Zeus^{IOPS} Fibre Channel 3.5-Inch Solid State Drive Product Manual

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MANUAL 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 an electrical shock that may harm or otherwise prove fatal to the user.

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.

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.

REVISION HISTORY

Revision Status Summary Sheet

Revision	Date	Sheet(s) Affected
0.1	11/30/2006	All. Initial release.
1.0	02/16/2007	Official release.

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SCOPE

Figure 1. *The Zeus^{IOPS} 3.5-Inch Fibre Channel Solid State Drive*

MANUAL OVERVIEW

This product manual describes the applications, specifications, and installation of the 3.5-inch Zeus^{IOPS} Fibre Channel Solid State Drive (SSD). *See Figure 1*. The contents of this product manual can be quickly ascertained by reviewing the abstracts described under the *Scope* section.

PRODUCT IDENTIFICATION CODES

The Zeus^{IOPS} Fibre Channel SSD is available in four models. Each model has a product identification code (Product ID) associated with it. *Table 1* lists the product ID code of each drive and the approximate capacity.

Table 1. *Product ID Codes*

Product ID Code	Capacity (Approximate)
Z16F318C	18 Gigabytes
Z16F336C	36 Gigabytes
Z16F373C	73 Gigabytes
Z16F3146C	146 Gigabytes

AUDIENCE

This manual is intended for system engineers or system designers employed by an Original Equipment Manufacturer (OEM). This product manual 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 this manual, is primarily concerned with industrial, commercial or military applications.

CAUTION: This device can be damaged by Electrostatic Discharge (ESD). When handling the device, always wear a grounded wrist strap and use a static dissipative surface.

Any damage to the drive that occurs after its removal from the shipping package and ESD protective bag is the responsibility of the user.

STANDARDS AND REFERENCE DOCUMENTS

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

STANDARD FEATURES

This section lists the standard features of the Zeus^{IOPS} 3.5-inch Fibre Channel SSD.

PRODUCT DESCRIPTION

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

PERFORMANCE CHARACTERISTICS

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

ELECTRICAL SPECIFICATIONS

This section describes the power requirements and power consumption parameters of the Zeus^{IOPS} 3.5-inch SSD.

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^{IOPS} 3.5-inch Fibre Channel SSD. This section also provides a table of the SCSI commands implemented on the Zeus^{IOPS} 3.5-inch Fibre Channel SSD, followed by subtopic discussing the use of each command.

Fibre Channel Standard

This section discusses the implementation of the Fibre Channel Arbitrated Loop (FC-AL) specific to the Zeus^{IOPS} 3.5-inch Fibre Channel SSD.

Installation

This section discusses issues relating to the installation of the SSD in a server 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^{IOPS} 3.5-inch Fibre Channel SSD.

Standards and Reference Documents

This section discusses various standards for electronic products, and how those standards apply to the Zeus^{IOPS} 3.5-inch Fibre Channel SSD.

Electromagnetic Susceptibility

The Zeus^{IOPS} 3.5-inch Fibre Channel SSD is intended for installation by the user in an appropriate enclosure, i.e., a server or alternate enclosure. The enclosure must be designed so that the use of the drive does not impair nearby electronic equipment within the same enclosure and external to the enclosure.

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.

Reference Documents

The following list of ANSI Fibre Channel documents relate to the Zeus^{IOPS} 3.5-inch 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^{IOPS} 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 2.1250/1.0625 Gb/s Fibre Channel Arbitrated Loop-2 host interfaces
- Dual-ported operation support
- Full-duplex operation support
- Unique worldwide name for connection to a fabric
- FCP-SCSI protocol
- “Hot plugging” support

PERFORMANCE

- Maximum Read of 200 Mbytes/sec
- Maximum Write of 100 Mbytes/sec
- Cache of 512MBytes
- Command queuing of up to 512 commands
  (256 commands per port)
- Background processing of queue

PHYSICAL CHARACTERISTICS

- 3.5-inch standard form factor
  5.787 inch x 4.004 inch x 1.00 inch (146.0 mm x 101.6 mm x 25.4 mm)
- Light-weight aluminum alloy case, less than 0.947 lbs. (430 grams)

MEDIA CHARACTERISTICS

- Single Level Cell (SLC) flash memory
- Wear-leveling algorithm
- ECC correction

FIRMWARE UPGRADES

- Download upgrades via the Fibre Channel interface

UNFORMATTED CAPACITIES

- 18, 36, 73 and 146 Gigabytes

RELIABILITY

- Data Retention of 10 years
- Bad Block mapping
- Patented wear-leveling algorithm
- 16-bit CRC for added data security and error prevention
- EDC/ECC algorithms
- Solid-state design (no electromechanical failures)
- Rugged aluminum alloy case
- 5 year warranty

ENVIRONMENTAL CHARACTERISTICS

- Operating Temperature Range
  - Commercial range of 0°C to 55°C
- 0dB Noise Amplitude

POWER

- Input Voltage: +12 V DC ± 10%
- Typical consumption:
  - Idle/Standby of 5.4W
  - Read of 8.4W
  - Write of 8.1W

PRODUCT DESCRIPTION

GENERAL DESCRIPTION

The Zeus^{IOPS} 3.5-inch Fibre Channel Solid State Drive (SSD) incorporates advanced Single-Level Cell (SLC) NAND flash memory technology to deliver a state-of-the-art, non-volatile mass storage device. The interface is fully SCSI compliant and conforms to the same mechanical and mounting requirements as a standard rotating disk drive. The SSD is an easy-to-install, drop-in replacement for standard SCSI-compliant hard disk drives (HDDs). No additional device drivers are required to fully support the drive as a boot or data storage device.

FIBRE CHANNEL INTERFACE

The SSD can be installed in any operating system environment that supports FCP-4 devices. 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 fabric-switched and arbitrated-loop network topologies.

DRIVE CAPACITIES

Zeus^{IOPS} 3.5-inch SSDs are available with unformatted memory capacities of 18, 36, 73 and 146 gigabytes. The SSDs are ideal for applications that require high reliability and high tolerance to shock, vibration, humidity, altitude and temperature. Since there are no moving parts, the SSDs are completely maintenance-free.

PERFORMANCE

The SSDs can operate at sustained data transfer rates of up to 200 megabytes per second. The drives are capable of performing 50,000 random operations per second. Power consumption is kept to a minimum; the SSDs can be powered from a single 12-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).

DATA SECURITY

Zeus^{IOPS} SSDs offer erase and data sanitization (purge) features. Erase times vary according to the capacity of the drive. The drive can also be “sanitized”, thereby making data recovery impossible. See *Erase Times* and *Sanitize* on page 10.

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. Typically, the write/erase cycles for flash media ranges between 100,000 and 300,000. To extend the life of the SSD, special Wear-Leveling and Bad-Block Mapping algorithms are integrated into the firmware, increasing the overall endurance rating of the drive to 2,000,000 Write/Erase cycles.

WEAR-LEVELING ALGORITHM

The dynamic wear-leveling algorithm guarantees that erase/write cycles are evenly distributed across all 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 MANAGEMENT

The bad-block management scheme will detect faulty blocks during operation. Bad blocks are flagged in a defect list. Blocks within the defect list are excluded and are never used for data storage.

DATA RETENTION

Data stored on Zeus^{IOPS} SSDs will remain valid for ten (10) years without requiring power support. The unit can be stored at temperatures between -40^{0}C and 70^{0}C 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 8 random or 12 sequential bytes in 1,024 bytes. The possibility of undetected errors or incorrect correction is eliminated with additional CRC.

RELIABILITY

- DC power is maintained as specified in the product manual.
- Errors caused by host are excluded from rates.
- Errors from the same causes are counted as 1 block.
- Data stream is assumed random.

MOUNT TIME

The amount of time required to initialize and mount a Zeus^{IOPS} SSD varies according to the operating system (Windows®, Linux®, etc.) and the storage capacity of the drive.

ACCESS TIME

Unlike a magnetic rotating disk, the Zeus^{IOPS} SSD has no moving read/write head or platter. The access time ranges from 20µsec to 120µsec. The actual access time may be affected by the operating system and the storage capacity of the drive.

DATA TRANSFER RATES

The data transfer rates of the SSD are outlined in *Table 2*. Access times are measured under nominal temperature and voltages from a representative sample of the drive. The 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.

Table 2. *Data Transfer Rates*

Parameter	Value	Units
Average Access	20 - 120	µsec
Average Latency	0	m/sec
Sustained Read	200	Megabytes/sec
Sustained Write	100	Megabytes/sec
Duplex Burst Read	400	Megabytes/sec
Duplex Burst Write	400	Megabytes/sec
Minimum Sector Interleave	1:1	

ERASE TIMES

The time required to erase a Zeus^{IOPS} SSD varies according to the total capacity of the drive. The Erase utility will erase every physical memory storage location that can be accessed by the host interface. It will also destroy any saved messages. Once initiated, the SSD will be offline and the host will be unable to access the drive. Once the erase operation is completed the SSD will be restarted. If power ceases during this operation, the operation will be restarted when power is restored. *See Table 3*.

Table 3. *Erase Times*

Capacity	Erase Time
18 GB	30 sec
36 GB	60 sec
73 GB	120 sec
146 GB	240 sec

SANITIZE

For sensitive data that requires more stringent security measures, the SSDs are designed to comply with industry-standard data protection methods. The SSDs support the sanitize standards as detailed in DoD 5220.22-M, AFSSI 5020 and NSA 130-2. The Sanitize feature will erase every physical memory storage location and then will write data patterns to all possible NAND locations that are accessible to the host system. It will also destroy any saved messages. The time required to sanitize a Zeus^{IOPS} SSD varies according to the drive capacity and the sanitize type. Each sanitize type requires different levels of erase/write cycles. If power is lost during this operation, the operation will be restarted when power is restored. *See Table 4*.

Table 4. *Sanitize Times and Standards*

Standard	DoD 522.22-M	AFSSI 5020	NSA 130-2
Capacity	Minutes	Minutes	Minutes
18 GB	6	6	18
36 GB	12	12	36
73 GB	24	24	72
146 GB	48	48	144

Cache Operations

The Zeus^{IOPS} SSD is configured with 512 MB of cache. Write data can be flushed to the cache with the Synchronize Cache command.

Hot Plugging

The Zeus^{IOPS} 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 loop. It will synchronize with the device that is currently transmitting data to the SSD. All devices then go through loop initialization.
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 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 following voltage specification applies to the drive power connector. Connections to the drive should be made in a safety extra low voltage (SELV) circuit.

The drive *does not use* the +5V supply input pins available on a typical 40-Pin SCA-2 connector. The drive uses the +12V supply input. The 5V ground pins are connected to the common ground plane within the unit.

Adequate secondary over-current protection must be incorporated in the host system (drive enclosure, backplane, etc.). A 10 amp limit is required for safety purposes.

CAUTION: To avoid damage to the drive, power supply voltage transients must not exceed 16 volts.

POWER REQUIREMENTS

The Zeus^{IOPS} 3.5-inch Fibre Channel SSD requires a 12V +/-10% 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.

Table 5. *Zeus^{IOPS} 3.5-Inch SSD Power Requirements*

Item	Requirement
Input Voltage	12V +/-10%
Minimum Voltage	10.8
Maximum Voltage	13.2

POWER CONSUMPTION

Table 6. *Zeus^{IOPS} Fibre Channel SSD Typical Power Consumption*

Activity	Average Current (mA)	Average Power (W)
Startup	1,200	14.4
Idle	450	5.4
Max Read @ 200MB/sec	700	8.4
Max Write @ 100MB/sec	675	8.1
Read, 1 Block Random I/O @ > 50,000	525	6.3
Write, 1 Block Random I/O @ > 18,000	660	7.9

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.

FAULT LED OUT SIGNAL

The Fault LED Out signal is driven by an open collector driver capable of sinking 30mA. It is driven low when an internal fault is detected along with both Enable Bypass signals.

READY LED OUT SIGNAL

The Ready LED Out signal is driven by an open collector driver capable of sinking 30mA. It will typically be connected to the cathode of an LED in the enclosure. The Ready LED function is nearly identical to the SFF-8045 specification for hot-plugging implementations; however, since the drive has no motor, it behaves as follows:

- Drive not mated:
  The signal is de-asserted (i.e., High). The LED is off.
- Drive mated, power-up diagnostics in progress:
  The signal is asserted for 1/3 of a second and de-asserted for 2/3 of a second. This represents a *1Hz Short flash*.
- Drive mated, firmware running, drive in progress of becoming ready:
  The signal is asserted for one-half second and de-asserted for one-half second. This represents a *1Hz Normal flash*.
- Drive mated, firmware running and drive ready:
  The signal is asserted when either of the loops is brought up. The signal will de-assert when the drive is active on either of the fibre loops.

-PARALLEL ESI AND SEL_*n*/P_ESI_*n*

SEL_*n*/P_ESI_*n* are a set of dual purpose pins that are used to convey either a Loop Identifier address or Enclosure Service Information (where this is supported by the backplane) to the SSD.

-Parallel ESI determines the function of Sel_*n*/-P_ESI_*n*. It is a TTL open-drain output from the SSD.

When -Parallel ESI is de-asserted (high), the backplane must present SEL_ID information on SEL_*n*/P_ESI_*n*. *See SEL_ID Function*.

When -Parallel ESI is asserted (low), the backplane must present Enclosure Service Information (if supported) on SEL_*n*/P_ESI_*n*. *See SEL_ID Function* on page 16.

Note: The maximum response time to a change in state of -Parallel ESI is 1µS.

SEL_ID FUNCTION

The SEL_*n* (TTL compatible) inputs (defined when -Parallel ESI is de-asserted) provide a binary value of a loop identifier to the drive. These seven (7) signals define 128 possible values and are directly translated into an 8 bit hard Arbitrated Loop Physical Address (AL_PA). Only AL_PAs with neutral disparity are valid values. The drive will attempt to acquire this hard AL_PA during the LIHA phase of the Loop Initialization Process (LIP). *Table 7* lists the SEL_ID/AL_PA translation in hexadecimal format.

NOTE: An AL PA value of 0x00 is not valid for an NL_Port. A SEL_ID of 0x7F will force the SSD to obtain a soft address.

Table 7. *SEL_ID to AL_PA Translation*

SEL_ID	AL_PA	SEL_ID	AL_PA	SEL_ID	AL_PA	SEL_ID	AL_PA
00	EF	20	B2	40	72	60	3A
01	E8	21	B1	41	71	61	39
02	E4	22	AE	42	6E	62	36
03	E2	23	AD	43	6D	63	35
04	E1	24	AC	44	6C	64	34
05	E0	25	AB	45	6B	65	33
06	DC	26	AA	46	61	66	32
07	DA	27	A9	47	69	67	31
08	D9	28	A7	48	67	68	2E
09	D6	29	A6	49	66	69	2D
A	D5	2A	A5	4A	65	6A	2C
B	D4	2B	A3	4B	63	6B	2B
C	D3	2C	9F	4C	5C	6C	2A
D	D2	2D	9E	4D	5A	6D	29
E	D1	2E	9D	4E	59	6E	27
F	CE	2F	9B	4F	56	6F	26
10	CD	30	98	50	55	70	25
11	CC	31	97	51	54	71	23
12	CB	32	90	52	53	72	1F
13	CA	33	8F	53	52	73	1E
14	C9	34	88	54	51	74	1D
15	C7	35	84	55	4E	75	1B
16	C6	36	82	56	4D	76	18

17	C5	37	81	57	4C	77	17
18	C3	38	80	58	4B	78	10
19	BC	39	7C	59	4A	79	F
1A	BA	3A	7A	5A	49	7A	8
1B	B9	3B	79	5B	47	7B	4
1C	B6	3C	76	5C	46	7C	2
1D	B5	3D	75	5D	45	7D	1
1E	B4	3E	74	5E	43	7E	NA
1F	B3	3F	73	5F	3C	7F	SOFT

P_ESI_*n* FUNCTION

The SEL_N (TTL compatible) inputs and outputs (defined when -Parallel ESI is asserted) provide an interface between the enclosure and the drive. *Table 8* summarizes the signals.

Table 8. *SEL_N/P_ESI_N Signal Definitions*

-Parallel ESI (High)	-Parallel ESI (Low)
Sel_0 (Input)	P_ESI_0 (Input)
Sel_1 (Input)	P_ESI_1 (Input)
Sel_2 (Input)	P_ESI_2 (Input)
Sel_3 (Input)	P_ESI_3 (Input)
Sel_4 (Input)	P_ESI_4 (Input)
Sel_5 (Input)	P_ESI_5 (Input)
Sel_6 (Input)	-EFW (Input)

SFF-8045 ENCLOSURE SERVICE INTERFACE

The SFF-8045 Enclosure Service Interface defines 7 bits of enclosure status. This status is read by the drive, and presented to the Initiator, upon receipt of appropriate Receive Diagnostic command. The definitions of the status bits are vendor specific. The drive will not interpret the status. The drive assumes -EFW is status and treats it as if does the other P_ESI_n signals.

-ENBL_BYP CH1 AND -ENBL_BYP_CH2

These two signals are TTL outputs from the drive and provide 4mA of sink capability. The signals are intended to control the state of the loop port bypass circuit on the backplane. The drive powers up with these signals turned off. It is assumed that the backplane will provide a 1K ohm pull-down resistor that will ensure the drive is bypassed on the loop when it is not present, or when it is powering up. The drive will attempt to enable itself on both loops after a successful power up.

START_n MATED

These signals are used to control the motor spin on rotating media drives. Because the Zeus^{IOPS} SSD is a solid-state device and has no motor, these signals are ignored by the drive.

-DRIVE PRESENT

This signal is connected to the ground plane of the drive. The backplane can use this signal to detect the presence of the drive.

DEV_CTRL_CODE_X

The DEV_CTRL_CODE_2 through DEV_CTRL_CODE_0 signals provide a binary code to the drive to control functions such as FC link rate, Power Failure Warning (PFW) and Hard Reset. The control function is either identified by a code or a sequence of codes on the DEV_CTRL_CODE signals. *Table 9* lists the functions and the associated codes that use a decode value on the DEV_CTRL_CODE signals.

The Hard Reset function uses a sequence of values on the DEV_CTRL_CODE signals. The sequence is 5, 1, 3, 2, 3, 1 and 5. A drive detecting a valid Hard Reset sequence shall perform the equivalent of a power-on reset.

4.7K ohm pull-up resistors to 3.3V are provided on the drive for both DEV_CTRL_CODE_2, DEV_CTRL_CODE_1 and DEV_CTRL_CODE_0 to ensure that each signal is maintained in its high state unless a low is provided from the backplane.

Note: Please refer to the SFF-8045 Specification for more information.

Table 9. *DEV_CTRL_CODE_N Signal Definitions*

	DEV_CTRL_CODE_N		
Link Rate	CODE_2	CODE_1	CODE_0
1.0625 GHz	1	1	1
2.1250 GHz	1	1	0
Reserved	1	0	1
Reserved	1	0	0
Reserved	0	1	1
Reserved	0	1	0
Reserved	0	0	1
Power Failure Warning	0	0	0

INTERFACE SPECIFICATIONS

SSD OPERATION

The Zeus^{IOPS} Fibre Channel SSD is comprised of the following primary functional blocks: the SCA-2 interface connector, a Host FPGA, which contains a processor, NAND FPGA, NAND flash memory, and DRAM.

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

The FPGA NAND flash controller interfaces with the NAND flash chips and sequences the data flow between the DRAM and flash.

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

The controller will decode an incoming host command, and will configure the appropriate interrupts and status for the local microprocessor to handle various SCSI commands. For read and write transfer commands, there are hardware functions that minimize firmware overhead to enhance performance.

Read and Write commands have dedicated hardware functions that do not require firmware support, thereby increasing performance. Some commands may require the host controller to use external circuitry that do not involve the flash memory controller.

When a Read or Write operation is requested, the integrated DMA controllers transfer the Fibre Channel frames to and from the SSD DRAM.

SCSI Interface Block

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

SCA-2 Interface Connector

The 3.5-inch 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 2* shows the location of Pins 1, 20, 21 and 40 relative to the connector housing. *See Connector Pinout* on page 19.

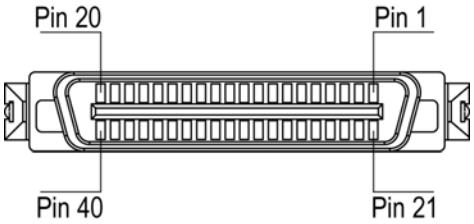


Figure 2. *SCA-2 Interface Connector*

CONNECTOR LOCATION

Figure 3 shows the relative location of the SCA-2 connector on the rear of the SSD. Please note the location of Pin 1 relative to the connector.

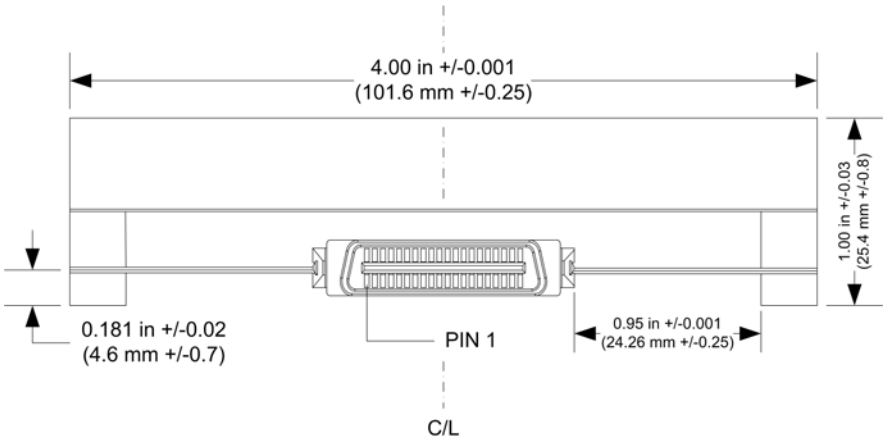


Figure 3. *Relative SCA-2 Connector Location*

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 SSD. Refer to *Table 10* for the 40-pin SCA-2 connector pin-out.

Table 10. *40-Pin SCA-2 Connector Pinout*

Pin	Signal Name	Signal Type	Pin	Signal Name	Signal Type
1	-ENBL BYP CH1	Low Voltage TTL Output	21	12V Charge	
2	12 Volts		22	12V Ground	GND
3	12 Volts		23	12V Ground	GND
4	12 Volts		24	+Port 1_In	Differential PECL Input Pair
5	-Parallel ESI		25	-Port 1_In	
6	-Drive Present	GND	26	12V Ground	GND
7	Ready LED Out	Open Collector Out	27	+Port 2_In	Differential PECL Input Pair
8	Power Control		28	-Port 2_In	
9	Start_1/Mated	TTL Input	29	12V Ground	GND
10	Start_2/Mated	TTL Input	30	+Port 1_Out	Differential PECL Output Pair
11	-ENBL BYP CH1	Low Voltage TTL Output	31	-Port 1_Out	
12	SEL_6/-EFW	TTL Input/Output	32	5V Ground	GND
13	SEL_5/-P_ESI_5	TTL Input/Output	33	+Port 2_Out	Differential PECL Output Pair
14	SEL_4/-P_ESI_4	TTL Input	34	-Port 2_Out	
15	SEL_3/-P_ESI_3	TTL Input/Output	35	5V Ground	GND
16	Fault LED Out	Open Collector Out	36	SEL_2/-P_ESI_2	TTL Input/Output
17	DEV_CTRL_CODE_2	TTL Input	37	SEL_1/-P_ESI_1	TTL Input/Output
18	DEV_CTRL_CODE_1	TTL Input	38	SEL_0/-P_ESI_0	TTL Input/Output
19	5 Volts		39	DEV_CTRL_CODE_0	TTL Input
20	5 Volts		40	5 Volts Charge	

Voltage and Ground Signals

The 12V contacts provide all the power required by the drive. The 5V Charge and 5 Volt contacts are not used. All 5V ground and 12V ground contacts are connected to the drive ground plane.

FC-AL FEATURES

LOOP CONNECTIONS

The Zeus^{IOPS} 3.5-inch Fibre Channel SSD features two independent FC-AL ports. These ports may be connected in different loops or the same loop. In addition, the drive can send transfers while receiving frames on both ports. This capability is called “full-duplex”.

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, the drive reads the settings from the connector. If the SCA connector is configured for a hard address, only one of the ports will be seen on the loop; only one port can acquire the ID.

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”.

Table 11 summarizes the FC-AL options supported by the drive.

Table 11. *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

SUPPORTED SCSI COMMANDS

Table 12 summarizes the SCSI commands supported by the Zeus^{IOPS} SSD. Command queuing is supported with all tag types (Head of Queue, Ordered Queue and Simple Queue). A maximum of 256 commands may be queued against each fibre channel port. This section only provides an overview of the SCSI commands supported by the Zeus^{IOPS} SSD. For more information, please consult the SCSI specification, *Fibre Channel Protocol - 3 (FCP-3), Project T10/1560D, ANSI INCITS 416-2006*.

NOTE: Linked SCSI commands are not supported. NACA does not apply to the Fibre Channel standard. As a result, all the Control bytes of all the commands are ignored.

Table 12. *Supported SCSI Commands*

Command Code	Command Name
A0h	Report Luns
00h	Test Unit Ready
08h	Read (6)
0Ah	Write (6)
12h	Inquiry
	Vital Product Data Page (00h)
	Unit Serial Number Page (80h)
	Device Identification Page (83h)
16h	Reserve (6). Obsolete, but supported.
17h	Release (6). Obsolete, but supported.
1Ah	Mode Sense (6)
1Dh	Send Diagnostics Page
4Dh	Log Sense
25h	Read Capacity
28h	Read Extended (10)
2Ah	Write Extended (10)
2Eh	Write and Verify (10)
2Fh	Verify (10)
3Bh	Write Buffer
35h	Synchronize Cache (10)
5Ah	Mode Sense (10)

56h	Reserve (10). Obsolete, but supported.
57h	Release (10). Obsolete, but supported.
5Eh	Persistent Reserve In
5Fh	Persistent Reserve Out

REPORT LUNS (A0h)

The REPORT LUNS command will request that the peripheral device logical unit inventory accessible to the I_T nexus be sent to the application client. The logical unit inventory is a list that shall include the logical unit numbers of all logical units having a Peripheral Qualifier value of 000b. Logical unit numbers for logical units with Peripheral Qualifier values other than 000b and 011b may be included in the logical unit inventory. Logical unit numbers for logical units with a Peripheral Qualifier value of 011b are excluded from the logical unit inventory. The Zeus^{IOPS} SSD only appears as a single LUN (Logical Unit Number). Byte 2 and Byte 11 are ignored.

Table 13. *Report Luns Command*

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (A0h)							
1	Reserved							
2	Select Report							
3	Reserved							
5								
6	(MSB)	Allocation Length						
9								(LSB)
10	Reserved							
11	Control							

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. Byte 5 is ignored..

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							

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.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. Byte 5 is ignored.

Table 15. *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							

WRITE (6) COMMAND (0Ah)

The WRITE (6) command requests that the target write the data transferred by the initiator to the medium. 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. Byte 5 is ignored.

Table 16. *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							

INQUIRY COMMAND (12h)

The INQUIRY command requests that information regarding parameters of the drive be sent to the initiator. Byte 5 is ignored. *See Tables 17 and 18*.

Table 17. *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 18. *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 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 19 and 20*.

Table 19. *Mode Sense CDB*

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (1Ah)							
1	Logical Unit Number (RSVD)			Reserve	DBD	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 20. *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	

SEND DIAGNOSTIC PAGE(1Dh)

The SEND DIAGNOSTIC command is a six byte CDB. The Parameter List Length is two bytes (Bytes 2 and 4). Bytes 1 through 5 are ignored.

Table 21. *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							

LOG SENSE COMMAND (4Dh)

The LOG SENSE command provides a method for the application client to retrieve statistical or other operational information maintained by the SCSI target device about the SCSI target device or its logical units. The command is complementary to the LOG SELECT command. The only LOG SENSE page code supported is 0x00. The PPC and SP bits (Bits 1 and 0 of CDB Byte 1) must be zero and the PC bits must select the cumulative values (CDB Byte 1 must be set to 0x40). Bytes 1, and 5 through 8, are not supported. The Drive will return a CHECK condition if non-zero. Byte 2 must be 0x40, as only cumulative values are supported.

Table 22. *Log Sense Command*

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (4Dh)							
1	Reserved						PPC	SP
2	PC		Page Code					
3	Reserved							
4								
5	(MSB)	Parameter Pointer						
6								(LSB)
7	(MSB)	Allocation Length						
8								(LSB)
	Control							

READ CAPACITY (25h)

The READ CAPACITY command provides a means for the initiator to request information regarding the capacity of the logical unit. Bytes 1 through 9 are ignored. If a Byte 8 is a non-zero, Illegal command will be returned.

Table 23. *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. Byte 1 and Byte 9 are ignored.

Table 24. *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. Bytes 1 and 9 are ignored.

Table 25. *Write Extended (10) (2Ah) 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							

WRITE AND VERIFY (10) (2Eh)

The WRPROTECT field and DPO and BYTCHK bits in CDB Byte 1 are all ignored.

VERIFY (10) (2Fh)

The VRPROTECT field in Byte 1 is ignored. If the DPO and BYTCHK bits in CDB Byte 1 are not both zero, or the GROUP NUMBER field in Byte 6 is non-zero, the command is rejected. If any bit in Byte 1 is set other than LUN, or if any bits in Bytes 6 and 9, an Invalid field in the CDB is reported.

WRITE BUFFER COMMAND (3Bh)

The WRITE BUFFER command is complementary to the READ BUFFER command as a diagnostic function for testing logical unit memory in the SCSI target device and the integrity of the service delivery subsystem.

Table 26. *Write Buffer Command (3Bh)*

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (3Bh)							
1	Reserved				Mode			
2	Buffer ID							
3	(MSB)	Buffer Offset						
5								(LSB)
6	(MSB)	Parameter List Length						
8								(LSB)
9	Control							

The only mode fields supported are:

Mode	Value	Description
5	05h	Download microcode and save.
7	07h	Download microcode with offsets and save.

SYNCHRONIZE CACHE (10) (35h)

The Logical Block Address and Number of Blocks fields are checked to ensure that the fields are in range, but are then ignored and considered set to zero. All outstanding data is written out to the non-volatile memory. The SYNC_NV and IMMED bits in CDB Byte 1 are ignored.

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. Byte 9 is ignored.

Table 27. *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 28. *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	

PERSISTENT RESERVE IN (5Eh) COMMAND

The PERSISTENT RESERVE IN (5Eh) command will obtain information about persistent reservations and reservation keys that are active within the device server. The command is complementary to the PERSISTENT RESERVE OUT (5Fh) command. Byte 9 is ignored for both commands.

Table 29. *Persistent Reserve In*

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (5Eh)							
1	Reserved				Service Action			
2	Reserved							
6								
7	(MSB)	Allocation Length						
8								(LSB)
9	Control							

PERSISTENT RESERVE OUT (5Fh) COMMAND

Table 30. *Persistent Reserve Out*

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (5Fh)							
1	Reserved				Service Action			
2	Reserved							
6								
7	(MSB)	Parameter List Length						
8								(LSB)
9	Control							

UNSUPPORTED COMMANDS

Table 31 lists the mandatory commands that are not supported by the Zeus^{IOPS} drive.

Table 31. *Unsupported Mandatory Commands*

Command	Command Code	Description
Request Sense	03h	Device returns sense data with every failed command as part of response information.
Format Unit	04h	The device must be formatted using provided utility.

FIBRE CHANNEL STANDARD

The Fibre Channel standard has coined various terms that are important to know when using the Zeus^{IOPS} 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

The “Fibre” or “link” refers to 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^{IOPS} SSD is a node with two ports that is linked with a copper cable, or fibre.

Nodes are connected in a “topology”. The SSD may be connected to an “Arbitrated Loop” (AL), where the nodes of the loop are connected in a circle. *See Figure 4*.

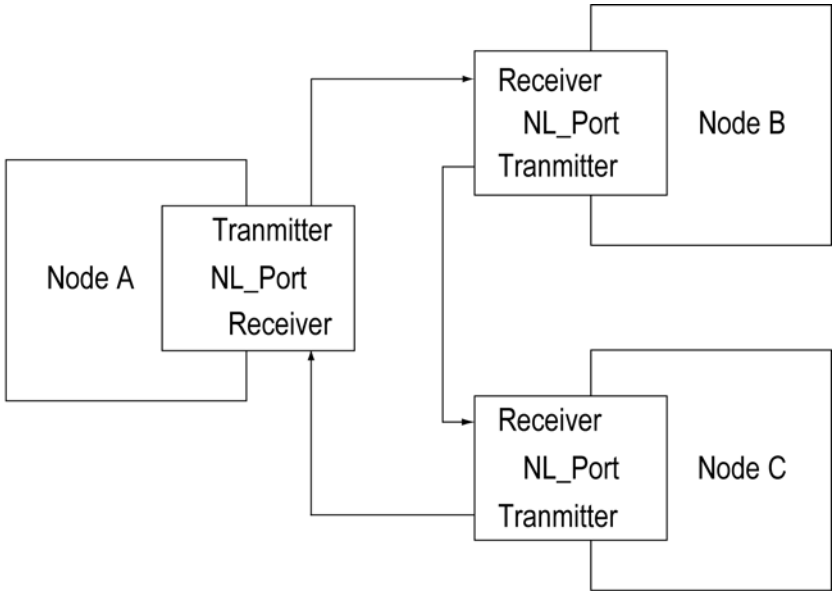


Figure 4. *Arbitrated Loop Topology Connection*

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 when 10-bit encoded. 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 to the on a loop, but only 126 will be functional, with the remaining unable to obtain valid addresses.
4. If the AL-PA of a device is not unique on the loop, the device will not participate on the loop. 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^{IOPS} SSD can also be connected to a “fabric” where any node on the fabric can connect to any other node in the fabric. *See Figure 5*.

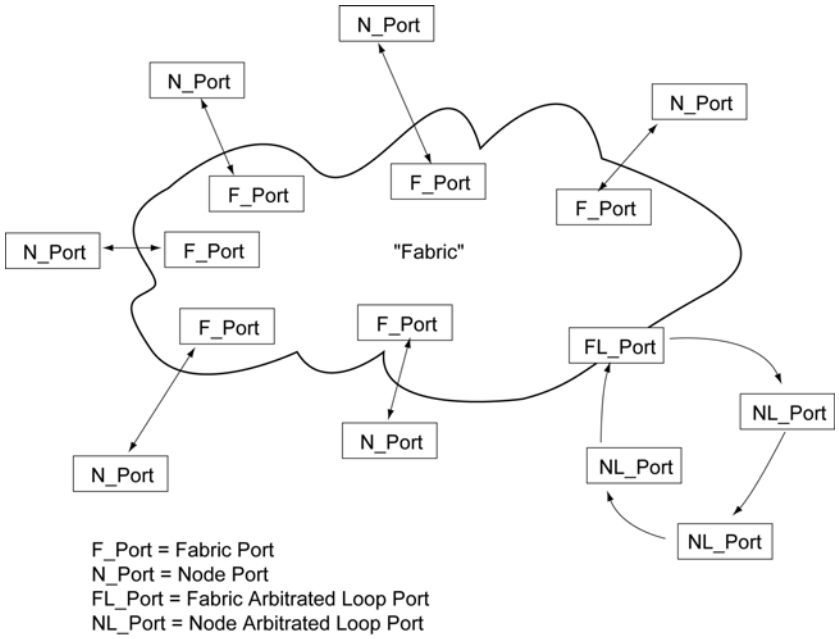


Figure 5. *Fabric Node Connection*

An Arbitrated Loop has the following states:

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

A node can be “hot plugged” where it is inserted or removed from the 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 6*. 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.

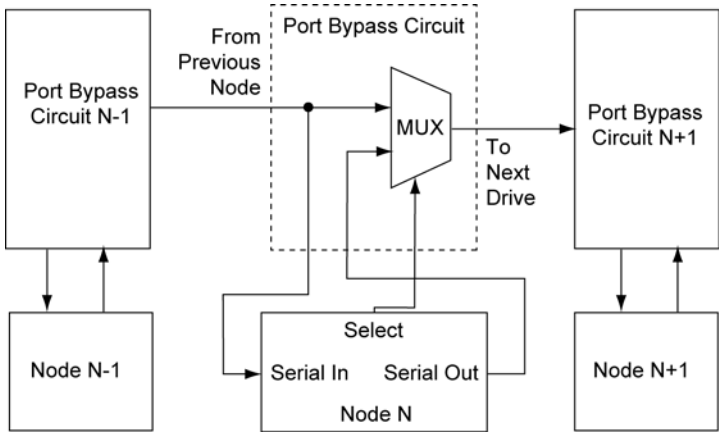


Figure 6. *Typical Backplane Bypass Circuit*

The Fibre Channel standard is structured into FCP Function Levels, where “FCP” is “Fibre Channel Protocol”. There is a hierarchy of function levels, written FC-0 to FC-4, and on top of those lies the Upper Level Protocols or ULP. *Table 32* summarizes each FCP level.

Table 32. *FCP Function Levels*

FCP Level	Description
FC-0	This level defines the cable, transceivers, and connector. For example, the Zeus^{IOPS} 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 “stripping” 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^{IOPS} SSD has FCP-SCSI as its ULP.

PHYSICAL CHARACTERISTICS

GENERAL PHYSICAL CHARACTERISTICS

MATERIALS

All acceptable enclosure materials have been independently tested by an NRTL and are certified to comply with the following standards:

- ANSI/UL60950-1-2002
- CAN/CSA-C22.2 No.60950-1-03

DRIVE ASSEMBLY WEIGHT

The weight of a Zeus^{IOPS} SSD varies according to the specific set of design characteristics of the drive. The following characteristics must be considered 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 33 lists the available formatted capacities, total data bytes, and corresponding total logical data blocks in hexadecimal values of the Zeus^{IOPS} SSDs.

Table 33. *Formatted Capacities*

Model	Formatted Capacity	Total Data Bytes	Total Logical Data Blocks
Z16F318C	18 GB	18,253,611,008	35,651,584 (2200000 Hex)
Z16F336C	36 GB	36,507,222,016	71,303,168 (4400000 Hex)
Z16F373C	73 GB	73,014,444,032	142,606,336 (8800000 Hex)
Z16F3146C	146 GB	146,028,888,064	285,212,672 (11000000 Hex)

EXTERIOR DIMENSIONS

Zeus^{IOPS} SSD internal components are housed within precision machined aluminum alloy enclosures. The overall dimensions for the 3.5-inch form factor are illustrated in *Figure 7*.

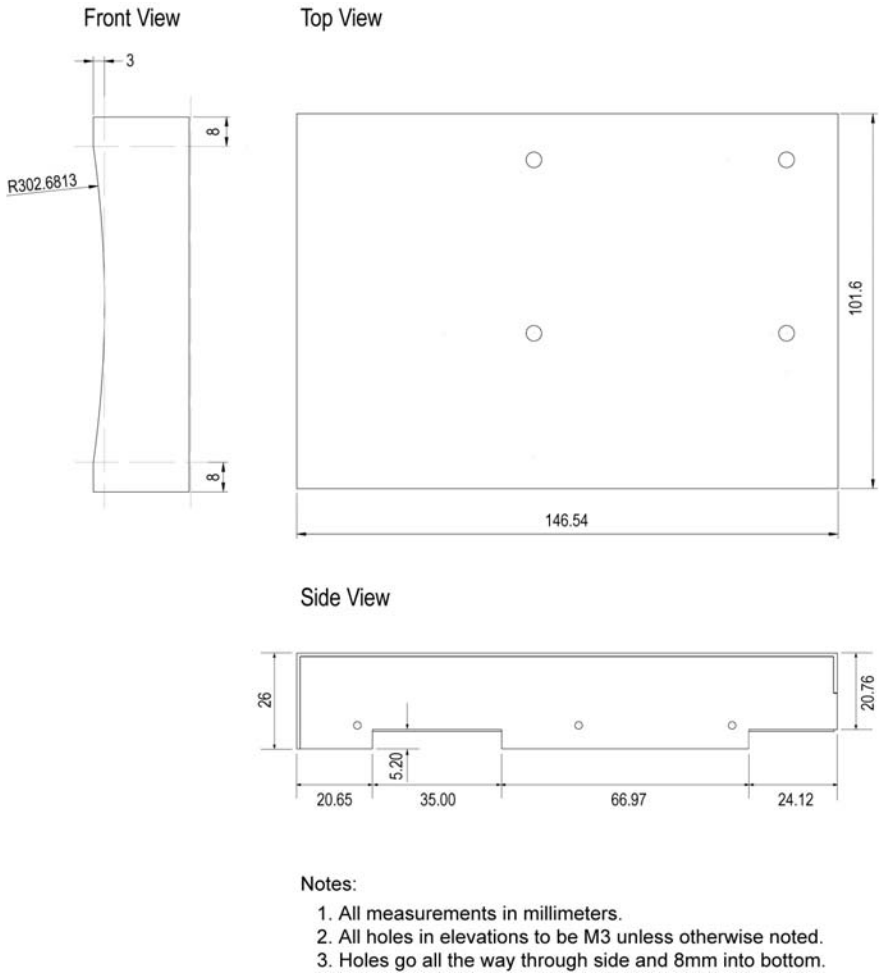


Figure 7. *Zeus^{IOPS} 3.5-Inch Dimensions*

ENVIRONMENTAL CHARACTERISTICS

OVERVIEW

Zeus^{IOPS} 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. The SSDs operate without degradation within the ambient temperature, relative humidity and altitude ranges as specified in the following sections.

TEMPERATURE CONDITIONS

Temperature parameters for the 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 34*.

Table 34. *Operating Temperatures*

Operating Requirement	Criteria
Case Temperature	
Commercial	0^0C to 55^0C
Industrial	TBA
Maximum Temperature Gradient	TBA

STORAGE TEMPERATURES

Note: Non-operating conditions include shipment and storage environments. *See Table 35*.

Table 35. *Storage Temperatures*

Storage Requirement	Criteria
Temperature Range	-40^0C to 70^0C
Maximum Temperature Gradient	TBA
Short Duration Temperature	TBA

MAXIMUM COMPONENT TEMPERATURES

Critical drive component temperatures must be kept within certain limits to prevent damage to the SSD. The approximate component locations within the drive are illustrated in *Figure 8*. *Table 36* lists the maximum component temperatures. Forced air cooling will be required in most applications to ensure optimal conditions.

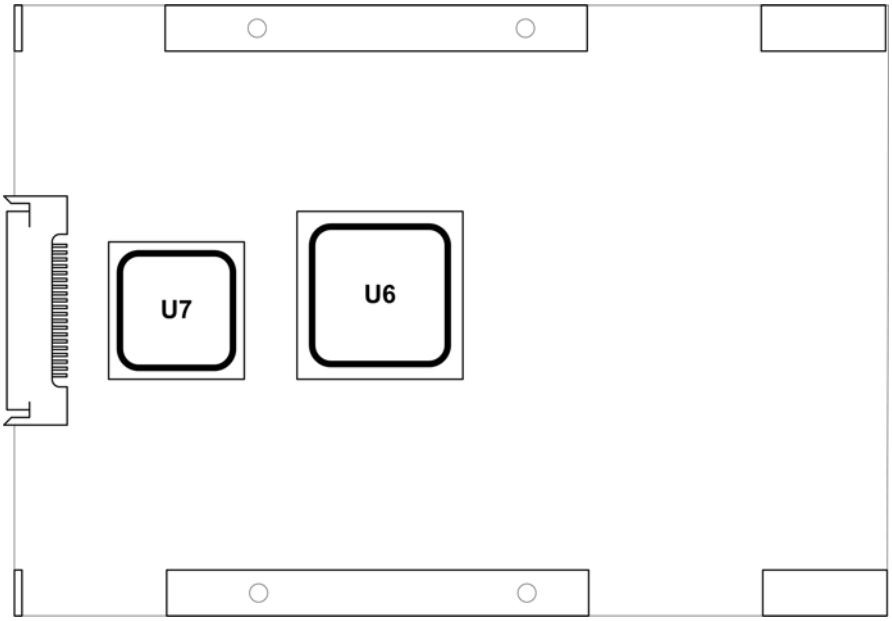


Figure 8. *Component Locations*

Table 36. *Maximum Component Temperatures*

Component	Designator	Maximum Package Temperature
Processor	U7	95°C
Flash Controller	U6	80°C

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 electrical 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^{IOPS} 3.5-inch Fibre Channel SSD can be installed in an operating system environment that supports SCSI-3 or greater devices (the 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.

Make sure the following is on hand before installing the SSD:

- Phillips screwdriver
- Six M3 machine screws
- A cable suitable to connect the backplane or tailgate card to the HBA
- An available tailgate card or backplane connection.
- Available 12V power source

SINGLE CHANNEL OPERATION

The Zeus^{IOPS} SSD is dual-ported and can be accessed simultaneously down both ports or channels. This allows the drive to be used on systems that have multi-pathing software, also known as “Dynamic Multi-Pathing” or DMP. The DMP software allows for two completely separate paths from the one host machine to access the same drive; the two separate paths are recognized as being logically connected together. This allows for some redundancy to be incorporated into the system. Systems that support DMP typically send commands to the drive down both channels, using the channel that is the least busy. If one channel fails for any reason then all commands are automatically switched to use the remaining active channel.

For host systems that are not DMP capable, having two paths from the same host machine to the same drive can cause problems. For example, if the two channels are connected to the same host machine when running an operating system that does not support DMP, two separate disks will be reported by the operating system even though both reported disks are the same physical storage. This can cause corruption to occur if the drive is subsequently accessed down both channels. *See Single Channel Mode for Early Revision Drives* on page 66.

DRIVE CONFIGURATION

To accommodate both DMP and non-DMP capable systems, the SSD can be configured so that it only operates (and is only visible) down one of the two channels. This feature is most likely to be used on systems that do not support DMP but where the drives in the same JBOD chassis are to be mirrored. Enabling just the A channel for the main drive and the B channel on the mirror drive will cause both drives to be visible via separate host channels, thereby preventing any single point of failure.

The feature is enabled by inserting a 2mm option jumper onto the two pins marked as JP1 on the underside of the drive. Please note that jumper JP1 is located on the 10-way right-angled connector that also serves as a test connector during manufacture. The drive will require power cycling after JP1 is installed or removed. When this feature is enabled, the LSB of the SELECT_ID determines the port that the drive will use. If the SELECT_ID is even, then port A is used. If the SELECT_ID is odd, then port B is used.

WARNING: Only insert a jumper across the pins clearly labeled as JP1 on the PCB silk-screen. If JP1 is not marked, then please read the following for information regarding early revision drives.

FAULT SIGNALS

Under certain conditions, the SSD will drive the Fault LED Out (fault signal) on the SCA-2 interface. In most system configurations, this will normally be connected to an LED on the chassis that is visible to the user.

POWER-ON FAULT CONDITIONS

The fault codes listed in *Table 37* indicate that a fault has been detected during the power-on sequence. As a result, the unit is in a non-operational state and remedial action is required to replace the unit.

Power-on fault codes are indicated as a series of flashes. The fault light will illuminate for 0.25 seconds (250mS), then turn off for 0.25 seconds (250mS), followed by a 2 second off interval. The number of flashes between each 2 second off period is used to indicate the different fault conditions.

Table 37. *Power-On Fault Codes*

Flash Series	Condition
1 Flash	Memory strobe adjustment failure.
2 Flashes	Memory address failure.
3 Flashes	Memory data failure.
4 Flashes	ECC error encountered during memory test.
5 Flashes	ECC detection/correction circuit failure.

The fault code should be noted (along with the drive serial number if possible), and either the supplier of the SSD unit or technical support should be contacted.

OPERATIONAL FAULT CODES

The following codes indicate that a fault has been detected during drive operation. The drive will remain operational despite the fault. The drive should be replaced at the earliest possible opportunity.

Operational fault codes are indicated as a series of flashes. The fault light will illuminate for 1 second, then off for 1 second, followed by a 10 second off delay. The number of 1 second flashes between each 10 second delay period are used to indicate the different fault conditions: 5, 7 or 9 flashes.

Table 38. *Operational Fault Codes*

Code	Condition	Description
5 Flashes	Power Backup Device Faulty	The power backup circuit has failed. The power backup circuit supplies power to the drive for a short period in the event of a power failure. The backup power allows the firmware to ensure that any active writes are completed. It also allows information to be saved so that the drive becomes ready promptly (< 30 seconds) when power is restored. If this fault code is active and power is unexpectedly lost, the drive may require several minutes to come ready when the power is restored. If this occurs, only the data blocks that were most recently written by the host will be lost. If those same data blocks are read when power is restored, the prior contents (prior to the lost write) will be returned. *No data will be permanently lost*. When this fault code is active the drive will save all information and prepare for power loss if a SYNCHRONIZE CACHE (10) command (Opcode 0x35) is received via the host SCSI interface. Most operating systems (Windows, Solaris, Linux, etc.) will issue this command automatically when shut down by the user. This will alleviate the potential problems associated with this fault condition.
7 Flashes	NAND Flash Write Protect Error	A write protect error was returned when the unit attempted to write to the flash media. The most likely cause is a faulty connection or voltage converter. If this error occurs continuously then access from the host machine will be locked out.
9 Flashes	NAND Busy Error	The BUSY pin from a NAND flash chip was asserted for too long. The most likely cause is a faulty connection. If this error occurs continuously then access from the host machine will be locked out.

SINGLE CHANNEL MODE FOR EARLY REVISION DRIVES

On early revisions of the drive, JP1 did not exist. These drives are identified by having a serial number of “50” or less and only have an 8-way right-angled manufacturing connector. For this revision of drive, the feature is enabled by setting bit 6 of the LOOP_ID to “1”. The LOOP_ID is set using the SELECT_ID pins on the SCA-2 connector within the chassis to which the SSD is connected. *See the SEL_ID Function on page 30*.

The SELECT_ID bits are normally configured by jumpers or a switch that allows the ID of the drive to be set using the backplane of the SCA-2 connector. *Table 39* lists the various configurations of the SELECT_ID function.

Table 39. *SELECT_ID Configurations*

Bit 6	Bits 5 -1	Bit 0	Configuration Result
0	XXXXX	X	Loop ID 0 - 63 Drive operates down both channels.
1	XXXXX	0	Loop ID 64 - 126 and even Drive operates down channel A only.
1	XXXXX	1	Loop ID 65 - 127 and odd Drive operates down channel B only.

DRIVE ORIENTATION

The 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 9*.

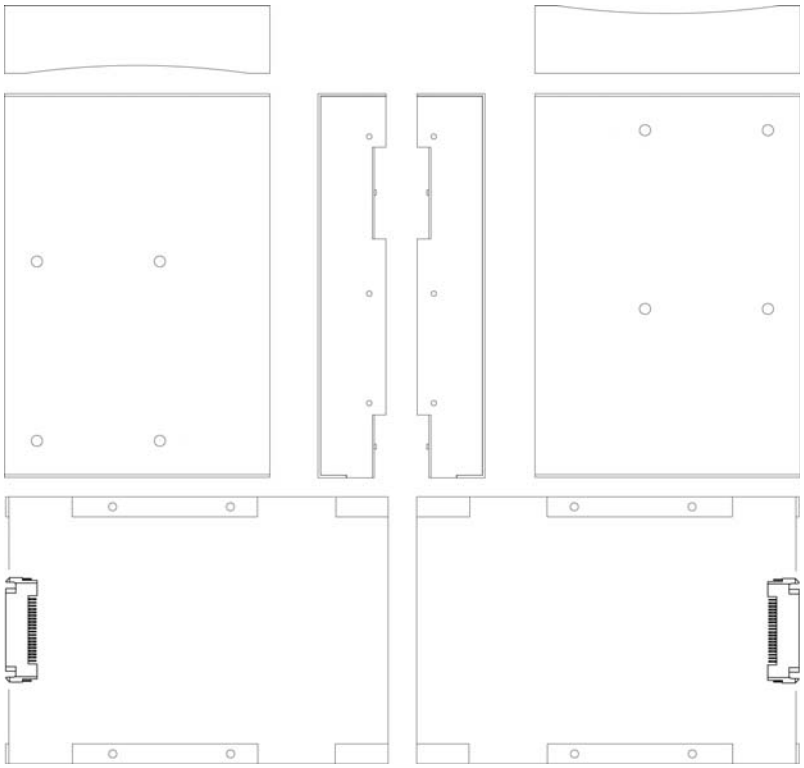


Figure 9. *Possible Drive Orientations*

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. The suggested air flow patterns are shown in *Figure 10*.

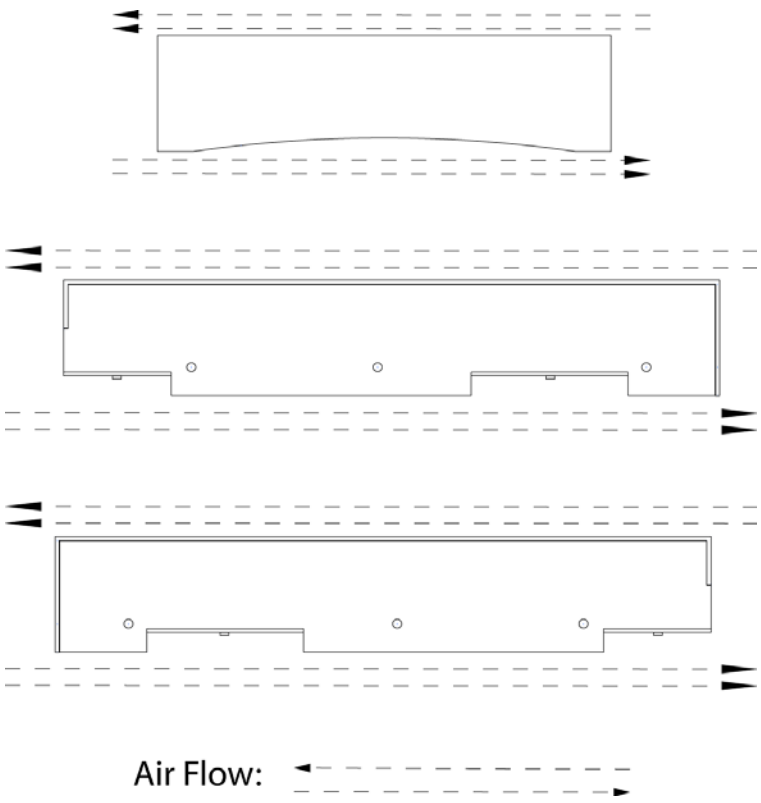


Figure 10. *Suggested Air Flow Patterns for Cooling*

MOUNTING HOLE DIMENSIONS

Figure 11 shows relative locations 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; the maximum screw penetration is 5 mm. The mounting screw threads are M3 and the recommended torque is 0.5 Nm to 0.8 Nm.

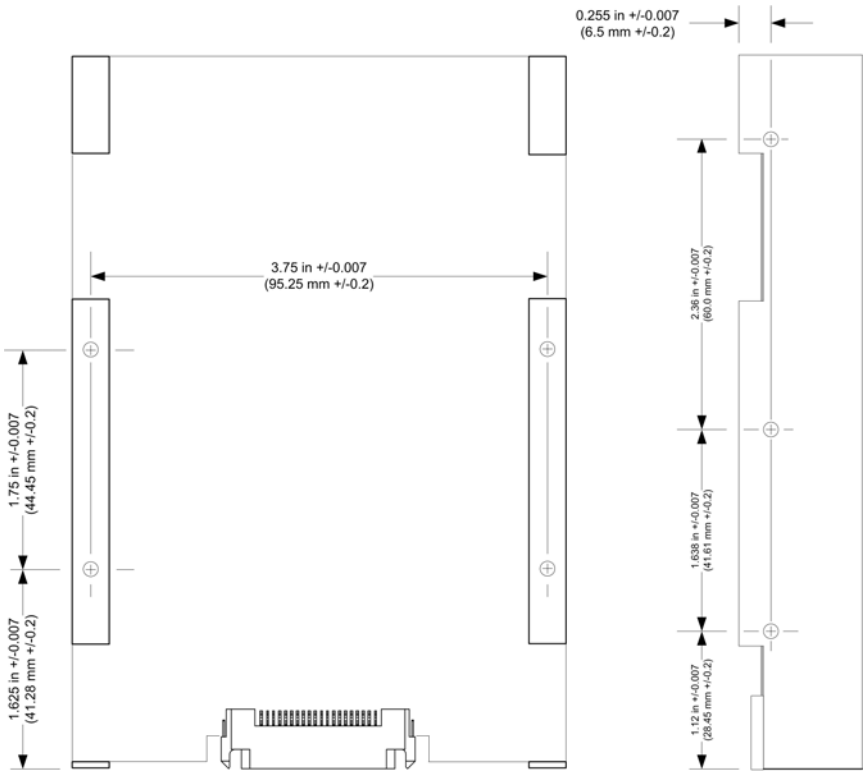


Figure 11. *Exterior Mounting Specifications*

Underside Mounting Holes	Side Mounting Holes
(4x) M3 Screws	(6x) M3 Screws
Maximum Depth: 5.0mm	Maximum Depth: 5.0mm
Maximum Torque: 0.8 Nm	Maximum Torque: 0.8 Nm

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 SDD in a server or host system:

1. Power down the computer/host system.
2. Remove the access cover.
3. Position the SSD in an available drive bay or choose a suitable mounting location.
4. Connect the SSD to the backplane or tailgate card. The connector on the drive is keyed to ensure that the signal and power connections to the drive are correctly oriented.
5. Secure the SSD within the drive bay or to the mounting surface using M3 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 60. The user may mount the drive using the side or underside mounting holes. Four (4) M3 screws will be required to mount the drive from the bottom; six (6) M3 screws to mount the drive using the side holes. It is recommended that the user secure the drive with at least four screws. To avoid damaging the drive, consider the thickness of the mounting surface when deciding on the screw length to use.
6. Replace the access cover and power on the computer/host system.

GROUNDING REQUIREMENTS

No special grounding circuitry is required. 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 Specifications

The Zeus^{IOPS} 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 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:

- Linux Distributions (with Fibre Channel support)
- Sun Microsystems Solaris 8 and 10
- SGI IRIX
- HPUX

System POST, Boot and Resume Times

The time required for the drive to become ready varies according to the capacity. The average time is 30 seconds. The total boot time will vary depending on the state of the capacitor-based power backup module. Under normal operation, the module will remain in a state where it holds enough of a charge to that the charging causes no delay to the boot-up. When the drive is new or remains without power for many hours, the capacitors on the power backup module will be discharged. If the capacitors are fully discharged the drive will take longer to start. For example: 18GB, fully discharged 35 seconds, charged 11 seconds; 146GB fully discharged 45 seconds, charged 23 seconds.

SSD MANAGEMENT UTILITY

The firmware and hardware on a Zeus^{IOPS} SSD can be upgraded in the field. The drive management utility, “Giddy”, uses signed Java applet technology and the Java native interface to maintain the SSD. *Table 40* lists the supported operating systems, Java Runtime Environments (JREs) and compatible web browsers. The documentation for the Management utility is found at ***http://www.gnutek.co.uk/giddy.pdf***.

Notes:

1. *The end user is required to have administrator rights to execute the management utility*.
2. The utility is capable of updating the firmware or the programmable gate arrays (“hardware upgrade”).
3. The SSD will log internal events during normal operation. These “messages” are transparent to the host. In the event of an error, the utility is capable of extracting these messages that can be sent to the manufacturer for diagnostic purposes.
4. The user can choose to erase or sanitize the drive.
5. The utility will not permit updating the device with firmware intended for another model or version of the device.

Table 40. *Zeus^{IOPS} Management Utility Requirements*

Operating System	JRE	Web Browser
Windows 2003	1.5.0	Internet Explorer 6.0+ Mozilla Firefox 1.4+ Netscape Navigator 7.0+
Windows 2000	1.5.0	Internet Explorer 6.0+ Mozilla Firefox 1.4+ Netscape Navigator 7.0+
Windows XP	1.5.0	Internet Explorer 6.0+ Mozilla Firefox 1.4+ Netscape Navigator 7.0+
Windows ME	1.5.0	Internet Explorer 6.0+ Mozilla Firefox 1.4+ Netscape Navigator 7.0+
Linux	1.5.0	Mozilla Firefox 1.4+ Netscape Navigator 7.0+
Solaris	1.5.0	Netscape Navigator 7.0+

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 develops firmware to support a wide range of NAND flash versions and vendors. Please contact STEC 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.

REGULATORY COMPLIANCE

MARKING, APPROVALS AND SUPPORTING DOCUMENTATION

The SSDs will have the following marks, approvals and documentation as outlined in *Table 41.*

Table 41. *Regulatory Marks and Documentation*

Mark/Approval	Documentation	Mark
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 be marked (CE) accordingly.	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. The SSDs are compliant with the European Parliament and Council Directive, i.e., assembled with Pb-free or lead-free components.

FCC DECLARATION OF CONFORMITY

The FCC (Federal Communications Commission) Declaration of Conformity (DoC) will contain the following:

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

Radio Frequency Emissions

The Zeus^{IOPS} 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 42*.

Table 42. *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 SSDs 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 43* lists the ESD requirements.

Table 43. *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 44. *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

Contact Information

For more information on Zeus^{IOPS} Solid State Drives, contact the STEC Solid State Drive Team.

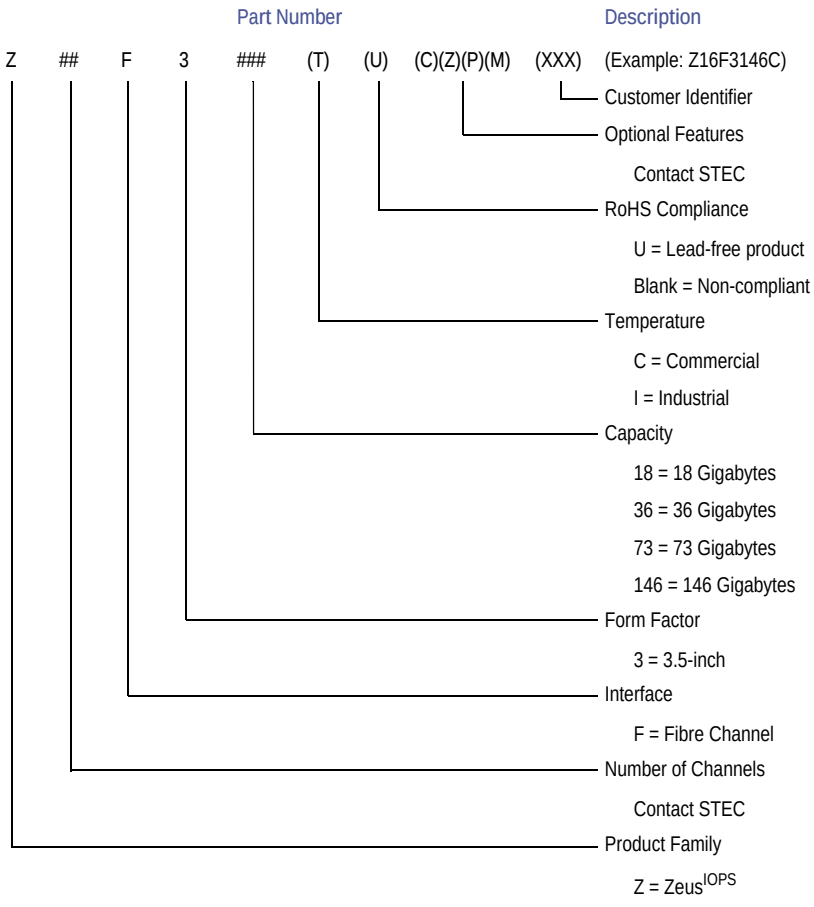
Telephone: 800-796-4645 (Toll free; U.S. and Canada only)

All Others: (949) 260-8345

Fax: (949) 851-2756

E-mail: ssd@stec-inc.com

Ordering Information



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CERTIFICATION AND WARRANTY

FCC Declaration of Conformity

Zeus^{IOPS} 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 interference.
- This device must accept any interference 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 the 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 the 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 an experienced radio/television technician for help.

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

Limited Warranty

STEC Inc., Solid State Drives 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 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.

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