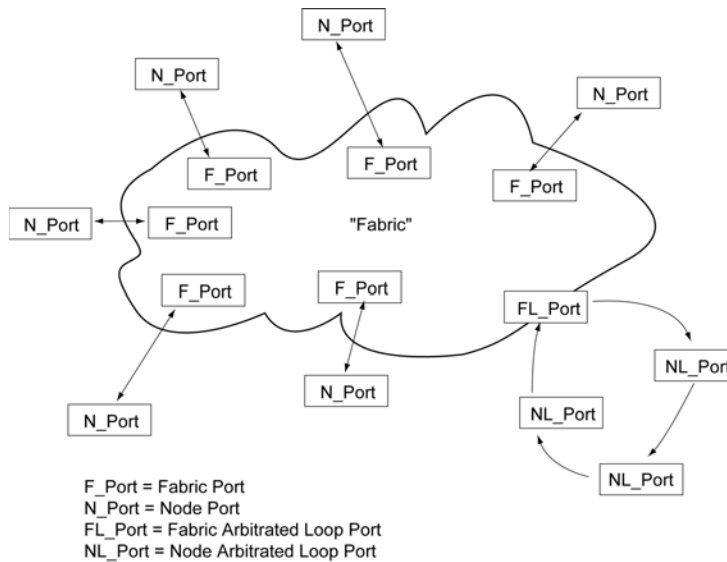
Figure 7.   Fabric Node Connection

An Arbitrated Loop has the following states:

Monitoring	Each port acts as a repeater while listening for further instructions.
Arbitration	A port requests to own the loop.
Open	A port wins arbitration and connects to another device.
Closed	The port relinquishes ownership of the loop, and the loop is an the process of returning to a monitoring state.

A node can be "hot plugged" where it is inserted or removed from a loop. When hot plugged, the loop loses "sync" and must "reinitialize". The loop will be able to recover any lost communications during the hot-plugging. Typically, a backplane may have a "bypass" circuit. *See Figure 8.* When enabled, the bypass circuit will remove the device from the loop while keeping the loop connected. The loop will remain operational while the device is connected, performs its POSTs, and becomes ready.
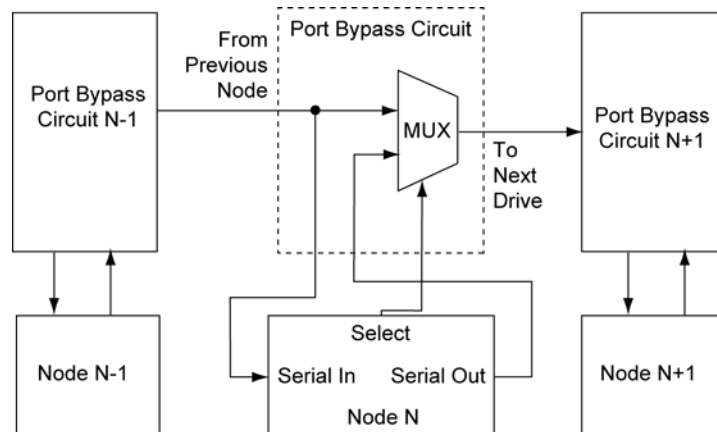
Figure 8.   *The Backplane Bypass Circuit Block Diagram*

The Fibre Channel standard is structured into FCP (Fibre Channel Protocol) Function Levels. There is a hierarchy of function levels, FC-0 to FC4, and above those lies the Upper Level Protocols or ULP. *Table 39* summarizes each FCP level.

Table 39.   FCP Function Levels

Level	Description
FC-0	This level defines the cable, transceivers, and connector. For example, the Maracite 3.5-inch Fibre Channel SSD uses copper cable and a 40-Pin SCA-2 connector.
FC-1	This level defines the 8B/10B encoding of the basic word in the data stream. This encoding consists of four characters. A word contains data, or contains an ordered set that serves as control information.
FC-2	This level defines how the words are structured in frames, sequences, exchanges, and packets.
FC-3	This level defines the common services. All communication through a node passes through the common service protocol level, allowing networking features such as "striping" data, and "multicasting" to many nodes.
FC-4	Maps the lower protocols to the ULPs.
ULP	This is the protocol that is transported by the Fibre Channel. For example, the Zeus has FCP-SCSI as its ULP.

PHYSICAL CHARACTERISTICS

Materials

All acceptable enclosure materials are HB rated or higher if approved by the safety agencies (UL, CSA, TUV, etc.) All printed circuit boards shall have a flammability rating of UL94V-0.

Drive Assembly Weight

The weight of a Zeus SSD varies according to the specific set of design characteristics of the drive. A standard 3.5-inch Zeus SSD with a capacity of 80 gigabytes weighs less than 0.3kg (0.7 lbs). The following characteristics must be taken into consideration to determine the exact weight of the drive:

- Storage capacity
- IC stacking technology
- Case material (aluminum alloy or plastic)
- Flash controller/memory configuration

Storage Capacities

Table 40 lists the available capacities of the Zeus 3.5-inch Fibre Channel SSDs and the corresponding LBA (Logical Bit Addressing) and CHS (Cylinder, Head, Sector) information. The *CHS Capacity* is expressed as *User-Addressable LBA Sectors*.

Note: The extended use of the device shall not reduce the LBA count. The LBA count will remain constant over the life of the SSD.

Table 40.   Zeus SSD Capacities

Capacity Unformatted	Logical Bit Addressing (LBA Data)	Cylinder, Head, Sector (CHS) Data			
	User-Addressable LBA Sectors	CHS Capacity	Logical Cylinders	Logical Heads	Logical Sectors
10 Gigabytes	TBD	16514064	16383	16	63
40 Gigabytes	TBD	16514064	16383	16	63
80 Gigabytes	TBD	16514064	16383	16	63

Exterior Dimensions

Zeus SSD internal components are housed within precision machined aluminum alloy enclosures. The 3.5-inch form factor assembly and overall dimensions are illustrated in *Figure 9*.
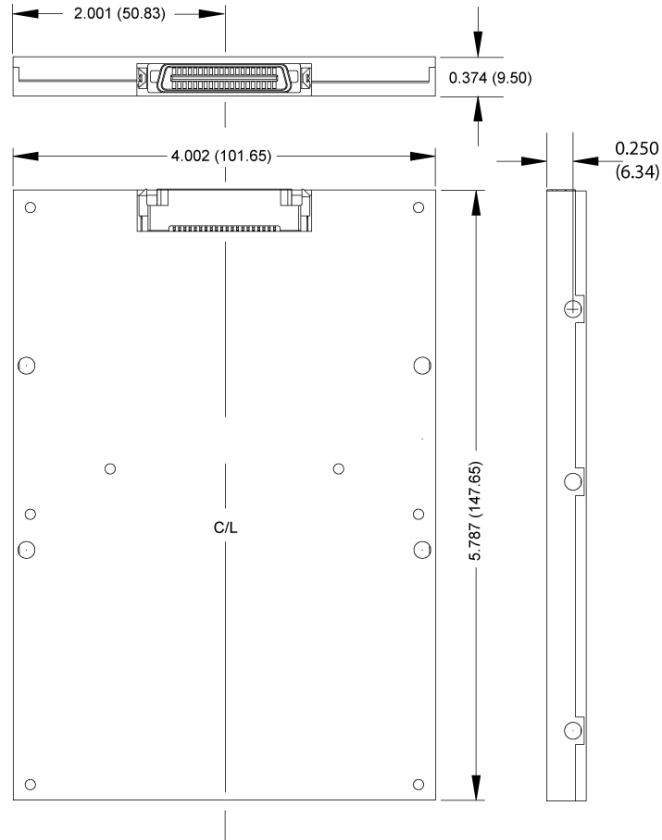
Figure 9. *Zeus 3.5-Inch SSD Assembly Dimensions*

40-Pin SCA-2 Connector Dimensions

Figure 10 shows the dimensions of the 40-pin SCA-2 connector.
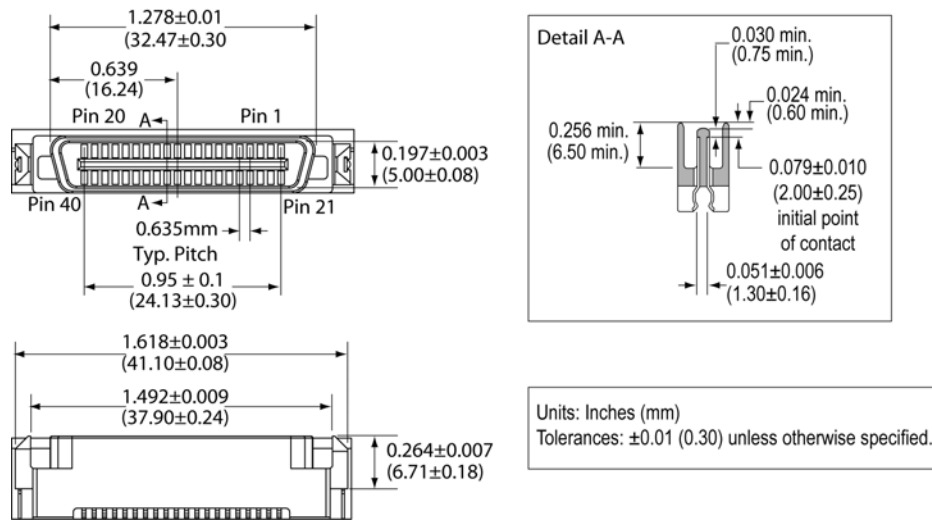
Figure 10. *40-Pin SCA-2 Connector*

ENVIRONMENTAL CHARACTERISTICS

Zeus SSDs are subjected to a series of environmental tests to validate the portability and suitability of the SSDs for operation in harsh and mobile conditions. Zeus SSDs operate without degradation within the ambient temperature, relative humidity and altitude ranges as specified in the following sections.

Temperature Conditions

Temperature parameters for Zeus SSDs are divided into Operating, Storage and Case Temperature Conditions.

Operating Temperatures

Note: For the operating temperature, the ambient air temperature is that of the inlet air for the equipment. *See Table 41.*

Table 41.   Operating Temperatures

Operating Requirement	Criteria
Case Temperature	
Commercial	0^oC to 70^oC
Industrial	-40^oC to 85^oC
Maximum Temperature Gradient	30^oC/h

Storage Temperatures

Note: Non-operating conditions include shipment and storage environments. *See Table 42.*

Table 42.   Storage Temperatures

Storage Requirement	Criteria
Temperature Range	-55^oC to 95^oC
Maximum Temperature Gradient	30^oC/h
Short Duration Temperature	-82^oC for 2h

Case Temperature Conditions

Temperature and humidity ranges are specified such that condensation does not occur. To determine the operating temperature, place the drive in its final environment and enclosure configuration and perform reads/writes until the temperature is stabilized. Measure the operating temperature at the point shown in *Figure 11*.
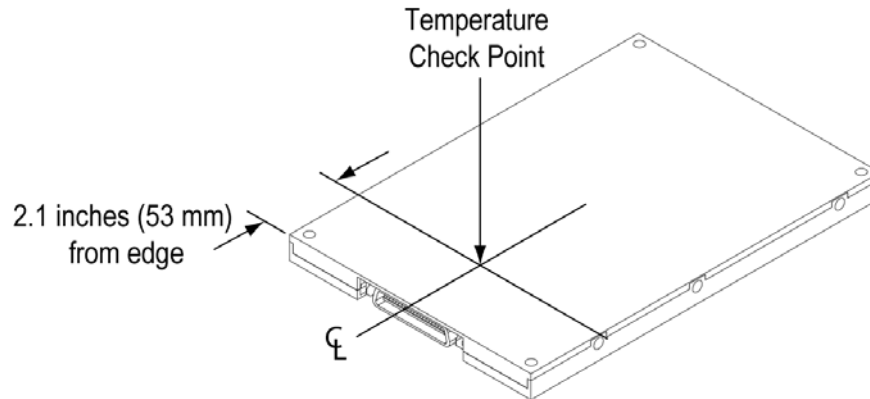
Figure 11.   *Temperature Check Point Location*

Notes:

1   Sustained temperatures outside the operating temperature range may reduce drive life; however, brief case temperatures outside the range may occur without significant reduction of drive life.

2   Altitude is referenced to sea level on a standard day at 58.64°F (14.8°C).

3   Shock and vibration are specified on the drive chassis. Resonance may occur if the drive is placed in an enclosure. It is the responsibility of the user to design the mounting such that drive movement is within the specified ranges despite resonance.

Relative Humidity

Table 43 lists the operating and storage relative humidity criteria for the Zeus SSD.

Table 43.   Relative Humidity Requirements

Operating	Criteria
Relative Humidly Range (Non-Condensing)	5% to 95%
Maximum Wet Bulb Temperature	29°C
Maximum Relative Humidity Gradient	20%/h
Storage (Non-Operating)	Criteria
Relative Humidly Range (Non-Condensing)	5% to 95%
Maximum Wet Bulb Temperature	38°C
Maximum Relative Humidity Gradient	20%/h

Altitude Parameters

Operating and non-operating (storage) altitude parameters for the Zeus SSD are the same, with a low-altitude limit of -1,000 ft. (-304.80 m) and a high-altitude limit of 80,000 ft. (24,384 m). Altitude is referenced to sea level on a standard day at 58.64°F (19.8°C).

Shock and Vibration

This section specifies the capability of the device to withstand shock and vibration. Shock and vibration are specified on the drive chassis. Resonance may occur if the drive is placed in an enclosure. It is the responsibility of the user to design the mounting such that the drive movement is within the specified ranges despite resonance.

Failure Criteria

Test failures are defined as:

- Any single hard unrecoverable error
- Damage that renders a product unacceptable because it becomes inoperable
- Damage that adversely affects the performance specifications

Operating Shock and Vibration

For random vibration, the device will perform without errors after being tested at 15 min/axis on three axes (X, Y and Z). During the operational vibration, the drive will be performing continuous reads. The SSD also adheres to 16.3G RMS per MIL-STD-810F (Random, 20Hz to 2,000Hz; 3 vibration axes).

Operating shock and vibration levels are listed in *Table 44*. In addition to the aforementioned Failure Criteria, during the operating random vibration, the transfer rate of the drive should not degrade by more than 10%.

Table 44.   Operating Shock and Vibration Levels

Parameter	Value	Condition
Operating Shock	1,500	G, half-sine, 0.3 to 0.75ms duration, 3 cycles per 3 axes.
Operating Vibration	16.3	G, RMS, random, 20Hz to 2000Hz, 1 hour duration, 3 axes

Drop Testing

The Zeus SSD will withstand three (3) drops on a concrete floor from 60 inches (1.524m) on each of six (6) axes, +/-X, +/-Y, and +/-Z, without any damage when packaged.

Conformal Coating

As an option, the user can choose to have a conformal coating applied to the electronic circuitry of the SSD to further protect against moisture, dust, chemicals and temperature extremes. The material coating may actually reduce the effects of mechanical stress and vibration on the circuitry.

The coating material should achieve an approximate thickness of between 50 and 100 micrometers after curing. A thicker coating may be required when liquid water is present due to microscopic pinhole formation when the coating material thins on the sharp edges of the components. Enough material is applied to completely cover the components to a depth equal to or greater than the highest metallic conductor on the PCB.

The conformal coating physical characteristics meet IPC-CC-830 regulations for the qualification and performance of electrical insulating compounds for printed wiring assemblies. The workmanship standard is in accordance with IPC-A-610, Section 10.5.2.

The HumiSeal 1B31 Acrylic coating is applied to both sides of the PCB, and masks the connector body and pins of connectors J2, J400, J401, J402, and the component topsides of U417 and U418. *See Figure 12.*
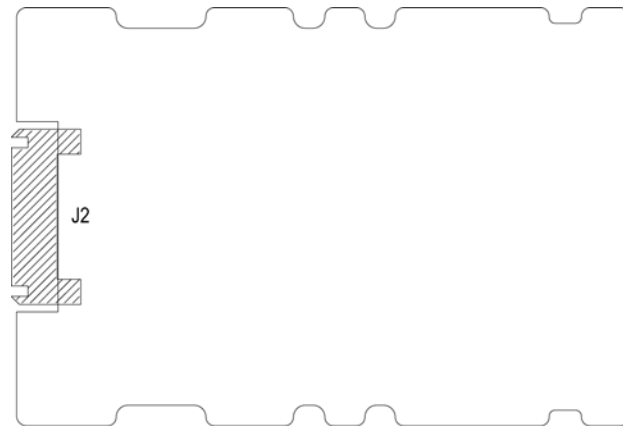
Top Side
(This side faces the bottom side of the frame.)
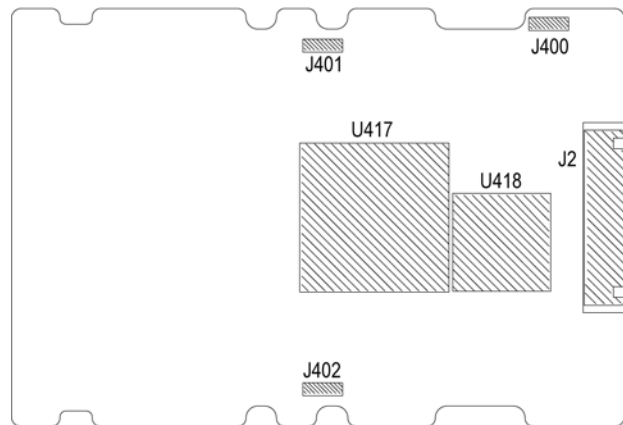
Bottom Side
(This side faces the top side of the frame.)

Figure 12. *Conformal Coating Application*

INSTALLATION

System Requirements

There is a risk of electrocution! Use extreme caution when handling the solid state drive and while connecting it to a power source. Observe all applicable safety rules while installing the solid state drive. Make sure to read and thoroughly understand this section before attempting to install the drive.

SCSI Connections

The Zeus 3.5-inch Fibre Channel SSD can be installed in operating system environment that supports SCSI-3 or greater devices (Zeus Fibre Channel SSDs are intended to be compliant to future SCSI-4 standards). If the system does not have a Fibre Channel AL-Port, the user will need to supply and install an adapter before proceeding with the installation. If the system fails to recognize the drive, make sure the most recent drivers for the host adapter are installed. If the drive is connected to the motherboard, the drivers are provided by the motherboard manufacturer. Changes to the operating system are not required: Zeus SSDs support all ATA and ATAPI devices, including CDs, DVDs, tape devices, high-capacity removable devices, Zip drives and CDRWs.

Make sure you have the following before installing the Zeus SSD:

- Phillips screwdriver
- Six 6-32 UNC machine screws
- SCSI interface cable, 39 inches (1 meter) maximum length
- Operating system with FAT32 or NTFS
- Computer with Fibre Channel connector on motherboard or installed Fibre Channel host adapter
- Available 5V power source

Loop Initialization

Low-level formatting is not needed. Set a unique AL-PA on the backplane or the adapter for the drive. The drive will inherit this hard address when plugged into the loop. The loop will signal an alert if the user-selected hard address is not unique on the loop. If you cannot find a unique hard address, set the AL-PA to zero and the loop will assign a soft address for the drive.

Mount the drive with its axes in any orientation. Once the drive is mounted and plugged into the backplane, the drive will perform the POST (Power On Self Test). After the drive becomes ready, and if a bypass circuit (if used) is enabled, the loop will initiate. After the loop initiates, the drive is ready for use by the operating or network system.

Connector Requirements

Table 45 lists the recommended connectors that should be used with the Zeus 3.5-inch SSD.

Table 45.   Recommended Connectors

Drive Side Connector	Molex 87641-1012
Recommended Mating FPC	
Width	TBD
Thickness	TBD
Length	TBD
Impedance	50 Ohm Typical
Plating	Gold over Nickel
Adhesive	Heat Hardened
Durability	TBD (TBD) Insertions
Operating Temperature	-40°C to +85°C

Drive Orientation

The Zeus SSD can be installed in any number of orientations within the enclosure. The drive will operate and meet all the requirements as outlined in this specification regardless of the mounting orientation. *See Figure 13.*
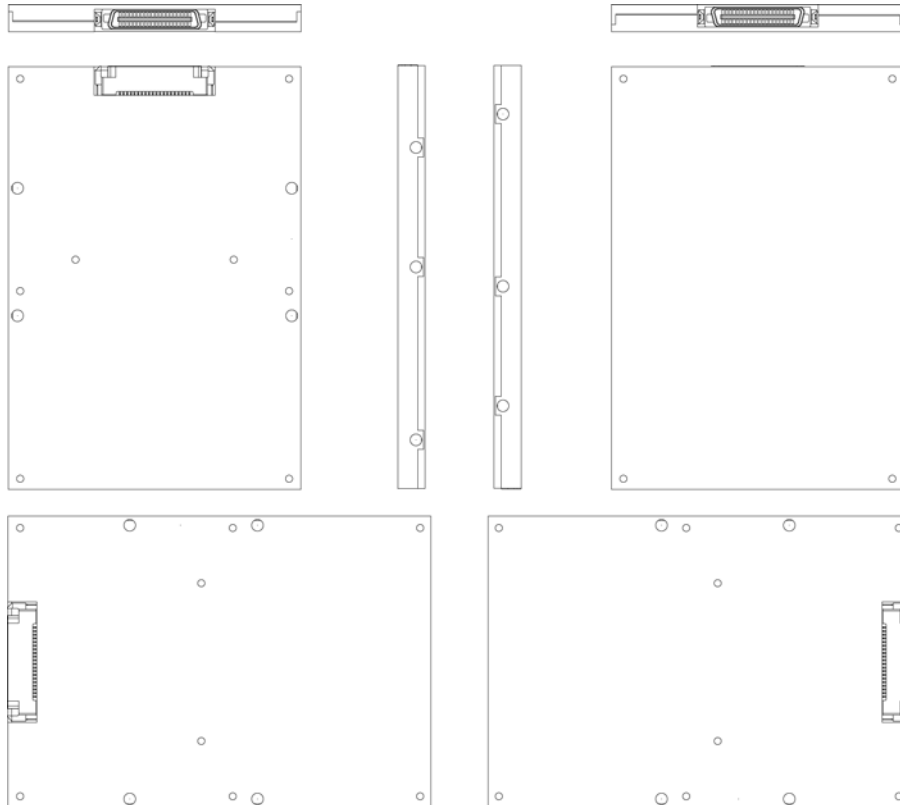
Figure 13.   Possible Drive Orientations

Cooling Requirements

If necessary to maintain the required operating temperature range, the host enclosure may remove heat by conduction, convection, or other forced air flow. Four suggested air flow patterns are shown in *Figure 14*.

Air flows above drive:

Air flows below drive:
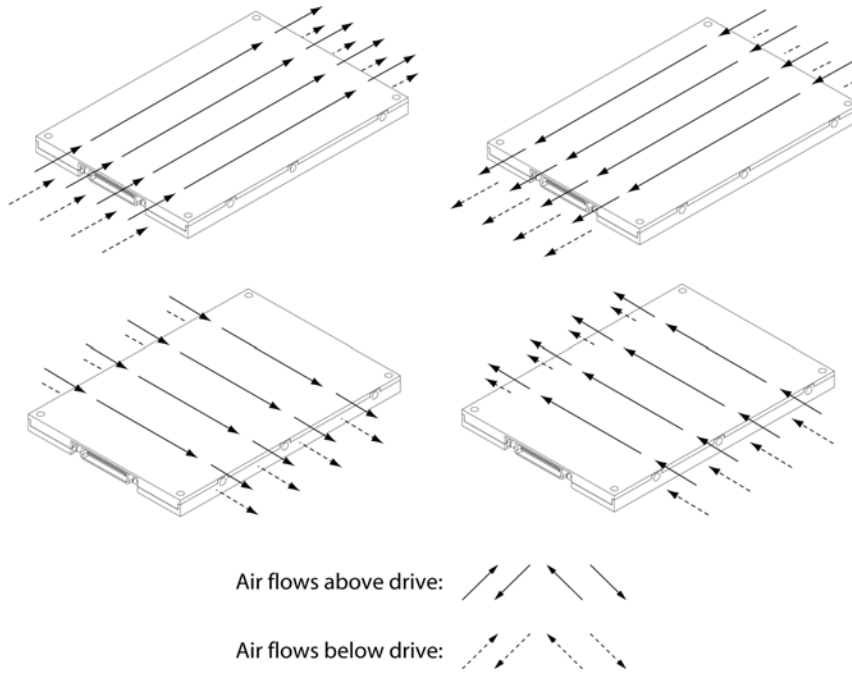
Figure 14.   *Suggested Air Flow Patterns for Cooling*

Mounting Dimensions

Figure 15 shows the exterior dimensions of the 3.5-inch form factor with the relative dimensions of the mounting holes. Careful attention should be made to the length of the mounting screws and the recommended torque to prevent damage to the enclosure.
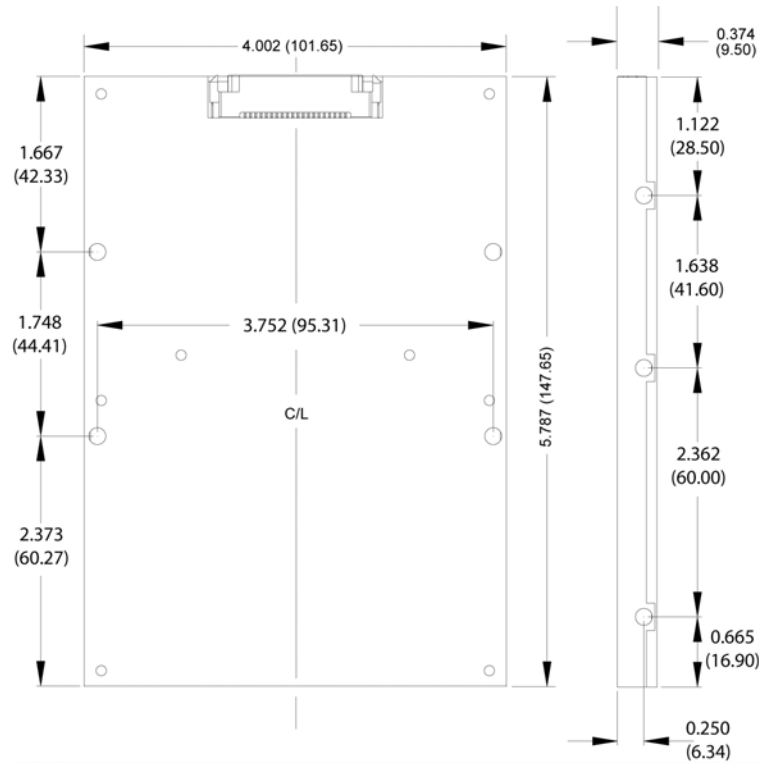
Figure 15.   Exterior Mounting Specifications

Side Mounting Holes, 6 places, 6-32 thread	
Maximum Screw Penetration	0.16 in (4mm)
Recommended Torque	6.0 in-lbs (0.675 N-m)
Bottom Mounting Holes, 4 places, 6-32 thread	
Maximum Screw Penetration	0.16 in (4mm)
Recommended Torque	6.0 in-lbs (0.675 N-m)

Drive Installation

Electro Static Discharge or ESD can seriously damage the electronic components of the host system and solid state drive. It is very important to discharge any static electricity before you begin the installation procedure. You can touch an unpainted, grounded metallic surface to discharge any static charges that may be present on your body or clothing. As an alternative, you can also use an ESD protective wrist strap. You can minimize the possibility of damage due to ESD by avoiding physical contact with the electronic components.

To install the Zeus Fibre Channel SSD in a PC or host system:

1   Power down the computer/host system and remove the access cover.

2   Position the Zeus SSD in an available drive bay or choose a suitable mounting location.

3   Connect one end of the cable to the Zeus SSD and the other end of the cable to the Fibre Channel adapter on the host. *The connector on the drive is keyed to ensure that the signal and power connections to the drive are correctly oriented.*

4   Secure the Zeus SSD within the drive bay or to the mounting surface using 6-32 machine screws. Apply sufficient torque to ensure that the drive is secure.

   Note: Be aware of the depth of the drive's mounting holes. The maximum penetration depth of the drive's mounting holes is indicated in *Figure 15* on page 67. You may mount the drive using the side or bottom mounting holes. It is recommended that you secure the drive with a least four screws. To avoid damaging the drive, consider the thickness of the mounting surface when deciding on the screw length to use.

5   Replace the access cover and power on the computer.

Grounding Requirements

No special grounding circuitry is required. Pins 6, 22, 23, 26, 29, 32 and 35 serve as Ground signals of the Fibre Channel connector configuration. The signal and chassis grounds are not connected together in the drive. The user should provide maximum surface contact area when connecting the drive to the chassis ground to ensure minimal electromagnetic (EM) emissions.

Operating System Requirements

The Zeus SSDs are compatible with Microsoft Windows® and alternative operating systems. The SSDs are low-level formatted at the factory. However, the SSDs must be partitioned and high-level formatted. The SSDs can be formatted as boot drives or data storage drives using any standard disk partitioning and formatting utility.

Microsoft OS Compatibility

The Zeus SSDs are fully compatible with the following Microsoft operating systems, using the native drivers supplied with the OS:

- Windows 2000, Service Packs 2, 3 and 4
- Windows 2000 Server, Advanced Server
- Windows XP Home and Windows XP Professional, Service Packs 1 and 2
- Windows XP, 64-Bit Extended
- Windows 2003 Standard, Enterprise, 64-bit, Web, Datacenter, Small Business Server
- MS-DOS
- Windows Pre-boot Environment (WinPE)

The drives are compatible with the current version of MS-DOS real-mode drivers bundled with any of the Microsoft operating systems for reading files from optical media.

Alternative Operating Systems

The drives are fully compatible with the following operating systems, using the native drivers supplied with the OS:

- Red Hat Linux 2.1
- Red Hat Linux 3.0
- DRMK (Dell Real-Mode Kernel) DOS

System POST, Boot and Resume Times

The drive's effect on the time required for the system to POST, boot and resume under Microsoft Windows XP is minimized. Device implementation will target minimum impact to such. The drives also comply with the Microsoft Fast Boot/Fast Resume Requirement, which is <= 2.5 seconds for Resume from Standby (S3), <= 20 seconds for Resume from Hibernate (S4).

NAND Flash Support

The device will support multiple mutually agreed upon and approved NAND flash memory vendors prior to release to manufacturing for proposed capacities in the design without changes to the hardware or firmware. STEC Inc. develops firmware to support a wide range of NAND flash versions and vendors. Please contact STEC Inc. for a list of supported flash and flash vendors.

Diagnostic Software

The computer or system manufacturer is responsible for providing any diagnostic software or utilities.

SMART Specification

This section provides the SMART requirements for all Zeus Fibre Channel products. Unless specified, all SMART implementations will comply with the industry specifications. *Table 46* lists the default factor settings for the Zeus SSD.

Table 46.   Default SMART Settings

SMART Settings	Notebook Products
SMART Enable/Disable	Enabled
Offline Read Scan	Disabled
SMART Self Test	When power is lost or the drive is reset while the Drive Smart Self-Test Short (DST-Short) operation is in progress, the self-test status value will change to 20h. This will indicate that the DST operation was aborted.
SMART Write Log/Smart Read Log	The vendor will be consistent in the number of logs supported between the SMART Write Log and SMART Read Log. If the SMART Read Log maintains multiple logs, then the SMART Write Log will also support multiple logs. The same holds true for single log support.
Temperature Register in SMART ID 194	SMART ID 194 should be used to register the drive current temperature. The raw attribute should also include minimum and maximum temperatures the drive has experienced. Case temperature is measured in the location as previously described in this specification.

REGULATORY COMPLIANCE

Marking, Approvals and Supporting Documentation

Zeus SSDs will have the following marks, approvals and documentation as outlined in *Table 47.*

Table 47.   Regulatory Marks and Documentation

Mark/Approval	Documentation	Mark
UL	Electrical Equipment sold in the United States of America shall comply with the requirements of UL 1950 or other applicable UL standard and be marked (UL or other NRTL marking) accordingly. STEC Inc. will provide the Declaration of Conformity (DoC). UL Notice of Acceptance letter (with corresponding file number) indicating compliance with UL 60950-1.	Yes
CE	Electrical equipment sold in the European Economic Area (EEA) will comply with the requirements of CAN/CSA-C22.2 No 60950-1-03 and have the CE mark accordingly.	Yes
CSA (or ULc)	Electrical equipment sold in Canada will comply with the requirements of CAN/CSA-C22.2 No. 959-M98 or other applicable Canadian Standards Association standard and be marked (CSA, cUL) accordingly.	Yes
EU	In the European Community (European Union or EU), Information Technology Equipment (ITE) is governed within the EC (EU) by Directive 73/23/ECC ("Low Voltage Directive") for Product Safety and 89/336/EEC - Harmonized standards ("EMC Directive") EN55022, 1998 and EN55024, 1998 for Emissions and Immunity, and all applicable amendments. EC (EU) members are bound by its requirements. Equipment may demonstrate compliance with the directive by being approved to a recognized standard by an EC (EU) recognized agency such as TUV or VDE and a signed Declaration of Conformity, plus the CE mark on the device.	Yes
TUV/SEMKO/UL/etc.	Germany, being part of the EC, is bound by the Low Voltage and EMC Directive. In addition, Germany's Equipment Safety Law requires that equipment will be "... in accordance with the generally recognized rules of technology and the work safety and accident prevention regulations..." Equipment may demonstrate compliance with the directive by being approved to a recognized standard by an EC (EU) recognized agency such as TUV or VDE.STEC Inc. will provide CB Certificate and Test Report with the supporting Type Certificate (e.g., TUV Certificate, from the Agency that approved the CB Test Report)	No
MIC (Korea)	Certificate (with certification number)	Yes
BSMI (Taiwan)	Certificate (with corresponding applicant code number)	Yes
VCCI (Japan)	Certificate or Declaration of Conformity. Self declaration that the product has been evaluated in a VCCI compliant lab is sufficient.	Yes
C-TICK (Australia)	Declaration of Conformity (DoC) (with supplier code number) and a Letter of Authorization from supplier giving Dell permission to import and sell the product in Australia using STEC's C-TICK.	Yes
FCC	Federal Communications Commission Declaration of Conformity	Yes

Restriction of Hazardous Materials

STEC Inc. has adopted the RoHS Directive, also known as the Restriction of Hazardous Substances directive. Zeus SSDs are compliant with the European Parliament and Council Directive, i.e., assembled with Pb-free or lead-free components.

CB Certificate and CB Report

STEC Inc. will provide a complete CB Report. These documents will include the current and voltage ratings, and prove compliance with the currently applicable versions of IEC 60950-1:2001, Safety of Information Technology Equipment, including all national deviations.

STEC Inc. will also provide the EMC test report indicating compliance with the currently applicable versions of:

- EN-55022:1998 (Emissions)
- EN-55024:1998 (Immunity)
- PCC 47CFR Part 15, Class B

Declaration of Conformity

The Declaration of Conformity (DoC) will contain the following:

- Product type and model number
- Marks and countries (e.g., CE, FCC, C-Tick)
- The appropriate technical statement(s) required by the respective regulatory agencies
- STEC Inc. name and address
- STEC Inc. signature
- List of all applicable standards to which the drive conforms

Radio Frequency Emissions

The Zeus SSD has passed radiated emissions testing (10 meter chamber) with a minimum margin of 4dB below the EN55022 radiated emissions limits in all applicable customer platforms, without any required changes to the system platforms.

Emissions testing in a 3 meter chamber for over 1GHz per the FCC limit for Class B was performed up to 2GHz with the -4dB margin relative to the FCC Class B limit.

In preparation for the new CISPR 22 standard change that may go into effect in the year 2007, the drives will pass EMI tests up to the higher frequency of either 6GHz or the fifth harmonic of the highest signal on the drive. This requirement is applicable to all products being qualified after this version is released. The specification limits are listed in *Table 48*.

Table 48.   EMI Specification Limits

Class B	1 to 3 GHz is 50dB (uV/m) @ 3 m
Class B	3 to 6 GHz is 54dB (uV/m) @ 3 m

Radio Frequency Immunity Requirements

This specification is targeted as part of the design for quality and reliability expectations and is not part of the regulatory requirements. The SSDs meet the following radio frequency immunity requirements:

- 3 V/m over frequency range of 80 MHz to 1 GHz

- The signal will be amplitude modulated with a 1KHz sine wave to a depth of 80%

- Failure criteria:

  - More than 10% throughput degradation

  - Test setup will follow the procedures in the customer's HDD Radio Frequency Immunity Characterization Requirements

EMI Test Site Correlation

STEC Inc. will only use EMI test sites that are currently correlated with the customer's test facilities. STEC Inc. will contact the customer's engineering staff for the list of approved laboratories.

Verification Samples

STEC Inc. will submit the three worst-case drives used to obtain the emissions test data previously obtained from the customer's test facilities for verification testing. The Regulator Engineer will use these drive samples, and others among those submitted for qualification, for emissions verification in the customer's systems.

Verification Testing

Verification testing will be performed by the customer's Compliance Peripheral Group.

Electrostatic Discharge (ESD)

The SSD will meet the ESD limits specified in the 61000-4-2 guidelines and the customer's enhanced ESD procedure. The specification will determine whether the contact or air discharge method should be used. Performance degradation is defined as a decreased throughput rate. No data errors are allowed. *Table 49* lists the ESD requirements.

Table 49.   ESD Requirements

Climatic Conditions		
Ambient Temperature	15°C to 35°C	
Relative Humidity	30% to 60%	
Atmospheric Pressure	86kPa (860 millibar) to 106 kPa (1,060 millibar)	
Voltage Level	Discharge Type	Pass/Fail Performance Criteria
+/-2 kV	Contact	A
+/-4 kV	Contact	B
+/-6 kV	Contact	B
+/-8 kV	Contact	C
+/-2 kV	Air	A
+/-4 kV	Air	A
+/-8 kV	Air	B
+/-12 kV	Air	B
+/-15 kV	Air	C

Acceptance Criteria Definitions

The following table lists the acceptance criteria definitions for the ESD limits.

Table 50.   Acceptance Criteria Definitions

A	The apparatus will continue to operate as intended, i.e., normal unit operation with no degradation of performance.
B	The apparatus will continue to operate as intended after completion of the test. However, during the test, some degradation of performance is allowed, provided there is no data lost or operator intervention to restore apparatus function.
C	Temporary loss of function is allowed. Operator intervention is acceptable to restore apparatus function.

Note: Hardware failures are not acceptable for any level of the above performance criteria.

CONTACT AND ORDERING INFORMATION

Contacting STEC

For more information on Zeus Solid State Drives, contact the STEC Solid State Drive Team.

Telephone:	800-796-4645 (Toll free; US and Canada only)
All Others:	(949)260-8345
Fax:	(949) 851-2756
E-mail:	ssd@stec-inc.com

Ordering Information

Part Number   Description

Z ## F 3 ## (T) (U) (C)(Z)(P)(M) (XXX) (Example: Z4F340IUCZPM)

Customer Identifier

Optional Features

Contact STEC

RoHS Compliance

U = Lead-free product

Blank = Non-compliant

Temperature

C = Commercial

I = Industrial

Capacity

10 = 10 Gigabytes

40 = 40 Gigabytes

80 = 80 Gigabytes

Form Factor

3 = 3.5-inch

Interface

F = Fibre Channel

Number of Channels

Contact STEC

Product Family

Z = Zeus

ACRONYMS AND ABBREVIATIONS

A

ARM (Advanced RISC Machine) <processor> (ARM, Originally Acorn RISC Machine). A series of low-cost, power-efficient 32-bit RISC microprocessors for embedded control, computing, digital signal processing, games, consumer multimedia and portable applications.

ATA (AT Attachment) The IDE interface is officially known as the ATA specification. ATA-2 (Fast ATA) defined the faster transfer rates used in Enhanced IDE (EIDE). ATA-3 added interface improvements, including the ability to report potential problems (see S.M.A.R.T.). Starting with ATA-4, either the word "Ultra" or the transfer rate was added to the name in various combinations. For example, at 33 MBytes/sec, terms such as Ultra ATA and ATA-33 have been used. In addition, Ultra ATA-33, DMA-33 and Ultra DMA-33 are also found.

B

Bad-Block Mapping Also known as Bad-Sector Mapping. Bad-block mapping is a process implemented by the manufacturer, firmware or operating system that prevents data from being written to damaged sectors of a disk drive. Usually bad-blocks are mapped and identified during the manufacturing process, thereby preventing data from being written into the faulty sectors.

BIST (Built-In Self Test) A test performed by the disk drive during the power-on phase to confirm that all microcontroller and memory operations are functioning correctly.

C

CFA (Computer Fraud and Abuse Act of 1986) The CFA is a series of laws that penalize the unauthorized access to computer systems and networks. The Act applies to "federal interest computers" which include systems used by the U.S. government, as well as most financial institutions. The Act makes unauthorized penetration or other damage to such systems a felony.

CHS Cylinder, Head, Sector. A disk-drive system and method for generating logical zones that each have an approximate number of spare sectors, and that are used to translate logical block addresses.

CISC (Complex Instruction Set Computer) Pronounced "sisk". The traditional architecture of a computer that uses microcode to execute very comprehensive instructions. Instructions may be variable in length and use all addressing modes, requiring complex circuitry to decode them.

D

DMA (Direct Memory Access) Specialized circuitry or a dedicated microprocessor that transfers data from memory to memory without using the CPU. Although DMA may periodically steal cycles from the CPU, data are transferred much faster than using the CPU for every byte of transfer.

DoD (Department of Defense) The military branch of the U.S. government, which is under the direction of the Secretary of Defense, the primary defense policy adviser to the President.

DSL (Digital Subscriber Line) A technology that dramatically increases the digital capacity of ordinary telephone lines (the local loops) into the home or office. DSL speeds are tied to the distance between the customer and the telco central office (CO). DSL is geared to two types of usage. Asymmetric DSL (ADSL) is for Internet access, where fast downstream is required, but slow upstream is acceptable. Symmetric DSL (SDSL, HDSL, etc.) is designed for short haul connections that require high speed in both directions.

DSLAM (DSL Access Multiplexer) A central office (CO) device for ADSL service that combines voice traffic and DSL traffic onto a customer's DSL line. It also separates incoming phone and data signals and directs them onto the appropriate carriers network.

E

EDC/ECC (Error Detection Code/Error Correction Code) A memory system that tests for and corrects errors automatically, very often without the operating system being aware of it. When writing the data into memory, ECC circuitry generates checksums from the binary sequences in the bytes and stores them in an additional seven bits of memory for 32-bit data paths or eight bits for 64-bit paths. When data are retrieved from memory, the checksum is recomputed to determine if any data bits have been corrupted. Such systems can typically detect and automatically correct errors of one bit per word and can detect, but not correct, errors greater than one bit.

F

FPGA (Field Programmable Gate Array) A type of gate array that is programmed in the field rather than in a semiconductor fabrication facility. Containing up to hundreds of thousands of gates, there are a variety of FPGA architectures on the market. Some are very sophisticated, including not only programmable logic blocks, but programmable interconnects and switches between the blocks. The interconnects take up a lot of FPGA real estate, resulting in a chip with very low gate density compared to other technologies.

H

HDD (Hard Disk Drive) The primary computer storage medium, made of one or more aluminum or glass platters, coated with a ferromagnetic material. Most hard disks are "fixed disks," which have platters that reside permanently in the drive.

I

I/O (Input/Output) Transferring data between the CPU and a peripheral device. Every transfer is an output from one device and an input into another.

IDE (Integrated Drive Electronics) A type of hardware interface widely used to connect hard disks, CD-ROMs and tape drives to a PC. IDE was always the more economical interface, compared to SCSI. Starting out with 40MB capacities years ago, 40GB IDE hard disks have become entry level, costing a fraction of a cent per megabyte.

L

LBA (Logical Block Addressing) A method used to support IDE hard disks larger than 504MB (528,482,304 bytes) on PCs. LBA provides the necessary address conversion in the BIOS to support drives up to 8GB. BIOS after mid-1994, which are sometimes called "Enhanced BIOS," generally provide LBA conversion. LBA support is required for compatibility with the FAT32 directory.

LSB (Least Significant Byte) "Byte" defines a sequence of 8-bits, with the right-most bit being the least significant and the left-most bit being the most-significant.

LSW (Least Significant Word) "Word" denotes sequence of 4 bytes, or 32 bits, with the left-most being the least significant, and the right-most being the most significant. "Double-word" denotes sequence of two words, or 64 bits, with the left most word being the least significant, and the right-most - the most significant. Note, that the definition of "word" defines a little-endian scheme, so for big-endian platforms, or network applications, special steps need to be taken to reorder the bytes form the input stream.

M

MLC (Multi-Level Cell) A flash memory technology that stores more than one bit of data per cell. Traditional flash memory defines a 0 or 1 bit according to a single voltage threshold. The patterns of two bits (0-0, 0-1, 1-0, and 1-1) can be achieved with four voltage levels and eight levels of voltage can yield all the combinations in three bits.

MSB (Most Significant) "byte" defines a sequence of 8-bits, with the right-most bit being the least significant and the left-most bit being the most-significant.

MSW (Most Significant Word) "Word" denotes sequence of 4 bytes, or 32 bits, with the left-most being the least significant, and the right-most being the most significant. "Double-word" denotes sequence of two words, or 64 bits, with the left most word being the least significant, and the right-most - the most significant. Note, that the definition of "word" defines a little-endian scheme, so for big-endian platforms, or network applications, special steps need to be taken to reorder the bytes form the input stream.

N

NAND (Not AND) A Boolean logic operation that is true if any single input is false. Two-input NAND gates are often used as the sole logic element on gate array chips, because all Boolean operations can be created from NAND gates.

P

PIO (Programmed Input/Output) The data transfer mode used by IDE drives. PIO modes use the registers of the CPU for data transfer in contrast with DMA, which transfers directly between main memory and the peripheral device.

R

RISC (Reduced Instruction Set Computer) A computer architecture that reduces chip complexity by using simpler instructions. RISC compilers have to generate software routines to perform complex instructions that were previously done in hardware by CISC computers. In RISC, the microcode layer and associated overhead is eliminated.

S

SATA (Serial AT Attachment) The evolution of the ATA (IDE) interface that changes the physical architecture from parallel to serial and from master-slave to point-to-point. Unlike parallel ATA interfaces that connect two drives; one configured as master, the other as slave, each Serial ATA drive is connected to its own interface.

SLC Single-Level Cell A flash memory technology that stores one bit of data per memory cell; supporting only two states: erased (1) or programmed (0).

SMART (Self-Monitoring Analysis and Reporting Technology) An "early warning system" for anticipating pending drive problems. The drive's integrated controller works with various sensors to monitor several aspects of the drive's performance. Using this status information, SMART determines if the drive is behaving normally or not, and then makes the information available to software that probes the drive.

SSD (Solid State Disk) A disk drive that uses memory chips instead of rotating platters for data storage. Used in battery-powered handheld devices as well as desktop computers and servers, solid state disks (SSDs) are faster than regular disks because there is zero latency (there is no read/write head to move). They are also more rugged than hard disks and offer greater protection in hostile environments.

T

True-IDE Flash memory devices (such as CF cards) have a pin that when connected to the proper voltage at power-up selects the "True-IDE" mode of operation instead of the "PC-CARD-ATA" mode of operation. This is the mode used in the interface.

U

Ultra ATA An enhanced version of the IDE interface that transfers data at 33, 66 or 100 Mbytes/sec. These enhancements are also called "Ultra DMA," "UDMA," "ATA-33," "ATA-66," "ATA-100," "DMA-33," "DMA-66" and "DMA-100."

Ultra DMA (see Ultra ATA)

W

Wear-Leveling Wear-leveling is a process implemented by the manufacturer, firmware or operating system that ensures that the write/erase cycles are evenly distributed across all the flash memory block locations. Wear-leveling prevents repeated writes to the same physical flash memory location, thereby preventing premature wear.

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CERTIFICATION AND WARRANTY

FCC Declaration of Conformity

Zeus Solid State Drives carry the FCC Mark in accordance with related Federal Communications Commission (FCC)-USA directives. This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

- This device may not cause harmful interferance.

- This device must accept any interferance received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Re-orient or relocate the receiving antenna.

- Increase the separation between equipment and receiver.

- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

Consult the dealer or experienced radio/television technician for help.

Modifications made to this device that are not approved by STEC will void the authority granted to the FCC to operate this equipment.

Limited Warranty

STEC, Inc., ("STEC") Fibre Channel Solid State Drives ("SSD") are warranted against defects in material and workmanship, and will operate in substantial conformance with their respective specifications under normal use and service for a period of five (5) years from the date of shipment. Subject to the conditions and limitations set forth below, STEC will, at its own option, either repair or replace any defective SSD product that proves to be defective by reasons of improper workmanship or materials, if the buyer notifies STEC of such failure within the stated warranty period. Products repaired or replaced during the applicable warranty period shall be covered by the foregoing warranties for the remainder of the original warranty period or ninety (90) days from the date of reshipment, whichever is longer. Parts used to repair products or replacement products may be provided by STEC on an exchange basis, and will be either new or refurbished to be functionally equivalent to new.

STEC INC. DISCLAIMS ALL OTHER WARRANTIES, EITHER EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, WITH RESPECT TO ITS PRODUCTS AND ANY ACCOMPANYING WRITTEN MATERIALS. FURTHER, STEC INC. DOES NOT WARRANT THAT SOFTWARE WILL BE FREE FROM DEFECTS OR THAT ITS USE WILL BE UNINTERRUPTED OR REGARDING THE USE, OR THE RESULTS OF THE USE OF THE SOFTWARE IN TERMS OF CORRECTNESS, ACCURACY, RELIABILITY OR OTHERWISE.

STEC INC. is not responsible for updates or functionality of third-party software. Software is provided with notices and/or licenses from third parties which govern your use.

Modifications

Any changes or modifications made to this device that are not expressly approved by STEC INC. will void the user's warranty. All wiring external to the product should follow the provisions of the current edition of the National Electrical Code.